A NEW PERSPECTIVE ON THE DESIGN OF PRESSURE RELIEF CUSHIONS FOR THOSE WITH SPINAL CORD INJURIES

A Thesis submitted for the degree of Doctor of Philosophy

By

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ABSTRACT

The aim of this study is to develop new insights which pressure relief (PR) cushion designers can use to guide the design of new cushions with greater efficacy at preventing pressure ulcers than contemporary cushions.

A methodological framework was formulated which incorporated a number of research techniques from the user-centred methodology USER*fit*, and included methodological triangulation.

Exploratory interviews and observational work were conducted in a specialist unit for spinal cord injury (SCI). This involved ten patients, four physiotherapists, two nurses and an outpatient technician. Additionally, two questionnaires were designed and circulated amongst SCI patients and staff with completed responses from 41 patients and 31 staff.

From the analyses of the data gathered from the literature, observational work, interviews and questionnaire responses, 28 recommendations for cushion design were formulated. These recommendations covered the principles which underpin cushion design, cushion usability and the future direction of cushion design.

As a consequence of their passive unresponsive relationship with the user limiting their usability, currently contemporary cushions are not preventing all pressure ulcers.

This thesis recommends that contemporary static and dynamic PR cushions should be referred to as "*first generation*" cushions, due to their passive relationship with the user. Through the innovative use of the technological advancements since the inception of PR cushions, it is now possible to conceive a new "*second generation*" of, "*smart*" or "*intelligent*" cushions. These second generation cushions, known as "*Ulcer Prevention*" cushions not Pressure Relief (PR) cushions, will have real-time autonomous responses to attend to the needs of the user.

Through the enhanced usability achieved by creating a cushion with an active responsive relationship with the user, a "*smart*" cushion will be able to prevent the pressure ulcers which contemporary cushions are unable to, thus reducing the overall incidence rate of pressure ulcers.

This thesis is dedicated to the memory of my father Phil Lance

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ABBREVIATIONS

ADL	Activities of Daily Living
AP	Alternating Pressure
AT	Assistive Technology
BAI	Barthel's ADL Index
BIME	Bath Institute of Medical Engineering
BMI	Body Mass Index
CLP	Constant Low Pressure
CRPF	Christopher Reeve Paralysis Foundation
CVA	Cerebrovascular Accident
DLF	Disabled Living Foundation
DLCC	Disabled Living Centres Council
DTI	Deep Tissue Injury
EPUAP	European Pressure Ulcer Advisory Panel
FIRA	Furniture Industries Research Association
HTA	Health Technology Assessment programme
IADL	Instrumental Activities of Daily Living
ICU	Intensive Care Unit
IDRCLI	Impact Damping Rigid Contoured Loading Indenter
IP	Interface Pressure
ISAP	International Association for the Study of Pain
ISDB	Indirect Self-Destructive Behaviour
ISO	International Organisation for Standardisation
MASCIP	Multidisciplinary Association of Spinal Cord Injury Professionals
MDA	Medical Devices Agency
MHRA	Medicines and Healthcare product Regulatory Agency
MWP	Manual Wheelchair Propulsion
NHS	National Health Service
NICE	National Institute for Clinical Excellence
NPUAP	National Pressure Ulcer Advisory Panel
NSIC	National Spinal Injuries Centre
PASA	NHS Purchasing and Supply Agency
PR	Pressure Relief or Pressure Redistribution
PSV	Pressure Setting Valve

PU	Pressure Ulcer
RCT	Randomised Controlled Trial
RESNA	Rehabilitation Engineering and Assistive Technology Society of North America
RTA	Road Traffic Accident
RUH	Royal United Hospital Bath
SDH	Salisbury District Hospital
SIA	Spinal Injuries Association
SMH	Stoke Mandeville Hospital
SCI	Spinal Cord Injury
SCIC	Spinal Cord Injury Centre
TVN	Tissue Viability Nurse
TVS	Tissue Viability Society
WUG	Wheelchair Users Group

GLOSSARY

Anthropometry	The measurement of the human individual for the purposes of understanding human physical variation.
Catheter	A flexible tube for insertion into a narrow opening so that fluids may be introduced or removed.
Cellultis	An infection of the deep dermis of the skin by ß-haemolytic streptococci.
Cytotoxic drugs	A drug that damages or destroys cells and is used to treat various types of cancer.
Denude	To make bare; strip.
Erythema	Flushing of the skin due to dilation of the blood capillaries in the dermis.
Excoriation	The destruction and removal of the surface of the skin or the covering of an organ by scraping, the application of a chemical, or other means.
Exudation	The slow escape of liquid (the exudate) containing proteins and white cells through the walls of intact blood vessels.
Fascia	Connective tissue that envelops organs and tissues, forms sheaths for muscles.
Ischemia	An inadequate flow of blood to a part of the body, caused by constrictions or blockage of the blood vessels supplying it.
Hyperaemia	The presence of excess blood in the vessels supplying a part of the body.
Hysteresis	The effect when a lag occurs in a physical process between the application and removal of a force, or field, and its subsequent effect.
Medical	1. Of or relating to the science or practice of medicine. 2. Of or relating to conditions that require attention of a physician rather than a surgeon.
Nociceptive	Describing nerve fibres, endings or pathways that are concerned with the condition of pain.
Occlusion	The closing or obstruction of a hollow organ or part.
Osteomyelitis	Inflammation of the bone due to infection.
Pyrexia	Rise in body temperature above the normal, i.e. above an oral temperature of 37℃, usually caused by a bacterial or viral infection.
Thermal mass	The capacity of a body to store heat. It is typically measured in units of J/℃ or J/K (which are equivalent).

Chapter 1

INTRODUCTION

1.1 Introduction to the Project

Pressure ulcers have always afflicted the immobilised, whether they have been immobilised through illness, injury or infirmity. Despite the progress made in modern medicine, pressure ulcers continue to beset the immobilised. Globally the number of people developing pressure ulcers annually runs into millions. Each year in the UK alone an estimated 412,000 people will develop one or more pressure ulcers (Bennett *et al* 2004). To care and treat hundreds of thousands of pressure ulcers per year costs the British tax payer billions of pounds (Enoch 2004).

Whilst pressure ulcers are closely associated with the bed ridden, so much so that until recently they were commonly referred to as "*bed sores*", a large proportion of pressure ulcers occur whilst seated. It has been estimated that between 34-50% of all pressure ulcers can be attributed to sitting in a wheelchair (Geyer *et al* 2001).

It has been estimated that there are 1.2 million wheelchair users in England (Gallop 2004). One of the patient groups which form the wheelchair using population is particularly vulnerable to pressure ulceration. In patients with a spinal cord injury (SCI), it has been estimated that up to 85% of patients will experience a pressure ulcer at some point during their life, with an annual incidence of pressure ulcers amongst people with SCI being between 23-30% (Byrne and Saltzberg 1996).

To reduce the incidence of pressure ulcers whilst sitting in a wheelchair, SCI patients use a pressure relief (PR)[1] cushion as a preventative measure. It was during the early 1970's that the need for some form of preventative measure to protect wheelchair users from pressure ulcers led to the

[1] The term "*pressure relief"* is an umbrella term for all "*pressure-reducing"* and "*pressure-redistributing"* cushions. This term is consistent with the recent National Institute for Clinical Excellence (NICE) guidelines on the use of pressure-relieving devices (Yerrell *et al* 2003 reprinted 2005).

production of the first PR cushions; for example the ROHO "*Dry floatation*" cushion, which continues to be widely used today (ROHO 2008a).

These first PR cushions were based on the then new principles of, pressure-reduction and pressure-redistribution (Rithalia 2005). It was from these principles that cushion types such as air filled, gel, contoured foam (Hobson 1999) were created. It is these same PR cushion types which continue to be used today. Thus, today's contemporary PR cushions remain the product of forty year old science and technology.

Although the designs of these PR cushions are now forty years old the uptake and continuing widespread use of PR cushions, at considerable financial cost, attests to the prophylactic value with which cushions are regarded. However despite the near universal use of PR cushions by SCI patients, the incidence of pressure ulcers experienced by SCI patients on the anatomical sites in contact with a PR cushion when sitting, namely the ischiums, sacrum and greater trochanters, remains high.

The high incidence of pressure ulcers on the seat area of the body suggest that there is both the need and scope for improving the preventative qualities of contemporary PR cushions. An improved PR cushion design better equipped to prevent pressure ulcers would not only benefit the user but would make a substantial monetary saving for the National Health Service (NHS). A reduction of 1% of the UK annual incidence rate of pressure ulcers, approximately 4000 pressure ulcers, would save the NHS between £16 million (cost to treat 4000 Grade 1 ulcers at £4000 per ulcer) and £160 million (cost to treat 4000 Grade 4 ulcers at £40,000 per ulcer) each year.

1.2 The Aim and Objectives of the Project

Large established medical equipment manufacturers, such as Invacare and Sunrise Medical, form a multi million dollar global industry geared to producing millions of PR cushions. These companies have research and development (R&D) departments, with access to finances and resources which are not available to one researcher. Therefore the expectation that a single postgraduate researcher could produce a new model of PR cushion capable of directly competing with these companies is unrealistic.

It is feasible for a postgraduate researcher to investigate the design of contemporary PR cushions in order to identify where these designs are either weak or deficient. With such an investigation there lies the potential to gain insights which will stimulate innovation and thereby improve the efficacy of future cushion designs.

Such an investigation represents a substantial challenge as the leading contemporary PR cushions are designs based on principles and approaches which have remained largely unchanged since they were first defined in the early 1970's; despite the lack of a tangible reduction in the incidence rate of pressure ulcers on the seat area of cushion users. The adherence to these founding principles and approaches suggests an inability within the industry to find or accept new ways of looking at the problem of pressure ulcer prevention and innovate new products. It is therefore of value for someone outside the industry culture to examine the design of contemporary PR cushions in order to gauge if the concepts and approaches which currently guide PR cushion design continue to hold true after forty years or if there are issues with these concepts and approaches which require rethinking.

The aim of this project is to develop new insights which PR cushion designers can use to guide the design of new cushions with greater efficacy at preventing pressure ulcers than contemporary cushions. This aim will be achieved by conducting a review of contemporary PR cushion design from which a set of recommendations will be produced.

These recommendations seek to stimulate innovation in design. They will furthermore provide future designers with information to guide the creation of new more advanced cushions.

This aim will be achieved through the completion of two objectives:

- The identification of weaknesses and/or deficiencies in contemporary pressure relief cushion design
- The production of a set of recommendations for the design of future pressure ulcer preventative cushions.

1.3 The Thesis Structure

This thesis documents the work undertaken to complete the two objectives. The work, culminating in a set of recommendations, was carried out as a series of stages. The work conducted to complete these stages has been reported in this thesis in twelve chapters, see figure 1-1

STAGE 0: PROJECT INTRODUCTION

Chapter 1. Introduction

This chapter consists of a brief statement as to the scale of the problem posed by pressure ulcers and a statement as to the aim and objectives of this project.

Chapter 2. Background

This chapter provides greater detail as to the scale of the problem to be addressed. It considers the impact pressure ulcers hold for the individual, who is at risk of developing pressure ulcers and finishes by considering the financial cost of pressure ulcers.

STAGE 1: LITERATURE REVIEW

Chapter 3. Literature Review Part 1: A Review of Contemporary Pressure Relief Cushion Design

This chapter records the findings of the review of contemporary pressure relief cushion design. This review encompassed the principles designers use, pressure-reduction and pressure-redistribution, and how these principles have been applied by leading cushions such as the ROHO and the Jay cushion.

Chapter 4. Literature Review Part 2: A Review of the Pressure Ulcer Knowledge Base

This chapter records the findings of the review of the published material on the aetiology of pressure ulcers. This review considered the understanding of pressure ulcer development which underpin the principles of pressure-reduction and pressure-redistribution.

STAGE 2: METHODOLOGY DEVELOPMENT

Chapter 5. Methodology

This chapter recounts the formulation of the methodological framework which guided this project.

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STAGE 3: GENERATION OF RESEARCH SUPPOSITIONS

Chapter 6. Pressure Relief Cushion Use in Practice

This chapter reports on the qualitative work undertaken, including interviewing SCI patients, and the induction of a series of research suppositions from the findings of interviews

STAGE 4: TESTING OF RESEARCH SUPPOSITIONS

Chapter 7. Conducting Two Surveys of PR Cushion Use in the Community

This chapter chronicles the design and development of questionnaires and the activities conducted for their circulation.

Chapter 8. Findings of the SCI Patient Questionnaire

This chapter reports on the findings of the questionnaire circulated amongst those professionals involved in the care and treatment of those with SCI.

Chapter 9. Findings of the SCI Professional Questionnaire

This chapter reports on the findings of the questionnaire circulated amongst SCI wheelchair users.

STAGE 5: TRIANGULATING RESEARCH SUPPOSITIONS

Chapter 10. Triangulation

This chapter delineates the triangulation of the findings made by this project, and their correlation to published literature, in order to establish whether the research suppositions are valid.

STAGE 6: RECOMMENDATIONS

Chapter 11. Recommendations

This chapter relates the synthesis of the findings into a set of recommendations as to how future cushion design might progress so as to avoid or overcome the weaknesses and deficiencies found in contemporary PR cushions.

Chapter 12 Summary and Conclusions

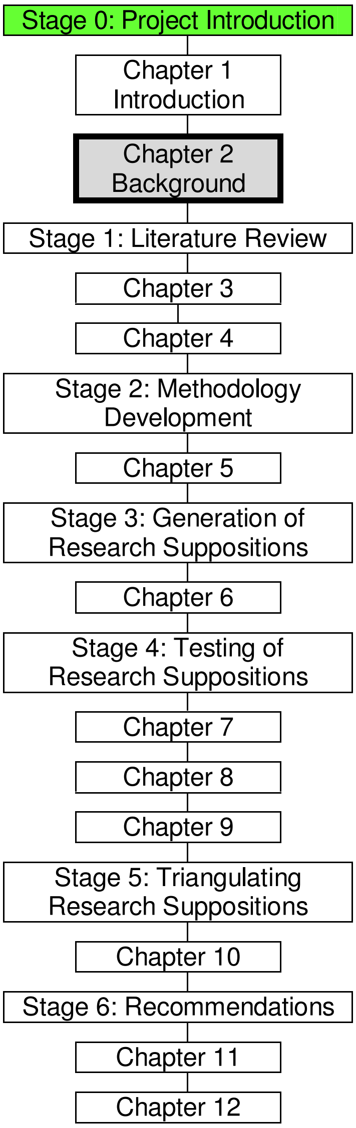
This chapter summarises the work carried out in the project and then draws conclusions.

Figure 1-1 The thesis structure

Chapter 2

BACKGROUND

2.1 Introduction



In preparation for this project work was undertaken concerned with the nature and scale of the problem posed by pressure ulcers. This work was undertaken to ascertain the potential benefits to be gained from working in this field and identify where to direct this project.

In order to identify the potential benefits to be gained by preventing pressure ulcers, the matter of how pressure ulcers impact the individual was studied.

Next the financial implications of preventing and treating pressure ulcers were considered. This revealed the scale of the potential savings to be made by preventing pressure ulcers.

This was followed by studying the issue of who is affected by pressure ulcers. This was studied in order to identify who is affected and how many individuals would benefit from preventing pressure ulcers. Based on this it was decided that this project would focus on pressure relief cushions for patients with a spinal cord injury.

2.2 The Impact of Pressure Ulcers

The extent to which the skin has been damaged will govern the impact of a pressure ulcer on an individual. Pressure damage can range from superficial red marks, which might be resolved with a single night's bed rest (Ratcliffe and Rose 2000), to full thickness skin loss with damage to underlying structures and bone (EPUAP 1999). To treat a full thickness pressure ulcer may require hospitalisation and in some cases require skin graft plastic surgery, see figure 2-1.

Figure 2-1 A large pressure ulcer on the sacrum[1] (Horch *et al* 2005)

In addition to the issues related to tissue loss, pressure ulcers can become infected. Once infected the healing process is slowed and may include the complications of pain, fluid loss through exudation, malodour, cellulitis and pyrexia (Hampton and Collins 2004). In most severe cases, infection can result in death. For example, although Christopher Reeve[2] received close medical attention he developed a pressure ulcer which became inflected and subsequently led to heart failure (Lewis 2004). Reeve is not an isolated case. In the U.S., between 1990 and 2001, pressure ulcers were reported as the cause of death in 114,380 cases (Redelings *et al* 2005).

As well as being potentially fatal, pressure ulcers can cause an individual pain. This pain can severely impact the quality of an individual's life.

[1] A Vacuum-Assisted Closure (V.A.C) device used to provide continuous negative pressure until proper wound bed preparation has been achieved ready for surgery (Horch *et al* 2005).

[2] A Hollywood actor remembered for his role as Superman; and the founder of the Christopher Reeve Paralysis Foundation (CRPF).

Rastinehad conducted a study to describe and interpret the complexities of the pain experienced by individuals with pressure ulcers. Many of the study participants reported that the pain they experienced was constant and unremitting, and that this pain affected their sleep and activities. Based on this work Rastinehad found that current pain descriptors and nociceptive categories were insufficient for relating the experience of living with pressure ulcers. In particular, Rastinehad challenged the International Association for the Study of Pain (IASP) definition of pain, "*An unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage*" (ISAP 1994). Rastinehad stated, "*The term "unpleasant" does not reflect the misery, anguish, desperation, and urgency of persons living with pressure ulcer pain*" (Rasinehad 2006).

Not only can pressure ulcers cause pain, they can also curtail an individual's independence. Once skin has been damaged by pressure, it is important not to impede or set back the healing process by reapplying pressure. Thus, when a wheelchair user develops a pressure ulcer on the seat area of the body, in order not to reapply pressure on the ulcer they are restricted from sitting. This in turn prevents the wheelchair user from sitting in a wheelchair effectively consigning them to bed until the ulcer has healed. This takes away the wheelchair users mobility and therefore independence. This loss of independence will last as long as it takes for the ulcer to heal, which may take between one to five months and in some cases longer[3].

For example, in 2004 a member of the Spinal Injuries Association (SIA), when addressing the Multidisciplinary Association of Spinal Cord Injury Professionals (MASCIP) annual conference on the subject of "*User Perspectives on Skin Management*", spoke of his experience of losing independence as a consequence of developing pressure ulcers. These pressure ulcers would keep him in bed for five to eight months at a time and out of the eleven years as a paraplegic he had spent a total of three years in bed. Not only did these pressure ulcers curtail his independence, they resulted in the amputation of one of his feet.

[3] In the case of a normal healing Grade 1 ulcer it has been estimated that the mean time taken for the ulcer to heal is 28 days, whereas the time taken for a normal healing Grade 4 ulcer to heal is 155 days (Bennett *et al* 2004).

2.3 Financial Implications

The money spent on the treatment of pressure ulcers is an opportunity lost as this is money which could be spent elsewhere. Any reduction in the incidence of pressure ulcers would make savings which could be used in other areas of care; Enoch suggested that the money spent to treat ten grade 2/3 pressure ulcers would cover the total cost of nine pacemakers, five knee replacements and five coronary vein bypass grafts (Enoch 2004).

As large sums of money is spent on the cost to treat pressure ulcers, by improving prevention there is the potential to save substantial sums of money to spend on other areas of care. However the magnitude of the potential savings is unclear as although it is widely recognised that the financial cost of pressure ulcers is considerable there is some disagreement as to the magnitude of this cost. Some authors offer estimates in the billions of pounds sterling whilst other authors offer estimates in the low hundreds of millions. For example Bennett estimated that pressure ulcers cost the National Health Service (NHS) annually between £1.4 and £2.1 billion (Bennett *et al* 2004). Enoch estimated this cost to be £2.5 billion (Enoch 2004). At the other end of the spectrum there is the earlier estimate generated by the accountancy firm Touche Ross, at £180 to £321 million per annum (Touche Ross 1993).

Although the Touche Ross estimate is still widely cited (Stockton and Parker 2002, Benbow 2006), this estimate should be treated with caution being over fifteen years old, during which time inflation and the introduction of new equipment and practices will have caused this cost to rise. Also, even at the time it was first produced the Touche Ross estimate was conservative compared to other contemporary estimates, for example the West's 1994 estimate of £755 million per annum (West and Priestly 1994) and Reid's 1994 estimate of £1 billion (Reid and Morison 1994).

Whilst the estimates produced by Bennett and Enoch, of approximately £2 billion, are similar they should still be treated with caution as there are inconsistencies; for instance Bennett found that a Grade 1 ulcer costs £1,064 to treat, increasing to £10,551 to treat a Grade 4 ulcer (Bennett *et al* 2004); whereas Enoch suggested that a Grade 1 ulcer on average costs £4,000 to treat, and £40,000 to treat a Grade 4 ulcer (Enoch 2004). This discrepancy is indicative of an error in one or both estimates.

These estimates do not reveal the full financial cost of pressure ulcers as these estimates only account for the costs involved in the prevention and treatment of pressure ulcers. They do not include the increasing sums that are paid out in litigation. Between April 2002 and April 2004 the average cost of a claim was £37,295, with individual claims ranging up to £370,000 (Iglesias *et al* 2006).

Of the billions spent on prevention and treatment a substantial proportion is spent on pressure care products. According to the NHS Purchasing and Supply Agency (PASA), in 2003 the NHS spent £88 million on purchasing new pressure care products and cushions (Gebhardt 2004).

There is a variety of pressure care devices available for preventing pressure damage in different situations. Some of these devices can be expensive, for example, according to the Health Technology Assessment programme (HTA), a pressure relief bed can cost up to £30,000 (Cullum *et al* 2001).

Although individual pressure relief cushions are not in the same price range as pressure relief beds, collectively they represent a substantial financial cost. A simple estimate, which serves only as a guide, of the total value of pressure relief cushions in service in the UK is £350 million. This estimate is based on the following estimated number of wheelchair users multiplied by the following estimated average cost of a pressure relief cushion.

As a national clinical database does not exist, only estimates of the number of wheelchair users are available (Gallop 2004). Published estimates of the number of wheelchair users vary; Stockton estimated that there are 650,000 wheelchair users in England and Wales (Stockton and Parker 2002) whilst Gallop estimated that there are 1.2 million wheelchair users in England alone (Gallop 2004). For the purposes of this calculation the number of wheelchair users has been estimated to be one million.

Currently a "*high-risk*" cushion is in the price range of £300-£400 (Kennedy *et al* 2003), although dynamic cushions can be priced much higher, e.g. the *Airpulse PK* cushion costs between $3,300 - $3,700 depending on the model (Aquila Corp. 2006a). Dynamic cushions represent only a small proportion of cushions used. For the purposes of this calculation the average cost of a cushion has been assumed to be in the order of £350.

2.4 Populations at Risk

Historically pressure ulcers have been perceived as an affliction affecting the bed ridden, whether the stay in bed was the result of illness, injury or infirmity. Consequently, pressure ulcers were commonly known as "*bed sores*". In the U.S. pressure ulcers are still frequently referred to as "*decubitus ulcers*", where decubitus is derived from the Latin word "*decumbere*" meaning "*lying down*" (Ousey 2005).

When lying in bed, a healthy person is protected against pressure damage by a defence mechanism referred to as the "*pressure reflex*" (Gebhardt 2004). This reflex prevents pressure damage occurring by prompting the body to change position upon sensory stimulation. This movement tends to be a spontaneous act and happens whether awake or asleep. However when sensory and/or mobility function is impaired the pressure reflex is compromised and pressure damage becomes a hazard. Thus, it is individuals with diminished sensory and/or mobility functions who are at risk of developing pressure ulcers.

People at risk of pressure ulceration are found in community settings, hospitals and in nursing homes. Kaltenthaler found that in the UK the pressure ulcer prevalence rates in the community range from 4.4% to 6.8%, in hospitals from 5.1% to 32.1%, and in nursing homes from 4.6% to 7.5% (Kaltenthaler *et al* 2001). These differing rates reflect the diversity of health care scenarios to be found, different case-mixes, practices, resource levels and so on. These reported prevalence rates conceal higher rates to be found in more specific settings for example de Laat found the rate in intensive care units (ICU) range from 14% to 42% (de Laate *et al* 2006). Also certain specific patient groups experience higher prevalence rates, for example the prevalence rates for elderly in-patients with orthopaedic problems can be as high as 70% (Grey *et al* 2006).

Epidemiological studies reveal that pressure ulcers affect a large number of people each year. For example, Bennett's study found that in 1999/2000 320,000 UK inpatients developed pressure ulcers, and estimated that overall in the UK 412,000 people annually develop a pressure ulcer (Bennett *et al* 2004).

Pressure ulcers are not just a UK phenomenon, in the United States each year an estimated 1.5 to 3 million Americans will have developed a pressure ulcer (Wang *et al* 2000).

Extrapolating this figure across the developed world, there are millions of pressure ulcers occurring each year. Further, the number of people experiencing pressure ulcers is likely to grow even if the incidence rates are reduced. This is because the population at risk of developing a pressure ulcer is growing, partly due to the increasing number of elderly[4] people, and also to the improvements in medical care which are improving the survival rates of the acutely ill and those involved in serious trauma (Fisher *et al* 2004). Therefore, even a small percentage improvement in the field of pressure ulcer prevention will benefit a large number of people.

Of those at risk, the largest group is the elderly. According to both Simpson and Thomas, approximately 70% of all pressure ulcers occur in individuals over 70 years of age (Simpson *et al* 1997) (Thomas 2001). This group is at particular risk as they can, for various reasons, experience both a reduction in mobility and sensory function. These difficulties are then compounded by the fact that age is also a predisposing factor for the development of pressure ulcers. As skin ages it experiences a loss of elasticity, a loss of subcutaneous fat, a decrease in cell proliferation and collagen disposition and a degree of muscle atrophy, all of which combine to weaken the skin's ability to tolerate pressure (Simpson *et al* 1997). It is important to note that not all of the pressure ulcers the elderly experience develop whilst in bed. In fact, Geyer reports that 34% to 50% of these pressure ulcers are attributed to sitting in wheelchairs (Geyer *et al* 2001). As 70% of pressure ulcers occur to the over 70's and 50% of these pressure ulcers are attributed to sitting, at least one third of all pressure ulcers that develop occur whilst sitting.

Although aged skin is more vulnerable to pressure ulcers, it is immobility and sensory loss which are the variables which put a person at risk. A young healthy person, once immobilised and deprived of sensation, is at risk of

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[4] In the UK the population over 65 is expected to increase from 9.2 million to 11.3 between 2000 and 2020, an increase of 23% (Bennett *et al* 2004).

developing a pressure ulcer. For example, some young women experience pressure damage during childbirth when an epidural anaesthesia is used. The loss of sensation with a degree of motor block is thought to explain the occurrence of pressure damage in patients otherwise thought to be at low risk (Hughes 2001). A general anaesthetic, which immobilises and deprives sensation, also places an individual at risk of pressure damage. Baker found that 8% of patients who have undergone surgery for more than three hours will develop pressure ulcers within four days of the operation. In addition Baker has estimated that up to 25% of the pressure ulcers which develop in hospital start in operating theatres (Baker and Leaper 2003).

Not only can mobility and sensory function be reduced and lost as a consequence of aging or the application of sedatives or general anaesthetics, it can result from degenerative illness, congenital disability and injury such as Multiple Sclerosis, Spina Bifida and Spinal Cord Injury (SCI) respectively.

Of these patient groups those with SCI are particularly vulnerable to pressure ulceration due to the impact of the SCI on their body. For instance, an injury to the spinal cord has an adverse affect on the body’s ability to control vasoconstriction and vasodilatation, which impairs the body’s ability to regulate the blood flow in the microcirculatory system (Pedley 2000). Schubert compared the response of skin microcirculation to pressure, of patients with SCI and healthy volunteers. He found the pressure required to occlude blood flow over the sacrum to be significantly less in the SCI patient group (Schubert and Fagrell 1991 cited Pedley 2000). Thus, some SCI patients can be very vulnerable to pressure damage and may only take one hour to develop a pressure ulcer (Greenough and Edmonds 2006).

Consequently SCI patients are subject to a very high level of pressure ulcer incidence. Lippert-Grüner found that 80% of this patient group were affected by pressure ulcers in the gluteal region (Lippert-Grüner 2003). Byrne quoted the annual incidence of pressure ulcers amongst individuals with SCI as being between 23% and 30% and suggested that up to 85% of individuals will experience a pressure ulcer at some point in their lifetime. He also reported that between 7-8% will die as a result of complications related to pressure ulcers (Byrne and Salzberg 1996).

2.5 The Choice of Spinal Cord Injured Patients for Study

Of the different patient groups at risk of developing pressure ulcers, wheelchair users account for a substantial proportion of all the pressure ulcers which develop. It has been estimated that between 34% and 50% of all pressure ulcers can be attributed to sitting in a wheelchair (Geyer *et al* 2001).

The exact number of individuals who sit in a wheelchair is unknown. Published estimates of the number of wheelchair users vary; Stockton estimated that there are 650,000 wheelchair users in England and Wales (Stockton and Parker 2002) whilst Gallop estimated that there are 1.2 million wheelchair users in England alone (Gallop 2004).

Although the wheelchair population can be perceived as one homogenous group, the wheelchair user population is comprised of different patient groups. According to Coggrave, the majority of wheelchair users are aged over sixty, whose impaired mobility arises from conditions such as neuromuscular or musculoskeletal disease, chronic lung or heart disease (Coggrave and Rose 2003). The remaining wheelchair population is comprised of a number of smaller patient groups such as multiple sclerosis, muscular dystrophy and spinal cord injuries.

It was decided to limit the scope of this study to just one of these patient groups. The group chosen for study was the SCI patient group[5]. It has been estimated that there are 40,000 people with SCI and that this number increases each year by less than 1,000, for instance in 2001 there were 745 new patients admitted to UK spinal injuries centres (SIA 2004).

Although the SCI patient group represents a small minority of the wheelchair user population, this group was chosen because pressure ulcers are a major life long complication of spinal cord injury and can have serious repercussions on the health and quality of life of SCI patients.

[5] The issue of sub-groups within the SCI patient group such as paraplegic and tetraplegic, and in-patients and out-patients is discussed later, see section 7.2.2.

In addition, once stabilised after the initial injury there is limited variability in their injury which allows the measurement of other factors without the patient's injury being a changing variable.

Another consideration was that SCI patients are particularly vulnerable to pressure ulcers with an annual incidence rate of between 23% - 30% (Byrne and Salzberg 1996), and up to 85% experiencing a pressure ulcer at some point in their lifetime (Niazi *et al* 1997). With such a vulnerable group any improvements in cushion performance will benefit a high proportion within this group. Additionally, this vulnerability means that they are very demanding of their cushions particularly in their day-to-day use, and any weaknesses or shortcomings with their cushions will be more immediately apparent. By better understanding the needs of arguably the most vulnerable/ demanding user group, designing for the other user groups should be a simpler affair, with hopefully many developments appropriate and transferable to cushions for other patient groups.

It was also noted that patients with SCI experience a high proportion of their pressure ulcers on the seat area of the body. Out of the six studies reviewed which recorded the occurrence of pressure ulcers upon the different anatomical sites of the body, on average the seat area of the body accounts for 62% of the total number of pressure ulcers which occur across the body, see table 2-1.

Table 2-1 Studies which recorded the occurrence of pressure ulcers upon an anatomical site

Anatomical site (from head to foot)	Number of pressure ulcers (all grades of pressure ulcer included)					
	Ash (2002)	Garber (2003)	Sheerin (2005)	Sumiya (1997)	Yarkony (1995)	Young (1981)
Occipital:	12 (8%)	-	4 (9%)	-	(0.0%)	2 (<1%)
Scapular:	2 (1%)	-	8 (19%)	-	(1.2%)	8 (<1%)
Spinous process	3 (2%)	-	-	-	(0.8%)	33 (2%)
Ribs:	-	-	-	-	(0.4%)	4 (<1%)
Torso:*	-	-	-	-	-	-
Elbows:	8 (5%)	-	-	-	(1.6%)	51 (2%)
Iliac crest:	-	-	-	-	(0.4%)	25 (1%)
Coccyx:	-	-	-	19 (10.1%)	-	-
Sacrum:	70 (46%)	14 (14%)	15 (36%)	62 (33.1%)	(20.3%)	551 (26%)
Ischium:	4 (3%)	36 (35%)	3 (7%)	81 (43.3%)	(24.3%)	497 (23%)
Greater trochanter:	9 (6%)	14 (14%)	-	11 (5.9%)	(12.5%)	222 (10%)
Genitals:	-	-	-	-	(4.2%)	68 (3%)
Penis:	9 (6%)	-		-	-	-
Knee:	-	-	-	-	(3.8%)	58 (3%)
Malleolus:	5 (4%)	-	-	-	(7.2%)	146 (7%)
Heels:	30 (20%)	-	12 (29%)	-	(10.9%)	267 (12%)
Feet:	-	-	-	-	(7.6%)	148 (7%)
Feet/ankles:	-	26 (26%)	-	-	-	-
Toe:	1 (1%)	-	-	-	-	-
Unclassified location:	-	-	-	-	(4.8%)	79 (4%)
Unknown:	-	3 (3%)	-	-	-	-
Other:	-	9 (9%)	-	14 (7.5%)**	-	-
Total:	153 (100%)	102 (100%)	42 (100%)	187 (100%)	(100%)***	2159 (100%)

* A collective term used by this study which encompasses the anatomical sites, scapular, spinous process and ribs

** Sumiya defines "*others*" as "*the medial and lateral malleoli, the feet, the head of fibula, the thighs and so forth*"

*** Yarkony's paper only quoted the occurrence of pressure ulcers on a specific anatomical site as a percentage of the total number recorded. This total number is unclear.

Although these studies have used people with SCI as their subjects, these studies have focused on different sub groups within this population, for example Garber studied American veterans whereas Sumiya studied Japanese paraplegics. The differences in the design of these studies prevent definitive conclusions to be drawn from direct comparisons. However, considering just the anatomical sites which are located within the seat area of the body; these studies show a persistent occurrence of pressure ulcers on these sites since 1981, see figure 2-2.

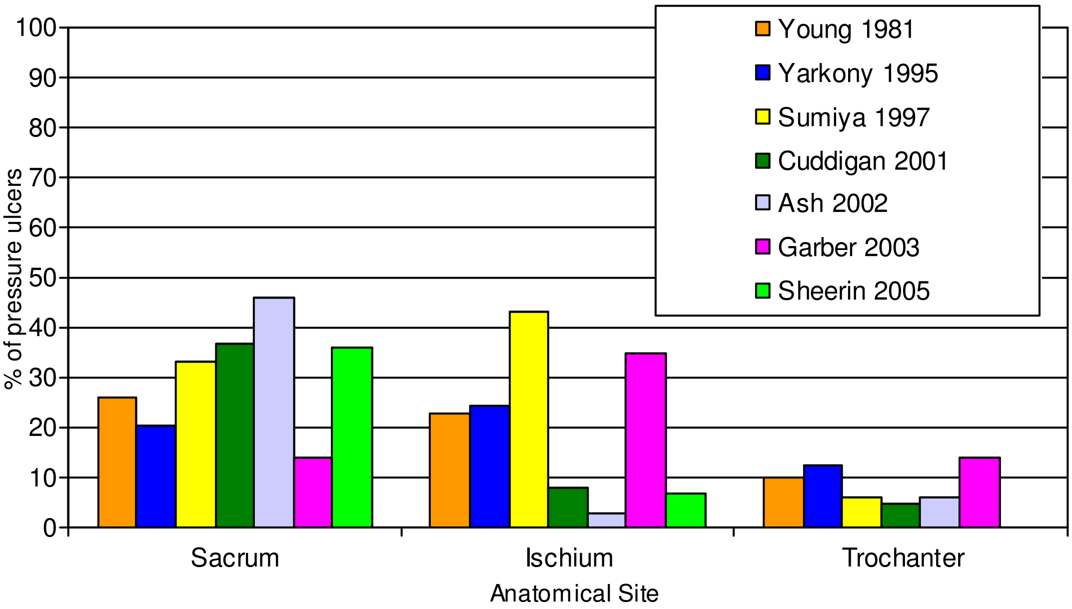


Figure 2-2 Percentage of pressure ulcers which are experienced on the pelvic site

2.6 Pressure Relief Cushions for Wheelchairs

The ultimate goal is the elimination of pressure ulcers and many individuals in fields such as bioengineering and medical research are involved in working towards this goal. In the case of people with SCI the solution to preventing pressure ulcers whilst sat in a wheelchair may come as the result of engineering a better form of mobility, for example the robotic callipers being developed in Japan (Honda 2010); or by healing the paralysis which results from an injury to the spinal cord, perhaps through developments in stem cell research. Until such solutions are available SCI patients will need a means of preventing pressure ulcers whilst sat in a wheelchair.

Although there is a wide range of wheelchairs available, from collapsible canvas types to sophisticated motorised chairs, the fundamental structure of the wheelchair has remained unchanged with a conventional sitting position being central to the design, see figure 2- 3.

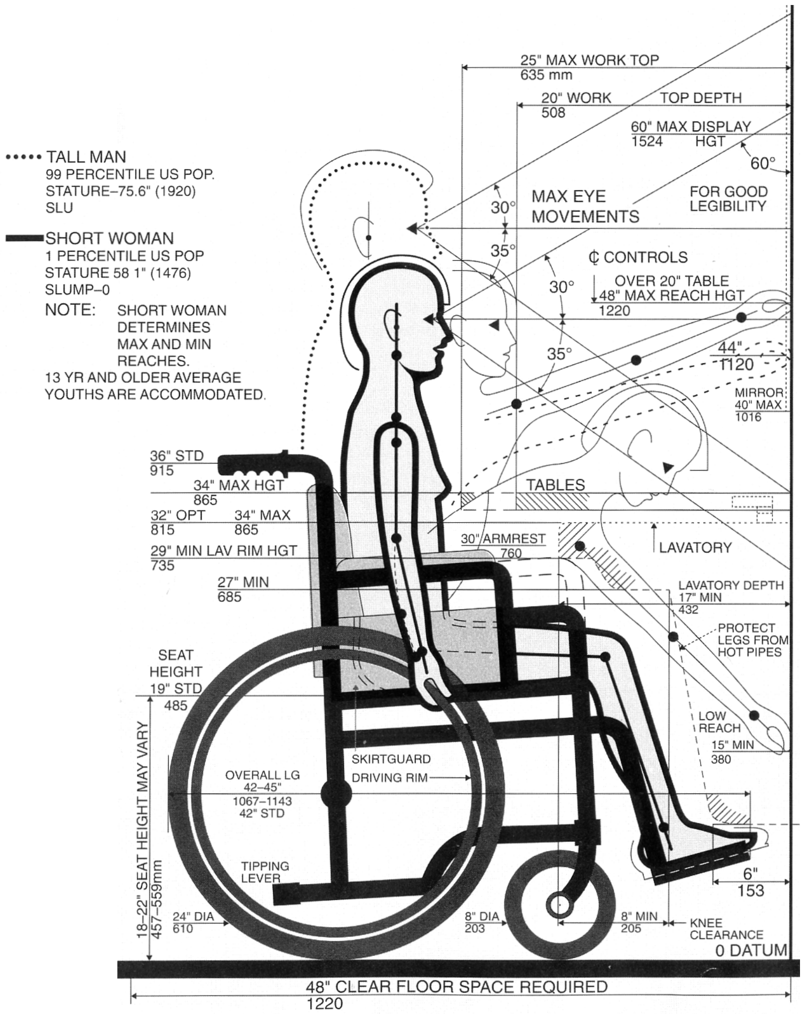


Figure 2-3 Anthropometry of the 99 percentile US wheelchair population (Tilley 2002)

To aid the prevention of pressure ulcers whilst sat in a wheelchair PR cushions were designed specifically for use on a wheelchair seat. Although these PR cushions have been in wide spread use by those with SCI there remains a persistent level of incidence of pressure ulcers on the seat area of the body, see figure 2-2.

The persistence of pressure ulcer occurrence on the seat area of the body of SCI patients suggests that there are limits to which contemporary PR cushions can prevent pressure ulcers on SCI patients. Possibly these limits are concerned with the conventional sitting position adopted in wheelchair design, see figure 2-2. Ergonomic research in chair design for the able bodied has found advantages with alternative sitting positions and have designed chairs to correspond with these different sitting positions such as the Kneeling chair and the Saddle chair (Cranz 1998).

Currently there is a consensus amongst healthcare providers about the positioning of SCI patients in wheelchairs and how best to manage posture, see section 3.6. Whilst a re-appraisal of posture management and sitting positions might lead to a reduction in the incidence rate of pressure ulcers, and possibly improve the general health and the quality of life of SCI patients, this line of inquiry is more the domain of bioenginneering.

However, the factors which are currently limiting contemporary PR cushions may well be the result of inherent weaknesses and deficiencies in their design. If there are weakness and deficiencies which are limiting contemporary PR cushions from preventing pressure ulcers then there is the potential to reduce the current incidence rate of pressure ulcers by redesigning PR cushions which either avoid or overcome their current weaknesses and deficiencies. Thus, this project was tasked with the identification of any weaknesses and deficiencies in contemporary PR cushion design to enable new cushions to be designed which are more effective at preventing pressure ulcers and thereby reduce the current incident rate of pressure ulcers.

2.7 Conclusions

It was found that pressure ulcers can be more than just an unpleasant wound but a debilitating injury with the potential to cause pain, reduce the quality of life, curtail independence and even death. It was therefore concluded that it would be a worthy endeavour to act towards the reduction in the incidence rate of pressure ulcers.

No precise figures were found for the total number of individuals who develop a pressure ulcer each year in the UK. However it was clear from the epidemiological studies found relating to the incidence of pressure ulcers in different patient settings that a substantial number of individuals develop pressure ulcers each year, with hundreds of thousands developing pressure ulcers in the UK rising to millions globally. Thus, even a modest reduction in the incidence of pressure ulcers could potentially benefit thousands of people.

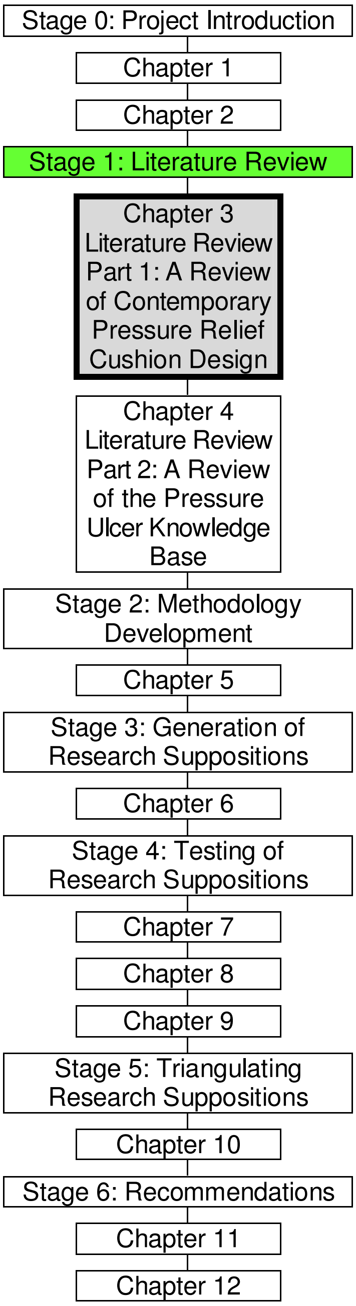
Only estimates on the financial cost to prevent and treat pressure ulcers were found. Whilst these estimates have to be treated with caution they still suggest that the cost to the UK is substantial, with estimates rising to billions of pounds sterling. With the estimated cost to one nation, the UK, being in the region of two billion pounds sterling, the combined financial cost of comparable nations, such as the European nations and the USA, will be significantly more. With such large sums of money involved any improvement which can reduce the incidence rate even by as little as 1% still has the potential to save many millions of pounds sterling.

Any undertaking leading to the reduction of pressure ulcers would be valuable to both patients and the economy. Having found that potentially one third to a half of all pressure ulcers occur when sitting in a wheelchair, and that SCI patients experience a high incidence of pressure ulcers on the seat area of their body, it was decided that this project would be focused on the design of PR cushion for SCI patients. An improvement in the efficacy of PR cushions has the potential to prevent many thousands of pressure ulcers each year, liberating these cushion users from the issues resulting from pressure ulcers such as pain and loss of independence.

Chapter 3

LITERATURE REVIEW PART 1: A REVIEW OF CONTEMPORARY PRESSURE RELIEF CUSHION DESIGN

3.1 Introduction



This chapter covers the first of the two assignments tasked under ‘Stage 1’ of the project. This assignment was to review[1] the design of the leading contemporary cushions in service, such as the ROHO and Jay cushions.

The review began by considering the two principles which underpin pressure relief (PR) cushion design, pressure-reduction and pressure-redistribution, followed by a review of the leading PR cushions.

The focus of cushion design on interface pressure (IP)[2] management and its effectiveness was next considered, followed by and how cushions are designed for patients “*at-risk*” of pressure ulceration.

As cushions play a prominent role in supporting a user’s sitting position the subject of posture was also reviewed.

Finally, a series of aspects related to a cushion’s “*usability*” were reviewed.

[1] A description of the search strategy used has been included in the appendices, see appendix B

[2] Section 4.5.2 includes a description of Interface Pressure (IP)

3.2 The Concepts used in Pressure Relief Cushion Design

During the early 1970's the first pressure relief (PR) cushions were produced. To create these first cushions designers applied the principles "*pressure-reduction*" and "*pressure-redistribution*" to create the concepts of "*static*" and "*dynamic*" cushions, see figure 3-1, and sections 3.4.1 and 3.4.2. Both principles of pressure-reduction and pressure-redistribution were derived from research on pressure ulcers conducted in the 1950's and 60's, see section 4.5.7.

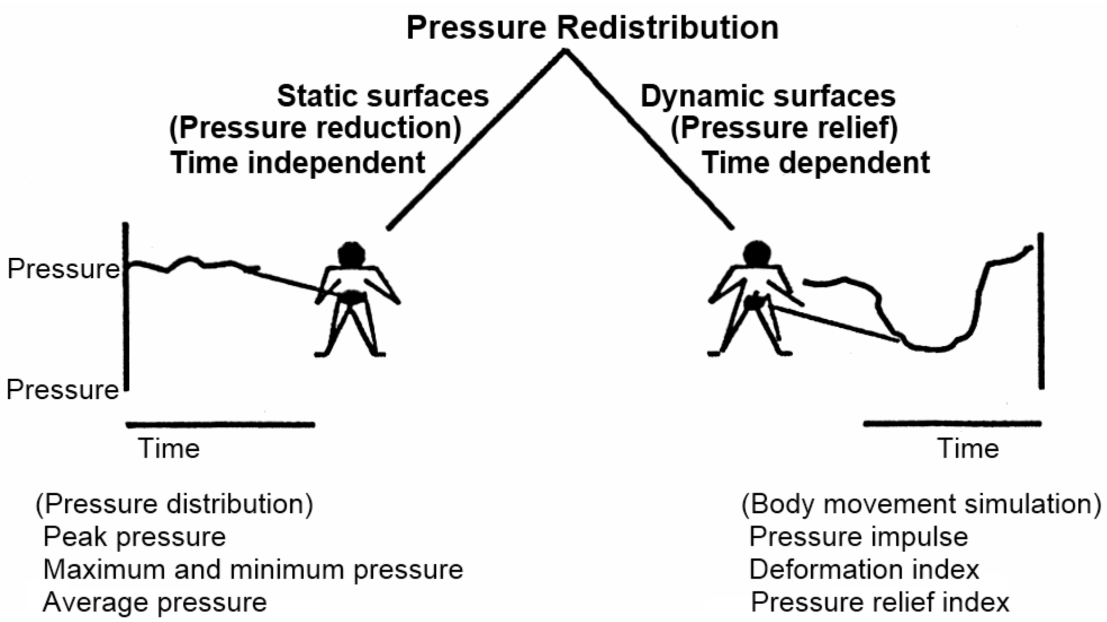


Figure 3-1 The two concepts used by support surfaces (Rithalia 2005)

- The first principle for managing interface pressure (IP) is pressure-reduction. The principle is to prevent pressure damage by reducing IP to below a safe pressure-intensity threshold, see section 4.5.7. Based on this principle designers have developed the concept of the static cushion, see section 3.2.1, also referred to as either pressure-reducing or constant low pressure (CLP)[3] devices.
- The second principle for managing IP is pressure-redistribution. The principle is to prevent pressure damage by reducing the exposure

[3] CLP = Constant Low Pressure. Definition used by NICE "*CLP devices mould around the patient to distribute their weight over a larger area*" (Yerrell *et al* 2003 reprinted 2005).

to IP to below a safe pressure-duration threshold, see section 4.5.7. Based on this principle designers have developed the concept of the dynamic cushion, see section 3.2.2, also referred to as either pressure-redistributing or alternating pressure (AP)[4] devices.

3.2.1 Static Cushions

Static devices have been categorised by the National Institute for Clinical Excellence (NICE) as belonging to the group 'Low Tech Devices'; stating, "*These* [static devices] *provide a conforming support surface that distributes the body weight over a large area*". These low tech devices include, standard foam, high-specification foam, viscoelastic foam, convoluted foam, cubed foam, gel-filled, fluid-filled, fibre-filled and air-filled. (Yerrell *et al* 2003 reprinted 2005).

Static, or Constant Low Pressure (CLP) cushions are designed to exploit the safe pressure threshold aspect of the Intensity-Duration relationship, see section 4.5.7. Static cushions aim to reduce the risk of pressure ulcers by reducing IP to a level within the safe pressure threshold. To reduce IP, static cushions disperse the patient's body weight as evenly as possible. By spreading the patient's weight both the mean IP and any localised points of high peaking IP, such as under bony prominences, are reduced. To achieve an even dispersal of body weight, static cushions employ the properties of immersion and envelopment.

Immersion is the characteristic defined by a patient's ability to 'sink' into the cushion,

> *Immersion allows the pressure concentrated beneath the bony prominence to be spread out over the surrounding area. Immersion also increases the potential for body weight to be shifted to areas around other bony prominences. For example, when a person is sitting on a relatively hard cushion, a disproportionately large portion of the*

[4] AP = Alternating Pressure. Definition used by NICE "*AP devices mechanically vary the pressure beneath patients so that the duration of pressure is reduced*" (Yerrell *et al* 2003 reprinted 2005).

body weight is born by the tissue beneath the ischial tuberocities. On a softer surface, the protrusions of the ischial tuberocities become immersed in the cushion and weight is distributed to the area beneath the greater trochanters. With this greater immersion, the body weight is divided between these additional bony prominences and pressure is decreased.

(Brienza and Geyer 2000)

Envelopment is the characteristic defined by the surface’s ability to follow the shape being pressed into it,

A support surface's ability to envelop describes its ability to deform around irregularities on the surface without causing a substantial increase in pressure. Examples of irregularities are creases in clothing, bedding or seat covers, and protrusions of bony prominences … Poorly enveloping support surfaces may cause locally high peak pressures that could increase the risk of tissue breakdown.

(Brienza and Geyer 2000)

For static pressure relief cushions it is important that a high level of immersion and envelopment is achieved because the ischial tuberocities, “*the sitting bones*”, see figure 3-2 [5], are particularly prominent creating substantially higher localised peaks of IP, see figure 3-3.

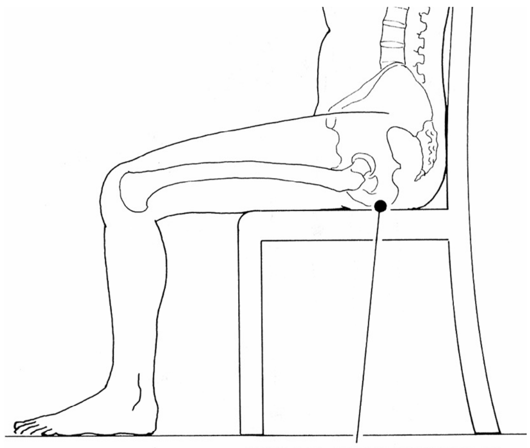
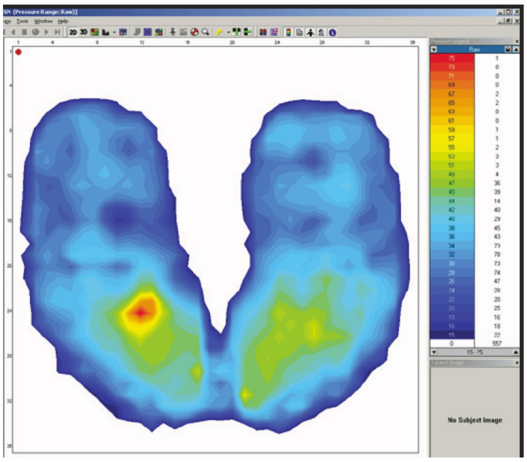
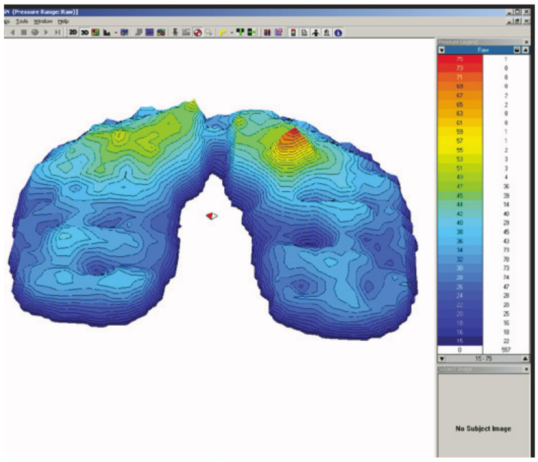


Figure 3-2 The areas under the ischial tuberosities are vulnerable to pressure when sitting (Rodgers 1986)

[5] Note how in figure 3-2 the back of the hamstring is in contact with the front of the seat. The popliteal height is slightly too low, see figure 3-77.



A 2-D pressure map with colour coded regions of pressure



A 3-D graphical representation of pressure levels

Figure 3-3 Visual displays of pressure map results (Xsensor 2008)

The designers/manufactures of static cushions promote the efficacy of their cushions based on the cushion's ability to keep peak and mean IP below a safe intensity threshold, this threshold being widely regarded as the occlusion pressure of capillaries normally quoted as 32mmHg, see sections 3.4.1, 4.4.2 and 4.5.4.

To create a static cushion with good immersion and envelopment characteristics manufacturers employ various approaches and materials, see section 3.3.

3.2.2 Dynamic Cushions

Dynamic devices have been categorised by NICE as belonging to the group 'High Tech Devices'. NICE describe these dynamic devices as, "*Alternating pressure devices: the patient lies on air-filled sacs, which sequentially inflate and deflate and relieve pressure at different anatomical sites for short periods*". Included in the high tech devices group are, air-fluidised devices, low air loss devices and turningbeds/frames. (Yerrell *et al* 2003 reprinted 2005).

Dynamic, or Alternating Pressure (AP) cushions are designed to exploit the safe time threshold aspect of the Intensity-Duration relationship. Dynamic cushions aim to reduce the risk of pressure ulcers by providing the skin with temporary respites from IP, within the safe time threshold, by alternating the points on the body which support the patient's weight. The concept of regular respites from pressure is a response to Kosaik's pronouncement, "*since it is impossible to completely eliminate all pressure for a long period of time, it becomes imperative that the pressure is completely eliminated at frequent intervals in order to allow circulation to the ischemic tissue*" (Kosiak 1961), see section 4.5.7.

Dynamic AP cushions are made up of individual air filled cells or cylinders arranged lengthwise, inter-digitally or in some pattern, see figure 3-4. Air is then pumped into these cells in set periodic intervals creating arrangements of alternating inflated and deflated cells, see figure 3-5.

Figure 3-4 The Airpulse PK dynamic cushion manufactured by the Aquila Corporation (USA TechGuide 2008)

For example, during time interval **Cycle A** the even numbered cells are inflated and the odd numbered cells are deflated. At this moment the even numbered cells are carrying the weight of the body and so the tissue resting on the even numbered cells are subject to a high level of IP. However, the odd numbered cells are deflated and so carry none of the weight of the body. Consequently, the skin over the odd numbered cells is not subjected to IP. Before the skin resting on the even inflated cells becomes damaged by IP, the dynamic AP system switches to time interval **Cycle B,** when the even numbered cells deflate and the odd numbered cells inflate. Now the previously IP free skin carries the weight of the body and the skin which had been subject to IP is relieved of IP and given a period of time in which to recuperate before the system switches back to time interval **Cycle A**.[6]

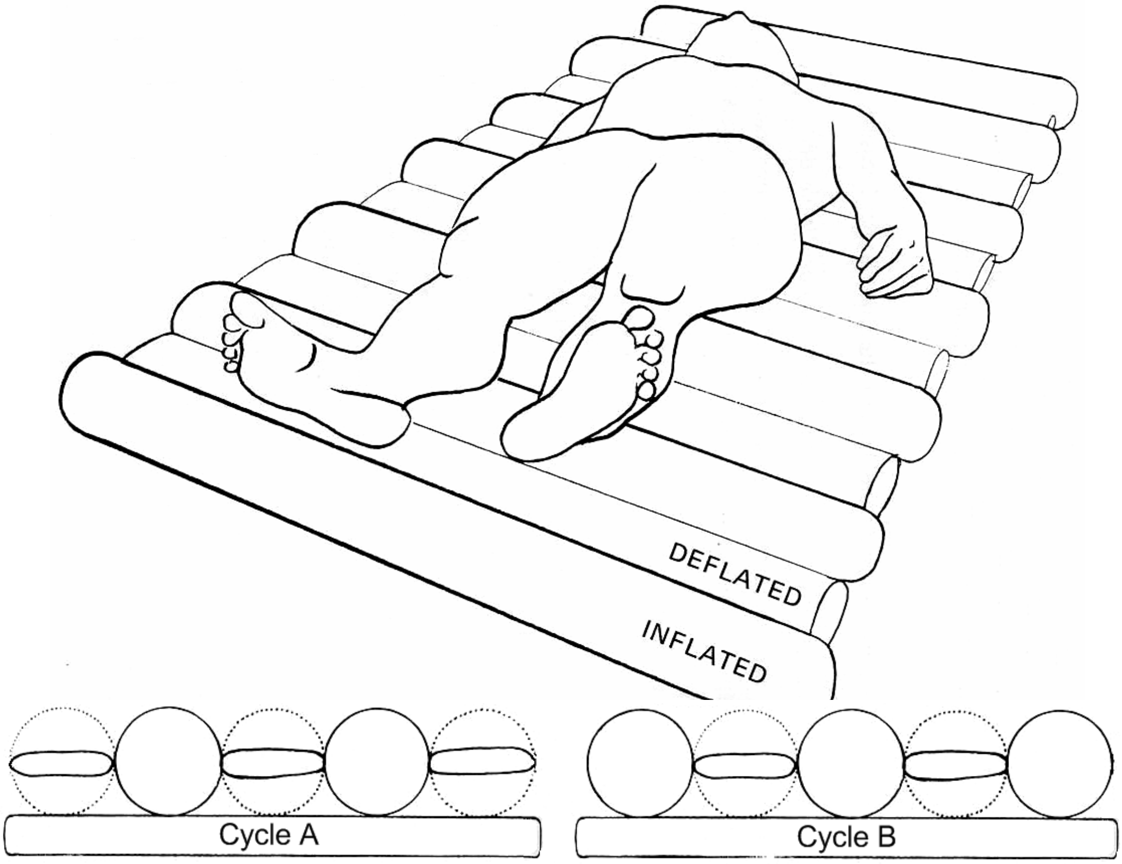


Figure 3-5 A diagram of an alternating pressure mattress showing air cells alternately inflated and deflated (Torrance 1983)

The physical parameters of the dynamic approach is little understood with considerable development work still to be conducted,

> *The lack of sufficient study of the tissue responses to alternating pressure leaves many questions regarding this type of support surface. Namely, what are the ideal characteristics of the support surface: geometry of the surface (size/shape of cells and space between cells), material, depth, composition and shape of the supporting structure? Also, what are the ideal characteristics of the alternating cycle (rise time, hold time, duration of total cycle, pattern of relief)?*

(Brienza and Geyer 2000)

[6] 'Pulsating' pressure differs from 'alternating' pressure in that the duration of peak inflation is shorter and the cycling time is more frequent. 'Pulsating' pressure appears to have a marked effect on increasing lymphatic flow, much like massage (Brienza and Geyer 2005).

This concept also does not fully appreciate the physiology of skin. Whilst there are mechanisms within tissue to manage pressure, these are limited. Some of these limits revolve around recuperation times and repetitive loading. Of particular concern is a condition known as 'Ischemic Reperfusion Injury'. This is where the microcirculation structure collapses, having been over stressed through too rapid or too many repetitions of loading and unloading, see section 4.5.8.

Dynamic (AP) cushions are proffered to patients considered to be at very high risk of developing pressure ulcers[7] and to patients who already have pressure ulcers primarily on the basis that they offer better protection against pressure ulcers than static (CLP) cushions. This is despite a lack of evidence to suggest that one type of cushion is better at prevention than the other (Collins 2004). The assumption that dynamic "*high tech*" cushions are better than "*low tech*" static cushions should be treated with caution when institutions such as NICE remain unable to suggest one type of cushion is better than another, "*The relative merits of AP and CLP devices, and of the different AP devices, for pressure ulcer prevention are unclear*" (Yerrell *et al* 2003 reprinted 2005).

[7] The subject of pressure ulcer risk assessment is covered in more detail in section 3.5.2

3.3 Contemporary PR Cushions

The two principles used to manage IP, pressure-reduction and pressure-redistribution, have given rise to the design concepts of static cushions and dynamic cushions. Following these two concepts designers have engaged in various different approaches employing different materials and technologies, such as viscoelastic foam and silicon gels. These different approaches are found in the multitude of different cushions on the market, see figure 3-6. According to advice given by staff from two different spinal cord injury centres (SCIC) the current leading PR cushions are the Flo-tech, Jay 2, ROHO, Vicair and Varilite; with the Jay 2 and ROHO being the most popular. These cushions are exemplars of the leading approaches, for example the ROHO is an air filled cushion, the Jay uses gel and the Flo-tech uses contoured foam.

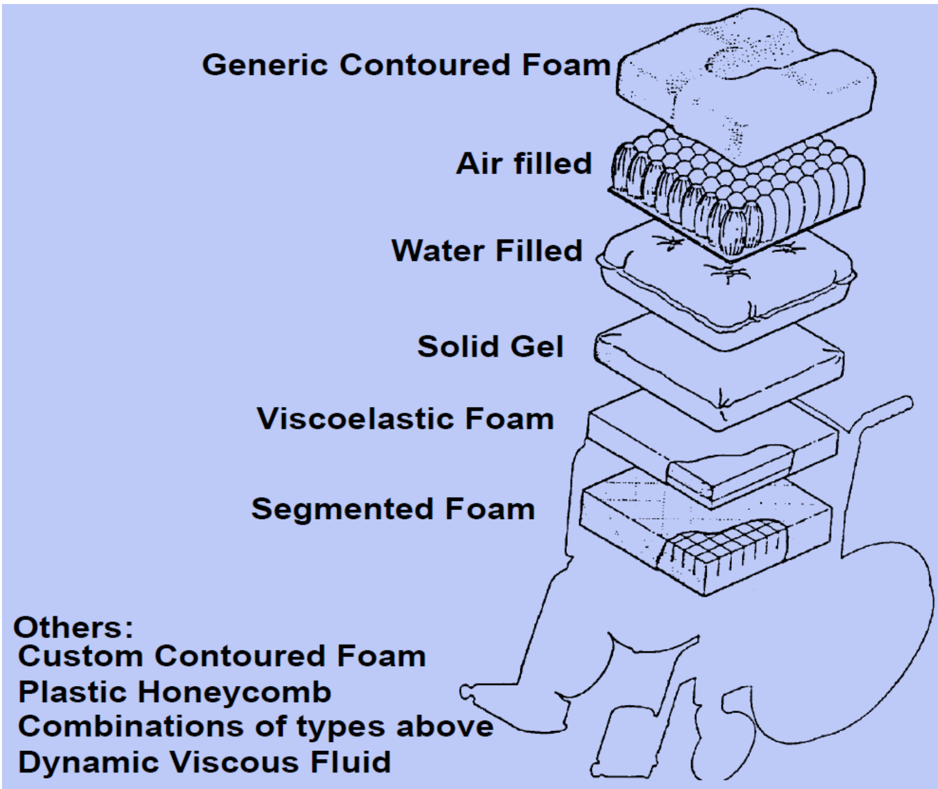


Figure 3-6 Leading approaches to cushion design (Hobson 1999)

The following sections describe in detail the five leading contemporary PR cushions as identified by staff from two SCIC. As these five makes of cushion are based on the static design concept an additional cushion, the Airpulse PK, was also included as an example of the cushions produced following the dynamic design concept.

3.3.1 ROHO

3.3.1.1 Features of the ROHO

ROHO cushions are based on the "*Dry-floatation*" approach. This approach was formulated by Robert H. Graebe, an electrical engineer, who became concerned about pressure ulcers whilst working at a hospital (ROHO 2008b).

Since their incorporation, in 1973 by Robert Graebe, the ROHO Group Inc. have been producing a range of air-filled cushions based on Graebe's "*Dry-floatation*" approach such as the High Profile see figure 3-7, (ROHO 2008c).

The dry-floatation approach is based on the static cushion concept of pressure-reduction whereby pressure ulcers can be prevented by lowering IP to below some safe pressure-intensity threshold, see section 4.5.7. To achieve this pressure-reduction the dry-floatation approach uses immersion and envelopment to disperse the user's body weight, see section 3.3.1.

Figure 3-7 A *High Profile® Quadtro Select®* Cushion, with cover folded back (ROHO 2008a)

A dry-floatation cushion is a matrix of individual interlinked air cells which allows air to flow within the cushion as a fluid. This free flow of air enables the user's contours to sink into the cushion and so immerse and envelop the user, see figure 3-8.

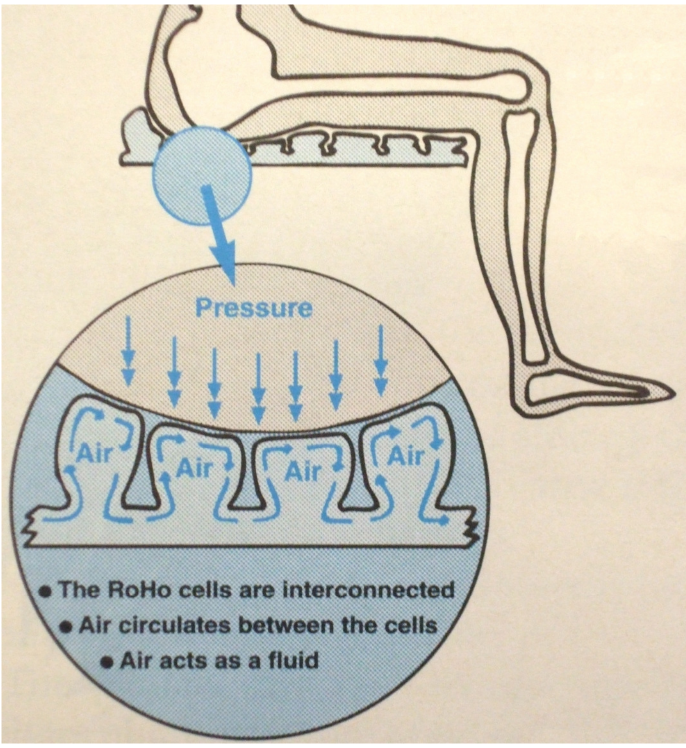


Figure 3-8 A diagram which illustrates the air flow between the interlinked cells. Diagram taken from an advertisement by the Scandinavian Mobility UK Ltd in the March 1999 issue of the Journal of Wound Care

Provided these air cells are set at an appropriate internal air pressure, the air within each cell balances out so that the cushion surface will immerse the user and conform to the contour of the user's bottom, see figure 3-9.

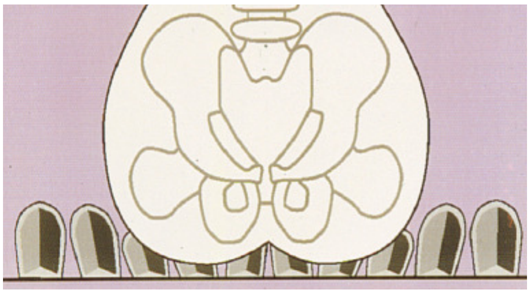
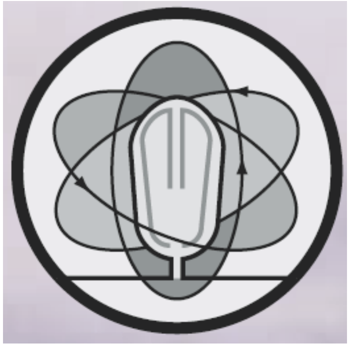


Figure 3-9 User immersed into cushion (Cooper 1998)

This system has good envelopment properties and will deform to envelop complex and well defined shapes, see figure 3-10.

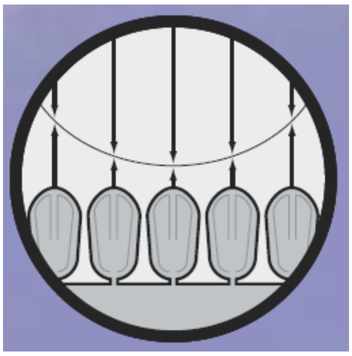
Figure 3-10 Complex shape enveloped by cushion (Turnbull and Huynh 2008)

ROHO promote the benefits of individual interlinked cells under the guise of "*four principles*", see figure 3-11. These four principles relate to the benefits of individual interlinked cells namely,



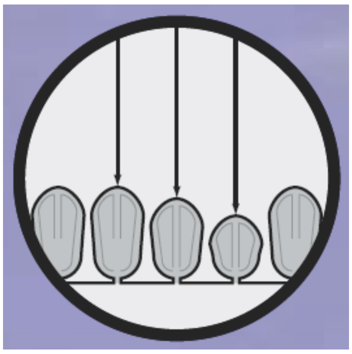
Six Degrees of Freedom

ROHO cushions are constructed of individual cells that move independently, allowing each cell to twist, turn, bend, move up and down, and adapt precisely to the contours of the client.



Constant Restoring Forces

When a patient is immersed in a ROHO DRY FLOATATION product, the forces and pressures pushing back are kept equal at all contact points. As the body is immersed, greater contact area is achieved for dispersion of pressure. Thus, the pressure on any one area is minimised.



Low Surface Tension

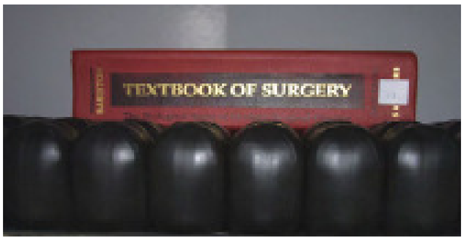
The unique cellular design allows for immersion into the cushion without deforming the tissue, minimising the chance of tissue breakdown.

Low Friction and Shear

As a result of the three previous principles, DRY FLOATATION technology provides a low friction and low shear environment. Friction acts to oppose the direction of motion or impending motion. Shearing occurs when opposite, but parallel forces meet. The outcome of these forces inhibits blood flow. The slick or non-friction surface of the ROHO cells combine with the independent movement of each cell greatly reduces friction and shear as clients move throughout the day.

Figure 3-11 The four principles of Dry-flotation (ROHO 2007)

The efficacy of this dry-floatation system is completely dependent on the correct setting of the internal air pressure. As noted by Cooper (1998) during a randomised controlled trial (RCT) of dry-floatation surfaces on 100 orthopedic patients (5 ROHO mattresses, 5 Sofflex mattresses and 10 ROHO Quadtro cushions). "*It is essential to have the correct amount of air in the mattress* [dry-flotation device]*; over-inflation leads to the patient lying on top of the mattress cells, while under-inflation leads to the mattress 'bottoming out' under the patient*" (Cooper *et al* 1998), see figure 3-12.



Book laying on top of an over-inflated cushion

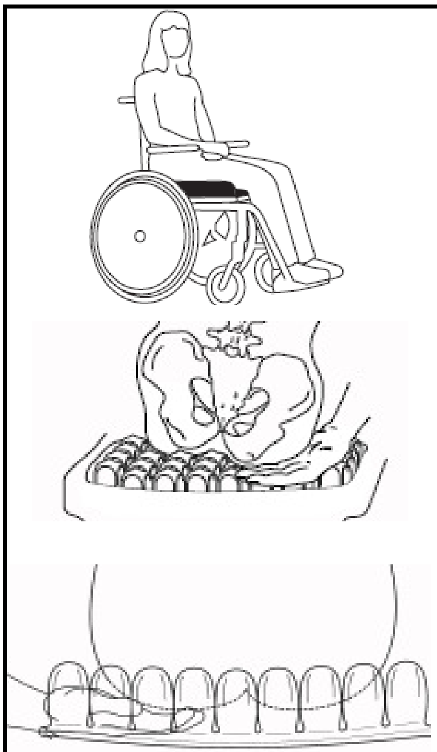
Book immersed in correctly 'set' cushion

Book 'bottomed out' on under-inflated cushion

Figure 3-12 A dry floatation cushion inflated with different air pressures (Rehab WA 2008)

As both over and under-inflation can result in the user resting on a hard surface, potentially causes skin marking and ulcers (Fiddy 2005a), the correct setting of the internal air pressure is paramount[8]. It is imperative then that the setting of the air pressure is correct each and every time. However being an adjustment sometimes left to the user, errors can be made, for example as reported by Fitzgerald, "*some individuals may overinflate an air-filled cushion in an attempt to prevent bottoming out but in the process negate the benefits of the cushion as the individual can no longer conform to or sink into the seating surface*" (Fitzgerald *et al* 2001). The official advice from ROHO as to the adjustment of air pressure to achieve a correct setting is as follows, see figure 3-13

[8] Achieving the correct amount of inflation in a dry-flotation device is referred to as the correct '*setting*' of the equipment (Cooper *et al* 1998), see figure 3-13



Step 1

Sit on the cushion in your normal sitting position with armrests and footrests properly placed.

Step 2

Slide your hand beneath your buttocks to locate your lowest bony prominence, usually the ischial tuberosities. If necessary, your clinician or caregiver should assist you.

Step 3

Leaving one hand in place beneath the lowest bony prominence, use the other hand to open the valve. As air is released from the cushion insert, you will begin to sink into it. When your fingertips touch its base, close the valve. Approximately ½" or 1.25cm of air should be between your lowest prominence and the base of your cushion.

Figure 3-13 Inflation adjustment instructions from a ROHO cushion user manual (ROHO 2001)

This method of air pressure setting, as described by ROHO, is practiced by users of ROHO cushions, as confirmed by a physiotherapist from the National Spinal Injuries Centre (NSIC) Stoke Mandeville, see section 6.4.2.

With the basic design of a ROHO cushion, all the air cells are interlinked to form a single compartment which allows air to circulate freely around the whole cushion. This free flow limits the postural support the cushion can provide. For users with postural issues such as sacral sitting or pelvic obliquity ROHO provides a Quadtro version. Although visually the same as a single compartment cushion the Quadtro version is in fact comprised of four compartments, see figure 3-14.

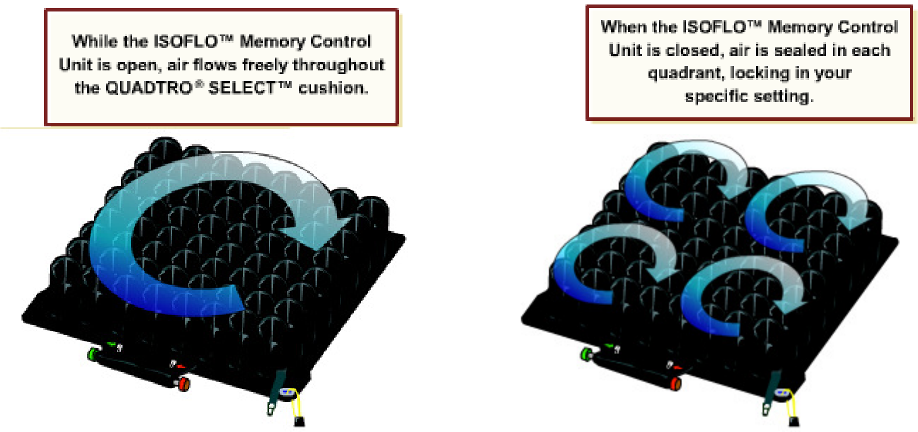


Figure 3-14 ROHO Quadtro cushions with four independent compartments (ROHO 2008d)

For users who require more postural support ROHO produce a Contour version, which uses various sized air cells to form a surface contour see figure 3-15. It is also has four compartments cushion like a Quadtro.

Figure 3-15 The *ROHO® CONTOUR SELECT®* cushion (ROHO 2008a)

3.3.1.2 Observations on the ROHO

The dry-floatation approach, based on a matrix of interconnected air cells, makes good use of the fluid properties of air to produce a cushion which when set correctly immerses and envelops the user well.

There are weaknesses with the ROHO application of this approach. The performance of the ROHO is completely dependent on maintaining the correct setting of the internal air pressure. Hamanami (2004) found that a small deviation from the optimum internal air pressure can have a large effect on the user's IP, see figure 3-16.

It is important once the optimum internal air pressure has been set for the day it is maintained for the duration of the episode of usage, typically a full day. In some cases just a small drop in internal pressure can greatly increase the peak IP, for instance with '*Subject 1'* a drop of internal pressure from 16mmHg to 14mmHg saw the peak IP increase from approximately 80g/cm^2 to 150g/cm^2. Such small drops in internal air pressure in practice can result from a slow puncture or a drop in ambient temperature.

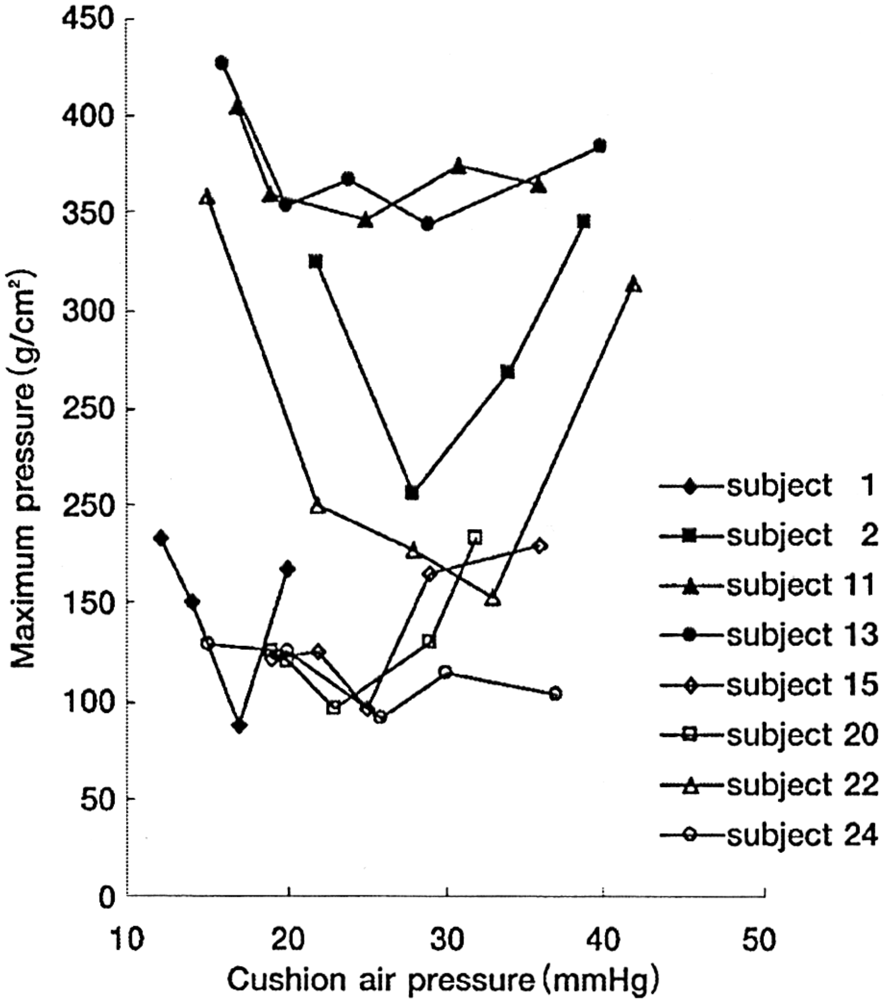


Figure 3-16 Relationship between peak IP (g/cm^2) and internal air pressure (mmHg) (Hamanami *et al* 2004)

Hamanami also found that different users have different optimum internal air pressures. The lowest peak IP '*Subject 1'* experienced was when the internal air pressure was set at 16mmHg whereas the lowest peak IP '*Subject 22'* experienced was when the internal air pressure was set at 36mmHg (Hamanami *et al* 2004).

Thus, it is important that the setting of the internal air pressure is flexible and accurate. However whilst the ROHO method for setting the pressure is flexible, it is imprecise creating an opportunity for the user to sit unwittingly on a cushion not set to its optimum internal air pressure.

The unregulated free flow of air results in the surface lacking any solidity leaving the user sat on an unstable surface. This lack of stability can lead to an imbalance and potentially a bottoming out event, see figure 3-17.

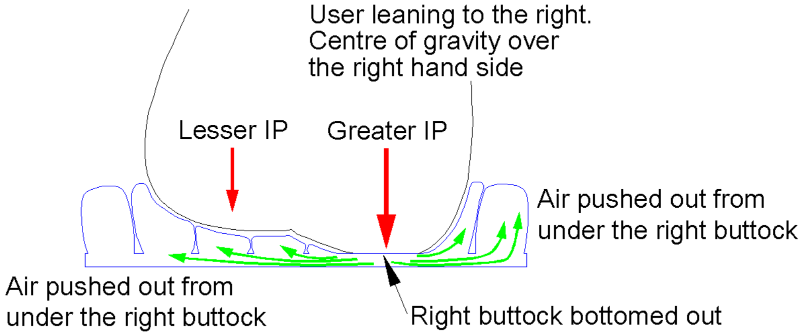


Figure 3-17 The free flow of air within a ROHO leaving an unbalanced user sat bottomed out

The high immersion and envelopment properties of the dry-floatation approach limit the ability of this cushion to hold its shape. This is an advantage if the cushion is distorted, as when used on the canvas sling seat of a collapsible wheelchair without a baseboard, see figure 3-18.

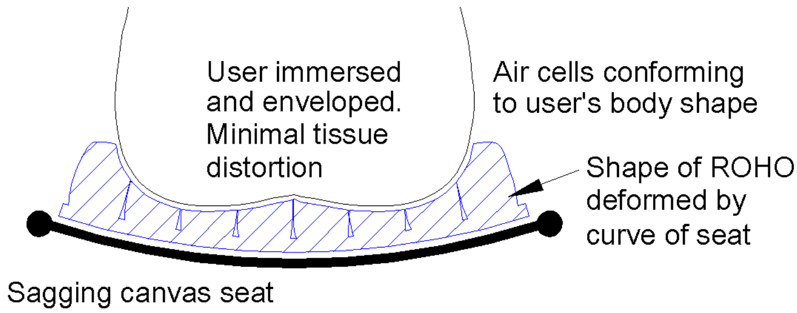


Figure 3-18 The free flow of air within a ROHO enabling the air cells to conform to the user

To support posture a contour is commonly used to hold a user in position. By yielding easily the dry-flotation approach cannot keep a shape and therefore cannot hold a user in position. To create some form of contour, ROHO have devised a Quadtro version and Contour Select version. The Quadtro, by creating four separate compartments, increases the complexity of setting the internal air pressure and so reduces its convenience and increases the chances of error.

The primary method ROHO provide for securing their cushions to wheelchairs is by means of the cushion cover they provide as standard with their cushions. The ROHO ‘Universal Cushion Cover’ consists of a Lycra top; side panels made from a three layered knit polyester; and a textured panel, which has a high co-efficient of friction, on the bottom. ROHO refer to this bottom panel both in their brochures (ROHO 2007) and their user manuals (ROHO 2001) as a “*non-skid base*”. This non-skid base approach relies on the interaction of friction between the cushion and the wheelchair to hold the cushion in place. This approach is vulnerable to active users overcoming the static frictional force (F_s), see figure 4-17, with vigorous movements which can push the cushion either forwards or backwards, see figures 3-83, 3-84, 3-85 and 3-86. The 'Universal Cushion Cover' also includes Velcro straps which can be used to secure the cushion to a wheelchair (ROHO 2007). The ROHO cushion itself has metal eyelets on each corner which can be used as anchor points to tie the cushion directly to the wheelchair but these eyelets are not available when a cover is put over the cushion.

When cleaning a ROHO cushion each of the air cells which make up the matrix requires gentle scrubbing, including the gaps in between cells. This is not a simple or convenient task.

3.3.2 Varilite

3.3.2.1 Features of the Varilite

In the early 1970's, two former Boeing engineers, based on their interest in backpacking, created the world's first self-inflating camping mattress. They formed a company Cascade Designs and marketed this invention as '*Therm-a-Rest®*'[9] (Cascade Designs 2008). As Cascade Designs grew they developed more products. Varilite™ is now a division of Cascade Designs which specialise in wheelchair positioning products. Varilite cushions are an application of the air-foam floatation approach originally developed as a camping mattress. Varilite's Evolution PSV cushion is one of Varilite's air-foam floatation cushions (Varilite 2008b) see figure 3-19.

Figure 3-19 Varilite's Evolution PSV cushion, with cover cut away (Varilite 2008b)

[9] *Therm-a-Rest®* air-foam floatation camping mattresses are still on sale. See their website http://www.thermarest.com

The air-foam floatation approach, like dry-floatation, employs the static cushion concept of pressure-reduction whereby pressure ulcers are prevented by lowering IP to below some safe pressure-intensity threshold. The air-foam floatation approach achieves this pressure-reduction by dispersing the user's body weight through immersion and envelopment, see figure 3-20.

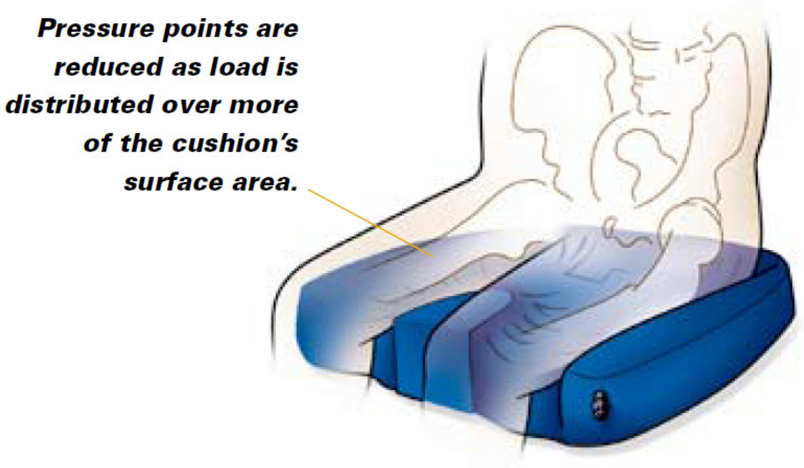
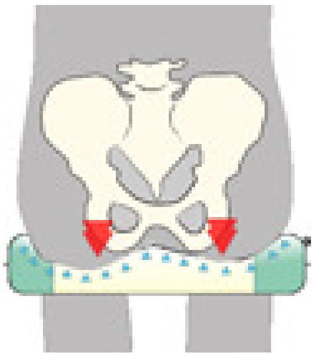


Figure 3-20 An air-foam floatation cushion immersing a user (Cascade Designs 2007)

As with the dry-floatation approach the air-foam floatation approach makes use of air's capacity to flow like a fluid. With a dry-floatation cushion, air flows around a matrix of individual rubber cells, with an air-foam floatation cushion air flows around the cellular structure of foam, see figure 3-21.



Air in a VARILITE cushion supports the load, while foam keeps the air where it's needed and preserves the cushion shape

Air-Foam Flotation Technology

How does it work?

By combining the best characteristics of air and foam:

Air:

- *Fluid & displaces under load*
- *Provides pressure relief*

Foam:

- *Acts like a spring & compresses under load*
- *Provides support and conformation*

Air-Foam Floatation works because of immersion.

- *The valve releases air to immerse the user in the foam*
- *Each cell of the open-cell foam provides support and distributes the pressure*
- *Increased immersion provides increased load distribution and stability*
- *Optimal pressure distribution is achieved over the largest possible area*

Figure 3-21 Varilite's Air-foam floatation approach (Varilite 2008c)

Air-foam floatation cushions are foam cushions with an air tight fabric bonded to the foam, see figure 3-22. The air tight fabric traps air within the cushion. When a user sits on the cushion the trapped air can be released by means of an air valve. By releasing some of the air the user immerses into the foam.

Figure 3-22 An exploded view of Varilite's 'Evolution PSV' cushion (Varilite 2008b)

As with the dry-floatation approach, air-foam floatation is dependent on the correct setting of the internal air pressure. For the cushion to provide optimum pressure-reduction the cushion has to be set at a partially inflated level. A user sat on an over or under inflated cushion will experience unduly high IP, see figure 3-23. If all the air is released from the cushion the user can 'bottom out' which may lead to skin damage (Fiddy 2006).

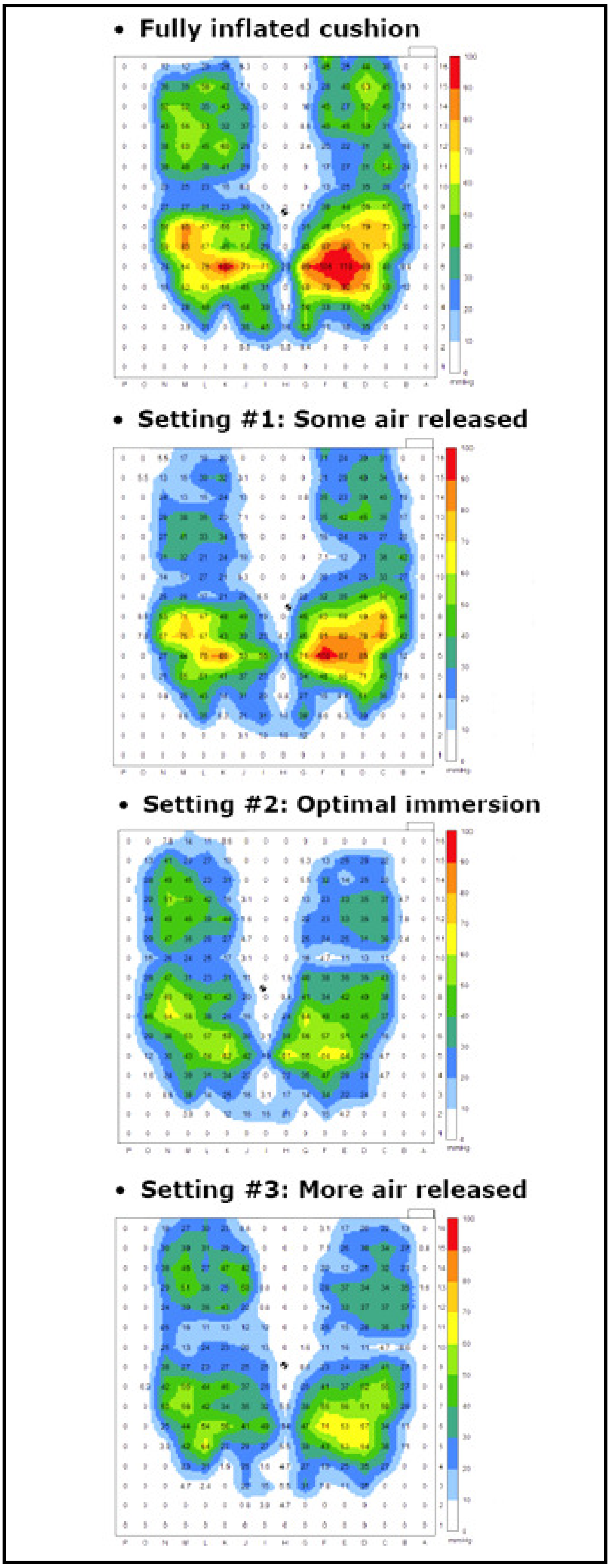


Figure 3-23 Effect of cushion's internal air pressure on IP (Varilite 2008b)

The adjustment of the internal air pressure is performed by using an air valve. Varilite produce two different valves for this purpose, the Standard Air Valve and the Pressure Setting Valve (PSV).

The *Standard Air Valve* works on the same principle as the ROHO cushions.

Adjusting the Cushion using a Standard Air Valve

1. *Begin with the cushion on the wheelchair, fully inflated with the valve closed.*
2. *Transfer onto wheelchair. Sit in the proper position.*
3. *Turn the valve counterclockwise to open the valve and release air. You want to sink down about 1 to 2 inches (2.5cm to 5cm).*
4. *Close the valve when the air level that provides the support you need for comfort and functionality is reached. Generally, this is when there is between 1 and 1/2 in. (2.5 and 1.3cm) of cushion between the user's ischial tuberosity and the seating surface.*

(Cascade Designs 2006)

The Pressure Setting Valve (PSV) works on a similar principle except that this time only a set amount of air is released so that the internal air pressure is set to the same pressure each time.

Adjusting the Cushion using a PSV (Pressure Setting Valve)

1. *Begin with the cushion on the wheelchair, fully inflated with the valve closed.*
2. *Transfer onto wheelchair. Sit in the proper position.*
3. *Open the valve by turning it counterclockwise until the predetermined position number ("1", "2", or "3") appears in the indicator window.* ***Unless otherwise instructed by your therapist, use position "2".*** *Air will escape until the valve automatically shuts off (approximately 10-15 seconds).*
4. *Once the valve has shut off the release of air, close the valve by turning it clockwise. This will prevent the inadvertent release of additional air due to weight shifting, transferring, manual propelling, and so forth*

(Cascade Designs 2006)

To support the user's posture the *Evolution* cushion uses three different density foams, see figure 3-24.

Multi-Stiffness Foam

Functional areas of the cushion are created by three types of foam: soft foam for the decubitus-sensitive area of the IT's; medium foam for the thigh trough, pelvic bucketing and pre-ischial bar; and firm foam for the perimeter and the thigh separator.

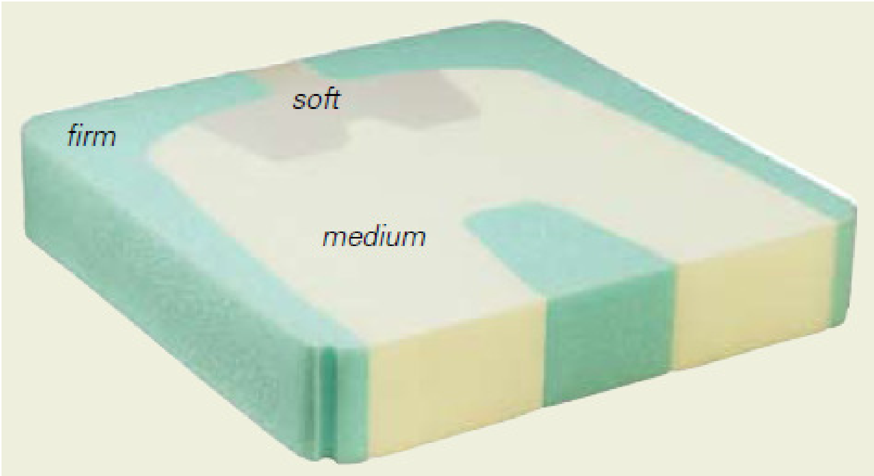


Figure 3-24 Various density foams within an Evolution cushion to support posture (Varilite 2008d)

This arrangement of different densities is intended to ease the IP the ischial tuberosities are subjected to and help the user maintain an upright sitting position, see figure 3-25.

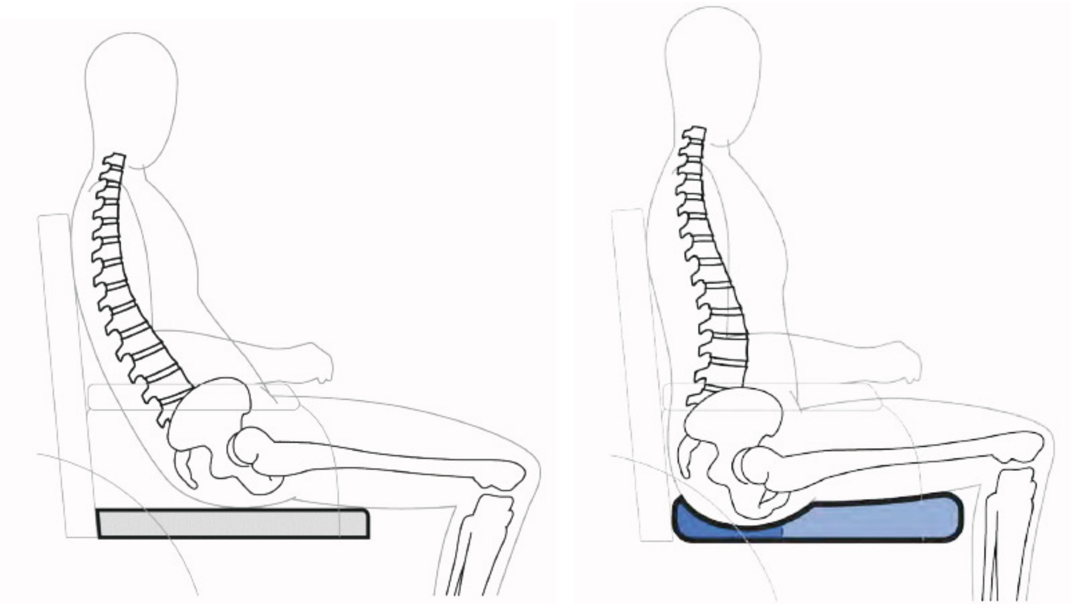


Figure 3-25 Varilite's multi foam cushion capturing the ischial tuberosities preventing the user from sliding forward and slouching (Wilber 2007)

3.3.2.2 Observations on the Varilite

The air-foam floatation approach, based on an open cellular structured foam encased in an airtight fabric, makes use of the fluid properties of air to produce a cushion which when set correctly immerses and envelops the user.

There are weaknesses with the Varilite's application of this approach. The optimum performance of the Varilite is dependent on maintaining the correct setting of the internal air pressure. However being predominantly a foam cushion the foam will immerse and envelop the user to some extent regardless of the air pressure. As such the Varilite is not as dependent on the setting of the internal air pressure as the ROHO, and not as vulnerable to bottoming out when there is an error in the setting the internal air pressure.

As with the ROHO, different users will have different optimum internal air pressures and as such the Varilite has to have the flexibility to set the internal air pressure accordingly. The Varilite standard air valve employs the same principle of air release as the ROHO to set the internal air pressure. Varilite do offer an alternative with its Pressure Setting Valve (PSV). In an attempt to address the problems of convenience, accuracy and consistency, the PSV has only three fixed air pressure settings to choose from. This does reduce the potential for error.

Being composed of foam, even when the air is freely moving around the cushion there remains some solidity to the surface. This provides the user with a more stable surface.

Although the Varilite does not have a contoured shape to support a user's posture, the use of different density foams allows the cushion to effect a contour. The low density soft foam positioned under the ischials more readily compresses than the high density firm foam around the edge of the cushion. This 'captures' the pelvis, preventing the user from sliding forward and slouching, see figure 3-25. For those who need more postural support Varilite also provide positioning bases which have different contour shapes to impose a contour shape onto the cushion.

Like the ROHO, Varilite principally relies on the bottom of the cover having a high co-efficient of friction to prevent the cushion from sliding over the seat of the wheelchair. In addition they have included "*hooks and loops for added security*" (Varilite 2008d).

To clean a Varilite cushion requires a wipe with a damp cloth (Fiddy 2006). This is a simple and easy task.

3.3.3 Vicair

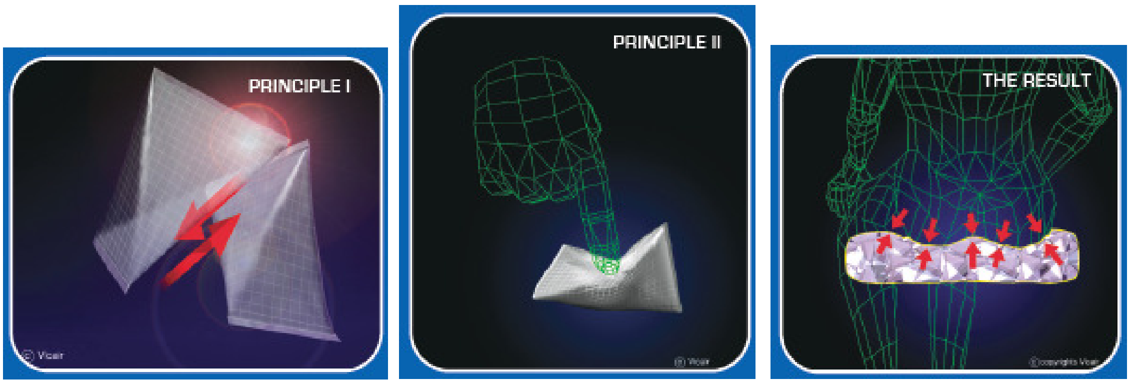
3.3.3.1 Features of the Vicair

Vicair B.V. introduced the Netherlands to the *Vicair® Academy* cushion in 1993, see figures 3-26 and 3-27. Then in April 1995 introduced the Vicair® cushion to the world at the Geneva Exhibition for Inventions, where it was awarded with the 'Grand Prix' for innovations (Vicair 2008).

Figure 3-26 Vicair's Academy Adjuster cushion without it's cover (Comfort Company 2008b)

Figure 3-27 Vicair's Academy Adjuster cushion within it's cover (Comfort Company 2008b)

The Vicair employs the static cushion concept to prevent pressure ulcers by lowering IP to below some safe pressure-intensity threshold. To achieve this pressure-reduction the Vicair approach uses "*Comfort Cells*" to immerse and envelope the user to disperse their body weight. Vicar describes the Comfort Cell approach under the guise of two principles, see figure 3-28.



Principle I

The encapsulation of air by numerous, flexible Comfort Cells, provides primary adaption to the body contours due to the movement of cells amongst each other.

Principle II

Deformation of the individual Comfort Cells provides secondary adaptation to minor body contours.

The Result

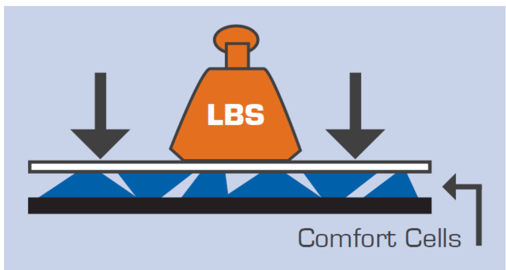
A dynamic but stable adaptation to body contour with a high level of pressure and shear relief.

Figure 3-28 Vicair's Comfort Cell approach (Comfort Company 2008c)

As with dry-floatation and air-foam floatation cushions, the Vicair approach employs air to achieve immersion and envelopment but unlike dry-floatation and air-foam floatation the air within the cushion is not free to flow around the cushion but is encapsulated within tetrahedron shaped cells, Comfort Cells. These cells are then loosely contained within compartments which form the cushion, see figure 3-29.

Figure 3-29 A Vicair Academy cushion which shows the internal Comfort Cells (Hill-Rom 2002)

These Comfort Cells allow the user to immerse into the cushion as they are free to move over one another and are able to deform individually.



- *Comfort Cells are slightly compressed by the body and become a little flatter.*
- *The body's pressure makes Comfort Cells move and slide against each other creating CONTOUR & PRESSURE DISTRIBUTION.*
- *Each Comfort Cell blocks other cells when pressed together by the body. This creates functional stability.*

Figure 3-30 Vicair's Comfort Cells interlocking to provide stability (Comfort Company 2008c)

Unlike dry-floatation and air-foam floatation which requires regular re-inflation and a controlled release of air to maintain the optimum level of internal air pressure, the Comfort Cell approach relies on the number of air cells in each compartment to control the level of immersion, see figure 3-31.

Figure 3-31 Vicair's use of Comfort Cells to control level of immersion (Comfort Company 2008c)

By adding or removing cells the desired level of immersion can be achieved for the user. It is stressed that the process of adjusting the number of cells is carried out only under the direct supervision of a therapist (Hill-Rom 2002). Inappropriate adjustment can lead to tissue damage. For example, too few cells can result in the user bottoming out, see figure 3-33.

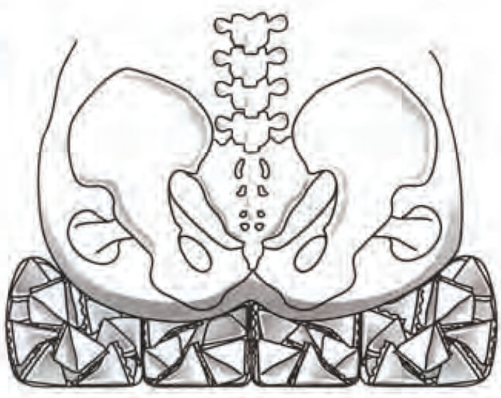


Figure 3-32 A Vicair cushion filled with an appropriate number of Comfort Cells (Comfort Company 2008c)

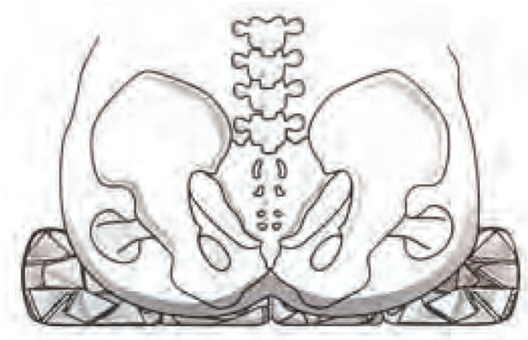


Figure 3-33 A Vicair cushion not filled with enough Comfort Cells (Comfort Company 2008c)

The capacity to adjust the number of comfort cells within each compartment enables the cushion to be adjusted to custom fit the sitting position of the user. For instance the number of cells in the rear compartment can be reduced to create a deeper contour so as to capture the ischial tuberosities and prevent sliding forward, see figure 3-34.

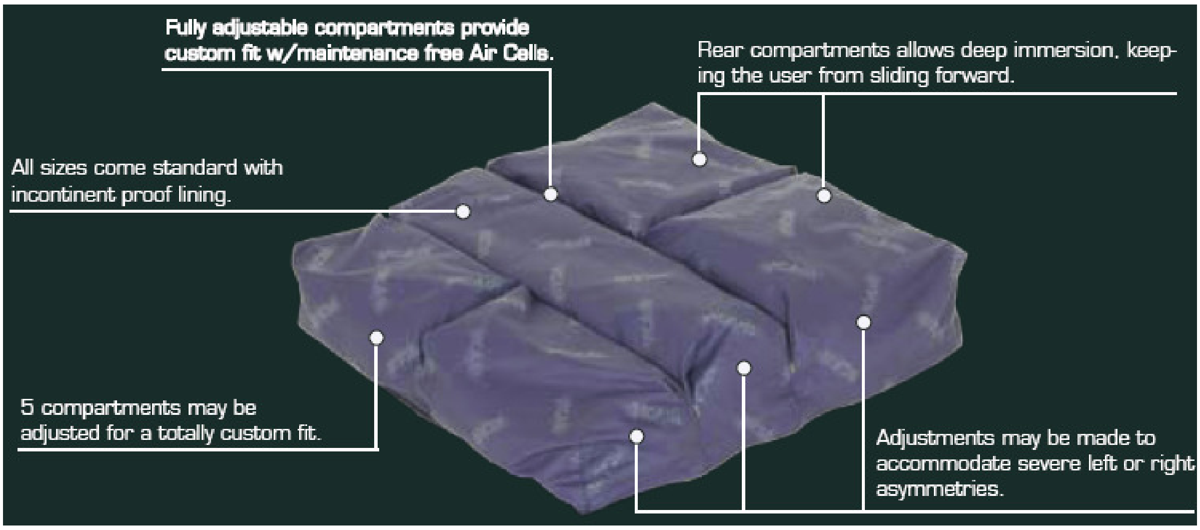


Figure 3-34 Vicair's Academy Adjuster Cushion (Comfort Company 2008d)

This adjustment should be left to a qualified professional as an error can cause problems with the user's posture, see figure 3-35. Poor posture is undesirable for the user as this can lead to complications, see section 3.6.1.

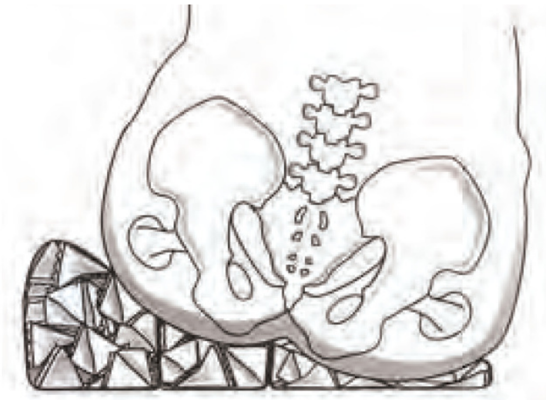


Figure 3-35 A Vicair cushion with too few Comfort Cells in the right rear compartment (Comfort Company 2008c)

3.3.3.2 Observations on the Vicair

The Vicair is an air cell cushion based on the Comfort Cell approach. Unlike the ROHO and the Varilite, the Vicair does not rely on the fluid properties of air to immerse and envelop but relies on the ability of the cell to deform and the cells freedom to move over one another to enable the compartments to mould to the shape of the user and thereby immerse and envelope the user.

By not relying on internal air pressure the Vicair does away with the issue of setting and maintaining an optimum air pressure. However, there can be error with the number of comfort cells used in each compartment. If too few cells are used, the user can bottom out, see figure 3-33.

Being comprised of a series of closed compartments the movement of the cells from compartment to compartment is prevented. The cell's inability to flow from compartment to compartment provides the user with a stable surface, see figure 3-30. Also, by not being able to flow from one compartment to another leaning cannot become exaggerated like the ROHO, see figure 3-17.

Although the Vicair does not have a contoured shape to support a user's posture, by adjusting the number of comfort cells in each compartment a contour can be effected. A reduced number of cells in the compartments under the ischials will allow the user to sink deeper into the cushion. This 'captures' the pelvis, preventing the user from sliding forward and slouching, see figure 3-25. The adjustment of the quantity of cells in each compartment is a skilled task and should only be carried out under the supervision of a therapist, as indicated both in the user manual (Hill-Rom 2002) and by spinal cord injury centres (Fiddy 2005b).

It is important that the cushion is placed on the wheelchair in the correct orientation so the correct compartment is under its intended part of the body. The Vicair has a set of colour coded loops, with the rear loops additionally marked “*rear*”, to secure the cushion to the wheelchair (Hill-Rom 2002). Tying a cushion does fix the cushion securely to the wheelchair but managing knots is a cumbersome method and knots are known to come undone.

A Vicair cushion can be cleaned with a household disinfectant although the inner cushion should not be submerged in water as this may damage the cushion (Hill-Rom 2002). This is a simple and easy task.

The light weight structure and composition of this cushion makes this cushion easier to transfer and helps to minimise the overall weight of the wheelchair.

3.3.4 Flo-tech

3.3.4.1 Features of the Flo-tech

The Flo-tech range of cushions is manufactured by the Cardiff based company Medical Support Systems Ltd (MSS Ltd), who started trading in 1983 (NHS Purchasing 2008). Although MSS Ltd was acquired by Invacare Inc in 2005 it continues to manufacture the Flo-tech range of cushions at its Cardiff site (Invacare 2008a), see figures 3-36 and 3-37. Invacare is a multinational corporation producing home health care and medical equipment and sells products in 80 countries with approximately $1.5 billion in net sales (Invacare 2008b).

Figure 3-36 The Invacare Flo-tech Contour cushion without it’s cover (Invacare UK 2008)

Figure 3-37 The Invacare Flo-tech Contour cushion within it’s cover (MSS 2005)

The Flo-tech contour cushion employs the static cushion concept whereby pressure ulcers are prevented by lowering IP to below some safe pressure-intensity threshold. To achieve this pressure-reduction The Flo-tech cushion approach uses contoured foam to disperse the user's body weight through immersion and envelopment, see figure 3-36.

To improve the immersion quality of the cushion, the surface of the Flo-tech is contoured to accommodate the shape of the user. Flat, un-contoured, cushions are often referred to as 'linear' cushions (Collins 2007) or 'slab' cushions (Conine 1993). The flat sitting surface of slab cushions relies purely on the physical characteristics of the cushion, typically the density of the foam, in order to immerse the user. The contouring, also known as a moulding, added to the Flo-tech increases the immersion quality of the cushion by allowing the user to sit in the cushion rather sit on top of the cushion, see figure 3-38.

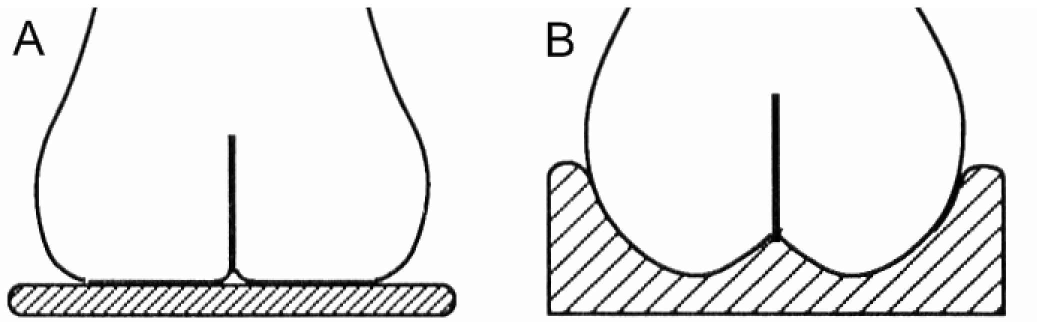


Figure 3-38 In case **A** the user is sat on top of a slab cushion and experiences a large amount of tissue distortion. In case **B** the user is sat in a contoured cushion and is subject to less tissue distortion (Luo 1991)

The Flo-tech approach also incorporates a cross-cut pattern onto the surface of the cushion. This segmenting of the surface divides the surface into free moving "*cubes*". These cubes can move independently and so can flex to the movement of the user (Collins 2007). This reduces the level of shear and friction the user is subject to, see figure 3-39. This is fundamentally the same principle as the independent free moving air cells of the ROHO approach, see figure 3-11.

Moulded foam cushion

Moulding allows Flo-tech cushions to provide a three-dimensional form, which can not be emulated in cut foam. Moulded foam is highly durable, increasing the product's longevity.

Contoured seating surface

Offers improved stability and postural support; castellations reduce shear and friction forces on tissue.

Figure 3-39 The Flo-tech approach (MSS 2005)

Whilst the contouring of the surface improves the immersion of the user, it also supports the user's posture. The raised centre slightly separates the user's legs and rocks the pelvis backwards which helps to reduce lumbar strain and the sides and rear of the cushion are raised to improve the user's stability (Young 1997). The deep portion of the rear of the cushion captures the user's pelvis preventing the user from sliding forward (Collins 2007).

3.3.4.2 Observations on the Flo-tech

The contoured foam cushion approach still relies on the physical properties of foam to immerse and envelop the user but uses a contoured shape to enhance the immersion of the user. By allowing the user to sit in the cushion rather than sit on top, the body shape of the user is less deformed.

There are weaknesses with the Flo-tech application of this approach. The Flo-tech comes in a range of set contour shapes. For optimum performance, as each user has an individual body shape, each contour should be bespoke to the user. Having to match one of the Flo-tech range as a closest fit relies on the experience and expertise of the professional at the seating clinic. With a range of 83 different sizes (MSS 2005) this presents an opportunity for error.

Once a Flo-tech cushion has been matched to the user the contour remains fixed even when the user's body shape fluctuates after an episode of rapid weight loss or weight gain.

With a fixed contour there is the potential for the contour to be distorted if used on a wheelchair with a sagging seat, see figure 3-40.

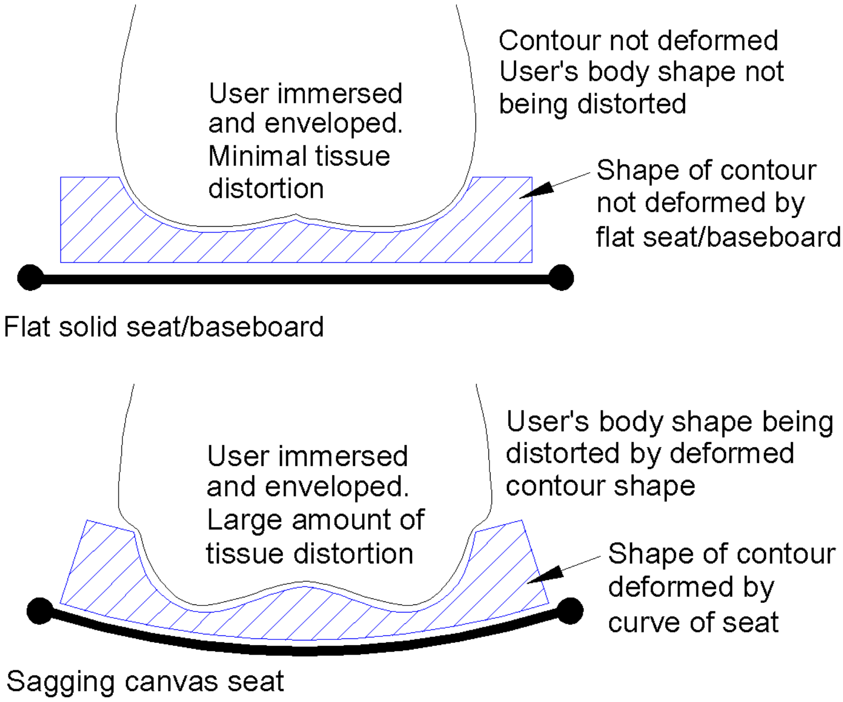


Figure 3-40 Contour cushion without a baseboard deformed by the sag of a canvas seat

This potential problem has been addressed with a feature MSS describes as a sag compensator, which is basically an internal baseboard (MSS 2005).

Without a fluid component to flow around, this cushion is inherently stable and not prone to exaggerate a lean in the manner of a ROHO, see figure 3-17.

The contour shape, with its deeper “*bucket*” shape for the ischials and prominent pummel, supports the user’s posture by ‘capturing’ the pelvis to prevent the user from sliding forward and slouching, see figure 3-25.

The method Invacare, and previously MSS (MSS 2005), provide for preventing their Flo-tech cushions from sliding over the seat of a wheelchair is by means of the cushion cover they provide with their cushions. The top and sides of the Flo-tech cover consists of a two-way stretch, water resistant and vapour-permeable fabric. The bottom of the cover has a textured panel, which has a high co-efficient of friction, on the bottom. Invacare refer to this bottom panel in their brochures as an “*anti-slip base*” (Invacare 2008). This anti-slip base approach, the same as ROHO’s “*non-skid base*” approach, relies on the interaction of friction between the cushion and the wheelchair to hold the cushion in place.

A Flo-tech cushion can be cleaned with a damp cloth and normal household cleaners. This is a simple and easy task. However, if the foam is contaminated with incontinence the cushion has to be replaced as the foam is absorbent and cannot be cleaned (Fiddy 2005c).

The light weight structure and composition of this cushion makes this cushion easier to transfer and helps keep the overall weight of the wheelchair down.

3.3.5 Jay

3.3.5.1 Features of the Jay

The Jay range of cushions was first produced by the Jay Medical Ltd company, founded in 1982 in Boulder Colorado. The Jay range continues to be produced by the Jay Division of Sunrise Medical Inc; after Sunrise Medical Inc. acquired Jay Medical Ltd in 1994 (SEC 1996). Sunrise Medical Inc. is a multinational corporation with sales in over 90 countries. Sunrise Medical Inc. is composed of a series of divisions referred to as brands. It is the *Jay®* division which produce seating and positioning equipment, see figure 3-41. The other divisions are *Quickie®* which produce wheelchairs; *Sterling®* which produce scooters; *Coopers®* which produce daily living aids such as crutches and bath safety equipment; and *Oxford®* which produce lifting hoists (Sunrise Medical 2008a).

Figure 3-41 The Jay J2 Deep Contour cushion without its cover. Note the ischial compartments to limit gel migration (Sunrise Medical 1998)

Figure 3-42 The Jay J2 Deep Contour cushion within its cover. Note the retaining hooks on the side of the cushion for securing to the wheelchair (Sunrise Medical 1998)

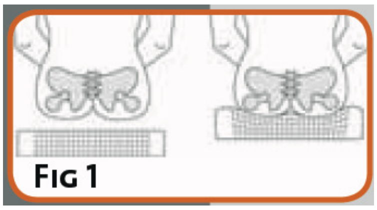
The Jay range of cushions employs the static cushion concept to prevent pressure ulcers by lowering the IP to below some safe pressure-intensity threshold. To achieve this pressure-reduction the Jay cushion approach combine a contoured foam base with a gel pack resting on top to disperse the user's body weight through immersion and envelopment, see figure 3-43.

Figure 3-43 An exploded view of a J2 Deep Contour cushion (Sunrise Medical 2005)

Although the Jay cushion includes a gel pack, it is of the viscous fluid cushion type of cushion not the solid gel type. An example of a solid gel type of cushion is the EZ Feel gel cushion, manufactured by JCM Seating, Petersfield, Cambridge, which uses a polyurethane gel.

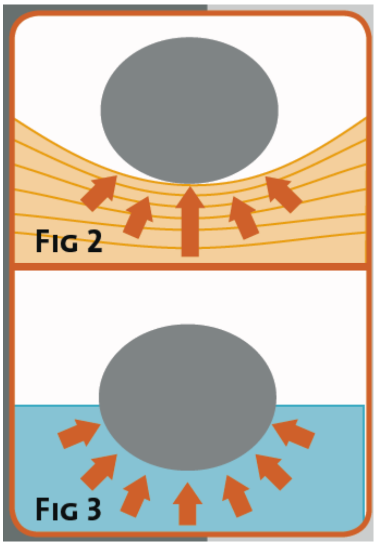
The Jay 2 cushion's gel pack compresses of a urethane sac which contains a viscous fluid. The viscous fluid originally used in the Jay2 cushion was "*flolite®*", a silicon gel (Ferrarin *et al* 2000). Sunrise Medical has since replaced the flolite in their Jay cushions with another viscous fluid which they have only have disclosed as "*Jay Flow™"* fluid.

Jay ascribe to the use of gel for pressure distribution, but recognise the limitations of viscous fluids and gels compared to liquid and gas (air) filled cushions, see figure 3-44.



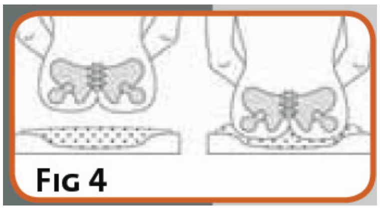
Skin integrity is optimised by spreading the weight of the client

- *over as wide a surface area as possible*
- *away from bony prominences to areas that can take the load*
- *by reducing peak pressures in pressure sensitive areas*



Solid materials; including foams, viscos and gels

- *conform to the shape of the client to a varying degree dependent on the type of material (fig 2)*
- *can provide some pressure reduction, BUT as solids there is always a material counter force*
- *high compression creates counter-intuitive reactive pressure in the critical areas*
- *do not redistribute pressure from pressure sensitive areas*



Liquids and gases (non-Newtonian)

- *differ from solids as they displace, conforming completely to the form of the client without any counterforce working against the client (e.g. floating in a pool) (fig 3)*
- *the entire body of the client is suspended in the fluid = hydrostatic force (fig 4)*
- *spread pressure evenly across entire body in contact*

Figure 3-44 Pressure distribution using solids, liquids and gases (Sunrise Medical 2008b)

The Jay range does not use air to immerse or envelop the user and as such does not depend on the correct setting of an internal air pressure. However the Jay range does use a viscous gel which still requires frequent and regular manual adjustment. The gel being a fluid can be pushed to the sides of the pack. Should enough gel be displaced within the gel pack and the user would experience a bottoming out event, see figure 3-45.

Checking for bottoming out on the J2 Cushion

Bottoming out occurs when you displace the fluid out from underneath your seat bones, which leaves you sitting on the foam base. It sometimes occurs on very thin individuals, people using recliner wheelchairs, people who slouch when sitting, or if using a cushion which is too wide.

When bottoming out occurs, increased pressure is placed onto the ischials and coccyx increasing the risk for skin break down.

To check for bottoming out, sit on the cushion without the cover for a minimum of two minutes. Transfer up and off the cushion (or have someone help you transfer), trying not to disturb the fluid underneath you. Push down in the depressions on the pad where your ischials (seat bones) and coccyx (tailbone) were. You should have to push through at least ½" (1cm) of fluid before you feel the firm cushion base below.

If the cushion is properly positioned and the foot rests are properly adjusted, and there is not at least the minimum ½" (1cm) of fluid, the cushion is bottoming out and should not be used. If you are bottoming out, discontinue use of the cushion and see your clinician. Usually bottoming out is easily solved by using fluid supplement pads (part #F119).

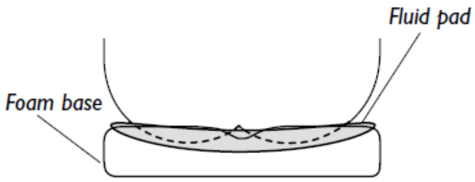


Figure 3-45 Adjustment of gel instructions from a Jay cushion user manual (Sunrise Medical 1998)

The Jay range incorporates a contoured foam base to aid the immersion of the ischials, see figure 3-46, and to provide the user with some form of postural support. In particular the Jay cushions use a deeper rear portion to help capture the pelvis to prevent the user from sliding forward.

Figure 3-46 A Jay 2 cushion immersing the ischials (Sunrise Medical 2005)

The Jay has a system for securing the cushion to the wheelchair. They provide retaining hooks and stoppers which attach to the wheelchair frame. The cushion itself has a set of corresponding hooks on the baseboard, see figure 3-57. Jay refer to the gel pack, foam base and baseboard ensemble as the "*solid drop seat*".

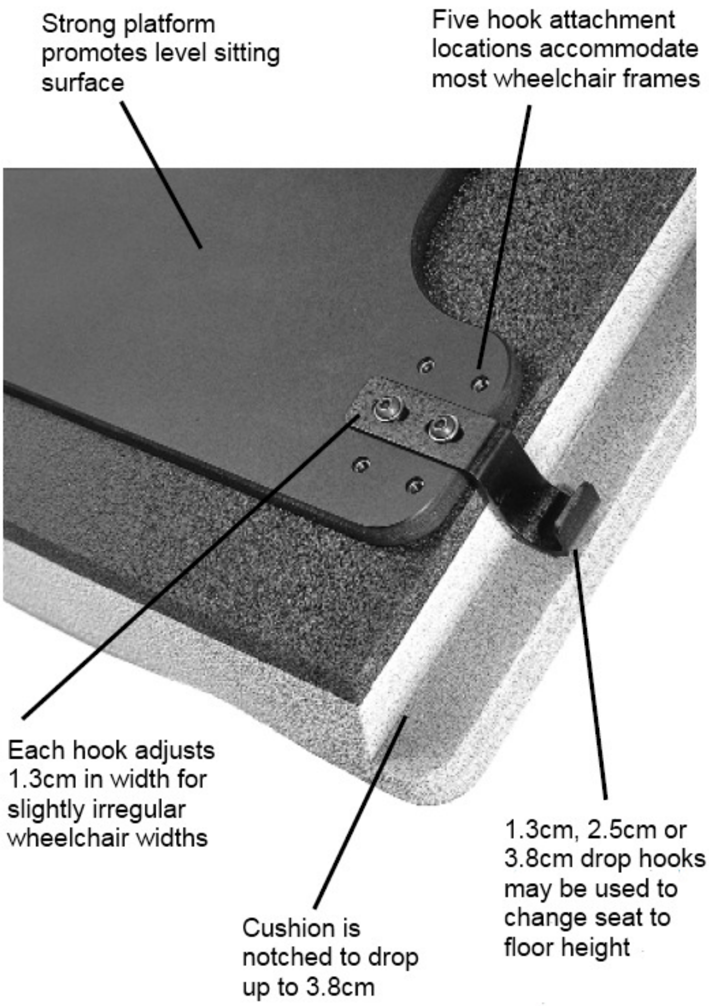


Figure 3-47 Securing hooks on Jay cushion base (Sunrise Medical 1998)

The gel, baseboard and high density foam base combine to create a cushion substantially heavier than it's peers with the Jay 2 weighing up to 5kg (Sunrise Medical 2008d), compared to the ROHO High Profile weighing up to 2kg (ROHO 2007), the Flo-tech Contour at 1.4kg (MSS 2005), the Vicair Adjuster at 1.1kg (Comfort Company 2008c), and the Varilite Evolution PSV at 1kg (Varilite 2008d). The weight is such that Jay advise that when one of their cushions is first attached to a wheelchair the centre of gravity is checked as the weight of the cushion may make the wheelchair easier to tip backwards.

3.3.5.2 Observations on the Jay

The gel cushion approach exploits the fluid property of gel to displace within the cushion to enable the surface to conform to the user's body shape thereby immersing and enveloping the user.

There are weaknesses with the Jay application of this approach. As the gel is free to flow within the pack the gel can flow from under the areas subject to the greatest load to areas put under less load. Potentially this can result with the user bottoming out, see figure 3-48.

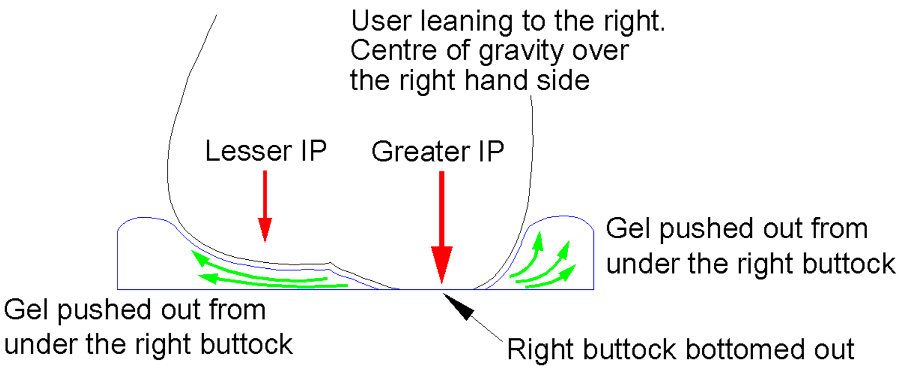


Figure 3-48 The free flow of gel within a gel pack leaving an unbalanced user sat bottomed out

To prevent a bottoming out event the dispersal of gel has to be frequently checked and the gel manually pushed back. Having to frequently check and redistribute the gel means that there is an opportunity for error which can lead to pressure damage. Jay does try to minimise this effect by compartmentalising the gel to restrain its movement, notably under the ischial tuberosities see figure 3-41. However, the potential for the user to bottom out remains. Caution and awareness of bottoming out is stressed in the User Instruction Manual (Sunrise Medical 1998) and in the information sheet provided by the Salisbury pressure clinic (Fiddy 2008).

The gel, Jay Flow™, being a fluid requires a waterproof pack to contain it. This material is therefore not vapour permeable and can increase a user's production of sweat. Jay produce a cover for their cushion which is designed to counter this but there can be occasions in a user's life when a cover is not available, for instance when it is being laundered.

The Jay is not a pure gel cushion but a combination cushion using a contoured foam base. The contour shape, with is deeper "*bucket*" shape for the ischials and prominent pummel, supports the user's posture by 'capturing' the pelvis to prevent the user from sliding forward and slouching, see figure 3-25.

Rather than relying on a textured fabric panel on the base of the cover to prevent the cushion from sliding the Jay has a system of retaining hooks which fastens the cushion to the wheelchair frame, see figure 3-47. This is a much more secure method than the high co-efficient of friction base option favoured by the other cushion designs.

Both the gel pack and the foam base can be cleaned with a damp cloth and normal household cleaners. This is a simple and easy task (Fiddy 2008).

3.3.6 Airpulse PK

3.3.6.1 Features of the Airpulse PK

The Aquila Corporation is an American small business owned by ex-servicemen, which have been manufacturing wheelchair cushion systems since 1999. Aquila produce a dynamic cushion, the Airpulse PK designed for those at high risk of developing a pressure ulcer or already have a pressure ulcer, see figure 3-49. Each cushion produced by Aquila is custom built to address the specific physical characteristics of the client (Aquila Corp. 2008a).

Figure 3-49 The Aquila *Airpulse PK* cushion with cover (Aquila Corp. 2006b)

The Airpulse PK cushion employs the dynamic cushion concept whereby pressure ulcers are prevented by reducing the length of time the skin is subjected to IP to below some safe pressure-duration threshold, see section 4.5.7. To achieve this pressure-redistribution the Airpulse PK approach uses a series of pneumatic air cells to redistribute the load bearing points across the seat area of the body at programmed intervals, see figure 3-50.

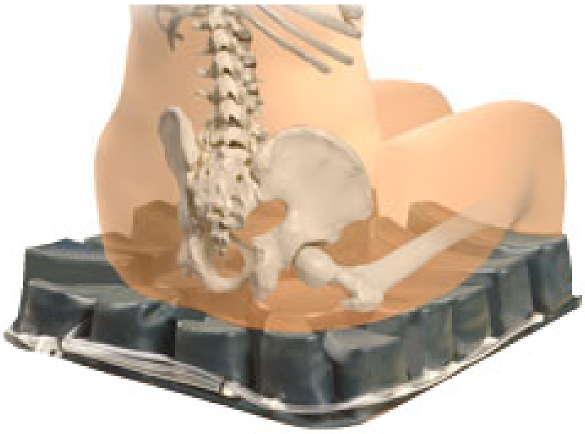


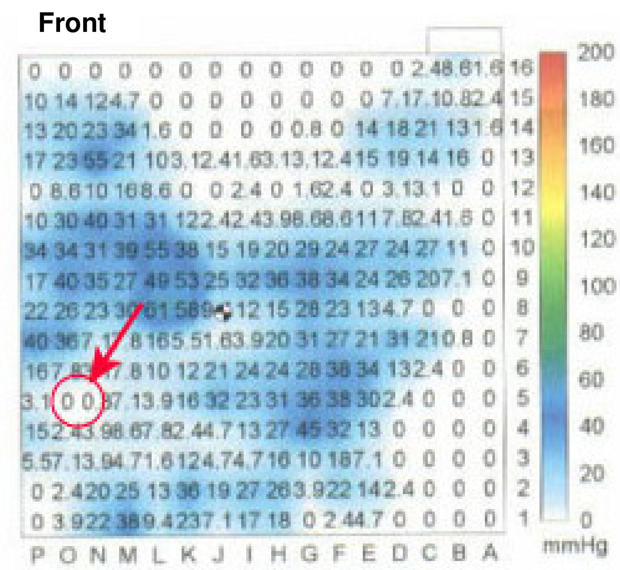
Figure 3-50 The Airpulse PK supporting the user on alternate air cells (Aquila Corp. 2008a)

The Airpulse PK cushion is composed of an arrangement of neoprene air cells, of varying size and shape, and a control module, the ‘controller’, which houses the pump, batteries and control systems, see appendix C.

Being a pneumatic system there is no manual adjustment required to obtain an optimum internal air pressure, as in the case with dry-floatation and air-foam floatation devices. The internal air pressure of each cell is governed at any given point in time by the duration and frequency of the inflate/deflate cycles. The inflate/deflate profile of each cell is co-coordinated to alternate the load bearing points of the user, see figure 3-51. These cycle times are adjustable using the control system. To prevent a bottoming out event, should the air pressure system fail, there is an internal foam structure, see appendix C.

Figure 3-51 The air cells of an Airpulse PK alternately inflated and deflated to redistribute the load baring points (Aquila Corp. 2008c)

By using the inflated cells to carry the weight of the user, the areas of skin over the deflated cells are suspended and free of IP. This feature can be exploited by the Airpulse PK to protect existing pressure ulcers from being exposed to any IP. This is achieved by setting the air cell directly under the pressure ulcer to remain deflated, see figure 3-52.



- *Male, 91Kg, 60 yrs. old sitting on Airpulse PK automatically inflated cushion system*
- *Current Stage IV Pressure Sore on Left ischial*
- *When custom making this cushion, the left ischial cell was isolated such that it applies no upward pressure to the existing sore*

Figure 3-52 A pressure ulcer on the left ischial subjected to zero IP due to deflated air cell (Aquila Corp. 2008d)

By controlling the internal air pressure of each cell some level of postural support can be achieved. Keeping the air pressure in the cells below the thighs higher than the air pressure under the ischial tuberosities will form a contour whereby the ischial tuberosities will sit deeper in the cushion and in so doing will prevent the user from sliding forward.

3.3.6.2 Observations on the Airpulse PK

The dynamic, or alternating pressure (AP), concept relies on rotating the load bearing points of the support surface so that areas of tissue can be temporarily relieved of pressure in order to recuperate, see section 3.2.2.

There are potential weaknesses with the Aquila application of their approach. The pneumatic cells, which are the load bearing points, are arranged in a pattern of various sizes and shapes with an adjustable inflate/deflate cycle profile. Whilst Aquila will have gone through a process to determine the best sizes, shapes and inflate/deflate cycle profiles for their cushions, these cushions remain Aquila's own interpretation of what is effective. At present there is a lack of consensus as to the optimum cell size, shape, depth, spacing between cells, cell arrangement, internal air pressures, time taken to inflate/deflate cells, inflation intervals, inflation cycle patterns. This suggests that these are all matters which are still unresolved, see section 3.2.2.

Being a mechanical device there are a series of limitations related to its practicality, such as battery life, battery charging times, cables and connectors, noise, weight and with working parts it is vulnerable to mechanical failure.

With a constantly shifting support surface, a fixed contour is not possible but by using the arrangement of the cells and the internal air pressures the cushion can effect a contour. Aquila can custom build each cushion to suit the physical characteristics of the user.

The feature Aquila provides for preventing their Airpulse PK cushions from sliding over the seat of a wheelchair is incorporated into the cover they provide with their cushions. The top and sides of the Airpulse PK cover is made from Lycra and the bottom is made from a rubberised fabric which has a high co-efficient of friction. Aquila refers to this bottom panel in their Airpulse PK Cushion System Product Specification as a "*non-slip bottom*" (Aquila 2008e). This non-slip bottom approach, the same as ROHO's "*non-skid*" and Invacare's "*anti-slip*" approach, relies on the interaction of friction between the cushion and the wheelchair to hold the cushion in place.

As with the ROHO, when cleaning an Airpulse PK cushion each air cell which make up the cushion requires gentle scrubbing, including the gaps in between cells. This is not a simple or convenient task.

Cost was not mentioned in regard to the other cushions as they tend to be similar, costing in the region of a few hundred pounds. However, the cost of the Airpulse PK is a consideration as it is much more expensive than its static cushion counterparts. A typical static cushion for high risk patients costs between £300-£500 (Kennedy *et al* 2003), compared to the Aquila cushion for high risk patients, the Airpulse PK, which costs between $3,300 - $3,700 (Aquila Corp. 2006a).

3.3.7 Cushion Covers

Cushion manufactures supply a cover to correspond with each cushion. These covers are an integral part of the cushion, protecting the cushion and managing pressure ulcer contributing factors, principally moisture. For instance, whilst a cover cannot physically stop a person sweating an inappropriate cover can increase a person sweating. So as not to increase sweating, and to deal with the sweating that does occur, covers tend to be vapour permeable, for example the Jay range use a "*humidity wicking*" material for their covers (Sunrise Medical 2008b). The best materials for minimising sweating are natural fibres such as cotton. Most cushions can be supplied with a stretchy terry towelling material cover (Ratcliffe and Rose 2000).

It is essential that anything that covers a PR cushion must not compromise a PR cushion's pressure relieving qualities. In particular it must not interfere with a static cushions ability to immerse and envelop, and it must not prevent dynamic cushions from fully unloading areas of skin during alternate inflation cycles. Cushion covers should therefore be constructed from a multi-stretch material (Collins 2001b). For example, Varilite supply their cushions with a cover made from a "*four-way-stretch mesh*" (Varilite 2008d).

Most manufactures focus on the practicalities of cushion covers and produce a discrete darkly coloured cover in black or dark blue. ROHO has recognised that some users would like their cushion cover to be more expressive and have produced a range of more personalised expressive covers, see figures 3-53 and 3-54.

Figure 3-53 The ROHO 'Rainbow Tie Dye' cover (ROHO 2008d)

Figure 3-54 The ROHO 'Go Tiger' cover (ROHO 2008d)

3.4 PR Cushions and Pressure Relief

3.4.1 Pressure Relief Cushion's Focus on Interface Pressure

The main emphasis of cushion design has been, and still is, placed on managing IP. As noted by Gefen, "*Presently, commercial cushioning products for pressure ulcer prevention are being evaluated for their protective effect exclusively based on their interfacial pressures between the cushion/mattress and the patient*" (Gefen and Levine 2007).

This focus on IP is not a recent development, as support surfaces have been evaluated by measuring the amount of pressure applied to anatomical landmarks, most commonly the sacrum, since the early 1970's (Clark *et al* 2005). This longstanding emphasis on IP is a consequence of how pressure ulcers have been understood to develop, "*Prolonged external pressure over bony prominences has long been identified as the primary etiology in pressure ulcer development*" (Brienza and Geyer 2005). As Barnett, an advanced biomedical engineer with *Hill-Rom*, points out,

> *Clinical efficacy of a support surface is logically based on the etiology of the disease it is intended to prevent – in this case, pressure ulcers. Although there are important intrinsic factors in the etiology of pressure ulcers a support surface has its primary benefit in the management of extrinsic factors (i.e., pressure, shear, friction, moisture and temperature). As the dominant, extrinsic factor, pressure has received the most attention.*
>
> (Barnett and Shelton 1997)

There is a consensus that pressure ulcers are caused by pressure, see sections 4.3 and 4.4. It is widely believed that the corollary is that lowering the IP an individual is subjected to prevents the development of a pressure ulcer and that the capillary occlusion pressure of 32mmHg is the safe *pressure-intensity* threshold, see section 4.5.4. A point recognised by Oertwich, "*As a result of this study* [Landis 1931]*, health care providers have judged 32mmHg to be the usual capillary closing pressure of patients. This judgement is widely used to make decisions regarding the development, marketing, and purchase of support surfaces*" (Oertwich *et al* 1995). This view of 32mmHg as a safe threshold continues to be espoused, "*pressures under 32mmHg are assumed by many clinicians to be safe. This benchmark is further defined as interface pressure. Products aimed at reducing or relieving pressure have tended to use interface pressure as the standard for judging product efficacy*" (Salcido 2004).

The notion that a cushion's ability to reduce IP is a means by which to judge its efficacy has led to laboratory-based evaluations and RCTs to concentrate on evaluating the IP measured between the support surface and the body prominences (Jones 2005). Also, reviews of devices and comparative studies tend to focus on IP map readings. There may be merit in this approach, Agram found three studies (Brienza *et al* 2001, Conine *et al* 1993, Conine *et al* 1994) which reported some correlation between pressure ulcer incidence and high peak and mean IP (Agram and Gefin 2007). This relationship is not yet confirmed and is subject to doubt. Geyer found that the few studies of elderly wheelchair users which exist do not clearly demonstrate a relationship between interface pressure magnitudes and the incidence of pressure ulcers (Geyer *et al* 2001). In fact, when Reger analysed the literature relating IP to the prevalence of pressure ulcers he found, "*Results suggest a nearly non-existent or slightly negative correlation between interface pressure and ulcer prevalence in general and spinal cord injured populations*" (Reger *et al* 2007).

With the emphasis of cushion evaluation being placed on IP measurement, manufactures have predominantly advertised the efficacy of their devices by demonstrating their ability to manage IP, typically by comparing pressure map results. For example Varilite advertised the efficacy of their Evolution PSV cushion by comparing a pressure map of their cushion with a pressure map produced by a ROHO cushion, see figure 5-4.

The concept of a 32mmHg safe pressure-intensity threshold and a reliance on objective IP map measurements to demonstrate efficacy may well be overly simplistic as the limitations of pressure mapping for predicting and preventing pressure ulcers is becoming more apparent with works such as "*The false premise in measuring body-support interface pressures for preventing serious pressure ulcers*" (Gefin and Levine 2007). Gefin considered the impact of internal stresses acting within the muscle over IP acting on the skin surface and found that, "*Measuring interfaces pressures alone, therefore,* *hardly gives the full picture of the risks developing inside the muscle*" and concluded "*interfacial body-support pressure measurements to evaluate the performance of mattresses and wheelchair cushions in preventing DTI* [deep tissue injury[10]] *can be misleading*" (Agram and Gefin 2007).

The focus on IP management has led to other important cushion design issues being neglected such as the shocks and vibrations wheelchair users experience, a point recognised by DiGiovine "*Cushions designed for static pressure relief may not perform well in other areas potentially related to secondary injuries such as vibration*" (DiGiovine *et al* 2000).

3.4.2 Assessing the Efficacy of PR Cushions based on Interface Pressure

The continuing emphasis on assessing the efficacy of cushions on IP may be a reflection of the difficulties to be found with measuring clinical outcomes. Conducting trials involving pressure ulcers are fraught with the sort of ethical and practical difficulties encountered when conducting trials with vulnerable patients and where nurses and assessors are 'blinded' to the different interventions (Bale *et al* 1999). Consequently, there are now numerous studies, reviews, evaluations and trials focused on IP whilst there remains a paucity of evidence on the absolute and relative merits of pressure relieving equipment. This lack of evidence leaves the selection of equipment to opinion, of which there is little consensus (Gebhart 2004). In each case the selection of cushion for efficacy and appropriateness is left to the experience of the provider, leaving many providers, such as physiotherapists and occupational therapists, to bemoan the lack of reliable evidence with which to help choose between the continually growing array of products.

One possible line of evidence providers might use to distinguish between cushions might be found in epidemiological studies. As PR cushions are intended to prevent pressure ulcers, they should have an impact on the rates of pressure ulcer incidence and prevalence. Such an impact should then be discernable through epidemiological studies. Ideally a manufacturer would be

[10] DTI was formally identified in 2001 by the NPUAP. The NPUAP added a definition of DTI to their pressure ulcer staging in February 2007 (NPUAP 2007), see section 4.3.1.

able to point to incidence/prevalence studies before their cushion came into service and then point to a corresponding drop in these rates following the introduction of their cushion.

However, there are numerous methodological difficulties such as those arising from the use of classification/grading scales, see section 4.3.2, and patient risk assessment tools, see section 3.5.2. This makes it difficult to draw comparisons between studies and any comparisons that are made are of limited use. For example in 1981, one study found the incident rate of pressure ulcers for those with spinal cord injuries (SCI) to be 30% (Young and Burns 1981), then fourteen years on and after the wide spread introduction of PR cushions in 1995 Yarkony found the incidence rate for those with SCI to be 31.7% (Yarkony and Heinemann 1995). There are many difficulties in drawing a direct comparison between these two findings and any conclusions made by making a comparison would have to be treated with caution, these two studies are discussed in more detail later in section 8.2.2.

These two studies are indicative of the difficulties presented by reviewing epidemiology studies for the purpose of drawing conclusions about cushion efficacy. It is understandable then that cushion manufactures prefer to stay on the safe ground of objective IP measurement as a means of demonstrating efficacy rather than placing the onus on improving incidence rates.

Reger commented on this disconnect between IP measurement and incidence/prevalence, "*Due to the paucity of other relevant data, healthcare providers continue to rely on research that primarily address interface pressure to select pressure–relief support devices … Correlating the interface pressure measured for various pressure-relieving support surfaces with relevant prevalence or incidence information will be useful in understanding the role of pressure reducing pressure ulcers and the effectiveness of pressure-relieving systems*" (Reger *et al* 2007).

Even though there has been much work centred on the IP performance of PR cushions there is a dearth of evidence on which to gauge the efficacy. Without sufficient evidence, no one has been able to draw a distinction between the different cushions based on efficacy. For example NICE has stated, "*No seat cushion has been shown to perform better than another, so this guideline* *makes no recommendation about which type to use for pressure redistribution purposes*" (Yerrell *et al* 2003 reprinted 2005). As the variation in IP performance between the different cushions is known yet the variation in cushion efficacy remains unknown, the association between IP and pressure ulcer development cannot be too great. Had IP been critical in the development of pressure ulcers then IP performance would have been more discernibly related to pressure ulcer development. Therefore, to evaluate the efficacy of PR cushions one will have to look further than simply IP measurements.

3.4.3 Efficacy of Pressure Relief Cushions

Despite the perceived association between IP management and cushion efficacy, work such as that by DeFloors has raised doubt whether pressure relief cushions are effective at relieving pressure. DeFloors having studied the IP of 29 cushions on 20 healthy volunteers, in a laboratory setting using an Ergocheck™ system for IP measurement, concluded that only 13 of the 29 cushions had any pressure-relieving effect; that despite its wide spread use gel has no pressure-relieving effect; that whilst some foam cushions reduce IP very well others actually increase IP; and that the lowest IP's measured were on air-filled cushions (DeFloor *et al* 2008).

Concerns that PR cushions are not effective at reducing IP were raised shortly after their inception, as Souther highlighted in 1974. Souther tested 11 makes of cushion using a pressure manometer system to measure the IP under the ischials of 10 healthy volunteers. None of the cushions reduced the IP to below 40mmHg whilst 32mmHg was cited as the capillary occlusion pressure. Souther concluded that, "*The possibility exists, therefore that no device can reduce pressures generated in the sitting position to a level less than capillary closing pressure. When the same weight is distributed over a larger area, however, as for example in the supine position, theoretical and measured pressures fall below capillary pressure*" (Souther *et al* 1974).

With cushion evaluations being predominantly based on pressure map comparisons between cushions, whereby one cushion is seen to be better at managing IP than another, the intent of cushions being effective at preventing pressure ulcers has been clouded. This clouding is such that even the question of whether or not a cushion is effective at reducing IP has been lost; all that is important is that the pressure map results, revealing peak and mean IP, are better than its competitors.

3.4.4 Pressure Relieving

Despite all the attention given to IP, so far neither static nor dynamic cushions have been sufficiently effective as to remove the necessity for the user to perform manual pressure relieving. A point conceded in the advice given by the NSIC spinal outpatient services, "*Sophisticated wheelchair cushions do not do away with the need to pressure relieve – they are purely an adjunct to relieving sitting pressure*" (Ratcliffe and Rose 2000).

In response to the limitations of PR cushions, some form of manual pressure relieving is widely practiced by wheelchair users, notably paraplegics. Pressure relief is performed when the wheelchair user carries out a movement which shifts the weight of the body off the normally weight bearing areas. By taking the load off these normally weight bearing areas they are temporarily relieved from IP. Such pressure relieving movements are shown in figure 3-55.

The 'Lift-off'*

The individual pushes straight downwards onto the wheelchair armrests to perform a straight arm lift to take the bottom off the support surface. #

The 'Roll'*

The individual rolls from side to side raising one buttock at a time. #

The 'Forward lean'*

The individual leans forward with the chest towards the thighs while the bottom remains in contact with the cushion. #

* Image taken from Stockton (Stockton and Rithalia 2007).

Text taken from Stockton (Stockton and Parker 2002).

Figure 3-55 Images of three different pressure relieving movements

In 2003, the practice of manual pressure relief was studied at the NSIC Stoke Mandeville. They concluded that,

> *Sustaining the traditional pressure relief by lifting up from the seat for the extended duration is neither practical nor desirable for the majority of clients due to strain on upper body limb joints, and sometimes other constraining health conditions.*
>
> (Coggrave and Rose 2003)

The results of the study prompted a change in clinical practice at the NSIC. The pressure relief movements now recommended are,

A '*Forward lean*' –

The same as 'the Forward lean', as described above.

A '*Side-to-side*' –

The same as 'the Roll', as described above

A '*Tilt back*' -

this method is recommended for those unable to perform a forward or side-to-side lean. The whole seating unit is tilted backwards. The degree of tilt required to provide effective pressure relief is 65° or greater. This can be achieved using a 'tilt in space' chair or manually in other chairs. (Coggrave and Rose 2003)

Figure 3-56 A wheelchair user in a 'Tilt back' position (Stockton and Rithalia 2007)

To gain a reduction in IP, the angle the user has to be titled back is large with the NSIC recommending an angle of inclination of greater than 65°. The necessity for a large angle of inclination has been replicated by others. Hanson found tilting a wheelchair by 10° to 20° had no effect and 35° produced a minimal reduction. It was not until the wheelchair was tilted by 65° that Hanson achieved a significant reduction in IP (Hanson *et al* 2006). Betz also looked at the effect of tilting on IP, using pressure mapping. She found that when the seat backrest was also inclined, a less extreme seat tilt of 45° was needed to achieve a reduction in IP, see figure 3-57 (NWRSCIS 2004).

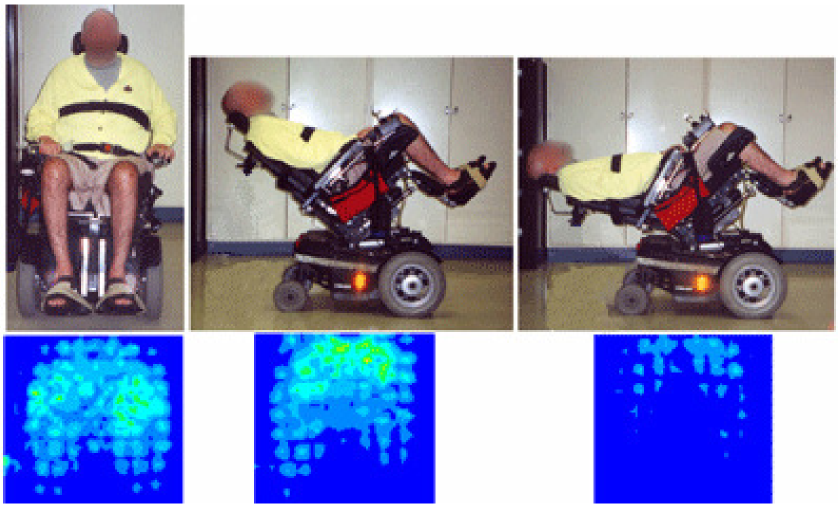


Figure 3-57 Pressure maps from left to right: upright; 45° tilt; 45° tilt with recline. In this case the 45° tilt with recline gives the best pressure relief (NWRSCIS 2004)

The 45° tilt with incline sitting position not only achieves a better IP reduction it has the added advantage of allowing the user to sit close to the neutral body position. The neutral body position is the position a relaxed human body will assume when fully unloaded, as found under microgravity conditions, see figure 3-58. This definition of neutral body position was developed by NASA's Human Factors and Ergonomics Laboratory at the Johnsons Space Centre (Mount *et al* 2003).

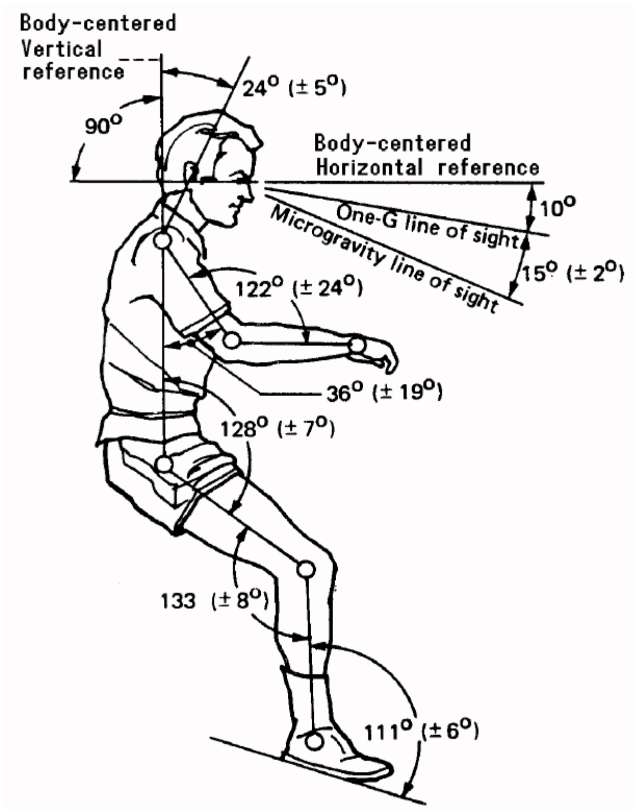


Figure 3-58 The neutral body position developed by NASA (Mount *et al* 2003)

Pressure relieving movements, such as a 'lean forward', have to be performed frequently enough and held for a sufficiently long duration to be effective. Currently the NSIC suggests, if possible, such pressure relieving movements should be performed for 60-90 seconds every half hour (Ratcliffe and Rose 2000). This is interesting as both Kosiak and Husain's work points to a "*Critical Time Threshold"* of approximately two hours, below which it is supposed that even high levels of pressure should be tolerable, see section 4.5.7.

Pressure relieving, or repositioning, is only effective if it is performed regularly and consistently. Forgetting to conduct consecutive episodes of manual pressure relieving could mean that the skin might not receive any relief from IP for a few hours, easily longer than the Critical Time Threshold. Going beyond an individual's Critical Time Threshold will start to damage the skin and the longer the delay, the greater the damage. Thus, remembering to perform manual pressure relief is important. This poses a stiff challenge as remembering to do something periodically is difficult, particularly when distracted. This is a common problem and one the Bath Institute of Medical Engineering (BIME) has tried to help by developing a small programmable device to provide periodical reminders when to perform manual pressure relief, in the form of a pager style vibration.

Others have tried to unburden the wheelchair user of the necessity to perform manual pressure relief by designing a seat which simulates some of the pressure relieving movements. For example Hefzy (1996) designed a seat to simulate the side-to-side movement, see figure 3-59. Such pressure relief simulating devices have not been adopted into mainstream use.

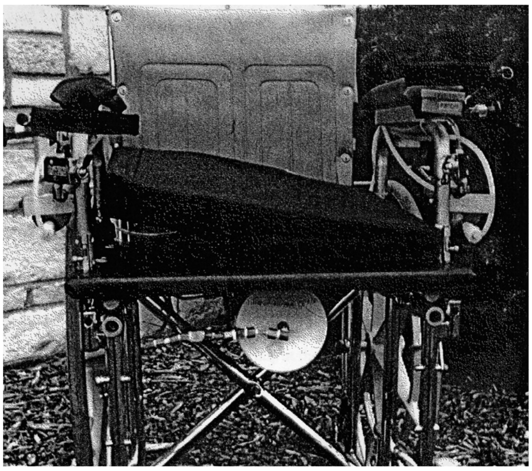


Figure 3-59 A seat, designed for individuals with quadriplegia, to simulate the side-to-side pressure relief movement (Hefzy *et al* 1996)

3.5 PR Cushions and At-Risk Patients

3.5.1 Designing PR Devices for At-Risk Patients

The two principles of pressure-reduction and pressure-redistribution dominate the design of PR devices, such as mattresses, overlays and cushions. These guiding principles have led to various approaches such as contoured foam and air-filled cells. These different approaches are not targeted at specific patient groups, such as stroke patients and SCI patients, but at the different levels of pressure ulcer risk. Patients assessed as being at the highest risk of developing a pressure ulcer are provided with the most preventative devices.

For example, at the Royal United Hospital Bath (RUH) they match PR mattresses to patients not according to patient group, eg orthopaedic, stroke, etc, but by the patient's pressure ulcer risk assessment score[11]. Very-high-risk patients receive Band A mattresses, the highest order of preventative mattress typically an AP device, whilst low-risk patients receive Band D mattresses, the lowest order typically specialist foam (Purser 2005), see figure 3-60.

[11] The risk assessment tool they use is the Waterlow Score, see section 3.5.2 for more detail.

Royal United Hospital Bath NHS Trust
Pressure Ulcer Prevention and Management

Pressure Reducing / Relieving Surfaces

RUH currently has a rental agreement with Pegasus and uses Trinova, Cairwave or Convertible 2 mattresses. However, several other makes are also used within the Trust. Select an appropriate mattress using the patient's Waterlow score and your clinical judgement. Also consider clinical and cost-effectiveness – a pressure relieving mattress is not a substitute for good nursing and pressure area care.

25+ Very high risk	**Band A**
20+ High risk	**Band B**
10+ At risk	**Band C**
<10 Low risk	**Band D**

	Make of Mattress	**Maximum Weight**	**Type of Mattress**	**Risk**
Band A	Cairwave (Pegasus)	254kg / 40 stone	Alternating pressure	Very high
	Convertible 2 (Pegasus)		Low air loss	Very high
	Nimbus 2 (Huntleigh)		Alternating pressure	Very high
	Nimbus 3 (Huntleigh)	250kg / 39 stone	Alternating pressure	Very high
	Parkhouse Delta	275kg / 43 stone	Alternating pressure	Very high
	Parkhouse Phase 2		Alternating pressure	Very high
Band B	Trinova (Pegasus)	22kg / 35 stone	Alternating pressure	High
	Pegasus Bi-wave Plus		Alternating pressure	High
	Pegasus Aircare			High
	Pegasus Airwave			High
	Pegasus Bi-wave			High
	Pegasus Overture			High
	Pegasus Proactive			High
	Transair 1001 (Karomed)	22 stone	Alt. pressure overlay	High
	Bi-wave Carer (Pegasus)	222kg / 35 stone	Alt. pressure overlay	High
	Auto X Cell (Huntleigh)	203kg / 32 stone	Alt. pressure overlay	High
	Harvest Supreme	152kg / 24 stone	Alt. pressure overlay	High
Band C	MSS Softform Premier (Purple)		Foam	At risk
	Alpha X Cell (Huntleigh)		Alt. pressure overlay	At risk
Band D	Transform (Karomed)		Foam	Low
	MSS Softform Original (Pink)		Foam	Low

Figure 3-60 The RUH guide to matching patients to an appropriate pressure relieving mattresses according to their risk assessment (Purser 2005)

The advantage gained by designing a device for a certain level of pressure ulcer risk, rather than for a particular patient group, is that the device has the flexibility to be used across a spectrum of patients be they young and fit such as a young person involved in a Road Traffic Accident (RTA), or elderly and infirm such as an elderly individual who has suffered a stroke, a Cerebrovascular Accident (CVA).

The logic used to categorise PR mattresses, based on at-risk levels, has been applied to PR cushions. Certain cushions are considered appropriate for each level of risk, with some cushion designs considered adequate for at-risk users with other designs being considered more suitable for very-high-risk users. As the main criterion for assessing the efficacy of a PR device is their ability to manage IP, see sections 3.4.1 and 3.4.2, a cushion's categorisation as an at-risk cushion or as a very high risk cushion is based predominantly on its ability to manage IP. Hence, the poorer IP reducing foam cushions are categorised as for at-risk patients whereas the better IP reducing dry-flotation cushions are for high to very high risk patients[12]. For example, the foam cushion the Nestor Contour Cushion, with a mean IP of 109.2mmHg (Swain *et al* 1997) was categorised by Cowen as a "*cushion for patients at low to medium risk of developing pressure sores*" (Cowen 1997); whereas the dry-flotation cushion the ROHO high profile, with a mean IP 93.4mmHg (Swain *et al* 1997), was categorised by Cowen as a "*cushion for patients at high to very high risk of developing pressure sores*" (Cowen 1997).

The PR cushion manufacturer Karomed produces a range of cushions designed to cater for the different levels of risk, see figure 3-61. The Transoft cushion is a fibre-filled cushion, the Flotair is a dry-floatation cushion and the Transair is an alternating pressure cushion (Cooper 1998). Generally foam, gel and fibre-filled cushions are designed for at-risk and medium risk patients with dry-floatation and alternating cushions for those at high and very-high risk, although there are some exceptions (Cowen 1997).

[12] How patients level of risk is assessed is explained in the following section, section 3.5.2

The Karomed range of pressure-relieving cushions	
Cushion	**Risk status**
Checkpad	At risk
Transoft	At risk
Transfoam	At risk to medium risk
Transflo	Medium to high risk
Flotair	High to very high risk
Transair	High to very high risk

Figure 3-61 The range of PR cushions produced by Karomed (Cooper 1998)

3.5.2 The Use of Risk Assessment Tools

The use of PR devices on the basis of risk assessments has some inherent difficulties.

Over the last forty years a multitude of risk assessment tools have been developed and implemented to suit different scenarios. For example, the Waterlow Score, was specifically developed, for acute care patients (Waterlow 1996) whilst the Norton Score was developed for elderly patients (Norton *et al* 1962 reprinted 1975). A summary of some of the more widely used Risk Assessment Tools has been compiled and can be seen in appendix D. It has been found that these risk assessment tools are not accomplished at predicting the development of an ulcer. Schoonhoven made a study of three of the most commonly used risk assessment tools, Braden, Norton and Waterlow, and concluded, "*Although risk assessment scales predict the occurrence of pressure ulcers to some extent, routine use of these scales leads to inefficient use of preventive measures*" (Shoonhoven *et al* 2002).

In addition, risk assessment tools use a scoring system to grade risk. This grading introduces "*cut-offs*" between risk grades, for example a Waterlow score of 19 grades a patient to be high-risk whilst a score of 20 would grade the patient at very-high-risk, see figure 3-62.

WATERLOW PRESSURE SORE PREVENTION/TREATMENT POLICY

RING SCORES IN TABLE, ADD TOTAL. SEVERAL SCORES PER CATEGORY CAN BE USED

BUILD/WEIGHT FOR HEIGHT	★
AVERAGE	0
ABOVE AVERAGE	1
OBESE	2
BELOW AVERAGE	3
CONTINENCE	★
COMPLETE/ CATHETERISED	0
OCCASION INCONT	1
CATH/INCONTINENT OF FAECES	2
DOUBLY INCONT	3

SKIN TYPE VISUAL RISK AREAS	★
HEALTHY	0
TISSUE PAPER	1
DRY	1
OEDEMATOUS	1
CLAMMY (TEMP↑)	1
DISCOLOURED	2
BROKEN/SPOT	3
MOBILITY	★
FULLY	0
RESTLESS/FIDGETY	1
APATHETIC	2
RESTRICTED	3
INERT/TRACTION	4
CHAIRBOUND	5

SEX AGE	★
MALE	1
FEMALE	2
14 - 49	1
50 - 64	2
65 - 74	3
75 - 80	4
81+	5
APPETITE	★
AVERAGE	0
POOR	1
N.G. TUBE/ FLUIDS ONLY	2
NBM/ANOREXIC	3

SPECIAL RISKS	★
TISSUE MALNUTRITION	★
e.g.: TERMINAL CACHEXIA	8
CARDIAC FAILURE	5
PERIPHERAL VASCULAR DISEASE	5
ANAEMIA	2
SMOKING	1
NEUROLOGICAL DEFICIT	★
eg: DIABETES, M.S, CVA, MOTOR/SENSORY PARAPLEGIA	4 - 6
MAJOR SURGERY/TRAUMA	★
ORTHOPAEDIC - BELOW WAIST,SPINAL	5
ON TABLE > 2 HOURS	5
MEDICATION	★
CYTOTOXICS, HIGH DOSE STEROIDS ANTI-INFLAMMATORY	4

SCORE	10+ AT RISK	15+ HIGH RISK	20+VERY HIGH RISK

Figure 3-62 Waterlow Risk Assessment Tool (Waterlow 1996)

These cut-offs have proven to be a weakness and NICE recommends that, "*assessment and allocation of devices should not be driven solely by artificial cut-off points on risk assessment scales that denote 'at risk' and 'very high risk'"* (Yerrell *et al* 2003 reprinted 2005). Further NICE find terms such as 'at-risk' and 'very high risk' to be so unhelpful that they specifically do not use them in their own guidelines,

> *The terms 'vulnerable to pressure ulcers' and 'at elevated risk of pressure ulcers' are used in this guideline rather than the terms 'at risk' and 'at very high risk'. The latter terms imply that there are reliable cut-off points for identifying risk, yet there is little evidence to show that using a pressure ulcer risk assessment tool is better than clinical judgment for assessing risk, or that allocation of pressure-relieving devices can be linked to risk assessment tools.*
>
> (Rycroft-Malone and McInnes 2003)

All risk assessment tools can do is provide a snap-shot of a patient's condition (Morrison 2001). As a snap-shot the score can only indicate the level of risk, based on the condition of the patient, at the time of the assessment. The condition of most patients is not static, their condition may improve or decline. This change in condition may alter the patient's propensity to developing pressure ulcers. As a patient's health declines, the risk of developing a pressure ulcer might increase and so more preventative PR devices may be required. Alternatively, as a patient's health improves, the risk of developing a pressure ulcer may well reduce and so pressure relieving measures may no longer be necessary. Consequently, the risk assessment process is dynamic with the patient requiring routine updating of their assessment, or re-assessment after a change in condition.

The frequency at which risk assessments should be performed will vary according to the clinical situation. In acute areas, some patients may have to be assessed daily, whereas in chronic areas, some patients may only require a weekly assessment and in the community, for some patients, an assessment every three months might be sufficient (Dealey 1997). According to the Royal United Hospital Bath (RUH) policy statement "*Pressure Ulcer Prevention and Management*" the interval between risk assessments is determined by the patient's pressure ulcer risk assessment score (Purser 2005).

RUH standards for pressure ulcer risk assessment:

- *within 2 hours of transfer to a ward area*
- *every 48 hours if Waterlow 20 or above*
- *every 72 hours if Waterlow 10 or above*
- *every week if Waterlow below 10.* (Purser 2005)

3.5.3 Design of PR Cushions for Patient Groups

The logic that patients considered to be at high-risk of developing a pressure ulcer will need a PR device designed for high-risk cases, has led to the practice of targeting both PR mattresses/overlays and PR cushions at the categories used by pressure ulcer risk assessment tools, at-risk, high risk etc. This simplistic characterisation does not appreciate the different roles PR mattresses/overlays and PR cushions play in the lives of their users.

The first difference is the need for PR devices to have the flexibility to manage a procession of very different patients. Whilst it is desirable for a PR mattress to be able to support a procession of different patients, RTA patients to CVA patients, this flexibility is less advantageous in PR cushions. In fact, in most cases once a cushion has been issued/purchased it will remain with its sole user for the whole of its working life and it will not be frequently re-issued amongst a range of different users.

There exists a significant price difference between beds and cushions. In the case of beds for very-high-risk patients the cost is in the region of £30,000. At such prices, it makes economic sense to provide less sophisticated, cheaper beds for patients at less risk of pressure ulceration. In the case of cushions the price difference between a cushion for a very-high-risk patent and a patient at *low-risk* is negligible compared to the tens of thousands of pound difference to be found in the price of beds. The potential money saved by catering for a range of risk is likely to be out weighed by the money that has to be spent by firstly having to produce and manage a range of different risk cushions and secondly the cost of treating the pressure ulcers that occur when the risk has been incorrectly assessed.

The purpose of PR mattresses/overlays is to prevent people who are immobilised and laid out in bed from developing pressure ulcers. These are static individuals in a fixed environment. With patients in this situation there is little variation in life style or range of functional ability. However, PR cushions are used by people with a wide variation in life styles and functional ability. Some are able to participate in work and physical leisure activities, such as sailing or horse riding, whereas others lead sedimentary life styles. The different life styles and activities of daily living experienced by wheelchair users place a broad and differing range of demands on PR cushions.

The targeting of PR devices at specific categories of pressure ulcer risk offers certain advantages for the design of PR mattresses/overlays. These advantages are less pronounced for PR cushions. Further, for the design of PR cushions there are certain shortcomings with this approach.

It is possible that PR cushion design would benefit from moving away from the practice of designing cushions for categories of risk and adopt the approach of designing specific cushions for the different user groups within the wheelchair using population.

3.6 Sitting Position and PR Cushions

Sitting is a dynamic activity whereby many different postures are assumed according to comfort, stability, disability and the activities being performed. The sitting positions taken can have ramifications on the daily activities and the well being of the seated individual, see table 3-1.

Table 3-1. A list of complications arising from poor posture (Mayall and Desharnais 1995)

Some complications arising from poor posture:	
Contractures and deformities	Infection, urinary tract infection
Tissue breakdown	Respiratory insufficiency
Masked ability	Fatigue
Reduced performance and tolerance	Discomfort

3.6.1 Anatomy of Seating

The pelvic bones form the intermediary between the spinal column and the lower extremities and as such play a critical role in the transfer of load from the trunk to the legs. However the shape of the pelvis is awkward for sitting on. The ischial tuberosities are relatively small, rounded and in the seated person are located around four centimetres below the femoral heads, see figure 3-63.

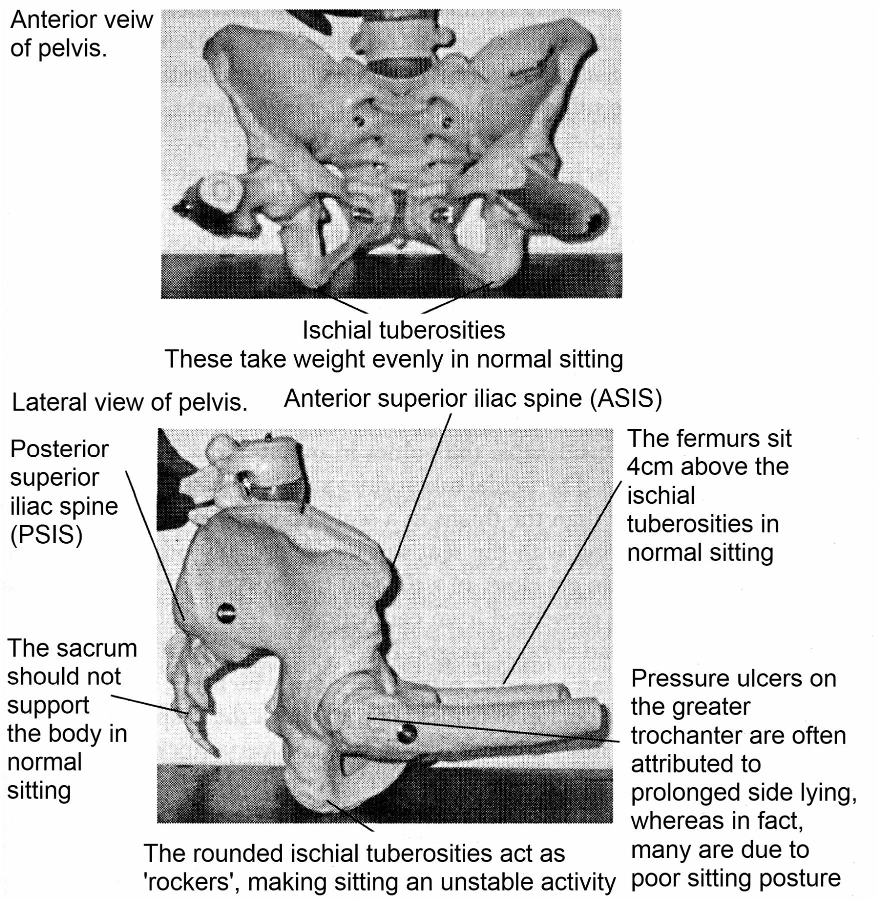


Figure 3-63 Front and side views of the pelvis (Hampton and Collins 2004)

In what is described as “*normal sitting*” or “*correct seating*”, the joints of the lower limbs are in the mid range of movement and the upper body weight should be evenly balanced between the ischial tuberosities. The pelvis should be in a slight anterior tilt so that neither the pubis or the sacrum supports any of the body weight. In this position the pelvis will allow the hip joint to rest at 90° flexion, the knees should be flexed to 90° and the feet placed flat on the floor, or footplate. In this optimum position the pelvis will enable the spine to retain its normal anterior and posterior curves and the head will sit in a neutral alignment over the pelvis (Collins 1999a).

Some individuals may not be able to achieve a normal sitting position due to a disability, for instance a curvature of the spine such as scoliosis forces an oblique rotation of the pelvis, “*pelvic obliquity”*, see 3-64.

Equally, a poor supporting cushion may result in pelvic obliquity causing scoliosis (Spinal Outreach Team 2007). Pelvic obliquity is one of the positional rotations achievable with the pelvis, see figure 3-65.

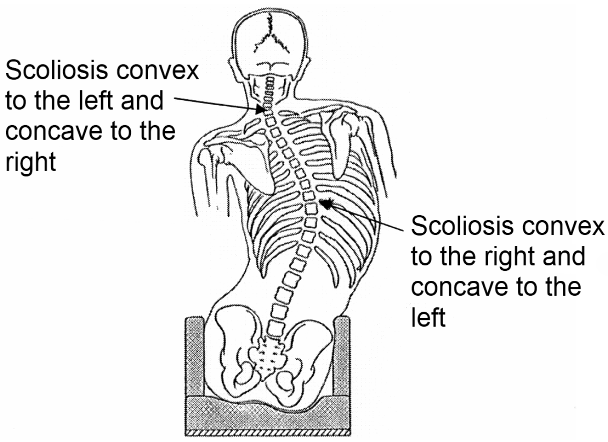
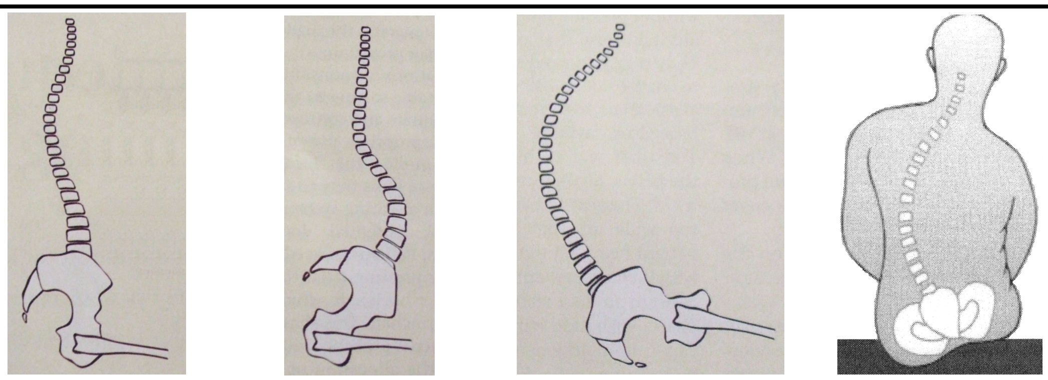


Figure 3-64 Pelvic obliquity and scoliosis (Spinal Outreach Team 2007)



Normal sitting position*	Anterior pelvic tilt and lordosis*	Posterior pelvic tilt and kyphosis*	Pelvic obliquity and scoliosis#

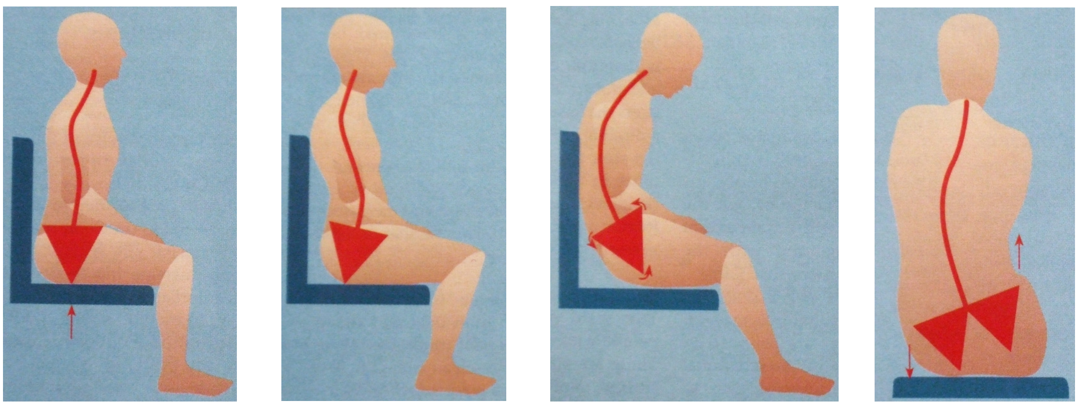
* Image taken from Collins (2001a), # Image taken from Hampton and Collins (2004)

Figure 3-65 Rotation of the pelvis and the curvature of the spine

Of these pelvic rotations the anterior pelvic tilt, see figure 3-66 tends to be more associated with physical condition rather than seating provision. Anterior pelvic tilt is commonly seen in people with muscular dystrophy or spina-bifida. Both posterior pelvic tilt and pelvic obliquity can be the result of a person's physical condition but they are also the two most common postural problems to occur as a result of sitting for long periods of time (Collins 2001c).

Posterior pelvic tilt is associated with gravity and the seated person sliding down the chair, see figure 3-66. This sliding may be the result of the person being seated on a chair that is too high. In this case the person slides forward until the feet can reach the floor. The sliding may be the result of the backrest being too low and not providing sufficient support (Collins 2001c). This sliding may also occur due to the cushion not providing sufficient support. When posterior pelvic tilt, also referred to as "*sacral sitting*" (Collins 1999b), occurs the ischials point forward not downwards increasing shear and friction. Also, the weight of the person now rests on the sacrum and coccyx which further increases this risk of the person developing a sacral pressure ulcer.

Pelvic obliquity is associated with leaning laterally to one side, see figure 3-66. This leaning may be the result of the person being seated in a chair that is too wide or when a person with poor trunk stability uses an arm rests. This leaning may occur due to the seat sagging or the cushion not providing sufficient support (Collins 1999b). When pelvic obliquity occurs, the balance of the person's weight is shifted onto just one of the ischials. A pronounced obliquity can also put weight onto the greater trochanter. The rotated pelvis increases the shear and friction around the ischial, which coupled with the increase in IP, increases the risk of developing a pressure ulcer (Collins 2001c).

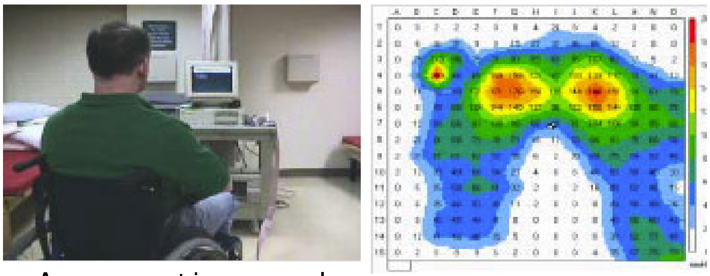


Normal sitting position | Anterior pelvic tilt | Posterior pelvic tilt | Pelvic obliquity

Figure 3-66 Sitting positions (Collins 1999b)

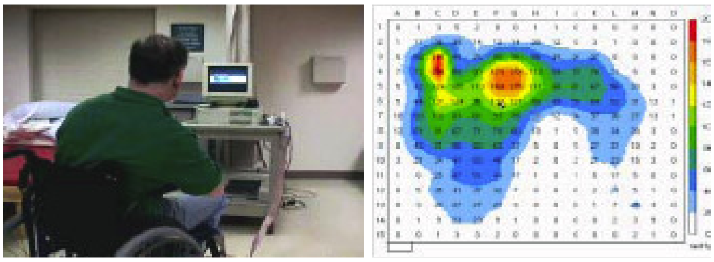
3.6.2 Sitting Position and Interface Pressure

A seated individual will alter their sitting position over the day whilst carrying out normal day-to-day activities such as leaning forward to reach an item on a table, or leaning backwards to relax. These movements cause the pelvis to rotate relocating the load bearing points, see figure 3-67.



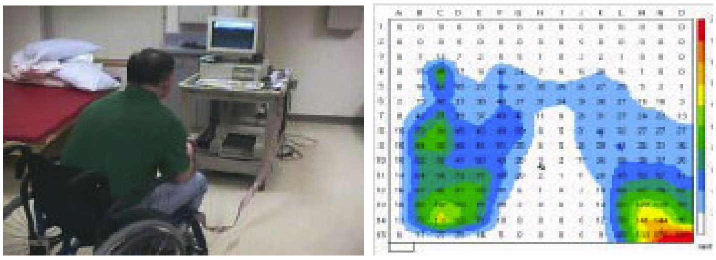
A person sat in a normal sitting position

Body weight balanced over both ischials, with neither the pubis or the sacrum supporting any of the body weight. Centre of gravity (CoG) on the mid line and over the ischials



A person leaning to the right (pelvic obliquity)

Majority of body weight over right ischial. CoG moved over right ischial



A person leaning forward

Right side Left side

Majority of body weight over thighs. CoG well forward of pelvis and slightly to the left of the mid line

Figure 3-67 Various sitting positions with different IP distribution. Images taken from Hobson (1999)

Different sitting positions locate the body's Centre of Gravity (CoG) over different portions of the body. This has implications for IP. For example, sitting with a lean to the right shifts the CoG over to the right. With the CoG now over the right ischial the balance of IP is shifted over to the right, with the right ischial under greater IP than the left. How this movement of CoG translates into IP is very much dependent on the support surface sat upon at the time. Koo's often cited comparative study between two cushions, explored the effect of sitting positions on IP (Koo *et al* 1996). Koo compared a

ROHO high profile cushion (Roho) with a polyurethane foam cushion manufactured by the Severn Seas Chemical Ltd (Foam), the use of a base board was specified and the IP was measured using an Oxford pressure monitor. The subjects were six paraplegic men, see figures 3-68 and 3-69.

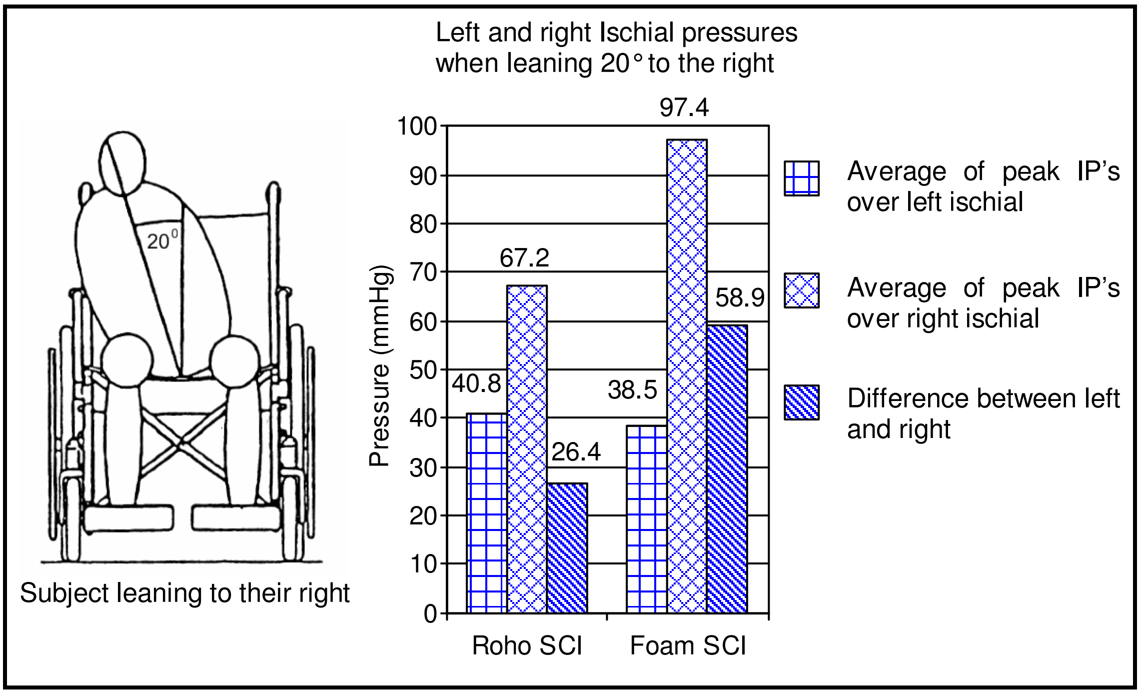


Figure 3-68 The IP found when subjects leaned 20° to the right (Koo *et al* 1996)

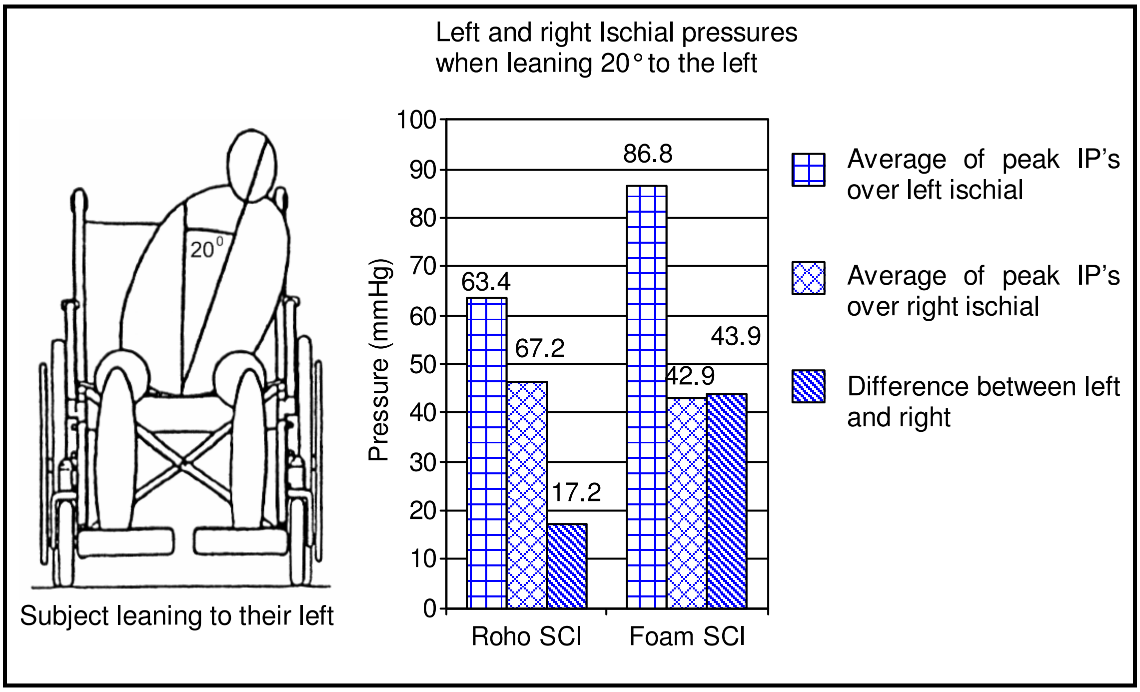


Figure 3-69 The IP found when subjects leaned 20° to the left (Koo *et al* 1996)

Koo found that the mean pressure difference between the left and right ischials recorded on the (Foam) cushion was more prominent than on the (Roho). Having found that this difference was statistically significant Koo concluded that, "*Roho cushion is more capable of minimizing the pressure difference between left and right ischial tuberosities when subjects bend laterally.*" Koo did note that there was a difference of 22% when comparing the two cushions when leaning left (86.8mmHg compared to 63.4mmHg) but did not mention the 31% difference when leaning right (97.4mmHg compared to 67.2mmHg). Koo made no conclusions about the cushion's ability to minimise IP when bending laterally or the significance of the prominent difference between the IP's found between the cushions other than to say "*Results also suggested that the pressure distribution between the left and right ischial tuberosities on the PU foam cushion is more sensitive to lateral pelvic tilt as compared with the Roho cushion.*"

Further, Koo made no conclusions about the difference found between leaning left and leaning right (97.4mmHg compared to 86.8mmHg for the (Foam) a difference of 11%; 67.2mmHg compared to 63.4mmHg for the (Roho), a difference of 6%).

Koo's study also recorded the angle of pelvic tilt of the test subjects when leaning 20° laterally. The mean pelvic tilt when leaning right on the (Roho) was 19.7° and 14.2° on the (Foam). When leaning to the left on the (Roho) it was 16.2° and 13.6° on the (Foam). Koo attributed this difference to the stability of the cushion where the free flowing air of the air-filled (Roho) is more unstable than the more solid foam (Koo *et al* 1996). Koo drew no conclusion between the disparity between pelvic tilt and IP. The subjects experienced greater pelvic tilt but less IP when leaning on the (Roho) than when leaning on the (Foam) cushion. The greater pelvic tilt will set up greater internal stresses, *shear*, around the ischial. As such when sat on the (Roho), although the IP at the surface acting on the ischial will be less than the (Foam), the internal stresses will be higher than on the (Foam). From the data it can be suggested that when leaning laterally, the (Foam) cushion is better at minimising internal stress, and therefore is better at protecting against pressure damage, than the (Roho) even though the IP reducing capacity of the (Roho) is greater than the (Foam).

Koo's study did not report a mean IP under the left and right ischials when sat in a normal sitting position. This meant that it is not possible to determine how leaning, and leaning on an armrest, effects IP relative to the IP experienced when sitting in a normal upright sitting position, with and without armrests.

Swain (1997) studied the effect of posture and wheelchair adjustment on IP when using a 7.6cm foam (grade CMF 55) cushion. Swain recorded the mean IP's under the ischials when sat normally, "*Upright*" and when leaning. Swain found that leaning to the right altered the balance of IP distribution, increasing the IP on the right relative to the left by 26% compared to Koo's finding of a 31% difference. As Swain had also recorded the IP when sitting in a normal position, 'upright', it is possible to notice that leaning on an armrest, although still altering the balance of IP between the ischials, does reduce the IP acting on both the ischials, see figure 3-70. Swain made no conclusions about this finding.

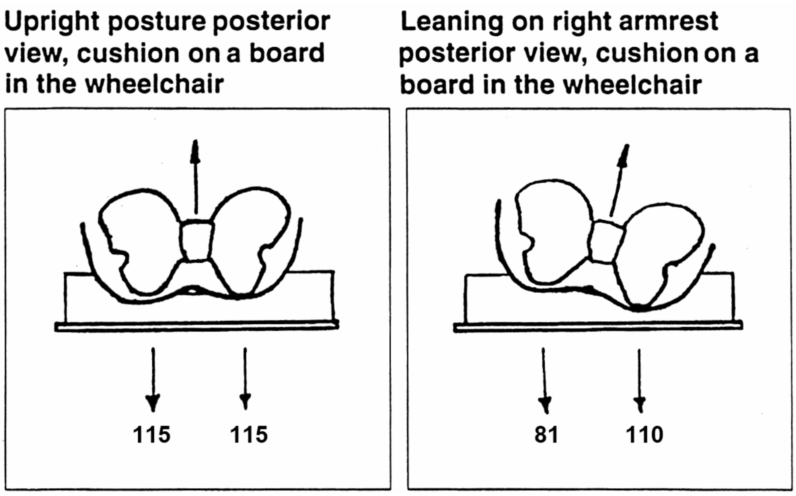


Figure 3-70 IP's acting on ischials when upright and when leaning to the right. Pressures shown are in mmHg (Swain and Peters 1997)

Swain's study examined the effect of leaning when the cushion was placed on a base board, a feature of Koo's study. Swain also examined leaning when the base board was removed and the cushion was placed on the sagging canvas seat of the wheelchair. Paradoxically he found that the IP on the opposite side to the lean was now greater, see figure 3-71. Swain concluded that the canvas allowed the pelvis to swing sideways towards the lean pulling the canvas taught on the opposite side. This pulling tight of the canvas pressed upwards against the ischial opposite the lean and so increased the IP (Swain and Peters 1997).

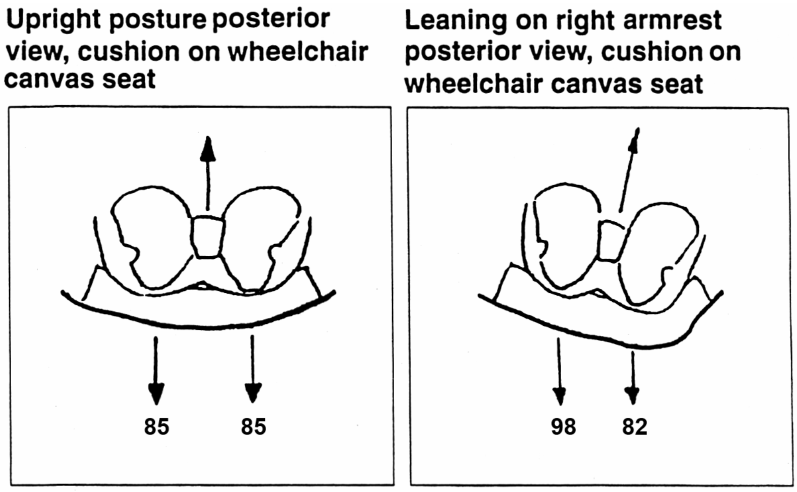


Figure 3-71 Subject sat on cushion not supported by a base board. Pressures shown are in mmHg (Swain and Peters 1997)

3.6.3 Stability and Interface Pressure

Changing the sitting position shifts the body's centre of gravity. This in turn alters the IP distribution pattern and affects a seated person's stability. The stability a seated person experiences, along with the IP, is influenced by the support surface being sat upon.

Aissaoui (2001) studied the effect of the cushion on the dynamic stability of wheelchair users with paraplegia during a reaching task. Assaoui set up two switches one slightly to the right of the seated person and the other set away at 45° from the shoulder and at 130% of the subject's arm length. This arrangement forced the subject to reach out and to the right. Positioned under the subject was a Force Sensing Array (FSA) mat to record the subjects changing IP distribution whilst reaching, see figure 3-72. Aissaoui then used nine subjects to test three different types of cushion, a 7.6cm polyurethane HR45 generic contoured foam (**ISCUS**), an air filled cushion (**ROHO**), and a 5.1cm polyurethane HR35 flat foam cushion (**FF**)

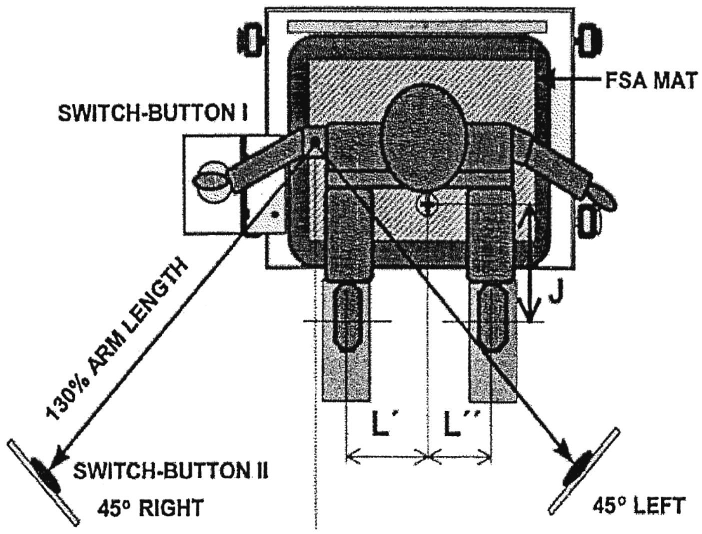


Figure 3-72 Reaching test rig (Assaoui *et al* 2001)

Using the IP data from the FSA mat the location of the Centre of Pressure (CoP) was located. As the subject reached out to touch "*switch-button II"* and returned to a normal sitting position the trajectory of the CoP was tracked. The CoP tracks the CoG, so by recording the CoP trajectories, produced by the three different cushions, it was possible to compare how each cushion influenced the movement of persons CoG relative to a set task, in this case reaching out to touch "*switch-button II*", see figure 3-73. The horizontal distance between the CoG and the CoP should always be minimised to ensure stability.

AP = Anteroposterior direction (forward)

ML = Mediolateral direction (sidways)

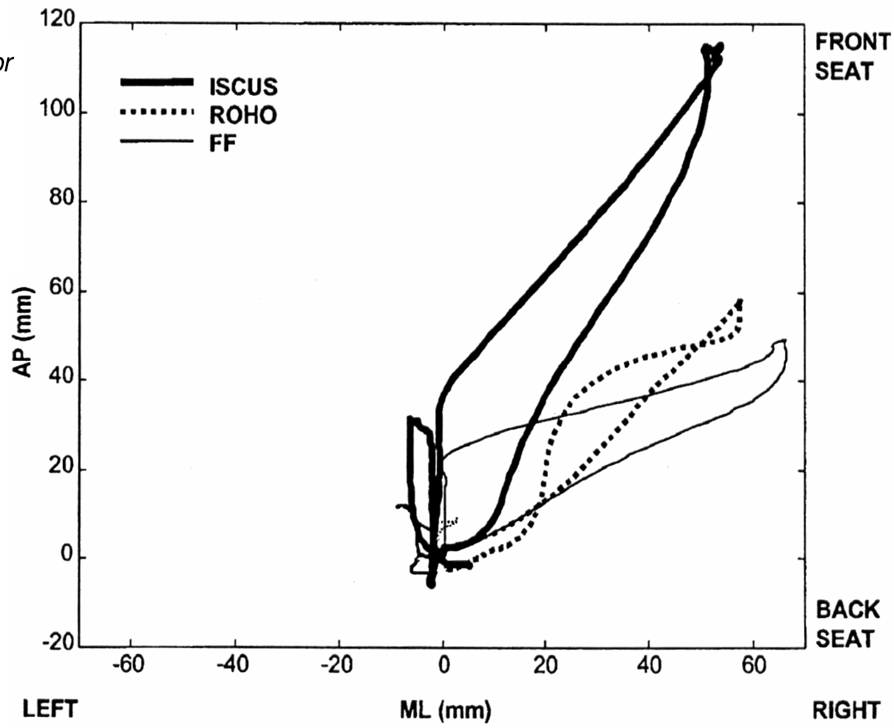


Figure 3-73 The CoP trajectories of three cushions. Note the hysteresis of the trajectories (Assaoui *et al* 2001)

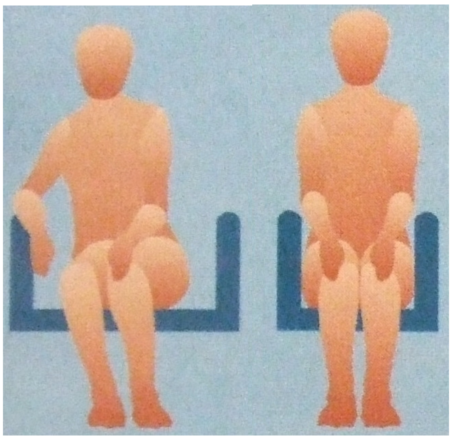
Aissaoui found that the CoP trajectory of the contoured foam cushion (ISCUS) approximately followed the 45° direction of reaching movement keeping the horizontal distance between CoG and CoP to a minimum. The CoP trajectories of the flat foam (FF) and the air celled ROHO followed approximately a 30° path. This discrepancy between the direction of reaching movement and CoP will have increased the horizontal distance between CoG and CoP reducing stability. Aissaoui suggested that the ISCUS cushion seems more stable because the concave shape of the contour lowered the seated persons CoG. Further, Aissaoui suggested that fluid-filled cushions such as air and gel are more unstable than foam because they tend to transmit the energy of dynamic loading to the body via the gluteal muscles for dissipation whereas foam absorbs energy on impact. This explanation does not correlate to how the FF cushion performed relative to the ROHO.

Additionally, by recording the CoP trajectories a hysteresis envelop between the forward and backward reaching movement was found (Aissaoui *et al* 2001). Aissaoui does not give an explanation for this effect or it significance.

The difference in the shape of the hysteresis envelops produced by cushions is significant as it characterises the stability of a cushion. A completely stable surface would result in a thin envelop being plotted, which in this case would follow the 45° path made by the user as they reach for *switch-button II*. This thin 45° centred envelop would show that the user has been able to reach directly towards the *switch-button II* and that the backward return movement closely matches the forward reach movement. Cushions with less stable surfaces will cause the user to sway as they reach forward and sway again as the make the backwards return movement. The more unstable the cushion the more the user will sway when reaching, which in turn will result in a larger hysteresis envelop being plotted. Also, cushions with less stable surfaces can result in a pronounced sway which deviates the user from their desired path. In this case whilst the forward reach movements of the test subjects sat on an ISCUS cushion was close to the desired 45° path, the forward reach movements of the test subjects sat on the ROHO and FF cushions were closer to 30° than the desired 45° path. Therefore the ISCUS cushion was more stable than the ROHO or FF cushions.

3.6.4 Seating Adjustment and Interface Pressure

The maladjustment of a person's seating can distort the sitting position and in so doing alter the IP distribution pattern which can increase the seated person's risk of developing a pressure ulcer (Collins 1999b).

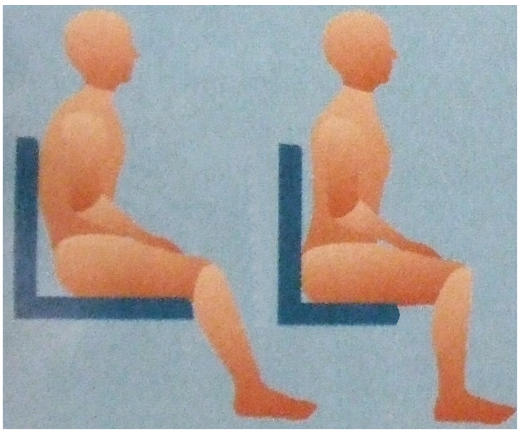


Seat too wide Seat too narrow

Figure 3-74 Seating with incorrect width (Collins 1999b)

A seat that is too wide will result in the user leaning to one side causing pelvic obliquity. This will increase the IP over the ischial being leaned on. A pronounced lean will also place IP onto the greater trochanter being leaned on.

A seat that is too narrow will subject the greater trochanters and the sides of the thighs to IP, see figure 3-74.

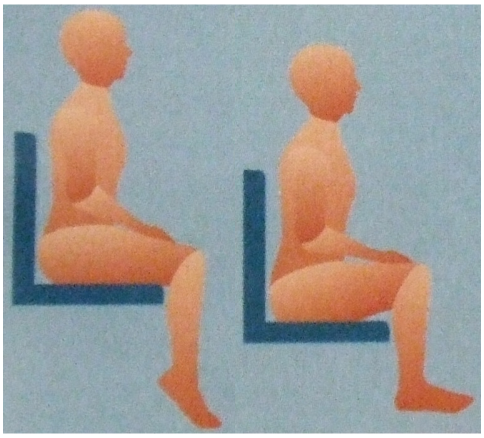


Seat too long Seat too short

Figure 3-75 Seating with incorrect depth (Collins 1999b)

A seat that is too long will result in the user having to slide forward causing posterior pelvic tilt. This will subject the sacrum to IP. Additionally this will increase the pressure behind the knee, potentially causing pressure ulcers in the popliteal fossa. Also, this increase in pressure can inhibit blood flow causing ischemia in the lower leg and damage the popliteal nerve.

A seat that is too short will not support the whole length of the leg. This reduction in load bearing area increases the IP on the remaining area supporting the user. Additionally the loss of contact area will reduce the user's stability, see figure 3-75.



Seat too high Seat too low

Figure 3-76 Seating with incorrect height (Collins 1999b)

A seat that is too high will result in the user having to slide forward causing posterior pelvic tilt. This will subject the sacrum to IP. If the chair is too high for the feet to reach the floor the body's surface area in contact with the cushion will have to carry the additional weight of the lower legs. This additional weight increases the IP. Also the user's stability will be decreased.

A seat that is too low will push the knees higher than the hips. This lifts the thighs off the cushion and slightly tilts the pelvis causing some posterior pelvic tilt. This will subject the sacrum to IP. This IP will be even greater as the thighs will not be supporting any of the body's weight, see figure 3-76.

When setting the height for a user the adjustment should ensure that the area behind the knees, the popliteal area, is not in contact with the front of the seat (Openshaw and Taylor 2006). Where it is not possible to adjust the seat height to its optimum height, close to the popliteal height see figure 3-77, it is preferable to adjust the seat height so that it is slightly lower than optimal rather than a height which is higher than optimal (Pheasant 1999).

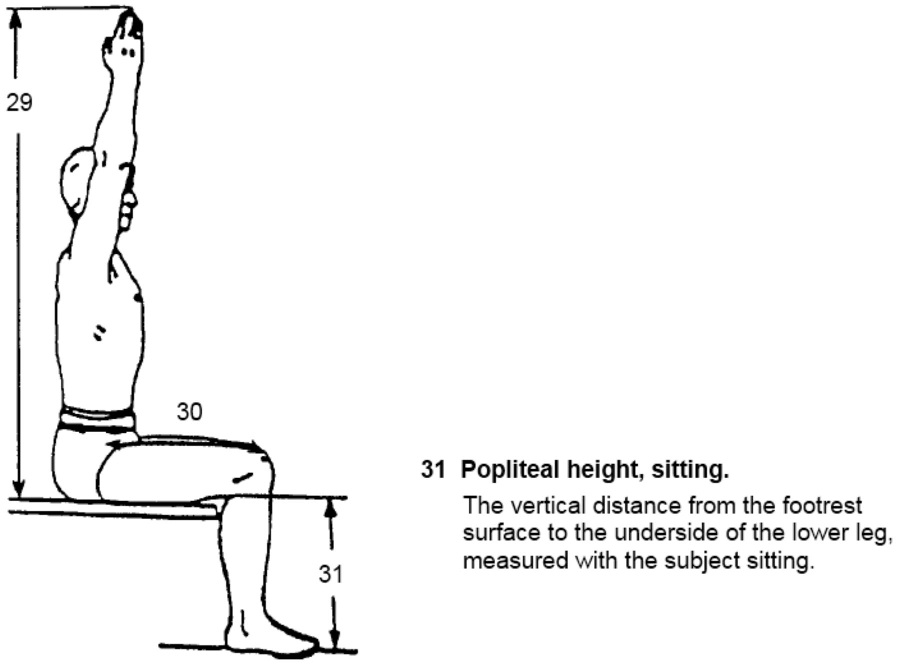


Figure 3-77 A diagram showing the optimum seat height. Note the separation between the popliteal area and the front of the seat (FAA 1996)

The relative height of the sitting position, when sat in a wheelchair, can be altered by the adjustment of the wheelchair's footplate. Similarly to a chair set too low, a footplate set too high raises the knees so that they are above the level of the hips lifting the thighs off the front of the cushion, see figure 3-78. Similarly to a chair set too high, a footplate set too low forces the user to slide down to reach the footplate, see figure 3-79.

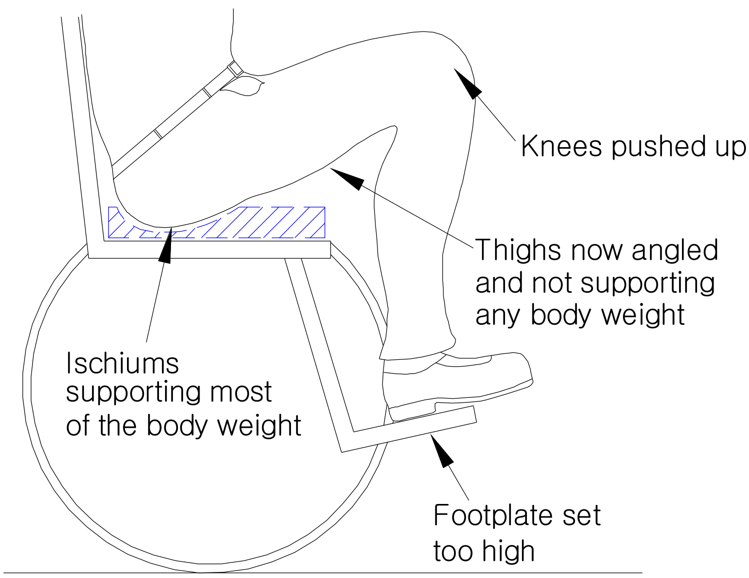


Figure 3-78 Footplate set too high which pushes knees up

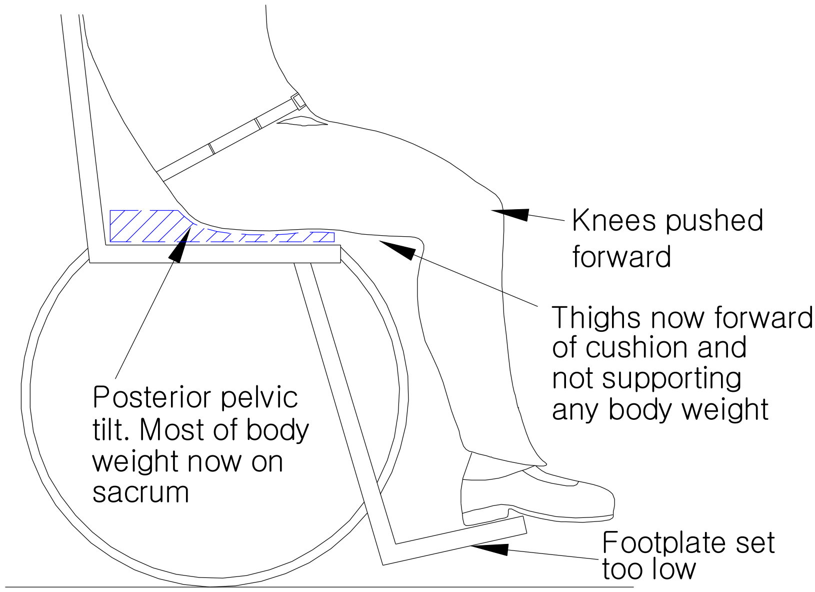


Figure 3-79 Footplate set too low which pushes knees forward

The extent of the increase in interface pressure on the ischial tuberosities, resulting from raising the footplate, is significant. Boumans stated that, "*Proper adjusted footrests can take up to 12% of the weight of the body off the buttocks*" (Boumans 2005). Conversely, an incorrectly adjusted footrest can multiply the affect of the body weight. As Swain found, "*raising the footplate can increase the ischial interface pressure by as much as 100%, compared to when they are as low as possible but still supporting the feet*" (Swain and Peters 1997). This increase in interface pressure is sufficient to negate any advantage using a specialist pressure relief cushion may have over a standard cushion, "*Thus, using a cushion from the group that gave the lowest interface pressures can potentially give pressures higher than the standard cushion if the wheelchair is not correctly adjusted for the user*" (Swain *et al* 1997).

3.7 Usability Considerations for PR Cushions

The multi-factorial aetiology of pressure ulcers is well known and understood by health care practitioners and is discussed in the literature. It has been found that designers/manufacturers tend to focus primarily on just the one issue interface pressure (IP), see section 3.4.1, with the efficacy of cushions being primarily assessed by means of IP mapping, see sections 3.4.2 and 5.3. For as long as this remains the case, the design/manufacturing community will continue to prioritise the reduction and management of IP and not fully appreciate the significance of the usability of the cushion. For a cushion to provide a level of usability sufficient to support independent living, it will have to not just manage IP but it will have to address all the challenges to be found in daily life.

It is already appreciated by healthcare practitioners that there are a number of regularly performed activities which form the basis of independent living, commonly referred to as the Activities of Daily Living (ADL). ADL has been defined as, "*the things we normally do in daily living including any daily activity we perform for self-care (such as feeding ourselves, bathing, dressing, grooming), work, homemaking, and leisure*" (Webster's New World Medical Dictionary 2003). Models based upon the activities of living have been produced and are often used to assess the independence of patients with disabilities. A widely used scale for assessing severely disabled patients is the Barthel's index of activities of daily living (BAI), which is a ten point index with categories such as 'Mobility' and 'Feeding' (Wade and Collin 1988). Also in common use is the Roper-Logan-Tierney Model of Nursing. This model defines "*what living means"* into twelve categories such as 'Communication' and 'Breathing' (Roper *et al* 2000). As well as these two commonly used methods for measuring the functional status of a patient, there are other ADL assessment tools such as the Katz ADL *scale* and the Lawton IADL *scale*. The Katz ADL scale considers the '*Basic ADL's*' to be,

- *bathing*
- *continence*
- *dressing*
- *feeding*
- *toileting*
- *transferring.*

(Katz *et al* 1970)

The Lawton IADL scale considers the 'Instrumental ADL's'. These are the instrumental activities which are not necessary for fundamental functioning but enable an individual to live independently in the community,

- *ability to handle finances*
- *ability to use telephone*
- *food preparation*
- *housekeeping*
- *laundry*
- *mode of transportation*
- *responsibility for own medications*
- *shopping.*

(Lawton and Brody 1969)

Not all of a SCI patient's ADLs will place demands on a PR cushion; 'breathing' and 'feeding' are not likely to make demands of a cushion but certainly 'transferring' will. How these ADL demands on a cushion are addressed can make a user's life either easier or harder. For example the ADL of 'food preparation' can be made either easier or harder depending on the design of the food preparation equipment used such as the design of a food processor. How easy a cushion is to use is therefore an important consideration in its design. The ease with which a product can be used is regarded as its "*usability*". Usability is a an important consideration as it is concerned with the extent to which a user of a product, in this case a PR cushion, is able to work with the product effectively, efficiently and with satisfaction. The International Organisation for Standardisation (ISO) defines usability as, "[the] *extent to which a product can be specified by users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use*" (ISO 1998).

A number of design features related to a cushion's usability are already known. The following is a summary of known usability goals, such as cleaning and transferring. These goals have been listed alphabetically and not by significance, see below.

Age Deterioration:

Cushions deteriorate with age. Age and wear weakens a cushion's resilience. This loss of resilience may not be obvious to a visual inspection, with the cushion retaining its original thickness when unloaded, yet it is easily compressed leading to bottoming out events. The loss of resilience can be a gradual process which can pass unnoticed until the performance has faded to a point where the skin starts to mark or even be subject to pressure damage (Swain *et al* 1997).

Bottoming out:

A "*bottoming out"* event occurs when the downward compressing force, produced by the weight of the body, overcomes the cushion's ability to resist compression and so is squashed flat. The user comes to rest on the hard base surface located under the support surface (Jay 1995), see figure 3-80.

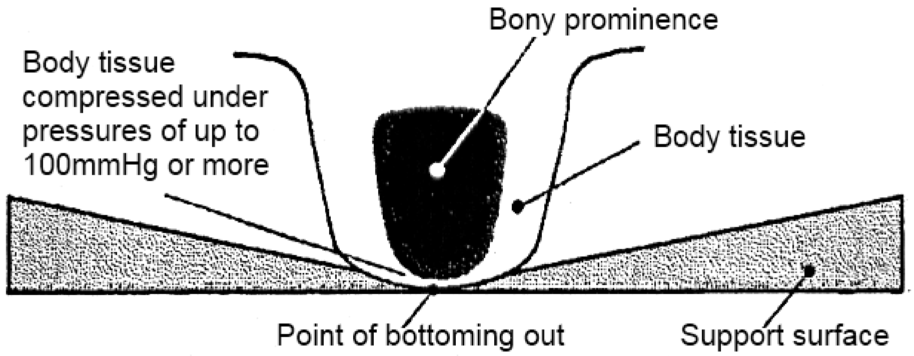


Figure 3-80 A diagram showing a support surface "*bottoming out*" (Jay 1995)

Cleaning:

Hygiene is very important in maintaining tissue integrity with hygiene being cited as an exacerbating factor in pressure ulcer development, see section 4.4.4. As all support surfaces are in close contact with the user it is vital that their cleanliness is maintained. All of the owner's instruction manuals reviewed, such as the ROHO (ROHO 2001) and the Jay (Sunrise Medical 1998), contained a section devoted to the cleaning of their cushion. Some cushions are easier to clean than others. The Jay for example requires little more than to be wiped clean with warm water whereas the ROHO requires each air cell and the spaces in between to be gently scrubbed.

Comfort:

Many wheelchair users tend to spend the majority of their day in their wheelchair. Estimates of the length of time a typical wheelchair user spends in their wheelchair vary from three to ten hours a day (Mayall and Desharnais 1995) to twelve to eighteen hours a day (WIliams 1997). Anyone spending these lengths of time sat on a cushion need to find their cushion comfortable. As such, comfort is a very high priority for cushion design as an uncomfortable design will be rejected by the user. "*The comfort provided by the sitting surface, is of prime importance. If a patient finds the seat* *unacceptable, he or she will not use it, even if it has been prescribed with the utmost diligence*" (Collins 1999a).

Comfort is related to the users sitting position. Any sitting position, including the "*normal sitting position*", if held for long enough will become uncomfortable as the points of the body under stress become fatigued, for instance the neck and shoulders. Cushion design should be able to manage the various sitting positions safely to allow the user to adopt different sitting positions as each position in turn becomes uncomfortable.

Cost:

Cushions vary widely in price. Cushions for the lowest level of pressure ulcer risk, typically a specialist foam, tend to be the cheapest with the cushions for the highest risk, typically a dry-floatation or alternating pressure (AP) cushion, being the most expensive. Of the cushions for the highest risk there is a marked difference in price between dry-floatation cushions and AP cushions with dry-floatation cushions priced around £500 whereas the AP cushions cost in the region of $3 - 4,000, see section 2.3.

It has been recognised that expensive cushions may be cost effective if they prevent pressure ulcers from developing and the user being admitted to hospital (DLF 2006).

Cushion Orientation:

Some cushion designs, such as a linear "*slab*" foam cushion, have no features which define a front edge or a top. Such cushions can therefore be placed on the wheelchair in any orientation. Many other designs do have features which impose a front edge and a top, in particular cushions with contouring. It has been known for individuals unfamiliar with contour cushions to inadvertently position such cushions incorrectly, for instance with the front edge of the cushion placed against the back of the wheelchair (Conine *et al* 1993). Incorrectly positioned cushions can lead to skin damage. The Salisbury NHS Foundation Trust, advice on the use of the Jay 2 cushion includes orientation stating, "*Placing the foam base, gel pad or the complete assembled cushion the wrong way round can cause significant skin damage*" (Fiddy 2008).

Durability/Reliability/Maintenance:

Wheelchair users spend much of their time sat on their cushion, see *Comfort* above. During this time the cushion has to perform, as failure to perform places the user at risk of pressure damage.

The multitude of designs leads to cushions with different life expectancies and vulnerabilities. For example, the Flo-tech cushion has a life expectancy of 18-24 months and is vulnerable to the foam slowly losing its resilience, whereas the ROHO has a life expectancy of up to ten years but is vulnerable to punctures at any time.

Fire Retardancy:

Cushions should not readily combust and emit toxic fumes as this may cause injury to the user and people in their vicinity.

Recent experience has indicated that enhancements, to meet fire retardancy standards, by the addition or variation of chemical constituents have occurred at the expense of comfort, pressure redistribution and durability characteristics. It has been recognised that as cushions manage tissue integrity they are medical devices and therefore their characteristics should be aligned with the medical needs of the user rather than the requirements for other applications, notably furniture fire retardancy specifications. The latest advice to manufacturers from the *International Organisation for Standardisation* (*ISO 16840-2: Wheelchair seating – Part 2: Determination of physical and mechanical characteristics of devices intended to manage tissue integrity – Seat cushions*) is to consider the balance of risk of tissue damage against risk of injury to the user from fire, and that fire resistant characteristics may be compromised to achieve the required performance to prevent pressure ulcers (ISO 2007).

Foreign Objects:

High peaks of IP result from prominences acting on the skin at the support surface interface. Normally, the prominences present are the bony prominences internal to the user. However it is possible for foreign objects to be unintentionally present between the support surface and the user. These objects act as prominences resulting in peaks of IP with the potential to cause pressure damage. Such objects include coins, the rivets on jeans and the seams on clothing (Dunne 2004). Prominent seams can be found on some seats as a decorative feature of the upholstery, for instance some seat designs used by Jaguar cars. Also, incontinence pads on top of a cushion can compromise its ability to distribute pressure (Ratcliffe and Rose 2000).

Hammocking:

Hammocking occurs when the surface material lacks the elasticity to stretch to conform to the user shape. A "*hammocking"* surface suspends the user over the cushion, preventing the user from benefiting from the immersion characteristics of the cushion, see figure 3-81.

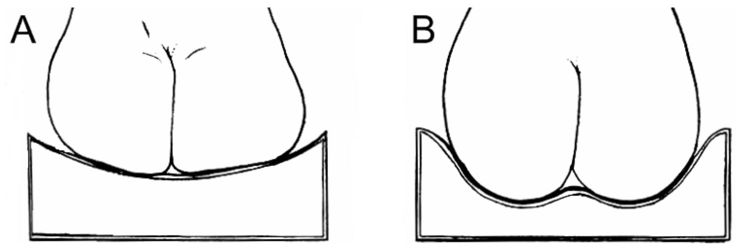


Figure 3-81 In case **A** the user is sat on an inelastic surface which "*hammocks*" the buttocks distorting the tissue. In case **B** the user is sat on an elastic surface which stretches to conform to the shape of the buttocks causing minimal distortion (Torrance 1983)

The manufacturers of cushions provide covers which have been designed for use with their cushion. These are typically made from a two way stretch material and conform well to users, see section 3.3. These covers present a low risk of hammocking their user. The potential for hammocking occurs when a material is used to cover a cushion other than a specifically designed cushion cover, for example a pillowcase, bed sheet or blanket.

Heat:

The temperature of the skin is important in maintaining tissue integrity with increased skin temperature being cited as an exacerbating factor in pressure ulcer development, see section 4.4.4. As all support surfaces are in intimate contact with the user, how they manage heat is important. It is known that foams and gels are heat insulators and do not dissipate heat well whereas air has a lower thermal mass, also known as thermal capacitance, and dissipates heat more effectively (Sunrise Medical 2008b).

Impact Damping (Shock/Vibration absorption):

Wheelchair users carrying out day-to-day activities often cover a variety of terrains from carpets to cobbles. During manual wheelchair propulsion (MWP) surfaces with bumps, curbs, trips and cracks cause shocks and vibrations, which are in turn transmitted through the wheelchair and the cushion to shake the user. It is important to minimise these shocks and vibrations as high impact shocks and frequent shocks may lead to pain and injury to the back and pelvis. Also shocks and vibrations can induce fatigue (Fitzgerald *et al* 2001).

The design of the cushion influences the extent to which these shocks and vibrations are transmitted to the user. The capacity to absorb the energy of a shock and so minimise the energy transferred to the user is referred to as "*impact damping".*

There is a British Standards test in BS ISO 16840-2 designed to assess the impact damping characteristics of a wheelchair cushion (ISO 2007). An apparatus, referred to as an Impact Damping Rigid Contoured Loading Indenter (IDRCLI) is placed on the cushion being tested which is in turn placed on an impact damping rig. This rig allows the cushion to free-fall a fixed distance. The impact experienced by the IDRCLI when the cushion suddenly stops at the end of the free-fall is measured by an accelerometer contained within the IDRCLI. The signal from the accelerometer enables the acceleration and deceleration of the IDRCLI to be plotted against time. By looking at this sinusoidal acceleration profile, as the IDRCLI rebounds, it is possible to measure the force of the peak impact and the peaks of the succeeding rebounds.

British Standards provide a typical result, see figure 3-82. At point (**a**) the holding block is removed and the cushion/IDRCLI free-falls within the impact rig. At point (**g**) the IDRCLI has reached the maximum indentation into the cushion and it is subject to its peak acceleration of -1.5g, where the minus indicates the force acting in an upward direction. It is therefore about to start its return rebound. At point (**b**) the indenter has reached the maximum height of the first rebound out of the cushion and it is subject to a peak acceleration of +0.4g, where the plus indicates the force acting in a downwards direction. It is therefore about to start its fall back into the cushion.

As the only force acting in this test system is gravity, the force acting on the cushion/IDRCLI is 1g. This should not be confused with how acceleration has been defined using g on the Y axis.

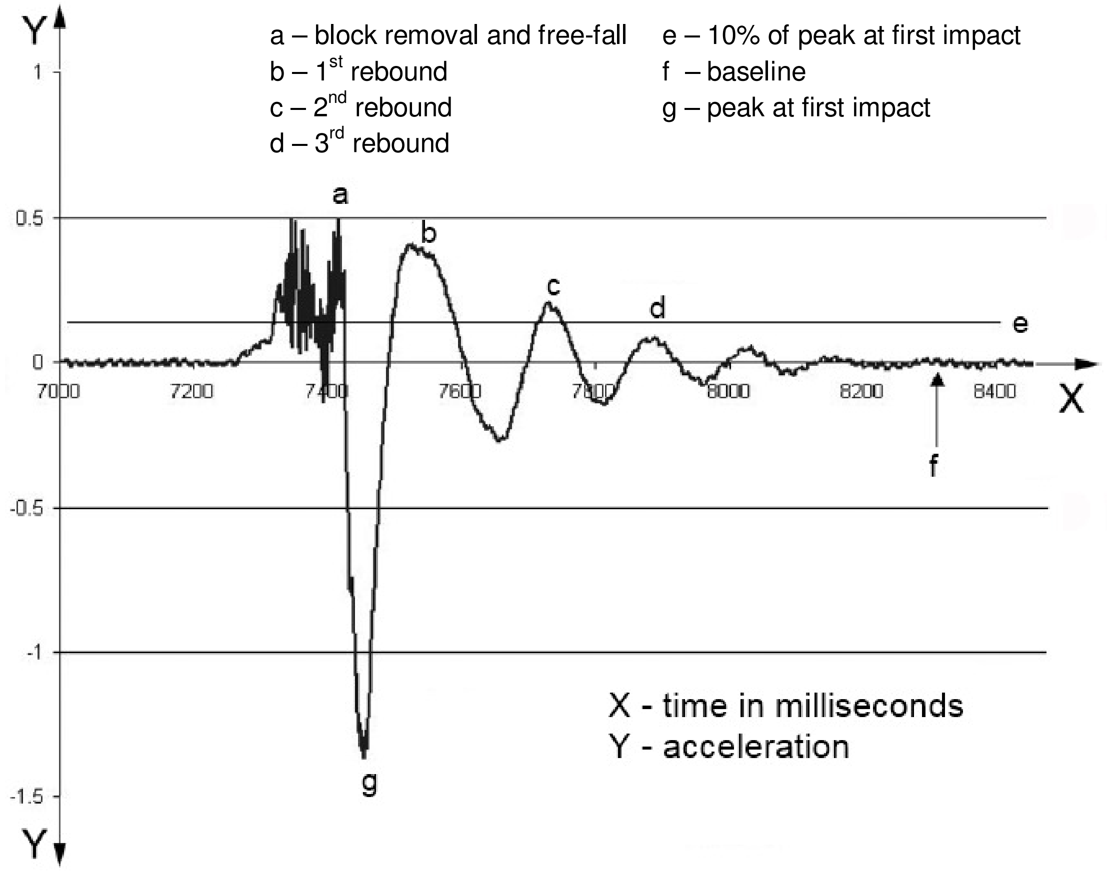


Figure 3-82 Typical result from an impact damping test performed on a cushion (ISO 2007)

DiGiovine (2000) compared the management of vibration during MWP by four cushions, a Jay Active, a ROHO Low Profile, a Varilite Solo and a Pindot Comfort-mate. DiGiovine found the Varilite was more effective at damping vibrations than the other three cushions. DiGiovine concluded that the Varilite was more effective at damping due to the boundary between the air and foam parts of the cushion damping the vibrations, rather than the air damping some of the vibration and the foam damping further. (DiGiovine *et al* 2000).

Internal air pressure adjustment:

A number of cushion designs rely on an internal air pressure to provide the immersion capability of the cushion. If the internal pressure is too high the user is left sitting on top of a hard surface, if the pressure is too low the user bottoms out, see figure 3-12. It is critical then that the optimum internal air pressure is found and maintained.

To find this optimum internal air pressure designs such as the ROHO and the Varilite rely on the user, with or without help, to manually adjust the internal air pressure by releasing air from a fully inflated cushion until their lowest prominence, typically the ischials, are approximately 1.25cm above the base board, see figures 3-13 and 3-23.

Moisture:

Managing moisture is very important in maintaining tissue integrity with moisture being cited as an exacerbating factor in pressure ulcer development, see section 4.4.4. As all support surfaces are in close contact with the user, how they manage moisture is important. Many cushions use plastics or neoprene in their construction to hold gel or air. These materials prevent the dissipation of humidity and can increase sweating. These designs tend to rely on a vapour-permeable cover to manage moisture. For those users where incontinence is an issue, manufacturers such as ROHO (ROHO 2008e) and Varilite (Cascade Designs 2007) provide specifically designed incontinence covers. Incontinence pads used on top of a support surface can increase surface tension and so cause harm to the skin (Jay 1995).

Securing Cushion to Wheelchair:

Cushions which are not secured to the wheelchair can slide over the seat of the wheelchair. Mayall recommends that cushions should be fastened at all four corners, as cushions can slide both forwards and backward with the client (Mayall and Desharnais 1995).

Cushions which slide backwards can either be pushed up against the back rest of the wheelchair and behind the user, see figure 3-83; or in cases where the wheelchair has a gap between the seat and the back rest, for instance some collapsible wheelchairs, the cushion may slide out the back, see figure 3-84.

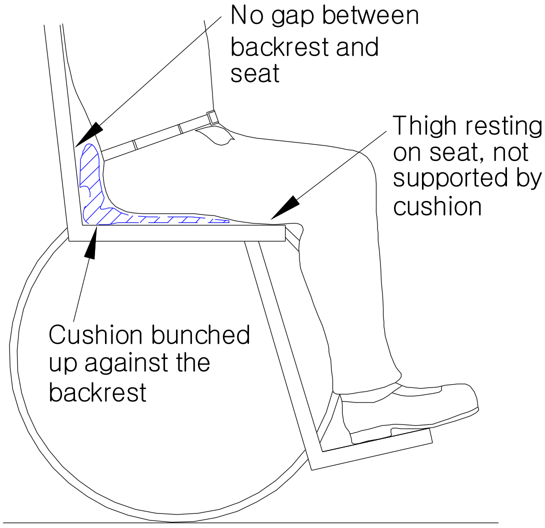


Figure 3-83 Cushion slid backwards and pressed against the backrest

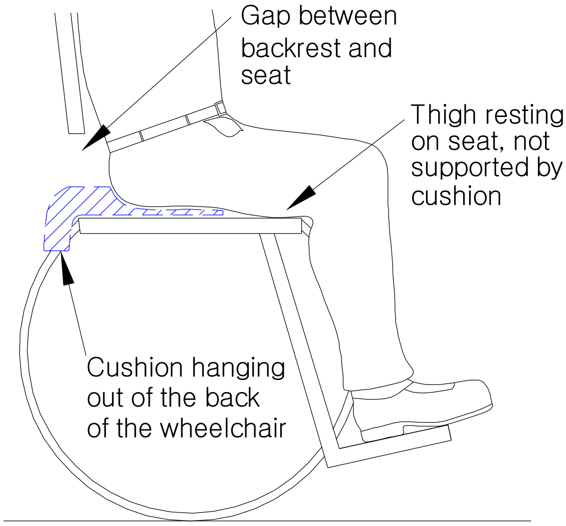


Figure 3-84 Cushion slid backwards and out under the backrest

Cushions which slide forward can either droop behind the knees of the user or cushions with solid base boards can continue to support the user, see figures 3-85 and 3-86.

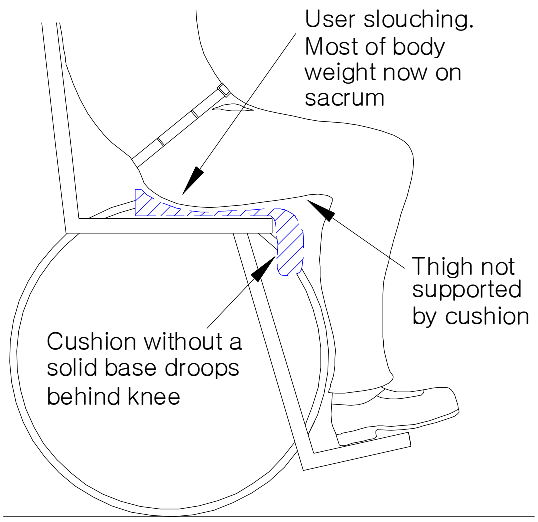


Figure 3-85 Cushion, without a solid base, slid forward

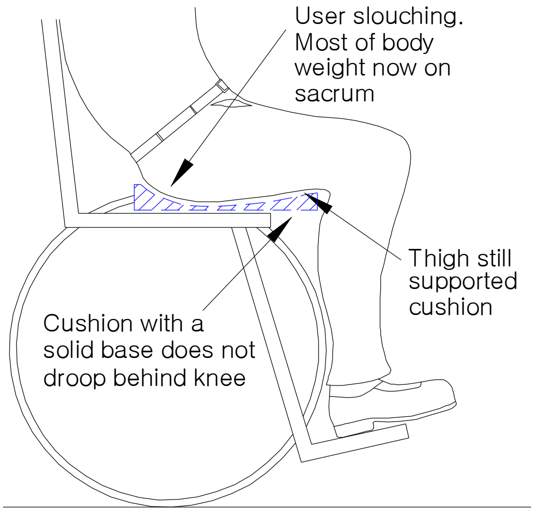


Figure 3-86 Cushion, with a solid base, slid forward

Surface Memory:

Surface memory is the term used to describe the behaviour of a material to return to its original shape having been compressed, for example when a foam cushion is compressed it "*remembers*" its neutral shape and will return to its neutral shape once the compressive force is removed. A feature of this elastic behaviour is that the foam under compression will exert a force opposing the compression force, see figure 3-87. This effect can be experienced when pressing down on a sprung mattress. The harder one presses down on the springs the more force the springs push back.

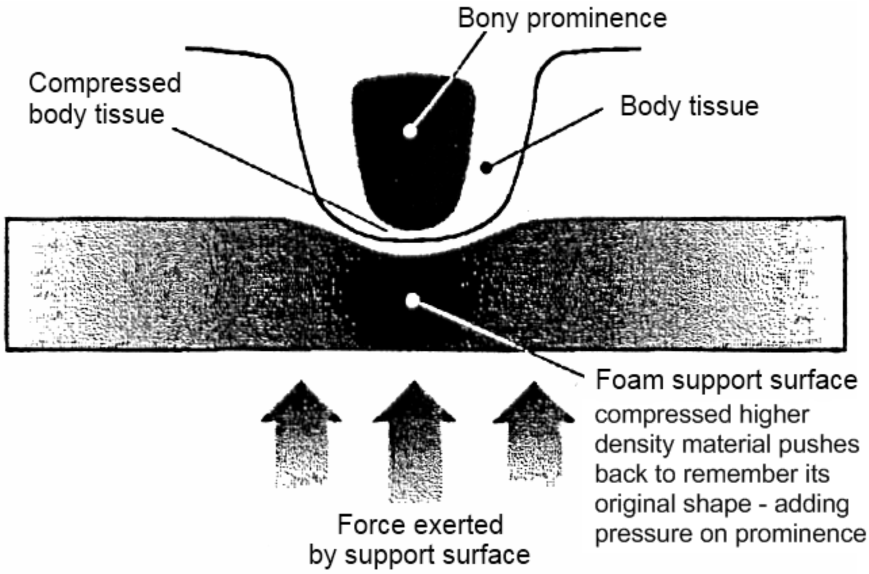


Figure 3-87 Foam's memory adding pressure to body (Jay 1995)

In comparison a fluid filled cushion, allows the fluid, for example air, to flow freely which equalises the pressure within the cushion eliminating the behaviour of memory and its characteristic of exerting an opposing force against an applied compression force (Jay 1995).

Transferring on/off cushion:

Transferring into and out of the wheelchair is an action performed by all wheelchair users whether they are able to manually transfer independently, with help, or with the aid of a hoist.

The degree of difficulty experienced with transferring is influenced by the design of the support surface. Cushions with contouring to immerse the ischials and prevent the user from sliding forward, such as the Flo-tech, can be more difficult to transfer on and off due the "*bucket effect*" (Mayall and Desharnais 1995). The bucket effect is a reference to the bucket hollow formed by the contour and how the user has to lift up and drop into the contour when transferring onto the cushion and lift up and out of the contour when transferring off the cushion.

If the patient does not lift their bottom fully out of the contour before moving across, the leading buttock will scrape the top edge of the contour, see figure 3-88. This scrape can then progress into a pressure ulcer, see section 4.4.4.

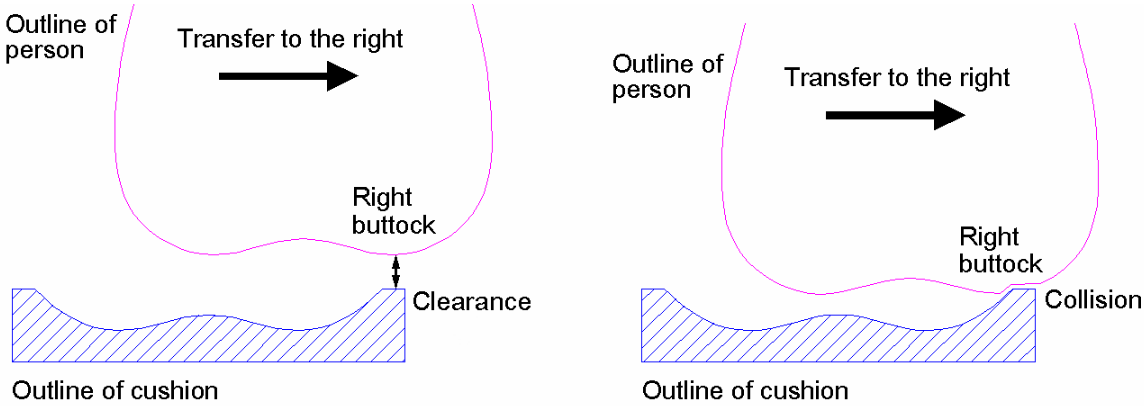


Figure 3-88 A person transferring from their cushion

It is easier to transfer on and off a cushion when the surface is flat as it becomes then a matter of sliding across. Wilber's presentation to RESNA reported that the design of the Varilite *Meridian* cushion included, as a design objective, a flat surface as this would make it easer for the user to transfer on/off (Wilber 2007).

Cushions which conform quickly to the body, namely fluid-filled designs, can make transferring more difficult. If the user has to push down on the cushion to gain leverage the contents of the cushion, for example air or gel, will move as soon as the body weight is lifted off the cushion, destabilising the user (DLF 2006), see figure 3-89.

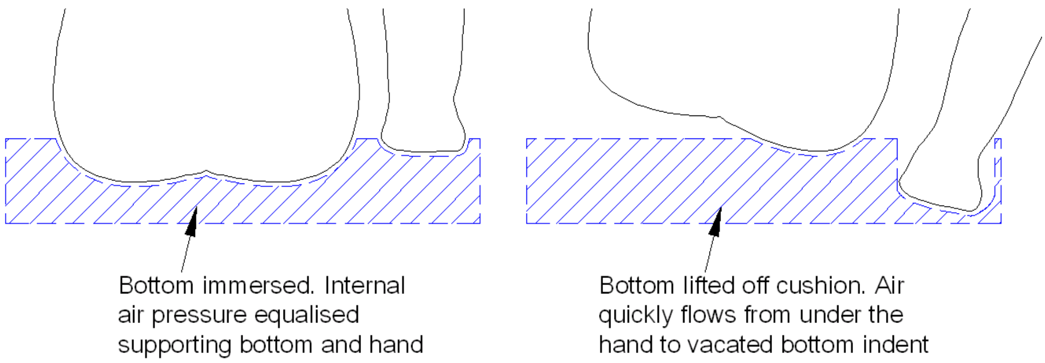


Figure 3-89 Fluid filled cushion's surface unstable during transfers

The issue of transferring is of such importance to the user that the latest thought of the Tissue Viability Society on the subject is, "*ease of transfer may be as important to consider as the degree of pressure redistribution offered by a cushion*" (TVS 2008).

Weight:

The difference in weight between the various types of cushions is substantial. The lightest cushion reviewed by this study was the Varilite PSV at 1kg compared to the heaviest, the Jay 2 at 5kg. With such a difference weight can be a consideration in the selection of which cushion to use. For example, cushion users who frequently lift their cushion into and out their wheelchair, for instance to use on a car seat or to collapse their wheelchair for transportation, will regard the portability of their cushion as important. The weight of a cushion is a factor in its portability, with the heavier cushions being harder to lift (DLF 2006).

3.8 Discussion

From the marketing literature and websites it is clear that there are many makes and models of PR cushions in service. No literature was found which specified how many cushions of each make are in service or provided a breakdown of the make of cushions used by the different patient groups. Epidemiological studies record the incidence of pressure ulcers within a patient group but do not mention of the type of cushions used by the patients. Evaluations and reviews of cushions report their findings and state how many subjects were included in their study, but they do not give details on how many cushions of the type they had studied were in use by wheelchair users or by individual patient groups. Detailed data, which is currently not available, about who is using which make of cushion and the pressure ulcer incidence rate associated with each of the different makes would be really useful as this data has the potential to provide designers with useful insights. This data would also assist healthcare service providers to distinguish between devices, see section 3.4.2.

Based on the quantity of published material relating to specific makes of cushion it was possible to make assumptions about which are the most commonly used cushions. However, without literature on how the various models of cushion are apportioned amongst wheelchair users it was not possible to be definitive as to which cushions are the most commonly used.

In order to be confident as to the choice of which cushions to review, advice was sought from professionals in the care and treatment of SCI patients from two SCIC. Two sites were chosen to avoid localised bias. There was agreement between the two SCIC as to the five most commonly used cushions, see section 3.3. According to both SCICs, all five of the most commonly used cushions used were of the static variety. Although the dynamic concept is widely used in the design of pressure relief mattresses and there are numerous dynamic cushions available with associated literature, according to the staff from the two SCIC a negligible percentage of their clients use a dynamic cushion, see section 3.3. It was therefore decided that in addition to the five most commonly used cushions, a dynamic cushion, the Airpulse, would be included to represent the dynamic concept of cushion design.

It was found that all the leading PR cushion designs are based on principles first devised in the early 1970's from work on the pressure intensity-duration relationship carried out in the 1950's and 60's, see section 4.5.7. However, right from the outset there have been questions raised about the credibility of these principles; for example Souther (1974) noticed that whilst lying down there is a sufficient surface contact area to disperse the body weight of an individual to a safe level, but the much reduced surface area in contact with a cushion limits the potential of a cushion to reduce IP by dispersing the body weight, see section 3.4.3. It was therefore decided that in addition to this review of contemporary PR cushions a literature review of the knowledge base on pressure ulcer development from which the principles of cushion design are derived was essential, see chapter 4.

Since the inception of PR cushions it has been the convention to design cushions to cater for the different categories of a pressure ulcer risk assessment tool; for example a patient categorised as being at the highest risk of developing a pressure ulcer would use a cushion which provides the highest level of pressure reduction, see section 3.5.1. No literature was found which questioned the usefulness of this convention, although the principle of at-risk categories with defined "*cut-offs*" was recently found by NICE to be a weakness in the allocation of PR devices, see section 3.5.2.

Cushions designed to comply with risk assessment categories present cushion users with a hazard. Seating assessments are conducted at intervals depending on the clinical situation of the patient. This can be in the region of three months or more, see section 3.5.2. During the interval between seating assessments a cushion user can experience changes in their physical condition, such as a rapid deterioration in health or a rapid weight gain/loss. A cushion user could develop a pressure ulcer during the intervening period between a rapid loss of weight and receiving a new cushion appropriate for the user's diminished body shape. No literature on this hazard to users was found. It was decided that it would be useful if the contribution this hazard makes to the incidence rate of pressure ulcers was explored, see sections 8.2.3 and 9.2.3.

There has been much written about the importance of maintaining good posture, and that poor posture can have severe physical consequences for the user including the development of pressure ulcers. This need to support posture has been recognised by cushion designers. Some cushions, such as the Jay and Flo-tech, have been designed to support a user's posture by the addition of a fixed contoured surface shape. This contouring is intended to "*capture*" the pelvis, see figure 3-28 and hold the user in the "*normal sitting*" position, see figure 3-70. All the leading cushions which provide postural support only support the one sitting position the "*normal sitting*" position. Although the normal sitting position is regarded as ideal, literature was found on the sitting positions other than the "*normal sitting*" position and how these positions influence IP levels; for example how leaning to one side can increase IP, and how IP is increased by incorrect seat adjustment such as a seat which is too low. Despite the awareness that different sitting positions have consequences for IP levels, there appears to be no attempt to design cushions which deal with the fact that users will, over the course of eight to ten hours, sit in positions other than the "*normal sitting*" position.

The literature contains various articles which discuss issues of usability as potential sources of pressure ulcers, for example when using an air-filled cushion the internal air pressure should be checked frequently to avoid the user from "*bottoming out*" and subsequently developing a pressure ulcer, see figure 3-13. No literature regarding the number of pressure ulcers which result from bottoming out due to low internal air pressure was found. Without data on this matter it is not possible for designers to know if the advice given about frequent checking is sufficient to prevent the users from developing pressure ulcers from under-inflated cushions, or if a substantial proportion of the thousands of pressure ulcers which still occur on the seat area of the body is as a result of low internal air pressure. The same lack of detail was found with the other issues of usability such as cushion orientation and transferring to and from the wheelchair. It was decided that these issues of usability need to be explored so as to appreciate their true significance in cushion design. Thus, the matter of usability was incorporated into this study, see chapter 5.

3.9 Conclusions

Contained within the literature were numerous articles concerned with various aspects of cushion design, from questions about the fundamental principles which underpin the design of PR cushions, to issues of usability such as internal air pressure. It was concluded that although there is an awareness of many of the weaknesses in the design of cushions, the focus on managing IP is such that all other concerns have become subordinate and remain poorly understood with their relevance not appreciated.

It was concluded that although not discussed in existing literature, cushions designed to match the patient's risk status present a hazard to users as any individual's health can deteriorate during the interval between seating assessments. It was also concluded that readdressing the convention of designing cushions for categories of pressure ulcer risk, presents an opportunity to consider changing to a convention where cushions are designed for specific patient groups. This would not only prevent users developing pressure ulcers when their health condition deteriorates but would also allow cushions to be tailored to match the different needs experienced by the different patient groups.

The link between poor posture and pressure ulcer development is well established. It has been concluded that in light of the technology available today, the 40 year old practice of simply relying on a fixed contour to provide postural support can be improved so that the user's need for sitting in different positions over an 8-12 hour day can be accommodated.

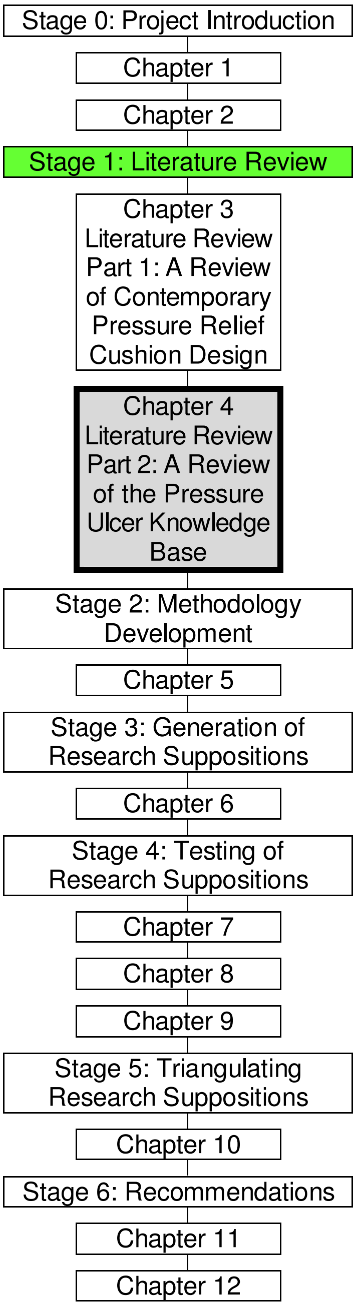
Having found various weaknesses and deficiencies in the design of cushions, it was concluded that there is scope to reduce the incidence rate of pressure ulcers by creating a better cushion.

It was further concluded that the current primary approach of assessing the efficacy of PR cushions by comparing the capacity of cushions to manage IP is too limited. Users and designers would be better served by assessing the efficacy of a cushion using broader criteria. These expanded criteria would include issues of usability related to pressure ulcer development, such as internal fluid, air/gel, distribution management.

Chapter 4

LITERATURE REVIEW PART 2: A REVIEW OF THE PRESSURE ULCER KNOWLEDGE BASE

4.1 Introduction



This chapter covers the second of the two assignments tasked under 'Stage 1' of the project. This assignment was to review[1] the aetiological knowledge base on pressure ulcers, upon which PR cushion design is founded.

The review began by establishing the historical context of the knowledge base, followed by a review of the definition of a pressure ulcer, as this defines the phenomenon to be prevented.

Having defined what is to be prevented, the factors which cause and contribute to the development a pressure ulcer, and therefore are to be mitigated, were reviewed.

The source of pressure ulcers, namely pressure, was then considered which was followed by a study of the relationship between pressure and pressure damage.

[1] A description of the search strategy used has been included in the appendices, see appendix B

4.2 Historical Context

Pressure ulcers have always afflicted those who have been immobilised, either through illness, injury or infirmity. Evidence of some of the earliest attempts at preventing pressure ulcers have been found on ancient Egyptians mummies. A priestess of Amen of the XXIth Dynasty (2050-1800BC) was found covered with carefully placed soft leather patches before embalming, probably in an attempt to restore physical integrity (Thompson 1961 cited Morison 2001).

Florence Nightingale's pioneering work in nursing practices included the use of two-hour turning to prevent soldiers from developing pressure ulcers during the 1854-56 Crimean War (Clark 1998).

It is only comparatively recently, that a concerted effort has been made towards advancing methods for pressure ulcer prevention. For example, the 1950's saw the first attempts to understand the pressure intensity-duration relationship using animal experiments (Husain 1953, Kosiak 1959). The 1960's saw the first risk assessment tool, the Norton Score (Norton *et al* 1962); and the introduction of new pressure relieving equipment such as ripple cell mattresses (Bedford *et al* 1961 cited Bliss 2003). The 1970's saw the first widely used pressure ulcer grading scale, devised by Shea (Shea 1975); the first turning clock devised by Lowthian (Lowthian 1979); and the introduction of pressure relief cushions such as the *ROHO* in 1973 (ROHO 2008b) and the Varilite in the early 1970's (Cascade Designs 2008).

The lack of impetus in the past towards the advancement of prevention equipment and techniques can be partially explained by the prevailing fatalistic attitude that pressure ulcers were inevitable. This period has been described as both the "*era of tropic fatalism*" and the period of "*therapeutic nihilism*" (Morison 2001). Although this fatalistic attitude was first challenged during World War I, this attitude would linger until the 1970's with the matter of prevention being regarded by the medical profession as being solely a nursing problem (Russell 1998). In 1981 Barton commented, "*It is a curious fact that while necrosis of other tissues, brain, heart, lung and even dental pulp, attract considerable medical and surgical attention, death of quite considerable* *parts of the skin and underlying tissues, although producing whole-body complications, attract little or no attention*" (Barton and Barton 1981).

However it was at about this time that things were beginning to change. The seminal 1975 bioengineering conference held at the University of Strathclyde, Glasgow, from which Kenedi produced the collective works "*Bed Sore Biomechanics*" (Kenedi *et al* 1976), has been cited by Gebhardt as possibly the single event which kick-started the modern UK interest in pressure ulcers (Gebhardt 2004). Shortly after this conference, the Tissue Viability Society was established in 1980. This society was set up to help promote the concept of "*tissue viability*" amongst the medical profession and the importance of a multidisciplinary approach to the care and prevention of all types of wounds (Dealey 1997). A few years later, in 1989, the National Pressure Ulcer Advisory Panel (NPUAP) was set up in America with the intention of improving clinical practice through education, research and public policy (NPUAP 1989). Its European counter part, the European Pressure Ulcer Advisory Panel (EPUAP) would not be set up until 1996. During the mid 1990's, further stimulus to advance pressure ulcer prevention arrived when a number of financial reports were produced which highlighted the cost to manage and treat pressure ulcers. For example, Touche Ross estimated this cost to be £180 to £320 million per annum and West and Priestly estimated it to be £755 million per annum, see section 2.3.

It was also at this time that the issue of pressure ulcers reached parliament, and in June 1993 pressure ulcers were the subject of the debate "*The Health of the Nation*" (Hansard 1993). As Dealey writes, "*It could be considered that pressure sores had 'arrived' politically*" (Dealey 1997).

With these developments, the 1990's saw significant advances in the full spectrum of research into pressure ulcers, ranging from basic science on the physiology of wound healing, to studies on optimal support surfaces (Cuddigan *et al* 2001). Today, the subject of pressure ulcers continues to remain on the agenda, so much so that the Department of Health's clinical practice benchmarking resource pack "*Essence of Care*" (DoH 2001), has included pressure ulcer care as one of the eight fundamental aspects of care (Hampton 2001). As for research, the body of literature on the subject now grows at the rate of hundreds of papers per year (Gebhardt 2004).

4.3 The Pressure Ulcer

A pressure ulcer is a wound resulting from a breakdown in the skin whereby previously healthy skin has been devitalised resulting in localised tissue death (Alexander *et al* 2003 cited Ousey 2005). The processes involved in this devitalisation are not fully understood but it is currently believed to be a consequence of the interruption of normal blood flow, ischemic reperfusion, the disruption of normal lymphatic function, increased interstitial fluid flow and or a combination of these, see section 4.4. An example of one such fundamental gap in understanding pressure ulcer pathology is that it has still to be established whether the damage to the tissue occurs deep in the tissue and breaks out on to the surface or whether it starts superficially and works its way down through the tissue layers, "*The issue of the progression of ulcers (i.e., top-down or bottom-up theories of pressure injury) is unresolved and inadequately explained by research*" (WOCN 2005). Further a "*middle model*" can now be found in the literature suggesting, "*Tissue damage may start anywhere between, and including, the skin surface and bone interface, concurrently or haphazardly, to produce a pressure ulcer*" (Sharp and McLaws 2005).

It is not sufficient to regard pressure ulcers purely as an area of localised tissue death, as a variety of circumstances can injure the skin, leading to ulceration. As noted by Defloor, with a variety of injuries it is very important to correctly differentiate between them, because their treatment and prevention strategies differ largely (Defloor *et al* 2005). Currently it is the source of damage which is used to define the various types of injury, such as burns, pressure ulcers and moisture lesions. The National Pressure Ulcer Advisory Panel (NPUAP) has recognised the similarity between various skin wounds, injuries, and pressure ulcers, but makes clear that the defining quality of pressure ulcers is prolonged pressure,

> *Skin breakdown may be caused by a variety of reasons including trauma (for example, skin tears), moisture (excoriation and maceration), arterial insufficiency (arterial ulcers), venous insufficiency (venous ulcers), and diabetic neuropathy (diabetic or neuropathic foot ulcers). These wounds are often confused with*

pressure ulcers. Pressure ulcers are caused by prolonged pressure and typically occur over bony prominences in bed- or chair-bound individuals. Wound characteristics can be used to distinguish pressure ulcers from other types of chronic wounds.

(NPUAP 2008a)

Pressure ulcers are a very specific type of wound defined by its aetiology rather than its physiological consequence.

4.3.1 The Definition of Pressure Ulcers

The understanding of the skin wound type, currently known as pressure ulcers, has developed over time and this development has, on occasion, prompted revisions in its definition and with this it's name. For example, in the past pressure ulcers were predominantly associated with the bed ridden and so were known as *"bed sores".* The term in current common usage is "*pressure ulcer"* and is the term of choice by both the European Pressure Ulcer Advisory Panel (EPUAP) and the NPUAP. However both bodies have produced their own definitions of pressure ulcers.

The EPUAP definition of a pressure ulcer is,

A pressure ulcer is an area of localised damage to the skin and underlying tissue caused by pressure, shear, friction and or a combination of these. (EPUAP 1999)

The EPUAP are, at the time of writing this thesis, undergoing a drafting process in collaboration with the NPUAP to formulate a new more current set of guidelines which will contain the latest EPUAP definition of a pressure ulcer.

The latest NPUAP definition of a pressure ulcer is,

A pressure ulcer is localized injury to the skin and/or underlying tissue usually over a bony prominence, as a result of pressure, or pressure in combination with shear and/or friction. A number of contributing or confounding factors are also associated with pressure ulcers; the significance of these factors is yet to be elucidated.

(NPUAP 2007)

This definition is a recent update from,

> *Any lesion caused by unrelieved pressure resulting in damage of underlying tissue. Pressure ulcers are usually located over bony prominences (such as the sacrum, coccyx, hips, heels) and are staged according to the extent of observable skin damage. Pressure ulcers vary from superficial tissue damage to deep craters exposing muscle and bone.*
>
> (NPUAP 1989)

This update was part of a review conducted by the NPUAP Staging Task Force which looked at the definitions used to stage pressure ulcers, see section 4.3.2. The final definitions were agreed upon during a consensus conference, held in February 2007, and were the culmination of over five years work beginning with the identification of 'deep tissue injury' (DTI) in 2001 (Black *et al* 2007).

These current definitions by the EPUAP and the NPUAP do not provide a description of what pressure ulcers are, instead they only specify what causes pressure ulcers namely, "*pressure, shear, friction and or a combination of these",* the structures damaged, "*localized injury to the skin and/or underlying tissue"* and in the case of the NPUAP definition a reference to where they might occur, "*usually over the bony prominences*". These definitions by being concise are inclusive of the full range of pressure damage, from observable red marks through to full-thickness tissue loss; and cover the full range of locations where pressure ulcers are likely to occur, namely any bony prominence. Although any area of skin exposed to a sufficiently intense level of pressure for a sufficiently long duration will break down (NPUAP 2007).

When an individual is at rest, be it seated or recumbent, it is the bony prominences, which are subjected to the most IP. In addition, the tissue covering these bony prominences tend to be thin lacking muscle or fat to act as padding, for example the skin at the elbow or heal. It is therefore possible, by identifying the bony prominences of the body, to be aware of the areas at greatest risk when recumbent, see figure 4-1, or in a seated position, see figures 4-2 and 4-3.

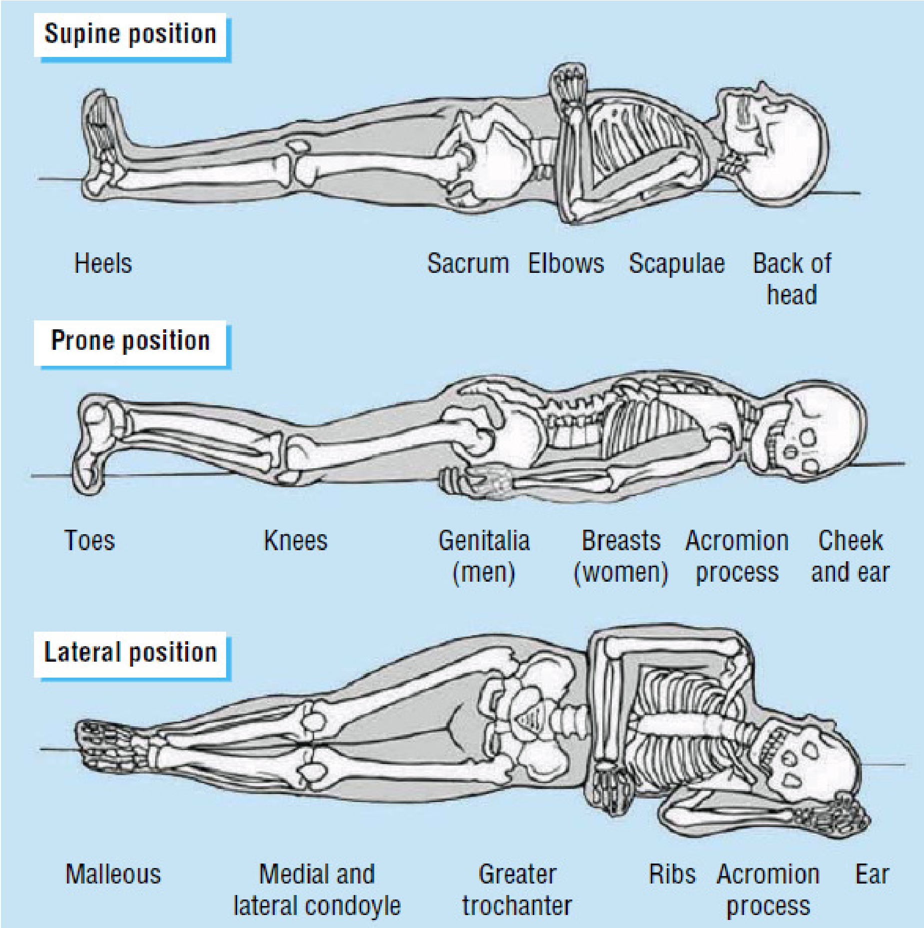


Figure 4-1 Diagram showing common at-risk areas (Grey *et al* 2006)

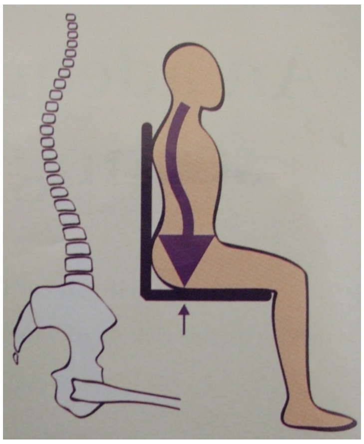


Figure 4-2 Pressure on the ischial tuberosities when sat upright (Collins 2001a)

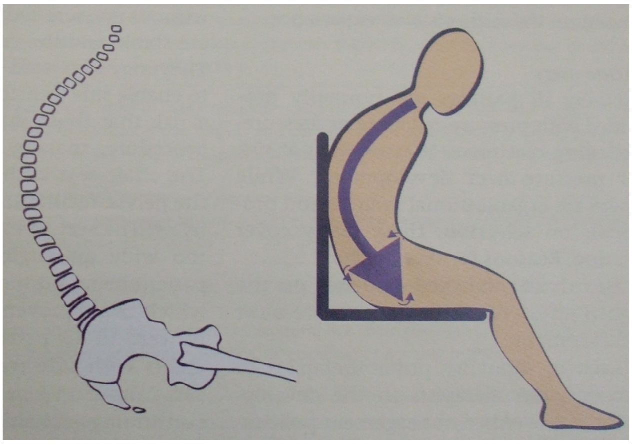


Figure 4-3 Pressure on the sacrum when sat in a slouched position (Collins 2001a)

These various definitions of pressure ulcers do not provide a physical description of pressure ulcers. For a description of what a pressure ulcer is one has to look at the definitions used to describe the various categories of pressure ulcer damage; referred to as the pressure ulcer *class*, *grade* or *stage,* depending on the categorising scheme.

4.3.2 Classification/Grading/Staging of Pressure Ulcers

Previously to the new NPUAP 2007 definition, the extent of pressure damage was commonly discussed as being a point on a spectrum of damage from red marks, see figure 4-4, through to deep craters penetrating down to bone, see figure 4-5, as reflected by the sentence contained in the previous 1989 NPUAP definition, "*Pressure ulcers vary from superficial tissue damage to deep craters exposing muscle and bone".* A view also held by Simpson, "*Pressure sores represent a continuum from an erythematous area of skin to an open wound extending deep in to the tissue*" (Simpson *et al* 1997).

Figure 4-4 A Grade 1 pressure ulcer, "*a red mark*", over the right greater trochanter (Grey *et al* 2006)

Figure 4-5 A Grade 4 pressure ulcer ,"*a deep crater*", over the right ischial tuberosity (Kordasiewicz 2003)

Numerous schemes have been devised to categorise the range of pressure damage. Depending on the scheme, these categories are referred to as either, *classes*, *grades* or *stages.* The categories are based on the pathology involved in pressure ulcer development (Doughty *et al* 2006). However, the exact division and categorisation of this spectrum has never achieved full agreement. This lack of consensus has led to numerous categorising schemes to be produced, such as the Shea classification system, see figure 4-6, and the EPUAP grading scale, see table 4-1.

The earliest system in the literature for classifying, grading or staging pressure ulcers was by Guttmann (Guttmann 1955). However, the first well documented system was the Shea scale (Shea 1975), which was widely used in the USA until the late 1980's (Black *et al* 2007). Shea proposed a four category 'Grade' scale based on the degree of penetration through the layers of skin. Shea included an extra category for "*Closed"* ulcers, see figure 4-6.

Shea categorised pressure ulcers by the number of layers damaged,

Pressure Sores:
Classification – Treatment

Grade	*Anatomic Limit*	*Treatment*
I	Dermis	Local wound care
II	Subcutaneous fat	Local wound care
III	Deep fascia	Surgery
IV	No limit – extensive	Radical surgery
Closed	Deep fascia	Surgery

The Shea Grading scale 1975

Damage to the epidermis, dermis not penetrated. One layer damaged

Damage to the dermis, subcutaneous layer not penetrated. Two layers damaged

Damage to the subcutaneous layer, underlying fascia not penetrated. Three layers damaged

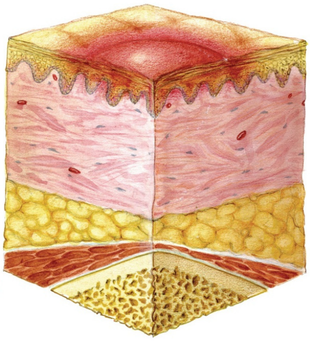
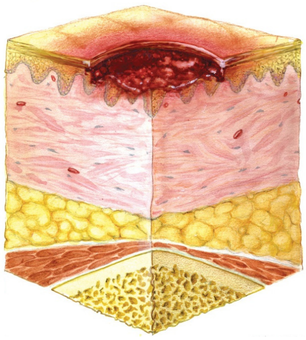
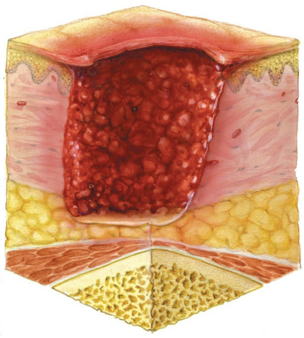
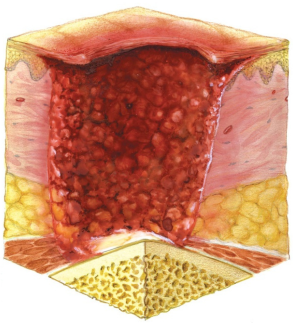
Damage to muscle and underlying structures, tendons, ligaments, bone. Four layers damaged

Figure 4-6 The Shea Grading Scale (Shea 1975)

Shea included a category which he labelled "*Closed*". This category was provided to describe the pressure ulcers which develop but are not open lesions but were "*caused by the same pathologic processes*" and that these *closed* pressure ulcers whilst presenting as a small benign-appearing wound measuring a few millimetres in diameter, conceal deep potentially fatal lesions (Shea 1975). Shea's description of a closed ulcer is similar to the NPUAP newly added pressure ulcer stage a "*suspected DTI*" (Black *et al* 2007).

The fundamentals of this first classification system, the categorising of pressure ulcers by the penetration of tissue layers, can still be seen in current systems such as the EPUAP grading scale, notably Grade I - the surface of the skin remains intact and Grade IV - the ulcer has penetrated right the way through all the layers of tissue, see table 4-1. There remains a broad agreement that Grade 1 ulcers are defined as an intact surface although the definition of an ulcer is a break in the surface[2]. For example, a duodenal ulcer is a break in the lining of the duodenum and a gastric ulcer break in the lining of the stomach (Oxford Dictionary of Nursing 2003).

Table 4-1 EPUAP scale, (EPUAP 1999).

European Pressure Ulcer Advisory Panel (EPUAP) – pressure ulcer scale	
 *	**Grade I** Nonblanchable erythema of intact skin heralding lesion of skin ulceration. In individuals with darker skin, discoloration of the skin, warmth, edema, induration or hardness may be indicators.
 *	**Grade II** Partial thickness skin loss involving epidermis, dermis, or both. The ulcer is superficial and presents clinically as an abrasion, blister, or shallow centre
 *	**Grade III** Full thickness skin loss involving damage to or necrosis of subcutaneous tissue that may extend down to, but not through underlying fascia. The ulcer presents clinically as deep crater with or without undermining of adjacent tissue
 *	**Grade IV** Full thickness skin loss with extensive destruction, tissue necrosis, or damage to muscle, bone, or supporting structures (e.g, tendon, joint capsule). Undermining and sinus tracts also may be associated with Stage IV pressure ulcers

* Image to illustrate grade of ulcer taken from the NPUAP website (NPUAP 2008b)

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[2] *Ulcer* is defined as "*a break in the skin or in the mucus membrane lining the alimentary tract that fails to heal and is often accompanied by inflammation*" (Oxford Dictionary of Nursing 2003).

Since Shea's scale was published, there has been little consensus over the exact form grading scales should take, with many more grading scales being published. Hitch conducted a literature review for the NHS Executive Nursing Directorate and compiled a table of ten "*Pressure Sore Classification*" systems, (Hitch 1995) and Russell found sixteen systems although only six were in regular use (Russell and Reynolds 2001). This multitude of grading scales is largely the result of a lack of consensus as to whether or not blanching erythema should be considered as a grade I ulcer. This proliferation of scales, using various definitions for a grade I ulcer, has led to a level of confusion which has directly impacted on the collection of reliable data, for example, "*The spot checks found that there was confusion over the defining of grade 1 sores and so they were excluded from the findings*" (Dealey 1991).

Attempts have been made to find consensus over grading definitions. The 1992 consensus conference held at the Stirling Royal Infirmary drew together experts from bioengineering, dermatology, geriatric medicine, nursing, pharmacology and spinal cord injury, to produce the 'Stirling' classification system. However this system was not adopted universally, let alone adopted nationally. Not only did Stirling fail to produce consensus, no other system has been successful in achieving consensus. Eight years after Stirling there were still calls for a single grading system, "*The key message which emerges in the literature is that a national grading tool is needed and until this is achieved, prevalence and incidence figures should be treated with caution*" (Harker 2000). So with a variety of systems still in use the difficulties over grade 1 ulcers continued, as identified by Bethell, "*Research indicates that poor inter-rater reliability means the incidence of grade 1 pressure ulcers is often under- or over-reported. Some researchers have not included these ulcers in incidence and prevalence studies for this reason*" (Bethall 2003).

Not only is there concern over the use of grading scales, in particular the consistency of reporting the incidence and prevalence of pressure ulcers due in part to the confusion brought about by the various definitions of Grade 1, there are other issues of concern as well. Studies have been conducted into grading scales which raise into question their validity (James 1998), utility (Healey 1996) and reliability (Russell and Reynolds 2001). These are issues which are still unresolved and remain a matter of concern (Doughty *et al* 2006).

The classification, grading or staging of pressure relief damage solely on the characteristic of skin layer penetration can be misleading as to the severity of the wound. The degree of layer penetration does not describe the depth of the ulcer, "*A pressure sore on the malleolus of a thin patient would need to be only 1mm deep before exposing bone, whilst a buttock sore on a well-nourished patient might be 100 times deeper at 10cm before bone is exposed*" (Healey 1996). Equally the severity of the wound includes the area of damage not just penetration, see figures 4-7 and 4-8.

Figure 4-7 A Grade 1 ulcer. Defuse high volume damage, a significant area of skin damaged although the epidermis is not penetrated. (Morison 2001)

Figure 4-8 A Grade 2, possibly Grade 3, ulcer. Localised low volume damage, a small area of skin damaged although the epidermis is penetrated. The condition of the wound bed makes it unclear as to the full extent of the ulcer (Romanelli 2005)

Further, observable damage is not necessarily the limit of the damage as an ulcer may include undermining, see figures 4-9 and 4-10 or tunnelling, see figures 4-11 and 4-12.

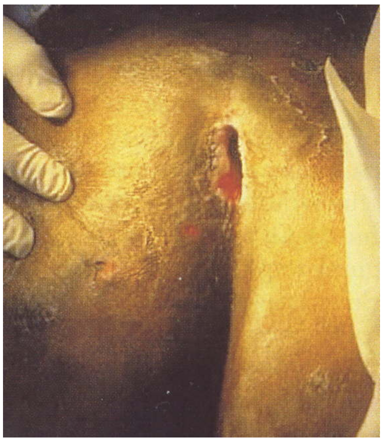


Figure 4-9 The majority of the wound bed is obscured, as this is an undermined ulcer (Morison 2001)

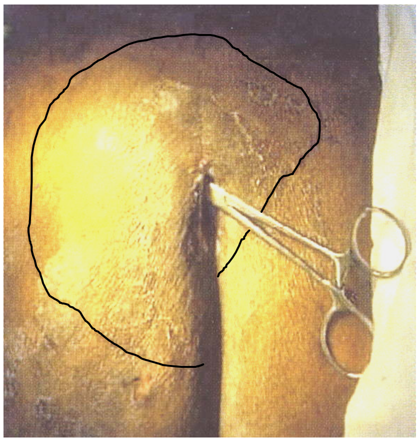


Figure 4-10 The black line outlines the true size of the ulcer. The true extent of the ulcer was found by the careful use of a probe (Morison 2001)

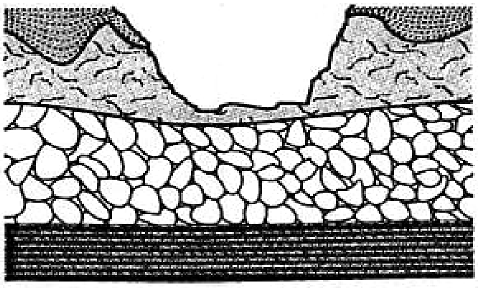


Figure 4-11 A Grade 2 ulcer as only the dermis has been penetrated (Healey 1996)

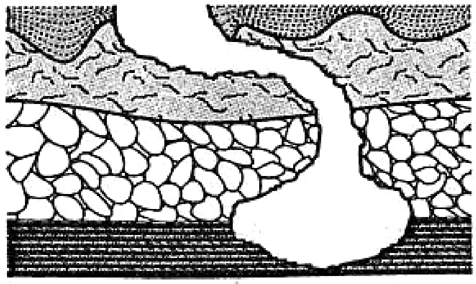


Figure 4-12 Visually a Grade 2 ulcer as it appears that only the dermis has been penetrated. However due to tunnelling this ulcer has progressed into a Grade 4 ulcer (Healey 1996)

The limits of classification/ grading/ staging systems to relate the severity of an ulcer is known,

> *Staging has limited value in directing therapy, which is guided by other, multiple factors that can be identified and assessed including size, shape, depth, presence of undermining/tunnels, tissue type, exudate, wound edges, presence of necrosis, signs of infection, as well as patient, caretaker, and socioeconomic and environmental factors that contribute to pressure injury. Staging should not be used as the sole parameter for treatment, evaluation of therapeutic effectiveness, or reimbursement.* (WOCN 2005)

This has prompted some to formulate severity indices to gauge pressure ulcer severity. Emparanza has published a severity index ranging from 0 (mildest damage) to 10 (most severe). This index considers three variables **CO**lour, **DE**pth and **D**iameter and has been entitled the CODED score (Emparanza *et al* 2000). Sanada has also published a severity index. This index considers six variables, **D**epth, **E**xudate, **S**ize, **I**nfection, **G**ranulation and **N**ecrosis, and has been entitled the DESIGN tool (Sanada *et al* 2004). In epidemiological studies the use of grading scales to formulate incidence and prevalence rates continue to dominate. No study was found whereby a severity scale was used in preference to an orthodox grading scale, despite the widely known weaknesses with grading scales.

Having reviewed grading scales, their application in regards to the reporting of incidence and prevalence rates, a key component of epidemiological studies, is cause for concern in relation to assessing the success or failure of equipment, notably PR cushion efficacy. Further work should be conducted into the categorisation of pressure damage, see section 12.3.3.

4.4 Factors which Lead to the Development of a Pressure Ulcer

4.4.1 Causal and Contributing Factors

The development of a pressure ulcer is seen as a consequence of unrelieved pressure, formed under the influence of contributing factors, "*There are many complex contributory factors in the formation of pressure ulcers, but only one true cause and that is unrelieved pressure*" (Hampton and Collins 2004).

Prolonged, or unrelieved, pressure is the defining quality of pressure ulcers and is the guiding feature behind the definitions used to categorise pressure ulcers. NPUAP defines pressure ulcers as, "*a result of pressure, or pressure in combination with shear and/or friction"* (NPUAP 2008a), whilst the EPUAP defines pressure ulcers as being "*caused by pressure, shear, friction and or a combination of these*", (EPUAP 1999). Additionally, during a lecture on "*Continuing Care of the Skin*", at the National Spinal Injuries Centre (NSIC) Stoke Mandeville, the causes of pressure ulcers were stated to be, "*Direct pressure, Friction, Shear*" (Dunne 2004). It is these then, pressure, shear and friction, see sections 4.4.1 and 4.5.2, that are the causative factors in the formation of pressure ulcers (Ratcliffe and Rose 2000). In addition to these causative factors are factors, such as hydration, which increase an individual's disposition to develop a pressure ulcer. Bader described these predisposing factors as the "*characteristics of vulnerability*" (Bader 1990). These factors are commonly referred to as the *contributing factors*, "*A number of contributing or confounding factors are also associated with pressure ulcers; the significance of these factors is yet to be elucidated"* (NPUAP 2007). These contributing factors, of varying potency, act to reduce an individual's tolerance to pressure. Thus, the intensity of unrelieved pressure may not cause a pressure ulcer until a contributory factor sufficiently weakens an individual's tolerance to pressure.

In 1996, Byrne and Salzberg conducted a literature review on contributing risk factors and identified more than two hundred risk factors associated with pressure ulcer development. For those with SCI, they listed seventy eight risk factors of which fifteen were classified as being "*Major Risk Factors*", see table 4-2 (Byrne and Salzberg 1996).

Table 4-2 Major risk factors for those with SCI (Byrne and Salzberg 1996)

Major risk factors for pressure ulcers
Severity of Spinal Cord Injury
1. Decreased level of activity
2. Immobility
3. Completeness of the SCI
4. Urine incontinence/moisture
5. Autonomic dysreflexia/severe spasticity
Pre-existing Conditions
6. Advanced age
7. Tobacco use/smoking
8. Pulmonary disease
9. Cardic disease/abnormal electrocardiograph
10. Diabetes/poor glycemic control
11. Renal disease
12. Impared cognitive function
13. Residing in a nursing home/hospital
Malnutrition and Anemia
14. Hypoalbuminemia/hypoproteinemia
15. Anemia

All contributing risk factors can in some way weaken the skin's tolerance to pressure, making the skin more vulnerable to pressure and therefore increase the risk of the skin being damaged by pressure. However, these contributing factors cannot in themselves inflict the damage which manifest as pressure ulcers. For example, smoking is a contributing factor as it reduces the oxygenation of blood. When Niazi looked at the recurrence rates of pressure ulcers amongst 176 patients with SCI, he found that of those who had smoked the recurrence rate was 42.2%, whilst of those who had not smoked the recurrence rate was 26.2%. From his results he concluded that smoking is an independent risk factor (Niazi *et al* 1997). Thus, smoking can contribute to the formation of a pressure ulcer although it cannot of itself cause a pressure ulcer. Similarly, the presence of moisture can weaken a patient's tolerance to pressure leaving the patient more vulnerable to ulceration. Moisture can weaken a patient's skin by macerating the skin. Maceration of the skin softens the stratum corneum, sees collagen crosslinks dissolved and reduces skin stiffness weakening the strength of connective tissue. Also over-hydrated skin increases the epidermal friction coefficient which increases the adhesion of the skin to the support surface which in turn increases maximum possible shear stress to build up (Reger *et al* 2007). Additionally, urine and faeces convert urea to ammonia, which destroys the acid mantle, while the high pH of urine activates protease and lipase, which breaks down the epidermis (Evans and Stephen-Haynes 2007). Despite the negative effect of moisture, moisture does not in itself exact *pressure damage* on the skin, "*Skin moisture in itself does not have a direct causal link to the development of a pressure ulcer but moisture may be an important factor when it acts as an effect modifier*" (Sharp and McLaws 2005). However care is required when regarding moisture and superficial pressure damage, as moisture can damage skin to form moisture lesions which are similar in appearance to pressure ulcers, see figures 4-13 and 4-14.

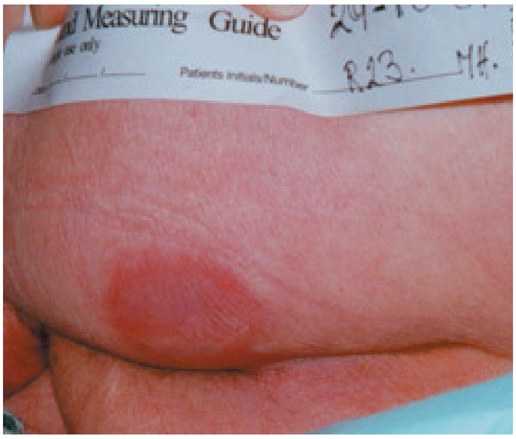


Figure 4-13 The red marks of a grade 1 pressure ulcer (Hampton 2005)

Figure 4-14 Damage caused by skin exposed to uncontrolled urinary incontinence. (Evans and Stephen-Haynes 2007). Red marks similar in appearance to a grade 1 pressure ulcer

This moisture damage can be mistaken for pressure damage, "*There is often confusion between a pressure ulcer and a lesion that is caused by the presence of moisture*" (Defloor *et al* 2005).

So, it does not matter which contributing factors are involved, the extent of the factors, how many factors are involved or in what combination, unless pressure acts on the skin to cause pressure damage a pressure ulcer will not form.

The factors involved in the formation of pressure ulcers, both causative and contributing, have been categorised as either "*extrinsic"* or *"intrinsic"* factors. NICE define the category labelled extrinsic as, "*Factors that are external to the individual*" and the category labelled intrinsic as, "*Factors present within the patient*" (Yerrell *et al* 2003 reprinted 2005). An example of an extrinsic factor is friction as this is a factor which acts externally on the skin, and an example of an intrinsic factor is nutrition as this is a factor which affects the skin internally from within the patient. Following this logic, many authors, such as Grey, Kelly, Morrison and Simpson, group together all external factors under the label extrinsic factors, and group together the internal factors and under the label intrinsic factors. Consequently, the three causative factors, pressure, shear, friction, are often grouped together with factors like moisture, temperature and skin irritants under the heading extrinsic factors (Grey *et al* 2006) (Kelly 1994) (Morrison 2001) (Simpson *et al* 1997). However NICE consider the extrinsic factors to be only the three causative factors, referring to factors such as moisture as exacerbating factors. NICE does not give a definition of exacerbating factors (Yerrell *et al* 2003 reprinted 2005). The concept of exacerbating factors has been adopted by other authors such as Collier who lists pressure, shear and fiction as extrinsic factors and lists bacterial contamination, skin moisture, spinal shock and sleep as exacerbating factors (Collier 2004). The concept of an additional category to extrinsic and intrinsic is not new, Dealey and Russell both wrote about external factors in the late 1990's (Dealey 1997) (Russell 1998).

Summaries of the factors found in the literature have been compiled based on the categories 'Extrinsic', 'Intrinsic' and 'Exacerbating' factors. The factors which have been included in the following summaries are the ones which have appeared most commonly. (Byrne and Salzberg 1996, Collier 2004, Dealey 1997, Grey *et al* 2006, Kelly 1994, Morison 2001, Ousey 2005, Radcliffe and Rose 2000, Russell 1998, Rycroft-Malone and McInnes 2001, Simpson *et al* 1997, Yerrell *et al* 2003 reprinted 2005).

4.4.2 Extrinsic Factors

The extrinsic factors according to Dealey; Ousey; and NICE are,

- pressure
- shear
- friction.

Some authors, such as Grey and Kelly, also include factors such as moisture and medication. They have been included in the category exacerbating factors.

4.4.3 Intrinsic Factors

This summary lists the intrinsic risk factors alphabetically, not by significance. Authors on this subject have tended not to show discernment between these factors based on the level of risk presented by a factor, even though certain factors do increase the risk more than others. Even Byrne and Salzberg who chose to produce a category "*Major risk factors for pressure ulcers*" did not list these factors in order of risk. This resistance to rank risk factors by significance is a reflection of how different individuals are more vulnerable to certain factors than others, and that pressure ulcers are multi-factorial in nature and so the impact of one risk factor can be multiplied when acting in concert with another risk factor.

Age -	As people age, their skin thins; the reduced elasticity and the loss of water, fat and collagen content in the skin increase the risk of pressure ulcers.
Body weight -	Underweight patients have less muscle and fat to act as padding between the bone and external surface. Overweight patients place a greater downward load on the pressure areas.
Circulation -	Arterial disease, hypotension and anaemia are conditions which effect the oxygenation of the tissue by the blood flow.
Malnutrition -	Reduced serum albumin, cholesterol and haematocrit contribute to the development of pressure sores and hinder the healing process.
Mobility -	Patients with reduced spontaneous movement will experience applied pressure for prolonged durations, increasing the risk of damage
Poor hydration -	Low water content of the tissue increases the risk of pressure ulceration.
Previous history of pressure damage -	Individuals which have previously developed a pressure ulcer are at a greater risk of developing further ulcers
Sensory loss -	Some diseases and disorders, such dementia, may make a patient less aware of pain and damage caused by continuous pressure.

From the perspective of PR cushion design, most of these factors are difficult to cater for directly, although it is important to remain aware of them. For example, whilst a cushion cannot directly affect the body weight of a patient, a patient who experiences fluctuating bodyweight is likely to benefit from a cushion which can adjust to a rapid increase or decrease in body mass.

4.4.4 Exacerbating Factors

This summary, as above, lists the exacerbating factors alphabetically not by significance.

Body-image, depression -	Patients who are depressed and view their body image as poor and consider their future to be bleak are likely to neglect personal care and so fail to prevent pressure ulcers from forming and allow pressure ulcers to worsen.
Hygiene -	Personal hygiene is important for all the regular reasons and washing away any incontinence is clearly a necessity, particularly as its presence can cause excoriation. Hygiene is a particular concern for individuals at risk as septic spots are known to develop into pressure ulcers (Rodgers 1986). Care is needed in cleaning as excessive washing and soap can damage the skin by removing the waterproofing barrier of epidermal lipids causing dry skin and exposing the skin to moisture and to bacteria.
Increased skin temperature -	Temperature is a serious concern because elevating the body temperature increases the metabolic activity of the tissues, resulting in an increase in the demand for oxygen and nutrients and an increase in the generation of metabolic waste products. An increase of 1 $^{\circ}$C increases the metabolic activity in the skin by 10% (Reger *et al* 2005). An increase in skin temperature is also problematic as it is likely to induce a sweat response potentially macerating the skin.
Injury –	Even tiny scratches and small bruises, if under pressure or shear forces, can easily develop into a full blown pressure ulcer.
Medication -	Sedation can lead to a loss in movement which results in prolonged lengths of time in one position. Steroids have an anti-inflammatory effect which impairs the inflammatory phase of the healing process. Cytotoxic drugs destroy normal cells and impair the healing process.
Moisture -	Moisture is destructive to skin integrity. Hydration of skin dissolves the molecular collagen cross links of the dermis and softens the stratum corneum. Skin maceration results in nearly complete loss of connective tissue strength (Reger *et al* 2005). Both excessive sweat and incontinence can be damaging as they can cause excoriation.
Poor adjustment -	Wrinkled bedding or clothing will imprint, aggravating the skin and can cause localised high pressure areas.

Smoking - Reduces the ability of the blood to carry oxygen.

From the perspective of PR cushion design, these factors present more areas of opportunity. For example, a well considered design will be able to influence elements such as ease of cleanliness and ease of adjustment.

Having reviewed the subject of contributing risk factors no reference was found in the literature regarding any form of seating as a potential risk factor. This was surprising as it is well known that being chair-bound increases an individual's risk. This lack of recognition has been noticed by others, "*A disproportionately low quantity of published literature on pressure ulcer refers to seating as a major causative factor, despite pressure ulcer incidence being frequently attributed to this*" (Hampton and Collins 2004).

4.5 Pressure Ulcers and Pressure

4.5.1 Pressure

The significance of the relationship between pressure and pressure ulcers has been recognised for centuries, however much of the nature of this relationship remains unknown and ambiguous. It is now over one hundred and fifty years since Brown-Sequard (1852) first demonstrated through experimentation with animals that it is not neurological damage but pressure which leads to the formation of pressure ulcers (Bader 1990). Since then progress has been made in furthering the understanding of the pressure-pressure ulcer relationship. However, this progress has been slow, "*Yet knowledge of the causes of PU's* [pressure ulcers] *is probably as rudimentary as it was 50 years ago and (possibly as a result) progress in developing effective preventative strategies is painfully slow*" (Gebhardt 2004). The context of this slow progress was covered in section 4.2.

Although not fully understood it is thought that pressure ulcers develop as a result of the normal processes within the skin being disrupted by the application of pressure at unsafe intensity-duration levels. These disrupted processes are studied under the pathology of pressure ulcers and include, the skin's microcirculation (Jones 2005), the lymphatic smooth muscle function (Gunther and Clark 2000) and interstitial spacing (Collier 2004).

As medical research and bioengineering expand our knowledge of the pathology of pressure ulcers, researchers and designers will be provided with new insights enabling more effective interventions into the ulceration process to be developed. These new prevention techniques, treatments and equipment may well have a significant influence on the design of future PR cushions.

However, it the current known pathology of pressure ulcers which is of interest to this project, as it is from this knowledge base from which the principles and approaches used in PR cushion design are derived. In the case of static cushion design the concept of pressure-reduction is based on the theory of a safe pressure threshold principally derived from capillary occlusion pressures, see section 4.5.4. In the case of dynamic cushions the concept of pressure-redistribution is based on the concept of a safe time threshold derived from the pressure intensity-duration relationship, see section 4.5.7.

4.5.2 Interface Pressure, Direct Pressure, Shear and Friction

It has been found that interface pressure (IP) is widely regarded as an objective measure for use in the evaluation of pressure relieving equipment, see sections 3.4 and 5.3. IP is generated between the skin and a support surface when they are in contact and has been described by Fletcher as, "*the measurement of pressure between the patient and the support surface*" (Fletcher 2001). Bell has since cited this description as a definition of IP (Bell 2005). This contact pressure, found between the body and the support surface, is the result of gravity pulling the body down onto the support surface. It has been generally accepted that IP can be expressed as,

$$\textit{Interface Pressure} = \frac{\textit{Body Weight}}{\textit{Skin Contact Area}} \qquad \text{(Collier 2004)}$$

IP is only representative of the level of forces acting between the body and the support surface. It has been conceived in such a way that it only takes into account the force generated by gravity, consequently "[IP] *does not distinguish the direction in which the forces operate and does not measure shear or friction components*" (Gardner *et al* 2006). IP is then a scalar quantity which provides information related to the magnitude of the load but not the direction (Rithalia and Kenney 2001). Therefore, whilst there might be both vertical and horizontal forces acting, these components are not resolved to find the direction of action rather only the vertical component is measured. This model is adequate for simple cases when,

- awareness of just the vertical component is sufficient and any horizontal components can be disregarded
- the subjects are stationary
- the characteristics of the subjects involved do not impose additional complexities, such as shape and deformation.

An example of such a case would be a book at rest on the surface of a desk, see figure 4-15. In this case the book is stationary and the only force acting is gravity and both interacting objects are flat, unyielding and of constant density.

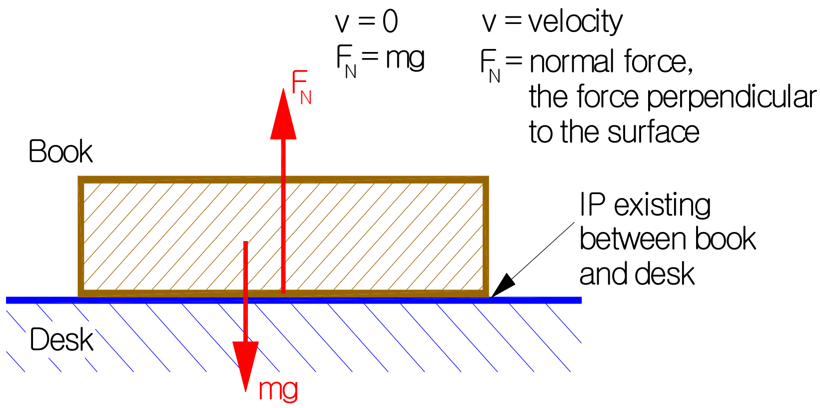


Figure 4-15 Forces acting between a book and a desk

This example is a simplification of real world cases, particularly with its lack of horizontally acting forces and the complexity of human anatomy. In the field of support surfaces it is not sufficient to be aware of only the vertical component of any forces acting, as the presence of a horizontal component has a direct bearing on the tissue, "*the mechanics of pressure ulcer formation are characterised by several key elements including magnitude, direction and the distribution of forces over the body surface and the tissue deformations associated with those forces*" (Brienza *et al* 2001). As force direction is important two additional models are also referred to.

Model 1:

This model is used when it is known that there are no horizontal forces acting. This type of contact is commonly referred to as direct pressure or simply as pressure, as used by both the EPUAP and NPUAP and is expressed as,

$$\textit{Pressure} = \frac{\textit{Perpendicular component of gravity force}}{\textit{Contact Area}}$$ (Reger *et al* 2005)

An example of such a case would be a motionless person lying completely flat in bed.

Case 1: IP found at the mid point of the back of the thigh, of a man motionless and lying flat in bed. For illustrative purposes the IP in this case was found to be 30mmHg

Both leg and bone are assumed flat and of constant density. The only force present is gravity.

With only gravity acting there are no horizontally acting forces. The resultant force is vertical and is referred to simply as pressure. Pressure acts only as a compressive force deforming the tissue by squashing the tissue between the bone and the support surface, see figure 4-16.

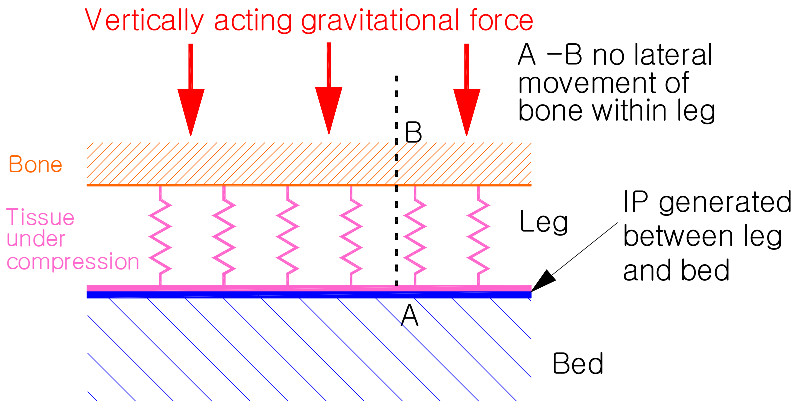


Figure 4-16 Mid point of a thigh lying on a bed, note there is no lateral movement of the bone with point B remaining over point A.

In real cases matters are more complex owing to both the leg and bone being of rounded irregular shape. Further, the distribution of bone, fat and muscle alters the density and mass of the leg across its length and width. Additionally, at the boundary between an area under compression and areas not under compression, the tissue in this region is subject to shear as the tissue under compression is pulled away from the tissue not under compression.

Model 2:

This model is used when it is known that there are horizontal forces acting. This type of contact is commonly referred to as *shear,* as used by both the EPUAP and NPUAP and is expressed as,

$$Shear = \frac{Tangential\ component\ of\ force}{Contact\ Area}$$ (Reger *et al* 2005)

An example of such a case would be a motionless person sat reclining in bed.

Case 2: IP found at the mid point of the back of the thigh, of a man motionless and sat up reclining in bed. For illustrative purposes the IP in this case was found to be the same as Case 1, 30mmHg

For illustrative purposes both leg and bone are assumed to be flat and of constant density. The leg is stationary. Gravity provides a vertically acting downward force. The angle of the torso creates a turning force which provides a horizontal component, see figure 4-19. This horizontal force is acting to push the leg down the bed. As this is a static model, the leg is prevented from sliding down the bed by another horizontal force, acting in an equal and opposite direction. This opposing force is a static frictional force. This force is a product of the gravitational force interacting with the support surface's coefficient of static friction (Gettys *et al* 1989).

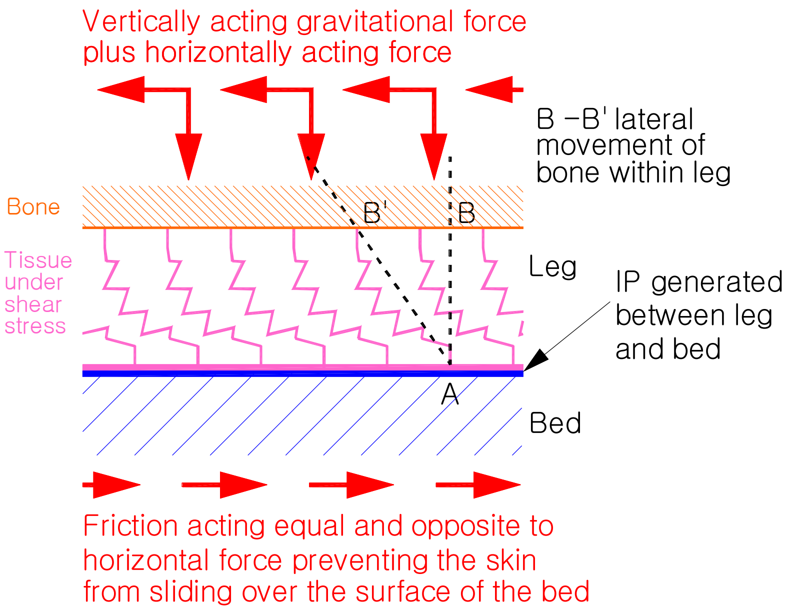


Figure 4-17 Mid point of a thigh lying on a bed, note the lateral movement of the bone with point B moving to point B'

With both vertical and horizontally forces acting not only is the tissue subject to compression but there is also shear. Shear stress, or tension, is the result of the lateral movement of the bone (B-B') within the leg, as the skin remains in place held by a static frictional force, see figure 4-17. Shear is therefore a pulling force which deforms the tissue by stretching, as the bone slides within the tissue. In real cases matters are more complex owing to both the leg and bone being of rounded irregular shape and not flat. Further the distribution of bone, fat and muscle varying the density and mass of the leg across its length and width.

As mentioned at the start of this section, IP measurements are scalar and so do not reveal the presence of any horizontally acting forces. Therefore, theoretically these two cases may provide the same IP measurements, however one case might be experiencing only pressure, as in Case 1, whilst the other might be experiencing pressure, shear and static friction, as in

Case 2. As a result even though both cases have the same IP reading, 30mmHg, Case 2 is at much greater risk of ulceration than Case 1.

Shear stress can only arise when a compression force, ‘pressure’, and a holding force, ‘friction’, is acting. Static friction is a resistance to an applied force brought about by the interaction of the normal force with the surface’s co-efficient of static friction, μ_s [3], see figure 4-18. Being an opposing force the static frictional force F_s will increase as the applied force F_a increases, until F_a becomes greater than $F_{s\ max}$. As F_a increases the shear stress in the tissue builds up. When $F_a = F_{s\ max}$ the tissue will be subject to its maximum shear as once $F_a > F_{s\ max}$, the object will move releasing the shear. As $F_{s\ max}$ is determined by the product of the normal force F_N and the coefficient of static friction μ_s, a reduction in either or both will reduce $F_{s\ max}$. With $F_{s\ max}$ reduced the maximum F_a can reach is reduced and so the maximum shear stress in the tissue is reduced.

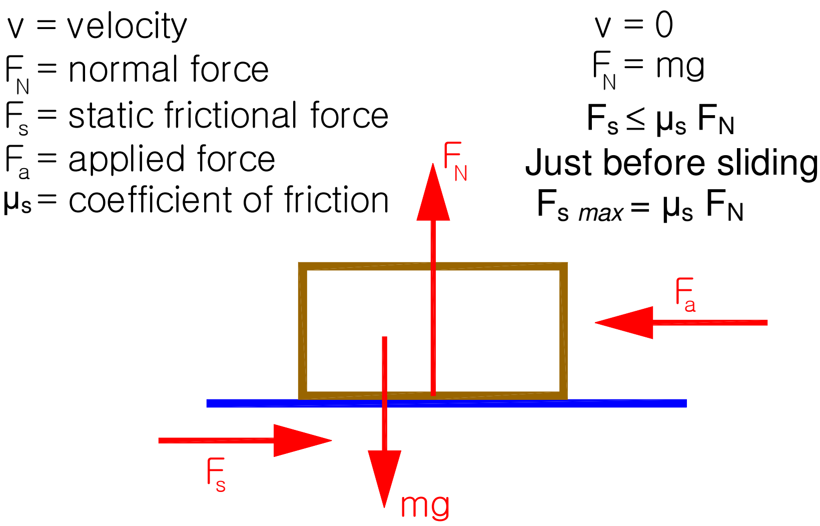


Figure 4-18 A diagram showing equilibrium between an applied horizontal force (F_a) and a static frictional force (F_s)

Shear forces typically arise when a patient sits up in bed, see figure 4-19. When the head of the bed is raised, if the static friction force is sufficient to prevent the patient sliding down the bed, the sacrum will move within the tissue. This movement creates shear stresses in the tissue between the sacrum and the skin. This will distort and wrinkle the tissue.

[3] Smooth, slippery surfaces have a low co-efficient of static friction, rough, gripping surfaces have a high co-efficient.

Before the body can slide down the bed, due to the skin slipping over the support surface, the shear force has to be greater than the opposing static friction force. Therefore surfaces with a high co-efficient of static friction, i.e. non-slippery, will allow high shear forces to build up in the tissue.

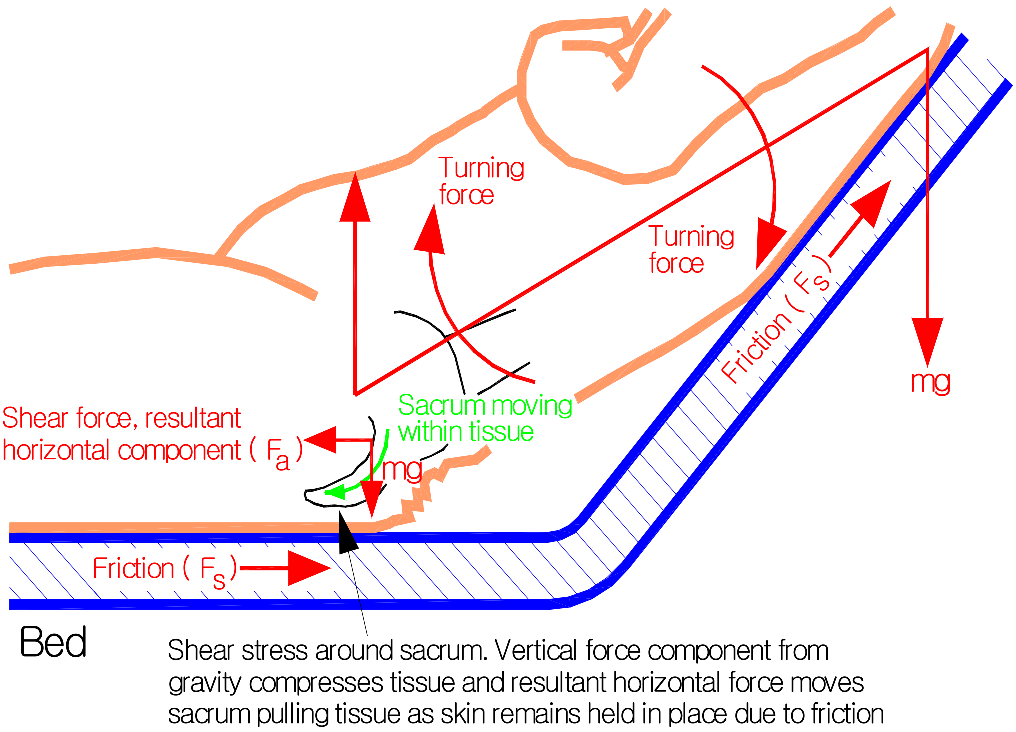


Figure 4-19 Shearing forces acting through the sacrum

It is impossible to generate shear stress without the presence of pressure and friction. Therefore pressure is the primary causative factor with shear and friction potential by-products. Although shear is a by-product of pressure it is by no means less significant than pressure. The presence of shear can enhance the destructive ability of compression by halving the pressure required to occlude the skin's vascular system (Agram and Gefin 2007). This would mean with the presence of shear the 32mmHg occlusion threshold would drop to 16mmHg. Fontaine is more emphatic suggesting, "*that shear may be 10 times more destructive to tissue than pressure alone*" (Fontaine *et al* 1998 cited Norman 2004, and Jones 2005).

It has been proposed that the destructive influence of shear might be related to capillaries lacking in tensile strength (Reger *et al* 2005) or possibly that the blood vessels approaching the skin surface perpendicularly are kinked by the sideways movement of the tissue and so are pinched closed occluding the blood flow (Reger *et al* 2007). However, the exact role that shear plays in the ulceration process and why it is so destructive is not well understood, as acknowledged by Fontaine, "*Although the effect of pressure against the skin in the development of skin ulceration is widely accepted, the pathophysiological effects of shear are less understood*" (Fontaine *et al* 1998).

It is important then that PR cushion design works to keep the maximum possible static friction force, $F_{s\ max}$, to a minimum to prevent shear stress from building up in the tissue to unsafe levels. This could be achieved by using a material with a very low coefficient of static friction. However the cushion also has to provide a secure surface, one that prevents the user from sliding into undesirable postures. This is achieved with a non-slip surface, one with a high coefficient of static friction. Therefore PR cushion design has to find a compromise, one which prevents slipping and still minimises $F_{s\ max}$. Ideally the prevention of slippage would be provided by some means other than the surface materials coefficient of static friction. This has led to some PR cushions to incorporate contouring of the surface into their design. A PR cushion which uses its surface shape to hold the user in position, rather than friction, is likely to subject it's user to less shear.

4.5.3 Kinetic Friction

It was found that many authors when writing about the causes of pressure ulcers cite the extrinsic factors of pressure, shear and friction, see sections 4.3.1 and 4.4.1. In this context authors generally use the one term "*friction*" to describe two very different phenomenon, static frictional force and abrasion. Although aware of these two phenomena by categorising them under the general heading friction, it does reveal a superficial understanding of the processes involved and perhaps a lack of awareness of their significance.

It has been found that friction increases the destructive quality of compression. Dinsdales work is often cited as work to confirm this. Dinsdale in 1974 applied pressure to pigs then pressure combined with friction. He found that when pressure alone was applied the pressure had to be in excess of 290mmHg for ulceration to occur. When friction was also applied the pressure required for ulceration dropped to 45mmHg (Dinsdale 1974). However, Dinsdale did not describe his method for applying friction so it is not clear whether he was referring to static friction, kinetic friction or abrasion.

It has been proposed that the destructive influence of friction might be related to the blood vessels being stretched (Reger *et al* 2005). As with shear the exact role that friction plays in the ulceration process is not fully understood, as recognised by Sharp, "*Further research is needed to establish the role of friction in the development of pressure ulcers*" (Sharp and McLaws 2005).

Static frictional force exists between two objects in contact when there is no relative motion, see figure 4-18, and abrasion is the rubbing effect which occurs between two surfaces when one is dragged over the other. For example a patient might be subjected to "*friction*" if dragged across a bed sheet, see figure 4-20, (Grey *et al* 2006).

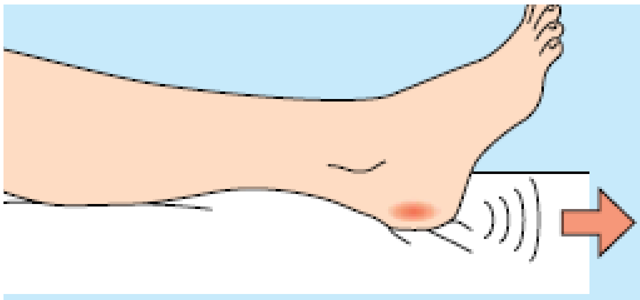


Figure 4-20 Friction forces generated when a patient is dragged across the bed (Grey *et al* 2006)

This rubbing can be the cause of tissue damage by the avulsion of sheets of epidermis and may even cause denuded areas of the dermis (Baranoski 2006). This can be particularly painful as it can expose nerve endings to the air (Ousey 2005). However this rubbing, widely described as friction, is not causing tissue damage by the application of unrelieved pressure but is causing damage through scrapping and tearing. This sort of damage is an abrasion, also known as a "*friction burn*", and is a trauma injury rather than a pressure injury. Abrasions can develop into pressure ulcers if subjected to unrelieved pressure. It is already recognised that minor cuts, scratches, bruises, burns are potential sources of pressure ulcers. These minor wounds have been included amongst the list of exacerbating factors under the category "*injury",* see section 4.4.4. Therefore PR cushion design has to manage the surface such that potential abrasive actions are avoided.

It is widely known that rough surfaces are more abrasive than smooth and that faster rubbing is more abrasive than slower. These are aspects of the kinetic frictional force. Kinetic frictional force exists between two objects when there is relative motion parallel to the contact surface. The kinetic frictional force is the force acting parallel to the surface and opposite to the velocity (Gettys et *al* 1989). Although key to abrasion there appears to be no recognition of this force in the literature. As with the static frictional force the kinetic frictional force is an opposing force and its magnitude is dependent on the force it is opposing. Hence greater velocities, and in the case of kinetic friction, greater coefficients of kinetic friction are more damaging. Therefore PR cushion design needs to mange the velocities involved in the relative motion between user and support surface and consideration given to the support surfaces coefficient of kinetic frictional force. This is particularly important when designing for ease of transferring into and out of the wheelchair.

4.5.4 Capillary Blood Pressure and Occlusion

Skin is supported by a network of vascular and lymph vessels, the microcirculatory system, to supply the nutrients and oxygen necessary for cell metabolism and to remove the resulting metabolic waste products. The blood capillaries transports the blood into the tissue and allows the exchange of nutrients, gases and other substances between the blood and the interstitial fluid (Morison 2001), the lymphatic capillaries remove the large molecules that cannot enter the blood capillaries such as proteins and when present cell debris and pathogens (Marieb 2001), see figure 4-21.

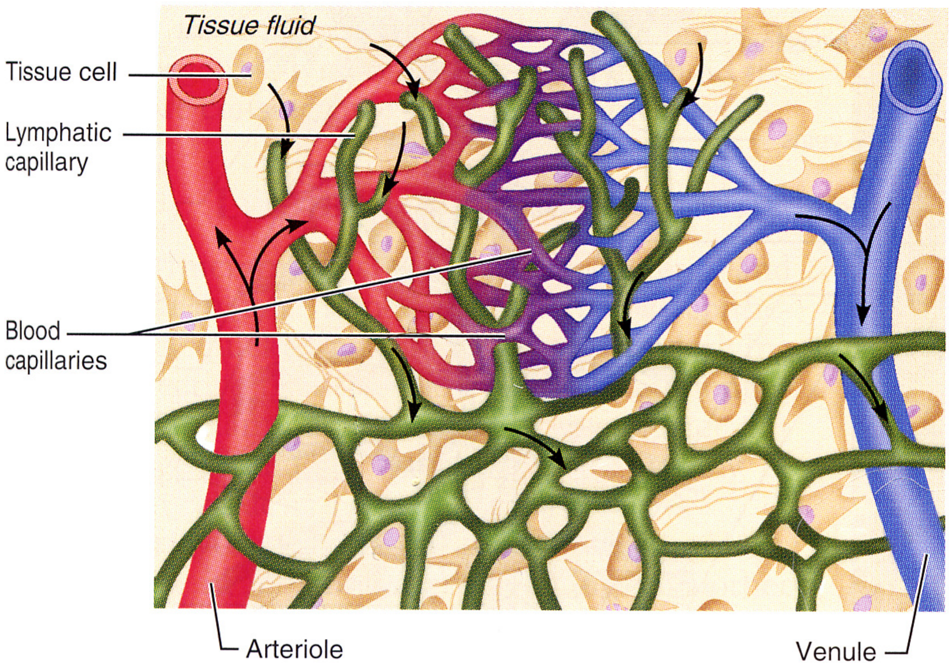


Figure 4-21 A network of blood and lymphatic capillaries (Mariab 2001)

Numerous authors suggest that when skin is subjected to compression pressures greater than the intra-capillary pressures, these capillaries collapse leading to tissue anoxia, a build-up of metabolic waste products and cell death (Agam and Gefin 2007, Bell 2005, Collier 2004, Jones 2005, Thompson 2005), see figure 4-22.

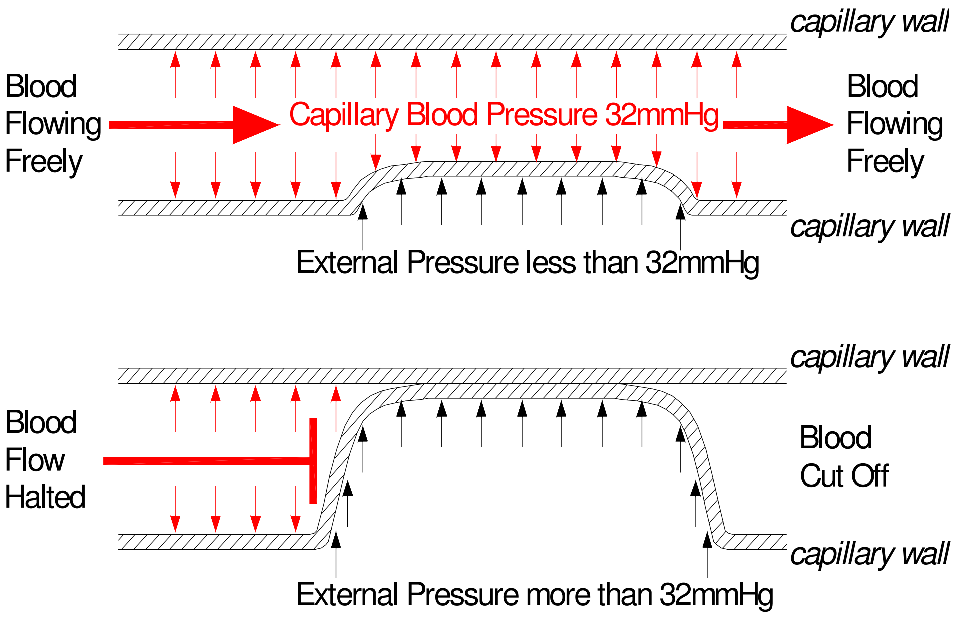


Figure 4-22 A diagram showing the walls of a capillary being squashed flat by an external pressure greater than the internal blood pressure and so being occluded

Almost without fail, authors writing about capillary occlusion cite at some point Landis's values for blood pressure in a human capillary loop, 32mmHg (Landis 1931). This citing tends to be in recognition of the fact that the value of 32mmHg is widely regarded as the occlusion threshold of capillaries. However, most of the more recently written papers having cited the 32mmHg threshold then go on to question its appropriateness. Issues raised in the literature with this 32mmHg value include,

- Landis' study only included healthy young volunteers (Collier 2004)
- 32mmHg was found using an invasive technique which is likely to have influenced the result (Jones 2005)
- the only capillaries tested were capillaries in the finger-nail beds of the test subjects (Norman 2004)
- 32mmHg is an average found in the arteriolar limb of the capillary loop whilst the average pressure in the venous limb is lower at 12mmHg (Fletcher 2001)

- one of the body's defence mechanisms against pressure is a self-regulatory mechanism which opens and closes local sphincters to allow capillary pressure to stabilise at levels higher than normal average values (Agam and Gefen 2007).

Possible issues not found in the literature are,

- the Bernoulli principle (Gettys *et al* 1989) acting within the capillary may well cause capillaries to snap shut when external pressures lower than the normal capillary blood pressure are applied. If the external pressure pressing on the capillary reduces the diameter of the capillary, then the flow of blood will increase dropping the pressure within the capillary. The drop in pressure within the capillary will result in a further decrease in diameter, speeding up the fluid flow which in turn drops the pressure still further.
- the two main forces acting on the blood as it passes through the capillary are the hydrostatic pressure of the blood and the solute potential of the blood (Barbor *et al* 2000). These can be affected by disease which will impact the efficiency of the vascular system making the tissue more vulnerable to pressure.

It was noticed that designers/manufactures are aware of the link made between capillary occlusion and tissue ischemia and that they equate capillary occlusion with capillary blood pressure, even though there is little evidence to confirm this. Further they have accepted Landis's capillary blood pressure value of 32mmHg (Landis 1931) and so have concluded that IP pressures of less than 32mmHg do not occlude capillaries and so regard pressures below this 32mmHg threshold as safe, "*Manufacturers of support surfaces adopt the theory that reducing interface pressures below occlusion pressure will prevent pressure ulcer development, despite the dearth of valid studies to support this*" (Norman 2004).

Increasingly Landis's value of 32mmHg for capillary blood pressure is being questioned, "*Contrary to traditional dogma, 32mmHg is not the magic number required to stop blood flow*" (Shelton and Lott 2003). Also there is growing criticism of its use in promoting PR equipment efficacy, some of which is caustic, "*Manufacturers promote their efficacy by comparing interface pressures with the magical capillary closing pressure of 32mmHg*" (Jones 2005). With Bader going further to conclude, "*32mmHg external pressure, as often quoted, is meaningless as other variables will impact on tissue and lymphatic drainage*" (Bader 2005). Despite this, manufactures continue to promote the concept that 32mmHg represents a safe IP threshold, "*Landis' observation (using a microinjection method) that 32mmHg capillary pressure is a threshold above which pressure ulcers occur is an often-used industry guideline for testing the effectiveness of a support surface*" (Reger *et al* 2007).

4.5.5 Pressure Gradients

When a body comes into contact with a support surface it is at the bony prominences where the greatest IP levels are found. When seated the bony prominences of primary concern are the ischial tuberosities. Whilst the area covering the ischial tuberosities are subject to the highest level of IP as one moves away from this area, notably down the hamstrings, the level of IP drops, see figures 4-23 and 4-24.

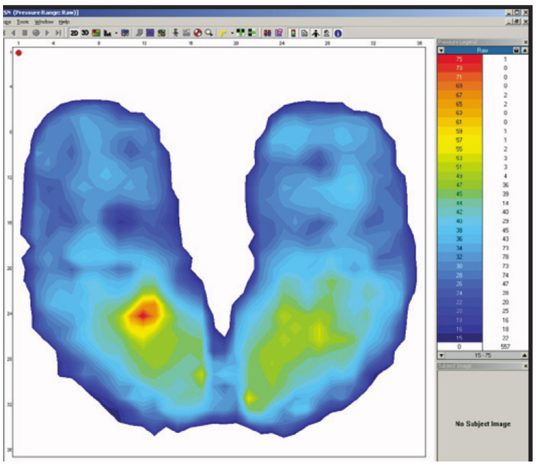


Figure 4-23 A 2-D pressure map revealing IP contours (Xsensor 2008)

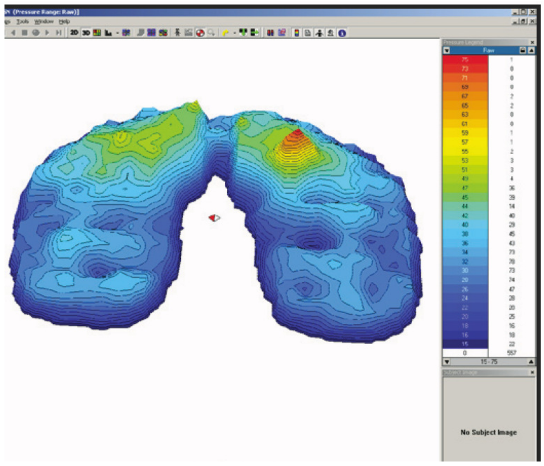


Figure 4-24 A 3-D graphical representation of IP levels (Xsensor 2008)

As can be seen in figures 4-23 and 4-24 the different areas of contact are subject to different pressures, under the ischial tuberosities the IP is high (red) whilst under the hamstrings the IP is low (dark blue). There is then a pressure difference between the ischial tuberosities and the hamstrings. This difference between pressures is referred to as a "*pressure differential*" and is the difference in pressure between two positions. The rate of change of pressure between two positions is the pressure gradient. For an example of a constantly increasing pressure gradient, see figure 4-25.

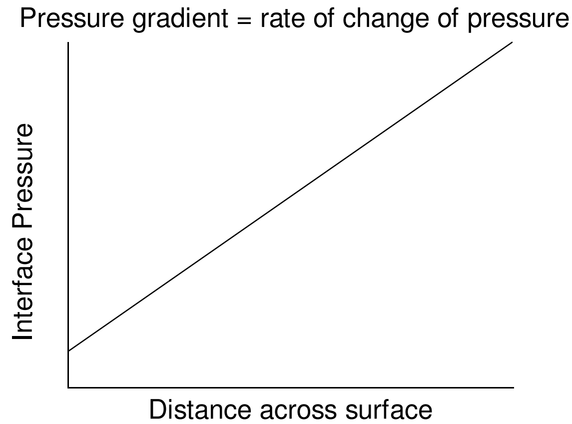


Figure 4-25 A graph showing the change in IP over the change in distance, the pressure gradient

An example of a pressure differential can be found where the leg extends beyond the front edge of a wooden chair, see figure 4-26. Note that in this example the popeliteal height of the seated person is too low allowing the popeliteal area to rest on the front of the chair, see figure 3-77.

Where a person's leg rests on the edge of the chair, a red mark will quickly develop on the skin, the first sign of pressure damage. However, the skin 10-20mm back in from this edge does not mark, even though the pressure is not significantly less than at the edge. It is thought that in this case the tissue at the edge of the chair is damaged not as a result of vascular occlusion but as a result of interstitial fluid draining away from the area under pressure to the surrounding areas under less pressure. This draining of fluid then increases the likelihood of intercellular contact and cellular ruptures (Brienza and Geyer 2000). The greater the difference between areas of pressure, the steeper the pressure gradient and the more pronounced the flow of interstitial fluid.

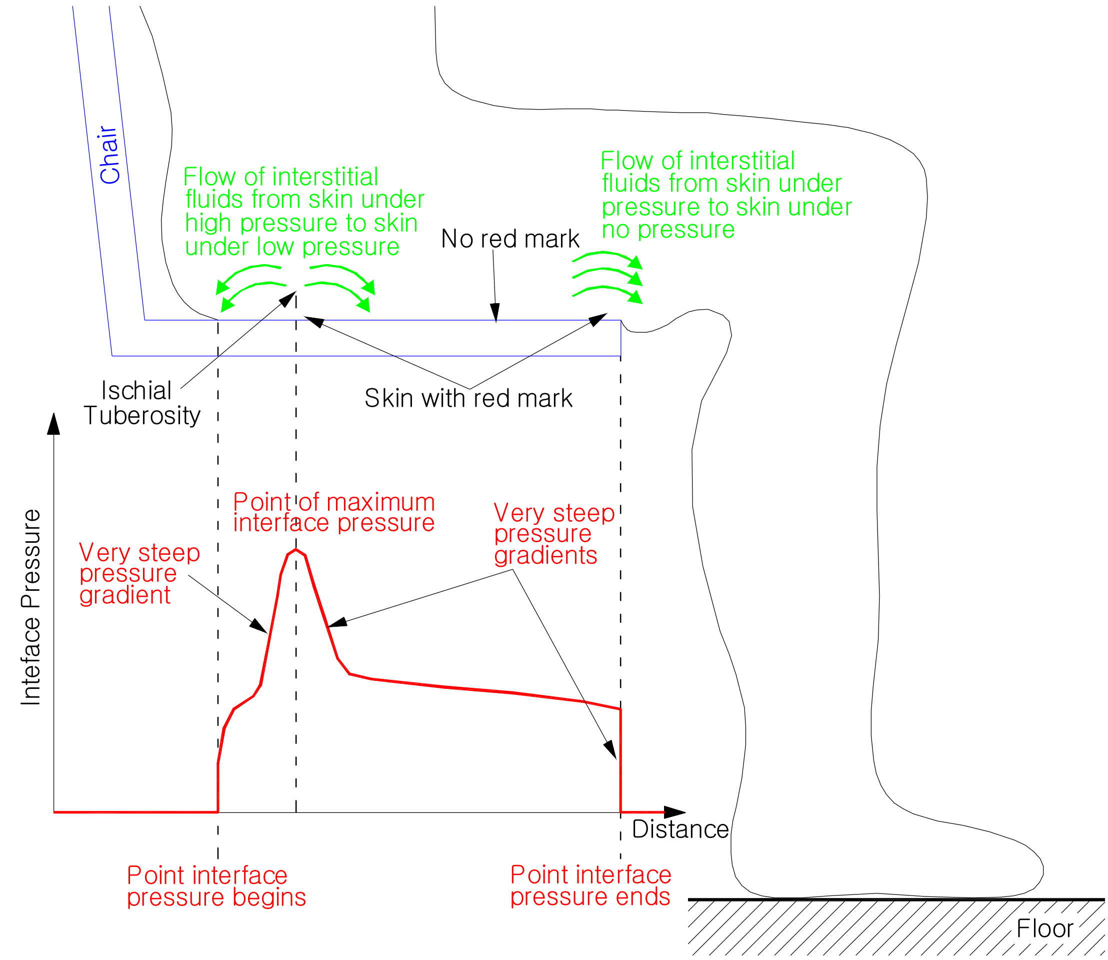


Figure 4-26 A diagram showing the pressure gradients at the edge of a seat and under the ischial tuberosities

In 2001, Brienza, whilst compiling a white paper on the state of the science on tissue integrity management, commented, "*Reddy et al proposed that it was the pressure gradient that induced the flow of interstitial fluid and thus they proposed that pressure gradients may be more significant in pressure ulcer aetiology than interface pressure (Reddy et al 1981)*" (Brienza *et al* 2001).

On the subject of IP, no material detailing the relationship between IP, pressure gradients and tissue damage was found and as such it is unclear as to the significance of the pressure gradient profile. For example, in the following case it is unclear from the literature which pressure gradient profile is more damaging to skin. Two pistons applying the same level of pressure create two different pressure gradient profiles, see figure 4-27.

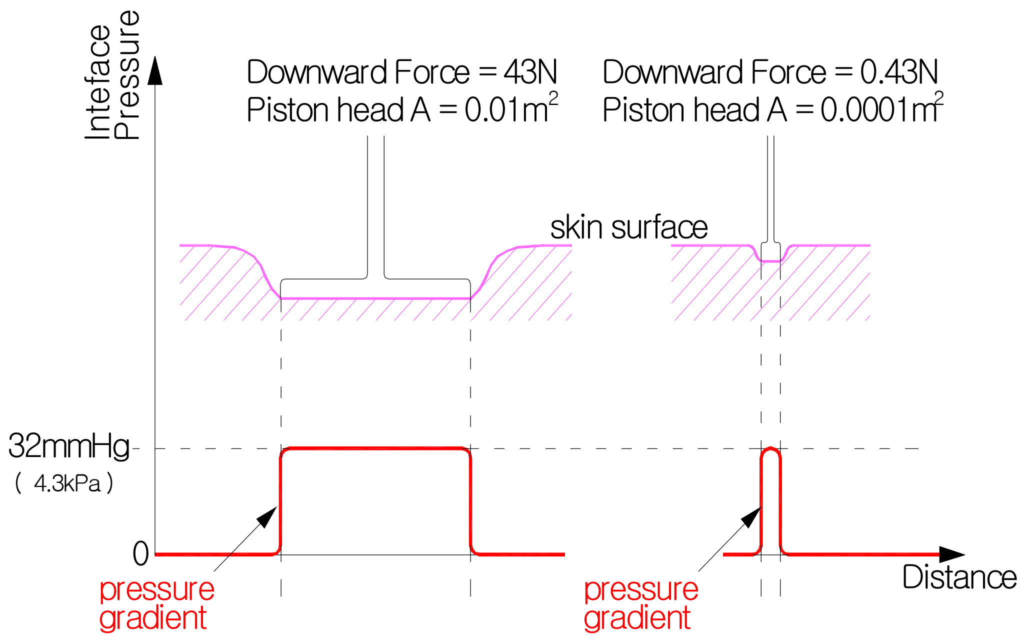


Figure 4-27 A diagram showing two different sized pistons applying the same IP but producing two different pressure gradient profiles

Although both profiles consist of two pressure gradients of the same angle and magnitude, with an IP of 32mmHg, the profiles are markedly different. The pressure gradient profile of the large headed piston is a wide flat plateau whilst the pressure grade profile of the small headed piston is a sharp spike. Which of these profiles is likely to have the most affect on the flow of interstitial fluid, if either, is unclear. It is however clear that the nature of the tissue distortion will be different; a broad deep constant pattern from the large headed piston and a sharp shallow point from the small headed piston. But again from the literature it is unclear which is more damaging. This is a very important matter with regards to PR cushion design. In particular, the dynamic approach to PR cushion design relies on alternating cells to support the weight of the patient. The size of these cells and their arrangement will determine the pressure gradient profile, see figure 4-28.

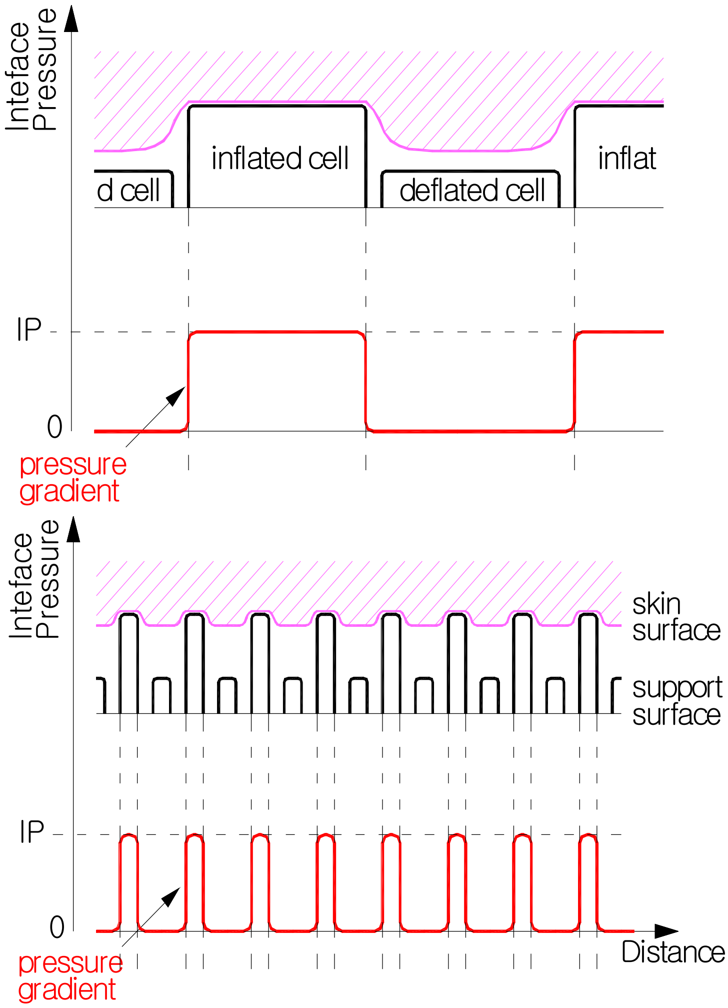


Figure 4-28 A diagram showing two different dynamic cell arrangements applying the same IP but producing two different pressure gradient profiles

Additionally, whilst interstitial fluid flow and the potentially damaging consequences of cell-to-cell contact (Collier 1999) are often commented on, the possible significance of pressure gradients, relative to tissue ischemia and capillary occlusion, do not appear reflected in the literature. This imbalance in research was also identified by Brienza, "*Other mechanical factors studied include pressure gradient, shear force, and tissue deformation, although investigations studying these factors are far less common than those focusing on pressure alone*" (Brienza *et al* 2001).

Looking at pressure gradient profiles may also indicate where tissue is experiencing shear stress. Where there is an asymmetrical pattern of IP contours the tissue will be under tension, in this context this tension is referred to as shear stress, see figure 4-29. Note that similarly to figure 4-26 the popliteal height of the seated in figure 4-29 is too low.

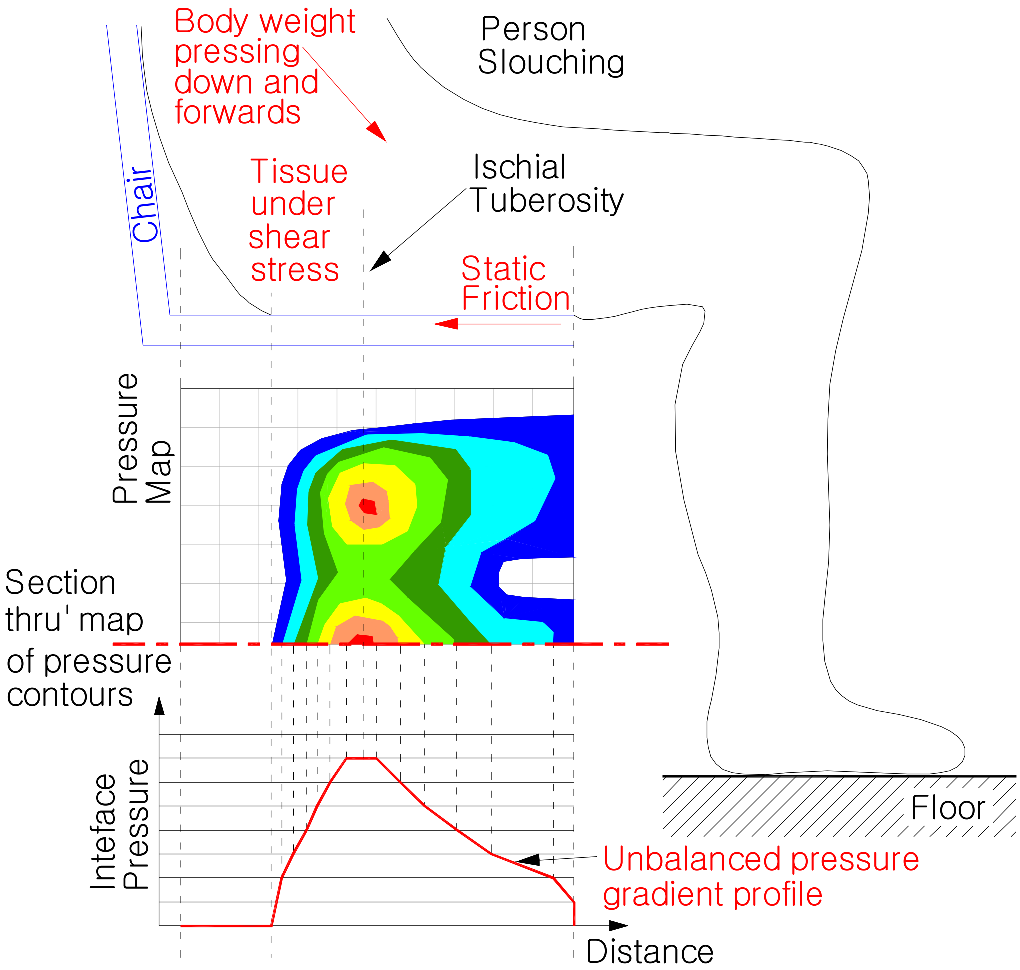


Figure 4-29 A diagram showing how shear stress is revealed by an unbalanced pressure gradient profile

The concept that shear stress is related to pressure gradients has already been considered. Hobson reported that his findings suggest that the steeper the pressure gradient between two points the higher the induced shear stress. Hobson did not elucidate this matter further (Hobson 1992).

Perhaps the potential of pressure gradient profiles remains largely unrecognised due to the primacy IP holds in how pressure ulcers are understood to develop. Certainly at this time, PR equipment evaluations such as MHRA 03129 (Bain *et al* 2004a) and MHRA 04101 (Bain *et al* 2004b)[4], continue to focus on peak and mean IP and disregard pressure gradients.

[4] These evaluations were conducted for the Centre for Evidence-based Purchasing (CEP) of the NHS Purchasing and Supply Agency (PASA), formerly the Device Evaluation Service (DES) of the Medicines and Healthcare product Regulatory Agency (MHRA)

4.5.6 Tissue Distortion

When pressure is uniformly applied it does not cause pressure ulcers. For example, a deep-sea diver when at depth is enveloped by water and is continuously subjected to water pressures of up to 1,000mmHg, possibly for many hours without relief. This pressure, although extreme, acts uniformly on the body and so does not distort the tissue, thus the diver is not at risk of developing a pressure ulcer from water pressure (Lowthian 1982). It is only when pressure is applied non-uniformly that tissue is distorted and consequently put at risk of tissue damage (Brienza *et al* 2001).

When a person is in contact with a support surface the skin is subject to IP which is non-uniform across the contact area. When non-uniform IP is applied to the skin the tissue is distorted which in turn crushes and kinks the vascular network disrupting the skin's normal functions which can lead to tissue necrosis, see section 4.4.2. The potential for external pressure to distort tissue does depend on the location of the body being subjected to the pressure. It is currently understood that pressure on the bony prominences increases the stresses and strains in the tissue around the bony prominence which in turn increases the level of distortion, see figure 4-30.

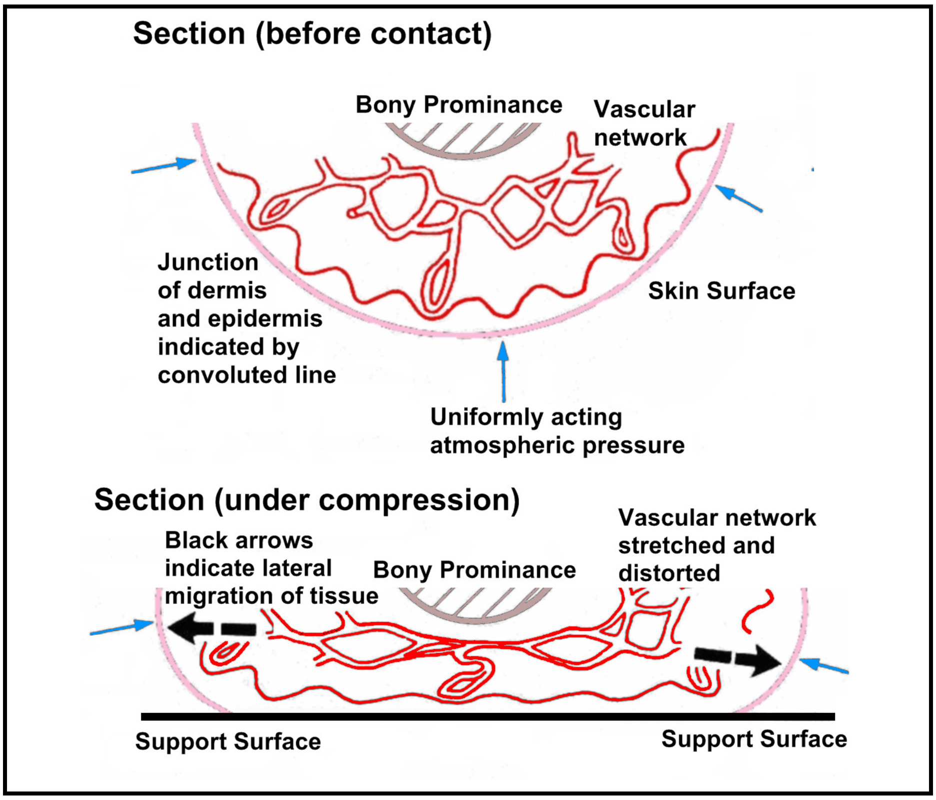


Figure 4-30 The distortion of soft tissues when under compression

IP mapping does not reveal the full picture of the internal tissue distortion, which result from the stresses built-up deep in the tissue. Le found using pressure needles inside the tissues of a pig model that the stresses inside the tissues increase considerably with depth. Le recorded a pressure of 47mmHg at the skin surface which increased to an internal pressure of 270mmHg at a depth of 12.5mm from the surface (Le *et al* 1984 cited Agram and Gefin 2007). Considering Le's work with his own, Agram concluded that, "*Measuring interfaces pressures alone, therefore, hardly gives the full picture of the risks developing inside the muscle*" (Agram and Gefin 2007). Le's work with pigs is in line with Gefin's work. Gefin constructed a physical phantom of the buttocks, which incorporated bovine muscle tissue and a geometric replica of the human ischial tuberosities, and found that the internal muscle stresses directly under the ischial tuberosities were five to eleven times greater than the muscle-support interface pressures. From this work Gefin concluded that "*interfacial body-support pressure measurements to evaluate the performance of mattresses and wheelchair cushions in preventing DTI* [deep tissue injury] *can be misleading*" (Gefin and Levine 2007).

As found by this review, the level of IP is not necessarily proportional to the amount of tissue distortion. The presence of a bony prominence pressing downwards distorts the tissue, and the presence of tangential forces increases the internal shear stress and so increases the amount of distortion experienced by tissue, see figures 4-30 and 4-31.

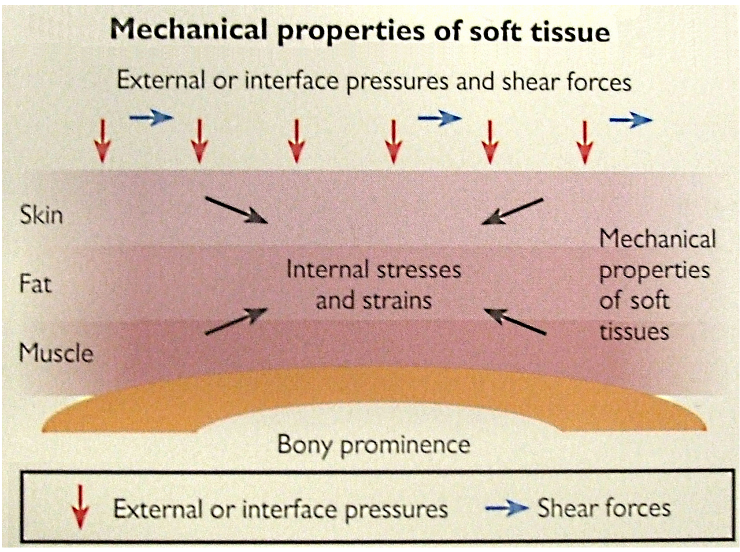


Figure 4-31 A diagram of the internal stresses and strains acting to distort the soft tissues (Bader 2005)

As with bony prominence and shear, the pattern of IP across the contact surface is important. Steep pressure gradients, as found at the front edge of a chair when the popliteal height is too low, see figure 4-32 will be more distorting than gradually declining IP, shallow pressure gradients, even if the peak IP is greater. Further, such IP differences carry the additional damaging characteristic of driving interstitial fluid flow.

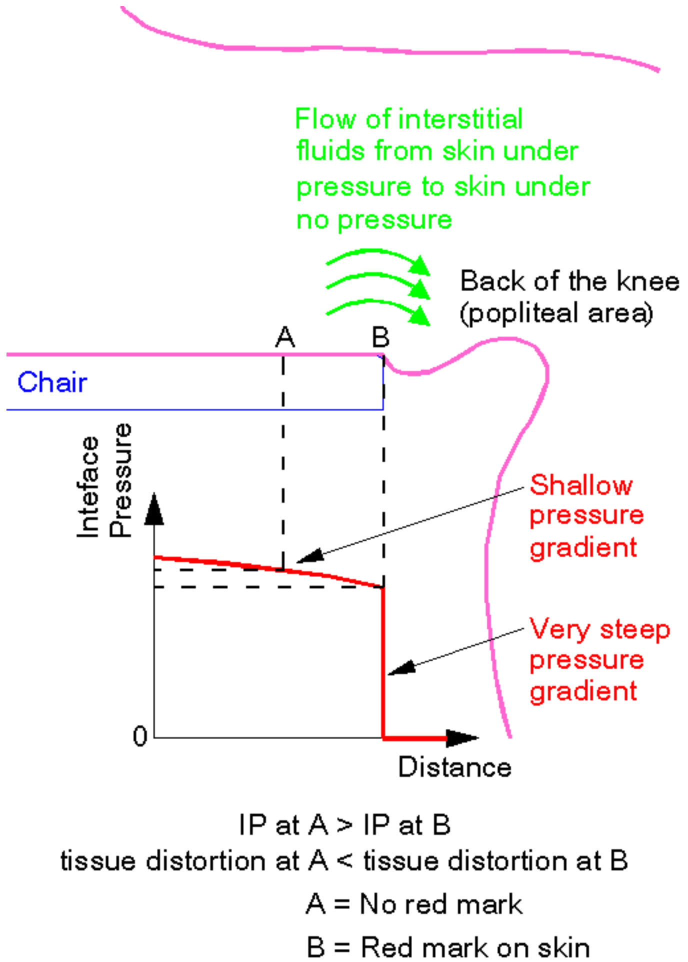


Figure 4-32 A diagram showing two points along the hamstring; point A is subjected to a higher level of IP than point B

Whilst the level of IP is important it is the extent of the tissue distortion which appears paramount not the level of IP. There is a real possibility that the level of distortion is more important than the level of IP. As identified by Levine (1990) who proposed that the quantification of tissue shape and deformity would provide a "*superior characterization of the seating interface*". Levine also noted the restrictions to this approach due to the current technical limitations of measurement systems (Levine *et al* 1990). If tissue deformity is more important than IP then this is a significant development for PR cushion design, affecting both the static and dynamic concepts.

In the case of static cushions, the principle of pressure reduction has been of benefit not because the IP the user is subjected to is reduced to below a safe threshold, but because immersion and envelopment has been minimising tissue distortion and flattening pressure gradients. This difference, whilst subtle, is significant as it would require a change in how cushions are perceived. This perception would have to change from one where the aim is to manage IP, to one where the aim is to manage the shape of the body so that tissue distortion is minimised and pressure gradients are smoothed out.

In the case of dynamic cushions, the principle of pressure redistribution starts to display some inherent weakness. Although localised areas of skin suspended over deflated cells might be temporarily relieved of IP they are still distorted as the skin sags into the unsupported space left by the deflated cell. Possibly of greater concern is the flow of interstitial fluid. Interstitial fluid is first driven out of the tissue compressed by the inflated cells to swell the relieved tissue suspended over the deflated cells. On the next inflation cycle, when the cells alternate from inflated-to-deflated and deflated-to-inflated, this fluid is then driven back from the swollen tissue in to the desiccated tissue. A potentially damaging cycle of fluid flow resulting in a reperfusion injury, see section 4.5.8.

4.5.7 The Pressure Intensity-Duration Relationship

The first well recognised work this review found towards understanding the nature of the pressure intensity-duration–tissue damage relationship was conducted in the 1950's. Before this time, understanding of the pressure-duration-damage relationship was limited to a simple awareness that the relief of pressure at frequent intervals prevented pressure ulcers, e.g. Nightingale's two hour patient turning. The seminal work into the pressure–duration–tissue damage relationship, for example by Husain (1953); Kosiak (1959); and Reswick and Rogers (1976), form the foundations of this understanding and are still cited in contemporary reference material such as by Morison (2001) and Simpson (1997).

The first work found was by Husain, who in 1953 applied pressure to the skin and muscle of rats and varied the intensity and duration. Although he did not mention any relationship between intensity and duration in terms of a parabolic curve he did find that there was a relationship between intensity, duration and damage. Of significance, he found that pressure of a high enough intensity must be applied for a sufficient duration before damage would occur, "*Clearly a threshold pressure of 100mmHg for 2hours must be reached in order to produce definite microscopic changes in the muscle of the rat's leg*". He also found that, "*low pressures maintained for long periods of time induce more damage than high pressures for short periods. The time factor is thus more important than pressure intensity*" (Husain 1953).

This work was followed by Kosiak who in 1959 conducted a series of experiments with dogs. Kosiak applied a series of different pressures, (*intensities*) over a range of differing time spans (*durations*). Plotting these results, see figure 4-33, Kosiak found an inverse non-linear relationship between intensity and duration.

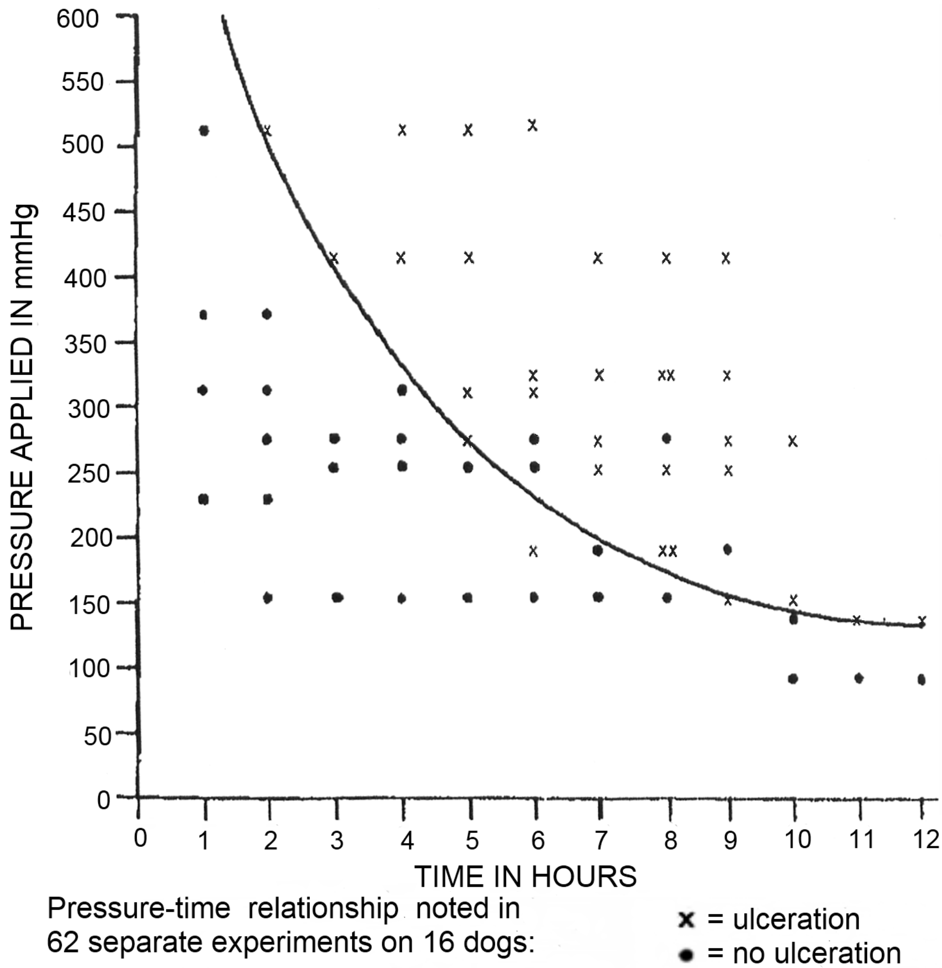


Figure 4-33 Graph plotting results of ulceration on dogs (Kosiak 1959)

As the duration was increased the intensity required to cause an ulcer decreased. Kosiak found that pressures of up to 600mmHg, far above the capillary occlusion threshold of 32mmHg, could be tolerated without inducing damage as long as it was relieved in under an hour.

As Kosiak did not differentiate between degrees of pressure damage, he was unable to draw distinctions between the severity of the damage induced after a period of high pressure for a short duration, and the severity of the damage induced after a period of low pressure for a long duration. Kosiak does not conclude that time is more important than pressure in the same manner as Husain (Kosiak 1959).

Considering the number of results plotted by Kosiak, the curve that he has drawn should be treated with caution. The following graph includes an alternative line which has been added guided by the Kosaik's results, Kosaik's curve has been retained as a dashed line, see figure 4-34. Without more results plotted it is not possible to know, with confidence, which line is reflective of the pressure intensity-duration relationship.

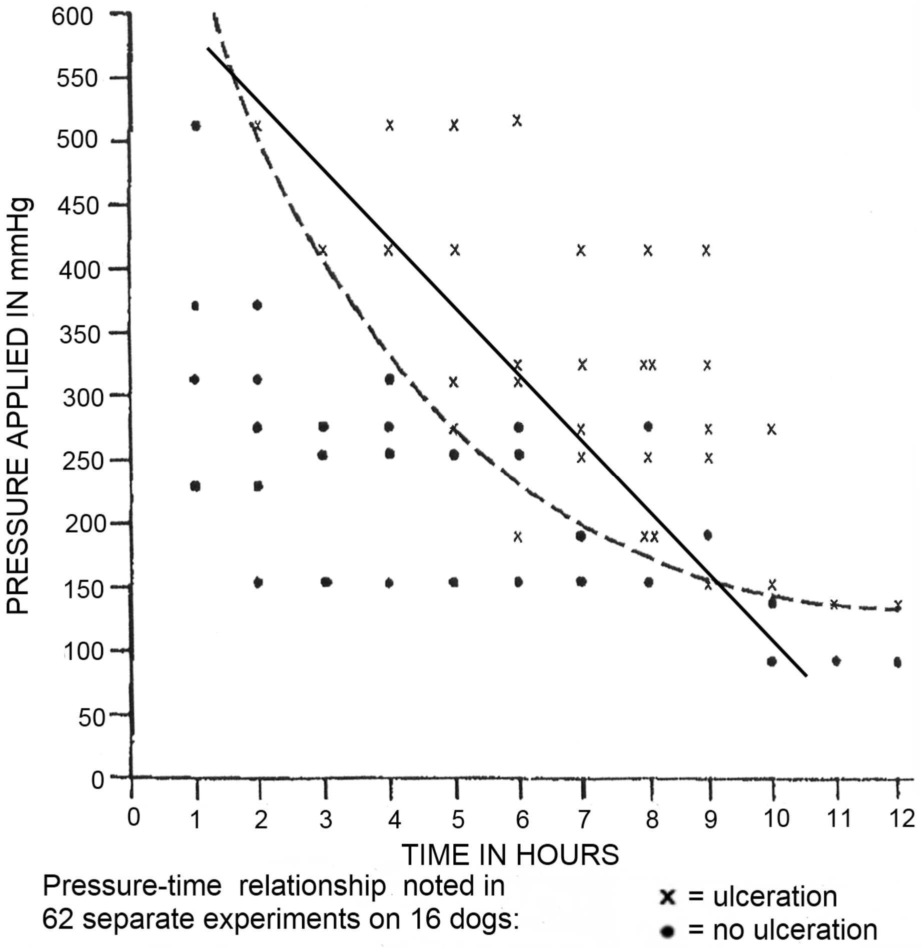


Figure 4-34 A graph based on Kosaik's 1959 work with two different lines drawn from the plotted results

Kosiak continued with this work and in 1961 applied pressures ranging from 35mmHg to 240mmHg to the muscles of rats for periods of one, two, three and four hours and examined the tissue microscopically. He found that only once the pressure applied was raised above a critical pressure threshold (35-70mmHg) and the application lasted beyond a critical time threshold (1-2 hours) would damage occur. This time Kosiak did record the degree of microscopic change. He found that pressures up to 190mmHg did not induce any changes in the tissue until it had been applied for longer than two hours, and that after four hours the extent of the damage produced would be the same whether 70mmHg of pressure had been applied or 240mmHg (Kosiak 1961). This result was consistent with Husain's earlier work with rats (Husain 1953). Based on these findings Kosiak concluded, "*Since it is impossible to completely eliminate all pressure for a long period of time, it becomes imperative that the pressure be completely eliminated at frequent intervals in order to allow circulation to the ischemic tissues*" (Kosiak 1961). This quote, or a variation of it, is often cited in literature in relation to the dynamic concept of PR cushions, for example by Brianza (Brianza and Geyer 2005).

Both Husain's and Kosaik's work were with animals, it would not be for another seventeen years before the intensity-duration relationship in humans would be the subject of a widely recognised study. In 1976 Reswick and Rogers accumulated data from actual patient experience. In total they amassed 980 observations from which they developed their own "*Parabolic Intensity-Duration Curve"* (Reswick and Rodgers 1976), see figure 4-35.

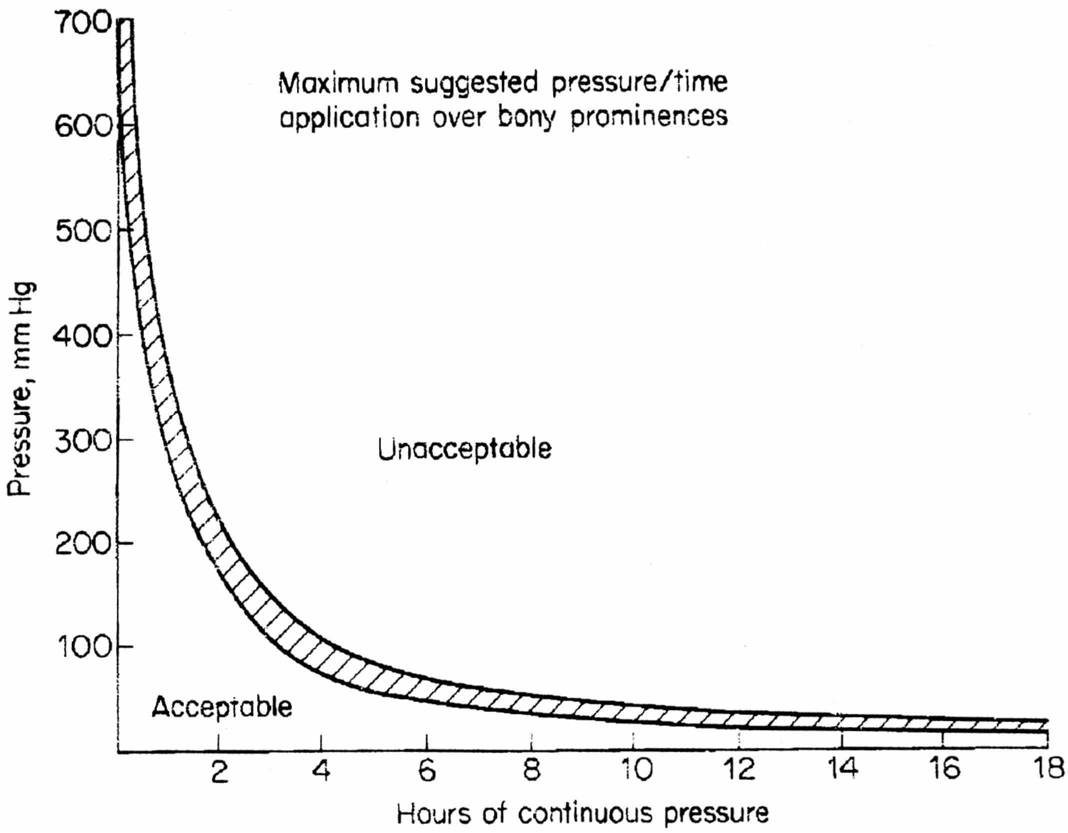


Figure 4-35 The Reswick and Rodgers parabolic pressure intensity-duration curve (Reswick and Rodgers 1976)

This curve corroborates the principle of an inverse intensity-duration relationship, as found by Kosiak, but the positioning and shape is markedly different. Kosaik's curve would suggest that 500mmHg could be tolerated safely for two hours whilst Reswick's curve would suggest 500mmHg could be tolerated for no more than fifteen minutes. Further, Kosaik's curve would suggest 100mmHg could be safely tolerated for at least twelve hours whilst Reswick's curve would suggest that only a maximum of 20mmHg could be tolerated for twelve hours. The most significant difference between Kosaik's curve and Reswick's curve is that Kosaik's curve is suggestive of a clear safe margin of tolerable pressure and time whereby only once the pressure applied was raised above a critical pressure threshold and the application lasted beyond a critical time threshold would damage occur, see figure 4-36.

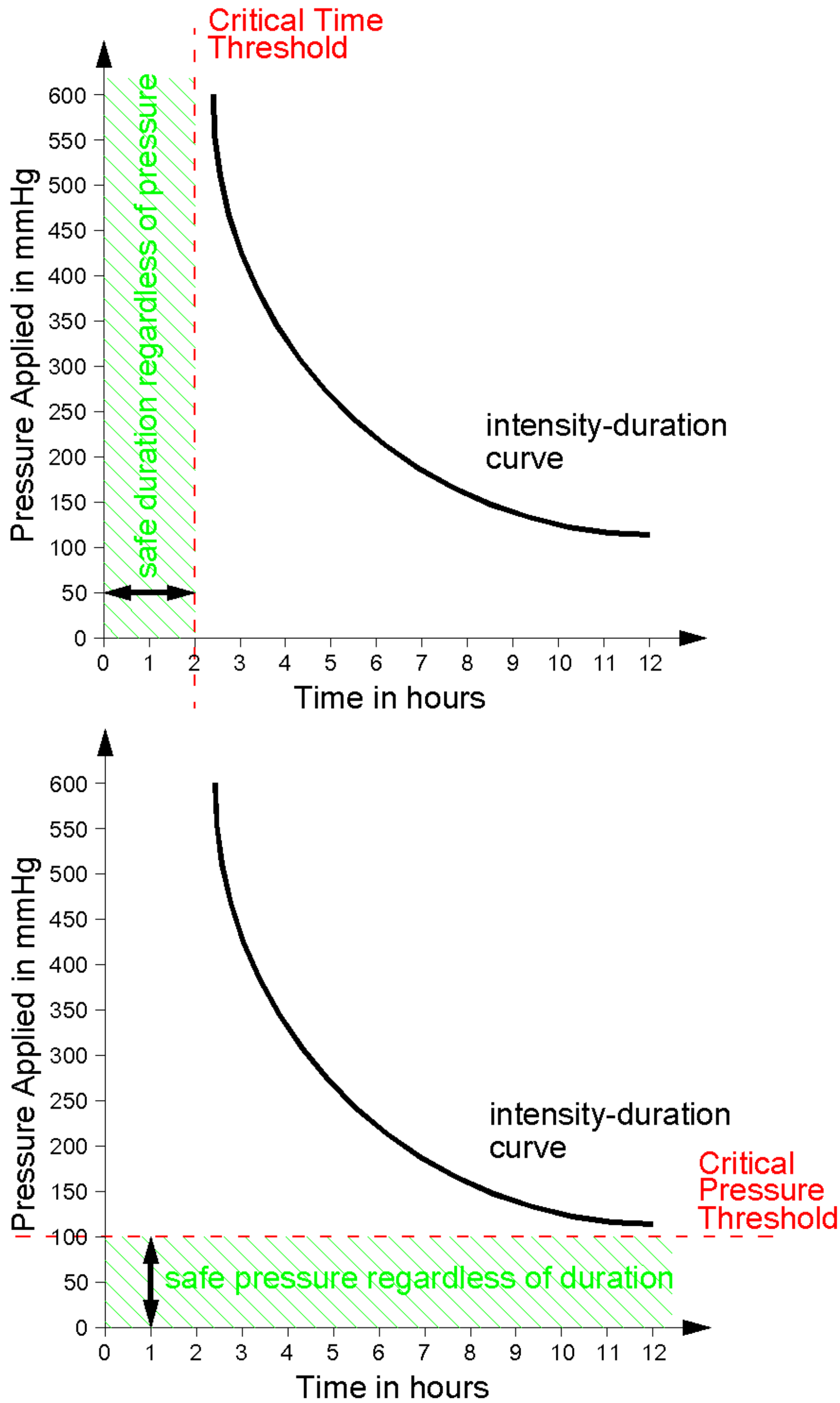


Figure 4-36 Pressure intensity-duration curves based on Kosiak curve with the critical thresholds marked

Unlike Kosaik's curve, Reswick's curve has thresholds found just beyond the zero axis, with the curve making contact with the pressure axis at approximately 600mmHg and approaching the time axis after eighteen hours, see figure 4-37.

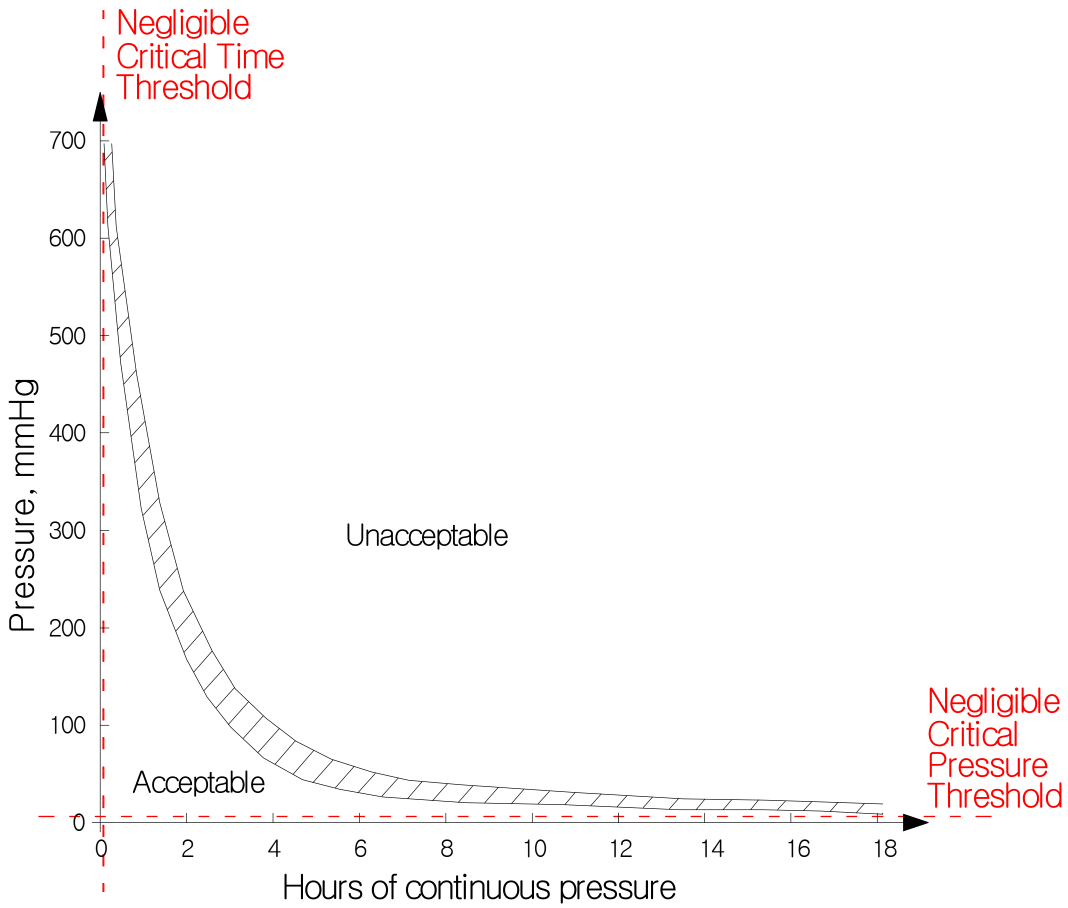


Figure 4-37 Reswicks pressure intensity-duration curve with the critical thresholds marked

Reswick's curve is a significant result as it challenges the concept of safe thresholds. Such a challenge has implications for the design of PR cushions as both the static and dynamic approaches to PR cushion design rely on the concept of safe thresholds.

Static cushions aim to prevent pressure ulcers by reducing IP to below some safe level. This pressure-reducing principle is based on the concept of a critical pressure threshold, which is often regarded to be 32mmHg, see section 4.5.4. Theoretically pressures below this critical pressure threshold can be tolerated for any length of time, thereby enabling the user to sit safely for any length of time. Without a critical pressure threshold there is no safe pressure threshold below which the user can sit indefinitely without being at some risk of pressure damage. Considering Reswick's curve, the pursuit of static cushions to reduce IP to below some safe IP level appears mistaken. All static cushions can do is improve the time intervals between episodes of pressure relieving. At present the advice from the NSIC is that regardless of which cushion used, pressure relieving should be performed for 60-90 seconds every half hour (Ratcliffe and Rose 2000). This is in spite of Reswick's curve suggesting IP of less than 32mmHg is safe as long as the duration is kept under ten hours.

Dynamic cushions aim to prevent pressure ulcers by alternating localised load bearing points of contact underneath the user before the pressure on these points have had sufficient time to cause damage, see section 3.2.2. This pressure-redistribution principle is based on the concept of a critical time threshold. Theoretically any pressure intensity can be tolerated if removed before exceeding the critical time threshold, so by alternating the points of contact within the safe period under the critical time threshold the user is safe from damage regardless of the pressure experienced at the points of contact. Without a critical time threshold IP once more becomes a hazard no matter how short the duration. According to Reswick's curve once the IP is above 580mmHg there is no safe period, and that tissue will be at risk of damage no matter how quickly the points of contact are rotated. This is noticeably different to Kosaik's curve which suggests that any pressure is tolerable so long as it is removed in under an hour.

The difference between Kosaik's and Reswick's curves most discernibly lies with their choice of test subjects.

- Kosaik's curve - experiments with dogs
- Reswick's curve - observations of humans.

This difference is significant as the composition of animal skin can be quite different from human skin. A matter identified by Thompson, "*dogs are loose-skin animals that do not have subcutaneous tissue to cushion a load. Extrapolating any effects recorded on dogs to human skin is therefore questionable*" (Thompson 2005). Further, the human microvasculature in skin and muscle is much more complex than both rat and pig, the most highly used animals in pressure ulcer research (Salcido *et al* 2006).

A second distinction between Kosaik's and Reswick's curves is the health status of the test subjects

- Kosaik's curve - healthy dogs
- Reswick's curve - patients in hospitals.

Kosiak performed his experiments on dogs whose health status is not commented on, therefore is presumably healthy. Reswick does not allude to the specific type/condition of the patients but did comment that each patient's skin and general health were different. The matter of health is significant as found by Daniel. In 1981 Daniel produced a pressure intensity-duration curve in normal swine and found the curve to be more in line with the Kosiak curve than with Reswick's, with 200mmHg taking fifteen hours to cause skin breakdown. However from this work Daniel did hypothesise that changes in soft tissue condition resulting from paraplegia, infection or repeated trauma can significantly lower the pressure-duration thresholds (Daniel *et al* 1981).

It was noticed whilst comparing Kosaik's with Reswick's curve that it was not possible to directly compare them as the exact level of tissue damage from which they were formulated is unknown. Kosaik's described the points plotted on the curve simply as "*ulceration*". It is not known if Kosiak was referring to an initial break in the epidermis, in which case he would be referring to a grade 2 ulcer, see table 4-1. In the case of a grade 2 pressure ulcer pressure damage has already occurred before the line of the curve is drawn.

Reswick described his curve as an "*allowable pressure vs time*" curve. This curve was not drawn using a certain degree of tissue damage. It is not known if Reswick based his curve on the first signs of tissue damage, a grade 1 ulcer.

If Kosaik's curve was based on grade 2 ulcers and Reswick's curve on grade 1 ulcers then it is not possible to directly compare these two curves.

A curve which has been drawn by plotting points of equal damage, be it a grade 1 or grade 2 ulcer, does not communicate the extent of damage at different intersections of intensity and duration. For example, the Kosiak curve indicates that ulceration occurs seven hours after 200mmHg has been applied. This curve does not inform the reader how much damage can be expected if 200mmHg is applied for nine hour or 16 hours. From such intensity-duration curves it remains unclear whether high pressure for short periods is more or less damaging than low pressure for long periods.

It was noted that the curves produced by animal experiment were produced under controlled conditions which meant that the extrinsic, intrinsic and exacerbating factors of pressure ulcer development were very much controlled if not eliminated. In particular these animal experiments were structured so that only vertically acting direct pressure was tested and so the effect of shear and friction was not taken into account. This weakness in the design of previous animal experiments was identified by Bennett whilst studying the shear forces generated at the rims of the piston heads used to press onto animal soft tissue (Bennett and Lee 1988 cited Thompson 2005). Shear and friction, along with any other risk factors, being affect modifiers multiply the impact of pressure, see section 4.5.2, and so will alter the shape of any intensity-duration curve and with it their pressure duration thresholds, see figure 4-38.

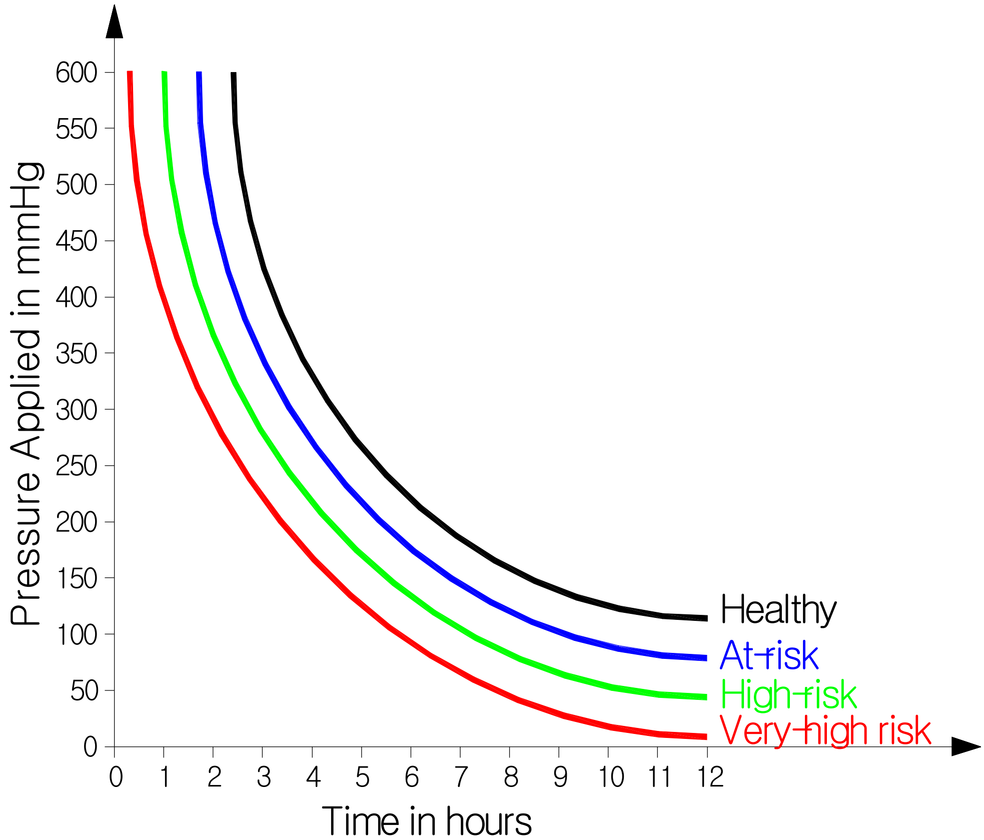


Figure 4-38 Average pressure intensity-duration curves for the different risk categories

It is clear that there is an inverse relationship between pressure intensity and the duration of pressure application. It is equally clear that this relationship is not fixed and standard, rather it is subject to various influences particularly from factors such as health. With such variability it is unlikely that there exists one generic curve, although it might be possible to formulate generalised average curves for certain sets of circumstances, for instance average curves for,

- different risk categories - at-risk; high-risk; very-high-risk; see figure 4-37
- different age ranges - 20-30 years; 30-40 years; 40-50 years; etc
- different patient groups - paraplegics; amputees; orthopaedic cases; etc.

Even such average curves may not be valid because the potential variability is too great. Particularly as each individual's curve will fluctuate depending on which causative/contributing factors are involved at any given time be it the nutritional status of the individual, the medication they are taking or whether moisture is present. Also, although not discussed here it is likely that the intensity-duration curve will be different relative to the various sites of the body, buttock, elbow etc. These difficulties with banding were identified some time ago. In 1998 Bader wrote, "*There are many instances, which demonstrate that a single pressure value or range, or band, of values would not be appropriate as a guideline to alert the clinician of potential areas of tissue breakdown in all patients. For this, some measure of tissue viability is required, which is dependent upon an adequate supply of nutrients as supplied by the blood*" (Bader 1998). With this intensity-duration curve, notably the critical thresholds, being a constantly changing variable there is limited value in trying to design PR cushions based on the concept of a fixed "*safe*" threshold, notably a "*safe*" threshold of 32mmHg.

It is perhaps due to the difficulties in defining an intensity-duration curve that there is comparatively little research into what is an important aspect of the development of pressure damage. In particular, there is a shortage of information as to the affect slight differences in pressure has on the skin, as noted by Clark, "*Virtually no information is available on the biological significance of differences in surrogate outcomes. For example, does 5mmHg difference between contact pressures exerted at the sacrum have any relevance for the prevention or healing of pressure ulcers? How big must the difference in contact pressure be before clinically relevant changes in skin condition are observed?*" (Clark *et al* 2005). These questions are very important when designing PR cushions and regarding their efficacy with information from a pressure map using a scale with increments of 1mmHg.

4.5.8 Reperfusion Injury and Repeat Pressure Loading

When sufficient pressure is applied to tissue, the micro vascular network is compromised as the capillaries are occluded. Capillary occlusion is widely believed to occur once compression pressure is above the intra-capillary pressure, see section 4.5.4. In such an event the function of both the vascular and lymphatic systems are impeded if not completely halted. The consequence of this breakdown of service is tissue anoxia and a build up of metabolic waste products, metabolites. This situation is described as the metabolic deficit and if allowed to persist long enough will result in tissue necrosis and possible ulceration. If the pressure is removed before tissue damage occurs, the tissue responds to this metabolic deficit with a mechanism known as reactive hyperaemia (Morison 2001).

Reactive hyperaemia is a process of the body used to revitalise ischemic tissue by increasing the flow of blood locally. Its effect is visible on the skin surface as a red flush, which whitens when pressed. This effect is commonly experienced and often referred to as a "*pillow mark*". However a red mark which does not whiten when pressed, non-blanching hyperaemia, is an area where damage to the microcirculation has occurred and is often termed a 'Grade 1 ulcer', see section 4.3.2.

The reactive hyperaemia response reperfuses the tissue with blood, revitalising the ischemic tissue and resolving the metabolic deficit. During this period of reperfusion, the blood flow back into the occluded area can be up to thirty times greater than the blood flow at rest. This over-stressing can lead to damage of the vessel walls (Collier 1999). It has also been proposed that during reperfusion, levels of oxygen-derived free radicals increase beyond the capacity of constitutive free radical scavenging mechanisms causing a cytotoxic effect in the tissue. This in turn activates endothelial cells to recruit circulating leukocytes. This leukocyte adhesion leads to permeability changes in the postcapillary venules and an increase of resistance to the flow of blood in the microcirculation (Peirce *et al* 2000). Additionally, the sudden removal of pressure can lead to a drop in interstitial pressure causing capillaries to burst resulting in interstitial flooding (Jones 2005). These damaging aspects of reperfusion can lead to a failure in the microcirculation and tissue necrosis. In this event the tissue has been subject to an ischemia-reperfusion injury.

The duration of the reperfusion period is directly related to the length of time the pressure was applied for. The longer the period under pressure, the longer the hyperaemia response last. Morison states, "*In normal healthy individuals the magnitude (maximum value), total hyperaemia and duration of the reactive hyperaemic response is related to the duration of the occlusion. The duration of the hyperaemic response is approximately ½ to ¾ of occlusion time*" (Morison 2001), see figure 4-39.

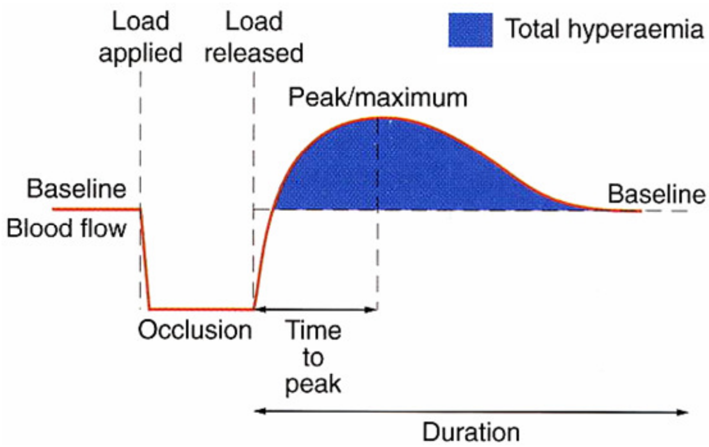


Figure 4-39 A schematic diagram of reactive hyperaemia (Morison 2001)

Note the diagram Morison provided to illustrate the relationship of the duration of hyperaemia to the length of time of occlusion differs from his statement that, "*the hyperaemic response is approximately ½ to ¾ of occlusion time".* In this diagram, without explanation, the hyperaemic response is three times that of the occlusion time.

A short reactive hyperaemia episode will result in the skin being subjected to the damaging effects of reperfusion for less time than a long reactive hyperaemia episode. As the duration of the hyperaemic response is related to the duration of occlusion it is advisable to minimise the duration of an application of pressure.

If the reactive hyperaemia response is triggered repeatedly the response to pressure by the tissue alters. The skin, in effect, develops a "*load history*" (Bader 2005). A healthy person subjected to repeat loading sees the tissue's vasomotor response strengthen to assist in maintaining tissue oxygen levels in the subsequent loadings. However the response by neurological and SCI patients to repeat loading is not the same as a healthy person. The tissue's vasomotor response does not strengthen to assist in maintaining tissue oxygen levels. Instead the oxygen levels within the tissue actually diminishes on each consecutive cycle of pressure, see figure 4-40 (Bader 1998).

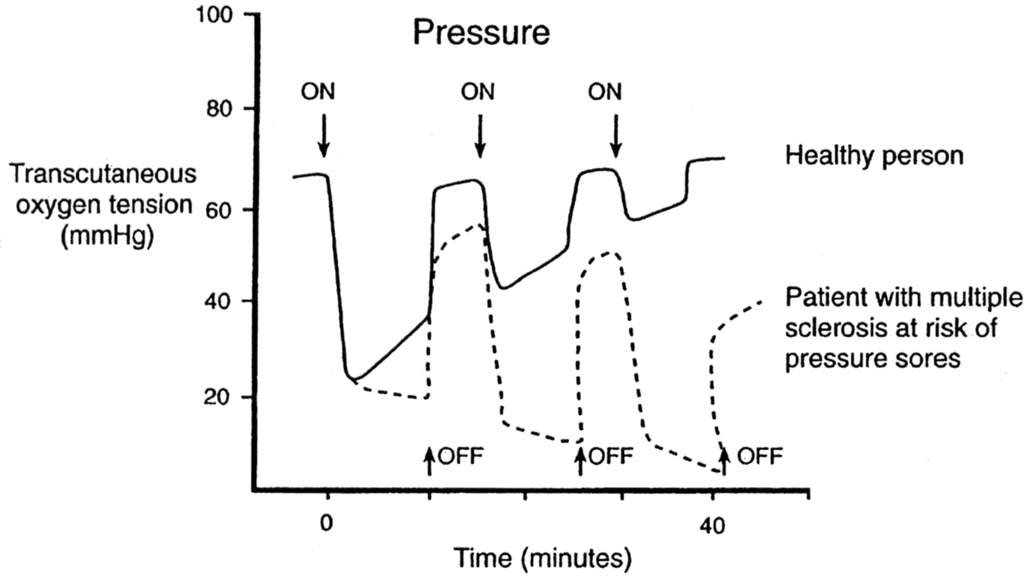


Figure 4-40 A schematic representation of two distinct responses of the soft tissues subjected to repetitive loading (Bader 1998)

Therefore repeat loading has to be taken into account and managed by any support surface intended for use by those with SCI.

It has been found that repeated ischemic-reperfusion injury is more damaging to tissue than if the tissue had been subject to prolonged pressure without relief. Peirce subjected rats to cycles of pressure to study the effect of reperfusion on ischemic tissue. He found that ten hours of continuous ischemia, from unrelieved pressure, resulted in 8% of the pressurised area becoming necrotic. However when ten hours contained five cycles of reperfusion, 13% of the pressurised area became necrotic (Peirce *et al* 2000).

It appears that the processes involved and the full effect of ischemic-reperfusion-injury are poorly understood and its significance underplayed. Although some authors, whilst discussing the aetiology of pressure ulcers, do raise the issue of ischemic-reperfusion-injury it is never cited as a cause of a pressure ulcer. As noted by Thompson, "*This phenomenon is not cited in any of the research on the causes of pressure ulcers*" (Thompson 2005).

Designer/manufactures of alternating pressure equipment are quick to promote the potential benefits of providing intervals of pressure relief but there is little made of how they manage the skins reactive hyperaemia response and how ischemic-reperfusion injury is avoided.

4.6 Discussion

It was found that whilst there is some variation in the exact terminology, it is generally agreed that the risk factors associated with pressure ulcer development should be categorised by where they act on the body, either internally or externally, see section 4.4. No literature was found which challenged the usefulness of this classification system. However, whilst this method of classifying risk factors is legitimate it does not reveal much as to the nature of the factors.

An alternative basis for classification would be of greater benefit, for instance, a categorisation system based on tissue pressure tolerance. This would be a two category system which would divide these risk factors into "*vulnerability multipliers*" and "*triggers*". When an individual's nourishment is compromised they progressively weaken, which in turn lessens their tolerance to pressure. Nutrition would therefore be a pressure ulcer "*vulnerability multiplier*". Poorly adjusted sheets/covers will imprint on the skin causing tissue damage. Poor adjustment would be an effect which would have overcome a skin's tolerance to pressure and "*triggered*" a pressure ulcer. Having categorised factors into multipliers and triggers, designers would then have a resource which would inform them which factors are vulnerability multipliers and have to be mitigated, and which are triggers and have to be eliminated.

Such a categorisation system will need further work in order to determine the factors which are vulnerability multipliers and which are triggers, see section 12.3.3. This endeavour will help to clarify the nature of each factor. For instance, is moisture a multiplier or a trigger? If a small quantity of liquid only slightly weakens the skin's tolerance and a large quantity greatly weakens a skin's tolerance, then moisture would be a vulnerability multiplier and a factor to be managed and mitigated. If the introduction of any quantity of liquid expedites the development of a pressure ulcer then this would be a trigger and a factor to be eliminated.

Having reviewed numerous risk factor categorising schemes it was found that there is general agreement that pressure is the causal factor of pressure ulcers. This understanding has been embedded into the definition of a pressure ulcer, "*A pressure ulcer is an area of localised damage to the skin and underlying tissue caused by pressure, shear, friction and or a combination of these*" (EPUAP 1999). However, on examination it was found that the role pressure plays in the devitalisation of tissue is poorly understood; with much about the skin's microcirculatory system, the lymphatic system, interstitial spacing, interstitial fluid flow and the release of hormones still unknown, see section 4.5. As such the level of confidence in the interpretation that it is the magnitude of IP which is the single most important factor in the prevention of pressure ulcers is unwarranted.

It has already been recognised that there are flaws in the interpretation that it is pressure, either applied perpendicularly or obliquely, which is the variable which determines whether or not there is tissue damage. Alternative explanations have recently been proposed; for instance by Brienza and Agram who have suggested that the variable which determines whether or not there is tissue damage is the extent to which tissue is distorted, see section 4.5.6. This alternative view is not new, with the earliest reference found of this alternative view having been published in 1981 (Neumark 1981).

If it is the case that pressure ulcers are the product of the internal stress patterns created when tissue is distorted, rather than the presence of pressure then the aim of cushions would be to minimise the distortion of the tissue to below an, as yet undefined, safe measure of body shape deviation rather than reduce IP to below a safe *pressure-intensity* threshold, see section 4.5.7.

In the past the common name for this type of wound was "*bed sore*". However, as this wound has become better understood the alternative name of "*pressure ulcer*" has become the common term. It is suggested that the name should once again be revised. Possible appropriate new names could include "*distortion ulcer*" or "*deformation ulcer*", see section 12.3.3. It may be that the term "*ulcer*" should also be revised to "*wound*" or "*injury*" to reflect that the spectrum of the wound begins with the skin still intact and that deep tissue injuries can occur and progress long before the skin is broken, see section 4.3.2.

4.7 Conclusions

It was found that until comparatively recently the prevailing attitude towards pressure ulcers was one of acceptance and resignation. This acceptance of pressure ulcers deterred progress. Although there has been progress since the 1970's our understanding of pressure ulcers remains rudimentary. It is the paucity of our understanding of the mechanics of pressure damage which has left a need for pressure relief devices. If the skin's vulnerabilities to pressure damage were better understood then a medical procedure, surgical or pharmacological, could possibly enhance the skin's tolerance to pressure, making pressure relief obsolete. It was concluded that with the science of pressure damage in its present state, such solutions are unlikely for the foreseeable future. Therefore in the mean time, skin will remain vulnerable to pressure damage and so there will continue to be the need for devices to prevent pressure damage.

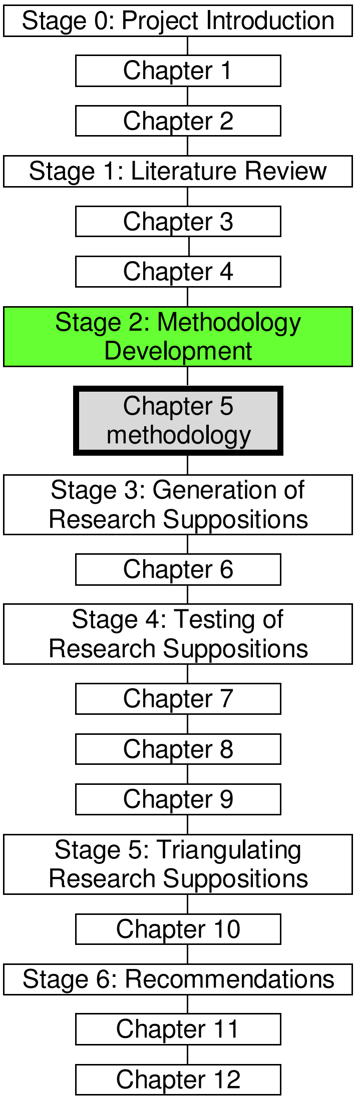
The role pressure has to play in the devitalisation of tissue is not fully understood. Without better information, it was concluded that designers have been overly confident in the assumption that it is the magnitude of IP which is the overriding issue in pressure ulcer prevention. Further, in light of the continuing incidence of pressure ulcers on the seat area of the body, the pursuit of simply reducing IP has been erroneous.

Without understanding how pressure damage is actually caused it would be a more prudent approach to provide the user with a skin friendly environment, rather than to focus on one issue in the hope that it will be efficacious in all cases. A skin friendly environment would be one where heat and moisture are controlled; but more importantly where the natural body shape is kept as close to normal as possible which will minimise the deformation the skin experiences. To keep the deviation of the user's body shape to a minimum will require pressure gradients to be truncated and kept symmetrical.

Chapter 5

METHODOLOGY

5.1 Introduction



This chapter charts the development of the methodological framework which guided this project.

The development process began by considering the rationale for the project, how cushions had been previously appraised and how this project might gain new insights into cushion design.

To pursue the notion that there are weaknesses with the design of cushions related to their usability, elements of the user centred design approach were considered. This included reviewing the design methodology USERfit.

This was followed by considering the approach this project might take and the strategy for the research work.

Finally, the elements considered previously were assembled into the framework used to guide the project.

5.2 The Rationale of this Project

Since its inception in the early 1970's, PR cushion design has been dominated by two principles, pressure-reduction and pressure-redistribution. Both these principles are a response to how pressure ulcers are understood to develop. Further, the basic forms of the first PR cushions remain principally the same today, for example air cells, gel and contoured foam cushions, see section 3.3.

Over the last forty years these basic forms have provided a degree of protection against pressure ulcers. This is tacitly acknowledged by their continued use by wheelchair users and health care professionals, at considerable financial cost, see section 2.3. However, as there continues to be a recordable level of pressure ulcer incidence on the gluteal region, despite the wide spread use of these PR cushions, see section 2.5. This suggests that there are weaknesses and deficiencies within their design limiting the prevention of more pressure ulcers.

Although PR cushions have remained fundamentally the same since the mid 1970's, technology and design techniques have progressed. This presents opportunities to advance PR cushion design and so enable the production of more effective PR cushions and further reduce the incidence of pressure ulcers on the gluteal region.

By appraising contemporary PR cushion design before generating new design concepts it will be possible to avoid propagating any weaknesses and shortcomings inherent to the current generation of cushions. Further, such a task will highlight opportunities for innovation.

The potential benefits of conducting some form of pre-design review or inquiry have been recognised by some; for example Nomos Management AB[1] have inserted such a review stage/phase into their own design processes, see figure 5-1.

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[1] Nomos is an independent usability and human factors consultancy who use user-centred design to provide an interface design and application implementation service. Their clients include Microsoft and Nokia (Whitehand and Claridge 2000).

Pre – design	Context Analysis 1	*
	Requirement gathering	*
	Review existing designs:	These activities are a means of obtaining usability/user interface design knowledge about existing interface implementations. This can provide useful input to *HOW* (and how not) to implement future interfaces.
	Context Analysis 2	*
	Scenario of use	*
Early design	Parallel Design	*
	Concept iteration	*
	Combined expert and user testing	*
Late design	Usability lab testing	*
	Subjective questionnaires	*
After release	Usage statistics	*
	Field observation	*
	Subjective questionnaires	*

* For brevity the description of this stage has been omitted

Figure 5-1 The design process used by Nomos (Whitehand and Claridge 2000)

The rationale for this research project is that a pre–design inquiry is beneficial to designers, and that an inquiry to appraise existing designs will provide previously unknown, unappreciated or misunderstood information regarding the weaknesses and areas of underperformance in contemporary PR cushions. With this information future PR cushion design will be able to avoid or overcome these weaknesses.

Thus this project is a supplement to the design process. Its intended function is not to supplant the design process but to augment the process by providing it with an additional insight not normally discerned, and thereby enhance the quality of the final design. For example, the design methodology Conceptual Design begins with a phase referred to as "*Need Identification and Analysis*" (Kroll *et al* 2001), see figure 5-2. The recommendations produced by this pre-design inquiry into existing product weakness/deficiency could be invaluable at this point to provide critical information which might be missed if this phase was only concerned with identifying and analysing user needs.

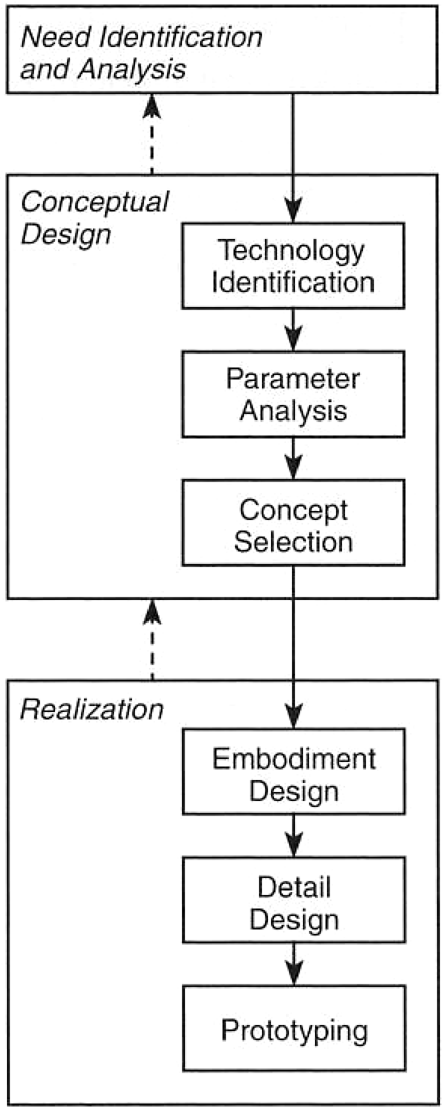

Figure 5-2 An overview of a design process as defined by Kroll (Kroll *et al* 2001)

5.3 The Appraisal of Existing Designs

The performance of existing PR cushions has already been, to some extent, appraised by the many evaluations and reviews carried out. It was found that these evaluations and reviews did not reveal much about the full experience of day-to-day living with a design and where cushions are poor or not fulfilling the needs of the user.

It was found that evaluations tended to focus on a small set of measurable assessment criteria under controlled conditions. This approach enables direct comparisons to be made either within the study or against other studies. Such evaluations provide some insight into the performance of a cushion in so far as one aspect of a cushion, under a specific set of circumstances, can be compared against another. For example one of the assessment criteria used by Swain during an evaluation for the Medical Devices Agency (MDA) was durability[2]. Swain found the durability of the Qbitus Supercontour Cushion to be better than that of the Sumed Ultra ’90 Cushion, with 1% Thickness Loss and 1% Hardness Loss compared to 1% Thickness Loss and 3% Hardness Loss (Swain *et al* 1997). Thus Swain’s evaluation revealed that the Qbitus Supercontour Cushion was more durable that the Sumed Ultra ’90. It did not reveal whether or not these cushions are durable enough to cope with the demands of their user’s day-to-day life style. Further Swain did not consider the design of these cushions looking for weaknesses which may reduce their durability.

It was noticed that evaluations typically used interface pressure (IP) as the primary criterion for assessing the efficacy of a cushion. Also, to assess IP some form of pressure mapping would be used. For instance, Takechi’s evaluation in 1998, “*Evaluation of wheelchair cushions by means of pressure distribution mapping*” used a tactile sensor sheet, a ‘Big-Mat type 2000’ Nitta Corporation, Japan, to produce a pressure map. This map revealed the peak IP to be under the ischial tuberosities. Takechi found the following peak IP’s:

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[2] The durability tests conducted were performed in accordance with *BS 4443: Part 5:1980: method 13 Constant load pounding test* and *BS 4443: Part 2 method 7: procedure A: 1980, Indentation Hardness Index.*

"*air cushion*" ranged from 87 – 257 g/cm^2,
"*silicon gel cushion*" ranged from 129 – 292 g/cm^2.
"*contour cushion*" ranged from 134 – 319 g/cm^2,
"*polyurethane foam cushion*" ranged from 123 – 386 g/cm^2,
"*cubicushion*" ranged from 174 – 401 g/cm^2.

(Takechi and Tokuhiro 1998)

Ferrarin's evaluation in 2000, "*Comparative biomechanical evaluation of different wheelchair seat cushions*" used a piezoresistive pressure sensor matrix, a 'Tekscan' Boston MA, to produce a pressure map. As with Takechi the peak IP reading were found under the ischial tuberosities. Ferrarin found the following peak IP's:

Jay 2 (Sunrise Medical, USA) ranged from 71 – 108 mmHg,
ROHO Low Profile (ROHO Inc, USA) ranged from 93 – 141 mmHg,
Dynamic cushion (Royal Medica S.r.l, Italy) ranged from 101 – 147 mmHg,
Dynamic Plus cushion (Royal Medica S.r.l, Italy) ranged from 112 – 186 mmHg.

(Ferrarin *et al* 2000)

Yuen's evaluation in 2001, "*Comparison of Three Wheelchair Cushions for Effectiveness of Pressure Relief*" used a computerised pressure mapping pad, an 'Xsensor' Crown Therapeutics, Belleville, Illinois. Yuen mapped IP by recording the number of sensors across the buttock-cushion interface which registered pressure levels between 60 and 99 mmHg and the number of sensors which registered pressure levels in excess of 100mmHg. Yuen found,

ROHO Enhanser (ROHO Inc, USA)

mean number of sensors registering levels between 60-99 mmHg = 204.14
mean number of sensors registering levels in excess of 100 mmHg = 42.71,

Pindot Ulti-mate (Invarcare Corp., USA)

mean number of sensors registering levels between 60-99 mmHg = 316.86
mean number of sensors registering levels in excess of 100 mmHg = 61.43,

Jay Extreme (Sunrise Medical, USA)

mean number of sensors registering levels between 60-99 mmHg = 319.00
mean number of sensors registering levels in excess of 100 mmHg = 101.14.

(Yuen and Garrett 2001)

Using pressure maps does enable cushions to be ranked by their ability to manage IP under controlled conditions, for example Takechi found the "*air cushion*", with a peak IP of 257g/cm^2 was better at reducing IP than the "*polyurethane foam cushion*" with a peak IP of 386g/cm^2 (Takechi and Tokuhiro 1998). However these IP readings do not provide any information as to their efficacy in preventing pressure ulcers and it they not reveal much about how well they serve their user in practical day-to-day situations. The matter of evaluations focusing on IP as a measure of a PR cushion's efficacy has been considered as part of the literature review, see section 3.4.

It was found that cushion reviews varied in scope. Some reviews were little more than a description of one particular cushion's physical characteristics, for example the review by Moody, "*Review of the STM range of pressure distribution products*" (Moody 1998) or the review by Williams "*RoHo Dry Floatation system: an alternative means of pressure relief*" (Williams 1998). Whereas other reviews compared a small number of aspects across a range of cushions, for example the review by Cowen. Cowen included 53 cushions of which 23 were categorised as "*Cushions for patients at low to medium risk of developing pressure sores*", fifteen as "*Cushions for patients at medium to high risk of developing pressure sores*" with the remaining fifteen categorised as "*Cushions for patients at high to very high risk of developing pressure sores*". This review was limited to five aspects of the cushion; the "*dimensions"*; the "*price"*; a brief "*description"*, the "*cover"* and "*other features"*. Using the Flo-tech Plus cushion as an example, the description was "*Moulded shaped foam cushion*"; the description of the *cover* was, "*Removable two-way stretch, waterproof, vapour-permeable*"; and a description of the other features was, "*Flo-tech Plus offers extra protection to ischial tuberosities*". (Cowen 1997).

Some of the reviews found were designed only to consider Randomised Controlled Trials (RCT). These reviews are hampered by the small number of RCT's carried out on seating. Over the last decade pressure ulcer prevention strategies have mainly concentrated on mattresses resulting in few RCT's being carried out on cushions (Russell 2001). An example of such a review of RCT's is the Cochrane review carried out by Cullum in 2004, "*Support*

Surfaces for Pressure Ulcer Prevention" (Cullum *et al* 2004). This review found 41 RCT's dating back to 1982. Of these 41 RCT's 38 were carried out on mattresses or overlays whilst three were carried out on cushions, Lim (1988), Conine (1993) and Conine (1994).

Lim's 1988 RCT was a prevention trial with a five month follow up. The participants were extended care patients, over sixty years of age and at "*high risk*" of developing pressure ulcers (Norton Score 14 or less) [3]. The form of a polyurethane foam cushion was studied; a "*slab cushion*" and a "*contoured cushion*". The outcome was 73% of the slab cushion users developed a pressure ulcer (19 out of 26) and 69% of the *contoured cushion* users developed a pressure ulcer (18 out of 26). Lim found no significant difference in the incidence of those using the slab or contoured cushion (Lim *et al* 1988).

Conine's 1993 RCT was a prevention trial with a three month follow up. The participants were extended care patients, over sixty years of age and considered to be at "*high risk*" of developing pressure ulcers (Norton Score 14 or less). The form of a polyurethane foam cushion was studied; a "*slab cushion*" and a "*contoured cushion*". The outcome was 68% of the slab cushion users developed a pressure ulcer (85 out of 125) and 68% of the contoured cushion users developed a pressure ulcer (84 out of 123). Conine found no significant difference in the incidence of those using the slab or the contoured cushion (Conine *et al* 1993). This result was in line with Lim's study (1988).

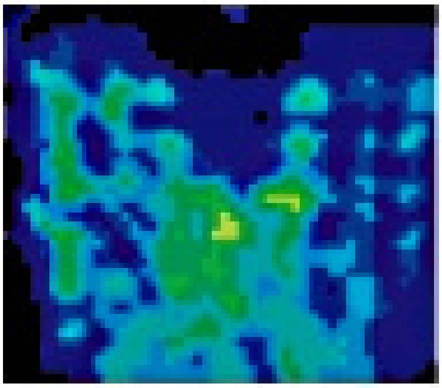
Conine's 1994 RCT was a prevention trial with a three month follow up. The participants were extended care patients (mean age 82 years), at "*high risk*" of developing pressure ulcers (Norton Score 14 or less). Two cushions were studied; a "*Jay cushion*" and a "*Foam cushion*". The foam cushion was supplied by *Broadway Foam and Fabric Supplies Ltd*. It was not specified if the foam was slab or contoured. The outcome was 25% of the *Jay cushion* users developed a pressure ulcer (17 out of 68) and 41% of the *Foam*

[3] The Norton score is a pressure ulcer risk assessment tool, see section 3.5.2

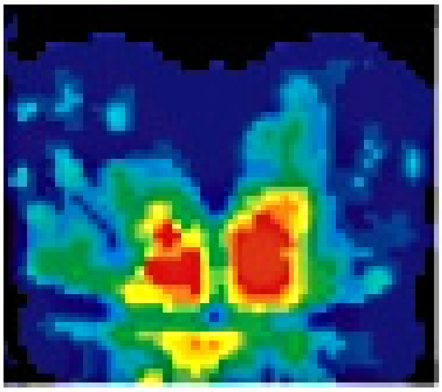
cushion users developed a pressure ulcer (30 out of 73). Conine found a significantly lower proportion of Jay users experienced pressure ulcers than those using the foam cushion (Conine *et al* 1994).

All three of these RCTs focused on the incidence of pressure ulcers in the study groups in order to compare outcomes between the cushions. Whilst this method for assessing cushions gives an indication of the relative performance between cushions, it provides little insight to the practical performance of the cushions. For example, Conine found 25% of the group using a Jay cushion developed a pressure ulcer compared to 41% who used a foam cushion (Conine *et al* 1994). Whilst the Jay compares favourably to the foam it is not possible to grade the efficacy of the Jay. Considering the study groups vulnerability to pressure damage, it is not clear if the Jays performance can be regarded as a good, bad or indifferent when 17 patients out of a study group of 68 developed a pressure ulcer within three months.

In addition to the evaluations and reviews examined, how manufacturers assess cushions was also considered. Often manufacturers maintain some form of awareness and understanding of their competitor's products. One method used by design teams for assessing a competitor's product would be competitive technical benchmarking. Manufacturers of PR cushions tend to use IP as a benchmark and regularly utilise pressure map results as a means to assess performance. For example ROHO used a pressure map to demonstrate that its cushion is better at reducing IP than foam cushions (ROHO 2008a), see figure 5-3, whilst both Varilite and Vicair used a pressure map to demonstrate that their cushions are better at reducing IP than ROHO cushions (Varilite 2008a) (Comfort Company 2008a), see figures 5-4 and 5-5.

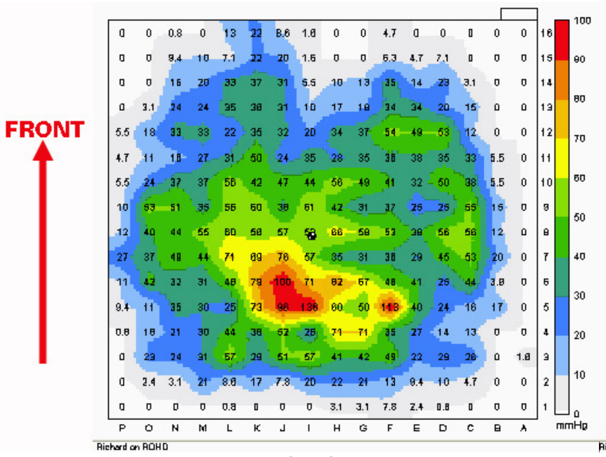


Pressure map of a ROHO cushion

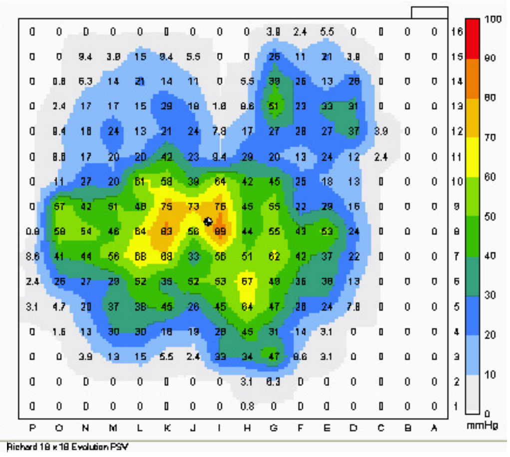


Pressure map of an unspecified foam cushion

Figure 5-3 A pressure map produced by ROHO to demonstrate their cushion is better at reducing IP than foam cushions (ROHO 2008a)

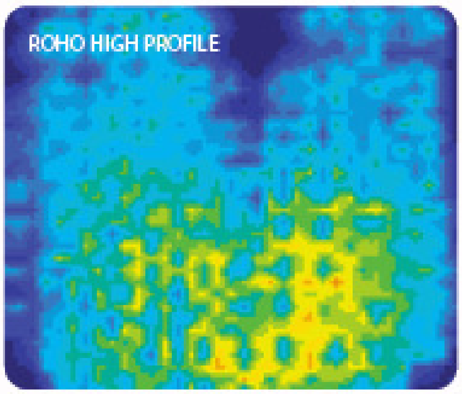


Pressure map of a ROHO high profile single compartment cushion

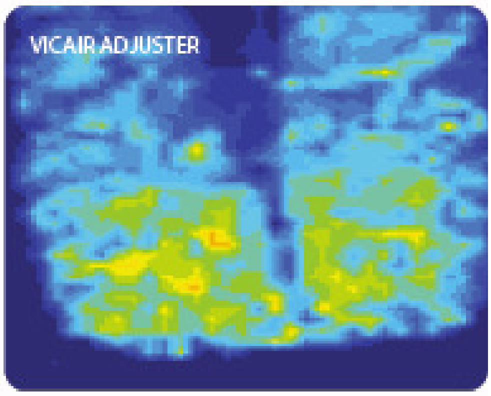


Pressure map of a Varilite Evolution PSV

Figure 5-4 A pressure map produced by Varilite to demonstrate their cushion is better at reducing IP than ROHO cushions (Varilite 2008a)



Pressure map of a ROHO high profile cushion



Pressure map of a VICAIR Adjuster cushion

Figure 5-5 A pressure map produced by Vicair to demonstrate their cushion is better at reducing IP than ROHO cushions (Comfort Company 2008a)

All these evaluations, reviews, trials and benchmarking show how one cushion might out perform another in certain categories, be it cost, weight or IP management. The limitation of these approaches is that they only compare against known aspects or features, they do not inquire into a user's satisfaction. Unlike these methods of assessment this project will take a different approach. This project will seek to appraise a user's satisfaction with existing cushions and seek to establish whether or not a user's need is met, rather than finding out how a cushion compares against others. A cushion could easily be the best at addressing a certain need but that does not necessarily mean that it is addressing the need to the satisfaction of a user.

In addition, evaluating or benchmarking against a set of known performance indicators perpetuates the emphasis of a design on established lines. For example how manufacturers compete to produce better pressure map results than their rivals. Such endeavours do not explore the nature of the design by scrutinising the previously unappreciated or misunderstood aspects of the design. This project will investigate what currently works for the user and what does not. From this it will be possible to identify where current PR cushions areas are weak or deficient which in turn will reveal opportunities for innovation.

5.4 A Pre–design Inquiry

This project is a pre-design inquiry for the purpose of ascertaining the performance of existing cushion design against the day-to-day needs of the user rather than making comparisons with other cushions. Additionally, it will investigate the nature of the design looking for the unknown, unappreciated or misunderstood so as to identify any weaknesses in the design. Thus, this pre-design inquiry is a means to address both objectives of this project, "*The identification of weaknesses and/or deficiencies in contemporary pressure relief cushion design*" and "*The production of a set of recommendations for the design of future pressure ulcer preventative cushions*", see section 1.2.

An example of how such a pre-design inquiry, looking for the unappreciated or misunderstood, can produce results is how this project has found that the preconceptions focusing PR cushion design towards interface pressure (IP) management are in need of reappraisal.

A traditional design process typically begins with some form of "*Need Analysis*" (Kroll *et al* 2001) or "*Problem Clarification*" (Cross 1995). At this early stage of the design process efforts are made to identify and understand the needs and context of the customer so that the eventual product can satisfy these needs. With a better understanding of the needs of the user a new design can be more in tune with the needs of the user and therefore more desirable.

In response to a growing appreciation of the contribution users can make in identifying and understanding the needs of the user, more sophisticated "*user-centred*" methodologies have been developed. These methodologies provide tools which enable a user-centred approach to be brought to the design process, in particular the task of "*Need identification*". Some of these user-centred methodologies contain tools to assist in the tasks of identifying and understanding the needs of the user. These tools, such as interviews, direct observation, questionnaires, etc (HUSAT Research Institute 1996), provide guidance with sourcing and collating research data gathered from users.

A typical user-centred based methodology if applied to the design of a new PR cushion would quickly identify IP as a key element in the list of needs of the user. Currently IP is the central tenet of contemporary PR cushion design based on the understanding that IP is the primary cause of pressure ulcers and is therefore the primary issue for PR cushion design. This regard for IP has been recognised by Barrett an advanced biomedical engineer with the major American medical equipment manufacturer Hill-Rom, "*Clinical efficacy of a support surface is logically based on the disease it is intended to prevent – in this case, pressure ulcers … As the dominant, extrinsic factor, pressure has received the most attention*" (Barnett and Shelton 1997)[4].

It would be understandable then for a design process, including user-centred based methodologies, to begin the design of a new PR cushion with IP management being a high, if not the highest, priority on the list of needs to satisfy. Yet after forty years of focusing on IP management, either by pressure-reduction or pressure-redistribution, users of contemporary PR cushions are still experiencing a large number of pressure ulcers. In this case, the apparently self evident nature of pressure ulcers being the consequence of pressure has resulted in the most fundamental need of the user metamorphosing from "*stop pressure ulcers*" to "*manage pressure*". This metamorphosis is so deeply engrained that it has been enshrined in how cushions are known, namely "*pressure relief*" (PR) cushions[5] rather than something more in keeping with the purpose of a cushion, for instance an "*ulcer prevention*" (UP) cushion. The term "*UP cushion*" is a novel term derived through the work of this project.

By studying contemporary PR cushion design this pre-design inquiry has found that for the last forty years designers have been focused on the question "*how do we manage IP?*" but have yet to satisfactorily address the more fundamental and pertinent question "*how do cushions prevent pressure ulcers?*".

Additionally by undertaking such a pre-design inquiry the knowledge gap which exists between designers, users and the medical community is diminished. It has been this gap which has enabled the design community to persevere under the notion that the management of IP will halt the development of pressure ulcers and so meet the user's need of pressure ulcer prevention.

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[4] PR cushion's focus on IP is discussed in sections 3.4.1 and 3.4.2

[5] Those who use the term "*pressure relief*" (PR) cushion include NICE who have used the term in their guidelines on pressure-relieving devices (Yerrell *et al* 2003 reprinted 2005)

5.5 User Centred Design

5.5.1 User Centred Methodologies

The central premise of *user-centred* design is that, "*the best designed products and services result from understanding the needs of the people who will use them*" and that "*Awareness of the experience of end-users can lead designers to question established practices and assumptions – and can yield innovation that delivers real user benefit*" (Black 2007).

This user-centred design approach originated from the field of *Human Factors*, also known as "*Ergonomics*". Human factors is a form of engineering which puts the human at the centre of design not machines or equipment (HUSAT Research Institute 1996).

Product designers, including designers in the AT sector see appendix E, have recognised that users can make a positive contribution to the design process and that a user-centred methodology can help guide and structure the interaction with users. The growing interest in the user-centred approach has prompted a variety of interpretations of this design approach and a flourishing of user-centred based methodologies such as, inclusive design, participatory design, usability engineering, user-focused design etc (Black 2007).

The fundamental premise of all these variants of the user centred approach is that the best designed products result from understanding the needs of the user. To which these variants typically draw upon the same research techniques, interviews, observation, questionnaires, etc, in order to gather data about the user. However, as different industries are designing different products for different users each methodology has to be adapted to accommodate the differing circumstances. For illustrative purposes an example of a user centred methodology variant specifically designed for computer systems designers is the ISO 13407: Human-centred design processes for interactive systems. This methodology has been formulated to provide, "*guidance on human-centred design activities throughout the life cycle of computer-based interactive systems*", where interactive systems are defined as a, "*combination of hardware and software components that* *receive input from, and communicate output to, a human user in order to support his or her performance of a task*" (ISO 1999).

Whilst some methodologies are formulated for a specific design area, such as interactive systems and their users, other methodologies are more general. Some of these methodologies emphasize a product's usability. The International Organisation for Standardisation (ISO) defines usability as, "[the] *extent to which a product can be specified by users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use*" (ISO 1998).

The intention of focusing on usability is to widen a products user base, for example Inclusive design. The British Standard definition of Inclusive design, as defined in BS 7000-6: 2005, is, "*design of mainstream products and/or services that are accessible to, and usable by people with the widest range of abilities within the widest range of situations without the need for specialist adaptation or design*" (BS 2005).

Similarly, the methodology Universal design has been formulated to support design to widen the usability and accessibility of products. The definition of universal design provided by the Centre for Universal Design is "*Universal design: The design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialised design*" (Connell *et al* 1997).

Such user centred methodologies intended to widen the usability and accessibility of mainstream products to include all people without the need for specialist adaption was not ideally suited to this project, instead a user-centred methodology specific to AT was sought.

5.5.2 A User Centred Methodology for Assistive Technology

A user centred methodology has been specifically developed for the AT sector. This methodology has been entitled "*USERfit*"[6]. USERfit was

[6] The full title of *USERfit* is "*USERfit: A practical handbook on user-centred design for Assistive Technology*". This handbook contains a full description of the data gathering techniques and tools within *USERfit* (HUSAT Research Institute 1996).

developed during the mid 1990's by the TIDE USER consortium[7]. USERfit was the outcome of the TIDE 1062 USER project (User Requirements Elaboration in Rehabilitation and Assistive Technology) as part of the TIDE (Technology Initiative for Disabled and Elderly people) DG XIII programme, funded by the European Commission (EC) (HUSAT Research Institute 1996).

Surveys conducted as part of this USER project found that developers in the telematic community often lacked the skills to effectively take usability issues into account. As the use of telecommunication systems and advanced technologies, such as speech recognition and robotics, were increasing in the AT sector, usability issues were becoming more important and so some form of structured design approach was required. In response to this weakness in addressing usability issues the TIDE USER consortium wanted to make human factors techniques, methods and tools more accessible and relevant to AT developers. Their response was the formulation of the structured framework USERfit. (Nicolle 1999)

USERfit was formulated drawing upon existing qualitative and quantitative research and the user oriented concepts and techniques developed in Human Computer Interaction (HCI) and Usability engineering (Poulson and Richardson 1998). This methodology is comprised of nine summary tools which combine to assist in the process of collating design information obtained using a variety of data gathering techniques. According to the TIDE USER consortium, USERfit is a meta-toolkit rather than a design tool in its own right (HUSAT Research Institute 1996).

Having formulated the USERfit methodology the TIDE USER consortium released it for general use. Its potential was quickly recognised with 2400 copies of the USERfit handbook being distributed within the first three years of publication. Additionally the EU funded INCLUDE project made a copy

[7] This consortium comprised of the Human Sciences and Advanced Technology (HUSAT) Research Institute (UK), COO.S.S. Marche scrl (Italy) and SINTEF Unimed Rehab (Norway), (HUSAT Research Institute 1996). HUSAT Research Institute was merged with the Institute for Consumer Ergonomics (ICE) in 2002 to form the Ergonomics and Safety Research Institute (ESRI) (ESRI 2008).

available as a download from their website "*www.stakes.fi/include*" [8] (Nicolle 1999). Also, in the academic year 1997/98 USERfit was first taught at undergraduate level when a new module, "*Design for Aging and Disability*", featuring USERfit, was introduced to an undergraduate degree course for industrial design in the Department of Design and Technology at Loughborough University (Torrens 2000).

Although USERfit was originally intended to aid the design of AT products its use of a user-centred approach to capture and specify user requirements has been recognised by other areas of design. For example, the USERfit methodology was used by the Enham Trust, a charity providing training and employment for people with disabilities, to produce a set of requirements for a tele-marketing service (Nicolle 1999). The ability of USERfit to be applied to other design scenarios has seen this methodology become the template of the **USERfit Tool**. This **USERfit Tool** is a software application designed to generate usability and accessibility specifications for any group of users in all kinds of situations (Abascal-González *et al* 2003).

USERfit, as a meta-toolkit, has been found, firstly by those in the AT sector and then by others, to be helpful in gathering data from users, and processing data, to generate user requirements for design purposes. This project will also incorporate use of some of the data gathering techniques, from within the USERfit toolkit, into the Methodological Framework, see figure 5-7.

[8] This website is no longer accessible but the USERfit handbook is, at the time of writing, available as a download from the European Commission's Information Society's "*Design for all*" webpage at http://ec.europa.eu/information_society/policy/accessibility/deploy/dfa/index_en.htm

5.6 Research Strategy

For this project to be of value to the assistive technology (AT) community it would have to identify the weaknesses in the design of contemporary cushions which are currently hampering their efficacy in preventing pressure ulcers. To increase the likelihood that this pre-design inquiry will identify the weaknesses and deficiencies in design which have remained unknown, unrecognised or unappreciated for the last forty years a systematic and rigorous approach was adopted. In order to be systematic and rigorous, a set of research methods and techniques were employed and combined into a methodological framework. The following describes the methodological framework developed for this project. This methodological framework has been charted, see figure 5-7. In addition, the thorough nature of a systematic and rigorous approach increases the confidence in the findings and recommendations.

This methodological framework would provide structure and direction to the various research techniques, methods and 'tools'[9] employed. A range of research techniques and methods would be used in order to provide the breadth and richness of data needed to identify the current weaknesses and synthesize a set of recommendations.

As this project would be drawing on a range of research techniques and methods it would not be a mono-method study, in the manner of a traditional quantitative study or qualitative study. Instead this project would be in keeping with a pragmatic study, incorporating a range of research methods and techniques, including both quantitative and qualitative research methods (Johnson and Onwuegbuzie 2004).

The use of a range of different research methods affords the opportunity to triangulate the findings. Triangulation is a technique used to validate findings. This matter is discussed in more detail later on in this section.

[9] Being a design research exercise this project included approaches and techniques from within design, in particular user-involvement/user-centred design 'tools', see section 5.5.2.

The adoption of a pragmatic approach enabled this project to utilise the major characteristics of traditional quantitative and qualitative research methods. The major characteristics of qualitative research being induction (discovery of patterns), discovery, exploration, theory/hypothesis generation, the researcher being the primary instrument of data collection and qualitative analysis; whilst the major characteristics of quantitative research are deduction (testing of theories/hypothesis), confirmation, theory/hypothesis testing, explanation, prediction, standardised data collection and statistical analysis (Johnson and Onwuegbuzie 2004).

As with all different strategies, approaches and methods of research, including the quantitative and qualitative research methods, each has its own set of strengths and weakness[10]. This pragmatic approach accords the researcher the opportunity to formulate a strategy, "*in such a way that the resulting mixture or combination is likely to result in complementary strengths and non-overlapping weaknesses*" (Brewer and Hunter 1989). An example of how a study can benefit from non-overlapping weaknesses can be seen with the general case verses specific case. Johnson and Onwuegbuzie (2004) identified a weakness with quantitative research, "*Knowledge produced may be too abstract and general for direct application to specific local situations, contexts and individuals*", whereas they found the converse weakness with *qualitative* research, "*Knowledge produced may not generalise to other people or other settings (i.e. findings may be unique to the relatively few people included in the research study)*"

This general verses specific case is an important consideration for this project. A purely quantitative study in order to be inclusive of all SCI patient cushion users regardless of the level of injury, gender, ethnicity, religion, age, height, weight etc might end up being so generalised and vague that it would not provide any real insight applicable to actual users. Equally, a purely qualitative study might, for example, produce great insight into the cushion use of male, paraplegic, white, under twenty-five years of age, 178cm tall, 82kg heavy,

[10] Both quantitative and qualitative research methods have numerous strengths and weakness. These have been listed by Johnson and Onwuegbuzie (2004) and can been seen in appendix E.

individuals but the results are then so specific to a particular small group of users that they can not be readily applied to any other users.

Although there are advantages to be gained from employing differing research methods with complementary characteristics within one study, this methodological pluralism found with a pragmatic approach is not without weaknesses[11]. One potential hazard for this project was, "*Pragmatism may promote incremental change rather than more fundamental, structural, or revolutionary change in society*" (Johnson and Onwuegbuzie 2004). This project was not seeking an incremental change in the design of PR cushions. The basis of this project is the contention that the basic approach to PR cushion design, pressure-reduction and pressure redistribution, has remained fundamentally the same, despite the incremental changes over the last forty years; and that a reappraisal of PR cushion design is required in order to overcome the weaknesses inherent to contemporary PR cushion design.

In addition to the benefits resulting from complementary strengths and non-overlapping weaknesses, a research strategy employing differing research methods and techniques to gather data is that such a strategy lends itself to the validation method Methodological Triangulation. Triangulation is one of various methods such as Factorial design which is used to validate findings. Methodological Triangulation is one of four types of triangulation;

1. ***Data Triangulation**, which entails gathering data through several sampling strategies, so that slices of data at different times and social situations, as well as on a variety of people are gathered.*
2. ***Investigator Triangulation**, which refers to the use of more than one researcher in the field to gather and interpret data.*
3. ***Theoretical Triangulation**, which refers to the use of more than one theoretical position in interpreting data*
4. ***Methodological Triangulation**, which refers to the use of more than one method for gathering data.*

(Denzin 1970 cited Bryman 2008)

[11] These weaknesses have been listed by Johnson and Onwuegbuzie (2004) and can been seen in appendix F.

Often Methodological triangulation is broken down into three different approaches, see figure 5-6.

Methodological triangulation	
Within method	Two or more variants of the same method are used, e.g. two different rating scales are used to measure stress or mixing open and closed questions in the same questionnaire
Between method	Differing bur complementary methods are used, e.g. semi-structured interviews and questionnaires
Holistic	Both within and between method approaches are used

Source: Adapted from Jick (1979)

Figure 5-6 The three different approaches of Methodological triangulation (Jick 1979 cited Nolan and Behi 1995)

Jick proposed that the "*Within method"* is best employed as a check on reliability whereas the "*Between method"* serves to support a study's validity (Jick 1979 cited Nolan and Behi 1995).

By using more than one method for gathering data, the Between method of methodological triangulation, for example a focus group, structured interview and questionnaire, more than one set of findings is produced. Where these findings converge, these sets of data may be mutually confirming. By cross-checking the findings with one another a multi method strategy may demonstrate Convergent Validity. There is the potential when performing a triangulation exercise on a multi method strategy that inconsistencies are found to exist between findings. Where the triangulation exercise fails to yield converging findings this may indicate the presence of problems in the execution of one of the data gathering techniques; or the fact that two sets of finding have not converged may prompt new lines of inquiry into the substantive area involved. Triangulations which yield convergent findings still have to be treated with caution, as both sets of data can be flawed. Additionally, in recent years triangulation and Convergent Validity has attracted some criticism. It has been accused of subscribing to a "*naïve* *realism*", which implies that there is a single definitive account to be found (Bryman 2008).

The value of Methodological Triangulation to this project is that it enhances confidence in the findings (Bryman 2008). By triangulating the findings of the different data gathering methods used during this study, the findings may demonstrate Convergent Validity and add weight to the findings from each method used to collect data. Additionally, such a triangulation exercise will provide the study an opportunity to determine whether the findings correlate with the published literature, see chapter 10.

For this project, a strategy was formulated into a methodological framework. This framework, taking a pragmatic approach, structured into a single process both quantitative and qualitative research methods and utilised some of the data gathering tools used by user-centred design. This work contributed to the completion of the first of this project's objectives, "*The identification of weaknesses and/or deficiencies in contemporary PR cushion design*". Also within this framework a triangulation exercise was included, before synthesising the findings to produce a set of recommendations. The completion of this set of recommendations would mark the completion of the second and final objective of this project, "*The production of a set of recommendations for the design of future pressure ulcer preventative cushions*", see section 1.2. This methodological framework has been charted, see figure 5-7.

5.7 The Project's Methodological Framework

Drawing from both the pragmatic and user-centred approaches to research and design, the following methodological frame work was formulated:

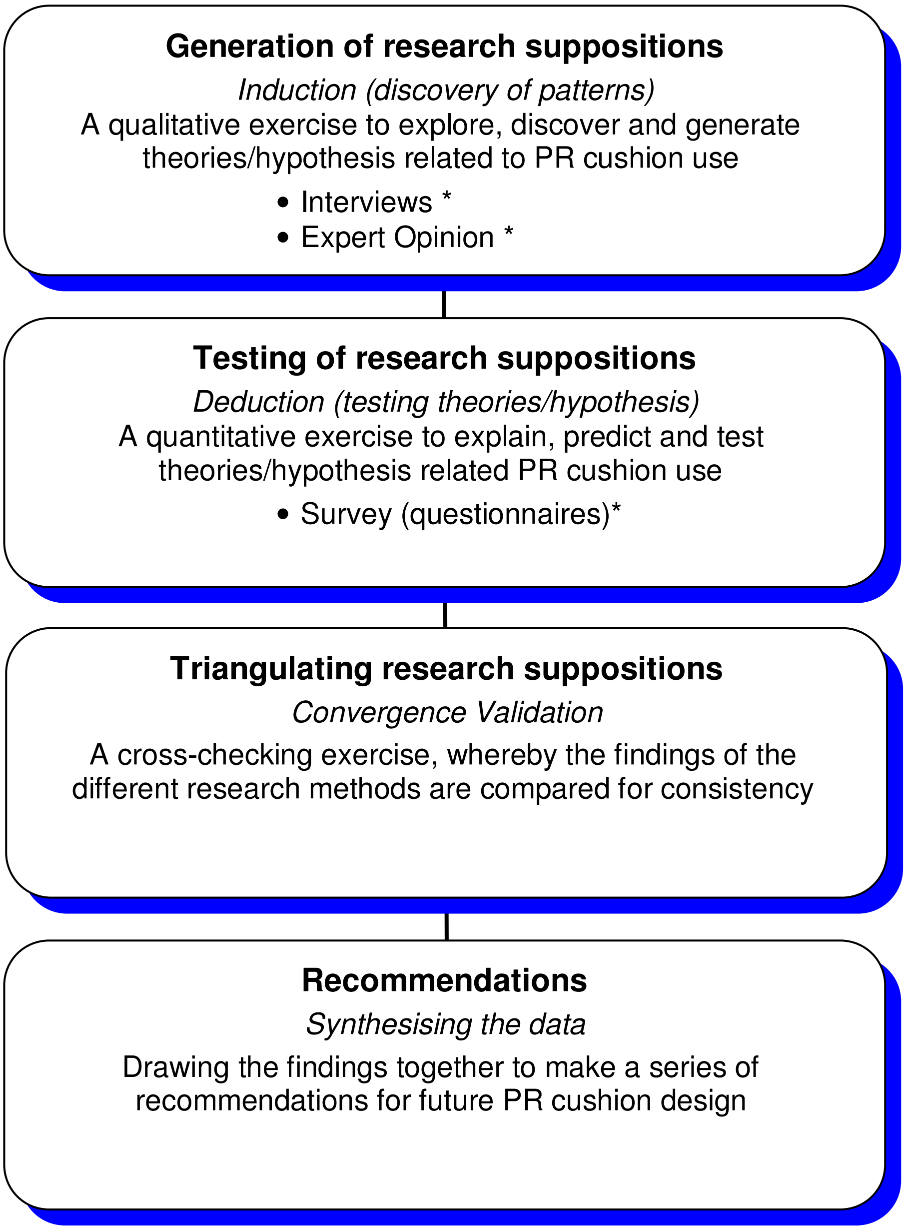


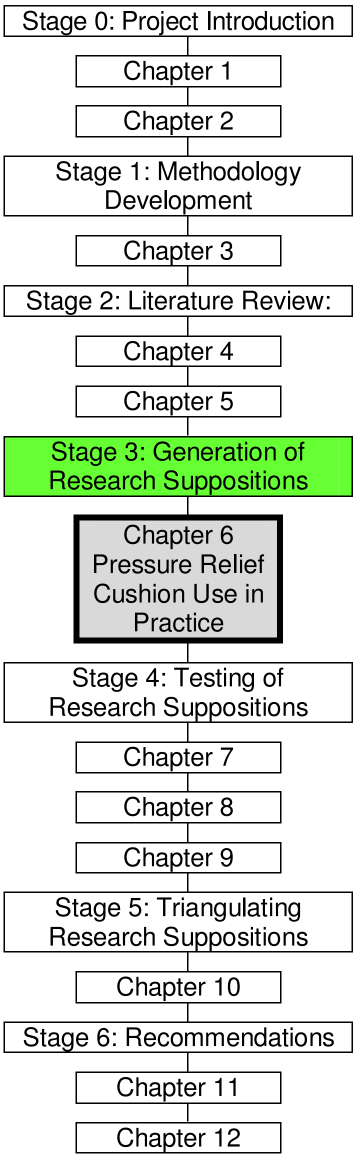
Figure 5-7 The methodological framework used to structure and guide this project

* data gathering techniques derived from the *USERfit* methodology

Chapter 6

PRESSURE RELIEF CUSHION USE IN PRACTICE

6.1 Introduction



This chapter reports on the work conducted to complete ‘Stage 3’ of the project. The project’s methodological framework tasked Stage 3 with the generation of a series of research suppositions.

To achieve this task a qualitative exercise to explore PR cushion use by those with SCI was undertaken. The techniques used to engage the user were based on some of the tools proffered in the USERfit methodology, see section 5.6.3.

Using the data gathered by the application of these tools, commonalities and themes were sought. From this analysis a series of research suppositions were inducted.

6.2 Ethical Considerations

Before engaging with users the issue of ethics was considered. This project adhered to the principles defined in the university's Ethics Policy document, see appendixH.

It was determined that approval by hospital Ethics Committee was not required because in part the data gathered would be anonymous with no names, addresses or e-mail addresses given to the researcher.

Before entering the spinal injuries wards and the spinal gym in the National Spinal Injuries Centre (NSIC), Stoke Mandeville a Criminal Records Bureau (CRB) check of the researcher was carried out. Once on site supervision of the researcher was given by a member of staff at all times. Patient anonymity was maintained throughout and patient records and notes were not accessed.

6.3 Interviews

6.3.1 Methodology

As part of the process in understanding the needs of the user and to identify where current cushions "*usability*" is weak, data on the users' experience with their cushion had to be gathered. This exercise was comparable to a user requirement stage of a design process. At this stage an unstructured interview is recommended by the USERfit methodology to allow the process to be user led (HUSAT 1996).

Following the USERfit methodology, this project adopted an unstructured approach. The interview process was also kept informal to make the interviewee feel at ease and to avoid making the interviewee feel threatened or embarrassed by the situation. This was to encourage the interviewees to speak freely and critically about their cushion. By speaking freely an interviewee might reveal something previously concealed, which could lead to a new insight and in turn to a design innovation.

This interview process was designed to draw out negative experiences with cushions. As such the interviewees would likely portray a bias against cushions and possibly inflate negative aspects of their cushion whilst disregarding or underplaying positive aspects. As such the outcome of an interview could result in a lack of accuracy and perspective by the interviewee and consequently misrepresent the performance of their cushion.

This possible distortion of perception by the user during the interview was considered. It was concluded that the goal of the interviews was to identify weaknesses and deficiencies in cushion design and as such at this point it was preferable to identify weaknesses even if their significance had been over stated by the user rather than miss a weakness due to the user not wanting to be seen to be complaining or considering a deficiency as not important enough to warrant mentioning.

The degree to which a weakness is relevant would not be judged on the results of these interviews alone. The results of this research method would be just one of the sets of data entered into the methodological triangulation procedure employed by this project, see section 5.6. If one interviewee were to over dramatise one experience so that a perceived weakness is recorded, without further corroborating evidence from the other research methods this perceived weakness would not pass through the triangulation to become the basis for one of the recommendations.

The interviews carried out were one-to-one based and the interviewee's anonymity was maintained and confidentially ensured. Only one interviewer was present, the author of this thesis.

The nature of the project was briefly described at the outset of the interview. It was made clear to the interviewee that notes would be made throughout the interviews but no audio recording would be made. The decision not to use audio equipment, and limit the number of interviewers present was taken so as to avoid intimidating the interviewee and to keep the interviewee at ease. This was important to allow the interviewee to discuss details and issues they may have considered not important enough or private in a more formal setting.

All the patients interviewed had undergone rehabilitation and had returned to the community. All the patients had lived with cushions on a day-to-day basis. These patients were being treated at the NSIC for conditions other than their SCI.

Patients at the NSIC who were new to SCI and were still in the process of rehabilitation were not interviewed as they had yet to live out in the community and as such had not yet gained any experience of day-to-day living with cushions.

6.3.2 SCI Ward 1, National Spinal Injuries Centre, SMH

An in-patient ward at the National Spinal Injuries Centre, Stoke Mandeville was visited. This ward was for long term SCI patients admitted for the treatment of other conditions. All the patients on the ward were male. Three patients volunteered to be interviewed.

Patient 1: Male, late 30's, paraplegic, currently using a ROHO cushion but planned to exchange it for a Vicar cushion soon

Patient 2: Male, late 50's, paraplegic, has been using a ROHO cushion for many years

Patient 3: Male, late 50's, paraplegic, currently using a ROHO Quadtro cushion

6.3.3 SCI Ward 2, National Spinal Injuries Centre, SMH

A second in-patient ward at the National Spinal Injuries Centre, Stoke Mandeville was visited. This ward had a different range of patients, all the patients had been admitted for the treatment of conditions other than their SCI, but had been described by the staff as, "*recent to SCI*". All the patients on the ward were male. Two patients volunteered to be interviewed.

Patient 4: Male, early 20's, paraplegic, currently using Jay cushion

Patient 5: Male, mid 40's, tetraplegic, ROHO type cushion

6.3.4 The Spinal Gym, National Spinal Injuries Centre, SMH

The Spinal Gym at the National Spinal Injuries Centre, Stoke Mandeville was visited. This gym is for patients undergoing physiotherapy and patients in the process of rehabilitation. Both male and female patients were using the gym at the time of the visit. Five patients volunteered to be interviewed.

Patient 6: Male, mid 40's, paraplegic, currently using Flo-tech, has used other cushions previously including a Jay 2 contour cushion

Patient 7: Male, mid 40's, tetraplegic, currently using a Jay 2 cushion

Patient 8: Male, mid 20's, paraplegic, currently using a Flo-tech cushion

Patient 9: Female, mid 40's, paraplegic, the patient could not remember offhand the type of cushion and as it was within a cushion cover and being sat on it could not be visually identified.

Patient 10: Male, late teens, tetraplegic, currently using a ROHO cushion but planned to exchange for a Jay 2 contour cushion soon.

6.3.5 Results

A total of ten patients were interviewed of which nine were male and one was female. This ratio of 9:1 is not reflective of the gender divide in the UK national population where females represent 51% (ONS 2009). However, whilst there are no official UK statistics regarding the ratio of males to females in the SCI population; in the USA according to the National Spinal Cord Injury Statistical Centre (NSCISC) 80.9% are male (NSCISC 2009).

Of the ten patients interviewed seven were paraplegic and three were tetraplegic. This ratio is broadly inline with the anecdotal ratio of ⅔ paraplegic to ⅓ tetraplegic for the UK SCI population. Currently there are no official UK statistics regarding the ratio of paraplegics to tetraplegics. However in the USA according to the National Spinal Cord Injury Statistical Centre (NSCISC) 50.5% are tetraplegic and 44.1% are paraplegic (NSCISC 2009).

Of the ten patients interviewed five used a ROHO, two used a Jay 2, two used a Flo-tech and one, Patient 9, used a cushion the make of which was not identified. According to advice given by staff from two different spinal cord injury centres (SCIC) the current leading PR cushions are the Flo-tech, Jay 2, ROHO, Vicair and Varilite; with the Jay 2 and ROHO being the most popular, see section 3.3

Each of the statements from the patients were put onto cards and clustered into groups with commonalities. These groups were then titled based on the theme of the group. The final groupings were agreed upon between the author and one of the project supervisors. These groups and the source of the statements within each group have been tabulated. The groups have been ordered alphabetically and not by significance, see table 6-1.

Table 6-1 The statements from the patients grouped by themes

Patient Issue Nos. (PIN)	Groups formed from issues raised by users	Ward 1			Ward 2		Spinal Gym					Nos of references
		Patent 1	Patent 2	Patent 3	Patent 4	Patent 5	Patent 6	Patent 7	Patent 8	Patent 9	Patent 10	
1	Adjusting internal air pressure						✓					1
2	Appearance			✓								1
3	Bottoming out (air)						✓					1
4	Bottoming out (gel)							✓				1
5	Checking internal air pressure	✓	✓									2
6	Cleaning		✓							✓		2
7	Comfort							✓				1
8	Cushion cover issues						✓			✓		2
9	Cushion size									✓		1
10	Extreme body shapes				✓	✓						2
11	Fitting cushion covers									✓		1
12	Footplate adjustment	✓										1
13	Foreign objects on surface				✓	✓					✓	3
14	Imbalance reinforcement	✓						✓			✓	3
15	Leaning and use of armrests					✓					✓	2
16	Portability		✓				✓					2
17	Pressure relief routine					✓						1
18	Range of postures					✓	✓	✓				3
19	Recurring damage/robustness		✓						✓			2
20	Securing cushion		✓	✓	✓		✓	✓			✓	6
21	Shocks/vibrations						✓	✓			✓	3
22	Skin Care vs Posture Compromise										✓	1
23	Slouched posture						✓					1
24	Sweating						✓		✓			2
25	Transfer issues (contour depth)						✓				✓	2
26	Vigorous movements			✓		✓						2
27	Wheelchair adjustment	✓		✓	✓	✓	✓		✓			6

6.4 Expert Opinion

6.4.1 Methodology

The USERfit tool "*Expert Opinion*" is an informal technique used to assist with the problem of identification and clarifying the issues relevant to a particular topic. It is often used to identify potential problems with products before they are released for more comprehensive evaluation but can be used at any stage of a design process. Typically an expert session would involve a prototype or product and would be carried out in the environment or setting in which the device would be used so as to make the experience as realistic as possible. In such a case it is common to have a prepared check list of the areas for the experts to consider. The results of expert opinion sessions are an adjunct to ascertaining the usability of a product and not a substitute for user involvement (HUSAT 1996).

The USERfit tool describes the experts in the user group as coming from the services and the technology involved with the user group. It also indicates that these experts are normally found in universities, research organisations, institutions and competence centres for disabled people (HUSAT 1996). For this project it was decided that the experts to draw from would be from the service side, namely those involved in the care and treatment of those with SCI, such as physiotherapists and nurses, as they would have experience and expertise on the use and the usability of pressure relief cushions. The institutions and competence centres in which these experts are found are the UK's spinal injuries centres.

Patients with chronic conditions can be viewed as "*expert patients*", for this project it was decided to maintain the USERfit distinction between patients as users and staff as experts as they have different experiences and perspectives to draw from. The different experiences and perspectives from these two groups contribute to the triangulation of the findings.

For this project expert opinion was sought as part of the process of understanding the needs of the user and to identify where current cushion's "*usability*" is weak. In this case there was no prototype or new product for the experts to pass comment on, rather this exercise was more akin to a user requirement stage of a design process. An unstructured interview approach was taken to allow the process to be expert led. Additionally, by not asking the expert to comment on a prototype or product the sessions could be carried out at times and places of their convenience, instead of arranging sessions in the setting in which the cushions would be used. This was helpful as it limited the disruption to the staff members and therefore more staff were able to contribute.

All the experts chosen were experienced with SCI and cushion use. Staff from different SCI centres were chosen to avoid localised bias. None of the experts consulted had an interest or prior involvement in this project. All involved gave their time freely and no payments were made.

6.4.2 Staff from the National Spinal Injuries Centre, SMH

Senior Physiotherapist:

This was a one hour exploratory meeting conducted in a conference room at the NSIC. Present was the Senior Physiotherapist, the author of this thesis and the three project supervisors. This meeting was of particular importance as it served to gain an insight into the key staff involved in the care of SCI patients and to guide further interviews and sessions.

Physiotherapist, working in the Spinal Gym:

This session was conducted in the Spinal Gym at the NSIC and lasted the whole morning. The session was conducted in two parts; the first part included an initial discussion about cushions and a viewing of some of the cushions used at the NSIC. The cushions shown were a Jay 2, a ROHO Quadtro, a Varilite and a Vicair. The second part consisted of shadowing the physiotherapist as she helped patients practice transferring to and from wheelchairs.

Physiotherapist, working on the SCI Wards:

This session was conducted in two wards at the NSIC and took the whole afternoon. The session was conducted in two parts; the first part consisted of a discussion about posture and preventing pressure ulcers. The second part consisted of shadowing the physiotherapist as she performed her duties in the wards.

Deputy Sister:

This one-to-one session was conducted in an office at the NSIC and lasted for 15 minutes.

6.4.3 Staff from the Duke of Cornwall Spinal Treatment Centre, SDH

Senior Clinical Nurse and Outpatient Technician:

This session was conducted in the Senior Clinical Nurse's office at the Duke of Cornwall Spinal Treatment Centre, Salisbury. Present was the Senior Clinical Nurse, an Outpatient technician and the author of this thesis. The session lasted for 90 minutes.

6.4.4 The Seating Clinic, National Spinal Injuries Centre, SMH

This session took place in the suite of rooms used during a seating assessment at the NSIC. The session was led by the physiotherapist responsible for the seating clinic. This session included demonstrations of their subcutaneous oxygen level monitor, a TCM3 machine manufactured by Radiometer Ltd, and their pressure mapping equipment manufactured by Force Sensitive Applications FSA. The pressure map demonstration included the taking of readings on a Jay 2 cushion, a Flo-tech cushion, an upholstered office chair and a wooden bench. The session lasted for one hour.

6.4.5 Results

Each of the statements from the experts were written onto cards and clustered into groups with commonalities. These groups were then titled based on the theme of the group. The final groupings were agreed upon between the author and one of the project supervisors. These groups and the source of the statements within each group have been tabulated. The groups have been ordered alphabetically and not by significance, see table 6-2.

Table 6-2 The statements from the experts grouped by themes

Expert Issue Nos. (EIN)	Groups formed from issues raised by experts	Deputy Sister	Physiotherapist, Spinal Gym	Physiotherapist, SCI Ward	Senior Physiotherapist	The Seating Clinic	Senior Clinical Nurse and Outpatient Technician	Nos of references
1	Adjusting internal air pressure		✓	✓	✓		✓	4
2	Appearance				✓		✓	2
3	Body shape fluctuations						✓	1
4	Cleaning	✓	✓					2
5	Comfort	✓	✓				✓	3
6	Contour surface					✓	✓	2
7	Cost		✓		✓		✓	3
8	Cushion cover issues						✓	1
9	Cushion orientation						✓	1
10	Cushion size						✓	1
11	Extreme body shapes			✓			✓	2
12	Fitting cushion covers						✓	1
13	Footplate adjustment						✓	1
14	Imbalance reinforcement			✓				1
15	Range of postures	✓	✓			✓	✓	4
16	Recurring damage/robustness		✓					2
17	Skin Care vs Posture Compromise		✓			✓	✓	3
18	Slouched posture						✓	1
19	Sweating						✓	1
20	Transfer issues (contour depth)						✓	1
21	Transfer issues (stability)		✓		✓			2
22	Weight				✓			1

6.5 Research Suppositions

A series of research suppositions were inducted based on the findings of the patient user interviews and expert opinion sessions, see table 6-3. Each of the issues raised by the patients were numbered with a Patient Issue Number (PIN), see table 6-1, and each of the issues raised by the experts were numbered with an Expert Issue Number (EIN), see table 6-2.

Table 6-3 A tabulation of the findings of the user interviews and expert opinion sessions and the resultant research suppositions

Research Supposition 1	Issue discussed in literature:	Air filled cushions are dependent on the setting of the internal air pressure. Over and under inflation can lead to the development of a pressure ulcer
	Findings from user interviews:	Users have difficulties with setting the internal air pressure to an optimum value (PIN 1)
	Findings from expert opinion session:	Experts have found that their clients have difficulties with setting the internal air pressure to an optimum value (EIN 1)
	Resultant supposition:	**Adjusting internal air pressure:** Users of air celled cushions are not always benefiting from the optimal internal air pressure, due to errors occurring as a result of the degree of difficulty involved in setting the internal air pressure
Research Supposition 2	Issue discussed in literature:	Personal taste is a subjective matter and disabled users can be sensitive to designs which are overly medical or project a negative self image
	Findings from user interviews:	Users consider the appearance of their cushion as important (PIN 2)
	Findings from expert opinion session:	Experts have found their clients make value judgements based on the appearance of their cushions (EIN 2)
	Resultant supposition:	**Appearance:** Users are sensitive about their appearance and they find the appearance of their cushion to be disagreeable
Research Supposition 3	Issue discussed in literature:	Rapid changes in body shape, either through weight gains or loses, can increase the patients risk of developing a pressure ulcer
	Findings from user interviews:	Issue not raised
	Findings from expert opinion session:	Experts have found that some of their clients who undergo a rapid body weight change, either weight gain or weight loss, go on to develop pressure ulcers (EIN 3)
	Resultant supposition:	**Body shape fluctuations:** Cushions are not meeting the additional requirements of a user undergoing a rapid change in body shape

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Research Supposition 4	Issue discussed in literature:	Air filled cushions can bottom out which can lead to the development of a pressure ulcer
	Findings from user interviews:	Users have experienced a loss of air pressure so that they have bottomed out and that this has caused problems (PIN 3)
	Findings from expert opinion session:	Issue not raised
	Resultant supposition:	**Bottoming out (air):** Users of air cell cushions are vulnerable to pressure damage resulting from a drop in the internal air pressure going unnoticed resulting in a bottoming out event
Research Supposition 5	Issue discussed in literature:	Gel filled cushions can bottom out which can lead to the development of a pressure ulcer
	Findings from user interviews:	Users have experienced a sufficient sideways migration of gel to cause bottoming out and that this has caused problems (PIN 4)
	Findings from expert opinion session:	Issue not raised
	Resultant supposition:	**Bottoming out (gel):** Users of viscous fluid gel cushions are vulnerable to pressure damage resulting from a sideways migration of gel going unnoticed resulting in a bottoming out event
Research Supposition 6	Issue discussed in literature:	Air filled cushions are dependent on the setting of the internal air pressure and that over and under inflation can lead to the development of a pressure ulcer
	Findings from user interviews:	Users are required to frequently check the level of air pressure and that this causes inconvenience and anxiety (PIN 5)
	Findings from expert opinion session:	Issue not raised
	Resultant supposition:	**Checking internal air pressure:** Air celled cushions are not serving the user optimally due to the necessity to frequently check the level of internal air pressure
Research Supposition 7	Issue discussed in literature:	The cleanliness of a cushion is part of a user's hygiene and that certain cushions are more difficult to clean than others
	Findings from user interviews:	Users are experiencing difficulties with cleaning their cushion and that this has caused inconvenience and anxiety (PIN 6)
	Findings from expert opinion session:	Experts have found that some of their clients experience difficulties with cleaning their cushion and that poor cleanliness can lead to pressure ulceration (EIN 4)
	Resultant supposition:	**Cleaning:** Users are hampered in their use of their cushion by the degree of difficulty involved in cleaning their cushion

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Research Supposition 8	Issue discussed in literature:	An uncomfortable cushion can cause the user discomfort and reduce the user's quality of life
	Findings from user interviews:	Users do find certain cushions more comfortable than others and do exchange cushions on the basis of comfort (PIN 7)
	Findings from expert opinion session:	Experts find their clients do experience different levels of comfort with different cushions and that comfort is very important to their clients (EIN 5)
	Resultant supposition:	**Comfort:** Users experience dissatisfaction with their cushion due to the level of comfort it can provide
Research Supposition 9	Issue discussed in literature:	The use of a cushion with the wrong contour shape can lead to the development of a pressure ulcer
	Findings from user interviews:	Issue not raised
	Findings from expert opinion session:	Experts have found matching the surface contour shape of the cushion to the client to be an important factor in the outcome of the use of the cushion (EIN 6)
	Resultant supposition:	**Contour surface:** Uses are exposed to an increased risk of pressure damage when issued with a cushion with a contour surface shape which is not optimally suited to their body shape
Research Supposition 10	Issue discussed in literature:	Cushion covers are an integral part of cushions
	Findings from user interviews:	Users find that their covers require attention and that their neglect can result in wrinkling which can lead to pressure damage. (PIN 8)
	Findings from expert opinion session:	Experts have found that their clients have various issues with their covers, including sweating, laundering, wear and tear, changing and appearance (EIN 8)
	Resultant supposition:	**Cushion cover issues:** Cushion covers are not satisfactorily addressing all the demands daily use puts upon them
Research Supposition 11	Issue discussed in literature:	A cushion positioned on a wheelchair in the wrong orientation can lead to the development of a pressure ulcer
	Findings from user interviews:	Issue not raised
	Findings from expert opinion session:	Experts are having to treat pressure ulcers which have resulted from the use of cushions positioned in wheelchairs in the wrong orientation (EIN 9)
	Resultant supposition:	**Cushion Orientation:** Users are exposed to an additional risk of pressure damage due to possible errors with how their cushion is oriented on their wheelchair

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Research Supposition 12	Issue discussed in literature:	The use of a cushion of the wrong size has ramifications for posture and can lead to the development of a pressure ulcer
	Findings from user interviews:	Users have been given the wrong sized cushion to use and this has affected, posture, comfort and the cushion's capacity to reduce pressure (PIN 9)
	Findings from expert opinion session:	Experts have found matching the size of the cushion to the client to be an important factor in the outcome of the use of the cushion (EIN 10)
	Resultant supposition:	**Cushion size:** Users are being put at additional risk of pressure damage when in receipt of a cushion of the wrong size, either too big or too small
Research Supposition 13	Issue discussed in literature:	An SCI can happen to any one and as such extreme body shapes have to be accommodated
	Findings from user interviews:	Tall users were found to experience problems with stability and posture, in particular slouching (PIN 10)
	Findings from expert opinion session:	Experts have found that clients come in all shapes and sizes and that they all require a pressure relief cushion (EIN 11)
	Resultant supposition:	**Extreme body shapes:** Cushions are not meeting the additional requirements of users with extreme physical characteristics, either extreme height, weight or both
Research Supposition 14	Issue discussed in literature:	Cushions fit inside their covers
	Findings from user interviews:	Users are experiencing difficulties with inserting and removing their cushion from their covers (PIN 11)
	Findings from expert opinion session:	Experts have found that some of their clients find inserting and removing their cushion from their covers to be difficult, in particular the manipulation of zippers (EIN 12)
	Resultant supposition:	**Fitting cushion covers:** Users are hampered in their use of their cushion by the degree of difficulty involved in changing their cushion cover
Research Supposition 15	Issue discussed in literature:	An incorrectly set footplate can prevent the user from sitting in an optimal position which can have ramifications for posture and can lead to the development of a pressure ulcer
	Findings from user interviews:	Users are using their wheelchair with their footrest incorrectly adjusted which in turn has effected their posture (PIN 12)
	Findings from expert opinion session:	Experts have found that their clients are having their knees pushed up by footrests set to high and that this is reducing the contact area with the cushion (EIN13)
	Resultant supposition:	**Footplate adjustment:** Users are exposed to an increased risk of pressure damage due to their cushions inability to adapt when a user's footplate is incorrectly set, see figures 3-78 and 3-79

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Research Supposition 16	Issue discussed in literature:	Foreign objects trapped between a user and the support surface can lead to the development of a pressure ulcer
	Findings from user interviews:	Users are sitting on their cushion unaware that a foreign object has become trapped between the skin and the support surface (PIN 13)
	Findings from expert opinion session:	Issue not raised
	Resultant supposition:	**Foreign objects on surface:** Users are exposed to an additional risk of pressure damage due to the inability of cushions to respond when their user is sitting on a foreign object
Research Supposition 17	Issue discussed in literature:	Fluid-filled cushions are designed so that the fluid can move within the cushion in order to immerse and envelop the user
	Findings from user interviews:	Users are finding that leaning can be exaggerated by the free flow of fluid in their cushion and that this can effect their posture and lead to bottoming out events (PIN 14)
	Findings from expert opinion session:	Experts have found some fluid filled cushions are not managing the migration of fluid within the cushion which results in an exaggeration of any leaning their clients may do (EIN 14)
	Resultant supposition:	**Imbalance reinforcement:** Users of fluid filled cushions are vulnerable to pressure damage resulting from the free flow of fluid from one side of the cushion to the other, which exaggerates a user's lean
Research Supposition 18	Issue discussed in literature:	When a user leans to one side the IP on the ischium being leaned on increases, whereas the IP on the ischium not being leaned on decreases
	Findings from user interviews:	Users with weakened trunk muscles tend to rely on one of their armrests to support their position which has caused problems (PIN 15)
	Findings from expert opinion session:	Issue not raised
	Resultant supposition:	**Leaning and the use of armrests:** Users are exposed to an additional risk of pressure damage due to the inability of cushions to respond to their user's sustained and repetitive leaning to one side
Research Supposition 19	Issue discussed in literature:	Users on occasion have to remove their cushion from their wheelchair
	Findings from user interviews:	Some cushions are causing users difficulties with attaching and detaching their cushion to their wheelchair (PIN 16)
	Findings from expert opinion session:	Issue not raised
	Resultant supposition:	**Portability:** Users are hampered in their use of their cushion by the degree of difficulty involved in the securing a cushion to a wheelchair

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Research Supposition 20	Issue discussed in literature:	Adhering to a pressure relief routine can help prevent pressure ulcers from developing
	Findings from user interviews:	Not all users adhere to a pressure relief routine (PIN 17)
	Findings from expert opinion session:	Issue not raised
	Resultant supposition:	**Pressure relief routine:** Users are not receiving the full benefits of a pressure relief routine due to their cushion failing to facilitate the practice of pressure relief
Research Supposition 21	Issue discussed in literature:	Sitting for extended lengths of time in a poor postural position, can have ramifications for a user's health and can lead to the development of a pressure ulcer
	Findings from user interviews:	Users are sitting for extended lengths of time in poor postural positions and this is causing discomfort, pain and pressure damage (PIN 18)
	Findings from expert opinion session:	Experts have found some clients sit in a poor postural position for lengths of time sufficient to cause muscle shortening and contractures (EIN 15)
	Resultant supposition:	**Range of postures:** Users are exposed to an additional risk of pressure damage due to the design of their cushion focusing on maintaining the "*normal*" sitting position and not sufficiently accommodating differing postures
Research Supposition 22	Issue discussed in literature:	Different cushions are vulnerable to different forms of damage, for instance air cells puncturing
	Findings from user interviews:	Users reported similar causes of damage, for instance punctures due to pet claws, or burns from smoking (PIN 19)
	Findings from expert opinion session:	Experts find the ROHO is prone to punctures (EIN 16)
	Resultant supposition:	**Recurring damage:** Users are hampered in their use of their cushion as a result of their cushion being repeatedly compromised due to certain forms of recurring damage
Research Supposition 23	Issue discussed in literature:	Cushions not secured to a wheelchair can slide both forwards and backwards, which can have ramifications for posture and can lead to the development of a pressure ulcer
	Findings from user interviews:	Users are finding that their cushion is free to slide forwards and backwards on their wheelchair seat and this is effecting their comfort and posture (PIN 20)
	Findings from expert opinion session:	Issue not raised
	Resultant supposition:	**Securing cushion:** Users are experiencing difficulties, including pressure damage, due to their cushion failing to remain secured to the seat of their wheelchair

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Research Supposition 24	Issue discussed in literature:	Users manually propelling wheelchairs can experience shock and vibrations, which can cause discomfort and fatigue the user
	Findings from user interviews:	Users who experience shock and vibrations can find that these shocks and vibrations can trigger spasms (PIN 21)
	Findings from expert opinion session:	Issue not raised
	Resultant supposition:	**Shocks/vibrations:** Users experience elevated discomfort due to their cushion not providing sufficient damping from shocks and vibrations
Research Supposition 25	Issue discussed in literature:	Certain cushions are better equipped to support a patient's posture than others. Users have to make a choice between cushions
	Findings from user interviews:	Users opt for a cushion with good skin care qualities, such as the ROHO, whilst their skin tolerance recovers after a pressure ulcer and then switch to a more postural cushion, such as the Jay (PIN 22)
	Findings from expert opinion session:	Experts find that clients use a more postural cushion until they develop a pressure ulcer at which time they switch to a more skin care oriented cushion. Once confident that the pressure ulcer episode has passed users return to a postural cushion (EIN 17)
	Resultant supposition:	**Skin care vs Posture Compromise:** Users are currently having to choose between cushions which provide optimum IP reduction or postural support
Research Supposition 26	Issue discussed in literature:	Sitting in a slouched position can have ramifications for a user's physical condition and can lead to the development of a pressure ulcer
	Findings from user interviews:	Users spent long lengths of time sat in a slouched position (PIN 23)
	Findings from expert opinion session:	Experts find that clients spend long lengths of time sat in a slouched position and that this increases IP which can lead to pressure ulcers (EIN 18)
	Resultant supposition:	**Slouched position:** Users are exposed to an increased risk of pressure damage due to their cushions inability to compensate or adjust for slouching
Research Supposition 27	Issue discussed in literature:	Moisture between the user and the support surface can increase the user's risk of developing a pressure ulcer
	Findings from user interviews:	Users experience more sweating with certain cushions and less with others and that this difference is sufficient to cause users to switch cushions (PIN 24)
	Findings from expert opinion session:	Experts find that the cover of a cushion has a large influence on a client's sweating pattern (EIN 19)
	Resultant supposition:	**Sweating:** Users experience difficulties, including pressure damage, due to their cushion failing to manage sweat and sweating

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Research Supposition 28	Issue discussed in literature:	Cushions with surface contours can have deep bucket like hollows which can pose a hazard when transferring in/out of a wheelchair
	Findings from user interviews:	Users are finding the necessity to lift up out of a deep contour, before transferring across arduous, and a hazard which can trigger pressure ulcers (PIN 25)
	Findings from expert opinion session:	Experts find that sometimes clients do not lift themselves high enough when transferring out of a contoured cushion and scrape their bottom across the edge. This can injure the bottom leading to a pressure ulcer (EIN 20)
	Resultant supposition:	**Transfer issues (contour depth):** Users experience additional difficulties, including pressure damage, when transferring to/from a contoured cushion, due to the lack of a flat surface
Research Supposition 29	Issue discussed in literature:	Fluid filled cushions, in particular air filled cushions, lack a solid stable surface from which to push off from or transfer weight onto. This makes transferring a precarious activity
	Findings from user interviews:	Issue not raised
	Findings from expert opinion session:	Experts find that clients with air filled cushions have difficulty with transferring because the unstable surface unbalances the client as they move (EIN 21)
	Resultant supposition:	**Transfer issues (stability):** Users of fluid filled cushions are experiencing additional difficulties, including pressure damage, when transferring to/from their cushion due to the lack of a solid stable base from which to transfer
Research Supposition 30	Issue discussed in literature:	Vigorous movements can result in users sitting in positions other than their optimum position
	Findings from user interviews:	Users can be displaced by vigorous manual propelling of their wheelchair (PIN 26)
	Findings from expert opinion session:	Issue not raised
	Resultant supposition:	**Vigorous movements:** Users are hampered in their use of their cushion as a result of their cushions failure to compensate for vigorous movements related to daily activities, such as propelling their wheelchair

The issues of "*Cost*" and "*Weight*" (EIN 7 and EIN 22) were not expanded into suppositions as these are aspects which should be minimised as a matter of sound design practice.

The issue of "*Wheelchair adjustment*" (PIN 27), for example patient 5 commented on the adjustment of his wheelchair head rest, was not expanded into a supposition as the issue of adjusting a wheelchair is a matter for wheelchair design not cushion design.

6.6 Discussion

During the user interviews and expert opinion sessions, two makes of cushions were prominent, the ROHO and the Jay. Less prominent but still mentioned were the Flo-tech, Varilite and Vicair cushions. This result was consistent with the advice given by staff from two different spinal cord injury centres (SCIC) as to the leading cushions in service, see section 3.3.

The informal unstructured approach employed for the interviews allowed the process to be led by the interviewees. This approach was successful in creating an atmosphere in which the interviewees felt at ease, and free to be critical of their cushion. Having chosen not to use audio recording equipment, as part of the effort to keep proceedings informal, it was not possible to transcript the interviews. Thus the following analysis of the results was limited to using the notes taken by the interviewer during the interviews. The notes made were adequate to identify themes with cushion use, such as "*Checking internal air pressure*", see table 6-1.

With the interview process being user led, each interviewee was free to express which issues concerned them the most. Some of the interviewees were more expansive than others, but all recounted personal experiences and grievances with cushion use.

Based on the literature, it had been anticipated that the interviewees would recount some usability issues and that these issues would be commonly experienced; for example the interviewees who have used air-filled cushions would have experienced at some point bottoming out due to deflation and so form the recurring theme of "*bottoming out (air)*". It was not anticipated that so many usability issues would have been raised (27 issues), whilst forming so few common themes (25 of the 27 issues reported by three or less users), see table 6-1. This result is a reflection of a more complex relationship between users and cushions than is currently acknowledged by the pressure-reduction concept.

Having gathered data from both patients and staff, it was found that whilst most of the issues raised were mentioned by both groups some of the issues were raised by only one of the groups, for example the issue of shocks/vibrations (PIN 21) was raised by only the patients, see table 6-3.

Whilst an issue might have been raised only by patients or only by staff, this does not devalue an issue's importance. It is a reflection of the experience and priorities of the individuals within the groups. For instance, none of the ten patients involved in these user led interviews raised the issue of cushion orientation. It is possible that all of these patients have never experienced a problem with the orientation of their cushion. However, the staff involved in this study, who treat and care for many patients, have to deal with the consequences when one of their patients has sat on a cushion positioned upside down. Thus, for staff cushion orientation was an issue.

Equally the issue of shocks/vibrations was raised only by the patients. For the patients who experience numerous shocks and vibrations every day shocks/vibrations are a daily discomfort, whereas to the staff this is not an issue which requires immediate medical attention and so is less of a concern.

All the usability issues raised during the user interviews and the expert opinion sessions had been found previously during the literature review. This study did not reveal any new usability issues.

The usability issues discussed in the literature tended to describe the issue, for example the need to check the internal air pressure of air-filled cushions and that over and under inflated cushions can lead to pressure ulcers. No published material was found which attempted to quantify the risk of pressure ulcer development posed by a lack of vigilance of internal air pressure, or the contribution pressure ulcers caused by inflation errors make to the overall incidence rate of pressure ulcers. Having conducted a series of user interviews and found the adjustment of internal air pressure (research supposition 1), checking internal air pressure (research supposition 6), and bottoming out on air-filled cushions (research supposition 4) to be issues raised by a small sample of users (ten patients); there is a suggestion that internal air pressure could be a much larger problem than one might ascertain from just the literature.

The interview process was designed to allow the user to lead the discussion. However the interviewees were directed to discuss their experience with cushion use. This would incline the interviewee to raise negative issues arising from cushion use. This was an intention of the interview process as the purpose of the project was to identify weaknesses in cushion design. A consequence of this approach was that the interviewee would be passing a personal judgement on the aspects of their cushion which they are unhappy with. Individual bias may cause this judgement to be overly severe or insufficiently assertive. The sample size was not large enough to assess the level of bias. As such the results of this exercise should be treated with caution. Although these results were not sufficiently definitive to draw conclusions from, there was sufficient confidence in the results to use them as the basis of a series of research suppositions for testing in the next phase of this project.

6.7 Conclusions

Various usability issues were found discussed in the literature; for example users of air filled cushions have to frequently check the internal air pressure of their cushion to avoid bottoming out which can result in a pressure ulcer. It could not be ascertained from the literature if users find the necessity to check the internal air pressure frequently a burden; or how many pressure ulcers are the consequence of errors related to checking the internal air pressure. Although the size of this study was not sufficiently large to draw conclusions on the contribution errors in checking the internal air pressure make on the incident rate of pressure ulcers it was concluded that in light of some of the users raising this issue, checking the internal air pressure is problematic for cushion users. Based on this result "*checking internal air pressure*" was one of the 30 research suppositions proposed for testing during Stage 4 of this project.

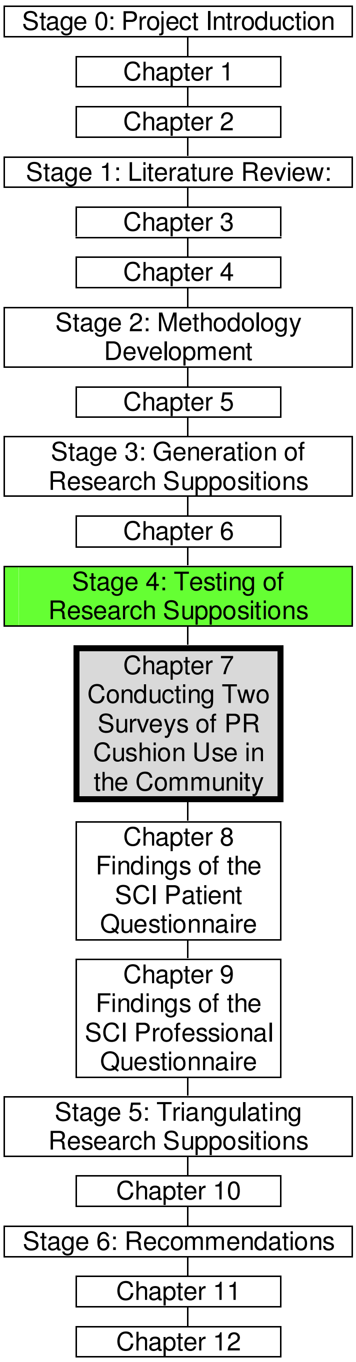
In total 30 research suppositions, all based on usability issues, were proposed. None of these research propositions represent a new insight as each research proposal was based on an issue which can already be found in the literature. It was concluded then that this exercise had not found a single new issue which if resolved would eliminate the pressure ulcers which still occur. What was revealed by this exercise was that despite knowing that these usability issues lead to the development of pressure ulcers, these issues have not yet been effectively addressed. For instance, in the literature it can be found that cushions must not be free to slide on the seat of a wheelchair. In response cushions such as the ROHO, Flo-tech, Varilite and Vicair provide a non-slip base on their cover to prevent their cushion from sliding on wheelchair seats. This study suggests that this non-slip base is not sufficient as users of these cushions are still sliding on the seat of their wheelchair.

It was also concluded that with so many usability issues still to be fully resolved it follows that there is scope for improving the design of cushions. In addition, if the design of cushions was to be improved, and the current usability issues resolved, then there is the potential to make substantial reductions in the current incidence rate of pressure ulcers.

Chapter 7

CONDUCTING TWO SURVEYS OF PR CUSHION USE IN THE COMMUNITY

7.1 Introduction



This chapter reports on the work carried out to produce and circulate the questionnaires used to gather data in order to complete 'Stage 4' of the project. The project's methodological framework tasked Stage 4 with the testing of research suppositions produced previously during Stage 3.

This work began by developing the methodology for the surveys. This development include d a review of texts on survey and questionnaire design, including the relevant sections in the USERfit methodology on questionnaires.

The questionnaires for the surveys were then designed and developed. This development included a pilot at two different spinal injuries centres.

The circulation of the SCI patient questionnaire was aided by the Spinal Injuries Association (SIA), and the SCI staff questionnaire was circulated at all eleven of the UKs Spinal Injuries Centres.

7.2 Development of the two Surveys

Following the methodological framework of this project, the research suppositions generated in Stage 4 now had to be tested by means of a quantitative exercise, see section 5.7. This task would be completed by conducting a survey of the SCI community.

7.2.1 Methodology

A methodology for the design and administration of this survey was developed by referring to texts on conducting surveys.

There has been much published on survey and questionnaire design. The fundamentals of survey design and administration are common to most descriptions of the process. A point recognised by McColl, "*Most basic texts on survey methods are in general agreement regarding the steps involved in carrying out a survey*" (McColl *et al* 2001). These fundamentals have been incorporated into the USERfit methodology concept of design and administrating questionnaires, including fundamentals such as construction of questionnaires and piloting draft versions.

Viewing these steps as contributing to a whole, whereby one step done badly can negatively affect the final outcome, has given rise to the notion of a "*total survey design*" approach. One such exponent of the total survey design approach is Weisberg, who recognised the value of "*total survey design*" when he wrote, "*the literature on surveys in the 1980's and 1990's has given much attention to "total survey design", stressing the need to consider every aspect of a survey in building a quality product*" (Weisberg *et al* 1996).

The steps Weisburg included in the "*total survey design*" can be seen in table 7-1 and the steps included by McColl can be seen in table 7-2.

The methodology formulated for this survey was composed of the fundamental found in these texts with the final strategy based on the review by McColl for the *NHS R&D Health Technology Assessment (HTA) Programme*:

> *Design and use of questionnaires: a review of best practice applicable to surveys of health service staff and patients*
>
> (McColl *et al* 2001)

Table 7-1 Weisberg's stages of the survey process (Weisberg 1996)

Stages of the Survey Process
Stage
Survey Design and Data Collection
Statement of study objectives
Preparation of study design
Sampling – choosing people to interview
Questionnaire construction and pretesting
Interviewing – data collection
Coding – categorising the responses
Entering the data into the computer
Data Analysis
Specification of hypotheses
Tabulation of responses
Building new measures
Hypothesis testing
Analysis of two-variable relationships
Use of control variables
Reporting Results
Writing research reports
Reading survey reports

Table 7-2 McColl's steps of the survey process (McColl *et al* 2001)

Steps in a survey
Define the aims of the study
Review the current state of knowledge on the topic
Conceptualise the study
Determine an appropriate study design (e.g. experimental vs. observational, prospective vs. retrospective) and assess feasibility within resource constraints
Decide upon hypotheses to be investigated, determine and operationalise data requirements
Choose the most appropriate method of data collection (e.g. self-completed questionnaires vs interviews)
Design or adapt data collection instruments
Conduct pilot work and refine methods and instruments
Design and select sample
Conduct data collection
Process data
Analyse data
Report findings

The survey process developed for this project is shown in table 7-3

Table 7-3 The 'total survey design' process developed for this survey

Step	Process	Section
1.	Generate the research suppositions for testing[1]	Chapter 6
2.	Identify target groups	7.2.2
3.	Select data gathering technique	7.2.3
4.	Design the questionnaires	7.3.1
5.	Pilot the questionnaires	7.3.2
6.	Circulate the questionnaires	7.4
7.	Data entry (process results)	7.4.1 and 7.4.2
8.	Analyse the results	Chapter 8 and Chapter 9

[1] This step equates to McColls survey process step "*Decide upon hypotheses to be investigated*" and Weisberg survey process stage "*Specification of hypotheses*"

7.2.2 Target Groups

7.2.2.1 The SCI Population

An injury to the spinal cord can occur to anyone at any time, with the three most common causes of SCI being,

- Falls (45.5%)
- Traffic accidents (39.2%)
- Sports injuries (10.2%) (SIA 2006)

Consequently, the range of people with SCI is as varied as the general population, encompassing all ages, ethnicity, gender, body shape, economic status etc. Although there are no official UK statistics regarding the age at injury of people with SCI; in the USA according to the National Spinal Cord Injury Statistical Centre (NSCISC) the average age at injury is 40.2 years. This average has increased since the 1970's when between 1973 and 1979 the average age at injury was 28.7 years. This increase in average age has tracked the increase in the median age of the population of the USA which has risen by 8 years since the mid 1970's. It is anticipated that the average age at injury will continue to increase following the growing aged population plus a number of other reasons such as improving survival rates of older persons at the scene of accidents (NSCISC 2009).

As any individual regardless of personal circumstance may have a SCI the survey aimed not to exclude any sub groups within the SCI population based on personal matters such as age, regional location, etc.

7.2.2.2 In-Patients and Out-Patients

A commonly drawn distinction in the SCI population is that of in-patient and out-patient status. This project is aimed at improving the design of PR cushions to support and enhance the independence of wheelchair users in their daily lives out in the community. As such it is the needs of those with SCI living out in the community, out-patients, which is of interest to this project and therefore was the target group of this survey.

This project is geared towards the design of cushions used by SCI patients living in the community. The needs of in-patients is a matter for PR cushion design to be aware of as potentially the needs of in-patients may well be sufficiently different to the needs of SCI patients living in the community to warrant separate consideration from PR cushion designers. This may well come in the guise of a specialist "*new to SCI*" PR cushion for use in hospital and during early rehabilitation. At this time the needs of in-patients, and any consequential development, is considered a separate issue to this project and a subject for further research.

7.2.2.3 Paraplegics and Tetraplegics

A commonly drawn distinction in the SCI population is that of the paraplegic and tetraplegic. Paraplegics have experienced a low level injury on the spine, below the sixth thoracic vertebrae (T6), resulting in paralysis to the legs. Tetraplegics have experienced a high level injury, above T6, resulting in paralysis to both arms as well as legs, see appendix A.

The focus of this project has been placed on the wheelchair user group formed by the SCI community, see section 2.5, which include both paraplegic and tetraplegic individuals. As such it is the needs of those with SCI living out in the community, regardless of the level of injury, which is of interest to this project, and so both the paraplegic and tetraplegic are included in this survey.

By including both paraplegic and tetraplegic individuals it will be possible to identify and compare differences in the needs between these two groups. It may be that the needs of the paraplegic and tetraplegic are sufficiently different to warrant different dedicated PR cushions for each group.

7.2.2.4 SCI Professionals

The care and treatment of SCI is a complex matter and as such requires a multidisciplinary approach. The membership of the Multidisciplinary Association of Spinal Cord Injury Professionals (MASCIP) reflects this multidiscipline approach. In 2006 the MASCIP membership consisted of 689 members comprising of:

- *282 (41%) Nurses*
- *109 (16%) Physiotherapists*
- *69 (10%) Occupational Therapists*
- *42 (7%) Medical Doctors*
- *33 (5%) Administrators*
- *22 (3%) Clinical Physiologists*
- *15 (2%) Dieticians*
- *14 (2%) Social Workers*
- *103 (14%) Others*

(MASCIP 2006)

Some of these professionals are closely involved with PR cushions, such as physiotherapists, whilst others are not, for example dieticians. Those professions closely involved with PR cushions offer a wealth of experience as to the limitations of PR cushions in preventing pressure ulcers, the problems cushion use imposes on their users and the difficulties users experience with day-to-day cushion use. It was therefore decided that this survey would target the professions whose work is involved with PR cushions namely the physiotherapist, occupational therapist and nurses, as well as SCI patients.

7.2.3 Data Gathering Techniques

The advantages and disadvantages of various data gathering techniques such as,

- face-to-face interviews
- telephone interviews
- self-completion questionnaires.

were considered by McColl whilst reviewing best practice in the design and use of questionnaires (McColl *et al* 2001).

Based on McColl's review, it was decided that this survey would be best served by circulating a self-completion postal questionnaire. Although it is known that postal surveys yield a low return rate typically of less than 10%, "*one return for every ten questionnaires sent out (for a postal survey) is considered to be a good rate of return*" (Holden 2010); the anonymous self-completion questionnaire format was selected as it offers a number of advantages,

- by circulating a fixed questionnaire, the same questions are asked consistently across the subject groups, so quantitative results may be obtained
- larger populations can be targeted
- questionnaires can be easily circulated across a diverse and geographically separated group of patients and staff
- the self-selection process of respondents answering a national appeal for volunteers provides a random selection of the community
- a self completing questionnaire designed to extract users experience of PR cushion use will elicit a bias towards negative experiences. This is advantageous as this project is aimed at establishing where PR cushion performance is weak so that design may address these issues
- the use of self-completion questionnaires retains an individual's anonymity. By being anonymous respondents are less inhibited and so are more likely to provide full honest answers

7.3 Developing the Questionnaires

7.3.1 Questionnaire Design

7.3.1.1 Questionnaire Content

The content of the questionnaires was determined by the research suppositions being tested in this survey, see table 7-4.

Table 7-4 A list of the research suppositions drafted into the pre-pilot questionnaire

Research Suppositions for Testing by Survey			
1.	Adjusting internal air pressure	16.	Foreign objects on surface
2.	Appearance	17.	Imbalance reinforcement
3.	Body shape fluctuations	18.	Leaning and use of armrests
4.	Bottoming out (air)	19.	Portability
5.	Bottoming out (gel)	20.	Pressure relief routine
6.	Checking internal air pressure	21.	Range of postures
7.	Cleaning	22.	Recurring damage
8.	Comfort	23.	Securing cushion
9.	Contour surface	24.	Shocks/vibrations
10.	Cushion cover issues	25.	Skin care vs Posture compromise
11.	Cushion orientation	26.	Slouched position
12.	Cushion size	27.	Sweating
13.	Extreme body shapes	28.	Transfer issues (contour depth)
14.	Fitting cushion covers	29.	Transfer issues (stability)
15.	Footplate adjustment	30.	Vigorous movements

It was important to ensure that the SCI patient questionnaire was designed such that the anonymity of the respondent was maintained. Therefore no questions which could be used to identify an individual or place of work were asked.

By drawing from the whole of the SCI population and using a postal returned questionnaire, the chance of it being re-traced back through the post to the sender was very low. It was therefore possible to ask questions related to physical characteristics without compromising an individual’s anonymity.

7.3.1.2 Questionnaire Structure

With thirty research suppositions to test, a compromise had to be made between the length of the questionnaire and the response rate. Long questionnaires are known to elicit poor response rates. For example, Orpwood from the Bath Institute of Medical Engineering (BIME) made use of a questionnaire as part of his work on a "*Pre-School Powered Mobility Vehicle*". Orpwood had 1200 questionnaires inserted into the National Association of Paediatric Occupational Therapists (NAPOT) yearbook. Of these 1200 questionnaires only 56 were returned, a return rate of 4%. They had concluded that the questionnaire being four pages long was a significant contributing factor to the low response (Orpwood *et al* 2004).

Not all long questionnaires receive a poor return rate. For example, the Senior Clinical Nurse of the Pressure Clinic at The Duke of Cornwall Spinal Treatment Centre, Salisbury District Hospital has successfully produced results from long questionnaires. Based on her past experience she was confident of a positive response to her latest questionnaire which consisted of seventy five questions, in three parts, spread over thirty pages. She ascribed this readiness of people with SCI to tackle lengthy questionnaires to their interest and motivation in research matters. She described them as being "*professional patients*". She did add the caveat that quality is very important as people with SCI will show little interest in questionnaires they regard as being of little merit.

Based on this advice, draft questionnaires were designed using techniques described by various authors of survey and questionnaire design such as Babbie (1990), Hague (1993) and Oppenhiem (1996). Firstly the thirty research suppositions, were grouped into five areas of enquiry, "*Cushions Used*", "*Practices and Behaviour*", "*Skin Care*", "*Sitting Posture in a Wheelchair*" and "*Utility/Practicality of Cushion*". The research suppositions were then converted into testable propositions, a process McColl called "*operationalisation of the hypotheses*" (McColl *et al* 2001). These *operations* were then converted into the questions presented in the questionnaires by considering the both the form of the question and the wording used.

7.3.2 Piloting the Questionnaires

7.3.2.1 The Pilot

The questionnaires were piloted with a small number of individuals, taken from the surveys' target populations. The comments provided were used to revise the questionnaires before wide circulation.

In order to avoid local bias, the individuals approached to comment on the questionnaires were drawn from two sites, the NSIC Stoke Mandeville and the Duke of Cornwall Spinal Injuries Treatment Centre, SDH.

- Nine copies of the SCI Patient Questionnaire were circulated amongst SCI cushion users by the SIA Peer Support Officer at the NSIC Stoke Mandeville

  (Three copies of the SCI Patient Questionnaire returned)

- Five copies of the SCI Patient Questionnaire and five copies of the Staff Questionnaire were sent to a Deputy Sister at the NSIC Stoke Mandeville, to circulate amongst colleagues

  (Two SCI Patient and two Staff Questionnaires returned)

- One copy of the SCI Patient Questionnaire and one copy of the Staff Questionnaire was given to an orthopaedic surgeon, with experience in SCI, at Stoke Mandeville Hospital

  (Both SCI Patient and Staff Questionnaire returned)

- Four copies of the SCI Patient Questionnaire and four copies of the Staff Questionnaire were sent to the Senior Clinical Nurse at the Duke of Cornwall Spinal Injuries Treatment Centre, SDH, to circulate amongst colleagues.

  (a summary of comments on the SCI Patient Questionnaire and a summary of comments on the Staff Questionnaire returned)

In addition the patient questionnaire was discussed with the Patient Educational Advisor, NSIC Stoke Mandeville.

7.3.2.2 The Revisions

There was consensus that the questionnaires were too long. A typical comment came from the orthopaedic surgeon, "*First impression: a lot of questions for a patient to answer*". It was clear that the length of the questionnaire would have to be reduced.

It would have been possible to cut the length of the questionnaires by increasing the density of text on each page, by reducing the blank space between questions and using a smaller font. However by increasing the number of questions per page reduced the clarity of the questionnaire making it more onerous to complete. It was decided to leave the text density unchanged so as not to make the questionnaire more arduous, which could deter potential respondents.

Instead a process of judicious editing was undertaken whereby the importance of each question to the survey was reconsidered. An example of this editing process was the removal all questions enquiring into dynamic cushion matters such as noise levels and energy consumption. It was advised that the overwhelming majority of SCI patients use static cushions and so committing space on the questionnaire to dynamic cushion questions would be an inefficient use of space. This was verified in the results of the questionnaires,

- out of the 41 SCI patients who responded not one used a dynamic cushion, see table M-39 in appendix M
- out of the 31 SCI staff who responded not one listed a dynamic cushion as one of the cushions they regularly come into contact with, see table O-18 in appendix O.

At the end of this process the length of both questionnaires had been significantly reduced.

- The SCI Patient questionnaire was reduced from 25 pages of questions (Q=124) to 15 pages (Q=83). A 33% reduction in the number of questions, and a 40% reduction in the number of pages.
- The Staff questionnaire was reduced from 21 pages of questions (Q=106) to 15 pages (Q=72). A 32% reduction in the number of questions and a 29% reduction in pages.

The pilot also raised concerns with the wording of some of the questions, in particular the use of jargon and the degree of difficulty posed by a question.

Following the guidelines[2] found in the literature on questionnaire design, the wording of the questions had already been deliberated when the testable propositions, referred to as 'operations', were converted into questions, see section 7.3.1.2. During this question formulation phase, it was assumed that the individuals sufficiently interested in answering the questionnaire would be familiar with certain terms and concepts regularly used in the field of spinal cord injury. However, this assumption was proved wrong by the pilot as various comments challenged the use of certain terms; the degree of difficulty and complexity of some of the questions; and the level of detail requested.

Therefore as a result of the pilot the wording of some of the questions had to be revisited because it is important to set the level of difficulty at an appropriate level as,

- questions which are difficult to answer might be incorrectly answered
- difficult questions might be left unanswered
- too many difficult questions and the whole questionnaire might be abandoned.

Having studied the comments returned from the pilot certain technical terms and phrases were singled out and simplified. For example the phrase "*interface pressure*" had raised comment being either unknown or referred to as a piece of jargon. It was therefore decided to simplify this phrase; for instance in the line "*The cushion's ability to achieve a low peak interface pressure*" was changed to, "*The cushion's ability to keep the pressure experienced by your skin low*".

The difficult and complex questions were simplified. A typical simplification was to change a scale from a percentage range, (ie 0-10%, 11-20%, etc) to a five point Likert scale using Likert items such as,

All the time	Frequently	Occasionally	Very Rarely	Never
☐	☐	☐	☐	☐

[2] The guidelines do not specify the practice of approaching a market research company for a second opinion on the comprehensibility of the questions before piloting a questionnaire

The decision to adopt simpler scales had to be balanced with a loss of accuracy. Some of the questions which had already used these simpler scales were an issue for some; for example one returned comment, "*Most questions are difficult to answer accurately as we are being asked to generalise what is "frequently" "occasionally" – this is all relative*".

This loss of accuracy had to be weighed against the real potential that the questionnaire might be poorly received generating a negligible return rate. One comment from one of the nurses, who returned the questionnaire unanswered, was simply, "*This is too complex to be filled in*". It was therefore decided to use the simpler scales.

In discussions with staff and colleagues on the efficient use of the limited space available on the questionnaire, a decision was made to reduce the number of questions asked by omitting all questions relating to shocks and vibrations. The questions on shocks and vibrations were chosen for omission because whilst they cause discomfort they are less relevant to the development of pressure ulcers.

7.4 Circulating the Questionnaires

7.4.1 The SCI Patient Questionnaire

The circulation of the SCI patient questionnaire, see appendix L, was conducted by promoting the questionnaire in the SCI community and seeking volunteers to come forward. Permissions were not required from institutions with a duty of care, such as a hospital, as the questionnaires were not circulated through such institutions.

The circulation phase ran for seven months, between May and December 2006. During this period a number of different avenues were taken to circulate this questionnaire including wheelchair sports clubs and the SIA website.

By the end of the circulation phase a total of 41 completed questionnaires had been collected, see table 7-5.

Table 7-5 The actions taken to circulate the SCI patient questionnaires

Circulation of SCI patient questionnaire		
Action taken	Number of returns	Return rate
Nine SIA peer support officers contacted. A total of 15 copies of the questionnaire were circulated.	4	27%
Electronic copy of questionnaire forwarded to 12 members in SIA Merseyside e-mail group.	3	25%
Electronic copy forwarded to 22 in the SIA executive director personal e-mail group.	5	23%
38 copies of questionnaire handed out at the 8th Annual MASCIP conference.	6	16%
A notice posted on SIA website message board. 184 viewings (Lance2006c)[3].	2	1%
Article in June 2006 publication of SIA magazine *FORWARD* (Lance 2006a). 7300 copies in print run. Article advertised a downloadable version of the questionnaire available on the BCUC website (Lance 2006d)[4].	17	Unknown

Continued on the next page

3 A copy of the posting on the SIA message board has been included, see figure K-1 in appendix K.

4 A copy of the article in the SIA magazine *FORWARD* has been included, see figure I-1 in appendix I, also a copy of the Buckinghamshire Chilterns University College (BCUC) webpage advertised in the *FORWARD* magazine article has been included, see figure I-2 in appendix I.

Continues from the previous page

SIA development officer forwarded electronic copy to associates, exact number forwarded unknown.	4	Unknown
Senior lecturer with a special interest in SCI handed out 10 copies to associates with a SCI.	0	0%
Four wheelchair activity groups contacted. One group reported that they had no members with SCI. Three groups did not reply.	0	0%
Three disabled sports clubs contacted. One club returned a list of disabled sports clubs in Hampshire. Two groups did not reply.	0	0%
Five wheelchair user groups contacted. One group said they would discuss the questionnaire at their monthly meeting. There was no further communication from them. One group replied that they were unable to participate due to NHS confidentiality policy. Three groups did not reply.	0	0%
TOTAL	41	-

On receipt of a completed questionnaire, the data were entered into the statistical software application SPSS ver.16 (SPSS Inc., Chicago, IL, USA).

7.4.2 The SCI Professional Questionnaire

The circulation of the SCI professional questionnaire, see appendix N, was conducted through intermediaries, who sought permission from their respective centres, to circulate the questionnaire amongst their colleagues.

The circulation phase also ran for seven months, between May and December 2006. During this period a number of different avenues were taken to circulate this questionnaire. In addition, the questionnaire was promoted among the MASCIP membership during the poster session at two of their annual conferences, see figures J-1 and J-2 in appendix J.

By the end of the circulation phase a total of 34 questionnaires had been returned, three of which had been returned unanswered, see table 7-6.

Table 7-6 The actions taken to circulate the SCI professional questionnaires

Circulation of SCI professional questionnaire		
Action taken	Number of returns	Return rate
10 questionnaires handed out to nurses by a physiotherapist at the NSIC Stoke Mandeville.	4 nurses (7 returned, with 3 unanswered)	40%
99 questionnaires handed out to physiotherapists and OT's by the heads of physiotherapy and OT departments across the UK's SCIC[5] excluding the NSIC. One questionnaire kept by a physiotherapist at the NSIC.	26 (17physios, 9 OT's)	26%
Promotion through MASCIP website (Lance 2006e) and newsletter 7(1):23 (Lance 2006b)[6].	1 (1 OT)	Unknown
Senior lecturer with a special interest in SCI handed out 10 copies to nurses working with SCI patients.	0	0%
TOTAL	31	-

On receipt of a completed questionnaire, the data were entered into the statistical software application SPSS ver.16 (SPSS Inc., Chicago, IL, USA).

[5] The towns and cities where the eleven UK spinal cord injury centres (SCIC) are located are, Belfast, Cardiff, Glasgow, Middlesbrough, Ostwestry, Salisbury, Sheffield, Southport, Stanmore, Stoke Mandeville and Wakefield

[6] A copy of the MASCIP homepage with the link to a downloadable version of the questionnaire has been included, see figure K-3 in appendix K, and a copy of the article in the MASCIP newsletter has been included, see figure I-2 in appendix I.

7.5 Discussion

A number of different avenues were followed to reach as many individuals of the SCI patient population as possible. Many of these avenues proved unproductive. All the sports clubs, activity groups and wheelchair user groups contacted failed to generate a returned questionnaire, see table 7-5. In certain cases this lack of response was explained; for instance, the wheelchair dance group "*Concord Dance*" explained that none of their wheelchair user membership had a SCI. In most cases there was no reply from the groups or clubs and so their reticence remains unexplained. It is possible that the choice of initiating contact by either by mail or e-mail was ill-advised as they regularly receive unsolicited requests and so tend to ignore such requests. Where dialogue was used to initiate contact more success was achieved. Dialogue with various individuals within the SIA, such as the Executive Director and a peer support officer, resulted in 35 out of the 41 returns (85%).

It appears that the establishment of direct communication with an individual within an organisation defined the success of a circulation activity. It is likely that the response of organisations such as sports clubs and activity groups could be improved by organising a visit and establishing a personal contact, although this was logistically not possible within the constraints of this project.

Having liaised closely with the editor of the SIA bimonthly magazine *FORWARD*, it was disappointing that the prominent article, see appendix I, included in their June issue was not more productive. The final count of the returned questionnaires following this exercise was 17. This magazine has a circulation of 7,300 copies amongst the SCI community. Had 2%, half the return rate achieved by Orpwood, see section 7.3.1.2, of this readership responded, then this exercise would have generated 146 returned questionnaires.

It is possible this exercise was thwarted by an error made by the magazine editorial team who incorrectly published the wrong website address for downloading a copy of the questionnaire. The subscribers of this magazine would have been in receipt of their copy of the magazine for more than a week before this error was identified. When this error was identified a link to the correct web page was inserted on the web page advertised in the article. However, during this week anyone who had read the article would not have been able to find the questionnaire which would have deterred them from taking part in the survey.

To maximise the questionnaire return rate, progress checks and encouragement were verbally communicated with the contacts at the SIA and multiple attempts were made to establish correspondence with the organisations, such as sports clubs and activity groups, who remained unresponsive. However in order to maintain anonymity, the researcher had no access to the respondents contact details and so it was not possible to send any individual a reminder or offer incentives. Had the option of using reminders been available the return rate may have been higher.

Assistance in the circulation of the professional questionnaire was obtained thorough personal contact with staff from the physiotherapy department at the NSIC, Stoke Mandeville. Through their efforts 100 questionnaires were circulated amongst the physiotherapy and occupational therapy departments of all eleven spinal injuries centres, see table 7-6. This wide spread distribution will have ensured that the returned questionnaires represented a good cross section of physiotherapist and occupational therapist practice. The contact made with staff from the physiotherapy department at the NSIC, Stoke Mandeville proved to be the most productive action taken to generate returned professional questionnaires. Their efforts resulted in 26 out of the 31 returns (84%).

Assistance from MASCIP was gained through personal contact. It was through the MASCIP Committee secretary that an article appealing to the MASCIP membership for volunteers to complete the questionnaire was included in their quarterly newsletter, see appendix I, a downloadable copy of the questionnaire placed on the MASCIP website and permission was granted to hand out questionnaires at their annual conference. It was disappointing that their assistance only generated returns from one occupational therapist and six patients, see tables 7-5 and 7-6.

Similarly to the patient questionnaire circulation activities, it was the activities conducted at a personal level which achieved the most productive results. Based on this experience, it is probable that the response rate could have been improved by establishing a personal contact at each of the SCIC. This would not have been logistically possible within the time and financial constraints of this project.

7.6 Conclusions

It was found that the individuals who did answer the questionnaire represented a good demographic cross section of the SCI population with both paraplegic and tetraplegics; men and women; young and old; tall and short; being represented, see section 8.2.1. It was therefore concluded that the decision to employ a range of intermediaries to reach different sections of the SCI population was sound.

Via staff from the physiotherapy department NSIC Stoke Mandeville, the professional questionnaire was distributed to the departmental heads of the physiotherapy and occupational therapy departments of the UK SCICs. Although the number of returned questionnaires represents a numerically small sample, it is from a cross section of the national physiotherapy and OT experience. It could be concluded that the decision to contact staff from the physiotherapy department NSIC Stoke Mandeville was sound.

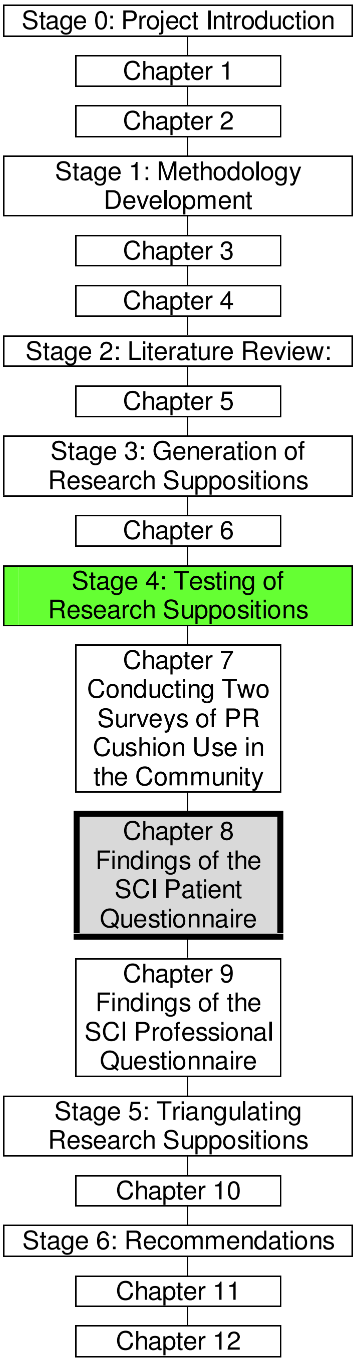
At the start of the circulation of the professional questionnaire process there was some doubt as to the success of this endeavour. Being aware that the professionals involved in the care and treatment of people with SCI, such as physiotherapists, occupational therapists and nurses, are very dedicated and hardworking, it was thought that the questionnaire might be still too long and too demanding for these professionals to divert so much of their time to this endeavour. It could be concluded that for so many of these busy individuals to voluntarily invest so much of their time into this questionnaire was a reflection of the potential merit seen by these professionals in this questionnaire.

Due to the time constraints on the project an inquiry into the effectiveness of the circulation activities was not undertaken. Without having undertaken such an enquiry it was not possible to definitively answer questions, such as; to what extent did the length of the questionnaires deter potential respondents?

Chapter 8

FINDINGS OF THE SCI PATIENT QUESTIONNAIRE

8.1 Introduction



This chapter reports on the findings of the SCI patient questionnaire, see appendix L, as part of 'Stage 4' of the project. The project's methodological framework tasked Stage 4 with the testing of the 30 research suppositions produced in Stage 3.

For the sake of clarity, due to the large number of questions asked of the respondents (83 questions), this chapter has been divided into four areas of discussion based on the areas of enquiry used to structure the questionnaires, see section 7.3.1.2. Tables of all results are shown in appendix M

The first area of enquiry discussed is the respondent's pressure ulcer history; followed by a discussion of the cushions used by the respondents; then a discussion on the respondent's posture and sitting position in a wheelchair; then a discussion on the practicalities relating to daily cushion use. This final discussion combined the two areas of enquiry "*Practices and Behaviour*" and "*Utility/Practicality of Cushion*", see appendix L.

This chapter ends with a set of conclusions drawn from the findings of this questionnaire.

8.2 Findings on the Respondents' Pressure Ulcer Histories

8.2.1 Demographic Profile

In total 41 people with SCI completed the questionnaire (approximately 1 in 1000 of the SCI population[1]).

This sample of the SCI population has representation from a cross section of the principle characteristics.

Of the 41 respondents:

- 25 (61%) were male with 14 (34%) female, two did not answer
- None of the respondents were under 25 years of age. One respondent reported being over 75 years of age
- The range of heights was between 5'2" to 6'5"
- Three of the respondents weighed less than 9st and one weighed more than 16st 6lb
- 7 (17%) were left handed, 31 (76%) right handed, and three did not answer
- 26 (63%) were tetraplegic and 15 (37%) paraplegic
- 25 (61%) had a complete injury, 13 (32%) an incomplete injury, two did not know and one did not answer
- None of the respondents had their injury for less than three years, with 34 (83%) having had their injury for more than 10 years.

(tables M-1 to M-4, M-6 to M-8 and M-10)

Various medical conditions that are found within the SCI population which are relevant to cushion design as they increase the skins vulnerability to pressure damage, such as excessive sweating patterns; the use of medication; or additional health conditions, has been represented (tables M-11 to M-13).

[1] The SCI population in the UK has been estimated to be 40,000 (section 2.5)

8.2.2 Pressure Ulcer Occurrence

Of the 41 respondents, 24 (59%) reported that they have experienced at least one pressure ulcer. Between these 24 respondents, they have experienced a total of 122 pressure ulcers, see figure 8-1.

At the time of completing the questionnaire, two respondents were experiencing a pressure ulcer (table M-14). This was an incidence rate of 4.9%. This result is in line with others studies, such as Kaltenthaler (2001) who found the incidence rate in the community to be between 4.4% and 6.8%.

The 24 respondents who reported that they have experienced at least one pressure ulcer in their life represent 59% of the total sample. This is a smaller percentage than found by others studies. A study conducted by Lippert-Grüner (2003) reported that 80% of the SCI patient group had experienced a pressure ulcer at some point in their life time, and a study by Byrne (1996) found 85%, see section 2.4. These studies marked the occurrence of pressure ulcers over the whole of a life time, unlike this study where the respondents still have a portion of their life ahead of them, particularly their old age when their risk of developing a pressure ulcer increases, see section 4.4.3.

8.2.2.1 Gender

Of the respondents, 25 (61%) were male and 14 (34%) female (table M-1). It was anticipated that more males would have responded than female as there are more men with SCI than women. However the difference was not as great as anticipated. Whilst there are no official UK statistics regarding the ratio of males to females in the SCI population; in the USA according to the National Spinal Cord Injury Statistical Centre (NSCISC) 80.9% are male (NSCISC 2009). Also, during the patient interviews a total of nine males (90%) compared to one female (10%), came forward to participate, see section 6.3.

It is possible that women formed a higher proportion of the respondents than anticipated as women maybe more conscientious about health matters and as such more concerned with matters related to pressure ulceration. It may be that more women responded as they are regarded as being more at risk of pressure damage, as indicated in the Waterlow risk assessment tool, see section 3.5.2. However, it was found that 36% of the men were either "*worried*" or "*very worried*" about the performance of their cushion leading to problems with their skin compared to 14% of the women (table M-42).

It had been anticipated that a similar proportion of males and females would develop pressure ulcers as other studies had found this to be the case. Suriadi (2006) found the proportion of males and females to be the same. In his study, 24 males out of 72 (33%) and 11 females out of 33 (33%) developed pressure ulcers (Suriadi *et al* 2006). Whittington (2004) found slightly more females developed pressure ulcers (52% of females; 46% of males) (Whittington and Briones 2004), whilst Young (1981) found slightly more males developed pressure ulcers (77% of males; 70% of females) (Young *et al* 1981).

This study found:

The mean number of pressure ulcers for both males (76/25 = 3.0) and females (46/14 = 3.3) was approximately three (table M-16).

However, with 16 out of 25, a higher proportion of males (64%) developed pressure ulcers somewhere on their body compared to females with 7 out of 14 (50%), (table M-15).

This difference in proportion of men and women reporting having ever experienced a pressure ulcer was found to be not statistically significant.

> Using Pearson's Chi Square, $X^2 = 0.73$; df = 1; (2-sided) $p = 0.39$, for significance $p < 0.05$.
>
> Using an Independent t-test, there was no significant difference in the number of pressure ulcers reported by men (M = 3.30, SD = 4.85), and women (M = 4.25, SD = 5.64; $t(34) = -0.53$, $p = 0.60$). The magnitude of the differences in the means was very small (eta squared = 0.008).

Although the difference in proportion between males and females was not found to be statistically different, this study did find 14% more males to have developed pressure ulcers than females (64% of males; 50% of females). This margin between male and female was greater than anticipated. The increased proportion of males may be the result of confounding factors such as age, for instance 50% of the male respondents were above 55 years of age compared to 29% of the females. Smoking is also known to increase an individual's vulnerability to pressure damage. The proportion of smokers in this survey is not known. The national average of adult male smokers is slightly higher, at 23%, than adult females, at 21% (ONS 2008); it is possible that more male smokers than female responded to this questionnaire.

Although gender is not commonly cited as a factor in the development of a pressure ulcer, see section 4.4, gender has been associated with pressure ulcers risk. The Waterlow risk assessment tool, one of the three most commonly used tools Braden, Norton and Waterlow (Collier 2004), considers females to be at greater risk than males, with a risk score of two compared to the males risk score of one (Waterlow 1996), see section 3.5.2. The role of gender in pressure ulcer development is not clear, with various studies finding the difference in proportion between males and females developing pressure ulcers to be small, (Whittington and Briones 2004) (Young 1981). Although this survey did not find a statistically significant higher proportion of males to develop pressure ulcers than females, this study is not conclusive enough to suggest that gender does not influence risk.

8.2.2.2 Tetraplegics verses Paraplegics

Of the respondents, 26 (63%) were tetraplegic and 15 (37%) paraplegic (table M-7). The ratio of tetraplegic to paraplegic respondents was greater than anticipated, as during patient interviews a total of three tetraplegics (30%) compared to seven paraplegics (70%), came forward to participate, see section 6.3; also anecdotally this ratio is said to be ⅓ tetraplegic to ⅔ paraplegic. However, although there are no official UK statistics regarding the ratio of tetraplegics to paraplegics; in the USA according to the National Spinal Cord Injury Statistical Centre (NSCISC) 50.5% are tetraplegic and 44.1% are paraplegic (NSCISC 2009).

It is possible that a much higher proportion of tetraplegics responded to this questionnaire than paraplegics, because the extent of the paralysis in tetraplegics is greater than paraplegics and as such tetraplegics tend to be more concerned with matters related to pressure ulceration. It was found that 35% of the tetraplegics were either "*worried*" or "*very worried*" about the performance of their cushion leading to problems with their skin compared to 13% of paraplegics (table M-42).

It had been anticipated that a greater proportion of tetraplegics would develop pressure ulcers than paraplegics as the more extensive paralysis experienced by tetraplegics tend to make them more vulnerable to pressure ulceration. The level of mobility/activity, as a risk factor has been incorporated into most of the leading pressure ulcer risk assessment tools, see appendix D.

This study found:

The mean number of pressure ulcers for both tetraplegics (73/26 = 2.8) and paraplegics (49/15 = 3.3) was approximately three (table M-16).

Also, with 15 out of 26 tetraplegics (58%) and 9 out of 15 paraplegics (60%), a near equal proportion of tetraplegics and paraplegics experienced pressure ulcers somewhere on their body (table M-15).

This observed difference in proportion of tetraplegic and paraplegic individuals was found to be not statistically significant.

> Using Pearson's Chi Square, $X^2 = 0.012$; df = 1; (2-sided) $p = 0.91$, for significance $p < 0.05$.
>
> Using an Independent t-test, there was no significant difference in the number of pressure ulcers reported by tetraplegics (M = 3.13, SD = 4.94), and paraplegics (M = 3.93, SD = 5.24; $t(36) = -0.47$, $p = 0.64$). The magnitude of the differences in the means was very small (eta squared = 0.006).

This parity between tetraplegics and paraplegics was contrary to expectation as it was anticipated that the lower mobility tetraplegics would have developed more pressure ulcers than the higher mobility paraplegics. It is not clear as to why this study did not find a statistically significant difference between these to groups. It may be that because higher risk is anticipated more behavioural measures are orchestrated to minimise risk.

8.2.2.3 Body Mass

Body mass is an intrinsic factor in the development of pressure ulcers, see section 4.4.3. It is known that both over and under weight patients are at greater risk; so it was anticipated that a higher proportion of the respondents who were either over or under weight would have experienced pressure ulcer than those respondents with an ideal weight.

To classify whether a respondent was either over or under weight the Body Mass Index (BMI) was used. Although there are a number of methods for classifying body composition, such as skinfold thickness measurements and the Rohrer index, the Body Mass Index (BMI) continues to be widely used as a means for classifying the over and under weight.

Using the respondent's height and weight (tables M-3 and M-4), the BMI score of 39 of the respondents could be calculated.

Of these 39 respondents, 21 (54%) had a score in the BMI "*Ideal weight*" range and 18 (46%) had a score in one of the other categories, either "*Under weight*", "*Over weight*", or "*Obese*". It should be noted that there was only one respondent who scored in the BMI range "*under weight*", six in the "*obese*" and none in the "*very obese*" range (table M-5). Therefore the sample size was not sufficient in these categories to draw conclusions, so no conclusions were made on the influence of BMI.

This study found:

The mean number of pressure ulcers for those in the ideal weight range was 6.7 (87/13 = 6.7), whereas for those outside the ideal weight range the mean number of pressure ulcers was 3.6 (32/9 = 3.6). Thus, those with ideal weight had a greater number of pressure ulcers.

Also, with 13 out of 21 (62%) a greater proportion of those in the ideal weight range experienced pressure ulcer somewhere on their body, compared to 9 out of the 18 (50%) who's BMI score was outside the ideal weight range.

This difference in proportion between the two groups was found to be not statistically significant.

> Using Pearson's Chi Square, $X^2 = 0.905$; df = 1; (2-sided) $p = 0.34$, for significance $p < 0.05$.
>
> Using an Independent t-test, there was a borderline difference between the two groups with regard to the number of pressure ulcers they experienced, e.g. those in the ideal weight range (M = 4.74, SD = 6.20), and those outside (M = 1.88, SD = 2.80; $t(34) = 1.74$, $p = 0.09$). The magnitude of the differences in the means was moderate (eta squared = 0.082).

This parity between those whose BMI score was within the ideal weight range compared to those outside the ideal weight range was contrary to expectation. It was anticipated that those outside the ideal range would have developed more pressure ulcers than to those within the ideal weight range.

8.2.2.4 Section Summary

The incidence rate of pressure ulcers found by the study (4.9%) was in the anticipated region and consistent with previous studies.

As anticipated this study found that the margin of difference between the proportion of males who developed a pressure ulcer and the proportion of females was so small as to be statistically not significant.

However, there were certain variations between how the groups within this study were expected to compare and the findings of this study.

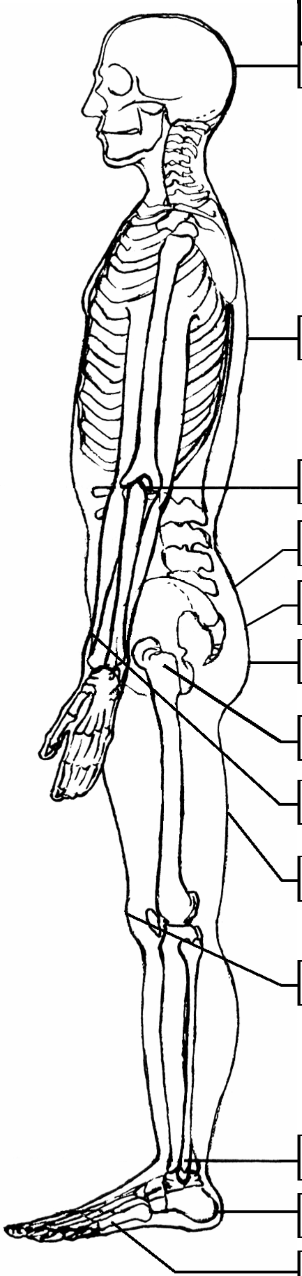
It had been anticipated that the proportion of tetraplegics who developed pressure ulcers would be greater than the proportion of paraplegics. This study found that the proportions were the same.

It had been anticipated those respondents whose body mass was outside the ideal weight range would have developed more pressure ulcers than those within the ideal weight range. This study found that more respondents within the ideal weight range developed pressure ulcers than those outside. This difference was bordering on statistical significance. On reflection it was considered that the sample size of each of the different weight ranges was too small to base any firm conclusions. However they appear to suggest that being overweight might offer a little protection.

These results suggest that gender is not a pressure ulcer risk factor. They also suggest that whilst the level of SCI (para/tetra) and body mass are recognised as pressure ulcer risk factors perhaps their influence is not as great as might be understood. Due to the size of the sample of this study caution is required when drawing conclusions.

8.2.3 Pressure Ulcer Anatomical Site Distribution

This survey recorded the occurrence of pressure ulcers on the anatomical sites which are considered at risk of pressure ulceration, such as heels and elbow as well at the sites on the seat area of the body the sacrum, ischial tuberosities and greater trochanters, see figure 8-1 (tables M-20 to M-28).



Number of pressure ulcers on an anatomical site			
Anatomical site*	Tetraplegic (n=15)	Paraplegic (n=9)	Total (n=24)
Head:	0	0	0
Torso:	0	2 (4%)	2 (2%)
Elbows:	2 (3%)	5 (10%)	7 (6%)
Base of spine:	16 (22%)	13 (27%)	29 (24%)
Interglutial cleft:	1 (1%)	0	1 (1%)
Buttocks:	26 (36%)	18 (37%)	44 (36%)
Hips:	4 (6%)	2 (4%)	6 (5%)
Genitals:	1 (1%)	0	1 (1%)
Back of Thigh:	6 (8%)	0	6 (5%)
Knee:	0	1 (2%)	1 (1%)
Heels:	6 (8%)	4 (8%)	10 (8%)
Ankles:	10 (14%)	4 (8%)	14 (11%)
Side of foot:	1 (1%)	0	1 (1%)
Total	73 (100%)	49 (100%)	122 (100%)

* Common names for anatomical sites were used by the questionnaire, e.g. buttock for ischial tuberosity. This concession was a result of the pilot finding that anatomical terms are jargon which patients might not be familiar with.

Figure 8-1 Distribution of pressure ulcers on the body

This result is broadly in line with earlier studies on occurrence of pressure ulcers on SCI patients. These studies were typically based on a number of pressure ulcers in the region of 100 pressure ulcers, for example Ash's study (2002) was based on 153 pressure ulcers; Garber's study (2003) was based on 102 pressure ulcers; and Sheerin's study (2005) was based on 42 pressure ulcers, see table 2-1.

The distribution of pressure ulcers across the body reported by these studies were broadly inline with one another, with the anatomical sites contained within the seat area of the body, namely the sacrum, ischiums and trochanters, accounting for most pressure ulcers, see figure 2-2. The average of the percentage of pressure ulcers found contained within the seat area of the body found by these studies was 62% (range 43 – 92.4). The percentage of pressure ulcers found contained within the seat area of the body found by this study was 71%.

Although these studies have focused upon people with SCI as their participants, they have focused on different sub groups within this population, for example Garber studied American veterans whereas Sumiya studied Japanese paraplegics. Therefore, due to the differences in the design of these studies, it was not possible to draw further conclusions from direct comparisons.

As well as recording the occurrence of pressure ulcers at the conventional pressure ulcer at-risk anatomical sites, namely the bony prominences such as heels and ischial tuberosities, this study also recorded the pressure ulcers which occur on the back of the thighs, "*the hamstrings*", where the leg rests on the edge of the cushion (tables M-22 and M-23). This site is not a bony prominence but a well muscled fleshy site. None of the various studies reviewed specified the number of pressure ulcers which occurred at this site, although Sumiya did include "*thighs*" in their category "*others*" (Sumiya *et al* 1997). The Tissue Viability Society did list the popliteal fossa (the back of the knee) as a potential site for pressure ulcer development (TVS 2008) although no statistics relating to incidence at this site was found.

The back of the thigh was specifically included in this study having considered pressure gradients and the steep pressure gradient which occurs at the edge of a chair, see figure 4-26 and the lengthy exposure to IP when slouching, sacral sitting. It is possible that the strong association between pressure ulcers and bony prominences, as denoted by the definition of pressure ulcers, see section 4.3.1, has led to a lack of appreciation that the back of the thigh is a potential site for pressure ulcers which in turn has led to this site being commonly overlooked by researchers.

This study found pressure ulcers to have occurred on the backs of the thighs of SCI wheelchair users, see figure 8-2, at a rate comparable to the rate of occurrence at the hips and elbows and at a greater rate than at the head and knees, see figure 8-1.

Of the 24 respondents who have experienced at least one pressure ulcer, 22 have experienced at least one pressure ulcer on the seat area of the body including the back of the thigh. Between the 22 respondents a total of 86 pressure ulcers have occurred on the seat area of the body and back of the thigh

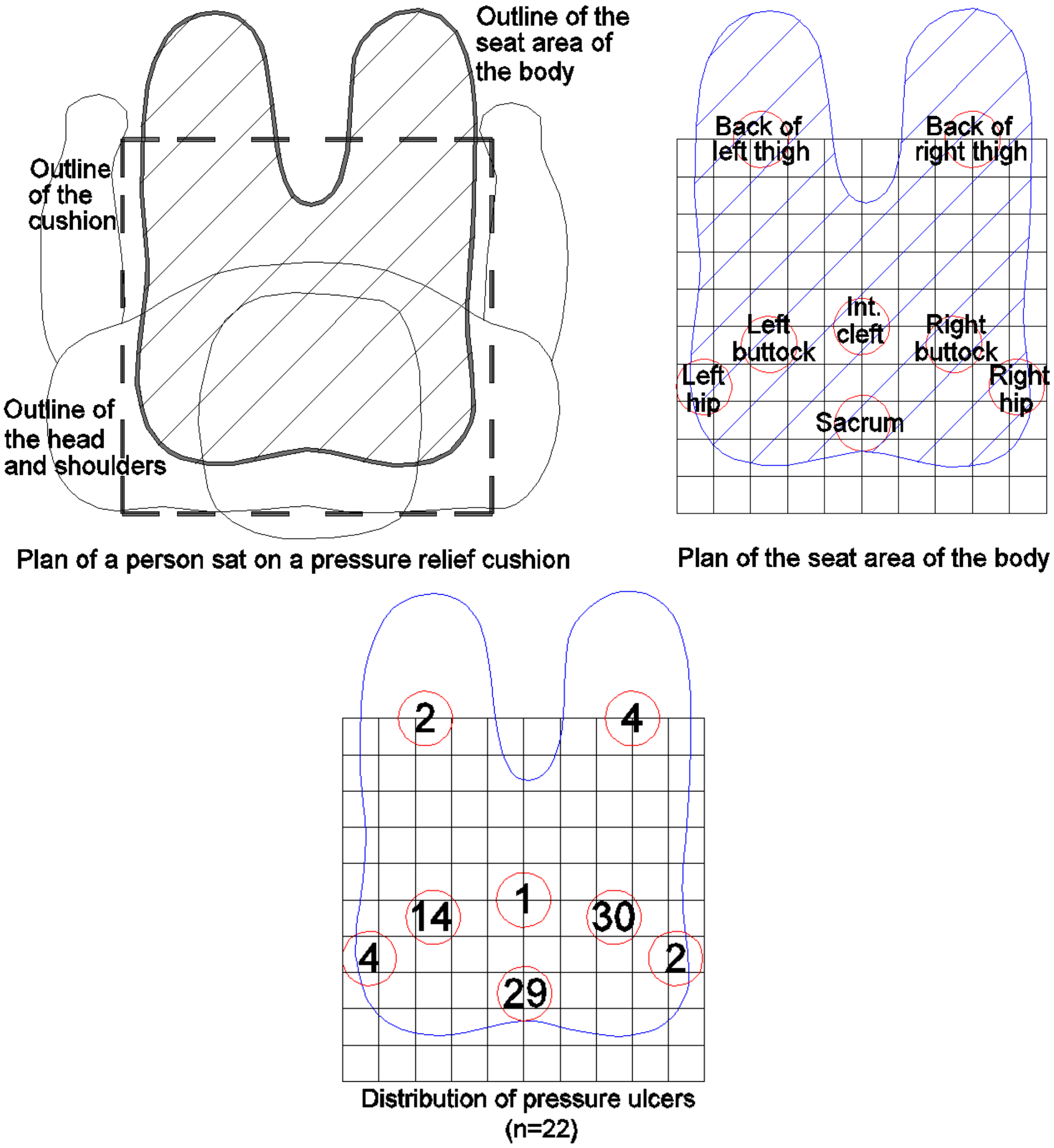


Figure 8-2 The distribution of pressure ulcers on the seat area of the body including the back of the thigh

By studying the distribution of pressure ulcers on the different sites of the seat area of the body a pressure ulcer distribution pattern can be seen.

These pressure ulcer distribution patterns reveal:

- differences in the numbers of pressure ulcers occurring at each site
- variations in the pressure ulcer distribution patterns between tetraplegic and paraplegic respondents.

Using the data from the 22 who had experienced a pressure ulcer on the seat area of the body, it was possible to consider the distribution of pressure ulcers in relation to the extent of the paralysis, see figure 8-3.

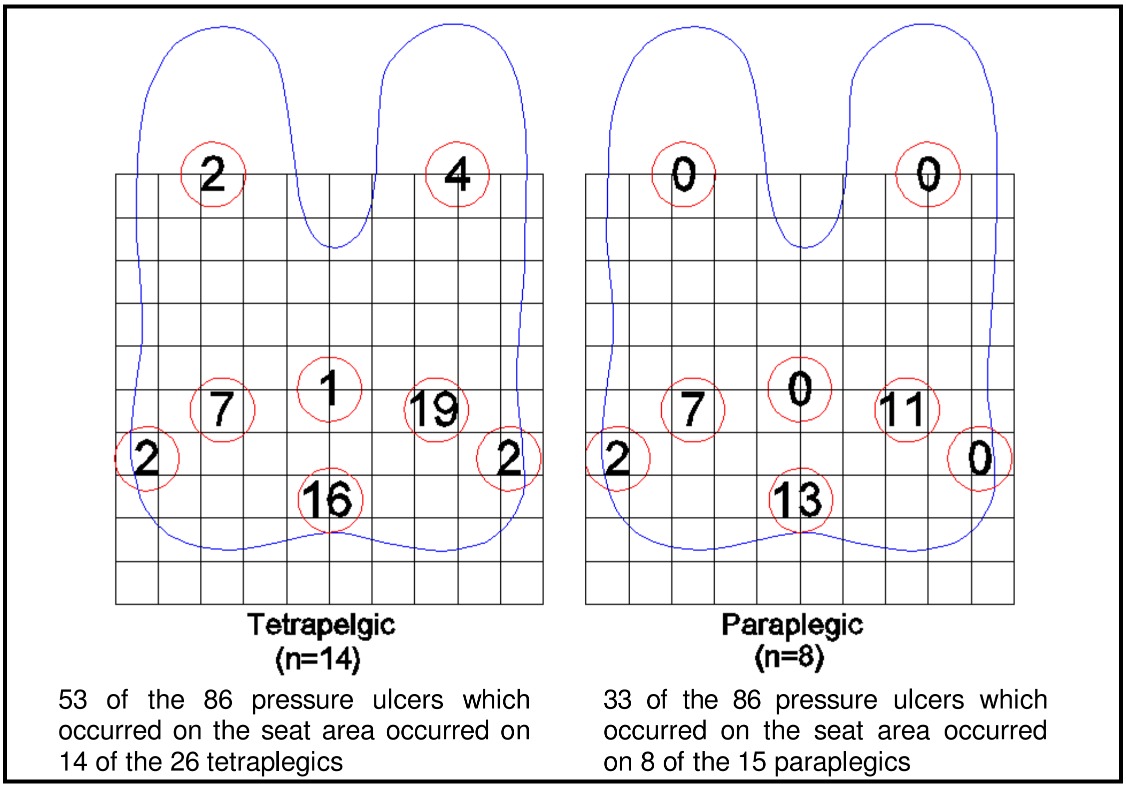


Figure 8-3 The different pressure ulcer distribution patterns of the tetraplegic and paraplegic

This study found:

An equal proportion of tetraplegics and paraplegics have experienced pressure ulcers on the seat area of the body, with 14 out of the 26 tetraplegics experiencing pressure ulcers (54%), and 8 out of the 15 paraplegics (53%).

The mean number of pressure ulcers which occurred on the seat area for both tetraplegics (53/14=3.8) and paraplegics (33/8=4.1) was approximately four, see figure 8-3.

Within this parity between paraplegics and tetraplegics there was a difference in the distribution pattern between these two groups.

Tetraplegics experience three times more pressure ulcers on the right ischium than on the left, whilst paraplegics experience less of a difference with one and a half times more pressure ulcers occurring on the right than on the left.

The tetraplegics experienced one and a half times more pressure ulcers on the backs of their thighs than on their hips, whilst none of the paraplegics in the sample experienced a pressure ulcer on the backs of their thighs.

This difference between paraplegics and tetraplegics would seem to suggest that there is a difference between the two groups which result in one group being more prone to pressure ulcers in certain areas than others. If IP was the dominant factor, then the distribution pattern would be the same regardless of the extent of the paralysis because IP is product of mass and contact area which is the same.

This variation between anatomical sites found between paraplegics and tetraplegics weakens the view that IP is the dominant factor in the development of pressure ulcers.

Designers/manufacturers of PR cushions have focused on pressure maps and the improvements they have made have been towards managing peak and mean IP, see sections 3.4.1 and 3.4.2.

It is apparent when looking at such pressure maps that the IP over both the left and right ischiums are the same, see figure 8-4.

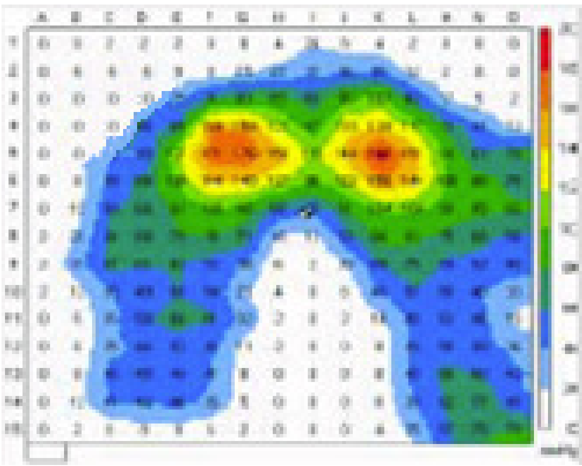


Figure 8-4 A 2-D pressure map revealing high levels of IP acting on the ischial tuberocities (Hobson 1999)

From the respondents' data it has been found that pressure ulcers are occurring on anatomical sites other than at the ischial tuberosities and that more pressure ulcers are occurring on the right side than the left, see figure 8-2. Thus, when a pressure ulcer develops on a site other than one of the ischial tubersities this skin will have broken down whilst the skin at the ischial tubersities, under a higher level of IP, will have maintained its integrity.

It has been found that the ischiums are not proportionally developing more pressure ulcers than at other sites in the way a pressure map might suggest. Looking at such a pressure map it would seem to indicate that the majority of pressure ulcers should occur over the ischiums. This study found that the combined sites of the two ischial tuberosities account for just over half the pressure ulcers occurring on the seat area of the body, with 44 out of 86 (51%). Further the left ischium site accounts for 16% (14 out of 86) of the pressure ulcers whilst the sacrum accounts for nearly three times as many at 35% (30 out of 86), see figure 8-2.

These distribution results are consistent with studies dating back to the early 1980's, see table 2-1, and over this same period designs/manufactures have remained, and continue to be, focused on IP and pressure maps as their guide to pressure ulcer prevention. This suggests that pressure ulcer development is more complex than just high IP levels, and that cushions designed simply to reduce IP is not sufficient. Also, with more pressure ulcers occurring on the right hand side it is plausible that the dominance of one side of the body over the other has an influence on the development of pressure ulcers. This is a subject which would benefit from further work, see section 12.3.3.4.

8.2.4 Pressure Ulcer Causes

Of the 22 respondents who have experienced at least one pressure ulcer on the seat area of the body, see figure 8-2, eight reported that a cushion of theirs has contributed to the development of at least one of their pressure ulcers, six reported that a cushion has never contributed to the development of a pressure ulcer, four reported that they do not know whether a cushion of theirs has contributed or not, and four did not answer (table M-29).

Of the eight respondents who reported that a cushion of theirs was thought to have contributed to the development of at least one of their pressure ulcers all eight gave a brief explanation as to how it was thought that their cushion contributed, see table 8-1.

Table 8-1 How respondents cushions' have caused pressure ulcers

Ways cushions have caused pressure ulcers	Groups		
	Respondents (n=8)*	Tetrapelgics (n=5)	Paraplegics (n=3)
Cushion had 'bottomed out'	2	1	1
Cushion did not have enough air pressure	1	1	
Error by carer setting air pressure too low	1	1	
Vinyl cover had caused sweating	1	1	
Surface was too hard	1		1
Spent too long on cushion at work without taking a rest	1		1
ROHO too soft so she sank too deeply into the cushion which pulled her buttocks apart which tore the skin in between which in turn developed into pressure ulcer	1	1	

* Of the 41 respondents, 8 reported that they have experienced a pressure ulcer on the seat area of the body and that their cushion was thought to have contributed to at least one of these.

As the average user spends potentially up to 18 hours a day in their wheelchair (Williams 1997) there is ample opportunity for pressure damage to occur whilst sitting on a cushion. Thus, it was anticipated that more than eight (36%) of the respondents would have attributed at least one of the ulcers that occurred on the seat area of the body to a cushion[2].

With only eight cases the implications of these findings are not self evident, for example with only two respondents reporting that they had developed a pressure ulcer as a result bottoming out it is not clear if this finding is an abortion of this study or an indication of a much larger problem. Based on these eight cases it is not possible to provide firm conclusions. However, only one of the eight respondents developed a pressure ulcer due to the surface of their cushion being too hard compared to six which indicated that the surface was in some way too yielding; this suggests that there is an issue with the pliancy of the surface of cushions. The goal of pressure-reducing static

[2] How the respondents who did not attribute their pressure ulcers to a cushion developed their pressure ulcers is explored later in this section

cushions is to manage IP by dispersing the user's body weight through immersion and envelopment, see section 3.2.1. The pursuit of improving IP management through improvements in immersion and envelopment will lead to ever more yielding support surfaces. Having found only one out of the 22 respondent with a support surface not sufficiently yielding compared to six which were too yielding suggests that the pressure-reducing model has for some users has reached the safe limit of support surface yield. As such, greater immersion and envelopment is unlikely to deliver better pressure ulcer prevention for these users, but may in fact start to cause more pressure ulcers.

The 22 respondents who developed at least one pressure ulcer on the seat area of their body were asked how often the pressure ulcers they have developed were identified as being the result of certain causes other than the cushion itself, such as an unsafe transfer (tables M-30 and M-31).

To test for differences between the tetraplegic and paraplegic groups with regards to the frequency pressure ulcers develop due to these certain causes the Mann-Whitney U test was used.

The Mann-Whitney U test is used to test for differences between two independent groups on a continuous measure. This test is the non-parametric alternative to the Independent t-test used earlier, see sections 8.2.2.1, 8.2.2.2, and 8.2.2.3.

Using a Mann-Whitney U test to compare between the tetraplegic and the paraplegic respondents, it was found that with $p < 0.05$ for significance there was no significant difference between how often,

> prominent seams in clothing caused a pressure ulcer, $z = -0.07$, (2-tailed) $p = 0.94$
>
> being left sat on a cushion for excessively long periods caused a pressure ulcer, $z = -0.75$, (2-tailed) $p = 0.46$
>
> an unsafe transfer caused a pressure ulcer, $z = -0.34$, (2-tailed) $p = 0.74$
>
> missed small objects caused a pressure ulcer, $z = -0.37$, (2-tailed) $p = 0.71$
>
> not performing a pressure relief routine regularly enough caused a pressure ulcer, $z = -0.12$, (2-tailed) $p = 0.90$
>
> a pressure relief routine not providing enough respite from pressure caused a pressure ulcer, $z = -0.21$, (2-tailed) $p = 0.84$.

It had been anticipated that there would have been differences between the paraplegic and the less mobile more vulnerable tetraplegic, in particular with regards to the causes related to pressure relief routines. Equally the more mobile paraplegics may be taking more risks resulting from a sense of being at less risk than the tetraplegics. It had not been anticipated that with all these causes there would be no statistical differences between the paraplegic and tetraplegic. Perhaps it may be that with all these potential causes of pressure ulcers being known, more behavioural measures are orchestrated to minimise risk they pose.

These causes were ranked by numbers of respondents who have reported experiencing a cause either, "*Frequently*" or "*All the time*", see table 8-2

Table 8-2 Causes, not due to the cushion, of pressure ulcers on the seat area of the body ranked by number of respondents who reported experiencing the cause as either "*Frequently*" or "*All the time*". The number of respondents who answered "*Occasionally*" was used to separate equal rankings.

Groups					
Respondents with PU's on seat area (n=22)		Tetraplegics (n=14)		Paraplegics (n=8)	
Rank	Cause	Rank	Cause	Rank	Cause
1	Unsafe transfers (28%)	1	Unsafe transfers (21%)	1	Unsafe transfers (38%)
2	Left too long on cushion (14%)	2	Left too long on cushion (14%)	=2	Not enough respite from PR (13%) PR not regular enough (13%)
3	Not enough respite from PR (9%)	3	Not enough respite from PR (7%)		
4	PR not regular enough (9%)	=4	PR not regular enough (7%) Prominent seams (7%)	4	Left too long on cushion (13%)
5	Prominent seams (5%)			5	Prominent seams (0%)
6	Small objects (0%)	6	Small objects (0%)	6	Small objects (0%)

As foreign objects between the user and the support surface is a much emphasised hazard, it had been anticipated that foreign objects such as "*Prominent seams*" and "*Missed small objects*" would have received more of a response. Perhaps users are so conscious of this hazard they are sufficiently vigilant to negate this occurrence.

It had been anticipated that "*Unsafe transfers*" would elicit a high response as transferring is recognised in the literature as being problematic for wheelchair users. "*Unsafe transfers*" ranked first for both the tetraplegics and paraplegic groups.

With 3 out of 8 (38%), a higher proportion of paraplegics reported "*Unsafe transfers*" as causing a pressure ulcer either "*all the time*" or "*frequently*" compared to the tetraplegics with 3 out of 14 (21%), (table M-31).

This difference in proportion of tetraplegics and paraplegics reporting "*Unsafe transfers*" as causing a pressure ulcer either "*all the time*" or "*frequently*" was found to be not statistically significant.

Using Fisher's Exact Test, (2-sided) $p = 0.62$, for significance $p < 0.05$.

The issue of transferring is a matter of concern and is examined in more detail later, see section 8.5.4.

It has recently been estimated that the current size of the SCI population is approximately 40,000, see section 2.5, and that to treat the simplest grade of pressure ulcer, a grade 1 pressure ulcer, has been estimated to be in the region of £1000, see section 2.3. With six of the 41 respondents (15%) having reported that they develop pressure ulcers as a result of "*Unsafe Transfers*" either "*All the time*" or "*Frequently*", cushions able to ease SCI patients transfers has the potential to prevent at least 6,000 grade 1 pressure ulcers. This in turn could saving £6 million pounds ((40000 x 0.15) x £1000) per annum. If this 15% finding was representative of the whole 1.2 million wheelchair users, the savings would be more in the region of £180 million ((1200000 x 0.15) x £1000) per annum.

When asked to add any other causes of pressure ulcers, 13 respondents (60%) provided additional information. The comments were varied, with one respondent referring to a pressure ulcer caused by the incorrect height adjustment of their footplate, whilst another described how they fell onto the floor when transferring from a car (table M-32).

These 22 respondents were asked if they had developed a pressure ulcer after rapidly gaining or losing a lot of body weight, of which four (18%) had (table M-33).

Reasons for rapid changes in body weight tend to be related to matters of health. Ill health, for instance an infection, is known to be a pressure ulcer contributing factor, see section 4.4. A cushion designed for an at-risk user may well be adequate for most of the time but during this period of vulnerability the user may well require more performance than an at-risk cushion can deliver, leading to pressure damage. Further, it is known that the size and shape of a cushion is important to its performance and that errors in size can be problematic for users and that there is a time lag between a seating assessment and the provision of a new cushion, see sections 6.3.5 and 8.3.3. It is possible that a rapid weight change can result in the user sitting on a cushion with the wrong contour shape increasing the risk of pressure damage.

The 22 respondents were asked if they had developed a pressure ulcer as the result of sitting in certain poor positions (tables M-34 to M-38).

It had been anticipated that lateral leaning, with its corresponding pelvic obliquity and increased IP on the leaned upon ischial, would lead to pressure ulcers. When leaning to one side the IP on the ischial tuberosity being leaned on is substantially greater than the other ischial tuberosity, see figure 3-67. This would suggest that the side being subjected to a higher level of IP would be at greater risk of developing a pressure ulcer. It is not known why so few pressure ulcers result from lateral leaning. Perhaps the respondents of this survey are managing to limit the length of time spent leaning sufficiently to prevent pressure damaging from occurring; or perhaps when pressure ulcers are developing on one side of the body, or the other, the contribution the sitting position is making is not being recognised.

The role handedness plays in the development of pressure ulcers does not appear to be fully appreciated. Although studies such as Swain (1997), have considered lateral leaning and the corresponding IP increases on the left and right hand side of the body, no mention was found in the literature concerned with the different incidence rates of pressure ulcers on the different sides of the body. It is possible that leaning and the additional stress imposed on the side of the body being leaned on has nothing to do with pressure ulcer development. None of the respondents in this study reported that they developed a pressure ulcer on the right hand side of their body from leaning on their right side. However, this study found twice as many pressure ulcers occurring on the right side than the left (36 pressure ulcers on the right hand side compared to 20 on the left), see figure 8-2.

It had been anticipated that some of the respondents would have experienced pressure ulcers as a consequence of sitting with a posterior pelvic tilt, the result of sitting in a *slouched* position, see sections 3.6 and 8.4. Of the 22 who had experienced at least one pressure ulcer on the seat area of the body two (9%) (one paraplegic and one tetraplegic) reported that they "*Frequently*" develop a pressure ulcer as a result of slouching/sliding forward on their cushion (table M-36). These 22 were also asked if they had ever developed a pressure ulcer as a result of slouching/sliding forward on the cushion pressing their genitals against the pummel of their cushion. None of the respondents reported developing a pressure ulcer in this manner (table M-37).

Based on the estimates of population size and cost to treat pressure ulcers used earlier in this section; with two of the 41 respondents (5%) having reported that they develop pressure ulcers "*Frequently*" as a result of "*Slouching*", a cushion able to manage slouching would potentially prevent at least 2,000 grade 1 pressure ulcers saving £2 million pounds ((40000 x 0.05) x £1000) from the SCI population. If this 5% finding was representative of the whole 1.2 million wheelchair users the savings would be more in the region of £60 million ((1200000 x 0.05) x £1000) per annum.

8.3 Findings on the Cushions Used by the Respondents

8.3.1 Cushions Used

The respondents were well-versed with their current cushion with 30 (73%) having used their cushion for more than a year, of which 20 (49%) had used their cushion for more than two years (table M-41).

Of the 41 respondents 83% (34 out of 41) used either the Flo-tech, Jay 2, ROHO, Varilite or Vicair; with the Jay 2 and ROHO dominating the choice with 17 (41%) using the Jay and 13 (32%) using the ROHO. This result was consistent with the result of the patient interviews, see section 6.3.5, and the advice given by staff from two SCIC, see section 3.3. The cushions used by the remainder were equally split between six other makes of cushions (table M-39).

In the paraplegic group the Jay was favoured over the ROHO, with eight using the Jay (53%) compared to three using the ROHO (20%). Whereas, in the tetraplegic group the ROHO was marginally favoured over the Jay, with 10 using the ROHO (38%) compared to nine using the Jay (35%).

This difference in proportion between the tetraplegic and paraplegic groups with their choice of cushion was found to be not statistically significant.

> Using Pearson's Chi Square, $X^2 = 1.83$; $df = 2$; (2-sided) $p = 0.40$,
> for significance $p < 0.05$.

Although the different proportions of paraplegics and tetraplegics who used the Jay and ROHO cushions was not found to be statistically significant there was a difference. This difference may be indicative of a quality, feature or characteristic which appeals to one group more than the other.

8.3.2 Cushion Selection

It had been anticipated that most users would not have chosen their own cushion having assumed that most users would have been prescribed a cushion from a seating clinic. Further it was anticipated that between the paraplegic and tetraplegic populations the more independent paraplegics would have been more likely to make their own choice.

This study found that of the 41 respondents, 25 (61%) reported that they had made the choice of which cushion to use, with the 17 (65%) tetraplegics choosing their own cushion compared to eight (53%) paraplegics (table M-43). Of the 17 tetraplegics who chose their own cushion six chose the Jay, six chose the ROHO and five chose a cushion from the "*other*" cushion group. Of the eight paraplegics five chose the Jay, one chose the ROHO and two chose a cushion from the "*other*" cushion group (table M-44).

When asked why they chose their current cushion the most common reason, with seven out of the 25 (17%), was that it was a cushion that they were used to and were happy with. The next most popular reason, with six out of the 25 (15%), was that it was the cushion recommended by the spinal centre's staff. The remaining reasons were, for the cushions pressure relieving qualities; for posture; for comfort; for body shape; due to the ease of adjustment; and being light weight (table M-44).

With the emphasis in the literature on IP management, it had been anticipated that more of the users would have chosen their cushion based on the pressure relieving qualities of their cushion. Possible reasons for why pressure relieving qualities were not cited more include, that IP management is an assumed ability and as such it was not considered necessary to mention; pressure relieving qualities were viewed by the respondents as a clinical consideration and not a matter for their judgement.

Of the 41 respondents 34 (83%) reported that they have used a different make/model of cushion before using their current cushion. Of the 26 tetraplegics, 20 (77%) have used a different cushion compared to 14 out of the 15 paraplegics (93%) (table M-45).

When asked why they stopped using their previous cushion the most common reason, with eight out of the 34 (24%), was that it had insufficient pressure relieving qualities. The equal next most popular reasons, both with five out of the 34 (15%), were that a change was recommended by the spinal centre's staff; and that the cushion had insufficient postural support. The remaining reasons were, developed a pressure ulcer; cushion was too heavy; uncomfortable; bottoming out; punctured easily; sweating problems; needed a wider cushion; better cushions had come onto the market; the gel was too runny; and the gel pack ruptured (table M-46).

Although the reasons reported for changing had been raised in the literature, bottoming out etc. see section 3.7, the variety of reasons had not been anticipated. With the emphasis in the literature on IP management, it had been anticipated that insufficient pressure relieving qualities would have dominated the reasons for changing.

A possible reason why insufficient pressure relieving properties did not dominate and that many different reasons were reported is that PR cushions are providing sufficient pressure relief but are not performing across the range of additional requirements, particularly those requirements related to usability and supporting life style.

In order to gain some sense of how cushion users prioritise the various features of their cushion, the respondents were asked how significant they regard certain aspects of a cushion when considering which cushion to use (tables M-47, M-48 and M-49).

Using a Mann-Whitney U test to compare between the tetraplegic and the paraplegic respondents, it was found that with $p < 0.05$ for significance there was no significant difference between how the cushion's,

ability to be fixed securely to the wheelchair is regarded, $z = -0.22$, (2-tailed) $p = 0.82$

ability to be kept clean is regarded, $z = -1.12$, (2-tailed) $p = 0.26$

ability to keep the pressure the skin is subject to low is regarded, $z = -1.12$, (2-tailed) $p = 0.26$

ability to maintain posture is regarded, $z = -0.40$, (2-tailed) $p = 0.69$

ability to prevent sweating is regarded, $z = -0.89$, (2-tailed) $p = 0.38$

appearance is regarded, $z = -1.23$, (2-tailed) $p = 0.22$

cost is regarded, $z = -0.65$, (2-tailed) $p = 0.52$

weight is regarded, $z = -0.91$, (2-tailed) $p = 0.36$

ability to provide comfort is regarded, $z = -0.56$, (2-tailed) $p = 0.58$.

This suggests that there is no difference in the significance tetraplegics and paraplegics regard these aspects of a cushion.

To test for differences between three or more independent groups on a continuous measure the Kruskal-Wallis test was used. This test is the non-parametric alternative to a one-way between-groups analysis of variance.

Using a Kruskal-Wallis test to compare between the respondents who use either a 'ROHO' cushion, a 'Jay' cushion or an 'Other' cushion, it was found that with $p < 0.05$ for significance there was no significant difference between how the cushion's

ability to be kept clean is regarded, $X^2 = 2.92$; df = 2, p = 0.23; Mean rank for the ROHO (24.71) Jay (19.82) Other (16.95)

ability to keep the pressure the skin is subject to low is regarded, $X^2 = 1.41$; df = 2, p = 0.49; Mean rank for the ROHO (20.50) Jay (21.71) Other (20.50)

ability to maintain posture is regarded, $X^2 = 0.92$; df = 2, p = 0.63; Mean rank for the ROHO (20.85) Jay (19.76) Other (23.09)

ability to prevent sweating is regarded, $X^2 = 1.60 = 2$, p = 0.45; Mean rank for the ROHO (22.91) Jay (18.18) Other (18.00)

appearance is regarded, $X^2 = 1.08$; df = 2, p = 0.58; Mean rank for the ROHO (22.95) Jay (18.79) Other (18.91)

weight is regarded, $X^2 = 3.02$; df = 2, p = 0.22; Mean rank for the ROHO (24.38) Jay (17.13) Other (19.41)

ability to provide comfort is regarded,.$X^2 = 41$; df = 2, p = 0.81; Mean rank for the ROHO (20.58) Jay (22.03) Other (19.91).

This suggests that there is no difference in the significance a 'ROHO' cushion, a 'Jay' cushion or an 'Other' cushion in regard to these aspects of a cushion.

However, still with $p < 0.05$, it was found that there was a borderline difference in significance between how the cushion's

ability to be fixed securely to the wheelchair is regarded, $X^2= 4.41$; df = 2; p = 0.11; Mean rank for the ROHO (26.62) Jay (18.44) Other (18.32)

cost is regarded, $X^2= 3.70$; df = 2; p = 0.16; Mean rank for the ROHO (21.92) Jay (15.97) Other (23.77).

With both these aspects there are clear differences between these cushions. The Jay cushion has a hook system for securing the cushion to a wheelchair, see figure 3-47 whereas the ROHO and Other cushions rely on a panel with a high co-efficient of friction to prevent the cushion from sliding, see section 3.3.

There is also a differential in the cost of the cushions with the ROHO being in the region of £500 compared to the Jay in the region of £350, see section 3.3. This finding suggests that cushion users do perceive a difference between cushions based on its ability to be secured to a wheelchair and its cost.

These aspects were then ranked using the number of respondents who reported considering an aspect as, "*Very Significant*", see table 8-3.

Table 8-3 Aspect of cushion ranked by number of respondents who regard an aspect as "*Very Significant*", when considering which cushion to use

Groups											
All Respondents (n=41)		Tetraplegics (n=26)		Paraplegics (n=15)		Jay Users (n=17)		ROHO Users (n=13)		Other Users (n=11)	
Rank	Aspect	Rank	Aspect	Rank	Aspect	Rank	Aspect	Rank	Aspect	Rank	Aspect
1	Low pressure (98%)	1	Low pressure (100%)	1	Low pressure (93%)	1	Low pressure (93%)	1	Low pressure (100%)	1	Low pressure (100%)
=2	Maintain Posture (76%) Comfort (76%)	=2	Maintain Posture (73%) Comfort (73%)	=2	Maintain Posture (80%) Comfort (80%)	2	Maintain Posture (82%)	=2	Maintain Posture (77%) Comfort (77%)	2	Comfort (82%)
						3	Comfort (71%)			=3	Maintain Posture (64%) Keep clean (64%)
4	Keep clean (42%)	=4	Keep clean (35%) Attach securely (35%)	4	Keep clean (53%)	4	Prevent sweating (47%)	=4	Prevent sweating (23%) Keep clean (23%)		
5	Prevent sweating (34%)			5	Prevent sweating (40%)	5	Keep clean (41%)			5	Attach securely (45%)
6	Attach securely (32%)	6	Prevent sweating (31%)	=6	Attach securely (27%) Weight (27%) Cost (27%)	=6	Attach securely (29%) Weight (29%)	=6	Attach securely (15%) Weight (15%) Cost (15%) Appearance (15%)	=6	Prevent sweating (36%) Weight (36%)
7	Weight (27%)	7	Weight (27%)								
8	Cost (22%)	8	Cost (19%)			8	Cost (24%)			8	Cost (27%)
9	Appearance (15%)	9	Appearance (12%)	9	Appearance (20%)	9	Appearance (12%)			9	Appearance (18%)

There was a consensus between the tetraplegic and paraplegic groups and Jay/ROHO/Other cushion user groups, with all finding "*Low pressure*" to be the most significant aspect and "*Appearance*" the lowest.

With the emphasis found to be placed on IP, see sections 3.4.1 and 3.4.2, it had been anticipated that "*low pressure"* would rank highest on the list of aspects considered significant. It was also anticipated that maintaining posture and comfort would elicit a positive response. With all the literature concerning posture and the potential for injury associated with posture it had not been foreseen that both the paraplegic and tetraplegic would regard posture and comfort equally.

When asked to add any other factors they consider when considering which cushion to use, 14 respondents (34%) provided additional factors. The two most common reasons, both with four out of 41 (10%), were the ease with which to adjust/vary internal pressure the cushion; and the ease from which to transfer on/off the cushion. Both these factors are considered in more detail later, see sections 8.3.4 and 8.5.4.

The respondents were asked to rate the overall performance of the cushion on a five point scale between "*Excellent*" and "*Useless*". Of the 41 respondents, 32 (78%) regarded the overall performance of their cushion to be either "*Excellent*" or "*Good*" with only two (5%) regarding it to be "*Poor*" and none rating their cushion as "*Useless*" (table M-51).

With continuing levels of pressure ulcer incidence plus the numerous design issues to be found with the design of cushions from their physical weight to the difficulties experienced when transferring into and out of wheelchairs, the high proportion of respondents (78%) who regard their cushion's overall performance as either "*Excellent*" or "*Good*" was unforeseen.

The respondents were asked to give reasons as to why they regard their cushion as either, "*Excellent*" or "*Good*". Of the 18 respondents who regard their cushion as "*Excellent*" the most common reason, with 13 out of the 18, for regarding the cushion as "*Excellent*" was that they have not developed a pressure ulcer whilst using this cushion. The next most common reason, with five out of the 18, was that it provides good pressure relief, closely followed by the support it gives their posture, with four out of the 18. There were a few other reasons mentioned such as, "*provides stability*" and "*easy to use*" (table M-52).

Of the 14 respondents who regard their cushion as "*Good*" the reasons were more diffuse but still the most common reason, with five out of the 14, for regarding the cushion as "*Good*" was that they have not developed a pressure ulcer whilst using this cushion. There were a few other reasons mentioned such as, "*limits sweating*" and "*easy to clean*" (table M-53).

For the respondents of this survey, the most important aspect when regarding a cushion's overall performance is the ability to prevent pressure ulcers, far surpassing the cushions ability to provide pressure relief. By distinguishing between avoiding pressure ulcers and providing pressure relief it was revealed that the respondents value cushions which prevent pressure ulcers over cushions which focus on reducing interface pressure.

8.3.3 Cushion Provision

Of the 41 respondents, 11 (27%) have used a cushion of the wrong size. Of these, four out of the 11 (36%) had this error corrected within two weeks, whilst four (36%) had to wait more than one year (table M-54).

When asked the extent of the problem using a cushion of the wrong size posed the skin, five out of the 11 (45%) reported that this caused either "*Major difficulties*" or "*Some difficulties*" (table M-55).

It had been anticipated that some users would have experienced using a cushion of the wrong size at some point. It had not been expected that of those who have used a cushion of the wrong size 36% would have used it for over a year. When it is considered that 45% of those who have used a cushion of the wrong size has experienced skin difficulties as a result, if this sample is typical of the population of wheelchair users this is an issue which should be addressed and which designers could contribute.

Of the 41 respondents, nine (22%) have used a cushion with the wrong contour shape. Of these, one out of the nine (11%) had this error corrected within two weeks, whilst five (55%) had to wait more than one year (table M-56).

When asked the extent of the problem using a cushion with the wrong contour shape posed the skin, seven of the nine (78%) reported that this caused either "*Major difficulties*" or "*Some difficulties*" (table M-57).

It had been anticipated that some users would have experienced using a cushion of the wrong contour shape at some point. It had not been expected that 55% would have used a cushion with the wrong contour shape for over a year. When it is considered that 78% of those who have used a cushion of the wrong contour shape has experienced skin difficulties as a result, if this sample is typical of the population of wheelchair users this is an issue which designers should address.

8.3.4 Cushions with Air Cells

Of the 41 respondents, 22 (54%) have used a cushion with air cells incorporated in its design. Of the 26 tetraplegics, 15 (58%) have used a cushion with air cells compared to seven out of the 15 paraplegics (47%) (table M-58).

It had been anticipated that as dry-floatation devices, such as the ROHO, are proffered as being for patients assessed to be at-high or very-high risk, see section 3.5.1, and that users with SCI are generally regarded as being at-high or very-high risk, see section 2.4, a higher proportion than 54% of the respondents would have experienced using a cushion with air cells. It is not known why more of the respondents, particularly the tetraplegics, have not used an air-filled cushion. Perhaps it is related to difficulties with the usability of this type of cushion, for instance the difficulties to be found with transferring on/off air-filled cushions, see sections 3.7 and 8.5.4.

The 22 respondents with experience of using a cushion with air cells were asked how often the internal air pressure of their air-filled cushion needs to be checked. The two most common answers, both with 5 respondents (23%) each, were "*A couple of times a month*" and "*It varies from day to day*", followed by "*Once a day*" with four respondents (18%) (table M-59).

Additionally, these respondents were also asked if there were other occasions when they check the level of the internal air pressure. One respondent added that they check the air pressure when travelling by air and another added that the ambient temperature effects the air pressure (table M-60).

It was anticipated that a high proportion of the respondents would have reported checking the air pressure at least once a day as daily checking is specified in the user manuals of cushions such as ROHO (ROHO 2001) and is the advice given by seating clinics (Fiddy 2005).

The 22 respondents with experience of using a cushion with air-cells were asked how difficult they found controlling the level of internal air pressure. Not one respondent reported that they find this task "*Very easy*", seven (33%) reported that they found the task "*Manageable*", six (28%) found the task either "*Difficult*" or "*Very difficult*" with three (14%) reporting that this is a task that they are not involved with (table M-61).

The descriptions on how to set the internal air pressure found in the user manuals describe a cumbersome process possibly involving a second person. It was anticipated then that this would be a task the users would find difficult. With a third of users finding this task "*Difficult*" or "*Very difficult*" there is a potential for error in the setting of the internal air pressure. As an error in setting the internal air pressure, both over- and under-inflation, has serious ramifications for the user, see sections 3.3.1 and 3.7. This is then an issue which design should address.

Of the 22 respondents who reported that they have used a cushion with air cells 55% (six paraplegics and six tetrapelgics) reported that they have experienced a cushion deflate so much so that they have ended up sitting on the solid base without noticing, their cushion had "*bottomed out*" (table M-62).

According to the literature, users of air-filled cushions are at risk of bottoming out. This might be the result of a puncture or an incorrect setting of the internal air pressure. Even with the known risks associated with a bottoming out event and the care then taken to avoid such an occurrence, it was anticipated that some users would have experienced a bottomed out event at some point. It was not anticipated that over half those who have used an air-filled cushion would have. If this sample is typical of the population of air-filled cushion users this is an issue which designers should address.

8.3.5 Cushions with Gel Packs

Of the 41 respondents, 35 (85%) have used a cushion with gel incorporated in its design. Of the 26 tetraplegics, 22 (85%) have used a cushion with gel compared to 13 out of the 15 paraplegics (87%) (table M-63).

It had been anticipated that a large proportion of the users would have experienced using a cushion with gel at some point as this is one of the leading approaches in PR cushion design, for example the popular Jay cushion, see section 3.3.5. It was not anticipated that most of the respondents (85%) would have used a gel cushion, as there are so many other types of cushion available, e.g. air cells, foam, honeycomb.

This survey found that less than half the respondents (44%) are currently using a cushion with gel, (17 Jay users and one Sumed ErgoNest see table M-39). With so many respondents having tried a gel cushion but were no longer using a gel cushion there must be a reason, or reasons, why so many have ceased using gel cushions. It is not known if this switching from gel is related to any particular aspect of the design of gel cushions.

The 35 respondents with experience of gel cushion were asked how long it takes for the gel to be pushed to the sides so that there is no longer enough gel underneath them to provide sufficient pressure relief. The most common answers, both with eight respondents (23%) were "*It depends on how active I'm being*" and "*There is always enough gel*" this was followed by "*A couple of hours*" and "*Most of the day*" both with five respondents (14%) (table M-64).

Considering the literature, see section 3.3.5, it had been anticipated that some of the users would have experienced sufficient quantities of gel migrating to the sides of their cushion so that there was no longer enough gel underneath them to provide sufficient pressure relief, a *bottoming out* event. It was not foreseen that 77% would have experienced this level of gel migration, as only eight (23%) respondents reported that they always have sufficient gel underneath (table M-64).

The 35 respondents with experience of gel cushions were asked how frequently certain movements/actions drive the gel out from underneath them towards the sides of the cushion (tables M-65 and M-66).

Using a Mann-Whitney U test to compare between the tetraplegic and the paraplegic respondents, it was found that with $p < 0.05$ for significance there was no significant difference between how frequently,

propelling the wheelchair drives the gel out from underneath them towards the sides of the cushion, $z = -1.05$, (2-tailed) $p = 0.30$

following a pressure relief routine drives the gel out from underneath, $z = -0.90$, (2-tailed) $p = 0.37$

simple fidgeting drives the gel out from underneath, $z = -0.62$, (2-tailed) $p = 0.54$

the gel gradually drifts to the sides, $z = -0.41$, (2-tailed) $p = 0.37$.

This suggests that there is no difference between tetraplegics and paraplegics in regards to how frequently these movements/actions drive the gel out from underneath.

However, still with $p < 0.05$, it was found that there was a borderline difference in significance between how,

spasms drives the gel out from underneath, $z = -1.34$, (2-tailed) $p = 0.18$.

A more defined difference between the tetraplegics and paraplegics had been anticipated. Spasms, if they occur, are confined to injuries to the vertebrae T10 and above (Pask 2000). Therefore whilst all of the tetraplegic group could be experiencing spasms, only the paraplegics in the paraplegic group whose injury was to either, their T7, T8, T9 or T10 vertebrae might be experiencing spasms. This finding suggests that whilst spasms might be considered mainly an issue for tetraplegics it is still an issue for some paraplegics.

The movements/actions which displaces gel were ranked by numbers of respondents who have reported a movement/action displacing gel either, "*Frequently*" or "*All the time*", see table 8-4

Table 8-4 Movements/actions which cause gel to be pushed to the sides ranked by number of respondents who reported the movement/action displacing gel as either "*Frequently*" or "*All the time*". The number of respondents who answered "*Occasionally*" was used to separate equal rankings

Groups					
Respondents who have used cushions with gel (n=35)		Tetraplegics (n=22)		Paraplegics (n=13)	
Rank	Movement/action	Rank	Movement/action	Rank	Movement/action
1	Drift to sides (52%)	1	Drift to sides (50%)	1	Drift to sides (54%)
2	Fidgeting (34%)	2	Fidgeting (36%)	2	Propelling wheelchair (46%)
3	Propelling wheelchair (32%)	3	PR movements (36%)	3	Fidgeting (31%)
4	PR movements (29%)	4	Spasms (27%)	4	PR movements (15%)
5	Spasms (23%)	5	Propelling wheelchair (23%)	5	Spasms (15%)

The difference between how the tetraplegic and paraplegic groups ranked spasms and wheelchair propelling was as anticipated. With tetraplegics more likely to be using a motorised chair self propelling would be less of an issue for this group. With spasms being more associated with tetraplegics spasms would be less of an issue for the paraplegic group.

It had been anticipated that the vigorous movements such as spasms and propelling the wheelchair would have been a more potent driver of the gel than simple drift. It is not known why this should be the case.

When asked to add any other movements/actions which drive the gel out from underneath them four respondents (10%) provided additional information (table M-67). Of these comments two provided additional insight, firstly that the gel disperses from under the most needy areas once it heats up and that the gel flows with gravity when the chair is tilted.

The 35 respondents with experience of gel cushions were asked how often they check the distribution of the gel to make sure there is sufficient gel underneath them. The most common answer, with 11 respondents (31%) was "*Once a day*" this was followed by "*Every few hours*" and "*Never check*" both with four respondents (11%) (table M-68).

Additionally, these respondents were also asked if there were other occasions when they check the distribution of gel. Of these comments one provided an additional insight; when the gel moves some of it bunches up in the genital area causing discomfort (table M-69).

It was anticipated that a high proportion of the respondents would have reported checking the distribution of gel at least once a day because *remoulding* the gel before each use is advised by seating clinics (Fiddy 2008).

Using immersion gel cushions can achieve good IP mapping results so long as the gel has been evenly dispersed across the cushion. Gel being a fluid can flow and will drift to the sides over time, 52% of the respondents reported that this drift occurs either "*Frequently*" or "*All the time*". Also, movements made by the user such as propelling the wheelchair can push the gel to the sides, 32% of the respondents reported that propelling their wheelchair pushes the gel to the sides either "*Frequently*" or "*All the time*". Some users are finding that the gel in their cushions migrates to the sides of their cushion in less than a day, while 20% of the respondents reported that the gel moves to the sides in a couple of hours or less. Most users check the dispersal of gel at least once a day, although some check less often, 20% of the respondents reported that they check either "*Once a week*" or "*never check*". Should a period of activity push the gel to the sides, and the user waits until the start of a new day to check the dispersal of the gel, the user could be left sitting without the benefit of the gel for possibly a few hours, which would be sufficient for pressure damage to occur.

The design approach of gel cushions is reliant on their users to check and remould the gel. A disruption to the daily routine or an increased work load or a series of distractions all could result in the user failing to notice the gel requires remoulding which in turn could result in pressure damage. It is desirable then to stop designing cushions which are dependent on their user for correct functioning, as this will reduce the opportunities for user error which in turn will reduce the number of occasions which pressure damage to the skin occurs.

8.4 Findings on the Respondent's Sitting Position in a Wheelchair

8.4.1 Sitting Position

It is documented that posture is important for wheelchair users with implications for their health. The respondents were asked if they had experienced any problems resulting from poor posture, of which 17 (41%) had. The most common problem was pain. This pain was not localised to one area but experienced across a range of anatomical sites, back; shoulders; neck; hip; scrotum; thighs (table M-70).

It had been anticipated that pain would be a feature and although it was known that incomplete SCI injuries can leave some sensation remaining below the level of the injury it was not foreseen that some SCI patients are experiencing pain in their hips, thighs and scrotum as a result of poor posture.

Of the 41 respondents, 30 (73%) reported that they can sit in what is described as a "*normal sitting*" position, upright and central in their wheelchair without leaning or slouching, see section 3.6.1. There was no distinction between the paraplegic and tetraplegics groups, with 73% of both groups able to sit in a "*normal sitting*" position, with 19 out of the 26 tetraplegics and 11 out of the 15 paraplegics (table M-71).

The respondents were asked how often they adopt certain sitting positions, such as slouching, leaning etc. (tables M-72, M-73 and M-74).

With the ratio of right to left handed people being 9:1 in the general population (Denny and O'Sullivan 2006), and the SCI population being drawn from the general population it had been anticipated that there would be more right handed respondents than left[3]. It would then follow that more of the respondents would report leaning to the right position either "*Frequently*" or "*All the time*" than leaning to the left. It had not been anticipated that of those who reported adopting a position either "*Frequently*" or "*All the time*" slightly more would have reported leaning to the left than to the right, see table 8-5.

[3] There were 31 right handed and seven left handed respondents (table M-6). A ratio of 4.5:1

It was not foreseen that there would also be a difference between the Jay and the ROHO users. Twice as many Jay users "*lean to the right*" (12%), either "*Frequently*" or "*All the time*", compared to those who "*lean to the left*" (6%). With the ROHO, nearly three times as many reported leaning to the left (23%) either "*Frequently*" or "*All the time*" than to the right (8%). It is not known why leaning to the right is more common with the Jay compared to the ROHO where it is more common to lean to the left. The influence of the dominance of an individual's side needs further work, see section 12.3.3.4.

Using a Mann-Whitney U test to compare between the tetraplegic and the paraplegic respondents, it was found that with $p < 0.05$ for significance there was no significant difference between how often they,

> lean to the right, $z = -0.63$, (2-tailed) $p = 0.53$
>
> lean to the left, $z = -0.66$, (2-tailed) $p = 0.51$
>
> slouch, $z = -1.45$, (2-tailed) $p = 0.25$.

This suggests that there is no difference between tetraplegics and paraplegics with how often they sit in these positions.

However, still with $p < 0.05$ for significance, it was found that there was a significant difference between how often they,

> tilt forward, $z = -2.10$, (2-tailed) $p = 0.04$.

It is not known why there was no difference in how often the tetraplegics and paraplegics slouch and lean yet there was a difference with tilting forward. Perhaps tetraplegics are more prone to tilting forward due to their level of paralysis effecting the control of their trunk which in turn limits their ability to prevent tilting.

To compare how often the respondents who use either a 'ROHO' cushion, a 'Jay' cushion or an 'Other' cushion adopt certain sitting positions a Kruskal-Wallis test was used.

It was found that with $p < 0.05$ for significance, there was no significant difference between how often the three different cushion user groups,

> slouch, $X^2 = 0.285$; df = 2, $p = 0.87$; Mean rank for the ROHO (15.50) Jay (16.27) Other (17.78)

lean to the right, $X^2 = 0.73$; df = 2, p = 0.70; Mean rank for the ROHO (12.92) Jay (12.58) Other (15.31)

lean to the left, $X^2 = 1.94$; df = 2, p = 0.38; Mean rank for the ROHO (11.56) Jay (14.73) Other (16.83)

tilt forward, $X^2 = 1.04$; df = 2, p = 0.59; Mean rank for the ROHO (12.88) Jay (16.58) Other (16.28)

This suggests that there is no difference between the 'ROHO' cushion, a 'Jay' cushion or an 'Other' cushion users with how often they sit in these positions. This is interesting as the Jay has been designed with a contoured foam base to provide pelvic capture to support a user's posture, see section 3.3.5.1, whereas the ROHO design is primarily aimed at immersing and enveloping the user and has limited postural support capability, section 3.3.1.1.

These sitting positions were ranked by numbers of respondents who have reported sitting in a position either, "*Frequently*" or "*All the time*", see table 8-5.

Table 8-5 Sitting position ranked by number of respondents who adopt a position either, "*Frequently*" or "*All the time*"

Groups											
All Respondents (n=41)		Tetraplegics (n=26)		Paraplegics (n=15)		Jay Users (n=17)		ROHO Users (n=13)		Other Users (n=11)	
Rank	Position	Rank	Position	Rank	Position	Rank	Position	Rank	Position	Rank	Position
1	Slouch (32%)	=1	Slouch (38%) Tilt forward (38%)	1	Slouch (20%)	1	Slouch (41%)	1	Tilt forward (31%)	1	Tilt forward (36%)
2	Tilt forward (30%)			2	Tilt forward (13%)	2	Tilt forward (24%)	2	Slouch (23%)	2	Slouch (27%)
3	Lean to the left (13%)	3	Lean to the left (15%)	=3	Lean to the left (7%) Lean to the right (7%)	3	Lean to the right (12%)	3	Lean to the left (23%)	=3	Lean to the left (9%) Lean to the right (9%)
4	Lean to the right (10%)	4	Lean to the right (12%)			4	Lean to the left (6%)	4	Lean to the right (8%)		

Although the rank order of these positions were the same for the tetraplegic and paraplegic groups the paraplegics were less prone to sit in these positions with 20% reporting that they slouch either "*Frequently*" or "*All the time*", compared to 38% of tetraplegics. The greater trunk strength and greater mobility is likely to account for the slightly better postural situation achieved by the paraplegics.

The rank order was distinctly different for the Jay users and the ROHO users. It was found that the most common position for the Jay users was the "*slouch*" (42%) unlike the ROHO users whose most common position was the "*tilt forward*" (31%). The second most common position for the Jay users was the "*tilt forward*" (24%) whereas for the ROHO users it was "*slouch*" (23%).

With seven out of the 17 Jay users (41%), a higher proportion of the Jay users reported that they slouch either "*Frequently*" or "*All the time*", compared to the ROHO users with three out of 13 (23%), (table M-74).

The difference in proportion between the Jay and ROHO cushion users who reported that they "*Slouch*" either "*all the time*" or "*frequently*" was found to be not statistically significant.

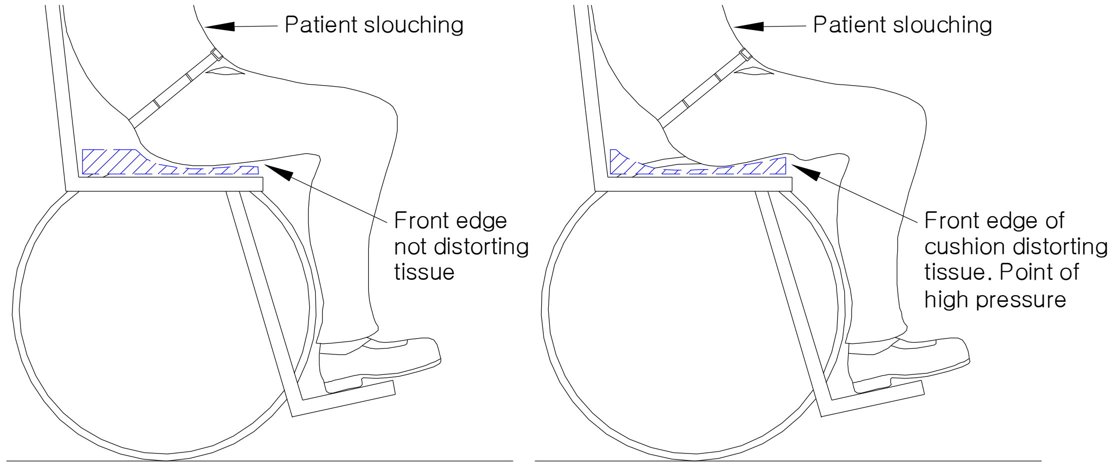
Using Fisher's Exact Test, (2-sided) $p = 0.45$, for significance $p < 0.05$.

This difference between the Jay and ROHO users was unforeseen. According to the literature the Jay uses a contoured foam base with a deeper rear portion to capture the pelvis to prevent the user from sliding forward, slouching, see figure 3-46 section 3.3.5.1. The ROHO cushion has no contouring to prevent slouching, although the *Quadtro* versions can provide a basic shape, see figure 3-14 section 3.3.1.1. It is not known why a greater proportion of Jay cushion users slouch "*Frequently*" or "*All the time*" compared ROHO users.

8.4.2 Slouching

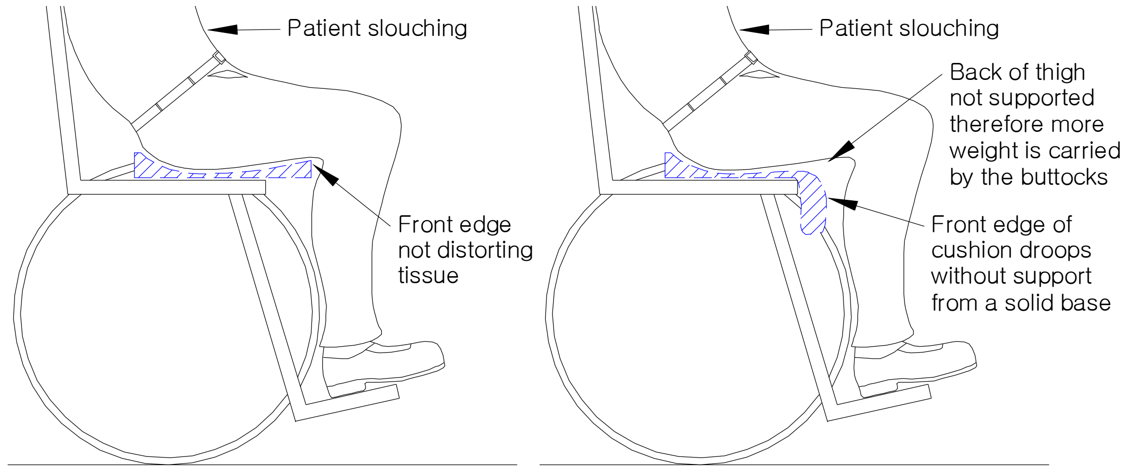
Slouching was found to be a common sitting position amongst the respondents, with 29 of the 41 respondents (71%) reporting that they sit on occasion in a slouched position. The proportion of tetraplegic and paraplegic who slouch was similar, with 10 out of the 15 paraplegics (67%) and 19 out of the 26 tetraplegics (73%). This similarity in proportion was also found between the different cushion user groups, with 12 of the 17 Jay users (71%), 10 of the 13 ROHO users (77%) and 7 of the 11 Other cushion users (64%) (table M-81).

When slouching, the wheelchair user can either slide over the surface of the cushion with the cushion remaining in place, see figure 8-5, or when they slide forward they push the cushion forward with them, see figure 8-6.



Cushion without a fixed contour shape | Cushion with a fixed contour shape

Figure 8-5 Slouching with cushion remaining in place



Cushion with a solid base | Cushion without a solid base

Figure 8-6 Slouching with cushion not secured in place and slid forward

When a person slouches by sliding over the surface of the cushion the front edge of the cushion can become an issue. If the cushion has a fixed contour shape the front edge of the cushion will no longer sit under the back of the knee as intended but press into the back of the thigh. In this case the shape of the contour becomes counter productive, acting to oppose envelopment and increasing localised tissue distortion, see figure 8-7. The use of contouring would be a case of the designer making a compromise, favouring IP reduction over the differing demands which result from the variety of sitting positions which follow a user's behaviour and life style.

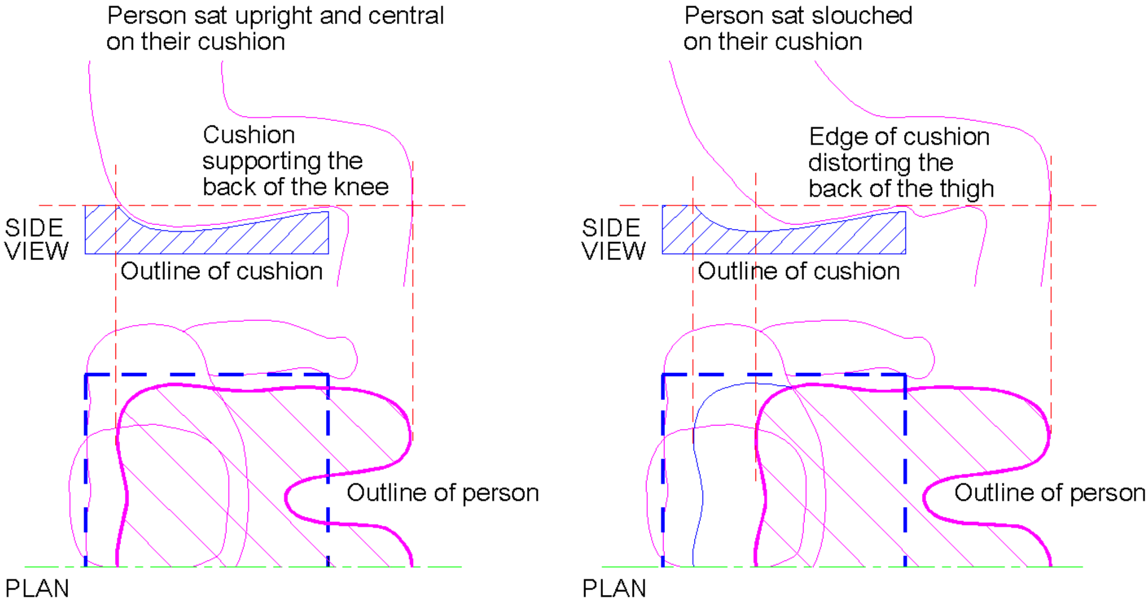


Figure 8-7 A person slouching on their cushion

The 29 respondents who slouch were asked when they slouch, how often do they slide over the surface of the cushion with the cushion remaining fixed in place. Of these 29 respondents, 22 (76%) reported that when they slouch they do slide over the surface of the cushion. Of these 22, 15 (68%) reported that they do so either "*Frequently*" or "*All the time*" (table M-82).

As Jay cushions use of a hook system for securing the cushion to the wheelchair, compared to the ROHO which relies on a high co-efficient of friction panel to prevent slipping see sections 3.3.1.1 and 3.3.5.1, it was anticipated that a higher proportion of the Jay users who slouch would have reported that they slide over the surface of their cushion compared to the ROHO users.

With six out of 10 (60%), a higher proportion of Jay users reported that when they slouch they either slide over the surface of the cushion "*Frequently*" or "*All the time*" compared to the ROHO users with three out of eight (38%) (table M-82).

There was found to be a borderline significance between Jay users and ROHO users.

> Using Pearson's Chi Square, $X^2 = 3.62$; df = 2; (2-sided) $p = 0.16$, for significance $p < 0.05$.

Thus, a greater proportion of Jay users slide over the surface of their cushion than ROHO users. This suggests that Jay cushions are less prone to sliding forward which is consistent with the notion that the Jay method for attaching a cushion to a wheelchair is more secure than the ROHO.

The 29 respondents who slouch were then asked when they slouch, how often does their cushion slide forward as well. Of these 29, a total of eight respondents reported that when they slouch their cushion also slides forward, with two reporting that this happens "*All the time*", three reporting that this happens "*Occasionally*" and one that this happens "*Very Rarely*", (table M-83).

As above, with the Jay cushion using a hook system for securing the cushion and the ROHO using a high co-efficient of friction panel; it was anticipated that a higher proportion of the ROHO users who slouch would have reported that when they slouch their cushion also slides forward, compared to the Jay users.

With two out of 7 (29%), a higher proportion of ROHO users reported that when they slouch they slide their cushion forward either "*Frequently*" or "*All the time*" compared to the Jay users with none out of eight (0%) (table M-83).

There was found to be a borderline significance between Jay users and ROHO users.

> Using Pearson's Chi Square, $X^2 = 3.54$; df = 2; (2-sided) $p = 0.17$,
> for significance $p < 0.05$.

Thus, a greater proportion of ROHO users slide their cushion forward when they slouch compared to Jay users. This suggests that ROHO cushions are more prone to sliding forward. This is consistent with the finding above where proportionally more Jay users slide over the surface of their cushion than ROHO users. Both these findings seem to indicate that the Jay method for attaching a cushion to a wheelchair is more secure than the ROHO.

8.4.3 Shifting Position

When possible, wheelchair users should sit in a "*normal sitting*" position, see section 3.6.1. However, wheelchair users do on occasion adopt other less ideal positions such as slouching.

The respondents were asked what the average length of time they spend sat in a position they regard as "*good*" for their disability before slipping into a "*poor*" sitting position. The most common response was it "*Varies greatly*" with 12 respondents of the 41 (29%). In total nine respondents (22%) slip from a "*good*" sitting position within two hours with one respondent slipping in less than ten minutes (table M-76). Thus, over a potentially 18 hour long day a large proportion of respondents will have to correct their sitting position many times.

Of the 17 Jay users, two (12%) reported that they slip into a poor sitting position in less than two hours compared to four out of the 13 ROHO users (27%). Additionally, two Jay users (12%) reported that they maintain a good sitting position for more than four hours compared to two ROHO users (13%).

The 30 respondents able to sit in a "*normal sitting*" position (table M-71), referred to in the questionnaire as a "*good postural position*", were asked how frequently certain movements/actions displace them from that "*good postural position*" (tables M-77, M-78 and M-79).

Using a Mann-Whitney U test to compare between the tetraplegic and the paraplegic respondents, it was found that with $p < 0.05$ for significance there was no significant difference between how frequently,

> they look for a more comfortable position, $z = -0.05$, (2-tailed) $p = 0.96$
>
> self propelling throws them from a good sitting position, $z = -0.27$, (2-tailed) $p = 0.079$.
>
> spasms alter their position, $z = -1.17$, (2-tailed) $p = 0.24$
>
> they fidget, $z = -0.78$, (2-tailed) $p = 0.44$

This suggests that there is no difference between tetraplegics and paraplegics with regards to the frequency these movements/actions dislodge them from a good postural position.

However, still with $p < 0.05$, it was found that there was a borderline difference in significance between how frequently,

> they drift into a poor position, $z = -1.34$, (2-tailed) $p = 0.18$

It had been anticipated that there would be a difference between the tetraplegics and paraplegics with regards to spasms and propelling wheelchair, as discussed earlier see section 8.3.5. It is not known why there was no difference with both these movements/actions and yet there was a difference with drifting into a poor position. Why a higher proportion of tetraplegics drift into a poor position is not known; again as in section 8.3.5, perhaps tetraplegics are less able to prevent drifting due to their level of paralysis effecting the control of their trunk which in turn limits their ability to prevent drifting into a poor sitting position.

Using a Kruskal-Wallis test to compare between the respondents who use either a ‘ROHO’ cushion, a ‘Jay’ cushion or an ‘Other’ cushion, it was found that with $p < 0.05$ for significance, there was no significant difference between how often ,

> they drift into a poor position $X^2 = 1.62$; df = 2, $p = 0.44$; Mean rank for the ROHO (16.09) Jay (16.32) Other (21.06)
>
> they look for a more comfortable position, $X^2 = 2.22$; df = 2, $p = 0.33$; Mean rank for the ROHO (14.13) Jay (13.27) Other (18.69)
>
> self propelling throws them from a good sitting position, $X^2 = 2.82$; df = 2, $p = 0.24$; Mean rank for the ROHO (15.06) Jay (13.81) Other (20.11)
>
> spasms alter their position, $X^2 = 1.44$; df = 2, $p = 0.49$; Mean rank for the ROHO (15.40) Jay (15.19) Other (19.61)
>
> they fidget, $X^2 = 0.72$; df = 2, $p = 0.70$; Mean rank for the ROHO (16.44) Jay (14.50) Other (17.72)

This suggests that there is no difference between the ‘ROHO’ cushion, a ‘Jay’ cushion or an ‘Other’ cushion users with how often these movements/actions dislodge the user from a good sitting position. This is interesting as it would seem to suggest whilst the Jay is regarded as being a cushion good for supporting posture, and the ROHO not so much, when it comes to preventing a user from being dislodged by movements/actions there is no statistical difference between them.

These reasons for moving from a “*good postural position*” were ranked by numbers of respondents who reported reason occurring either, “*Frequently*” or “*All the time*”, see table 8-6.

Table 8-6 Movements/actions which dislodge respondents ranked by number of respondents who reported a movement/action dislodging them either, "*Frequently*" or "*All the time*". The number of respondents who answered "*Occasionally*" was used to separate equal rankings

Groups											
Respondents (n=30)		Tetraplegics (n=19)		Paraplegics (n=11)		Jay Users (n=13)		ROHO Users (n=10)		Other Users (n=7)	
Rank	Movement/ action	Rank	Movement/ action	Rank	Movement/ action	Rank	Movement/ action	Rank	Movement/ action	Rank	Movement/ action
1	Gradual drift (43%)	1	Gradual drift (58%)	1	Self propelling (27%)	1	Gradual drift (46%)	1	Gradual drift (40%)	1	Gradual drift (43%)
2	Spasms (20%)	2	Spasms (45%)	2	Looking for comfort (18%)	2	Fidgeting (31%)	=2	Spasms (20%) Looking for comfort (20%) Self propelling (17%)	=2	Spasms (14%) Looking for comfort (14%)
3	Looking for comfort (20%)	3	Fidgeting (45%)	3	Gradual drift (18%)	=3	Looking for comfort (18%) Self propelling (17%) Spasms (9%)				
4	Fidgeting (20%)	4	Looking for comfort (21%)	4	Spasms (9%)					=4	Fidgeting (0%) Self propelling (0%)
5	Self propelling (17%)	5	Self propelling (11%)	5	Fidgeting (9%)			5	Fidgeting (20%)		

It had been anticipated that vigorous movements such as spasms and propelling the wheelchair would have been a more potent force for displacing a respondent from a "*good postural position*" than simply drifting from one. It is not known why this should be the case. A vigorous movement would be an event which a wheelchair user would recognise as a prompt to check their sitting position and adjust if necessary, but a slow drift into a poor position would not signal when to correct the sitting position. When drifting, the user might remain in a gradually worsening sitting position until the position becomes so extreme that they either notice themselves, someone else notices for them, or an event, such as the use of the toilet, generates a natural resetting of position. This delay before adjusting the sitting position may be sufficient for problems to arise such as back pain or pressure damage to the skin.

The 30 respondents able to sit in a good postural position where then asked to add any other reasons why they might be dislodged from a "*good postural position*", 10 (30%) provided additional information. These comments revealed a range of daily activities such as unloading shopping and picking objects off the floor (table M-80).

8.4.4 Checking Position

The sitting position of a user is firstly determined by the dimensions of the seat, for instance a seat which is too long will press into the back of the knees and cause the user to slouch, see section 3.6.4. Most dimensions of the seat such as the width are fixed when the wheelchair and cushion are issued and unless circumstances change, for instance if a user's body shape were to change following a weight gain or loss (table M-33), remain fixed and so do not need to be monitored.

The position of the footplate is adjustable and subject to change either by drifting out of position over time or by being knocked against something like a curb or a door frame. It is documented, see section 3.6.4, that the height of the footplate has an effect on the position of the legs and so influences the sitting position which in turn has an effect on IP with the potential to cause tissue damage. One of the respondents reported that they had experienced a pressure ulcer which was attributed to the height of their footplate (table M-32). It was anticipated that the adjustment of the footplate would be checked frequently. It was not foreseen that 13 respondents (32%) would report that they "*never check*" the height of their footplate or that 21 (51%) would leave checking to a matter of "*Whenever it's noticed that it is in the wrong position*" (table M-84). A poorly adjusted footplate increases the IP burden on the cushion which increases the risk of skin damage. The longer the user is subject to an incorrectly adjusted footplate, the greater the likelihood of damage and as such this exposure should be kept to minimum. This is difficult when the position of the footplate is only adjusted when its positioning is so far out as to draw attention to itself.

It would be desirable to provide the user with some form of automatic indication when the IP pattern had changed following the footplate changing position. This would warn the user that the IP burden had increased and enable the user to take remedial steps before pressure damage could occur.

The sitting position of the user is dynamic and subject to the user positioning and repositioning, depending on their disability and level of activity, see section 3.6.1. Thus, wheelchair users do sit in positions other than the preferred "*normal sitting*" position. Consequently they have to monitor, with or without help, their sitting position in order to make corrective adjustments as and when required. As some of the respondents would be unable to sit in a "*normal sitting*" position, the respondents were asked, when do you check that your sitting position is "*all right*", meaning their best personal position (table M-86).

It had been anticipated that as the potential consequences of poor posture can be severe, see section 3.6.1, a large proportion of the respondents would be checking their posture at least every couple of hours. It was not foreseen that only eight out of the 41 (20%) would report that they check every couple of hours (table M-86). When this small percentage is coupled with the result that 22% (nine out of the 41), reported that they slip from a good sitting position within two hours (table M-76). There is the potential for many users to be slipping from a good sitting position within two hours and not checking and correcting their position for more than two hours. This difference between slipping from a good position and checking the position is a period when the user might sit in a poor position from which damage can occur.

As different movements/activities can displace a person (table M-77) it could be that instead of relying on a time table or routine of times, as in every two hours, to check their sitting position users prefer to check their sitting position after undertaking one of these movements/activities.

Of the 30 respondents who can sit in a "*good postural position*", 15 (50%) reported that they are displaced by spasms either, "*All the time*", "*Frequently*" or "*Occasionally*" (table M-77). However, 11 out of the 41 respondents (27%) reported that they check their sitting position after a spasm (table M-86).

Of the 30 respondents, 14 (46%) reported that they are displaced by propelling their wheelchair either, "*All the time*", "*Frequently*" or "*Occasionally*" (table M-77). However, six out of the 41 respondents (15%) reported that they check their sitting position after propelling their wheelchair (table M-86).

These findings suggest that there are users who are being displaced from a good sitting position by movements/activities and then not checking their position in order to make the necessary corrective adjustments.

As users are recommended to follow a routine of conducting pressure relieving movements, typically every hour see section 3.4.4, this would be an opportune moment to check the sitting position. Of the respondents only 11 (27%) reported that they check their sitting position after conducting pressure relief (see table M-86). Further, most respondents 27 (66%) reported that do not follow such a routine and of those who do half reported that they regularly miss half of the scheduled pressure relieving episodes (table M-110).

Perhaps the lack of checking the sitting position by the respondents is a reflection of the respondent's lack of need to consciously check their position due to their continuous awareness of their sitting position. The respondents were asked how often can they tell for themselves whether or not they are sitting in certain positions.

Approximately half (51%) of the respondents are aware of the elements of their sitting position "*All the time*". The majority of the remainder have the capacity to be aware of their sitting position at least "*Some of the time*" (table M-88). It had been anticipated that most of the paraplegic group would be aware of their sitting position at least "*most of the time*", but it was thought that more of the less mobile tetraplegics would have difficulty with maintaining an awareness of their sitting position. This survey found that 80-90% of both paraplegics and tetraplegics are aware of their sitting position at least "*most of the time*".

If so many of the respondents are able to assess their sitting position, either individually or with the aid of a carer, it is not clear whether the respondents are sitting with a lateral lean or a slouch as a matter of choice or are compelled to do so for some reason. Either way cushion design should recognise that users will on occasion be sat in a position other than the "*normal sitting*" position and should not focus on trying to force individuals into sitting only in a "*normal position*", but should try to accommodate and compensate for the difficulties which arise when sitting with a slouch or a lean.

8.5 Findings on Cushion's Practicality

8.5.1 Daily Use

The daily use of cushions includes various activities related to their operation and upkeep, for example cleaning. Keeping a cushion clean is an aspect of preventing pressure ulcers since hygiene is one of the exacerbating factors in pressure ulcer development, see section 4.4.4. The close contact the user has with their cushion makes the cleanliness of the cushion part of the user's hygiene. Thus, the ability to be thoroughly cleaned is an important feature of a cushion. This importance has been recognised by the users and is reflected in the findings of this study. When considering which cushion to use, the respondents collectively ranked the ability of a cushion to be kept clean higher than the cost of a cushion, with 17 (42%) respondents considering this aspect to be "*Very significant*" compared to 9 (22%) for cost, see table 8-3.

Of the 41 respondents, 28 (68%) reported that they clean their cushion themselves, with all 15 paraplegics (100%) and 13 out of 26 (50%) tetraplegics cleaning their own cushion (table M-91). It had been anticipated that more of the paraplegics would be cleaning their own cushion compared to the more dependent tetraplegics who rely more on their carers. It was not foreseen that all the paraplegics would be cleaning their cushion or that as many as half the tetraplegics would be.

The different cushion designs create different cleaning issues. Some issues require more effort to accommodate than others for instance the open cell matrix structure of the ROHO cushion requires scrubbing between the cells compared to a wipe with a damp cloth for the Jay, see section 3.7. It had been anticipated that the Jay cushions users would find their cushion easier to clean than ROHO users. The findings of this survey seem to suggest this is the case, with 76% of Jay cushion users cleaning their own cushion compared to 38% of ROHO users (table M-91). However, it was not foreseen that when asked "*how easy is your cushion to clean?*", the comparative difference between ROHO and Jay users would be less than 10%, with five out of 13 (38%) ROHO users answering either "*Very easy*" or "*Easy*" compared to eight out of

17 (47%) Jay users (table M-92). It is not clear why the margin of difference between the ROHO and Jay users was not greater. It is possible that this similarity was unforeseen due to a lack of appreciation of the difficulties users face when cleaning the Jay. With only 47% of Jay users reporting that their cushion is either "*Easy*" or "*Very easy*" to clean, this suggests that there is more to cleaning this cushion than is currently appreciated.

A cushion's ability to be kept clean is a feature users regard very highly yet only half the respondents (51%) (table M-92) reported that their cushion is either "*Easy*" or "*Very easy*" to clean. Any future design should facilitate the cleaning process so that more users are not taxed by this necessary activity.

Currently, it is an operational requirement of a cushion that it is detachable from wheelchairs, so that various day-to-day tasks can be performed such as collapsing a wheelchair or changing the cushion's cover. The respondents were asked how often their cushion is removed for certain specified reasons (tables M-94, M-95 and M-96).

Using a Mann-Whitney U test to compare between the tetraplegic and the paraplegic respondents, it was found that with $p < 0.05$ for significance there was no significant difference between how often they remove their cushion from their wheelchair in order to,

change the cover, $z = -0.46$, (2-tailed) $p = 0.68$

check the distribution of gel, $z = -0.26$, (2-tailed) $p = 0.80$

collapse the wheelchair, $z = -0.37$, (2-tailed) $p = 0.73$

check for damage, $z = -1.31$, (2-tailed) $p = 0.27$.

This suggests that there is no difference between tetraplegics and paraplegics with regards to these reasons for removing their cushion.

However, still with $p < 0.05$ for significance, it was found that there was a borderline statistical difference with how often they remove their cushion from their wheelchair in order to,

check the air pressure, $z = -1.96$, (2-tailed) $p = 0.09$

and a statistically significant difference between

to clean the cushion, z = -,2.52 (2-tailed) $p = 0.02$.

to use the cushion on a different chair, $z = -2.91$, (2-tailed) $p = 0.01$

The borderline difference found with the checking of air pressure can be accounted for by the greater proportion of tetraplegics who use a ROHO (38%) compared to the proportion of paraplegics who use a ROHO (20%).

It is not apparent why a greater proportion of tetraplegics (58%) require their cushion to be removed to be cleaned than paraplegics (13%). Perhaps this is a reflection of the greater proportion of tetraplegics who use a motorised chair compared to the more light weight canvas type wheelchair more favoured by paraplegics.

It is not apparent why a greater proportion of tetraplegics (8%) require their cushion to be removed to use on another cushion than paraplegics (0%) because proportionally more of the paraplegics reported that they use their cushions when sitting on other chairs, for instance 27% of the paraplegics reported that they use their cushion either "*all the time*" or "*frequently*" when sat on a car seat compared to 15% of the tetraplegics (table M-107). This finding may be unrepresentative due to the small numbers involved (two tetraplegics and zero paraplegics).

Using a Kruskal-Wallis test to compare between the respondents who use either a 'ROHO' cushion, a 'Jay' cushion or an 'Other' cushion, it was found that with $p < 0.05$ for significance there was no significant difference between how often they remove their cushion from their wheelchair in order to,

> use on a different chair, $X^2 = 2.20$; df = 2, p = 0.33; Mean rank for the ROHO (15.50) Jay (12.85) Other (18.00)
>
> change the cover, $X^2 = 3.51$; df = 2, p = 0.17; Mean rank for the ROHO (15.05) Jay (14.61) Other (21.63)
>
> collapse the wheelchair, $X^2 = 0.01$; df = 2, p = 0.99; Mean rank for the ROHO (16.72) Jay (17.18) Other (17.00)
>
> check for damage, $X^2 = 1.90$; df = 2, p = 0.39; Mean rank for the ROHO (13.06) Jay (15.86) Other (18.83)
>
> clean the cushion, $X^2 = 0.52$; df = 2, p = 0.77; Mean rank for the ROHO (17.00) Jay (19.63) Other (19.91).

This suggests that there is no difference in the significance a 'ROHO' cushion, a 'Jay' cushion or an 'Other' cushion with regards to these reasons for removing their cushion.

However, still with $p < 0.05$, it was found that there was a statistically significant difference between these reasons for removing the cushion.

check the air pressure, $X^2 = 18.64$; df = 2, p = 0.00; Mean rank for the ROHO (6.85) Jay (19.67) Other (18.64)

check the gel sacks, $X^2 = 7.86$; df = 2, p = 0.02; Mean rank for the ROHO (19.64) Jay (10.68) Other (18.50).

These two results are consistent with the fact that the Jay cushions are gel cushions with no air cells, whilst the ROHO has air cells and no gel. Consequently the ROHO will need to have its air pressure check whilst the Jay will not; and the Jay will need its gel checked whilst the ROHO will not.

These reasons for removing a cushion from a wheelchair were ranked by numbers of respondents who have reported a reason occurring either, "*Frequently*" or "*All the time*", see table 8-7.

Table 8-7 Reasons for removing a cushion ranked by number of respondents who remove a cushion for a reason either, "*Frequently*" or "*All the time*". The number of respondents who answered "*Occasionally*" was used to separate equal rankings

Groups											
All respondents (n=41)		Tetraplegics (n=26)		Paraplegics (n=15)		Jay Users (n=17)		ROHO Users (n=13)		Other Users (n=11)	
Rank	Reason	Rank	Reason	Rank	Reason	Rank	Reason	Rank	Reason	Rank	Reason
1	Clean it (41%)	1	Clean it (58%)	1	Collapse wheelchair (47%)	1	Collapse wheelchair (35%)	1	Check air cells (62%)	1	Collapse wheelchair (45%)
2	Collapse wheelchair (39%)	2	Collapse wheelchair (35%)	2	Change cover (27%)	2	Clean it (29%)	2	Clean it (46%)	2	Clean it (36%)
3	Change cover (23%)	3	Check air cells (31%)	3	Check gel (20%)	3	Change cover (29%)	3	Collapse wheelchair (38%)	3	Check for damage (9%)
4	Check air cells (22%)	4	Change cover (19%)	4	Clean it (13%)	4	Check gel (24%)	4	Change cover (31%)	4	Check gel (9%)
5	Check gel (12%)	5	Check for damage (15%)	5	Check for damage (7%)	5	Check for damage (12%)	5	Check for damage (15%)	5	Check air cells (9%)
6	Check for damage (12%)	6	Use on different chair (8%)	6	Check air cells (7%)	6	Use on different chair (12%)	6	Use on different chair (0%)	6	Change cover (0%)
7	Use on different chair (5%)	7	Check gel (8%)	7	Use on different chair (0%)	7	Check air cells (0%)	7	Check gel (0%)	7	Use on different chair (0%)

When comparing Jay users with ROHO users, both rank "*Clean it*" as their second most common reason for removing their cushion, with 29% of Jay users having reported that they remove their cushion either, "*Frequently*" or "*All the time*" compared to 46% of ROHO users. The higher proportion of ROHO users who have to remove their cushion to clean it is consistent with the ROHO being a more difficult cushion to clean than the Jay.

The most common reason for removing the ROHO cushion (62%) was to check the air pressure. This result was not foreseen and counter to expectation. The literature on ROHO cushions, including its own operation manual, see section 3.3.1, describes a process whereby the air pressure is set by checking the depth the user has sunk into the cushion. Ideally this would be performed with the cushion in position in the wheelchair. Having to removing the cushion from the wheelchair to check the air pressure is an additional burden.

These various operational activities can prompt the removal of the cushion numerous times a day, with 19 (46%) reporting that they remove their cushion more than once a day (table M-93). Currently 26 (63%) of the respondents carry out this task by themselves either "*Frequently*" or "*All the time*" (table M-98).

As the collapsing of wheelchairs and changing covers are tasks that are not likely to cease in the foreseeable future, it is important that future designs continue to be at least as easy to detach from wheelchairs as current designs.

Following removal is the corresponding activity of attaching and securing the cushion to the wheelchair. On returning the cushion to the wheelchair the cushion should be secured to the wheelchair to stop it sliding about. Of the 41 respondents, 28 (68%) reported that they secure their cushion themselves, with 12 out of the 15 paraplegics (80%) and nine out of the 26 tetraplegics (35%) securing their own cushion "*All the time*" (table M-98). It had been anticipated that more of the paraplegics would be securing their own cushion compared to the more dependent tetraplegics who rely more on their carers. It was not foreseen that nearly all of the paraplegics (93%) would on occasion secure their own cushion, or that many as 13 of the tetraplegics (54%) would also on occasion secure their own cushion (table M-98).

The ability to fix a cushion securely to the wheelchair is an important feature. This importance has been recognised by the users and is reflected in the findings of this study. When considering which cushion to use, the respondents collectively ranked the ability of a cushion to be fixed securely to the wheelchair slightly higher than a cushion's weight, with 13 (32%) respondents considering the ability to secure a cushion as "*Very significant*" compared to the 11 (27%) respondents who consider a cushions weight as "*Very significant*", see table 8-3.

Of the 41 respondents, 28 (69%) reported that they find the task of securing the cushion to be at least "*Manageable*". The Jay cushion users do find it easier to secure their cushions than the ROHO, with eight out of the 17 Jay users (47%) reporting that they find this task either "*Easy*" or "*Very easy*" compared to four out of the 13 ROHO users (31%) reporting that they find this task either "*Easy*" or "*Very easy*" (table M-99).

Whilst some respondents find securing "*Easy*" or "*Very easy*" securing still is problematic with room for error, seven (17%) reported that their cushion is "*Frequently*" loose and free to slide around on their wheelchair (table M-100). Additionally, 12 (29%) reported that they either "*Frequently*" or "*All the time*" knock loose their secured cushion when transferring (table M-101). Future cushion designs need to be at least as easy to secure to wheelchairs as current cushion designs. As well as being easy to secure to a wheelchair any future designs should strive to prevent the cushion from breaking loose. In particular a future design should be able to withstand the forces involved in the transfer to and from a wheelchair.

The forces involved during a transfer are substantial and can on occasion knock loose a cushion secured to a wheelchair. These forces stress the cushion and have been cited as a cause of damage to their cushion by two respondents (table M-103). The nature of the various cushion designs results in different weaknesses, which are vulnerable to damage. Air cells are vulnerable to punctures and gel packs to splitting. It had been anticipated that a large proportion of the respondents would have had experienced similar activities/events which have damaged their cushions. Although 11 (27%) of the respondents had experienced damage to their cushion the forms of damage were more varied than expected, such as cells being pinched by a hoist sling (table M-103). Had there been a recurring theme such as cigarette burns puncturing air cells it would have been easier to design around these.

The limited restrained response would seem to suggest that current designs are more robust than anticipated. Any future design employing a fluid based technology will have to ensure that any cells or packs are at least as robust as current designs.

8.5.2 Cushion Use on Chairs as well as Wheelchairs

It is well documented that individuals with SCI spend great lengths of the day sat in their wheelchairs, see section 3.7. The findings of this study are consistent with this position with 33 (81%) of the respondents, 93% of paraplegics and 73% of tetraplegics, reporting that they spend more than eight hours in their wheelchair on an average day (table M-104).

During the course of the day someone with SCI, through choice or necessity, may have to sit in a chair/seat other than their wheelchair. With cars being a widely used form of transport, it was anticipated that a large proportion of respondents would spend part of the day sat on a car seat. Of the 41 respondents, 30 (73%) reported that do sit on car seats and that nine (22%) do so for more than one hour (table M-105). It was anticipated that many respondents would report the use of a variety of different types of chairs, particularly more leisure activity type seating, such as sailing. A variety of chairs were reported, for example one respondent reported using a fishing chair when angling. It was not foreseen that the use of so few different chairs would be reported (table M-106).

When sat on a chair, other than their wheelchair, a user can either rely on the chair's own immersion and envelopment properties or make alternative arrangements such as moving their cushion from their wheelchair onto the chair. This decision making process will have to consider the surface of the chair and the length of time sat on. Ten respondents (24%) reported that they sit on armchairs, of which one reported that when they sit on an armchair they do so for less than one hour (table M-105). Of these ten, eight (80%) reported that they never use their cushion when sitting on an armchair (table M-107). In these cases the individual is relying on the IP reducing properties of the armchair surface to be sufficient to sit on safely for extended lengths of time. It is possible that the 29 (71%) respondents who reported that they never sit on armchairs, may want to but are prohibited by the less developed immersion properties of the armchair surface not sufficiently reducing IP and would appreciate a cushion flexible enough to be used with both their wheelchair and armchairs. This is an aspect which requires further work. It may well be that a PR cushion type armchair insert might be a product which the SCI community would value.

Of the 30 respondents who reported that they sit on car seats, six (15%) reported that they use their PR cushion with their cars seat "*all the time*" compared to 18 (44%) who reported that they never do (table M-107). There are potentially many reasons why a respondent might not use their cushion when sat on a car seat. It could be related to concerns about safety, in particular concerns relating traffic accidents. It may be that the respondents who reported that they never use their PR cushion when sat on a car seat are satisfied with the pressure relieving properties of the car seats they sit on as they are well designed, such as the seats found in Volvos or designed by Recaro. It is possible that the respondents who currently do not use their PR cushions with their car seats are unable to do so because their PR cushions are unstable on top of a car seat. These cushion users may well appreciate a cushion designed to be used with both their wheelchair and car seats. This is an aspect which requires further work. It may well be that a PR cushion compatible with car seats might be a product the SCI community would value.

8.5.3 Pressure Relieving whilst Sat in a Wheelchair

Pressure relief is a practice whereby the user temporarily assumes an extreme sitting position, such as a pronounced lean to one side, in order to lift the body weight off the usual load bearing points on the body. By lifting the weight off these points the skin is relieved of IP. This restores blood flow and enables the tissue to revitalise and so prevent tissue necrosis. This practice is widely believed to work and is recommended by health care professionals from spinal injury centres, see section 3.4.4.

The findings suggest that those who follow a pressure relief routine are less prone to developing pressure ulcers than those who do not, see table 8-8.

Table 8-8 The distribution of pressure ulcers between those who did and those who did not follow a pressure relieving routine (n = 41) *

Distribution of pressure ulcers					
Those who followed a pressure relieving routine (n=12)			Those who did not follow a pressure relieving routine (n=27) #		
Developed pressure ulcers on seat area of the body	Developed pressure ulcers somewhere on the body but not on the seat area	Did not develop a pressure ulcer	Developed pressure ulcers on seat area of the body	Developed pressure ulcers somewhere on the body but not on the seat area	Did not develop a pressure ulcer
5 (42%)	1 (8%)	6 (50%)	17 (63%)	0 (0%)	7 (26%)

* 2 missing

3 respondents did not supply details of their pressure ulcer history, (table M-14)

As anticipated a higher proportion of those who did not follow a pressure relief routine had developed pressure ulcers on the seat area of the body than those who did follow a routine; with 17 out of the 27 (63%) who did not follow a routine experiencing pressure ulcers compared to five out of the 12 (42%) who did follow a routine, see figure 8-8.

However, this difference in proportion between those who follow a pressure relief and those who do not was found to be not statistically significant.

Using Pearson's Chi Square, $X^2 = 0.1.53$; df = 1; (2-sided) $p = 0.22$, for significance $p < 0.05$.

Based on this finding it is not possible to draw a firm conclusion that those who follow a pressure relief routine are less prone to developing a pressure ulcer than those who do not follow a pressure relief routine.

Without a difference between these two groups, this finding could be interpreted as suggesting that following pressure relief routine does not effect the development of pressure ulcers. Such a conclusion would not be taking into account the possibility that those who had followed a pressure relief routine might have experienced more pressure ulcers had they not followed a pressure relief routine. Equally those who had not followed a pressure relief routine may have avoided developing pressure ulcers had they followed a pressure relief routine.

However, with two out of every five of those who follow a pressure relief routine still developing pressure ulcers on the seat area of their body, there is room for improvement.

As pressure relieving is an activity advocated by spinal centres and is the subject of numerous articles, see section 3.4.4, it had been anticipated that a large proportion of the respondents would be performing some form of pressure relief. As anticipated, with 35 out of 41 (85%), most of the respondents reported that they carry out at least one of the recommended movements such as a "*Forward lean*" (table M-108).

The most commonly made pressure relief movement reported was "*Raising self up*" performed by 63% of respondents (67% of the paraplegics and 62% of the tetraplegics). The second most popular movement was the "*Leaning forward*", performed by 32% of the respondents (0% of the paraplegics and 50% of the tetraplegics).

The popularity of the "*Raising self up*" movement had not been foreseen as for the last few years the shortcomings of this movement has been known, such as long term shoulder damage, and other movements such as the "*lean forward*" has been recommended by spinal centres, see section 3.4.4.

The widespread use of pressure relief movements would seem to indicate that the majority of users regard pressure relieving movements as being purposeful and something to be included in their daily routine. This might be due to the advocacy by health care professionals of pressure relieving; or it may be a reflection of a lack of confidence in the pressure relieving qualities of cushions; or it may be a reflection of the role it can play for some users in preventing pressure ulcers.

It was not foreseen that a large proportion, 27 out of 41 (66%), of the respondents would report that they do not follow a fixed routine; plus of those who do follow a routine, half of these users regularly miss half their scheduled movement episodes (table M-110). The value of pressure relieving movements is found in its regular performance. Based on the pressure intensity-duration relationship, the pressure-redistribution principle suggests that pressure relief movements can provide the skin with respites from pressure which allows the tissue to revitalise and so stave off damage, see sections 3.4.4 and 4.5.7. The large proportion of respondents who do not follow a regular routine must, by implication, be missing out on relief episodes and failing to revitalise their skin. This would seem to indicate that, for a large proportion of the respondents, there is less requirement for frequent fleeting revitalisation, which diminishes the case for pressure relief routines as a prophylaxis for all. There are likely then to be individuals who are sporadically, but needlessly, performing pressure relief movements in the belief that it is beneficial for their skin. It would save the user inconvenience to be informed, by feedback from the cushion, when the skin requires a respite from pressure rather than relying on an arbitrary routine which may be disrupted causing important pressure reliving episodes to be missed.

There is potential benefit to be gained by informing the user when an episode of pressure respite is overdue. Those who do benefit and rely on pressure relief movements are vulnerable to interruptions in the routine. This study has found that a failure to perform pressure relief with sufficient regularity can lead to pressure ulcers with two of the 22 (9%) respondents, who have experienced at least one pressure ulcer on the seat area of the body, having reported that they develop pressure ulcers "*All the time*" as a result of "*Pressure relief routine not performed regularly enough*" with a further three respondents reporting this to be the case either "*Occasionally*" or "*Very rarely*" (table M-30).

8.5.4 Transferring into and out of Wheelchairs

All wheelchair users transfer into and out of their wheelchairs. Although unsafe transfers are not regarded as a factor in pressure ulcer development, see section 4.4, it is well known that transferring can be problematic for the user and that an unsafe transfer can trigger a pressure ulcer, see section 3.7. It is not clear from the literature what size of contribution unsafe transfers makes to the overall incidence rate of pressure ulcers.

This study found that unsafe transfers have caused a large proportion of the respondents to develop pressure ulcers. Of the 22 respondents who have experienced a pressure ulcer on the seat area of their body 13 (56%) of the respondents reported that they have experienced a pressure ulcer which was identified as being caused by an unsafe transfer and that of these, five (23%) reported that this was the case "*All the time*" (table M-30). Since 56% cited an unsafe transfer as a cause of their pressure ulcers, a reduction in pressure ulcers due to unsafe transfers would translate into a substantial reduction in the overall incidence of pressure ulcers. By making the transfer process easier, this will reduce the opportunities for the sort of error which triggers a pressure ulcer to occur.

Currently the various designs of cushion all create their own difficulties during transfers, such as the "*bucket effect*" associated with contour cushions, see figure 3-88, or unstable surfaces with air filled cushions, see figure 3-89.

The findings suggest that whilst many users do not find that their cushion creates difficulties when transferring some do, see table 8-9.

Table 8-9 The extent to which the respondent's cushion create difficulties when transferring into and out of their wheelchair

Groups		Extent of difficulties				
		Major Difficulties	Some Difficulties	Inconven-ient	Small Inconven-ience	Not a problem
All respondents (n=41)		0 (0%)	5 (12%)	1 (2%)	8 (20%)	27 (66%)
Tetraplegics (n=26)	Jay Users (n=9)	0	0	1	1	7
	ROHO Users (n=10)	0	1	0	5	4
	Other Users (n=7)	0	2	0	0	5
Paraplegics (n=15)	Jay Users (n=8)	0	0	0	1	7
	ROHO Users (n=3)	0	2	0	0	1
	Other Users (n=4)	0	0	0	1	3

With 14 out of 17 (82%) a higher proportion of Jay users reported that their cushion does not create addition difficulties during transfers compared to the ROHO users with five out of 13 (32%), see table 8-9.

This difference in proportion between Jay users and ROHO users was found to be statistically significant.

Using Fisher's Exact Test, (2-sided) $p = 0.02$, for significance $p < 0.05$.

Having found a statistically significant difference between the proportions of Jay users and ROHO users, who reported that their cushions create difficulties during transfers, it would seem that the stable contoured surface of a Jay cushion is easier to transfer from than the unstable contour-less surface of a ROHO.

8.5.5 Use of Covers

Most cushion designs incorporate a cover as an integral part of the cushion, see sections 3.3 and 3.3.7. It was anticipated that a large proportion of the respondents would be using the cover that comes with the cushion. This was confirmed with 33 (80%) of the respondents reporting that they use the cover that comes with their cushion "*All of the time*". The respondents were also asked if they used alternative coverings such as homemade covers or covers taken from different cushions, either altered to fit or unaltered. The results indicated that these alterative options are not widely used (table M-111).

With 80% of the respondents choosing to use the cover that comes with the cushion, and not opting for an alternative, it is clear that they favour the cover that comes with the cushion. It is likely then that when it comes to using a new cushion they will opt once again to use the cover that comes with the cushion. It is therefore important that when a new cushion is designed, its corresponding cover is at least as functional as currently available covers and does not include weaknesses which may lead to pressure ulcers.

Although none of the respondents reported that they had developed a pressure ulcer which was thought to have been caused directly by their cushion cover, see section 8.2.4; there remains the potential for certain aspects of covers to be problematic for the skin, for instance by creating a micro-environment conducive to sweating, section 3.3.7.

The respondents were asked how significant they regard certain aspects of their cover in relation to the development of pressure ulcers (tables M-113, M-114 and M-115).

Using a Mann-Whitney U test to compare between the tetraplegic and the paraplegic respondents, it was found that with $p < 0.05$ for significance there was no significant difference between how these certain aspects of their cover in relation to the development of pressure ulcers were regarded,

the texture of the cover material is too rough, $z = -0.29$, (2-tailed) $p = 0.79$

the weave or cloth pattern is too pronounced, $z = -0.77$, (2-tailed) $p = 0.47$

the cover holds too much moisture, $z = -0.29$, (2-tailed) $p = 0.79$

the cover is stretched too tight across the cushion affecting the cushions ability to disperse the weight of the body, $z = -0.95$, (2-tailed) $p = 0.38$

This suggests that there is no difference between how tetraplegics and paraplegics regard these certain aspects of their cover in relation to the development of pressure ulcers.

However, still with $p < 0.05$ for significance, it was found that there was a borderline statistical difference with how significant this aspect was regarded,

the cover becomes wrinkled or creased, $z = -1.32$, (2-tailed) $p = 0.19$

As wrinkles and creases in the material pose an equal risk to both the tetraplegic and paraplegic, it was not apparent why the tetraplegics might regard the cover being winkled as more significant than paraplegics. This might be a reflection of a behavioural difference between those with tetraplegia and paraplegia. As tetraplegics are considered to be more at risk of developing pressure ulcers they could be more sensitive to the potential hazard wrinkles and creases pose.

As 33 out of the 41 respondents (80%) reported that they use the cover that comes with the cushion for the purposes of this exercise it was assumed that when a respondent answered a question on their cover they were referring to the cover that comes with their cushion.

Using a Kruskal-Wallis test to compare between the respondents who use either a ‘ROHO’ cushion, a ‘Jay’ cushion or an ‘Other’ cushion, it was found that with $p < 0.05$ for significance there was no significant difference between how these certain aspects of their cover in relation to the development of pressure ulcers were regarded,

the texture of the cover material is too rough, $X^2 = 2.45$; df = 2, $p = 0.30$; Mean rank for the ROHO (17.95) Jay (21.33) Other (15.14)

the weave or cloth pattern is too pronounced, $X^2 = 1.94$; df = 2, $p = 0.38$; Mean rank for the ROHO (19.95) Jay (19.95) Other (15.00)

the cover holds too much moisture, $X^2 = 1.15$; df = 2, $p = 0.56$; Mean rank for the ROHO (18.00) Jay (20.50) Other (16.23)

the cover is stretched too tight across the cushion affecting the cushions ability to disperse the weight of the body, $X^2 = 0.13$; df = 2, $p = 0.94$; Mean rank for the ROHO (18.95) Jay (18.40) Other (19.86)

This suggests that there is no difference in the significance a 'ROHO' cushion, a 'Jay' cushion or an 'Other' cushion regard how these certain aspects of their cover.

However, still with $p < 0.05$ for significance, it was found that there was a borderline statistical difference with how significant this aspect was regarded,

> the cover becomes wrinkled or creased, $X^2 = 3.68$; df = 2, p = 0.16;
> Mean rank for the ROHO (19.21) Jay (23.00) Other (15.05)

As wrinkles and creases in the material pose an equal risk to all cushion users, it was not apparent why the 'Other' cushion user group might regard the cover being winkled as more significant than the ROHO or Jay cushion users.

These aspects were then ranked using the number of respondents who consider an aspect as either, "*Of Significance*" or "*Very Significant*", see table 8-10.

Table 8-10 Concern over certain aspects of a cover ranked by number of respondents who regard an aspect as either "*Very Significant*" or "*Of Significance*". The number of respondents who answered "*Significant*" was used to separate equal rankings

Groups											
All respondents (n=41)		Tetraplegics (n=26)		Paraplegics (n=15)		Jay Users (n=17)		ROHO Users (n=13)		Other Users (n=11)	
Rank	Aspect	Rank	Aspect	Rank	Aspect	Rank	Aspect	Rank	Aspect	Rank	Aspect
1	Wrinkled/ creased (71%)	1	Wrinkled/ creased (77%)	1	Wrinkled/ creased (67%)	1	Wrinkled/ creased (65%)	1	Wrinkled/ creased (69%)	=1	Wrinkled/ creased (82%) Weave (82%) Holds moisture (82%)
2	Weave (64%)	2	Stretched too tight (69%)	2	Weave (60%)	2	Stretched too tight (65%)	2	Stretched too tight (61%)		
3	Stretched too tight (63%)	3	Weave (65%)	3	Holds moisture (53%)	3	Weave (59%)	3	Texture (54%)		
4	Texture (59%)	4	Texture (62%)	=4	Stretched too tight (53%) Texture (53%)	4	Texture (47%)	4	Weave (54%)	4	Texture (82%)
5	Holds moisture (51%)	5	Holds moisture (50%)			5	Holds moisture (35%)	5	Holds moisture (46%)	5	Stretched too tight (63%)

With the effect moisture has on the skin, see section 4.4.4, plus much of the emphasis of cover design being focused on its ability to manage moisture through being, vapour-permeable, breathable or humidity wicking, see section 3.3; it had been expected that the covers capacity manage moisture would be considered "*Very Significant*" by most respondents. It was not foreseen that only half of the respondents would consider this aspect as either, "*Of Significance*" or "*Very Significant*", and that collectively this would be the aspect ranked last by the respondents. This result is perhaps less about the importance of a cover holding moisture than a reflection of the greater relative importance of these other aspects.

Collectively, the most important aspect of a cover for the respondents was "*The cover becomes wrinkled or creased*". Additionally, the respondents indicated that "*The cover is stretched too tight across the cushion affecting the cushions ability to disperse the weight of the body*" is also an aspect that they regard as "*Very significant*". Both of these aspects are the product of incorrectly tensioning a cover. A cover under no tension is free to ruffle up and gather into folds and creases. A cover under too much tension will stretch so tightly that it will "*hammock*" the user over their cushion.

Future cushion design will have to ensure that the cover is at least as able in managing moisture as current covers. More attention will have to be put into the tensioning of the cover so as to prevent wrinkling/creasing and hammocking.

Due to hygiene requirements cushion covers have to be changed regularly for cleaning. Of the 41 respondents, 25 (61%) reported that they change their cover themselves, with 14 out of 15 paraplegics (93%) and 11 out of 26 tetraplegics (42%) changing their own cover (table M-116). It had been anticipated that more of the paraplegics would be changing their own cover compared to the more dependent tetraplegics who rely more on their carers. It was not foreseen that nearly all the paraplegics would be changing their cover or that as many as half the tetraplegics would be.

Of the paraplegics, eight (53%) reported that they either "*Agree*" or "*Strongly agree*" that the process of changing the cover is easy for whoever undertakes the task. Of the tetraplegics this percentage was slightly less at 46% (12 out of 26) (table M-117). These results suggest that whilst the majority of users change their covers, only half find this task easy. Future cushion design should ensure in its design that covers are better integrated with their cushion so that they are easier to change than current designs.

The different cushion designs present different obstacles to over come when changing the cover, for instance gel cushions are distinctly heavier than simple foam cushions, see section 3.7. The respondents were asked whether or not they agreed with a series of statements about changing a cover (tables M-118, M-119 and M-120).

Using a Mann-Whitney U test to compare between the tetraplegic and the paraplegic respondents, it was found that with $p < 0.05$ for significance there was no significant difference between the level of agreement with the following series of statements about changing a cover,

> the cushion is bulky, so it is difficult to insert into the cover, $z = -0.21$, (2-tailed) $p = 0.86$
>
> the cover opening fastenings (zippers, buttons, press studs) are difficult, $z = -1.26$, (2-tailed) $p = 0.26$
>
> to fit the cover the cushion has to be removed form the wheelchair, $z = -0.62$, (2-tailed) $p = 0.64$

This suggests that between the tetraplegics and paraplegics, there is no significant difference in level of agreement with these statements.

However, still with $p < 0.05$ for significance, it was found that there was a borderline statistical difference in their agreement with the statements,

> the cover is difficult to adjust so that the surface is not wrinkled or creased, $z = -1.67$, (2-tailed) $p = 0.15$
>
> the cover is often not ready to put on as it is away being cleaned or repaired, $z = -1.62$, (2-tailed) $p = 0.14$

The borderline difference found between the tetraplegic and paraplegic groups, with regards to the degree of difficulty they experience with the adjustment of their cover so that the surface is not wrinkled or creased, may well be a reflection of their more compromised physicality due to their more extensive paralysis.

It is not apparent as to why slightly higher proportion of tetraplegics would find their cover not ready to be put on.

As above, with 33 out of the 41 respondents (80%) having reported that they use the cover that comes with the cushion, for the purposes of this exercise it was assumed that when a respondent answered a question on their cover they were referring to the cover that comes with their cushion.

Using a Kruskal-Wallis test to compare between the respondents who use either a 'ROHO' cushion, a 'Jay' cushion or an 'Other' cushion, it was found that with $p < 0.05$ for significance there was no significant difference between the level of agreement with the following series of statements about changing a cover,

> the cover is often not ready to put on as it is away being cleaned or repaired, $X^2 = 1.00$; df = 2, $p = 0.61$; Mean rank for the ROHO (16.80) Jay (17.30) Other (22.10)
>
> to fit the cover the cushion has to be removed form the wheelchair, $X^2 = 2.31$; df = 2, $p = 0.32$; Mean rank for the ROHO (19.15) Jay (20.16) Other (15.20)
>
> the cover is difficult to adjust so that the surface is not wrinkled or creased, $X^2 = 1.43$; df = 2, $p = 0.49$; Mean rank for the ROHO (20.60) Jay (16.20) Other (18.10)

This suggests that between the 'ROHO' cushion, 'Jay' cushion and 'Other' cushion users, there is no significant difference in level of agreement with these statements.

However, still with $p < 0.05$ for significance, it was found that there was a borderline statistical difference in their agreement with the statement,

> the cushion is bulky, so it is difficult to insert into the cover, $X^2 = 2.82$; df = 2, $p = 0.24$; Mean rank for the ROHO (14.95) Jay (17.30) Other (22.10)

and a statistically significant difference in the level of agreement with the statement

> the cover opening fastenings (zippers, buttons, press studs) are difficult, $X^2 = 6.29$; df = 2, $p = 0.04$; Mean rank for the ROHO (22.83) Jay (13.50) Other (20.85)

Although a borderline difference was found with the statement "*the cushion is bulky, so it is difficult to insert into the cover*" it had been anticipated that there would have been a significant difference due to the distinct difference in size and weight of the ROHO and Jay cushions. The Jay is a more substantial cushion weighing up to 5kg compared to the ROHO weighing 2Kg.

The significant difference found in the level of agreement relating to the ease of using fasteners on covers suggests that the users of ROHO cushions find it easier to use their cushion covers fastenings than Jay cushion users.

These statements were ranked by the numbers of respondents who reported that they either, "*Agree*" or "*Strongly Agree*" to a statement, see table 8-11.

Table 8-11 How the respondents find certain aspects of changing a cover, ranked by number of respondents who either "*Strongly Agree*" or "*Agree*". The number of respondents who answered "*Disagree*" was used to separate equal rankings

Groups											
All respondents (n=41)		Tetraplegics (n=26)		Paraplegics (n=15)		Jay Users (n=17)		ROHO Users (n=13)		Other Users (n=11)	
Rank	Aspect	Rank	Aspect	Rank	Aspect	Rank	Aspect	Rank	Aspect	Rank	Aspect
1	Remove from wheelchair (83%)	1	Remove from wheelchair (77%)	1	Remove from wheelchair (93%)	1	Remove from wheelchair (88%)	1	Remove from wheelchair (69%)	1	Remove from wheelchair (91%)
2	Cushion too bulky (27%)	2	Cushion too bulky (31%)	2	Cushion too bulky (20%)	3	Fastenings are difficult (29%)	2	Cushion too bulky (38%)	2	Next cover not ready (18%)
3	Fastenings are difficult (14%)	3	Fastenings are difficult (15%)	3	Fastenings are difficult (13%)	2	Cushion too bulky (24%)	3	Next cover not ready (8%)	3	Cushion too bulky (18%)
4	Next cover not ready (7%)	4	Adjust surface (12%)	4	Next cover not ready (7%)	4	Adjust surface (6%)	4	Adjust surface (8%)	4	Fastenings are difficult (9%)
5	Adjust surface (7%)	5	Next cover not ready (8%)	5	Adjust surface (0%)	5	Next cover not ready (0%)	5	Fastenings are difficult (0%)	5	Adjust surface (9%)

As most cushions covers are designed to encapsulate the cushion, the cushion has to be free to be inserted inside a cover. The findings of this confirmed that a large proportion of the respondents (83%) would agree that their cushion has to be removed from their wheelchair in order to change their cover.

It had been anticipated that a larger proportion of Jay cushions users would agree that their cushion is bulky and difficult to insert into a cover than ROHO users. The findings of this survey seem to suggest this is not case, with 24% of Jay cushion users agreeing their cushion is too bulky compared to 38% of ROHO users, see table 8-11. Perhaps the solid form of the Jay makes it easy to insert into a cover, despite being heavier, than the lighter but more floppy rubber cell matrix of the ROHO.

It had not been anticipated that there would be a difference between Jay users and ROHO users in regard to the difficulty they experience with the fastenings of their cover. However, with 5 out of 17 (29%), a higher proportion of Jay users reported experiencing difficulties with their cover fasteners compared to the ROHO users with none out of 13 (0%), see table 8-9.

This difference in proportion between Jay users and ROHO users was found to be statistically significant.

Using Fisher's Exact Test, (2-sided) $p = 0.05$, for significance $p < 0.05$.

Having found a statistically significant difference between the proportions of Jay users and ROHO users, who reported that they experience difficulties with the fastening on their covers, it would seem that the fasteners on the ROHO cover are preferable to the Jay cover. Thus, future cover designs should model the ROHO approach to fasteners rather than the Jay cover.

Any future design should ensure that the elements involved in the process of changing a cushion cover are kept simple, to facilitate this necessary activity.

8.6 Conclusions

The circulation process generated 41 responses, see section 7.4.1. These responses represent a sample of 0.1% of the 40,000 SCI patients in the UK. Although small, this sample represents the experience of 122 pressure ulcers. When considering the number of pressure ulcers represented by this sample, this study is comparable in size to number of pressure ulcers involved in previous studies, for example Ash (2002) with 153 pressure ulcers and Garber (2003) with 102 pressure ulcers, see table 2-1. On the basis that the number of pressure ulcers involved was comparable to previously published studies it was concluded that this sample was sufficiently large to draw conclusions from.

Having concluded that the sample was large enough to draw conclusions from, when it came to determining if differences were statistically significant the sample sizes in some cases proved to be too small. For example, with five out of seven the proportion of left handed respondents who developed at least one pressure ulcer was 71%, whereas with 18 out of 31 the proportion of right handed respondents who developed at least one pressure ulcer was 58% (table M-15). When comparing the proportion of left handed respondents against the proportion of right handed respondents the difference was found to be 13% (71% - 58%). However when using Fisher's Exact Test this difference in proportion was found to be not statistically significant ($p=0.68$, for significance $p<0.05$). It was concluded that in this case this finding should be regarded as indicative of a potential issue which is worthy of further investigation, rather than providing a definitive result.

It was concluded that the choice of focusing on the leading five cushions, the Flo-tech, Jay2, ROHO, Varilite and Vicair, as recommended by the staff from two SCIC, see section 3.3, was sound, as 82% of the respondents used one of these five cushions.

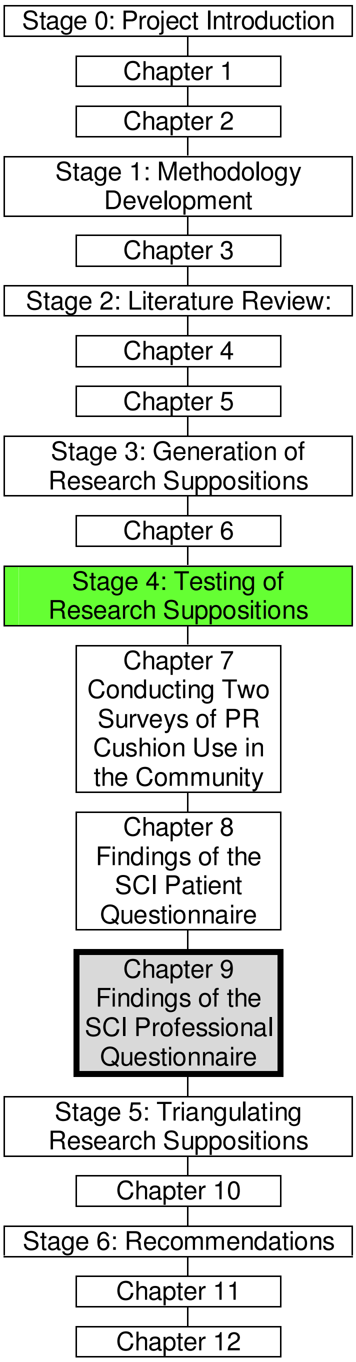
This project set out to identify weaknesses and deficiencies in PR cushion design. As part of the process of identifying these weaknesses and deficiencies 30 research propositions were formulated for testing by this questionnaire. Although the sample size limited the robustness of the findings, this questionnaire provided data which either substantiated or refuted the research propositions. For example from the literature it is known that an unsecured cushion is a hazard for users, see section 3.7, based on the previous work of this project one of the research propositions formulated proposed that securing a cushion to the wheelchair is still an issue for SCI patients, see section 6.5. This questionnaire found that 4 out of 17 (24%) Jay cushion users and 3 out of 13 (23%) ROHO cushion users find that their cushion is "*frequently*" unsecured and loose (table M-100). Although the sample size is too small to be definitive about the size of the problem of unsecured cushions in the SCI population it does provide a positive indicator that it may be a problem and offer some degree of substantiation for the research proposition.

In conclusion, this finding would suggest that contemporary cushions reliance on a non-slip base on their cover is not sufficient to secure a cushion to a wheelchair and is therefore a weakness in their design. This finding on its own only supports the notion that unsecured cushions are a problem for the SCI population. A full conclusion on this issue would be determined after this piece of evidence was added to the other data gathered and considered during the triangulation stage of this project, see section 10.2.

Chapter 9

FINDINGS OF THE SCI PROFESSIONAL QUESTIONNAIRE

9.1 Introduction



This chapter reports on the findings of the SCI professional questionnaire, see appendix N, as part of 'Stage 4' of the project[1]. The project's methodological framework tasked Stage 4 with the testing of the 30 research suppositions produced in Stage 3.

For the sake of clarity, due to the large number of questions asked of the respondents (72 questions), this chapter has been divided into four areas of discussion based on the areas of enquiry used to structure the questionnaires, see section 7.3.1.2. Tables of all results are shown in appendix O.

The areas of enquiry discussed were: the respondents' clients pressure ulcer histories; the cushions used by the respondents' clients; the respondents' clients posture and sitting position in a wheelchair; and the practicalities relating to daily cushion use which combined the two areas of enquiry "*Practices and Behaviour*" and "*Utility/Practicality of Cushion*", see appendix O.

This chapter ends with a set of conclusions drawn from the findings of this questionnaire.

[1] In total thirty one professionals responded, seventeen physiotherapists, ten occupational therapists and four nurses, see section 7.4.2.

9.2 Findings on the Respondents' Clients Pressure Ulcer Histories

The circulation process generated 31 completed questionnaires, of which 17 were from physiotherapists, ten from OT's and four from nurses, see section 7.1.2.

Details of the number of physiotherapists, OT's and nurses employed by the eleven UK'S SCIC were not available. The professional body organised for those involved in the care a treatment of those with SCI is MASCIP, the Multidisciplinary Association for Spinal Injury Professionals. Their membership includes 109 physiotherapists, 69 OT's and 282 nurses, see section 7.2.2.4. It was therefore estimated that the circulation process drew a sample of 10-15% of physiotherapists (17 out of 109) and 10-15% of OT's (10 out of 69) and a sample of less than 1% of nurses (4 out of 282).

9.2.1 Pressure Ulcer Occurrence

As body weight, both over- and underweight, is an intrinsic factor in the development of pressure ulcers, see section 4.4.3, it was anticipated that the respondents' clients whose weight lay at the extreme ends of this range would be developing pressure ulcers more frequently than those clients in the mid range. The respondents were asked to indicate how frequently clients across the range of body weights develop pressure ulcers (table O-1).

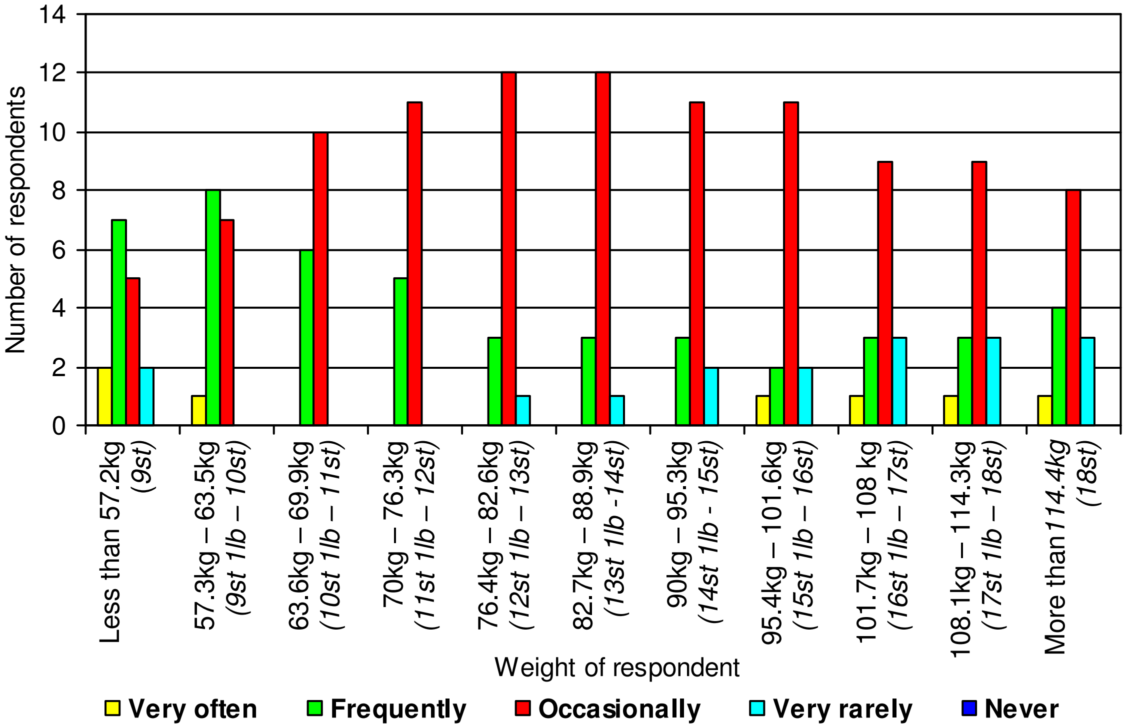


Figure 9-1 A graph showing the frequency clients of different weights develop pressure ulcers

These results suggest that there is an increase in the number of pressure ulcers experienced by clients at the extreme ends of the weight range, less than 57.2kg (9st) and more than 114.4kg (18st), compared to clients in the mid range.

Although no comment boxes were included as part of the questions relating to weight (appendix L), on the space surrounding the question on weight nine (29%) respondents added a comment. All the comments stressed that weight is not a factor in pressure ulcer development (table O-2).

It is possible that these findings reflect the difference between being light-weight and being under-weight. A 57kg light-weight client may not be at increased risk of developing a pressure ulcer, but a client whose weight has dropped to 57kg may be now underweight and therefore more at risk of developing a pressure ulcer. Thus, whilst extreme weight might not be a risk factor it might be an indicator of elevated risk if under- or over weight.

Based on the assumption that the respondents' clients whose weight lay at the extreme ends of the weight range would be developing pressure ulcers more frequently than those clients in the mid range, it was assumed that clients whose height lay at the extreme ends of the height range would also be developing pressure ulcers more frequently than those clients in the mid range (table O-3).

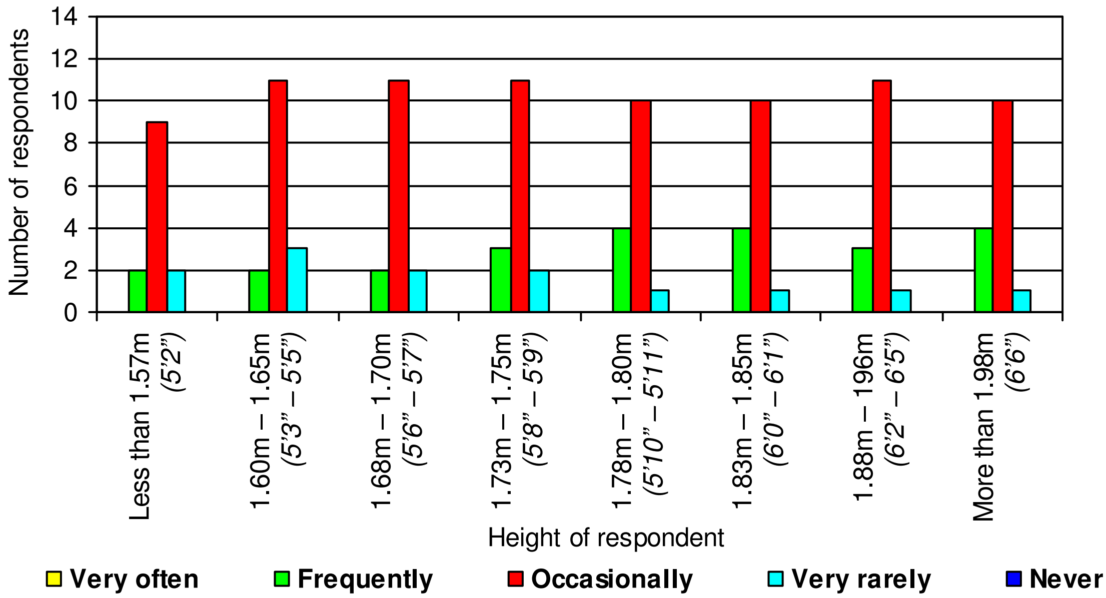


Figure 9-2 A graph showing the frequency clients of different heights develop pressure ulcers

These results suggest that clients at the extreme ends of the height range are not experiencing more pressure ulcers then clients in the mid range.

Unsolicited comments were also received from eight respondents (appendix N) all stressing that height is not a factor in pressure ulcer development (table O-4).

9.2.2 Pressure Ulcer Anatomical Site Distribution

To find out how often pressure ulcers occur on the different sites of the seat area of the body, the respondents were asked to indicate on a plan of the seat area of the body where pressure ulcers occur, "*Rarely*", "*Occasionally*" and "*Frequently*", see figure 9-3.

With pressure map results consistently revealing the ischial tuberosities to be the points of peak IP, see section 3.6.2, and that the studies of pressure ulcer incidence consistently find the ischial tuberosities to experience the highest rates, see section 8.2.3, it was anticipated that collectively the respondents would report that pressure ulcers appear on the area under the ischial tuberosities "*Frequently*", with the other areas such as the greater trochanters, less often.

Although not a typical site associated with pressure ulcer incidence, it was anticipated that the respondent would indicate that pressure ulcers do indeed occur on the backs of the thighs. This expectation was the result of considering the effect of pressure gradients and the steep pressure gradient which occurs at the edge of a chair, see section 4.5.5.

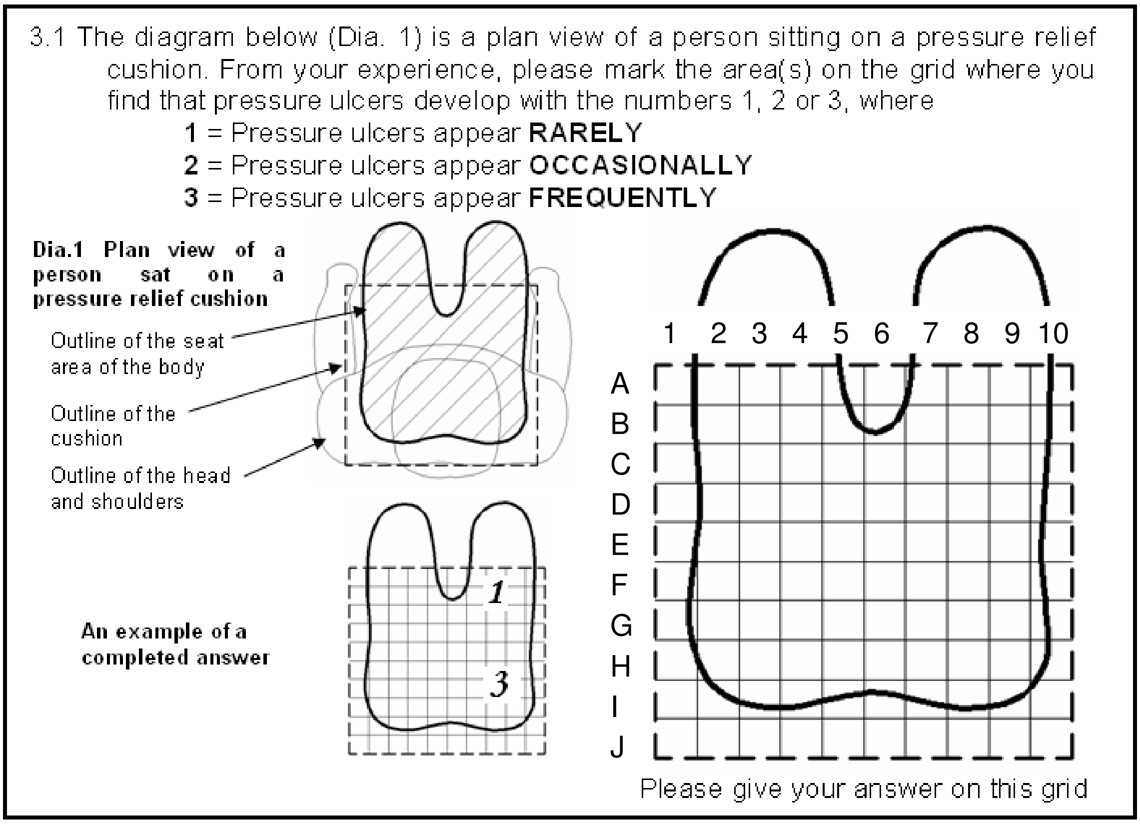


Figure 9-3 A plan of the seat area of the body and the back of the thighs, which the respondents were asked to indicate where and how often their clients develop pressure ulcers

(n=31)*

Where pressure ulcers occur ***Rarely***										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
A	1	3	13	3	1	0	3	11	6	1
B	1	2	7	2	1	0	2	7	2	1
C	1	1	3	2	1	1	1	4	2	2
D	1	0	1	1	2	2	2	2	2	0
E	0	1	0	0	2	2	1	0	1	0
F	0	1	0	0	0	0	0	0	1	0
G	0	2	0	0	0	0	0	0	1	1
H	0	0	0	0	0	0	0	0	0	0
I	0	0	0	0	0	0	0	0	0	0
J	0	0	0	0	0	0	0	0	0	0

*3 missing

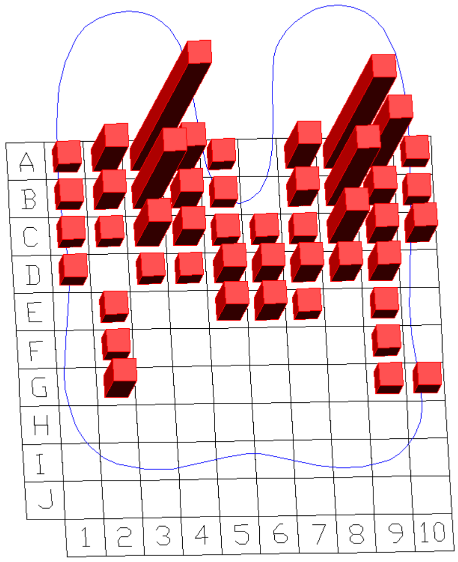


Figure 9-4 Where on the seat area of the body the clients develop pressure ulcers "*Rarely*"

(n=31)*

Where pressure ulcers occur ***Occasionally***										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
A	0	0	1	0	0	0	0	1	1	0
B	0	0	0	0	0	0	0	0	0	0
C	1	1	1	0	0	0	0	2	0	0
D	2	4	1	1	0	1	1	2	4	3
E	1	5	1	1	0	2	1	1	5	2
F	2	6	0	0	1	1	0	0	6	3
G	3	8	1	0	1	2	0	1	8	7
H	0	1	1	0	2	6	1	1	1	0
I	0	0	0	0	1	2	0	0	0	0
J	0	0	0	0	0	0	0	0	0	0

*3 missing

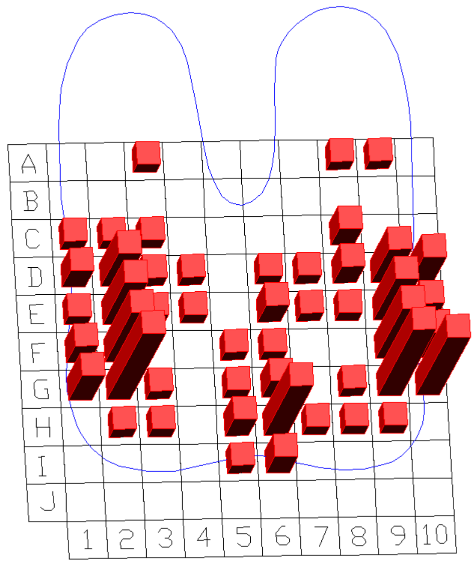


Figure 9-5 Where on the seat area of the body the clients develop pressure ulcers "*Occasionally*"

(n=31)*

Where pressure ulcers appear ***Frequently***										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
A	0	0	0	0	0	0	0	0	0	0
B	0	0	0	0	0	0	0	0	0	0
C	0	0	0	1	1	1	0	0	1	1
D	0	0	0	0	0	0	0	0	0	0
E	0	0	2	2	0	0	1	1	0	0
F	1	1	14	13	0	1	5	16	3	1
G	0	1	14	14	2	3	6	21	3	1
H	0	0	3	2	8	13	1	5	1	0
I	0	0	0	0	2	5	0	0	0	0
J	0	0	0	0	1	1	0	0	0	0

*3 missing

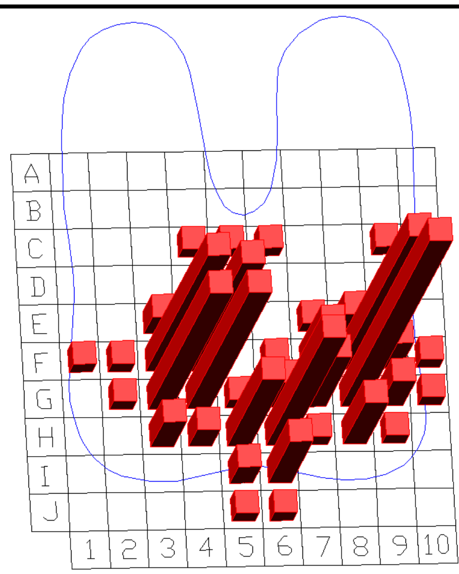


Figure 9-6 Where on the seat area of the body the clients develop pressure ulcers "*Frequently*"

As anticipated, the respondents observe pressure ulcers occurring on the area under their client's ischial tuberosities "*Frequently*". Based on the assumption that the dominance of one side of the body, either left or right, has as an influence on pressure ulcer development, and that one in nine of the general population are right handed (Denny and O'Sullivan 2006), it was anticipated more respondents would find pressure ulcers occurring "*Frequently*" on the right hand side of their client's bodies than on their left.

Of the 31 respondents, 21 respondents (68%) reported pressure ulcers occurring "*Frequently*" in square G8, the location of the right ischium.

Of the 31 respondents, 14 respondents (45%) reported pressure ulcers occurring "*Frequently*" in square G3, the location of the left ischium, see figure 9-6.

There are various reasons for this finding, see section 8.2.4. As such, whilst these results are not conclusive they do indicate that the dominant side of the body has some influence. This phenomenon should be a matter for further work, see section 12.3.3.4.

These results also reveal that a proportion of the respondents, 13 (42%), are finding that pressure ulcers are occurring on their clients sacrum "*Frequently*". This proportion is less than the proportion who reported the right ischium, 21 (68%) but comparable to the proportion who reported the left ischium 14 (45%), see figure 9-6.

If a high peak IP was the dominant factor in the development of pressure ulcers these findings would have found a similar level of pressure ulcer occurrence on the left ischial as on the right ischial, and that the level of occurrence experienced by the ischisals would have been higher than at the sacrum.

As anticipated, the respondents are observing the occurrence of pressure ulcers on the greater trochanter region "*Occasionally*" which is less than the rate of occurrence under the ischial tuberosities. However, the results indicate that the respondents are finding that pressure ulcers are occurring over both the left and right greater trochanters in equal numbers, with eight respondents reporting pressure ulcers occurring on the right hand side "*Occasionally*" in square G2 and in G9, see figure 9-5. It is not known why this should be the case.

The findings confirm the expectation that pressure ulcers do occur on the backs of the thighs of the respondent's clients, although less frequently than over the ischials, with 13 respondent (42%) reporting pressure ulcers occurring "*Rarely*" in square A3 and 11 respondents (35%) reporting pressure ulcers occurring "*Rarely*" in square A8, see figure 9-4. It was not foreseen that slightly more would have reported pressure ulcers occurring on the left rather than the right. It is not known why this should be the case.

9.2.3 Pressure Ulcer Causes

It is known that the average wheelchair user typically spends many hours a day sat in their wheelchair, with estimates ranging from ten to eighteen hours a day, see section 3.7. This study found that of the 41 SCI patients who responded 33 (81%) typically sit in their wheelchairs for more than eight hours a day. It was assumed then that the balance of pressure ulcers, which occur on the seat area of the body, would have developed whilst sat in a wheelchair, and therefore the cushion would have failed in prevention. Whilst a cushion might fail to prevent a pressure ulcer by not reducing pressure it can also trigger a pressure by incorrect use. The respondents were asked how often they had observed a client sitting on a cushion orientated the wrong way, either back-to-front or front-to-side. The most common answer was "*Occasionally*" with 17 respondents (55%) followed by "*Very rarely*" with 8 respondents (26%) and "*Frequently*" with (13%), one respondent (3%) answered "*Never*" (table O-5). The respondents were then asked how often an episode of sitting on a cushion facing the wrong way triggers the development of a pressure ulcer. The most common answer was "*Occasionally*" with 15 respondents (48%) followed by "*Frequently*" and "*Very rarely*" both with four respondents (13%), two respondents answered "*All the time*" whilst none of the respondents answered "*Never*" (table O-6).

The respondents were asked how often they had observed a client sitting on a cushion positioned upside down. The most common answers were "*Occasionally*" and "*Very rarely*" both with 12 respondents (39%); six respondents (19%) answered "*Never*" (table O-7).

This was followed by asking the respondents how often an episode of sitting on a cushion upside down triggers the development of a pressure ulcer. The most common answer was "*Frequently*" with 12 respondents (39%); two respondents answered "*Never*" (table O-8). This suggests that whilst cushions may only be positioned upside down rarely, when it does happen it frequently triggers a pressure ulcer.

The respondents were asked how often they had observed a client sitting on a cushion no longer performing to its optimum through old age. The most common answer was "*Occasionally*" with 18 respondents (58%) followed by "*Frequently*" with seven respondents (23%), none of the respondents answered "*Never*" (table O-9). The respondents were then asked how often an episode of sitting on a cushion no longer performing to its best through old age triggers the development of a pressure ulcer. The most common answer was "*Occasionally*" with 11 respondents (36%) followed by "*Frequently*" with seven respondents (23%), none of the respondents answered "*Never*" (table O-10).

These findings suggest that some of the pressure ulcers which are still occurring are not the result of a cushion failing to reduce IP but are the result of user error whereby the client is sat on a cushion in the wrong orientation, upside down or continued use beyond the cushion's safe working life.

The respondents were than asked the extent to which certain postural issues contribute to the development of pressure ulcers (tables O-11 and O-12).

These issues were ranked by the number of respondents who reported an issue as occurring either, "*Frequently*" or "*All the time*",

> "*An increase in direct pressure/compression due to an unbalanced position*" with 55%
>
> "*The skin was subjected to friction when the patient slides from their ideal postural position*" with 39%
>
> "*Skin subject to shear as body held in position is unable to slide any further*" with 26%
>
> "*Poor postural position distorted the skin creating folds and creases in the skin/tissue*" with 16%

It had been anticipated that postural issues would elicit positive responses as the relationship between posture and pressure ulcers is well known, see section 3.6. It had been anticipated that as shear is understood to be more damaging than direct compression, see section 4.5.2 the issue of developing shear when the body is unable to slide further would have elicited a higher response that the issue of direct pressure/compression resulting from sitting in an unbalanced position. It is not known why direct pressure/compression resulting from sitting in an unbalanced position, typically a lean, is more of a hazard than the shear developed when a body is unable to slide further, typically a slouch.

The respondents were then asked how often it was thought that the pressure ulcers on the seat area of their clients' bodies are caused by something unrelated to their client's cushion. The most common answer was "*about half the time*", with 16 respondents (52%) followed by "*most times*" with 10 respondent (32%) (table O-13).

This suggests that a substantial proportion of the pressure ulcers that occur on seat area of the body are thought to be the result of a cause not related to the function of a cushion

The respondents were asked how frequently certain causes, other than the cushion, of pressure ulcers occur (tables O-14 and O-15).

These causes were ranked by the number of respondents who reported a cause occurring either, "*Frequently*" or "*All the time*",

"*Unsafe Transfers*" at 48%
"*PR not regular enough*" and "*Left too long on cushion*" both at 26%
"*Not enough respite from PR*" at 23%
"*Missed small objects*" at 19%
"*Prominent seams*" at 13%
"*Poor cleanliness*" at 3%

It had been anticipated that "*Unsafe transfers*" would elicit a high response as transferring is recognised in the literature as being a hazard for wheelchair users, see section 3.7. The issue of transferring is a matter of concern and is examined in more detail later, see section 9.5.4. It was calculated that the potential cost of pressure ulcers in the SCI population triggered by unsafe transfers is in the region of £6 million pounds annually, see section 8.2.4.

When asked to add any other causes of pressure ulcers 17 respondents (55%) provided additional information. The causes were varied with none gaining prominence. The causes ranged from falling out of wheelchairs to sitting on catheter tubes (table O-15). Whilst some of these causes, such as falling onto the floor, cannot be mitigated or eliminated by cushion design others can. For instance these findings suggest that missed small objects such as catheter tubes or coins are being sat on by the respondent's clients which are in turn triggering pressure ulcers. Following the methodology of this project, if this finding is corroborated during the triangulation phase, see section 10.2, then the issue of small objects being on sat on would lead to a recommendation for cushion designers, see section 11.3.1.

The respondents were asked how often certain external events trigger pressure ulcers (tables O-16 and O-17).

These external events were ranked by the numbers of respondents who have reported an event triggering a pressure ulcer either, "*Frequently*" or "*All the time*",

"*An illness/infection*" with 51%
"*Rapid body weight loss*" with 32%
"*Travelling (eg car journey)*" with 16%
"*Rapid body weight gain*" with 10%
"*Pregnancy*" with 0%

It had been anticipated that the findings would confirm that rapid body shape changes, weight gains/losses[2], are triggering the development of pressure ulcers. It had not been foreseen that rapid weight gain, with 10%, would not feature as highly as rapid weight loss, with 32%. It was a surprise that pregnancy was not reported as triggering pressure ulcers more frequently, with none of the respondents reporting that pregnancy triggers pressure ulcers either "*Frequently*" or "*All the time*" and 16 (52%) reporting that pregnancy triggers a pressure either "*Occasionally*" or "*Very Rarely*" (table O-16).

[2] A rapid weight gain could follow the introduction of a new medication such as a course of steroids, and a rapid weight loss could be triggered by an illness such as an infection.

With a rapid weight gain the IP increases because the 'downward force' increases due to the increase in body weight whereas the seat area of the body the 'contact area' only slightly increases; therefore the IP being a quotient of 'downward force' by 'contact area' increases, see section 4.5.2. Equally, with a rapid weight loss the IP decreases as the downward force decreases. The difference between weight gain and weight loss is the level of tissue deformation. When a body rapidly gains weight the subcutaneous layer thickens. The thicker subcutaneous layer cushions the tissue from the bony prominences reducing the extent of the tissue distortion. When a body rapidly loses weight the subcutaneous layer thins. The thinner subcutaneous layer is less cushioning and the body prominences push deeper into the tissue causing more distortion. Although weight gain increases IP it is weight loss which is the greater hazard due to the greater increase in tissue distortion.

When asked to add any other external events which can trigger a pressure ulcer, 8 respondents (26%) provided additional information. The events were varied with none gaining prominence. The events ranged from burns to aeroplane journeys (table O-17). Whilst some of these events can not be mitigated or eliminated by cushion design, such as preventing an individual from catching an illness or infection, it can address others such as adapting to the changing body shape of an individual who is rapidly losing weight.

9.3 Findings on the Cushions Used by the Respondent's Clients

9.3.1 Cushions Used

The respondents were asked which cushions they come into contact with during the course of their duties.

Being a survey across all the UK spinal centres it was anticipated that a wide variety of cushions would be mentioned with a small number being in universal use. Based on the advice given for the literature review, see section 3.3 and results of the interviews and expert opinion sessions the cushions expected to be prominent were, in alphabetical order, the Flotech, Jay, ROHO, Varilite and Vicair, see sections 6.3.5 and 6.4.5.

The survey found 16 makes of cushions in use with the expected five makes reported by practically all, see figure 9-7 (table O-18).

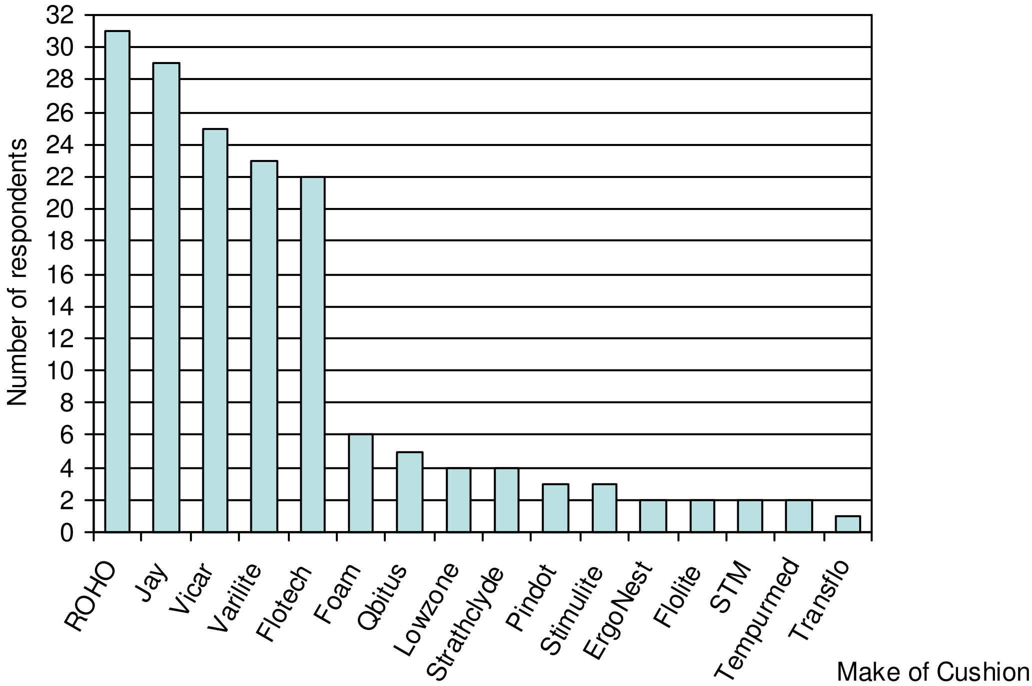


Figure 9-7 Cushions which the respondents come into contact with during the course of their duties

The respondents were also asked with which cushions they most commonly come into contact. Of the five cushions in widespread use, it was found that, with 19 of the 31 (61%) citing the Jay, this is the cushion with which the respondents most commonly come into contact (table O-19).

This result was consistent with the result of the patient interviews, see section 6.3.5, and the advice given by staff from two SCIC, see section 3.3.

9.3.2 Cushion Selection

There are a variety of cushions available on the market, thus for each client there is, theoretically at least, a choice of which cushion to use. The respondents were asked if there is one cushion they would recommend above the others and if so why. Out of the 31 respondents, 27 would not recommend one cushion above the others and four would recommend the Jay 2 (table O-22). The most common reason for recommending a cushion was "*It depends on patient's individual needs*" with nine respondents (29%) followed by "*For pressure relief*" and "*For postural support*" both with three respondents (10%) (table O-23). With the cushion design focusing on IP, see sections 3.4.1 and 3.4.2, it had been anticipated that a cushion with superior pressure reduction would be a candidate for recommendation and that pressure relief would be a principle reason for recommending a particular cushion. These results suggest that the ability to address the client's range of needs is more important than solely providing for pressure reduction.

The respondents were also asked if there was a cushion they would discourage using and if so, why. None of the leading cushions featured on the list and all of the types of cushions which were cited were of a foam variety (table O-20). The most common reason for discouraging the use of a particular cushion was "*It depends on patient's individual needs*" with three respondents (10%) followed by "*Not enough pressure relief*" with two respondents (6%) (table O-21). With the cushion design focusing on IP, see sections 3.4.1 and 3.4.2, it had been anticipated that a cushion with inferior pressure reducing properties would be a candidate for discouragement and that poor pressure relief would be a principle reason for discouraging the use of a particular cushion. These results suggest that the ability to address the client's range of needs is more important than solely providing for pressure reduction.

The respondents were then asked draw on their experience with the cushions used by their clients and indicate how significant they regard certain aspects of a cushion when considering its overall performance (tables O-24 and O-25).

These aspects were then ranked by the number of respondents, who reported considering an aspect as, "*Very Significant*",

"*Low pressure*" with 90%
"*Comfort*" with 77%
"*Maintain posture*" with 61%
"*Keep clean*" with 42%
"*Attach securely*" with 35%
"*Prevent sweating*" with 32%
"*Weight*" with 23%
"*Cost*" with 13%
"*Appearance*" with 3%

The aspect which ranked highest was "*The cushion's ability to keep the pressure experienced by the skin low*" with 28 respondents (90%). It had been anticipated that this aspect would feature highly as there is much emphasis placed on pressure reduction as a means of preventing pressure ulcers, see section 4.5.1. These finding also suggest that other aspects are also very important when regarding a cushions performance such as "*The level of comfort provided by the cushion*" with 24 respondents (77%).

The respondents were next asked to rate and give reasons for the overall performance of the cushion they most commonly come into contact with. The Jay cushion was cited by 19 respondents (61%) as the most common followed by the ROHO with two respondents (6%) (table O-26). Of the 19 respondents who cited the Jay, 7 (37%) regard the Jay as "*Excellent*" and ten (53%) regard the Jay as "*Good*". The two respondents, who cited the ROHO, both regard the ROHO as "*Excellent*" (tables O-27 and O-28).

The most common reason for regarding a cushion as "*Excellent*" with seven out of the nine respondents (78%) was "*pressure relieving properties*" followed by "*Good working life expectancy*" and "*Postural support*" both with four out of the nine respondents (44%) (table O-27). A similar pattern of reasons were given for regarding a cushion as "*Good*" (table O-28).

With the cushion design focusing on IP, see sections 3.4.1 and 3.4.2 it had been anticipated that a leading reason for regarding a cushion's overall performance as "*Excellent*" would be its pressure relieving properties. These results suggest that along side its pressure relieving properties there are other aspects which contribute to a cushion's excellence, such as its ability to support posture and the length of its expected working life.

The respondents were than asked how they regard the ability of most of the cushions they have experienced with regard to managing both skin care and posture. The collective opinion was divided with eight respondents (26%) finding cushions to be "*Strong in both posture and skin care*", nine respondents (29%) finding cushions to be "*Satisfactory in both posture and skin care*" and six (19%) finding cushions to be "*Strong in skin care but weak in maintaining posture*" (table O-29).

This lack of consensus as to the cushions level of ability to manage posture and skin care may be a reflection on the lack of one cushion dominating the client's choice of use. Without one design of cushion dominating, the respondents had to judge from a variety of cushions. For example, a ROHO high profile cushion, with its high immersion and envelopment properties but limited postural support, see figure 3-7, has different strengths and weaknesses compared to the Jay cushion, with its compartmentalised gel pack and contoured foam base, see figure 3-42.

With cushions offering different levels of performance related to skin care and postural support the respondents were asked to indicate how frequently the pattern of events in **Statement A** occurs.

Statement A:

Statement A

…."Patients initially tend to opt for a cushion, for their day-to-day use, whose foremost ability is to support the patient's posture. This choice is made in favour of a cushion whose foremost ability is skin care. If an ulcer should develop, the patient then switches from their first choice cushion, strong in postural support, to a cushion whose primary ability is skin care rather than posture. The patient then uses this cushion for a short period, whilst their newly healed skin regains some of its tolerance, after which they return once again to a cushion which is primarily good at supporting posture"…

A lack of agreement with this statement was found. Out of the 31 respondents ten (32%) reported that this happens "*Frequently*", and six (19%) reported that this "*Never*" happens (table M-30). The cause of this difference in experience is not known.

However, as only six respondents (19%) indicated that this is a pattern of events which never happens this finding should be regarded as indicative of a potential issue which is worthy of further investigation.

9.3.3 Cushion Provision

It is known that a seat's dimensions have a direct bearing on posture, and that when elements such as width and height are incorrect it adversely effects the sitting position, see section 3.6.1. This also applies to the dimensions of cushions. As the consequences of using an incorrectly sized cushion are well known, it was assumed that this would be a nominal occurrence. The respondents were asked how often they have observed clients using a cushion of the wrong size. None of the respondents answered "*Never*". The most common answer, with 22 respondents (71%), was "*Occasionally*" followed by "*Frequently*" with six respondents (19%) (table O-31).

Due to the potential consequences of using a cushion of the wrong size, it was assumed that should a client be found using a cushion of the wrong size, this error would be corrected quickly. The respondents were asked what the average length of time a client would have to wait for a correctly fitting cushion. The most common answer was "*less than 2 weeks*" with 13 respondents (42%) followed by "*1-3 months*" with eight respondents (26%) (table O-32).

Although no comment box was provided with this question, on the surrounding space 11 respondents added a comment on the waiting time for the provision of a correct size cushion. These comments stressed the difference between in-patients in spinal centres and out-patients living in the community. A client in a spinal injuries centre will have this error rectified quickly, whereas a patient out in the community may have to wait months (table O-33).

As the use of a cushion of the wrong size can result in pressure damage, the respondents were asked how often sitting on a cushion of the wrong size leads to a pressure ulcer. None of the respondents answered "*Never*". The most common answer was "*Occasionally*" with 16 respondents (52%) followed by "*Very rarely*" with six respondents (20%) (table O-34).

These findings suggest that there are currently occasions when clients are sat on cushions of the wrong size; and when it is found that a client has a cushion of the wrong size, there exists a delay whilst a correct sized cushion is supplied. Also, a number of SCI patients are developing pressure ulcers as a result of sitting on a cushion of the wrong size. Therefore, it is desirable to reduce the occasions when a cushion of the wrong size is used and the delay in the provision of a replacement is curtailed; as this will in turn reduce the incidence rate of pressure ulcers.

Some cushions use contouring to enhance their immersion quality and to support a "*normal sitting*" position, see section 3.3.2.1 and 3.3.4.1. To optimise their performance the contour should match the body shape of the client. An ill fitting contour can have adverse repercussions for a client, see section 3.6.1. As the consequences of using a cushion with the wrong contour shape is known it was assumed that this would be a nominal occurrence. The respondents were asked how often they have observed clients using a cushion with the wrong contour shape. The most common answer was "*Occasionally*" with 12 respondents (39%) followed by "*Very rarely*" with seven respondents (23%), four respondents (13%) answered "*Never*" (table O-35).

Due to the potential consequences of using a cushion with the wrong contour shape, it was assumed that should a client be found using such a cushion this error would be corrected quickly. The respondents were asked what the average length of time a client would have to wait for a correctly fitting contoured cushion. The most common answer with seven respondents (23%) was "*less than 2 weeks*" followed by "*1-3 months*" with six respondents (19%) (table O-36).

As the use of cushions with the wrong contour shape can result in pressure damage, the respondents were asked how often sitting on a cushion with the wrong contour shape leads to a pressure ulcer. None of the respondents answered "*Never*". The most common answer was "*Occasionally*" with 11 respondents (35%) followed by "*Very rarely*" with five respondents (16%) (table O-37).

These findings suggest that SCI professionals are observing some of their clients using a cushion with the wrong contour shape; and that a proportion of the clients who use a cushion with a poorly fitting contour shape will develop a pressure ulcer as a result. Although the number of pressure ulcers which develop from the use of a cushion with the wrong contour shape might only represent a small proportion of the overall incidence of pressure ulcers, it would still be desirable to prevent these pressure ulcers so as to avoid the associated complications, such as pain, which arise from pressure ulcers.

These findings suggest that the provision of a correct sized cushion is more prone to error than the provision of a correct shaped contour cushion; with 71% of respondents observing their clients using the wrong sized cushion "*occasionally*" compared to 39% observing their clients using the wrong shaped contour "*occasionally*" (tables O-31 and O-35). This is possibly because it is more obvious when a cushion is the wrong size, compared to when cushions with small errors in contour shape are used.

These findings suggest that whilst it is known that the provision of an incorrect sized cushion and the provision of an incorrectly shaped contoured cushion are a hazard for clients, both scenarios do still occur and pressure ulcers can develop as a consequence (tables O-34 and O-37). These pressure ulcers are not the result of how cushions manage IP but are the result of the cushion not matching the body shape of the client.

9.3.4 Cushions with Air Cells

The ability of an air filled cushion to prevent pressure ulcers, by reducing IP through immersion and envelopment, is determined by the level of internal air pressure. Each client has to set the internal air pressure to their personal optimum level, see section 3.7. As it is known that an incorrectly set internal pressure has an adverse effect on cushion performance, it was anticipated that the incorrect setting of internal air pressure would be a very rare occurrence. The respondents were asked how often the air cells of their clients' cushions are incorrectly set either by over or under inflation. None of the respondents answered "*Never*". The most common answer was "*Occasionally*" with 42% followed by "*Frequently*" with 39% (table O-38).

The incorrect setting of the internal air pressure can result from user error. Such errors can occur if the process of setting the internal air pressure is difficult and/or complicated. The respondents were asked whether or not they agreed that controlling the internal air pressure is easy. Opinion was divided with 11 of the 41 respondents (35%) agreeing that controlling the internal air pressure is easy compared to nine (29%) who disagreed (table O-39).

The respondents were also asked if they agreed whether or not their clients experience difficulties with certain aspects of setting the internal air pressure of their cushion. More of the respondents agreed that judging the level of air pressure is difficult than disagreed, with 52% compared to 32%. Also, more of the respondents agreed that the effort involved in adjusting the air pressure in the air filled cells is such that these adjustments are not being made as often as they should, with 38% agreeing compared to 26% disagreeing (table O-40).

As cushions are constructed from components and materials which are not absolutely air tight, cushions gradually deflate decreasing the internal air pressure. The respondents were asked how long it takes for air cells to deflate to a point where the cushion is no longer capable of providing sufficient pressure relief. The most common answer, with 12 respondents (39%), was "*don't know*" followed by "*It depends on how active the client is*" with nine respondents (29%) (table O-42). As only a few of the respondents answered with a fixed time interval such as "*A full day*", this suggests that deflation to a level unsafe for the client is not a fixed interval.

As the performance of an air filled cushion is dependent on maintaining the correct setting of the internal air pressure to above a safe level, it was assumed that the act of checking would be a regular and frequent activity. The respondents were asked how often their clients should check the air pressure of their cushions. Of the respondents, 13 (42%) answered once a day or less but an unexpectedly large proportion (29%) reported "*Once a week*" (table O-44). This may be a reflection of the different performances of the different air cushions. Two of the respondents raised this as an issue in the dialogue box provided with the question, specifically drawing a distinction in the different deflation rates between the ROHO and the Varilite (table O-45).

The skin of a client can be damaged if their cushion deflates to a point where a bottoming out event occurs, see section 3.7. As the potential repercussions from bottoming out can be severe it was assumed that the air pressure would be managed so that bottoming out was a nominal occurrence. The respondents were asked how often their clients find themselves bottomed out. Of the respondents, 29 (94%) reported that their clients do bottom out, with 19 (61%) reporting that this happens "*occasionally*" and nine (29%) "*very rarely*" (table O-46).

The respondents were then asked how often they have observed bottoming out on an air cell cushion to have triggered a pressure ulcer. Of the respondents, 25 (81%) reported this bottoming out does trigger pressure ulcers, with most respondents 19 (61%) reporting that bottoming out triggers pressure ulcer "*Occasionally*" (table O-47).

These finding would seem to indicate that the respondent's clients are using cushions whose immersing/enveloping properties are being compromised due to user error with the setting the cushions internal air pressure. It is plausible that some of the errors which occur during the setting of the internal air pressure of cushions are due in part to the difficulty/complexity involved in setting the air pressure. Additionally, in certain cases the length of time a user is sat on an incorrectly set cushion is prolonged due to the user vacillating over adjusting the air pressure due to the difficulty involved. Also, the regularity and frequency of checking the internal air pressure is an issue with deflation being allowed to go unchecked to the point where the client bottoms out and that clients are developing pressure ulcers as a consequence of these bottoming out events.

Based on these finding it would be desirable to improve the management of the internal air pressure so that the immersion/envelopment properties of the cushion are not compromised and that bottoming out events are prevented; as this will in turn reduce the incidence rate of pressure ulcers. However, as per the methodology of this project, these finding will have to be first triangulated with the findings of the other research methods undertaken during the project, see section 10.2, before these finding can be used as the basis for a recommendation, see section 11.3.1.

9.3.5 Cushions with Gel Packs

The ability of a gel cushion to prevent pressure ulcers, by reducing IP through immersion and envelopment, is determined by the distribution of gel within the cushion, see section 3.3.5. The distribution of gel is mutable, being displaced by the movements of user. This displacement of gel sees the gel migrate from beneath the user to the sides of the cushion. Once the gel has been pushed to the sides the user is left bottomed out on the base of the cushion, see section 3.7. The respondents were asked on average how long does it takes for the gel to be pushed to the sides so that there is no longer sufficient gel underneath the client to provide sufficient pressure relief. The most common answer was, "*It depends on how active the client is*" with 15 respondents (48%), followed by "*don't know*", with six respondents (19%). Only three respondents (10%) answered with a fixed time interval such as "*A couple of hours*" (table O-48), this suggests that the time taken for the gel to migrate to the sides is not a fixed interval.

As it is known that the migration of the gel is a cause for concern, it was assumed that the act of checking the dispersal of gel would be a regular and frequent activity. The respondents were asked how often their clients should check the gel distribution within their cushions. The most common answer was "*Once a day*" with 12 respondents (39%) followed by "*After every period of activity*" and "*It varies from day to day*" both with six respondents (19%) (table O-50). Additionally, eight respondents (26%) reported that the distribution of gel should be checked before/after transferring (table O-51). This finding suggests that the checking of the gel is not a practice governed by time but by the actions and movements of the user.

The respondents were asked how frequently certain movements/actions drive the gel out from underneath their clients towards the sides of a cushion (tables O-52 and O-53).

These movements/actions were ranking by the number of respondents who reported that the gel underneath their clients are displaced by a certain movement either, "*Frequently*" or "*All the time*",

"*Spasms*" at 23%
"*Transferring*" at 19%
"*Drift to sides*" and "*Pressure relief movements*" both at 16%
"*Fidgeting*" and "*Propelling wheelchair*" both at 6%

It had been anticipated that the vigorous movements such as spasms and propelling the wheelchair would have been a more potent driver of the gel than simple drift. It is not known why these finding suggest that these movements are not as potent at driving the gel to the sides as one might assume. Perhaps the gels being used are thixotropic fluids. Thixotropy is the property of certain gels or fluides to be viscous under normal conditions but become less viscous and flow over time when shaken, agitated or otherwise stressed.

The skin of a client can be damaged when sufficient gel migrates from underneath the client so that they are left bottomed out, see section 3.7. As the potential repercussions from bottoming out can be severe it was assumed that the distribution of gel would be managed so that bottoming out was a very rare occurrence. The respondents were asked how often their clients find themselves bottomed out. Of the respondents, 26 (84%) reported that their clients do bottom out, with 14 (45%) reporting that this happens "*occasionally*" and 11 (35%) "*very rarely*" (table O-54).

The respondents were then asked how often they have observed bottoming out on a gel cushion to have triggered a pressure ulcer. Of the respondents, 21 (68%) reported that bottoming out does trigger pressure ulcers, with the most common answer being "*Occasionally*" with 14 respondents (45%) (table O-55).

These finding suggest that the respondent's clients are currently using cushions which allows the gel to migrate from underneath the user to the sides when the patient is active, making vigorous movements/actions. Additionally, the gel can also drift out from underneath the patient. The potential for the gel to migrate at different rates requires that the distribution of the gel has to be checked regularly and frequently. These findings suggest that this is not always the case and that the issue of gel migration is sometimes allowed to go unchecked to the point where the client bottoms out and that clients are developing pressure ulcers as a consequence of these bottoming out events.

Comparing these findings with those on the air cell cushions, these findings suggest that the clients using gel cushions are less prone to bottoming out than clients using air cell cushions; with 45% of respondents observing their clients on gel cushions bottoming out "*occasionally*" compared to 61% observing their clients on air cell cushions bottoming "*occasionally*" (tables O-46 and O-54). This is possibly because with air cell cushions there is more scope for user error with managing the internal air pressure.

Also, there is the suggestion that the level of hazard from bottoming out on a gel cushion is less than bottoming out on an air filled cushion; with 61% of respondents observing their clients, who use an air filled cushion, developing a pressure ulcer from bottoming out "*occasionally*" compared to 45% of respondents observing their clients, who use a gel cushion, developing a pressure ulcer from bottoming out "*occasionally*" (tables O-45 and O-55). It is not known why bottoming out on an air cell cushion should be more hazardous than bottoming out on a gel cushion. Possibly this is because the most commonly used gel cushion is the Jay and this has a foam base which still provides some cushioning once the gel has migrated to the sides; whereas the most commonly used air cell cushion is the ROHO which has no foam base so when an individual bottoms out on a ROHO they are left sitting on whatever the surface the wheelchair seat is made of.

9.4 Findings on the Respondents Clients Sitting Position in a Wheelchair

9.4.1 Sitting Position

It is known that sitting in a poor postural position is a hazard for the client's skin, see section 3.6.2. It is also known that poor posture has a range of other health implications, including various spinal curvatures, see section 3.6.1. The respondents were asked to report which are the most common problems that they have observed their clients experience as a result of poor posture. The problem most reported was categorised as "*reduced functionality*" with 12 respondents (39%), followed by "*spinal deformities*" and "*skin problems*" both with 11 respondents (35%) (table O-56). This suggests that skin damage is one of the top three hazards from sitting in a poor sitting position.

In the literature one particular sitting position has been described as the "*normal sitting*" position and as the "*correct seating*" position. When sitting there are other positions such as "*slouching*", with its associated posterior pelvic tilt and shear stress around the sacrum. These other sitting positions are regarded as poor as they can lead to physical complications, see section 3.6.1.

The respondents were asked to gauge by how much certain sitting positions increase a client's risk of developing a pressure ulcer (table O-57).

These sitting positions were ranked by the number of respondents who indicated that a certain position presented a "*Major increase*" in risk.

"*Slouching*" at 35%
"*Leaning to the left*" at 32%
"*Leaning to the right*" at 32%
"*Lean forward*" at 3%

This suggests that these sitting positions do pose a hazard to a client's skin and that of these sitting positions slouching is marginally more hazardous than lateral leaning. This finding is contrary to the finding of the SCI patient survey, see section 9.2.3, which suggests that leaning is more of a hazard than slouching. This inconsistency is likely to be the result of the questions not specifying the extent of the lean and slouch. It is possible that a pronounced lean is more of a hazard than a slight slouch whilst a deep slouch is more of a hazard than a gentle lean.

As it is known that poor postural positions adversely affect the client, it was anticipated that time spent in a poor sitting position would be minimised to a point where poor posture would be a very rare occurrence. The respondents were asked how often they observe their clients sitting in certain positions (tables O-58 and O-59).

These sitting positions were ranked by numbers of respondents who reported that they observe their clients sitting in a certain position either, "*Frequently*" or "*All the time*",

"*Slouching*" at 77%
"*Leaning to the right*" and "*Leaning to the left*" both at 48%
"*Lean forward*" at 19%

This finding suggests that "*slouching*" is commonly practiced, along with leaning left and right. Therefore, clients are currently sitting in these positions despite the known problems which can arise from sitting in these positions, and the features in the design of cushions to "*capture the pelvis*" specifically intended to prevent slouching, see section 3.3.

9.4.2 Shifting Position

Whilst the "*normal sitting*" position is the preferred sitting position, this position is generally not sustained throughout the entire time spent in a wheelchair, with a variety of other sitting positions being assumed. This shifting between positions occurs for a variety of reasons. The respondents were asked how often certain movements/actions displace their clients from a good postural position (tables O-60 and O-61).

These movements/actions were ranked by the number of respondents who reported that their clients are displaced by one of these movements/actions either, "*Frequently*" or "*All the time*",

"*Spasms*" at 71%
"*Looking for comfort*" at 58%
"*Gradual drift*" at 55%
"*Fidgeting*" at 23%
"*Self propelling*" at 16%

This suggests that certain movements/actions do displace clients from a good sitting position and that spasms are particularly potent. It also suggests that clients simply drift gradually from a good sitting position without intention or with a noticeable indicator, such as a spasm, to prompt them to check their position.

As clients can potentially drift gradually from a good postural position, the respondents were asked on average how long a client will spend in a good postural position before slipping into a poor position. The most common answer was "*It varies greatly*" with 21 respondents (68%). None of the respondents answered "*More than 240 minutes*" (table O-62).

This suggests that the transition time from a good position to a poor position is variable, reflecting the variety of tasks and timings in a client's day, and is relatively short compared with the time spent in a wheelchair.

One of the poor postural positions a client might assume is the slouched position. A client can slide into a slouched position by either sliding over the top of the cushion leaving the cushion in place, see figure 8-5, or by sliding forward but instead of sliding over the surface of the cushion pushes the whole cushion forward, see figure 8-6. The respondents were asked how often their clients slide over the surface of their cushion when they slouch. The most common answer was "*Frequently*" with 16 respondents (52%). None of the respondents answered "*Never*" (table O-63).

The respondents were then asked how often their clients slide forwards and in so doing push their cushion forward as well. The most common answer was "*Occasionally*" with 16 (52%) respondents; followed by "*frequently*" with 8 (26%) respondents. None of the respondents answered "*Never*" (table O-64).

These findings suggests that a substantial proportion of clients are do spend time sat in a slouched position, either by sliding forward over the surface of the cushion or/and by pushing the whole cushion forward. They also suggest that slouching is more often the result of a cushions inability to prevent a client from sliding over the surface than by a client managing to push the whole cushion forward over the seat of their wheelchair.

Another poor postural position a client might assume is the lateral lean. When an individual leans to one side that person's centre of gravity moves following the direction of the lean. The side being leaned on is subject to greater IP than the side being leaned away from. If the type of cushion being used is a fluid filled cushion this imbalance of forces can drive the fluid from the side being leaned on to the other side, see figures 3-17 and 3-48. The respondents were asked to indicate the extent to which the flow of fluid in a fluid filled cushion can exaggerate a lean. There was general agreement that fluid filled cushions do to some extent exaggerate a client's lean, with 19 respondents (61%) indicating that fluid filled cushions do increase a lean compared to one respondent who indicated that fluid filled do not increase a client's lean. There was a difference of opinion as to the extent a fluid filled cushion increases a client's lean (table O-65).

Ranking the different levels a lean is increased by, the most common level of increase was,

"*Some increase in the lean*" at 29%
"*A slight increase in the lean*" at 16%
"*A definite increase of the lean*" at 10%
"*A significant increase of the lean*" at 6%
"*No increase in the lean*" and "*Never noticed*" both at 3%

This lack of consensus as to the extent a fluid filled cushion exaggerates a client's lean may be a reflection of the lack of one cushion dominating the clients choice, leaving instead the respondents to judge from a variety of fluid filled cushions. For example, the single compartment design of the ROHO high profile, see figure 3-7, will exaggerate a users lean more than the compartmentalised gel pack design of the Jay cushion, see figure 3-41.

9.4.3 Checking Position

The sitting position of a client is dynamic and subject to the client positioning and repositioning depending on their disability and activity, see section 3.6.1. Consequently they have to monitor, with or without help, their sitting position in order to make corrective adjustments as and when required. The respondents were asked to indicate approximately how many of their clients are able to check for themselves certain aspects of the sitting position. (tables O-66 and O-67).

Ranking these aspects by the number of respondents who reported that "*All*" or "*Most*" of their clients can check a certain aspect of their sitting position for themselves, the most common aspect was,

"*Sat upright*" at 80%
"*Sat squarely*" at 64%
"*Sat right back in chair*" at 61%
"*Full length of thigh in contact with cushion*" at 52%
"*Footplate set to correct position*" at 42%
"*Thighs level with floor*" at 32%

This revealed that certain aspects can be checked by most clients but other aspects cannot be checked by so many. Also, a large proportion of clients are unable to check certain aspects for themselves, for instance 18 respondents (58%) reported that half or less of their clients can check the height of their footplate for themselves. This indicates that a large proportion of clients are currently reliant on help to check at least some aspects of their sitting position.

As the sitting position is dynamic and subject to the client altering their position, the sitting position needs to be frequently checked so that any repositioning can be carried out as and when necessary. The respondents were asked when their clients sitting position is checked (tables O-68 and O-69).

These occasions when their clients sitting position is checked was ranked by the number of respondents who reported an occasion. The most common occasion was, "*Just after transferring into the wheelchair*" with 77%

"*After a spasm*" with 71%

"*After carrying out pressure relief*" and "*When they feel uncomfortable*" both with 61%

"*Every couple of hours*" at 39%

"*After propelling the wheelchair*" and "*When you remembered*" both with 16%

"*Occasionally*" with 10%

"*Never check*" with 3%

These results suggest that typically a client will start an episode in their wheelchair in their optimum sitting position and not check their position again until experiencing a spasm, carrying out pressure relief or starting to feel uncomfortable. As clients commonly depart from a good postural position by gradually drifting from it, see section 9.4.2, a client may well be sitting in a poor postural position for a considerable length of time before something prompts the client to check their position, for instance performing a pressure relief movement. This intervening time between having drifted into a poor position and being prompted to check the position is an opportunity for physical problems to develop.

These findings would seem to indicate that cushion users would find it beneficial to be made aware of when they have drifted beyond a predefined positional limit for longer than a safe duration. Informing a cushion user about the status of their sitting position could be a task a new design of cushion might perform. Following the methodology of this project if this finding is corroborated during the triangulation phase, see section 10.2, then the issue of alerting cushion users when they have sat in a poor position for too long will lead to a recommendation for cushion designers, see section 11.3.1.

9.5 Findings on Cushion's Practicality

9.5.1 Daily Use

In order to perform a number of the various daily chores associated with cushion use, such as cleaning or changing its cover, it is an operational requirement of cushions to be detachable from the wheelchair. The respondents were asked how often their clients have to remove their cushion for specified reasons (tables O-70 and O-71).

These reasons for removing a cushion from a wheelchair were ranked by the number of respondents who reported the reason as occurring either, "*Frequently*" or "*All the time*",

"*Collapse wheelchair*" with 87%
"*Clean it*" with 51%
"*Change cover*" with 35%
"*Check for damage*" with 32%
"*Check gel*" with 32%
"*Check air cells*" with 26%
"*To use on a different chair*" with 12%

These findings suggest that there are a wide range of reasons for removing a cushion from a wheelchair with some reasons occurring more often than others. It had been anticipated that cushions are frequently removed in order to allow a wheelchair to be collapsed as wheelchairs are regularly collapsed to transport in vehicles. Whilst design might be able to eliminate the need to remove a cushion in order to check the level of air pressure in an air cell cushion, reasons for removal such as to allow a wheelchair to collapse are not likely to be eliminated through design in the foreseeable future, so in future cushions will still have to remain detachable.

As the removal of cushions is part of the day-to-day use of a cushion the respondents were asked what proportion of their clients are currently able to perform this task for themselves. The most common answer was "*About half*" with 19 respondents (61%) (table O-72). The respondents were then asked how easy their clients find the task of removing and replacing their cushion.

The most common answer was "*Manageable*" with 18 respondents (58%) followed by "*Easy*" with eight respondents (26%) (table O-73). The respondents were also asked what proportion of their clients have complained that having secured their cushion to their wheelchair the cushion still becomes loose and slides around. The most common answer was "*Some of them*" with 22 respondents (71%) followed by "*Most of them*" with five respondents (16%) (table O-74).

These findings suggest that approximately half of the clients are not able to remove and replace their cushion (table O-72) and that only a small proportion of the clients regard this task as easy (table O-73). Also a large proportion of respondents have had cause to complain that after securing the cushion to the wheelchair it still becomes loose and slides about (table O-75).

Improving the facility to secure the cushion to the wheelchair will benefit the user by

- reducing the opportunity for cushions to become loose after being secured to the wheelchair
- making the lives of those who currently undertake this task a little easier
- widening the inclusivity of this product enabling more clients to undertake this task.

The forces involved when transferring into/out off a wheelchair are substantial and can on occasion knock loose a cushion secured to a wheelchair. The respondents were asked how often they have observed a client knock loose their cushion whilst transferring. The most common answer, with 17 respondents (55%), was "*Occasionally*", followed by "*Very rarely*" with seven respondents (23%) and "*Frequently*" with six respondents (19%) (table O-75). Additionally in section 9.6.4 below, the respondents reported that one of the difficulties which their clients experience during the transfer process is a loose cushion (table O-91).

There is a difference of opinion with a similar number of respondents reporting this event occurring "*Frequently*" (23%) or "*Very rarely*" (19%). This is possibly due the different cushions being considered by the respondent when answering this question. The Jay cushion has a clip system to secure the cushion to the wheelchair frame, see figure 3-47, which is likely to withstand a transfer, whereas the ROHO relies on a non-slip material on the base of the cover to secure the cushion which is likely to knock loose during a transfer.

The nature of the various cushion designs results in different weaknesses, which make them vulnerable to different forms of damage. Air cells are vulnerable to punctures and gel packs split open. It had been anticipated that a large proportion of the respondents would have observed their clients experiencing similar activities/events which have damaged their cushions. The respondents were asked how often they have observed certain forms of damage (tables O-76).

These forms of damage were ranked by the number of respondents who have reported that they have observed this form of damage either, "*All the time*", "*Frequently*" or "*Occasionally*",

"*Air cells punctured by cigarette burns*" with 58%
"*Gel packs splitting*" with 55%
"*Chunks of foam breaking off*" with 51%
"*Air cells punctured by a pets claws*" with 13%

When asked what other forms of damage have been observed, these forms of damage were more varied than expected ranging from being "*run over by cars*" to "*zips breaking*" (table O-77). Had there been a recurring theme such as cigarette burns puncturing air cells it would have been easier to produce a design to counter these.

These finding also suggest that whilst damage does occur to cushions it is not unduly prevalent. This would suggest that current designs are more robust than anticipated and not currently an issue with contemporary cushions. However, following the methodology of this project if a recurrent form of damage is identified during the triangulation phase, see section 10.2, then the issue of this particular form of damage would lead to a recommendation for cushion designers, see section 11.3.1.

9.5.2 Cushions used on Chairs as well as Wheelchairs

During the course of the day someone with an SCI, through choice or necessity, may have to sit in a chair/seat other than their wheelchair. The respondents were asked how often their clients use certain other chairs/seats (tables O-78 and O-79).

These chairs/seats were ranked by the number of respondents who have reported that their clients use a chair/seat either, "*All the time*", or "*Frequently*",

"*A car seat*" with 93%
"*A sofa*" and "*An arm chair*" both with 38%
"*A dining chair*" with 6%
"*An office chair*" with 3%

A number of other types of chairs/seats were reported. In total 14 different types were reported ranging from bean bags to glider seats. Out of these different chairs/seats one achieved prominence, the "*aeroplane seat*" with seven respondents (23%) citing its use (table O-79).

With cars being a widely used form of transport, it was anticipated that a large proportion of respondents would report that their clients often sit on a car seat and these findings support this assumption.

It was also anticipated that the respondents would report the use of a variety of different types of chairs, particularly more leisure activity type seating, such as sailing. It was not foreseen that whilst a wide range of chairs/seats have been reported there would be little consistency, with each respondent reporting the use of a different chair. This suggests that within the SCI community there is a wide range of activities pursued but, that no one activity is subscribed to universally, which is to be expected as everyone uses their leisure time differently.

As an individual might use their cushion when sat on one of these alternative chairs/seats, the respondents were asked if their clients use their cushion only with their wheelchair. The response was divided with 12 respondents (39%) answering "*yes*" whilst 18 respondents (58%) answered "*no*" (table O-80).

It is possible that this division reflects that whilst some of the respondent's clients use their cushion only with their wheelchair whilst others do use their cushion outside of their wheelchairs. With hindsight it would have been more informative to have asked the respondents to indicate the proportion of their clients which use their cushion only with their wheelchair.

The respondents whom indicated that their clients use their cushions outside of their wheelchair were asked to report where else they use their cushion (table O-81). The top three answers were,

"*In a car*" with 42%
"*In an aeroplane*" with 39%
"*Sat on the floor/ground*" with 16%

These findings suggest that the most commonly used chair/seats other than their wheelchair are car and aeroplane seats; and that the chairs/seats which clients most often use their cushion on are correspondingly car and aeroplane seats. Two respondents did add that they advise their clients not to use their cushion on a car seat as this can change the dynamics of the car seat, it can slide loose on the car seat and they are not safe in the event of an accident.

As an individual might not use their cushion when sat on one of these alternative chairs/seats, the respondents were asked how often their clients use a particular means of pressure relief as a pressure prophylactic when sat on a chair other than their wheelchair (tables O-82 and O-83).

These means of pressure relief were ranked by the number of respondents who reported the use of these means as either "*Frequently*" or "*All the time*",

"*The chairs own padding/cushioning*" with 68%
"*The chairs own built-in PR features*" with 42%
"*Their PR cushion from wheelchair*" with 16%
"*Sheepskin*" with 13%
"*Cut foam*" and "*A PR cushion, same type as one used in wheelchair*" both with 6%

It had been anticipated the respondents would have reported that their clients often use their cushion when sat on a chair other than their wheelchair. To some extent this has been found to be the case with five respondents (16%)

reporting that their clients do "*frequently*" use their cushion on chairs other than their wheelchairs. It was not anticipated that the findings would suggest that so many clients would rely on a chair's own padding/cushioning. It is not known why clients would use a chair without some additional means of pressure reduction. Perhaps an individual might believe the upholstery on their sofa is sufficiently yielding or that the time spent on these chairs is too short to cause damage. As such there may be pressure ulcers developing as a result of sitting on a chair without some form of pressure ulcer prophylactic. This phenomenon was reported as "*From sitting on a sofa*" and "*Not using a cushion at all*" (table O-15).

These findings suggest that it would also be advantageous if cushions were portable so that a cushion could be used on a wide range of other scenarios and not just in wheelchairs. In particular having found that 93% of the respondents reported that their clients sit on car seats either "*all the time*" or "*frequently*", these findings would seem to indicate that SCI patients would benefit from a having a cushion which could be used in conjunction with a car seat. Following the methodology of this project, if this finding is corroborated during the triangulation phase, see section 10.2, then the issue of cushion portability, including use with car seats, will lead to a recommendation for cushion designers, see section 11.3.1.

9.5.3 Pressure Relieving whilst Sat in a Wheelchair

Pressure relief is a practice whereby an individual carries out a particular movement, such as a *forward lean*, to relieve an area of the body of pressure. This relief provides the skin with a respite from IP in order to restore blood flow which enables the tissue to revitalise and in so doing prevent tissue necrosis, see section 3.4.4.

The respondents were asked how beneficial they regard pressure relief routines to be in preventing pressure ulcers. The most common answer was "*Very beneficial*" with 21 respondents (68%) followed by "*Beneficial*" with six respondents (19%) (table O-84).

The respondents were asked how often their clients carry out certain pressure relief movements (tables O-85 and O-86).

These movements were ranked by the numbers of respondents who have reported that these movements are made either "*Frequently*" or "*All the time*",

"*Leaning forward*" with 88%
"*Leaning to the right*" with 71%
"*Leaning to the left*" with 71%
"*Tilting backwards*" with 58%
"*Raising up*" with 55%

Three respondents added that they do not advise lifting/raising up as a pressure relief movement as this is damaging for the shoulders (table O-86).

It was anticipated that a large proportion of respondents would report that their clients are frequently carrying out pressure relieving movements, such as "*leaning forward"*. It was not foreseen that "*raising themselves up"* still features as a pressure reliving movement as the flaws with this movement are known, see section 3.4.4.

The respondents were also asked to report the most commonly used set of pressure relief timings their clients use. The most common answer was "*2 minutes every hour*" with nine respondents (29%) followed by "*Depends on the individual*" with five respondents (16%). The remaining respondents reported a range of times around 10-30 seconds every 15-30 minutes (table O-87).

It was anticipated that there would be a range of timings, reflecting the differing practices of the respective spinal centres and the different levels of pressure ulcer risk of the clients.

These findings suggest that all the timings used are under an hour. This is not consistent with Reswick and Rodger's *parabolic intensity-duration* curve, see figure 4-35. Based on Reswick and Rodger's curve pressures of up to 100mmHg can be safely applied over the bony prominences for up to approximately 3.5 hours. According to Ferrarins (2000) evaluation the peak IP for a Jay 2 cushion ranged from 71-108 mmHg, see section 5.3. As there is consensus amongst the respondents that pressure relief movements should be carried out every hour or less, Reswick and Rodger's curve suggestion that 3.5 hours is safe appears optimistic.

As these pressure relief movements have to be performed regularly and consistently, see section 3.4.4, there is the potential for clients to miss pressure relief movement episodes and thereby not conform to the routine.

The respondents were asked how often their clients, on an average day, manage to adhere to their pressure relief routine. The most common answer was "*Frequently (do most)*" with 18 respondents (58%) followed by "*Occasionally (miss about half)*" with nine respondents (29%) (table O-88).

These findings suggest that whilst a large proportion of the respondents regard pressure relief routines as "*Very beneficial*" in preventing pressure ulcers, numerous clients which are meant to follow a pressure relief routine, on an average day manage to adhere to their routine only half or less of the time. The phenomenon of pressure ulcers resulting from the failure to perform pressure relief regularly enough was raised, see section 9.3.3. When asked how often pressure ulcers are found to be caused by something other than the cushion the second most frequent cause, after "*An unsafe transfer*", was "*Pressure relief routine not performed regularly enough*" (table O-14). Thus, these findings seem to provide a positive indication that pressure ulcers are developing as a result of clients failing to perform their pressure relief routines frequently enough.

9.5.4 Transferring into and out of Wheelchairs

All wheelchair users have to transfer into and out of their wheelchair. It is well known that transferring can be problematic and that an unsafe transfer can trigger a pressure ulcer, see section 3.7. The respondents were asked if they have observed pressure relief cushions to cause their clients difficulties during the transfer process. All 31 respondents (100%) answered that they had (table O-89).

The respondents were then asked which cushion was the most difficult to transfer from and why (table O-90).

Some of the respondents cited more than one cushion. These cushions were then ranked as most difficult to transfer from by the number of respondents who cited them,

"*ROHO*" with 84%
"*Jay 2*" with 23%
"*Flotech*" and "*Vicair*" both with 6%
"*Varilite*" with 3%

The respondents provided numerous ways in which a cushion can cause a client difficulty when transferring (table O-91). The top three ways were,

"*Unstable surface/ difficult to balance on*" with 48%
"*Lacks firm surface, hands bottom out when pushing down*" with 23%
"*High contours/deep seat well*" with 16%

The respondents were then asked which cushion was the easiest to transfer from and why (table O-92).

Some of the respondents cited more than one cushion. These cushions were then ranked as the easiest to transfer from by the number of respondents who cited them,

"*Jay 2*" with 29%
"*Foam*" with 16%
"*Varilite*" with 13%
"*Vicair*" with 6%
"*Strathclyde*" with 3%

The respondents provided numerous aspects of a cushion which eases the transferring process (table O-93). The top three ways were,

"*No contouring/flat surface*" and "*Firm base/stable*" both with 32%
"*Depends on individual*" with 16%

It had been anticipated that stability and contours would be an issue raised by the respondents as it is known that air filled cushions present difficulties for the client during the transfer process due to their unstable surface and that the bucket affect of contour cushions also poses the clients difficulties, see section 3.7.

These findings suggest that between the ROHO and the Jay, the ROHO is the more difficult cushion from which to transfer from. Therefore, whilst both an unstable surface and a deep contour are undesirable, a stable contour is preferable to an undefined unstable surface.

These findings suggest that cushion users would find it beneficial to have a cushion able to provide a flat stable smooth surface at the moment of transfer. If this finding is corroborated during the triangulation phase, see section 10.2, then the provision of flat stable smooth surface at the moment of transfer will lead to a recommendation for cushion designers, see section 11.3.1.

9.5.5 Use of Covers

All the cushions reviewed include a cover. These covers are provided to fulfil a variety of tasks, such as drawing away sweat, see section 3.3. The respondents were asked how important they regard certain tasks a cover might fulfil (tables O-94 and O-95).

These tasks were ranked by the number of respondents who reported a task as either, "*Very important*" or "*Of some importance*",

"*To protect the cushion*" with 68%
"*Keep cushion clean*" with 64%
"*Reduce sweating*" with 62%
"*Draw moisture away from client*" with 54%
"*Conceal an ugly cushion*" with 19%
"*Complement a client's clothes*" with 16%

As anticipated the tasks of reducing sweating and drawing away moisture were regarded as important. However, the response to the aspects associated with aesthetics was more divided with six respondents (19%) reporting that the task of hiding an ugly cushion is either "*Very important*" or "*Of some importance*", compared to six respondents (19%) reporting that the task of hiding an ugly cushion is "*Of no importance*" (table O-94). This difference of opinion is possibly due to the different sensitivities of each respondent to their client's relationship with appearance and self esteem.

The role of self esteem should not be underestimated; it is known that SCI patients with low self body image are at an increases risk of developing pressure ulcers (Ratcliffe and Rose 2000). Further, self esteem is associated with depression and depression can lead to *Indirect Self-Destructive Behaviour* (ISDB). One of the manifestations of ISDB is a failure to relieve pressure (Cotter 2004).

As all the cushions reviewed include an integral cover, it was anticipated that the covers provided with the cushion would tend to be the covers used by the clients. The respondents were asked how often they observe their clients using certain covers (tables O-96 and O-97).

These covers were ranked by the number of respondents who reported observing the use of a cover either, "*Occasionally*", "*Frequently*" or "*All the time*",

"*The cover with cushion*" with 96%
"*Nothing, the cushion is coverless*" with 89%
"*A pillow case*" with 51%
"*A cover from a different cushion unaltered*" with 49%
"*A cover from a different cushion altered to fit*" with 45%
"*A homemade cover*" with 32%
"*A cotton sheet*" with 26%
"*A blanket*" with 9%

Although many cushions use a cover as an integral part of their design, for example the design of the Jay cushion relies on a vapour permeable cover to manage sweating, see section 3.3.5.1, it was anticipated that some of the clients would be using their cushion without a cover from time to time. It was not anticipated that so many of the respondents would indicate that their clients are regularly using their cushion without a cover. This suggests that many clients are using a cushion whose overall performance has been compromised due to a lack of a cover. This is a hazard for a client as it increases the user's risk of developing a pressure ulcer.

Clients may at times forgo the use of a cover as the difficulty in changing the cover is too burdensome. The respondents were asked whether or not they agreed that changing a cover is easy (table O-98) and whether or not they agreed that the effort involved in changing a cover is such that the cover is not changed as often as it should be (table O-99).

There was a division of opinion as to the degree of ease involved with changing a cover, with 16 respondents (52%) agreeing that covers are easy to change whilst 14 respondents (45%) either disagreed or abstained (table O-98). Most of the respondents either disagreed with the statement that the effort involved in changing a cover is such that the cover is not changed as often as it should, or abstained. However five respondents (16%) did agree (table O-99).

There was a general agreement that certain aspects of changing a cover do present difficulties (tables O-100 and O-101)

These aspects were ranked by the number of respondents who agreed that an aspect of changing a cover is problematic,

"*Cushion has to be removed from wheelchair*" with 89%
"*Cushion too bulky*" with 45%
"*Fastening are difficult*" and "*Next cover not ready*" both with 35%
"*Adjust away wrinkles*" with 10%

A cover can contribute to the development of a pressure ulcer in ways other than being absent. The respondents were asked how often they have observed certain circumstances occur whereby a cover can trigger a pressure ulcer (tables O-102 and O-103).

These circumstances were ranked by the number of respondents who reported observing a particular circumstance triggering a pressure ulcer either, "*Occasionally*", "*Frequently*" or "*All the time*",

"*Covers become wrinkled/creased*" with 64%
"*Covers are stretched too tight*" with 51%
"*Covers holds too much moisture*" with 32%
"*The cover's texture is too rough*" with 16%
"*The cover's weave is too pronounced*" with 10%

These findings suggest that regardless of the performance of the cushion the cover used to encase the cushion can induce a pressure ulcer by various means, such as by wrinkling or by the texture of the material the cushion is made of. If this finding is corroborated during the triangulation phase, see section 10.2, then the matter of cushion covers will lead to a recommendation for cushion designers, see section 11.3.1.

9.6 Conclusions

The circulation process generated 31 responses in total; 17 from physiotherapists; ten from OT's and four from nurses. Although these numbers are small it was estimated that response from both the physiotherapists and the OT's represented a sample of 10-15% of the members of MASCIP. It was estimated that the response from nurses represented less than 1% of those who belonged to MASCIP. Ideally this questionnaire would have drawn more responses to form a larger sample, but these four were all that were collected. The small numbers involved precluded the option of determining if the differences between professions were statistically significant.

During the circulation process the departmental heads of the physiotherapy departments and occupational therapy departments of 10 out of the 11 UK SCIC, were provided with five copies each of the questionnaire to circulate amongst their departments. The NSIC was approached separately. It was not possible to determine the response from each department due to the anonymity of the circulation process. It was therefore not possible to draw conclusions on how evenly across the nation the response was. As a consequence it was not possible to draw conclusions as to how representative this study was nationally or by region.

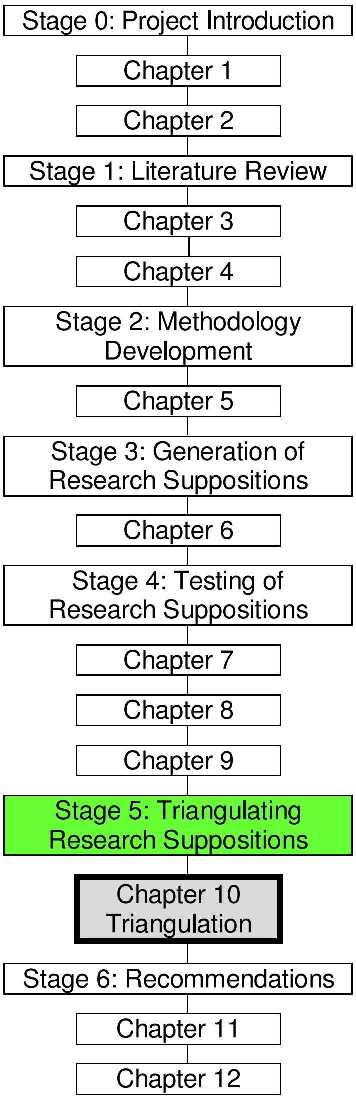
Whether the responses were received from all of the SCICs or from just a few of the SCICs, between the 31 responses the experience of hundreds of clients was expressed. This experience carries data on where clients are experiencing difficulties with their cushion. These difficulties are the result of the cushion not accommodating the need of the user through some weakness or deficiency in the design of the cushion. The aim of this project was to find weaknesses/deficiencies in PR cushions. Whilst it is not possible to compare the client experience between regions, the findings of this questionnaire does establish that professionals are observing their client's experience various difficulties with their cushions.

The size of the sample prevents definitive conclusions from being drawn but it does provide an indication as to where SCI cushion users are experiencing problems with their cushion. Of itself, the findings of this questionnaire would not be sufficient to be categorical about the weaknesses and deficiencies in contemporary PR cushions, but it is a valuable piece of evidence to be added to the data gathered for the triangulation stage of this project, see chapter 11.

Chapter 10

TRIANGULATION

10.1 Introduction



This chapter charts the work conducted to complete 'Stage 5' of the project. The project's methodological framework tasked Stage 5 with appraising the validity of the research suppositions using the method of Methodological Triangulation, see section 5.6.

Each of the 30 research suppositions were triangulated in turn, whereby the findings of the five research methods used over the course of the project, literature review, SCI patient interviews, SCI professional interviews, questionnaire survey of SCI patients, questionnaire survey of SCI professionals, was checked for consistency with the research proposition. The results of the triangulation process have been reported as a series of tables.

10.2 Triangulation of the Research Suppositions

This project was tasked with two objectives, the first objective was "*The identification of weaknesses and/or deficiencies in contemporary pressure relief cushion design*" and the second, "*The production of a set of recommendations for the design of future pressure ulcer preventative cushions*", see section 1.2.

By undertaking a series of different research methods a number of weaknesses and deficiencies in contemporary pressure relief cushion design were found, thus completing the first objective. The second objective required the identified weaknesses and deficiencies to be used as the basis for the formulation of a set of recommendations for future cushion design. It is critical that before formulating a recommendation based on one of the weaknesses that this weakness is real phenomenon and not an aberration of one of the research methods used. Therefore, before undertaking the exercise of formulating a set of recommendations confidence had to be established in the findings to be used.

The technique chosen during the development of the projects methodology to establish confidence was the validating technique 'Methodological Triangulation", see section 5.6.

Methodological triangulation is a cross checking exercise whereby the findings of the different research methods are compared for consistency. Where consistency is found the findings have demonstrated 'Convergent Validity'.

The 30 research suppositions were triangulated in turn in order to establish a level of confidence in the supposition. A supposition supported by the findings from,

4-5 methods = High confidence,
3 methods = Moderate confidence,
1-2 methods = Low confidence,
0 methods = No confidence.

The suppositions rated as, "*High*" or "*Moderate*", would be used as the basis for a making a recommendation, see section 11.3.

Table 10-1 Triangulation of the findings related to the supposition ‘Adjusting internal air pressure’

Research supposition:	**1. Adjusting internal air pressure:** Air celled cushions are not serving the user optimally due to the degree of difficulty involved with setting the internal air pressure		
Research method	Findings		Consistent / inconsistent
Issue discussed in the literature	Air filled cushions are dependent on the setting of the internal air pressure and that over and under inflation can lead to the development of a pressure ulcer		Consistent
User interviews	Users expressed that they are experiencing difficulties with setting the internal air pressure to an optimum value		Consistent
Expert opinion session	Experts have found that their clients have difficulties with setting the internal air pressure to an optimum value		Consistent
SCI patient questionnaire	None reported controlling the air pressure as “*Very easy*”, 28% reported the task of controlling air pressure as either “*difficult*” or “*very difficult*”		Consistent
Staff questionnaire	None reported that their clients never incorrectly set the air pressure. More disagreed (52%) that adjusting air pressure is easy than agreed (32%)		Consistent
Triangulated result	Consistent in 5 out of 5 methods	Confidence level:	**High**

Table 10-2 Triangulation of the findings related to the supposition ‘Appearance’

Research supposition:	**2. Appearance:** Current cushion design is not satisfying the users sensitivity towards the appearance of their cushion		
Research method	Findings		Consistent / inconsistent
Issue discussed in the literature	Personal taste is a subjective matter and disabled users can be sensitive to designs which are overtly medical or project a negative self image		Consistent
User interviews	Users expressed that they consider the appearance of their cushion as important		Consistent
Expert opinion session	Experts have found that their clients make value judgements on the appearance of their cushions		Consistent
SCI patient questionnaire	Although appearance was ranked last against a list of aspects, when choosing a cushion only seven respondents (17%) reported that appearance was “*of no significance*”		Consistent
Staff questionnaire	Although appearance was ranked last against a list of aspects, when regarding a cushion performance only one respondent (3%) reported that appearance was “*of no significance*”		Consistent
Triangulated result	Consistent in 5 out of 5 methods	Confidence level:	**High**

Table 10-3 Triangulation of the findings related to the supposition ‘Body shape fluctuations’

Research supposition:	**3. Body shape fluctuations:** Cushions are not meeting the additional requirements of a user undergoing a rapid change in body shape		
Research method	Findings		Consistent / inconsistent
Issue discussed in the literature	Being over or under weight known to increase the patient’s risk of developing a pressure ulcer. The rate of body weight change not listed as a pressure ulcer risk factor		Inconsistent
User interviews	Users did not raise this issue		Inconsistent
Expert opinion session	Experts have found that some of the clients who undergo a rapid body weight change, either weight gain or weight loss, go on to develop pressure ulcers		Consistent
SCI patient questionnaire	Of the 22 patients who have developed pressure ulcers 3 respondents reported developing a pressure ulcer after a rapid weight loss and 1 after a rapid weight gain		Consistent
Staff questionnaire	Of the staff, 32% reported that a rapid weight loss triggers a pressure ulcer either “*frequently*” or “*all the time*” and 10% reported that a rapid weight gain triggers a pressure ulcer either “*frequently*” or “*all the time*”		Consistent
Triangulated result	Consistent in 3 out of 5 methods	Confidence level:	**Moderate**

Table 10-4 Triangulation of the findings related to the supposition ‘Bottoming out (air)’

Research supposition:	**4. Bottoming out (air):** Users of air cell cushions are vulnerable to pressure damage resulting from a drop in the internal air pressure going unnoticed resulting in a bottoming out event		
Research method	Findings		Consistent / inconsistent
Issue discussed in the literature	Air filled cushions can bottom out which can lead to the development of a pressure ulcer		Consistent
User interviews	Users have experienced a loss of air pressure so that they have bottomed out and this has caused them problems		Consistent
Expert opinion session	Experts did not raise this issue		Inconsistent
SCI patient questionnaire	Of the 22 patients who reported that they have used a cushion with air cells 12 (55%) reported that the cells have deflated so much that they have bottomed out		Consistent
Staff questionnaire	Of the staff, 29 (94%) reported that their clients on air cells do bottom out, with 19 (61%) reporting that this happens “*occasionally*” and 9 (29%) “*very rarely*”		Consistent
Triangulated result	Consistent in 4 out of 5 methods	Confidence level:	**High**

Table 10-5 Triangulation of the findings related to the supposition ‘Bottoming out (gel)’

Research supposition:	**5. Bottoming out (gel):** Users of viscous fluid gel cushions are vulnerable to pressure damage resulting from a sideways migration of gel going unnoticed resulting in a bottoming out event		
Research method	Findings		Consistent / inconsistent
Issue discussed in the literature	Gel filled cushions can bottom out which can lead to the development of a pressure ulcer		Consistent
User interviews	Users have experienced a sufficient sideways migration of gel to cause bottoming out and this has caused them problems		Consistent
Expert opinion session	Experts did not raise this issue		Inconsistent
SCI patient questionnaire	Of the 35 patients who reported that they have used a gel filled cushion 27 (77%) reported that the gel has migrated so much so that they have bottomed out		Consistent
Staff questionnaire	Of the staff, 26 (84%) reported that their clients on gel cushions do bottom out, with 14 (45%) reporting that this happens “*occasionally*” and 11 (35%) “*very rarely*”		Consistent
Triangulated result	Consistent in 4 out of 5 methods	Confidence level:	**High**

Table 10-6 Triangulation of the findings related to the supposition ‘Checking internal air pressure’

Research supposition:	**6. Checking internal air pressure:** Air celled cushions are not serving the user optimally due to the necessity to frequently check the level of internal air pressure		
Research method	Findings		Consistent / inconsistent
Issue discussed in the literature	Air filled cushions are dependent on the setting of the internal air pressure and that over and under inflation can lead to the development of a pressure ulcer		Consistent
User interviews	Users have expressed that they have to frequently check the level of air pressure, and this has caused inconvenience and anxiety		Consistent
Expert opinion session	Experts did not raise this issue		Inconsistent
SCI patient questionnaire	Of the patients, 9 (22%) have used a cushion with the wrong contour shape. Of these, 5 (55%) reported that this caused *“major difficulties”* for their skin		Consistent
Staff questionnaire	Of the staff, 42% reported that their clients have to check the air pressure once a day or more		Consistent
Triangulated result	Consistent in 4 out of 5 methods	Confidence level:	**High**

Table 10-7 Triangulation of the findings related to the supposition ‘Cleaning’

Research supposition:	**7. Cleaning:** Users are hampered in their use of their cushion by the degree of difficulty involved in cleaning their cushion		
Research method	Findings		Consistent / inconsistent
Issue discussed in the literature	The cleanliness of a cushion is part of a user’s hygiene, and certain cushions are more difficult to clean than others		Consistent
User interviews	Users have expressed that they have experienced difficulties with cleaning their cushion, and this has caused inconvenience and anxiety		Consistent
Expert opinion session	Experts have found that some of their clients have experienced difficulties with cleaning their cushion, and that poor cleanliness can lead to pressure ulceration		Consistent
SCI patient questionnaire	Of the patients, 17 (42%) regard the cushions ability to be kept clean as “*very significant*”. Only half (51%) regard their cushion as “*easy*” or “*very easy*” to clean		Consistent
Staff questionnaire	Of the staff, 13 (42%) regard a cushion’s ability to be kept clean as “*very significant*” when considering it’s overall performance		Consistent
Triangulated result	Consistent in 5 out of 5 methods	Confidence level:	**High**

Table 10-8 Triangulation of the findings related to the supposition ‘Comfort’

Research supposition:	**8. Comfort:** Users experience dissatisfaction with their cushion due to the level of comfort it can provide		
Research method	Findings		Consistent / inconsistent
Issue discussed in the literature	An uncomfortable cushion can cause the user discomfort and reduce the user’s quality of life		Consistent
User interviews	Users have expressed that they find some cushions comfortable and others uncomfortable, and that they exchange cushions on the basis of comfort		Consistent
Expert opinion session	Experts find that their clients experience different levels of comfort with different cushions and that comfort is very important to their clients		Consistent
SCI patient questionnaire	Of the patients, 31 (76%) regard the comfort provided by a cushion as “*very significant*”. Additionally, 4 cited comfort as a reason for choosing their cushion and 1 for ceasing to use their previous cushion		Consistent
Staff questionnaire	Comfort was ranked above posture with 77% of the staff regarding comfort as “*very significant*” compared to 61%		Consistent
Triangulated result	Consistent in 5 out of 5 methods	Confidence level:	**High**

Table 10-9 Triangulation of the findings related to the supposition 'Contour surface'

Research supposition:	**9. Contour surface:** Uses are exposed to an increased risk of pressure damage when issued with a cushion with a contour surface shape which is not optimally suited to their body shape		
Research method	Findings		Consistent / inconsistent
Issue discussed in the literature	The use of a cushion with the wrong contour shape can lead to the development of a pressure ulcer		Consistent
User interviews	Users did not raise this issue		Inconsistent
Expert opinion session	Experts have found matching the surface contour shape of the cushion to the client to be an important factor in the outcome of the use of the cushion		Consistent
SCI patient questionnaire	Of the patients, 9 (22%) have used a cushion with the wrong contour shape. Of these, 5 (55%) reported that this caused *"major difficulties"* for their skin		Consistent
Staff questionnaire	Of the staff, 49% reported that they have observed cushions of the wrong contour shape, and 45% reported that this results in pressure ulcers either "*frequently*" or "*occasionally*"		Consistent
Triangulated result	Consistent in 4 out of 5 methods	Confidence level:	**High**

Table 10-10 Triangulation of the findings related to the supposition 'Cushion cover issues'

Research supposition:	**10. Cushion cover issues:** Cushion covers are not satisfactorily addressing all the demands daily use puts upon them		
Research method	Findings		Consistent / inconsistent
Issue discussed in the literature	Cushion covers are an integral part of cushions and issues such as moisture and hammocking are discussed		Consistent
User interviews	Users have expressed that their covers require attention, and that their neglect can result in wrinkling which can lead to pressure damage		Consistent
Expert opinion session	Experts have found that their clients have various issues with their covers, including sweating, laundering, wear and tear, changing and appearance		Consistent
SCI patient questionnaire	A large proportion of the patients indicated that they regard a series of aspects as "*very significant*", for instance 71% cited the cover being wrinkled as "*very significant*"		Consistent
Staff questionnaire	The staff have observed a range of circumstances whereby a cover can contribute to the development of a pressure ulcer		Consistent
Triangulated result	Consistent in 5 out of 5 methods	Confidence level:	**High**

Table 10-11 Triangulation of the findings related to the supposition 'Cushion orientation'

Research supposition:	**11. Cushion Orientation:** Users are exposed to an additional risk of pressure damage due to possible errors with how their cushion is oriented on their wheelchair		
Research method	Findings		Consistent / inconsistent
Issue discussed in the literature	A cushion positioned on a wheelchair in the wrong orientation can lead to the development of a pressure ulcer		Consistent
User interviews	Users did not raise this issue		Inconsistent
Expert opinion session	Experts are having to treat pressure ulcers which have resulted from the use of cushions positioned in wheelchairs in the wrong orientation		Consistent
SCI patient questionnaire	None of the patients have developed a pressure ulcer as a result of sitting on a cushion in the wrong orientation		Inconsistent
Staff questionnaire	Half of the staff 17 (55%) reported that they "*occasionally*" observe cushions being used in the wrong orientation, and 19 (61%) that this results in pressure ulcers either "*frequently*" or "*occasionally*"		Consistent
Triangulated result	Consistent in 3 out of 5 methods	Confidence level:	**Moderate**

Table 10-12 Triangulation of the findings related to the supposition 'Cushion size'

Research supposition:	**12. Cushion size:** Users are being put at additional risk of pressure damage when in receipt of a cushion of the wrong size, either too big or too small		
Research method	Findings		Consistent / inconsistent
Issue discussed in the literature	The use of a cushion of the wrong size has ramifications for posture and can lead to the development of a pressure ulcer		Consistent
User interviews	Users have been given the wrong sized cushion to use and this has affected posture, comfort and the capacity to reduce pressure		Consistent
Expert opinion session	Experts have found matching the size of the cushion to the client to be an important factor in the outcome of the use of the cushion		Consistent
SCI patient questionnaire	Of the patients, 11 (27%) have used a cushion of the wrong size. Out of these, 5 (45%) reported that this caused *"major difficulties"* for their skin		Consistent
Staff questionnaire	Of the staff, 97% reported that they have observed cushions of the wrong size being used, and 62% reported that this results in pressure ulcers either "*frequently*" or "*occasionally*"		Consistent
Triangulated result	Consistent in 5 out of 5 methods	Confidence level:	**High**

Table 10-13 Triangulation of the findings related to the supposition ‘Extreme body shapes’

Research supposition:	**13. Extreme body shapes:** Cushions are not meeting the additional requirements of users with extreme physical characteristics, either extreme height, weight or both		
Research method	Findings		Consistent / inconsistent
Issue discussed in the literature	Being over or under weight is a risk factor. Being heavy or light, tall or short is not included in the lists of risk factors		Inconsistent
User interviews	Tall users expressed problems with stability and posture, in particular slouching		Consistent
Expert opinion session	Experts have found that clients come in all shapes and sizes and that they all require a pressure relief cushion		Consistent
SCI patient questionnaire	The numbers of patients within each height and weight category was not sufficient to draw any conclusions		Inconsistent
Staff questionnaire	The findings suggest a slight increase in the incidence of pressure ulcers at the extreme ends of the weight range but the staff made it known that height and weight are not factors in pressure ulcer development		Inconsistent
Triangulated result	Consistent in 2 out of 5 methods	Confidence level:	**Low**

Table 10-14 Triangulation of the findings related to the supposition ‘Fitting cushion covers’

Research supposition:	**14. Fitting cushion covers:** Users are hampered in their use of their cushion by the degree of difficulty involved in changing their cushion cover		
Research method	Findings		Consistent / inconsistent
Issue discussed in the literature	Cushions fit inside their covers. Specific difficulties with changing covers, such as with zippers, was not found		Inconsistent
User interviews	Users expressed difficulties with inserting and removing their cushion from the cover		Consistent
Expert opinion session	Experts have found that some of their clients find inserting and removing their cushion from their covers to be difficult, in particular the manipulation of zippers		Consistent
SCI patient questionnaire	Of the patients, 48% agreed that covers are difficult to change		Consistent
Staff questionnaire	Half agreed (52%) that covers are easy to change the other half either disagreed or abstained. Also 16% did agree that the effort involved in changing a cover is such that the cover is not changed as often as it should		Consistent
Triangulated result	Consistent in 4 out of 5 methods	Confidence level:	**High**

Table 10-15 Triangulation of the findings related to the supposition 'Footplate adjustment'

Research supposition:	**15. Footplate adjustment:** Users are exposed to an increased risk of pressure damage due to their cushions inability to adapt when a user's footplate is incorrectly set		
Research method	Findings		Consistent / inconsistent
Issue discussed in the literature	An incorrectly set footplate can prevent the user from sitting in an optimal position which can have ramifications for posture and can lead to the development of a pressure ulcer		Consistent
User interviews	Users reported that on occasion their wheelchair footrest was incorrectly adjusted, which effected their posture		Consistent
Expert opinion session	Experts found that their clients are having their knees pushed up by their footrests being set too high, and that this reduces the contact area between the skin and the cushion		Consistent
SCI patient questionnaire	Half (52%) only adjust their footplate when it is noticed that it is in the wrong position. Also, 1 patient reported developing a pressure ulcer as a result of their footplate being in the wrong position		Consistent
Staff questionnaire	Half of the staff (52%) reported that half or fewer of their clients can not check the height adjustment of their footplate		Consistent
Triangulated result	Consistent in 5 out of 5 methods	Confidence level:	**High**

Table 10-16 Triangulation of the findings related to the supposition 'Foreign objects on surface'

Research supposition:	**16. Foreign objects on surface:** Users are exposed to an additional risk of pressure damage due to the inability of cushions to respond when their user is sitting on a foreign object		
Research method	Findings		Consistent / inconsistent
Issue discussed in the literature	Foreign objects trapped between a user and the support surface can lead to the development of a pressure ulcer		Consistent
User interviews	Users reported that they have sat on their cushion unaware that a foreign objects was located between their skin and the support surface		Consistent
Expert opinion session	Experts did not raise this issue		Inconsistent
SCI patient questionnaire	Of the 22 patients who developed a pressure ulcer on the seat area of the body, one cited small foreign objects as causing pressure ulcers "*occasionally*" and one "*very rarely*"		Consistent
Staff questionnaire	Nearly all the staff (96%) reported that small objects can cause pressure ulcers, with 19% reporting small objects cause pressure ulcers "*frequently*" and 42% "*occasionally*"		Consistent
Triangulated result	Consistent in 4 out of 5 methods	Confidence level:	**High**

Table 10-17 Triangulation of the findings related to the supposition 'Imbalance reinforcement'

Research supposition:	**17. Imbalance reinforcement:** Users of fluid filled cushions are vulnerable to pressure damage resulting from the free flow of fluid from one side of the cushion to the other, which exaggerates a user's lean		
Research method	Findings		Consistent / inconsistent
Issue discussed in the literature	A user of a fluid filled cushion can bottom out on one side due to fluid movement resulting from an unbalanced sitting position		Consistent
User interviews	Users are finding that leaning can be exaggerated by the free flow of fluid in their cushion and that this can affect their posture and lead to bottoming out events		Consistent
Expert opinion session	Experts have found some fluid filled cushions are not managing the migration of fluid within the cushion, which results in an exaggeration of any leaning their clients may do		Consistent
SCI patient questionnaire	ROHO users 28% lean left, 8% lean right. Jay users 12% lean right, 6% lean left. Of the group of other cushion users, mostly foam type cushions, 9% lean left, 9 % lean right		Consistent
Staff questionnaire	More than half (61%) reported that fluid filled cushions exaggerate a lean		Consistent
Triangulated res.	Consistent in 5 out of 5 methods	Confidence level:	**High**

Table 10-18 Triangulation of the findings related to the supposition 'Leaning and the use of armrests'

Research supposition:	**18. Leaning and the use of armrests:** Users are exposed to an additional risk of pressure damage due to the inability of cushions to respond to their user's sustained and repetitive leaning to one side		
Research method	Findings		Consistent / inconsistent
Issue discussed in the literature	When a user leans to one side the IP on the ischium being leaned on increases, whereas the IP on the ischium not being leaned decreases		Consistent
User interviews	Users with weakened trunk muscles mentioned that they tend to rely on one of their armrests to support their position and this has caused problems		Consistent
Expert opinion session	Experts did not raise this issue		Inconsistent
SCI patient questionnaire	Of the 57 pressure ulcers developed by right handed patients 23 (40%) were on the right ischium compared to 8 (14%) on the left ischium. Of the 28 pressure ulcers developed by left handed patients 6 (21%) were on the left ischium compared to 7 (25%) on the right ischium		Consistent
Staff questionnaire	68% reported observing pressure ulcers "*Frequently*" on the right ischium and 45% on the left. Also 4 staff cited leaning as a way posture can contribute to the development of a pressure ulcer		Consistent
Triangulated res.	Consistent in 4 out of 5 methods	Confidence level:	**High**

Table 10-19 Triangulation of the findings related to the supposition 'Portability'

Research supposition:	**19. Portability:** Users are hampered in their use of their cushion by the degree of difficulty involved in the securing a cushion to a wheelchair		
Research method	Findings		Consistent / inconsistent
Issue discussed in the literature	Users will on occasion have to remove their cushion from their wheelchair. Specific difficulties with securing cushions to wheelchairs were not found		Consistent
User interviews	Users expressed difficulties with attaching/ detaching the cushion to and from their wheelchair		Consistent
Expert opinion session	Experts did not raise this issue		Inconsistent
SCI patient questionnaire	Half (48%) do not find securing their cushion easy (section 8.5.1). Of the patients 30 (71%) sit on car seats, 8 (20%) use their cushion when sat on a car seat		Inconsistent
Staff questionnaire	One quarter (26%) reported that their clients find securing their cushion easy. (93%) reported that their clients sit on car seats "*all the time*" or "*frequently*", and 42% reported that their clients use their cushion on car seats		Consistent
Triangulated result	Consistent in 3 out of 5 methods	Confidence level:	**Moderate**

Table 10-20 Triangulation of the findings related to the supposition 'Pressure relief routine'

Research supposition:	**20. Pressure relief routine:** Users are not receiving the full benefits of a pressure relief routine due to their cushion failing to facilitate the practice of pressure relief		
Research method	Findings		Consistent / inconsistent
Issue discussed in the literature	Adhering to a pressure relief routine can help prevent pressure ulcers from developing		Consistent
User interviews	Not all users adhere to a pressure relief routine		Inconsistent
Expert opinion session	Experts did not raise this issue		Inconsistent
SCI patient questionnaire	Of the patients 35 (85%) who perform some form of PR movement, 27 (77%) do not follow a fixed routine. Of the 12 who do follow a routine 6 regularly miss half of the routine out		Consistent
Staff questionnaire	Of the staff, 21 (68%) regard pressure relief as "*very beneficial*". Also 27 (88%) reported that their clients pressure relieve by leaning forward either "*frequently*" or "*all the time*",12 (39%) reported that their clients miss half or more of their routine		Consistent
Triangulated result	Consistent in 3 out of 5 methods	Confidence level:	**Moderate**

Table 10-21 Triangulation of the findings related to the supposition 'Range of postures'

Research supposition:	**21.Range of postures:** Users are exposed to an additional risk of pressure damage due to the design of their cushion focusing on maintaining the "*normal*" sitting position and not sufficiently accommodating differing postures		
Research method	Findings		Consistent / inconsistent
Issue discussed in the literature	Sitting for extended lengths of time in a poor postural position, can have ramifications for a user's health and can lead to the development of a pressure ulcer		Consistent
User interviews	Users are sitting for extended lengths of time in poor postural positions causing discomfort, pain, pressure damage etc.		Consistent
Expert opinion session	Experts have found some clients sit in a poor posture positions for lengths of time sufficient to cause muscle shortening and contractures		Consistent
SCI patient questionnaire	Of the patients, 17 (41%) reported experiencing problems such as pain and scoliosis, as a result of sitting in a poor position. Also the patients reported sitting in a range of poor positions for example 29 (71%) slouch		Consistent
Staff questionnaire	All the staff reported that an unbalanced position increases IP which can on occasion contribute to the development of a pressure ulcer. Also 30 (97%) reported that their clients on occasion sit with a lean		Consistent
Triangulated res.	Consistent in 5 out of 5 methods	Confidence level:	**High**

Table 10-22 Triangulation of the findings related to the supposition 'Recurring damage'

Research supposition:	**22. Recurring damage:** Users are hampered in their use of their cushion as a result of their cushion being repeatedly compromised due to certain forms of recurring damage		
Research method	Findings		Consistent / inconsistent
Issue discussed in the literature	Different cushions are vulnerable to different forms of damage, for instance air cells puncturing. However, specific causes of damage were not found		Inconsistent
User interviews	Users reported similar causes of damage, for instance punctures due to pet claws, or burns from smoking		Consistent
Expert opinion session	Experts find the ROHO cushions are prone to punctures		Consistent
SCI patient questionnaire	There was no form of damage which was consistently reported by the respondents		Inconsistent
Staff questionnaire	There was no form of damage which was consistently reported by the respondents		Inconsistent
Triangulated res.	Consistent in 2 out of 5 methods	Confidence level:	**Low**

Table 10-23 Triangulation of the findings related to the supposition 'Securing cushion'

Research supposition:	**23. Securing cushion:** Users are experiencing difficulties, including pressure damage, due to their cushion failing to remain secured to the seat of their wheelchair		
Research method	Findings		Consistent / inconsistent
Issue discussed in the literature	Unsecured cushions can slide both forwards and backwards, which has ramifications for posture and can lead to the development of a pressure ulcer		Consistent
User interviews	Users are finding that on occasion their cushion is free to slide forwards and backwards on their wheelchair seat, and this is affecting their comfort and posture		Consistent
Expert opinion session	Experts did not raise this issue		Inconsistent
SCI patient questionnaire	27 (66%) patients reported that on occasion their cushion is unsecured and slides about. 30 reported (73%) that their cushion is knocked loose during transfers. Also, 8 (20%) reported that when they slouch they slide their cushion forward		Consistent
Staff questionnaire	30 (98%) staff reported that their clients can knock their cushions loose during transfers. Also, 29 (94%) reported that when their clients slouch they do on occasion slide their cushion forward		Consistent
Triangulated res.	Consistent in 4 out of 5 methods	Confidence level:	**High**

Table 10-24 Triangulation of the findings related to the supposition 'Shocks/vibrations'

Research supposition:	**24. Shocks vibrations:** Users experience elevated discomfort due to their cushion not providing sufficient damping from shocks and vibrations		
Research method	Findings		Consistent / inconsistent
Issue discussed in the literature	Users manually propelling wheelchairs can experience shocks and vibrations, which can cause discomfort and fatigue the user		Consistent
User interviews	Users reported experiencing shocks and vibrations and that these shocks and vibrations can trigger spasms		Consistent
Expert opinion session	Experts did not raise this issue		Inconsistent
SCI patient questionnaire	Questions relating to shocks/vibrations were omitted after the pilot of the questionnaire		Inconsistent
Staff questionnaire	Questions relating to shocks/vibrations were omitted after the pilot of the questionnaire		Inconsistent
Triangulated result	With the issue of shocks/vibrations omitted from the questionnaires, there were only three research methods from which to triangulate. With support from just two research methods only a '*Low*' level of confidence could be established	Confidence level:	**Low**

Table 10-25 Triangulation of the findings related to the supposition 'Skin care vs Posture Compromise'

Research supposition:	**25. Skin care vs Posture Compromise:** Users are currently having to choose between cushions which provide optimum IP reduction or postural support		
Research method	Findings		Consistent / inconsistent
Issue discussed in the literature	Certain cushions are better equipped to support a patient's posture than others and users have to choose between cushions. Specific difficulties arising from this choice were not found		Inconsistent
User interviews	Users opt for a cushion with good skin care qualities, such as the ROHO, whilst their skin tolerance recovers after a pressure ulcer and then switch to a more postural cushion, such as the Jay		Consistent
Expert opinion session	Experts find that clients use a more postural cushion until they develop a pressure ulcer at which time they switch to a more skin care oriented cushion. Once confident that the pressure ulcer episode has passed clients return to a postural cushion		Consistent
SCI patient questionnaire	It was not clear from the patients answers if a compromise had been made, when choosing their current cushion, between skin care and posture		Inconsistent
Staff questionnaire	Of the staff, 25 (81%) reported that they have observed a pattern of events whereby a client will opt for a cushion based on the most pressing need at the time skin care vs posture		Consistent
Triangulated res.	Consistent in 3 out of 5 methods	Confidence level:	**Moderate**

Table 10-26Triangulation of the findings related to the supposition 'Slouched position'

Research supposition:	**26. Slouched position:** Users are exposed to an increased risk of pressure damage due to their cushions inability to compensate or adjust for slouching		
Research method	Findings		Consistent / inconsistent
Issue discussed in the literature	Sitting in a slouched position can have ramifications for posture and can lead to the development of a pressure ulcer		Consistent
User interviews	Users reported that they spent long lengths of time sat in a slouched position		Consistent
Expert opinion session	Experts find that clients spend long lengths of time sat in a slouched position, and that this increases IP and can lead to pressure ulcers		Consistent
SCI patient questionnaire	Of the patients, 23 (63%) slouch on occasion, 4 reporting that they slouch "*all the time*". Of the 17 Jay users, 12 (71%) slouch on occasion despite it having a contour		Consistent
Staff questionnaire	Of the staff, 30 (97%) have observed their clients slouching and 28 (90%) reported that slouching increases the risk of developing a pressure ulcer		Consistent
Triangulated res.	Consistent in 5 out of 5 methods	Confidence level:	**High**

Table 10-27 Triangulation of the findings related to the supposition 'Sweating'

Research supposition:	**27. Sweating:** Users are experiencing difficulties, including pressure damage, due to their cushion failing to manage sweat and sweating		
Research method	Findings		Consistent / inconsistent
Issue discussed in the literature	Moisture between the user and the support surface can increase the user's risk of developing a pressure ulcer		Consistent
User interviews	Users reported that they experienced more sweating with certain cushions and less with others and that this difference is sufficient reason to switch cushions		Consistent
Expert opinion session	Experts find that the cover of a cushion has a large influence on a clients sweating patterns		Consistent
SCI patient questionnaire	Of the 22 patients who developed a pressure ulcer, one reported that they had developed a pressure ulcer due to a cushion causing sweating. Also, one patient cited sweating as the reason for ceasing to use their previous cushion		Consistent
Staff questionnaire	Of the staff, 30 (97%) regard a cushions ability to prevent sweating as significant. Also, 10 (32%) reported that "*occasionally*" covers contribute to the development of a pressure ulcer by holding too much moisture		Consistent
Triangulated res.	Consistent in 5 out of 5 methods	Confidence level:	**High**

Table 10-28 Triangulation of the findings related to the supposition 'Transfer issues (contour depth)'

Research supposition:	**28. Transfer issues (contour depth):** Users experience additional difficulties, including pressure damage, when transferring to/from a contoured cushion, due to the lack of a flat surface		
Research method	Findings		Consistent / inconsistent
Issue discussed in the literature	Cushions with surface contours can have deep bucket like hollows which can pose a hazard when transferring into and out of a wheelchair		Consistent
User interviews	Users are finding the necessity to lift up and out of a deep contour, before transferring across arduous and a hazard which can trigger a pressure ulcer		Consistent
Expert opinion session	Experts find that sometimes clients do not lift themselves high enough when transferring out of a contoured cushion and scrape their bottom across the edge. This can injure the bottom leading to a pressure ulcer		Consistent
SCI patient questionnaire	Of the 17 Jay users none reported experiencing difficulties when transferring		Consistent
Staff questionnaire	5 (16%) staff cited high contours/deep seat well as a cause of difficulty when transferring. Also 10 (32%) cited a flat contour-less surface as a feature which makes transferring easier		Consistent
Triangulated res.	Consistent in 5 out of 5 methods	Confidence level:	**High**

Table 10-29 Triangulation of the findings related to the supposition 'Transfer issues (stability)'

Research supposition:	**29. Transfer issues (stability):** Users of fluid filled cushions are experiencing additional difficulties, including pressure damage, when transferring to/from their cushion due to the lack of a solid stable base from which to transfer		
Research method	Findings		Consistent / inconsistent
Issue discussed in the literature	Fluid filled cushions, in particular air filled, lack a solid stable surface from which to push off from or transfer weight onto. This makes transferring a precarious activity		Consistent
User interviews	Users did not raise this issue		Inconsistent
Expert opinion session	Experts find that clients with air filled cushions have difficulty with transferring because the unstable surface can unbalance a client as they move		Consistent
SCI patient questionnaire	Of the 13 ROHO users, 3 reported experiencing difficulties when transferring		Consistent
Staff questionnaire	Of the staff, 15 (48%) cited an unstable surface as a cause of difficulty when transferring. Also 10 (32%) cited a firm stable base as a feature which makes transferring easier		Consistent
Triangulated res.	Consistent in 4 out of 5 methods	Confidence level:	**High**

Table 10-30 Triangulation of the findings related to the supposition 'Vigorous movements'

Research supposition:	**30. Vigorous movements:** Users are hampered in their use of their cushion as a result of their cushions failure to compensate for vigorous movements related to daily activities, such as propelling their wheelchair		
Research method	Findings		Consistent / inconsistent
Issue discussed in the literature	Vigorous movements can result in users sitting in positions other than their optimum position. Specific difficulties resulting from certain vigorous movements were not found		Inconsistent
User interviews	Users reported being displaced by vigorous movements such as manual propelling of their wheelchair		Consistent
Expert opinion session	Experts did not raise this issue		Inconsistent
SCI patient questionnaire	Of the patients, 20 (49%) reported a spasm will on occasion dislodge them from a good postural position and 19 (46%) reported that propelling their wheelchair will on occasion dislodge them from a good postural position		Consistent
Staff questionnaire	Of the staff, 29 (94%) reported that their clients are on occasion dislodged from a good postural position by a spasm and 29 (94%) reported that their clients are on occasion dislodged from a good postural position by propelling their wheelchair		Consistent
Triangulated res.	Consistent in 3 out of 5 methods	Confidence level:	**Moderate**

Having triangulated the thirty research suppositions, consistency was found in twenty seven cases. Of these twenty seven suppositions;

> twenty one suppositions were found to be supported by the findings from four or five of the five research methods used and were rated with a "*High*" confidence level,
>
> six suppositions were found to be supported by the findings from three of the five research methods used and were rated with a "*Moderate*" confidence level,
>
> three suppositions were supported by the findings from one or two of the five research methods used and were rated with a "*Low*" confidence level.

10.3 Discussion

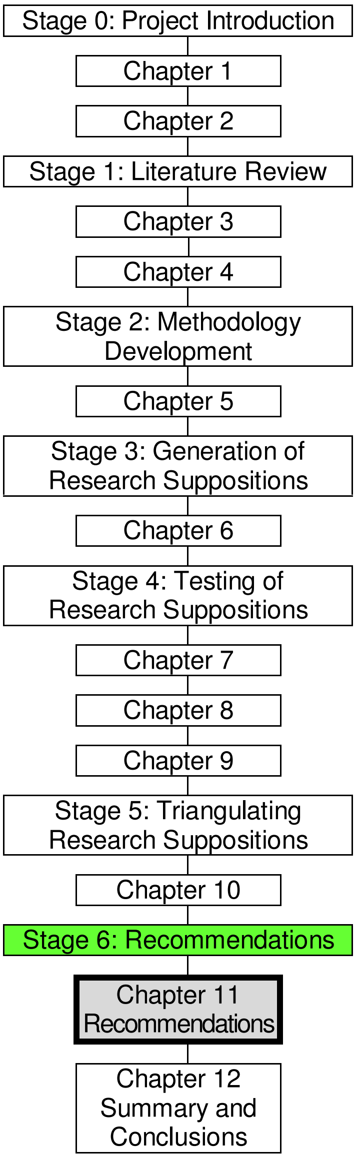
In isolation the findings from each of the five different research method used over the course of this project should be treated with caution, in particular the findings from the two surveys given the limitations of the statistical data see sections 8.6 and 9.6. As such the confidence with which an individual finding is representative of a real phenomenon is insufficient to directly derive a recommendation for how to design new more effective cushions. However using the validating technique of methodological triangulation the findings of the separate and different research methods are no longer viewed in isolation. Instead the findings are used in conjunction with one another to corroborate or refute the research suppositions.

Having applied the triangulation process to the 30 research suppositions the findings were found to be consistent and supporting of 27 of the suppositions. Thus, these 27 suppositions could now be regarded with sufficient confidence to be used as the basis for recommendations for future cushion design.

Chapter 11

RECOMMENDATIONS

11.1 Introduction



This chapter reports on the synthesis carried out to complete 'Stage 6' of the project. The project's methodological framework tasked Stage 6 with the formulation of a series of recommendations to progress cushion design.

Having identified weaknesses in the understanding which underpin the pressure ulcer prevention, the principles of pressure-reduction and pressure-redistribution, a recommendation was made that the principles upon which cushions are designed should be reappraised.

Having identified weaknesses with contemporary PR cushions usability, a series of recommendations were made which would improve future cushions performance with daily issues.

Finally recommendations were made as to the direction the next generation of cushions might take.

11.2 Revising the Principles of Cushion Design

Historically pressure ulcers have not attracted much attention by the medical community, see section 4.2. When the first commercially available pressure relief cushions such as the ROHO were being designed in the early 1970's, see section 3.3, the understanding of pressure ulcer development was rudimentary, see section 4.5.7. At the time it was appreciated that pressure was the instigator of pressure ulcers therefore it was assumed that by managing interface pressure then pressure ulcers could be prevented.

Animal experiments in the 1950's and 60's, for example by Kosiak (1961) (1963) and Husain (1953), led to the concept of an inverse intensity-duration pressure damage relationship i.e. as the intensity of pressure increases the time taken for damage to occur decreases. This relationship was expressed as a pressure intensity-duration curve. By not intersecting the axis this curve suggested the possibility of a safe pressure-intensity threshold and a safe pressure-duration threshold, see section 4.5.7. Thus the basic principles of pressure-reduction and pressure-redistribution were developed to exploit the safe pressure-intensity threshold and safe pressure-duration threshold, see section 3.2.

To create pressure-reducing cushions, cushion designers use the properties of immersion and envelopment to increase the surface contact area to distribute the weight of the seated person as evenly as possible. This is the static cushion concept of pressure ulcer prevention, see section 3.2.1. To create pressure-redistributing cushions, cushion designers have employed pneumatics to alternate the load bearing points around the contact area to provide temporary respites between load bearing phases which allow the tissue to revitalise before being subjected once again to pressure. This is the dynamic cushion concept of pressure ulcer prevention, see section 3.2.2.

Pressure remains central to the current understanding of how pressure ulcers form. Pressure ulcers are still understood to be caused by pressure, shear, friction and/or a combination of these, see section 4.4.1, and pressure ulcers continue to be defined as an area of tissue damaged by these three factors, see section 4.3.1. Consequently cushion designers still see the primary function of cushions to be the management of pressure, see sections 3.4.1 and 3.4.2. The primacy of this pressure management role has been enshrined in how cushions are referred to, being pressure relief cushions not pressure ulcer prevention cushions.

However, after nearly forty years of static and dynamic cushion use the incidence of pressure ulcers in wheelchair users has reached a plateau, see section 8.2.2. Cushions modelled solely on the basic principles of pressure-reduction and pressure-redistribution are regarded as beneficial and as such have merit, but if more effective cushions are to be designed these basic principles need to be revisited.

Both the principles of pressure-reduction and pressure-redistribution are an expression of the concept of an intensity-duration curve. Whilst it has been shown that there is an inverse relationship between pressure intensity and duration there are many weaknesses with expressing this relationship as a curve, see section 4.5.7. In real world conditions the multi-factorial nature of pressure ulcer development renders this curve, with its safe pressure-intensity and safe pressure-duration thresholds, unsound.

Since the concept of the intensity-duration curve was first proposed, the understanding of pressure damage has progressed. Although not fully understood, it is appreciated that shear stress resulting from an oblique application of pressure is more damaging than simple compression; that pressure gradients will drive interstitial fluid flow; capillary occlusion pressure is not fixed at 32mmHg; that a lateral movement of tissue can kink capillaries pinching them shut; and that IP measurements do not reflect the pressures acting deeper in the tissue, see section 4.5.

All these issues are symptomatic not of the level of pressure applied but to the extent of tissue distortion. For illustrative purposes, an indenter head applies 50mmHg for two hours to a thigh, and indents by 4mm. The tissue at this point is 40mm thick so the percentage of deformation is 10% and no pressure damage occurs. The same indenter applies 50mmHg for two hours to an elbow, and indents by 1mm. The tissue at this point is 2mm thick so the percentage of deformation is 50% and this time damage occurs. The potential that distortion and tissue deformation is more significant than IP has already been recognised by some researchers, for instance Levine (1990), see section 4.5.6.

The concept of minimising distortion being a priority over pressure reduction would suggest that pressure-reducing cushions using immersion and envelopment are not effective due to their ability to reduce pressure but are effective due to their ability to conform to the shape of the user thereby minimising distortion.

11.2.1 Recommendation

It is recommended that the principles upon which cushions are currently designed should be revised. In future cushions should not follow the design principles of pressure-reduction or pressure-redistribution but should follow a new principle based on tissue distortion-minimisation. How best to achieve tissue distortion-minimisation will be a new challenge for cushion designers as they begin their own design process to create a new cushion.

The benefit to be gained by adopting this recommendation is that future design will be redirected from pursuing ever lower mean and peak IP levels, but towards creating designs which will maintain the shape of the user in order to minimise the tissue distortion. By reducing the level of distortion; shear stress and internal pressure will be reduced; capillary tensioning and kinking will be reduced; and interstitial fluid flow will be decreased by declining pressure gradients and balancing asymmetrical pressure gradient peaks.

11.3 The Usability of Cushions

Having reviewed contemporary cushions, it was found that cushions are designed to either reduce pressure or redistribute pressure. This has focused design on managing IP which in turn has led to the efficacy of cushions to be principally assessed according to a cushion's ability to manage IP, see sections 3.4.1 and 3.4.2. Consequently the evaluations of cushion performance tend to focus on pressure map comparisons between cushions, see section 5.3. Comparing pressure map results is not an evaluation of a cushion efficacy as it does not address a cushion's performance as a pressure ulcer prophylactic.

An effective pressure ulcer prophylactic has to manage the user's exposure to pressure ulcer risk factors. This is more than just reducing mean and peak IP. A hypothetical example is, a wheelchair user sits on a cushion for eight months without developing a pressure ulcer, ostensibly by the cushion reducing mean and peak IP. However without changing the cushion's IP management performance, the user develops a pressure ulcer. The mean and peak IP levels did not change so the pressure ulcer was the result of the cushion failing to counter a change in circumstances. This change in circumstance will have been either the introduction of a new pressure ulcer risk factor, a pressure ulcer "*trigger*", see scenario **A**, or the change in the status of an existing pressure ulcer risk factor, a pressure ulcer "*vulnerability multiplier*", see scenario **B**.

Scenario **A**: A wheelchair user was in a rush one morning. When transferring into their wheelchair this person missed that their catheter tube was not passed over their leg but lay between the leg and the cushion. This error was not noticed for a couple of hours. The tube imprinted on the skin and a pressure ulcer developed. In this example the new factor, which the cushion as a pressure ulcer prophylactic failed to counter, was the introduction of a foreign object onto the support surface. This foreign object would be an example of a pressure ulcer "*trigger*", not being eliminated by the cushion.

Scenario **B:** A user went on holiday to somewhere hot, and sweated more than normal. The increase in moisture softened the skin reducing its tolerance to pressure and consequently the user developed a pressure ulcer. In this example the status of the risk factor moisture changed which the cushion as a pressure ulcer prophylaxis failed to address. This increase in moisture would be an example of a pressure ulcer "*vulnerability multiplier*", not being mitigated by the cushion.

11.3.1 Recommendations

To identify the hazards cushion users face with daily cushion use, namely the pressure ulcer triggers and vulnerability multipliers, the usability of contemporary cushions was investigated using a range of different research methods. The results identified twenty seven issues, ranging from the adjustment of internal air pressure to fitting cushion covers, see section 10.2, these issues formed the basis for synthesising the following recommendations. These recommendations have been tabulated alphabetically, see table 11-1.

These recommendations have not been prioritised or ranked by importance. It is recognised that designers would value some form of prioritisation in order to direct their resources or to determine how best to balance compromises between conflicting design issues, for example strength to weight ratios. However, as already well appreciated, pressure ulcer development is a multi-factorial process which is complicated and specific to an individual's propensities and individual circumstances. Therefore it has been decided that a holistic view of cushion design should be promoted rather than focusing on a limited number of prioritised issues; as is current practice whereby current cushion design is focused on IP management and to a lesser extent on heat and moisture. This view is consistent with current thought on pressure ulcer risk factor categorisation. Although weight loss is a factor known to significantly weaken the skin's tolerance to pressure and so is hydration, both are simply listed as intrinsic factors without attempting to rank them by importance, see section 4.4.3. This lack of ranking reflects that these are factors which have to be addressed and are not competing issues.

Table 11-1 The recommendations synthesised from the research suppositions found to be consistent across the range of findings

Recommendation 1	Research Suppositions:	1. Adjusting internal air pressure, 4. Bottoming out (air), 5. Bottoming out (gel), 6. Checking internal air pressure, 30. Vigorous movements
	Recommendation:	If future cushion designs are to include fluids, the fluid movement and levels should be internally monitored and self adjusted
	Anticipated Benefit:	A design which internally monitors and self adjusts its own fluid movement and levels is simpler and less demanding to use, having removed the burden of setting and checking from the user. By internally monitoring and self adjusting its own fluid movement and levels, such a cushion removes the current opportunities for pressure ulcers to be triggered by user errors such as, • over and under inflating air filled cushions • deflation going unchecked resulting in a bottoming out event • gel migration going unchecked resulting in a bottoming out event • a vigorous movement such as a spasm displacing more fluid than realised bringing on a bottoming out event sooner than expected
Recommendations 2 and 3	Research Supposition:	2. Appearance
	Recommendations:	2. In future, design should ensure cushions are sensitive to the user's self image and self esteem, and not overtly medical and demonstrative of disability
		3. A variety of covers should be provided. Discrete darkly coloured covers could be provided for more introverted user's and formal occasions and more flamboyant colourful patterned covers for more expressive users and fun occasions
	Anticipated Benefit:	A design which is more supportive of self image will be less harmful to self esteem which is associated with depression and indirect self destructive behaviour (ISDB). It is also more likely to be more accepted by wheelchair users and not dismissed as an unwelcome addition to their lives.
Recommendation 4	Research Suppositions:	3. Body shape fluctuations, 9. Contour Surface, 12. Cushion size
	Recommendation:	In future, design should ensure that cushions have a margin of adjustment so that the size and shape of the cushion can be altered to fit the user and the wheelchair
	Anticipated Benefit:	A design which has the flexibility to adjust its shape and size would prevent the pressure ulcers which are currently being triggered as a result of, • the delay between the issuing of an ill fitting cushion and the provision of a new correctly fitting replacement a fixed shape not being able to adjust to accommodate the change in body shape during an episode of rapid weight loss or gain.

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Recommendations 5., 6. and 7.	Research Supposition:	7. Cleaning
	Recommendations:	5. In future, design should ensure that new cushions do not introduce difficulties to the process of cleaning
		6. All parts of the cushion must be easily accessible for thorough cleaning. Recesses which could harbour bacteria should be avoided
		7. The cushion should be able to tolerate warm water and household detergents
	Anticipated Benefit:	A cushion which is easy to clean is less of a burden on the user. A cushion which is difficult to clean is likely to be on occasion not cleaned with due diligence. This in turn leaves the user sat on a poorly cleaned cushion which can trigger a pressure ulcer.
Recommendations 8 and 9	Research Supposition:	8. Comfort
	Recommendations:	8. In future, design should avoid causing discomfort by producing a conforming surface which maintains the user's body shape without imposing contours which distort the skin.
		9. Discomfort can be reduced by managing the user's posture by controlling the shape of the support surface in order to regulate the degree of pelvic tilt.
	Anticipated Benefit:	Cushions which are uncomfortable are discarded by users in favour of cushions which they do find comfortable. Failure to account for comfort will result in a cushion that will be rejected by users. A cushion that users find more comfortable than their current cushion is more likely to be accepted.
Recommendation 10	Research Supposition:	10. Cushion cover issues
	Recommendation:	In future, design should ensure that the tension the cover is put under is controlled
	Anticipated Benefit:	A cover which controls the tension in the material will remove the hazards associated with over and under tensioning. Ensuring that the cover has enough tension will prevent the pressure ulcers which are currently occurring due to the wrinkles and creases in loose material imprinting on the skin and triggering a pressure ulcer. Ensuring that there is not too much tension will prevent the pressure ulcers which are currently being triggered by the material hammocking the user
Recommendation 11	Research Supposition:	11. Cushion orientation
	Recommendation:	In future, design should ensure that cushions include a fail safe mechanism or bias to prevent the cushion from being positioned upside-down or back-to-front. This could be incorporated into the mechanism for securing the cushion to the wheelchair
	Anticipated Benefit:	Providing a means to prevent a cushion from being used in the wrong orientation will prevent the pressure ulcers which are currently occurring when a contemporary cushion is sat on having being accidently positioned upside down, back-to-front, front-to-side

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Recommendation 12	Research Supposition:	14. Fitting cushion covers
	Recommendation:	In future, design should ensure that cushion covers do not impose obstacles or difficulties with the changing process
	Anticipated Benefit:	A cover which is easy to change is less of a burden on the user. Covers which are difficult to change can cause a user to vacillate over changing the cover. An easy to change cover will prevent the pressure ulcers which are currently occurring due to the contribution made by users sitting on a cover which should have been changed more regularly
Recommendations 13	Research Supposition:	15. Footplate adjustment
	Recommendation:	In future, design should ensure that cushions can recognise when a user's knees have been pushed upwards by a footplate set too high
	Anticipated Benefit:	A design which can recognise when a pair of knees has been pushed upwards will be able to either adjust to counter the inclined thighs resulting from the raised knees, or warn the user that they are sitting in a hazardous position. This will prevent the pressure ulcers which are currently developing due to the increase in pressure on the ischial tuberosities resulting from the reduction in contact area by the inclined thighs.
Recommendation 14	Research Supposition:	16. Foreign objects
	Recommendation:	In future, design should ensure cushions incorporate a system for identifying when a potentially hazardous article, such as a coin or catheter tube, is present on the surface of the cushion
	Anticipated Benefit:	A design which incorporates a system for identifying the presence of foreign objects will remove an anxiety that they may be sitting on something which could trigger a pressure ulcer from the user. Having identified the presence of an object, a user can be alerted that steps should be taken to remove the object This will prevent the pressure ulcers which are currently occurring as a result of the presence of a foreign object
Recommendation 15	Research Suppositions:	17. Imbalance reinforcement 18. Leaning and the use of armrests
	Recommendation:	In future, design should ensure that a cushion's support surface adjusts to support the pelvis when a user leans laterally
	Anticipated Benefit:	Currently contemporary cushions which employ fluid do not regulate the fluid flow. These passive cushions positively reinforce leaning by allowing fluid to flow from the side under pressure to the side not under pressure. Not only does this exaggerate a user's lean, it can lead to a bottoming out event. Cushions which actively regulate fluid will be able to keep the fluid under the side being leaned on and can counter the lean. Such cushions will be able to support oblique pelvic tilt and prevent the pressure ulcers which are currently occurring when bottoming out results from this current lack of control.

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Recommendation 16	Research Supposition:	19. Portability
	Recommendation:	In future, design should ensure that cushions are easily transferable to other chairs/seats. In particular cushions should be compatible with car seats. This means that cushions should attach securely to the car seat and not put the user at increased risk in the event of an accident
	Anticipated Benefit:	SCI patients do sit on chair/seats other than wheelchairs, particularly car seats, often without a cushion. Contemporary cushions have not been designed to be compatible with car seats. Currently pressure ulcers are being triggered by car journeys. A cushion which has concessions and features to support its use on chairs/seats, particularly car seats, will prevent the pressure ulcers which are currently occurring as a result of the car journeys made without a cushion
Recommendations 17	Research Supposition:	20. Pressure relief routine
	Recommendation:	Ideally newly designed cushions will have removed the necessity for users to perform pressure relieving movements. For those users who might still have to perform pressure relieving movements, designs should facilitate their routine by providing a prompt when a pressure relieving movement is required
	Anticipated Benefit:	A design which incorporates a system for prompting a user to perform a pressure relieving movement will remove the anxiety from the user that they may miss an episode of pressure relieving movements which could lead to the development of a pressure ulcer. Prompting the users who have to adhere to a pressure relief routine will prevent the pressure ulcers which are currently being triggered by missed episodes of pressure relieving movements
Recommendation 18	Research Supposition:	21. Range of posture, 26. Slouched position
	Recommendation:	In future, design should ensure that a cushion can minimise the tissue distortion a user is subjected to regardless of the sitting position
	Anticipated Benefit:	Users will assume all manner of sitting positions regardless of the shape of the cushion. A cushion which does not have a fixed contour shape to capture the pelvis, but can adapt the shape of its support surface will not impose a non-matching contour on the shape of the user. Such a cushion will prevent the pressure ulcers which are currently occurring when a user slouches and the fixed contour no longer matches their body shape, distorting their skin and triggering a pressure

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Recommendation 19	Research Suppositions:	23. Securing cushion
	Recommendation:	Future designs should incorporate an attachment mechanism to securely fix the cushion to the wheelchair frame. To improve the usability of such a securing mechanism, particularly for those in the SCI community with limited hand function, this mechanism should be a simple snap shut and quick release mechanism which confirms attachment, possibly via an audible "*click*" or by visually changing colour. Additionally, the mechanism will have to be robust enough to withstand the twisting and pushing the cushion is subjected to during the user transferring to/from their wheelchair
	Anticipated Benefit:	A design which incorporates an attachment mechanism will make it easier for users to stop their cushions from sliding over the seat of their wheelchair. Securely fixing the cushion to the wheelchair frame will prevent the development of pressure ulcers which are currently occurring as a result of the cushion sliding forwards or backwards
Recommendation 20	Research Supposition:	25. Skin care vs posture compromise
	Recommendation:	In future, design should ensure that a gap does not exist between its ability to care for the skin and its ability to support posture
	Anticipated Benefit:	A cushion which is equally adept at skin care and postural support will remove the dilemma some users face when choosing a cushion to use. Being adept at both skin care and postural support will avoid having to make a compromise choice, and prevent the ramifications of using a cushion with either poor skin care or poor postural support.
Recommendations 21 and 22	Research Supposition:	27. Sweating
	Recommendations:	21. In future, design should ensure that cushions do not create micro-environments which are conducive to sweating
		22. In future, design should ensure that cushions have the capacity to draw away any sweat from the vicinity of the user's skin
	Anticipated Benefit:	At the support surface user interface, there is a micro-environment resultant from the heat and humidity generated by the user. A cushion which controls this micro-environment keeps the skin temperature low and allows air to circulate enabling the skin to breathe. Such an environment is not conducive to sweating. Failure to manage this micro-environment leads to a hot stifled climate which will prompt the skin to sweat. Excessive sweating is firstly an unpleasant experience for the user. Excessive sweating is also a hazard for the user as macerated skin is far more susceptible to pressure damage
Recommendation 23	Research Supposition:	28. Transfer issues (contour depth) 29. Transfer issues (stability)
	Recommendation:	In future, design should ensure that cushions include a transfer mode. When a user wants to transfer to/from their wheelchair, the user should be able to switch the cushion to a transfer setting. In this transfer mode the surface becomes hard, stable and flat
	Anticipated Benefit:	Providing a flat, firm, stable surface will make the transfer process less arduous for the user. Users are currently developing pressure ulcers as a result of unsafe transfers. A cushion which is easier to transfer to/from will reduce the occurrence of unsafe transfers with less pressure ulcers being triggered.

11.4 A New Approach to Cushion Design

Incorporation of all these recommendations will require a reappraisal of the concepts in cushion design. At present contemporary cushions are either of the static variety or the dynamic variety and they are categorised for use by patient pressure ulcer risk assessments, for example Karomed's Transoft cushion is categorised as being suitable for patients assessed to be at-risk, see figure 3-61.

Static cushions are based on the pressure-reduction principle, and dynamic cushions are based on the pressure-redistribution principle. It has been recommended that cushion designers should now look to innovate new means to minimise the deformation the user's skin is subject to when sitting, rather than continuing to persevere with pressure reduction/redistribution designs. Neither the static pressure-reduction cushion approach, nor the dynamic pressure-redistribution cushion approach has the potential to produce a high performance tissue distortion minimising cushion.

In the case of the fluid filled varieties of static cushions, such as air and gel, the movement of fluid immerses and envelopes the user. By conforming to the shape of the user's body the degree to which the tissue is distorted is minimised. However these fluids are passive and will migrate and disperse in an uncontrolled manner in response to the user's movements. This study has found that this lack of active fluid management leads to incorrect internal air pressure setting, bottoming out due to deflation, bottoming out due to gel dispersal, and the exaggeration of lateral leaning, all of which can result in the development of a pressure ulcer. This study also found that unmanaged fluid flow lacks the structure to support a user's posture.

In the case of the contoured foam varieties of static cushions, a bespoke contour foam cushion may match the shape of the user when sat in a "*normal sitting*" position but, as found by this study, users tend to spend considerable time sat in different positions such as a slouch, see sections 8.4.1 and 9.4.1. When a user slouches the fixed contour shape will no longer match the user's shape and its fixed contour will increase the level of tissue distortion the user experiences.

In the case of dynamic cushions the concept of alternating the load bearing points by definition distorts the tissue, with the load bearing points being compressed and the unsupported load free points sagging into the voids left by the deflated cells.

Contemporary cushions of both the static and dynamic varieties can be revised to include adaptations to increase their usability. For example the Varilite cushion currently relies on a non-slip base on its cover as its method for preventing the cushion from sliding about, see section 3.3.2.1. This is not very secure but the Varilite could be updated to include a securing system similar in nature to the Jay cushion, see section 3.3.5.1.

However, a number of the recommendations to improve and increase the usability of cushion design require more than additions and adaptations. For example both static and dynamic cushions are passive and require the user to react it they find themselves bottomed out. Bottoming out can be easily felt by a wheelchair user with sensation such as an elderly person with respiratory problems, however an SCI patient with no sensation could sit for a prolonged length of time and not notice that they have bottomed out. This study has found SCI patients using both air filled ROHO cushions and gel Jay cushions have bottomed out and that this has triggered pressure ulcers, see sections 8.3.4, 8.3.5, 9.3.4 and 9.3.5.

11.4.1 Recommendations

It is recommended that cushions should no longer be viewed as a single function device, namely a "*pressure relief*" cushion whereby the focus of cushion design is primarily directed at the single function of IP management. In the future cushions should be viewed as "*ulcer prevention*" (UP) devices instead of "*pressure relief*" (PR) devices. With this change in emphasis designers would have to adopt a more holistic view and not limit their task to IP management but aim to design a more complete pressure ulcer prophylactic.

The benefit to be gained by adopting this recommendation is that future designs, having been designed as a pressure ulcer prophylactic, will have been designed to eliminate and mitigate the pressure ulcer triggers and vulnerability multipliers associated with usability. These cushions will be better equipped to prevent the pressure ulcers which users are currently developing due to usability deficiencies with contemporary cushions.

It is recommended that the categories of static and dynamic cushions be relinquished as these design approaches lead to passive cushions totally dependent on input from the user.

In future, cushion designers should be creating active cushions, to reduce the cushion's dependency on input from the user. Such cushions would have the capacity to autonomously react to changes in the user's circumstances. This model of cushion could be categorised as either "*active*", "*smart*" or "*intelligent*", as opposed to contemporary cushions which would be categorised as "*passive*" cushions.

The benefits to be gained by adopting an active cushion approach are firstly, that an active cushion would be able to minimise the extent of distortion the user's skin is subject to. Using real time surface shape management the cushion will be able to constantly adjust to maintain a contour which conforms to the user's body shape as they assume different sitting positions. This would reduce shear stress in the sacrum when the user slouches and would compensate when the user leans to one side reducing the extent of distortion on the side being leaned on. This will reduce tissue distortion, which in turn will reduce the number of pressure ulcers which are occurring.

Secondly, not only will an active cushion be able to manage its surface shape it will also be able to address pressure ulcer triggers and vulnerability multipliers in real time. This will prevent the pressure ulcers which are currently being triggered by passive cushion weaknesses such as; incorrectly set air pressure; bottoming out events; the presence of foreign objects on the support surface; excessive cushion surface temperature; and the cushion being positioned on the wheelchair upside down.

Thirdly, active cushions would be a new source of data to provide better care and treatment of the user. In order to respond to the changes in the user's circumstances cushions would have to generate real time data relating to the user. These data could be recorded by incorporating into the design a small memory device to enable the real time data to be logged. These logged data would be directly beneficial to the user as it would enable staff to monitor and asses their condition and provide information which could help identify the cause of a pressure ulcer should one occur and thus prevent further pressure ulcers. Additionally, by collecting the logged data from many users, researchers could use these data to develop a better understanding of pressure ulcer development and the mechanics of sitting positions, posture and stability.

It is recommended that cushions should no longer be classified using categorises of risk taken from pressure ulcer risk assessments[1], see section 3.5.1. This classification system does not account for any usability issues or features appropriate for a particular patient group. Instead it arbitrarily assigns the cushions with the lowest mean and peak IP results with the highest at-risk status patients.

In future cushion design should not aim to create a range of cushions suitable for patients across the different risk categories, regardless of the nature of the disability. Instead they should aim to create a range of cushions designed to meet the different needs of the different patient groups within the wheelchair using population, regardless of risk assessments.

The benefits to be gained by adopting this recommendation are firstly, in future cushions will be designed so as to eliminate and mitigate the pressure ulcer triggers and vulnerability multipliers associated with a patient group. For example, two wheelchair users have been assessed to be at a high-risk of developing a pressure ulcer, however one of the users has a SCI and the other is an amputee. As a user with a complete SCI will have no sensation, this user will have different usability issues which the cushion has to address than the amputee who does have sensation.

Secondly, by designing cushions for a patient group rather than perpetuating a system of cushions intended for use by a particular patient risk level the hazard associated with the errors surrounding the cut-offs between assessment categories is removed.

[1] The use of risk assessments tools is discussed in section 3.5.2

11.4.2 A Second Generation of Cushion Design

The current generation of cushions are fundamentally a product of the early 1970's as their designs remain based on the science and technology of that time, see sections 3.3 and 4.5.7. It was concluded that with the advancements made over the last forty years, it would be advantageous to view contemporary PR cushions as a first generation of cushion design so as to encourage new approaches to be innovated.

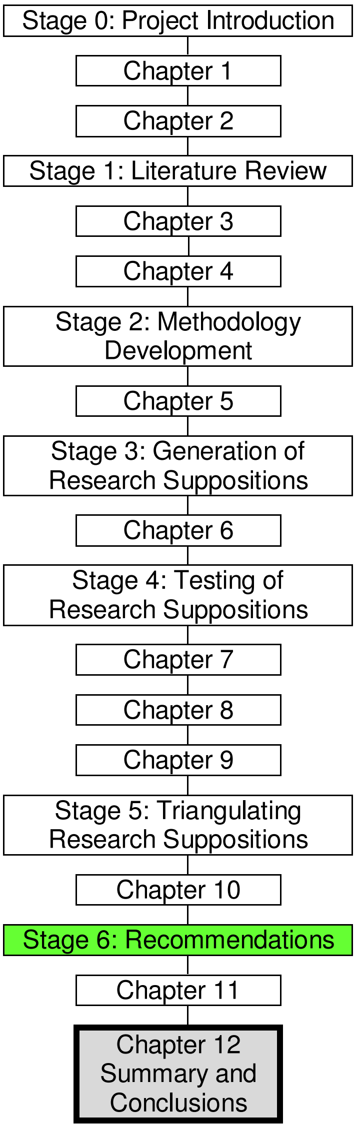
A second generation cushion, incorporating the recommendations of this project, would require a shift in how current cushion design is perceived. It is proposed here that the current concepts of passive static and dynamic cushions should be superseded by a new approach. This new approach of second generation cushions would lead to the creation of an active cushion designed to be a "*surface environment management system*". These active cushions would be targeted at specific patient groups, such as SCI patients; actively minimise tissue distortion; and provide better usability functionality.

How an active cushion might be constructed has not been considered at this point. The object of this project is to provide data to contribute to the "*Need Identification and Analysis*" phase of a design process. The recommendation of an active cushion is the product of identifying and analysing the user's needs; the discussion of specific technologies to construct an active cushion falls under the purview of the next phase of a design process "*Technology Identification*", see figure 5-2. Further, specific technologies are intentionally not listed or described at this juncture to avoid possibly prejudicing future designs by suggesting a line of development thereby clouding original thought and novel solutions.

Chapter 12

SUMMARY AND CONCLUSIONS

12.1 Introduction



This closing chapter of the thesis begins with a summary of the work undertaken during this project. It then considers the aim and objectives of this project, and lists the key points raised by this work.

This chapter then considers the material covered over the course of this project and identifies a number of subjects within the pressure ulcer knowledge base which if further work was conducted to improve the depth of understanding would assist designers of cushions.

This chapter is drawn to a close by highlighting the original contributions of this project and suggests the possible next step for the future following this project.

12.2 Summary

This project began with a literature review of contemporary PR cushions. Having reviewed the two leading concepts in cushion design, static and dynamic cushions, concerns were raised about the principles of pressure-reduction and pressure-redistribution from which these concepts are derived. This review also considered the leading PR cushions in current use, such as the ROHO and the Vicair, and found specific weaknesses in their designs such as the management of internal air pressure. In addition, this review found weaknesses in how cushion efficacy is assessed; how posture is managed; the practice of pressure relieving; how cushions are categorised by patient at-risk status and the cushion's usability.

A second literature review was undertaken to examine the knowledge base relating to pressure ulcer prevention from which the two principles of pressure-reduction and pressure-redistribution were derived. Issues such as contributing factors, interface pressure (IP), shear, friction, pressure gradients, tissue distortion and the pressure intensity-duration relationship were considered. It was found that there are certain inherent weaknesses in the understanding of these issues and concluded that the principles of pressure-reduction and pressure-redistribution are at least over simplified and possibly fundamentally flawed.

It was then decided to investigate further the issue of cushion usability drawing from the concept of user-centred design and in particular the methodology designed for assistive technology, USER*fit.* The new methodological framework developed for this project encompassed a range of research methods and included the validating technique of "*Methodological Triangulation*".

The first stage this of project was to collect qualitative data from SCI patients and from staff working in SCI centres. Based on the gathered data thirty research suppositions on cushion usability were proposed.

These research suppositions were then used to design two questionnaires to gather quantitative data from SCI patients and staff in SCI centres.

The data extracted from the literature, the qualitative study and the quantitative study were then triangulated in order to establish a level of confidence in the research suppositions. Out of the thirty research suppositions twenty were rated as "*high*" in confidence, seven as "*moderate*" and three as "*low*".

The twenty seven research suppositions which achieved a confidence level of high or moderate were used to form a set of recommendations for designers to use as a guide for creating new and more advanced cushions which would be better than contemporary cushions in preventing pressure ulcers.

Despite the use of PR cushions, wheelchair users are still developing pressure ulcers on the seat area of their body. In order to reduce the incidence of pressure ulcers in the future, a new approach leading to the creation of a new generation of cushions is suggested. These second generation cushions would differ from the first generation of static/dynamic cushions by moving the emphasis of cushion design from pressure (IP) management, by either pressure-reduction or pressure-redistribution, to surface environment management. In order to do this a second generation of "*smart*" cushions would need to use real time data to control the surface shape in order to minimise the extent to which the user's skin is distorted when sitting and to manage usability issues such as moisture and the presence of foreign objects.

12.3 Conclusions

12.3.1 The Aim and Objectives

The aim of this project was to develop new insights which PR cushion designers can then use to guide the design of new cushions with greater efficacy at preventing pressure ulcers than contemporary cushions.

In order to achieve this aim, two project primary objectives were set. The first objective, "*The identification of weaknesses and/or deficiencies in contemporary pressure relief cushion design*" was achieved by undertaking a series of research activities which found weaknesses in the principles which underpin cushion design and the usability of cushions. The second objective, "*The production of a set of recommendations for the design of future pressure ulcer preventative cushions*" was completed by the production of a set of recommendations which encompassed the principles which underpin cushion design, cushion usability, and the future direction of cushion design. These recommendations are a means to communicate the new insights developed by this project, which designers can now use to guide the creation of new cushion designs with greater efficacy at preventing pressure ulcers. Therefore the aim of this project has been met through the development of these recommendations.

12.3.2 Key points

Although current PR cushion designs have kept the incidence rate of pressure ulcers stable for 40 years, they have not been able to reduce their incidence.

It is suggested that the practice of prioritising interface pressure to the point of defining cushions as "*pressure relief*" (PR) cushions is misleading and detrimental to design and should be abandoned. Instead cushions should be redefined as "*ulcer prevention*" (UP) cushions in recognition of the multi factorial nature of pressure ulcer development and that in fact many pressure ulcers are the result of factors not related to pressure.

The two original guiding concepts of pressure-reduction and pressure-redistribution are not comprehensive and have led designers to focus primarily on interface pressure management. It is a recommendation of this project that a new concept should supersede these two concepts. This new concept would be to manage the surface environment rather than to manage interface pressure. The concept of surface environment management is intended to guide designers towards creating second generation cushions. These next generation cushions would be "*smart*" and use real time data to control the surface shape so that the extent to which the user's skin is distorted when sitting is minimised and that usability issues such as moisture and the presence of foreign objects are controlled.

It is a conclusion of this project that whilst the practice of categorising pressure ulcer risk factors by where they act on the body either internally as "*intrinsic*" risk factors or externally as "*extrinsic*" factors may well be factually correct it would be beneficial to designers if a new method of categorisation were developed. This new method would categorise risk factors as being either a "*vulnerability multiplier*" which a designer would have to mitigate or a "*trigger*" which a designer would have to eliminate.

It suggested that rather than designing cushions for the different categories of pressure ulcer risk assessment tools, such "*high risk*" or "*very high risk*", cushions should be designed for specific patient groups such as SCI patients or amputees.

On reflection, the stagnation found in cushion design appears to be a symptom of the historical perception of the nature of pressure ulcers. Until the 1970's pressure ulcers were perceived as a nursing problem not a medical problem, see section 4.2. To some extent this perception persists as the occurrence of a pressure ulcer is often regarded as a consequence of neglect. In relation to PR cushions when a pressure ulcer occurs on the seat area of the body it is not seen as the consequence of unsatisfactory equipment and weak design, but some other reason such as the selection of the wrong cushion, user error or simply an accidental oversight, for example using a cushion upside down. This inability to recognise and acknowledge the shortcomings in the performance of a cushion has allowed designers to assume that they are in general satisfying the needs of the user. Under these circumstances it is understandable that cushion design has not made any great strides since their inception forty years ago.

12.3.3 Further work

Although not directly associated with cushion design this project has found certain areas of understanding to be limited. With further work in the following areas, the knowledge base upon which cushion design is founded would be improved. This in turn would provide new insights which would assist in the development of new more effective approaches to pressure ulcer prevention.

12.3.3.1 Reappraise how contributing factors are categorised

It was found that whilst there are other methods for categorising pressure ulcer risk factors such as "*major risk factors*" and "*potential physical risk factors*", as described by Bryne (1996), it is common to categorise pressure ulcer risk factors by where they act upon the body either internally, such as hydration, or externally such as friction. Whether these categories are labelled *intrinsic*, *extrinsic, exacerbating* or *external* factors, this distinction remains an arbitrary, although technically correct, distinction. The purpose for making this distinction, between acting internally and externally, is not that apparent.

It would be beneficial for the design of cushions for a new system of categorising pressure ulcer risk factors to be developed. This system would categorise a risk factor as a pressure ulcer "*trigger*" or a pressure ulcer "*vulnerability multiplier*". A trigger would be a risk factor which if introduced would be likely to trigger the development of pressure ulcer. For example one of the exacerbating factors is "*hygiene*", this would be a trigger as the use of a dirty cushion can trigger a pressure ulcer. A pressure ulcer vulnerability multiplier would be a risk factor whose presence or influence when increased would be likely to result in the development of a pressure ulcer. For example one of the exacerbating factors is "*increased skin temperature*", this would be a vulnerability multiplier because as the temperature is increased the likelihood of developing a pressure ulcer is increased.

Armed with a list of triggers cushion designers would know what factors need to be eliminated, and with a list of vulnerability multipliers would know what factors to mitigate.

12.3.3.2 Reappraise the definition of pressure ulcers

In chapter 4 the definition used to define the wound referred to as a "*pressure ulcer"* was considered. It was found that there is a general agreement that a pressure ulcer is a localised area of damage, typically occurring over a bony prominence, caused by pressure, shear, friction and/or a combination of these.

This definition should be treated with caution. The use of the terms pressure, shear and friction is overly simplistic to the point of being misleading. It also does not reflect the various manifestations which may present, such as the pressure ulcer now referred to as a deep tissue injury (DTI); the pressure ulcer with intact unbroken skin and non blanching erythema, commonly referred to as grade 1 ulcer; and the pressure ulcer with undermining. Further, whilst the current name and definition of pressure ulcers emphasises pressure as the cause of a pressure ulcer, this definition does not reflect that it is not the intensity of the pressure which causes a pressure ulcer, but the extent to which the tissue is stressed through deformation which is the determinant in the outcome of tissue damage.

As our understanding has improved pressure ulcers have already undergone one name change, namely the change from "*bed sore"* to "*pressure ulcer"*. Perhaps the time has come to reappraise the name and definition, to reflect the improvements in how pressure ulcers are understood to develop, such as a "*deformation wound"* or a *"distortion injury"*. This would be of benefit to cushion designers as this would help to ease their focus from pressure management towards minimising tissue distortion.

12.3.3.3 Reappraise the system for categorising pressure damage

It was found that there are a variety of systems for categorising the degree of penetration achieved by a pressure ulcer. These systems are variously referred to as classification, grades or stages. Whilst there is consensus that there should be a system for categorising the spectrum of pressure ulcers based on depth of penetration, this variety of systems reflects the lack of consensus on the start point of pressure damage and the divisions used to scale this spectrum of damage. This lack of consensus is in part due to dissatisfaction with the utility and reliability of these systems.

These classification, grading or staging systems are central to the recording of pressure ulcer incidence which in turn is used to assess outcomes. It is probable that in future some assessments of cushion design will use incidence data based on a classification, grading or staging system.

With a number of versions of grading scale having already been designed it is unlikely that another attempt at designing a grading scale will lead to an improvement. Now might be the time to reappraise the purpose of categorising pressure ulcers as this might yield a new approach to recording the incidence rates of pressure ulcer damage, perhaps something more transparently linking the occurrence of an ulcer with the risk assessment of the patient.

12.3.3.4 Appraise the influence of the dominant side of individuals

It was found that there is a difference in the incidence of pressure ulcers between the left hand side of the body and the right hand side, with more pressure ulcers occurring on the right hand side than the left. Also, whilst more right handed individuals are developing pressure ulcers than left handed, the difference in incidence rate does not reflect the 9:1 ratio of right to left hand people, see section 8.2.3.

Currently the 'handedness' of individuals is not regarded as a factor in the development of a pressure ulcer. However, the difference in incidence between the left and right hand side does suggest that handedness has an influence on the development of a pressure ulcer.

At present the role and influence of handedness has received little attention. Through an improvement in the understanding of this phenomenon a better insight into how pressure ulcers develop will be gained from which it will be possible to formulate better strategies to prevent them.

The data logging facility, made possible with a second generation of "*smart*" cushions, would be a potentially rich source of data for studying this phenomenon.

12.3.4 Original Contribution of this Thesis

This project is original and unique in that it has provided a set of recommendations suggesting new directions for cushion design. Whilst some of the recommendations are just a restatement of known issues, such as the management of moisture, there are a number of recommendations which are new contributions to the field of cushion design.

- It is current practice to categorise the known pressure ulcer risk factors as either "*intrinsic*" or "*extrinsic*" factors whereby the intrinsic factors act internally to the patient, such as nutrition, and extrinsic factors act externally, such as moisture, see section 4.4. This thesis has produced the recommended that the method for categorising pressure ulcers should be revised. Instead risk factors should be categorised as either pressure ulcer "*triggers*" or "*vulnerability multipliers*", whereby a trigger would be a factor which could instigate a pressure ulcer, such as sitting on a catheter; whilst a vulnerability multiplier would be a factor which increases the likelihood of an occurrence, such as an increase in ambient temperature, see section 12.3.3.1.
- Contemporary pressure relief cushions are currently designed to reduce the interface pressure the user is subjected to when sitting in a wheelchair. Whilst contemporary PR cushions do address some usability functions, for example the Jay cushion have incorporated clips into their cushion so that users can secure the cushion to a wheelchair see figure 3-47, the usability of a cushion is not fully recognised for its role in preventing pressure ulcers. Therefore this thesis has recommended that cushions should no longer be perceived as a "*pressure relief*" (PR) cushion with one primary task, that of managing IP. Instead cushions should be perceived as "*ulcer prevention*" (UP) cushions so that the focus of cushion design is widened from reducing pressure to encompass the issues of usability, see section 11.4.1. Thus, new cushions will be designed with the range of pressure ulcer "*triggers*" and "*vulnerability multipliers*" more in mind, instead of focusing on just the one pressure ulcer factor, interface pressure.

- Although still to be proven, it is the position of this thesis that it is the degree to which tissue is distorted rather than the magnitude of the interface pressure which induces tissue damage, see sections 4.5.5, 4.5.6 and 4.5.7. Therefore this thesis has recommended that cushion design should no longer focus solely on IP management as indicated by the principles of pressure-reduction and pressure-redistribution but develop the concept of surface environment management in order to maintain the user's body shape and thereby minimise the extent to which the tissue is distorted, see section 11.2.1.

- The design of pressure relief cushions has always followed either the static concept based on pressure reduction or the dynamic concept based on pressure redistribution. This thesis has recommended that today's contemporary cushions should now be perceived as the first generation of cushions. Unlike the passive relationship of first generation static and dynamics cushions, the next generation of cushion design should engage in the development of smart or intelligent cushions which have an active, responsive relationship with the user, see section 11.4.2.

- This thesis has recommended that it would be advantageous for a new second generation cushions to incorporate a data logging system. The data to be logged would be the real time pressure map data used by a "*smart*" cushion to manage the surface environment, see section 11.4.2. Such a system could lead to new insights into pressure ulcer development by providing data on sitting positions, user behaviour and stability/balance issues, prior to the development of a pressure ulcer

- It is standard practice to use a cushion's ability to manage IP as a guide to its suitability for use by patients assessed to be at a certain level of risk of developing a pressure ulcer, see section 3.5.1. This thesis has recommended that this practice should be superseded. In future cushions should be designed to match the needs of the different patient groups who use wheelchairs, such as SCI patients, regardless of the at risk status of the patient.

12.3.5 Future work

The ultimate goal is to provide wheelchair users with a cushion which is more effective at preventing pressure ulcers than the cushions currently available. It was recognised that this would not be a simple challenge as there already a number of large established medical equipment manufactures which have been producing millions of PR cushions over the past few decades.

This project has resulted in a set of recommendations to guide future cushion design. The completion of this project marks the completion of this first step in designing a new more effective cushion. The next step will be to utilise these recommendations and develop a prototype "*smart*" cushion, based on the new concept of surface environment management.

To develop this prototype funding will be required and so the first action after this project will be to produce a proposal to take to funding bodies. At the time of writing, it is anticipated that the first organisation which will be approached on the matter of funding will be ATcare, a spin off organisation from NHS Innovations.

Appendix A: The Level of Injury on the Spinal Column

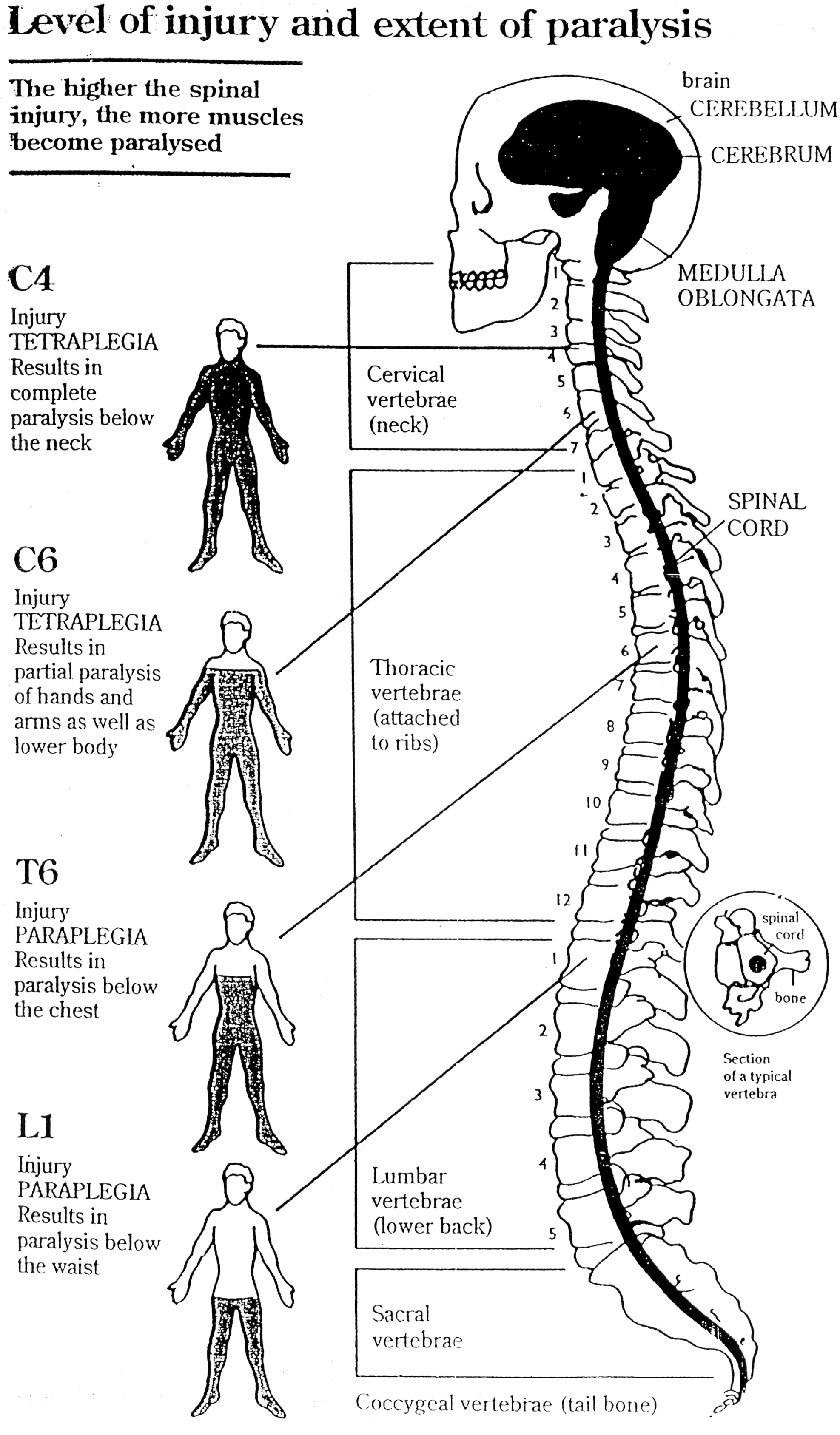


Figure A-1 A diagram showing the level of injury on the vertebral column and the extent of the resultant paralysis (Spinal Outpatient Service 2004)

Appendix B: Literature Search Strategy

A literature search strategy was developed by referring to texts on conducting literature reviews, by considering how other reviewers had performed their searches and by referring to the NHS Centre for Reviews and Dissemination (CRD) guidance on conducting reviews (CRD 2001). This CRD report was cited by the *Royal Collage of Nursing* (Yerrell *et al* 2003 reprinted 2005) and by the *Health Technology Assessment NHS R&D HTA Programme* (Cullum *et al* 2001).

B.1 Electronic Databases

The medical electronic databases *CINHAL*, *EMBASE* and *MEDLINE* were searched using *OvidSP*. The design/engineering electronic databases *Compendex*, *Taylor & Francis Journals* and *Wiley InterScience* were also searched.

Search strategies were developed and amended according to the database used. The key words used were:

Alternating pressure
Assessing
Assessment
At risk
Classification
Complications
Cost
Cushion
Damage
Decubitus sore
Decubitus ulcer
Design
Dynamic
Epidemiology
Evaluation
Exacerbating
Extrinsic
Friction
Grading
Incidence
Injury
Interface pressure
Interstitial
Intrinsic
Ischemia
Ischemic
Ischial tuberosity
Lymphatic
Management
Paraplegia
Paralysis
Posture
Pressure area care
Pressure gradient
Pressure map
Pressure mapping
Pressure redistribution
Pressure reduction
Pressure relief
Pressure sore
Pressure ulcer
Prevalence
Prevention
Reactive Hyperaemia
Rehabilitation
Reperfusion injury
Reposition
Risk assessment
Risk factors
Tissue
Treatment
Trochanter
Sacrum
Seating
Shear
Spinal cord injury
Staging
Static
Support surface
Wheelchair
Wheelchair user
Wound

B.2 Hand Searches

The following journals in the field were searched.

- *Advances in Skin and Wound Care*, 2000 – present
- *Advances in Wound Care*, 1998 – 1999
  (later *Advances in Skin and Wound Care* - searched until present)
- *Journal of Tissue Viability*, 1998 – present
- *Journal of Wound Care*, 1998 – present
- *Journal of Wound, Ostomy and Continence Nursing,* 1998 - present

B.3 The Internet

The websites, online archives and online conference proceedings of the following organisations, institutions, societies and cushion manufacturers were searched:

Aquila Corporation
British Medical Journal (BMJ)
European Pressure Ulcer Advisory Panel (EPUAP)
Foundation for Assistive Technology (FAST)
Invacare Inc.
Multidisciplinary Association of Spinal Cord Injury Professionals (MASCIP)
National Pressure Ulcer Advisory Panel (NPUAP)
Posture and Mobility Group (PMG)
ROHO Inc.
Spinal Injury Association (SIA)
Sunrise Medical Inc.
Tissue Viability Society (TVS)
Varilite
Vicair B.V.
World Wide Wounds

Appendix C: A Breakdown of the Airpulse PK Cushion

A. *Cushion is made of soft, durable neoprene rubber (no latex) and comes in six standard sizes or a custom size can be made.*
B. *Individual cells can be isolated so they do not inflate under an existing pressure sore and after the sore is healed can be easily reconnected to the system for normal operation.*
C. *Air cells have internal bladders for extra strength and are reinforced with foam for safety to prevent a bottoming out event.*
D. *Ischial cells have a Velcro backing and can be repositioned as desired or removed to make room for a wound vac.*
E. *Deflated air is channeled to the pad surface on ever cycle for positive ventilation to help keep the skin dry.*
F. *Cushion cover is constructed of 4-way stretch breathable nylon top and non-slip bottom.*
G. *Charger (Double Battery and Hybrid Models) is fully automatic and plugs directly into the controller to charge the battery. No need to remove the battery pack. International models available.*
H. *User adjustable firmness setting give you control over cushion inflation pressure.*
I. *User adjustable cycle times give you control over frequency of inflation.*
J. *Visual and audible indicators for pressure fault and low battery alert.*
K. *Power cables (Power chair Model) with a quick disconnect attach directly to the battery terminals and draw power evenly from both chair batteries.*
L. *Mini Remote Control (optional) with On/Off switch, system status, low pressure, and battery status indicator lights and beeper.*
M. *Air Hose (29 in.) from controller to cushion.*
N. *Deluxe Remote Control is an optional accessory that allows you to operate the system without accessing the control box. All system settings can be changed using the Deluxe Remote Control.*

Figure C-1 A breakdown of the component parts of the Airpulse PK (Aquila Corp. 2008c)

Appendix D: A Summary of Widely Used Risk Assessment Tools

Risk Assessment tool	Care Group	Predisposing Factors	Scoring System
Norton Score (Norton *et al* 1962)	Elderly Patients	General Physical Condition, Mental State, Activity, Mobility, Incontinence	The lower the score the higher the risk Max score 20, min 5. Less than 14 – liable to develop ulcer Less than 12 – risk very great
Knoll Score (Abruzzese 1982)	Acute Care Patients	General State of Health, Mental Status, Activity, Mobility, Incontinence, Oral Nutritional Intake, Oral Fluid Intake, Predisposing Diseases (Diabetes, neuropathies, vascular diseases, anemias)	The higher the score the higher the risk Highest score 33 Scores above 12 indicate high risk Borderline potential to develop a pressure ulcer; 2-3 above or below 12
Waterlow Score (Waterlow 1985)	Acute Care Patients	Build/Weight for Height, Continence, Skin Type Visual Risk Areas, Mobility, Sex/Age, Appetite, Special Risks (Tissue Nutrition, Neurological Deficit, Major Surgery/Trauma, Medication)	The higher the score the higher the risk 10 - 14 = at risk 15 – 19 = high risk 20+ =very high risk
Douglas Score (Prichard 1986)	General Medical Ward Patients	Nutritional state/haemoglobin, Activity, Incontinence, Pain, Skin State, Mental State, Special Risk Factors (Steroid Therapy, Diabetes, Cytotoxic therapy, Dyspnoea)	The lower the score the higher the risk. Highest score 24 Scores below 18 indicate patient at risk
Braden Score (Bergstrom *et al* 1987)	Nursing Home Patients	Sensory Perception, Moisture, Activity, Mobility, Nutrition, Friction and Shear	The lower the score the higher the risk Highest score 23, indicating low risk Lowest score 6, indicating high risk
Lowthian Score or Pressure Sore Prediction Scale Score (Lowthian 1987)	Orthopaedic Patients	Sitting up, Unconscious, Poor General Condition, Incontinence, Lift ups, Get up and walks	The higher the score the higher the risk Highest score 16 Scores above 6 indicate patient at risk

Table D-1 A summary of some of the more widely used assessment tools

Appendix E: User Centred Design in Assistive Technology

This premise of placing the user at the centre of the design process is pertinent to designing for aging and disabled users, as noted by Poulson. Poulson reported that in response to the negative perception of aging and disability in our society it is common for those with disabilities to try to deny or hide their disability, and so many reject aids which are overtly medical in appearance or in someway project a negative self-image. As a case in point Poulson highlights the design of plates designed for the visually impaired. Some of these plates are functionally good having been designed with raised edges to stop food from falling off however these designs are disliked as they are similar in appearance to children's bowls (Poulson and Richardson 1998).

A user involvement/user-centred approach can be brought to the design process by employing a user-centred methodology. The potential benefits from this has been realised by many in the Assistive Technology (AT) profession, who have since adopted user-centred methodologies and techniques within their own design processes.

This adoption of user-centred design is reflected by the subject featuring in assistive technology conferences. For instance, in 2006, Robin Gibbons, Head of Functional Electrical Stimulation (FES) rowing at the ASPIRE National Training Centre, Stanmore, gave a presentation on FES and its health benefits to the Recent Advances in Assistive Technology and Engineering (RAATE) annual conference organised by the Institute of Physics and Engineering in Medicine (IPEM). He also discussed how, as someone with paraplegia, he has been able to contribute to the project in his capacity as a user (Gibbons 2006).

Appendix F: Strengths and Weaknesses with Qualitative and Quantitative Research

Strengths and Weaknesses of Quantitative Research

Strengths

- Testing and validating already constructed theories about how (and to a lesser degree, why) phenomena occur.
- Testing hypotheses that are constructed before the data are collected. Can generalize research findings when the data are based on random samples of sufficient size.
- Can generalize a research finding when it has been replicated on many different populations and subpopulations.
- Useful for obtaining data that allow quantitative predictions to be made.
- The researcher may construct a situation that eliminates the confounding influence of many variables, allowing one to more credibly assess *cause-and-effect* relationships.
- Data collection using some quantitative methods is relatively quick (e.g., telephone interviews).
- Provides precise, quantitative, numerical data.
- Data analysis is relatively less time consuming (using statistical software).
- The research results are relatively independent of the researcher (e.g., effect size, statistical significance).
- It may have higher credibility with many people in power (e.g., administrators, politicians, people who fund programs).
- It is useful for studying large numbers of people.

Weaknesses

- The researcher's categories that are used may not reflect local constituencies' understandings.
- The researcher's theories that are used may not reflect local constituencies' understandings.
- The researcher may miss out on phenomena occurring because of the focus on theory or hypothesis *testing* rather than on theory or hypothesis *generation* (called the *confirmation bias*).
- Knowledge produced may be too abstract and general for direct application to specific local situations, contexts, and individuals.

Figure F-1 A list of the strengths and weaknesses found with the quantitative research approach (Johnson and Onwuegbuzie 2004)

Strengths and Weaknesses of Qualitative Research

Strengths

- The data are based on the participants' own categories of meaning.
- It is useful for studying a limited number of cases in depth.
- It is useful for describing complex phenomena.
- Provides individual case information.
- Can conduct cross-case comparisons and analysis.
- Provides understanding and description of people's personal experiences of phenomena (i.e., the "emic" or insider's viewpoint).
- Can describe, in rich detail, phenomena as they are situated and embedded in local contexts.
- The researcher identifies contextual and setting factors as they relate to the phenomenon of interest.
- The researcher can study dynamic processes (i.e., documenting sequential patterns and change).
- The researcher can use the primarily qualitative method of "grounded theory" to generate inductively a tentative but explanatory theory about a phenomenon.
- Can determine how participants interpret "constructs" (e.g., self-esteem, IQ).
- Data are usually collected in naturalistic settings in qualitative research.
- Qualitative approaches are responsive to local situations, conditions, and stakeholders' needs.
- Qualitative researchers are responsive to changes that occur during the conduct of a study (especially during extended fieldwork) and may shift the focus of their studies as a result.
- Qualitative data in the words and categories of participants lend themselves to exploring how and why phenomena occur.
- One can use an important case to demonstrate vividly a phenomenon to the readers of a report.
- Determine *idiographic* causation (i.e., determination of causes of a particular event).

Weaknesses

- Knowledge produced may not generalize to other people or other settings (i.e., findings may be unique to the relatively few people included in the research study).
- It is difficult to make quantitative predictions.
- It is more difficult to test hypotheses and theories.
- It may have lower credibility with some administrators and commissioners of programs.
- It generally takes more time to collect the data when compared to quantitative research.
- Data analysis is often time consuming.
- The results are more easily influenced by the researcher's personal biases and idiosyncrasies.

Figure F-2 A list of the strengths and weaknesses found with the qualitative research approach (Johnson and Onwuegbuzie 2004)

Appendix G: Some Weaknesses of the Pragmatic Approach to Research

Some Weaknesses of Pragmatism

- Basic research may receive less attention than applied research because applied research may appear to produce more immediate and practical results.
- Pragmatism may promote incremental change rather than more fundamental, structural, or revolutionary change in society.
- Researchers from a transformative-emancipatory framework have suggested that pragmatic researchers sometimes fail to provide a satisfactory answer to the question "For whom is a pragmatic solution useful?" (Mertens, 2003).
- What is meant by usefulness or workability can be vague unless explicitly addressed by a researcher.
- Pragmatic theories of truth have difficulty dealing with the cases of *useful but non-true* beliefs or propositions and *non-useful but true* beliefs or propositions.
- Many come to pragmatism looking for a way to get around many traditional philosophical and ethical disputes (this includes the developers of pragmatism). Although pragmatism has worked moderately well, when put under the microscope, many current philosophers have rejected pragmatism because of its logical (as contrasted with practical) failing as a solution to many philosophical disputes.
- Some neo-pragmatists such as Rorty (and postmodernists) completely reject correspondence truth in any form, which troubles many philosophers.

Figure G-1 A list of some of the weaknesses found with the pragmatic approach to research (Johnson and Onwuegbuzie 2004)

Appendix H: Buckinghamshire New University Ethics Policy

Ethics Policy

Effective from 10 June 2009

Contents

Preamble

All University formal documents relate to the policies, strategies, procedures and regulations of the University having been approved by the appropriate formally recognised and constituted body. All University staff and students are required to adhere to the formal processes and regulations of the University.

This document should not be read in isolation as other University processes/formal documents could be relevant. A full listing of all formal documents is available on the University's website.

Any interpretation of the content of this formal document will be at the discretion of the Chair of the University Research Committee.

All previous versions of this document as approved by Senate before June 2009 shall be rescinded.

The names of committees and titles of posts may change from time to time. This shall not invalidate the powers of the equivalent successor committees or post holders.

If required this formal document is available in an alternative format eg Braille, tape, disc, email or a larger font size. Please contact Student and Academic Services.

1 Guiding Principles

The University recognises its obligation to maintain high ethical standards across the breadth of its activities.

The University seeks to achieve this through raising awareness of ethical issues through debate and by formulating codes, guidelines and procedures as are necessary to ensure that a high regard to ethical, social and environmental issues is embedded throughout its activities.
Definitions and manifestations of ethical issues are subject to change. Therefore the development of codes of practice, guidelines and procedures will be an ongoing process.

2 Ethical Principles & Considerations

In broad terms, ethical considerations apply to all activities in the University.

The Nolan Committee Report on 'Standards in Public Life' (1995) indicated seven principles of conduct which underpin public life: integrity; selflessness; objectivity; accountability; openness; honesty; and leadership, and all members of staff are expected to embrace these principles.

All members of staff should observe codes of professional conduct that may relate to their specific discipline or area and be familiar with relevant internal policies and procedures that are in place (e.g. Data Protection Policy).

3 Ethics and Research

A more specific and well-recognised area of ethical consideration relates to research projects. All researchers are expected to conduct their research in accordance with internationally accepted ethical and professional standards and ensure they are cognisant of the University Code of Good Research Practice.

Researchers are expected to be honest in respect of their own actions in their research and in their responses to the actions of other researchers. Anyone who witnesses or suspects fraud or misconduct, should raise concerns with their line manager. Misconduct in research not only implicates the individuals directly responsible, but also threatens the integrity of all individuals associated with the research and the integrity of the University. The University will investigate all allegations of research misconduct fully and expeditiously.

When researchers cannot avoid real or perceived conflicts of interest, they should consult with their Supervisor or Line Manager in the first instance and take active steps to minimise bias, flawed judgement, harm or exploitation.

Researchers should be aware of and stay informed of professional, institutional and governmental regulations and policies in proposing, conducting and reporting research.

4 Fundamental Ethical Standards for Research Involving Human Participants

The University recognises the following general standards that apply to research involving human participants and have been widely adopted by diverse disciplines:

4.1 No research should cause harm (Non-maleficence):

Researchers have a duty to avoid, prevent, or minimise harm to others in the widest sense. Participants should not be subjected to unnecessary risks or discomfort and their participation in the project must be essential to achieving aims that could not be realised without their participation. The principle of minimising harm also requires that the minimum number of participants that will ensure valid data should be employed.

4.2 Research should ideally benefit the participant (Beneficence):

The physical, mental and social well being of the participant should be promoted. Protection of the participant is the most important responsibility of the researcher.

4.3 Consideration should be given to the risks versus the benefits of the study:

Ethics concerns minimisation of risk and weighing risk against benefits. All researchers should be aware of the ethical issues that may arise in the course of their work and should be encouraged to take responsibility for their own ethical actions.

4.4 Respect for justice:

Everyone involved in a project should be treated fairly. Researchers should weigh up and make judgements about competing claims and interest of all involved in the research, regardless of the vested interests of the researchers. Participants should be selected in an equitable way avoiding any populations that may be coerced into taking part. There should be equality in distribution of benefits and risks among the population group(s) likely to benefit from the research.

4.5 Researchers should seek free and informed consent from participants:

Participants must give their informed consent before taking part in a study. Valid consent must be given voluntarily (not forced by coercion or manipulation) by participants who are competent (not undermined by mental status, disease or emergency) and given sufficient information (i.e. 'informed') to make the judgement. Issues may arise where there are power imbalances or where informed consent is not always methodologically feasible. Participants should be informed of: the purpose of the research and the procedure to be followed; any potential benefits from participation; any potential risks or discomfort; the extent to which the results will be kept confidential; contact details of the researcher and given a statement that participation is voluntary and that they are free to withdraw from the study at any time without penalty.

4.6 Honesty should be central to the relationship between research and participant:

Deception (i.e. providing false information to the participant about the nature and/or purpose of the study) is discouraged, but on the rare occasion that it is required in order to conduct a valid research study the researcher must provide an in-depth justification that the use of deception is essential to the study. In this instance it is imperative that the participants are debriefed as soon as possible following their involvement to inform the participant about deceptive aspects of the study and to alleviate any stress or other undesirable feelings that the study may have caused. The use of one-way mirrors for observation in any study must be clearly justified.

4.7 Researchers should respect privacy and confidentiality of participants:

Researchers should take precautions to protect confidentiality of participants and data. Standards of privacy and confidentiality protect the access, control and dissemination of personal information. (Research that makes reference to the deceased may raise issues of privacy and confidentiality with regard to living relatives).

4.8 Consent of vulnerable people or groups or their representative's assent should be actively sought:

Respect for human dignity entails an ethical obligation towards vulnerable people or groups whose diminished decision making capacity makes them vulnerable. Vulnerable people include children, prisoners and adults with mental health problems or learning disabilities. The consent of individuals in a potential dependency relationship where there is an imbalance of power (e.g. students, patients and employees) should be carefully considered as their willingness to participate may be unduly influenced by the relationship.

4.9 Collection and storage of research data must comply with the Data Protection Act (1998) and other legislation:

Researchers are expected to comply with the Data Protection Act (1998) and comply with the University Data Protection Policy and Guidelines.

5 Ethics Framework

The University has adopted a two-tier approach using a checklist for all research to determine whether a research proposal requires full ethical review. The checklist will determine whether formal ethical review is required, and, if so, by which reviewing body. Where the potential for risk of harm to participants and others affected by the proposed research is minimal, an expedited review will be carried out. All research requiring formal ethical review will normally be submitted to the requisite

Faculty Research Ethics Committee. Approval for any research proposals involving NHS patients, patient records, staff or premises should be submitted using the NHS online Integrated Research Application System (IRAS). The University Research Ethics and Governance Committee will monitor and review the University's Ethics Framework in the light of the external ethics environment and will propose changes as required.

6 References and Further Sources of Information

The University Code of Good Research Practice

Medical Research Council Ethics and Research Governance:
http://www.mrc.ac.uk/Newspublications/Publications/Ethicsandguidance/index.htm

British Psychological Association – Code of conduct, ethical principles and guidelines:
http://www.bps.org.uk/the-society/code-of-conduct/code-of-conduct_home.cfm

NHS National Research Ethics Service:
http://www.nres.npsa.nhs.uk/

Statement of ethical practice for the British Sociological Association:
http://www.sociology.org.uk/as4bsoce.pdf

ESRC Research Ethics Framework:
http://www.esrc.ac.uk/ESRCInfoCentre/Images/ESRC_Re_Ethics_Frame_tcm6-11291.pdf

EPSRC Guide to Good Practice in Science and Engineering Research,
http://www.epsrc.ac.uk/ResearchFunding/GrantHolders/GuideToGoodPracticeInResearch.htm

Human Rights Act (1998):
http://www.opsi.gov.uk/ACTS/acts1998/ukpga_19980042_en_1

Social Research Association (2003), Ethical Guidelines:
http://www.the-sra.org.uk/ethical.htm

British Educational Research Association Revised Ethical Guidelines for Educational Research (2004):
http://www.bera.ac.uk/blog/category/publications/guidelines/

The RESPECT project:
http://www.respectproject.org/main/index.php

UK Data Archive (UKDA), Consent, confidentiality and ethics in data sharing
http://www.data-archive.ac.uk/sharing/confidential.asp

Research Ethics in Art, Design and Media
http://www.biad.uce.ac.uk/research/rti/ethics/about.html

Prepared by:	Research Unit	Date:	14 May 2009
Final Approval by:	Senate, 10 June 2009		
Review Date:			
Updated on:			

Appendix I: Articles Promoting Questionnaires

Newsround

A survey on the use and perception of pressure relief cushions as used by those with a spinal cord injury

A research team at the Buckingham Chilterns University College (BCUC) is currently working on a project to improve the design of pressure relief cushions, specifically to meet the needs of those with spinal cord injury. In order to design a cushion better suited to your needs, we have developed a questionnaire designed to draw on your practical experiences with the problems and difficulties presented by pressure relief cushion use. From the results of this questionnaire it will be possible to identify, clarify and prioritise the demands placed on the cushion by the user, enabling better pressure relief cushion design.

We now need people with SCI to help us by completing the questionnaire. This questionnaire is anonymous and your comments will be treated as confidential. If you would like to help, you can access this questionnaire by downloading a copy from our website at

www.bcuc.ac.uk

Alternatively, the questionnaire can be accessed through a link on the SIA website. This link can be found on the Research and Surveys page found on the Community Zone message board.

In addition, we can provide a paper version of the questionnaire and a reply-paid envelope upon request. We hope you do decide to complete this questionnaire.

By sharing some of your experiences with us, you will be contributing to the advancement of pressure relief cushion design. Thank you.

Philip Lance, BCUC

Find out more
Email **Philip Lance**
plance01@bcuc.ac.uk
Telephone **Glyn Weatherburn**
01494 605222 (this number has an answer phone, please leave your name and address)
Address.
Philip Lance,
Research Centre for Health Studies
Buckinghamshire Chilterns University College
Gorelands Lane
Chalfont St. Giles
Buckinghamshire HP8 4AD

Figure I-1 The article in the June 2006 issue of the SIA magazine *FORWARD,* (pg 44), appealing for individuals to complete the questionnaire (Lance 2006a)

Survey on the use and perception of pressure relief cushions by those involved in the care and treatment of spinal cord injury patients

For his Ph.D, Phil Lance has undertaken to research and design a pressure relief cushion for those with SCI. In order to advance pressure relief cushion design, he is attempting to understand how pressure relief cushions are used and how they fit into the SCI patient's life-style. It is in pursuit of this understanding that he has developed a questionnaire specifically for professionals involved in the care and treatment of SCI patients, as they have a wealth of practical experience with the problems and difficulties presented by pressure relief cushion use. From the results of this questionnaire, it will be possible to identify, clarify and prioritise the demands placed on the cushion by the user, enabling better pressure relief cushion design.

VISIT **WWW.MASCIP.CO.UK** WHERE THE QUESTIONNAIRE CAN BE DOWNLOADED FOR COMPLETION

Phil Lance, Ph.D. Researcher, Research Centre for Health Studies, Buckinghamshire Chilterns University College

Figure I-2 The article in the March 2006 edition of the MASCIP newsletter, appealing for individuals to complete the questionnaire (Lance 2006b)

Appendix J: Posters Promoting Questionnaires

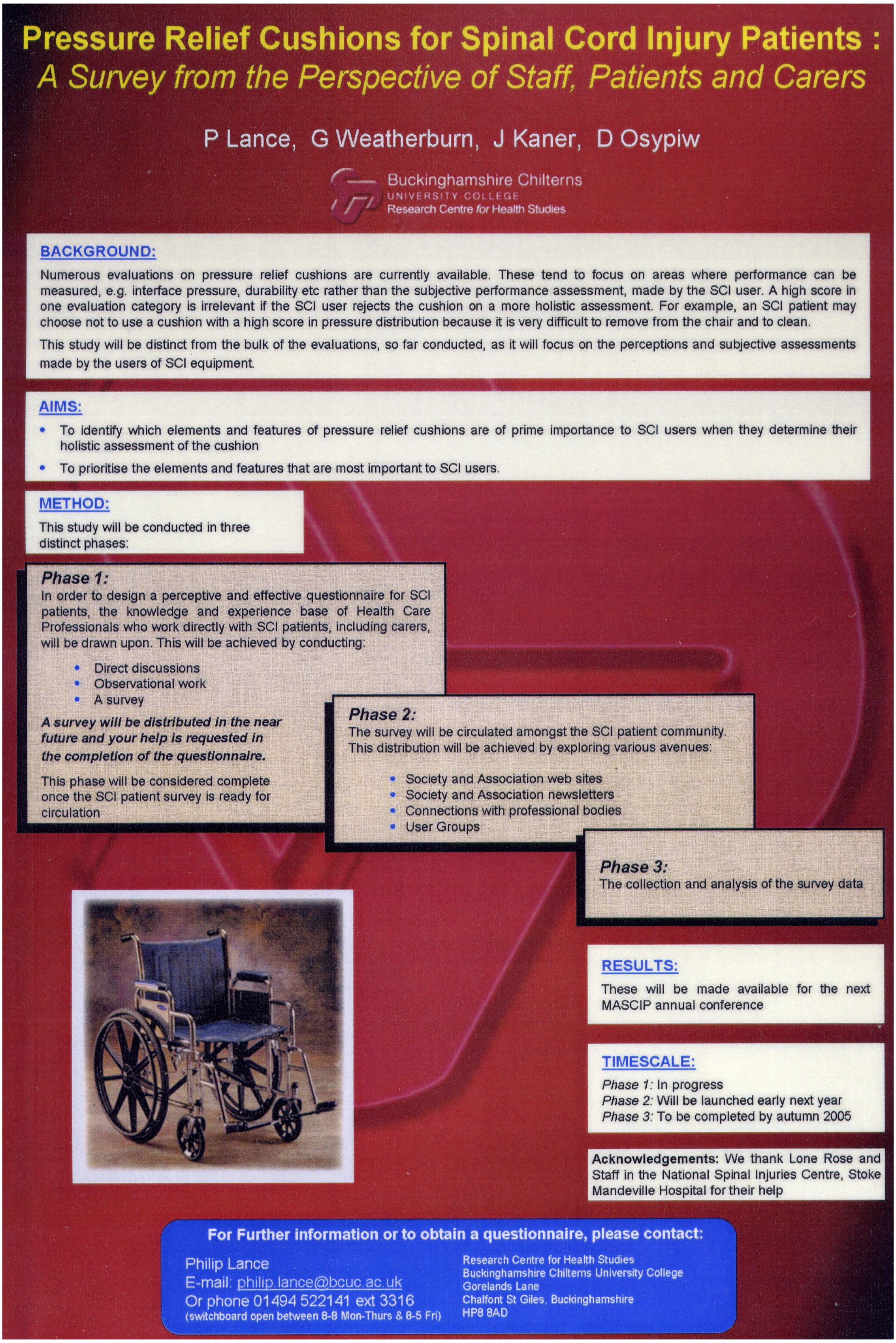
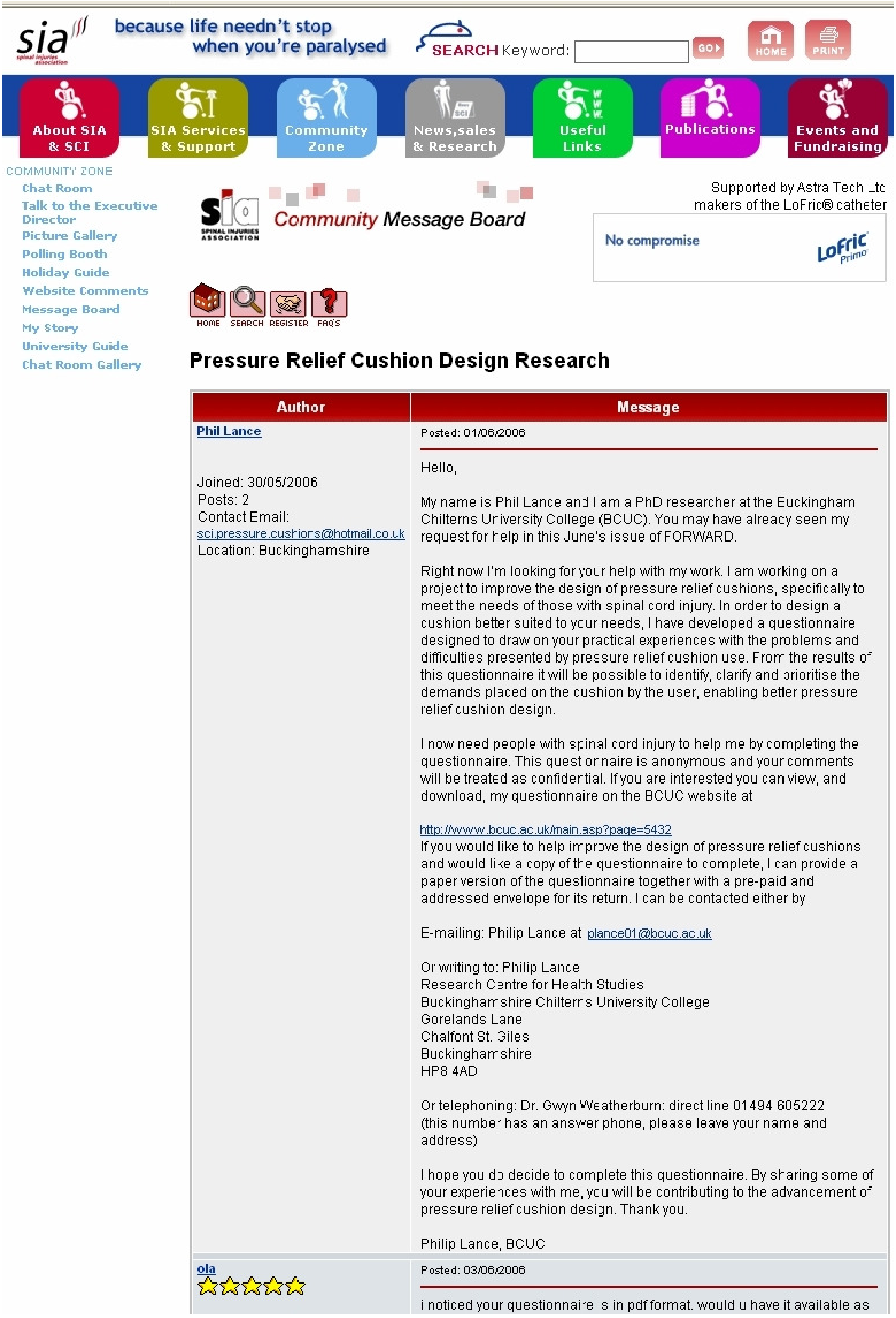


Figure J-1 A poster shown at the 2004 MASCIP annual conference. Poster used promote the questionnaire among the MASCIP membership (Lance *et al* 2004)

Figure J-2 A poster shown at the 2006 MASCIP annual conference held in November. Poster reported on preliminary results and was used to promote the questionnaire among the MASCIP membership before the circulation phase ended in December (Lance *et al* 2006)

Appendix K: Webpages Promoting Questionnaires



sia spinal injuries association

because life needn't stop when you're paralysed

SEARCH Keyword: GO HOME PRINT

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- Chat Room
- Talk to the Executive Director
- Picture Gallery
- Polling Booth
- Holiday Guide
- Website Comments
- Message Board
- My Story
- University Guide
- Chat Room Gallery

Community Message Board

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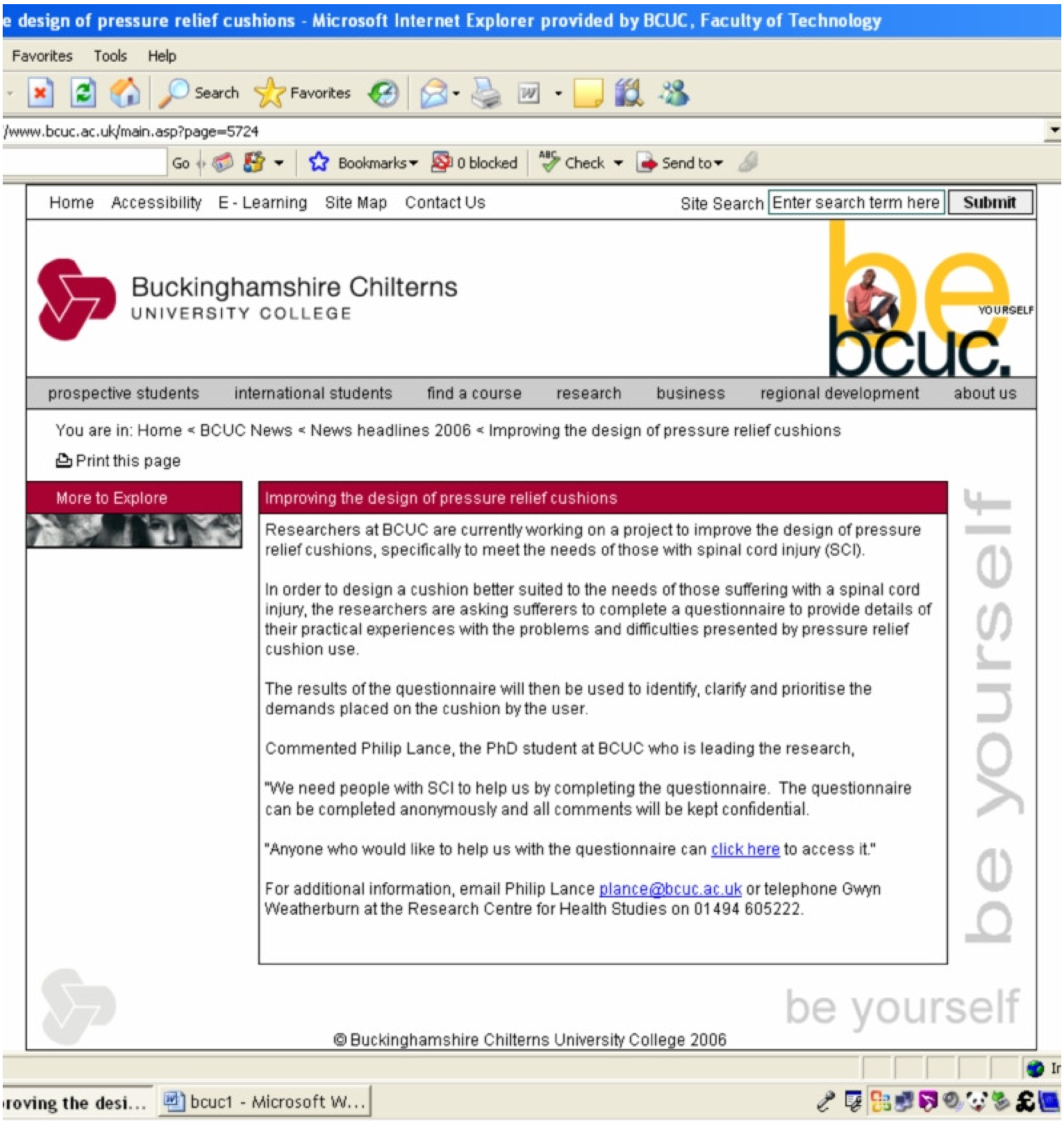
HOME SEARCH REGISTER FAQ'S

Pressure Relief Cushion Design Research

Author	Message
Phil Lance Joined: 30/05/2006 Posts: 2 Contact Email: sci.pressure.cushions@hotmail.co.uk Location: Buckinghamshire	Posted: 01/06/2006 Hello, My name is Phil Lance and I am a PhD researcher at the Buckingham Chilterns University College (BCUC). You may have already seen my request for help in this June's issue of FORWARD. Right now I'm looking for your help with my work. I am working on a project to improve the design of pressure relief cushions, specifically to meet the needs of those with spinal cord injury. In order to design a cushion better suited to your needs, I have developed a questionnaire designed to draw on your practical experiences with the problems and difficulties presented by pressure relief cushion use. From the results of this questionnaire it will be possible to identify, clarify and prioritise the demands placed on the cushion by the user, enabling better pressure relief cushion design. I now need people with spinal cord injury to help me by completing the questionnaire. This questionnaire is anonymous and your comments will be treated as confidential. If you are interested you can view, and download, my questionnaire on the BCUC website at http://www.bcuc.ac.uk/main.asp?page=5432 If you would like to help improve the design of pressure relief cushions and would like a copy of the questionnaire to complete, I can provide a paper version of the questionnaire together with a pre-paid and addressed envelope for its return. I can be contacted either by E-mailing: Philip Lance at: plance01@bcuc.ac.uk Or writing to: Philip Lance Research Centre for Health Studies Buckinghamshire Chilterns University College Gorelands Lane Chalfont St. Giles Buckinghamshire HP8 4AD Or telephoning: Dr. Gwyn Weatherburn: direct line 01494 605222 (this number has an answer phone, please leave your name and address) I hope you do decide to complete this questionnaire. By sharing some of your experiences with me, you will be contributing to the advancement of pressure relief cushion design. Thank you. Philip Lance, BCUC
ola	Posted: 03/06/2006 i noticed your questionnaire is in pdf format. would u have it available as

Figure K-1 A posting on the Spinal Injuries Association website message board, with a link to a downloadable version of the questionnaire, appealing for individuals to complete the questionnaire (Lance 2006c)



e design of pressure relief cushions - Microsoft Internet Explorer provided by BCUC, Faculty of Technology

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/www.bcuc.ac.uk/main.asp?page=5724

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More to Explore

Improving the design of pressure relief cushions

Researchers at BCUC are currently working on a project to improve the design of pressure relief cushions, specifically to meet the needs of those with spinal cord injury (SCI).

In order to design a cushion better suited to the needs of those suffering with a spinal cord injury, the researchers are asking sufferers to complete a questionnaire to provide details of their practical experiences with the problems and difficulties presented by pressure relief cushion use.

The results of the questionnaire will then be used to identify, clarify and prioritise the demands placed on the cushion by the user.

Commented Philip Lance, the PhD student at BCUC who is leading the research,

"We need people with SCI to help us by completing the questionnaire. The questionnaire can be completed anonymously and all comments will be kept confidential.

"Anyone who would like to help us with the questionnaire can click here to access it."

For additional information, email Philip Lance plance@bcuc.ac.uk or telephone Gwyn Weatherburn at the Research Centre for Health Studies on 01494 605222.

be yourself

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Figure K-2 A posting on the Buckinghamshire Chilterns University College website news section, with a link to a downloadable version of the questionnaire, appealing for individuals to complete the questionnaire (Lance 2006d)

Figure K-3 A link on the MASCIP website homepage connecting to a downloadable version of the questionnaire (Lance 2006e)

Appendix K: SCI Patient Questionnaire

Buckinghamshire Chilterns
UNIVERSITY COLLEGE

A Survey on the Use and Perception of Pressure Relief Cushions as used by those with a Spinal Cord Injury

The study team:
Philip Lance,
Dr. Gwyn Weatherburn,
Prof. Jake Kaner,
Dr David Osypiw,

Please return to Philip Lance *at***,**
Buckinghamshire Chilterns University College, Research Centre for Health Studies, Chalfont Campus, Gorelands Lane, Chalfont St. Giles, Buckinghamshire, HP8 4AD
(Tel: 01494 522141)

Dear Participant,

Thank you for taking the time to consider completing this questionnaire. This survey is completely voluntary. The information you provide is anonymous, we are interested in your answers we are not attempting to find out anything specifically about you. Please note that we will not show your questionnaire to your clinicians or carers.

Although this questionnaire appears lengthy it is anticipated that this questionnaire should not take longer than approximately 30 minutes to complete. Whilst it is desirable that all the questions relevant to you are answered, if there are any questions that you would rather not answer just leave them blank and move on to complete those questions you are comfortable with answering. The completion of this questionnaire is all that the research team is asking for. No follow up interviews or further questionnaires are planned.

The purpose of this study is to find out how pressure relief cushions are used and how they fit into the users life style. It is intended that through this study it will be possible to identify and clarify the demands placed on the cushion by the user so that pressure relief cushion design might further develop.

*A summary report of the findings will be available to those who complete this questionnaire. To receive a copy of this summary report please complete the request slip attached to the end of this questionnaire and return to the address on the slip **separate to the questionnaire**.*

We plan to circulate the findings of this survey through publication in scientific journals and through presentations at conferences.

If you have any questions, please telephone or e-mail:

Philip Lance *switchboard **01494 522141** ext.**3477*** ***philip.lance@bcuc.ac.uk***

Should you be unable to speak with Philip Lance, in the first instance, it is possible to leave a voicemail message with Dr. Gwyn Weatherburn on 01494 605222 and Philip will phone you back

Thank you for taking the time to consider this survey.

Philip Lance

There may be various reasons why you might decide not to complete this questionnaire. We would be interested to know what these reasons are, so if you decide not to answer this questionnaire, could you please note down your reason(s).

Please use this space for your answer

and return to,

Philip Lance,
Buckinghamshire Chilterns University College
Research Centre for Health Studies
Gorelands Lane
Chalfont St. Giles
Buckinghamshire
HP8 4AD

Should you wish to add any further information, there is space left at the end of this questionnaire for your comments, see **'Any Additional Information/Comments'**

Now please begin……

Please note that this questionnaire is inquiring into your use of pressure relief cushions. None of this questionnaire should be considered as a suggestion or recommendation as to the correct use of a pressure relief cushion.

Please place a tick ☑ or a cross ☒ in a box to indicate your answer

Section 1. Physical Features and Characteristics

1.1 Are you Male or Female? ……………………………………………… M ☐ F ☐

1.2 How old are you?

Less than 20 years old	20 - 25 years old	26 - 35 years old	36 - 45 years old	46 - 55 years old	56 - 65 years old	66 - 75 years old	More than 75 years old
☐	☐	☐	☐	☐	☐	☐	☐

1.3 How tall are you?

Less than 5' 2"	5' 2" to 5' 7"	5' 8" to 5' 9"	5' 10" to 5' 11"	6' 0" to 6' 1"	6' 2" to 6' 5"	More than 6' 6"	Don't know
☐	☐	☐	☐	☐	☐	☐	☐

1.4 How much do you weigh? *(an approximation is acceptable)*

Less than 8st 13lb…… ☐	12st - 12st 6lb… ☐	15st 7lb - 16st….. ☐
9st - 9st 6lb….. ☐	12st 7lb - 13st……. ☐	16st - 16st 6lb. ☐
9st 7lb - 10st…….. ☐	13st - 13st 6lb… ☐	16 7lb - 17st….. ☐
10st - 10st 6lb…. ☐	13st 7lb - 14st……. ☐	17st - 17st 6lb. ☐
10st 7lb - 11st…….. ☐	14st - 14st 6lb… ☐	17st 7lb - 18st….. ☐
11st - 11st 6lb…. ☐	14st 7lb - 15st……. ☐	More than 18st……. ☐
11st 7lb - 12st…….. ☐	15st - 15st 6lb… ☐	Don't know……….. ☐

1.5 What is your waist measurement?
(you can use your trouser waist measurement as a guide)

Less than 30"……….. ☐	34" - 36"……… ☐	40" - 42"…… ☐
30" - 32"………… ☐	36" - 38"……… ☐	More than 42"… ☐
32" - 34"……… ☐	38" - 40"…… ☐	Don't know……. ☐

1.6 Are you **Left** or **Right** handed?……………………………… Left ☐ Right ☐

1.7 Do you have any other conditions/medication which may have an impact on the condition of your skin?

e.g. diabetes, taking steroids

1.8 On an average day, which of these terms best describes the condition of your skin on the seat area of your body *(the area in contact with a pressure relief cushion, the buttocks/ back of the thigh)*?

Healthy…………	☐	**Clammy (raised temperature)**…….	☐
Tissue Paper…………	☐	**Discoloured**…………	☐
Dry…………	☐	**Damaged (broken/cracked)**……….	☐
Swollen /puffy…………	☐	**Don't know**…………	☐

	Yes	No
1.9 Do have you any sensation in the seat area of your body?…………	☐	☐
1.10 Do you experience excessive sweating?…………	☐	☐

1.11 How long have you had your injury?

Less than 6 months	6 to 12 months	1-2 years	3-4 years	5-9 years	10-20 years	More than 20 years
☐	☐	☐	☐	☐	☐	☐

1.12 What is the level of your injury?

C1 - C4	C5 - C6	C7 - T6	T7 - L1	L2 - L5	S1 - S5	Don't Know
☐	☐	☐	☐	☐	☐	☐

1.13 Is your injury?

Complete	Incomplete	Don't Know
☐	☐	☐

1.14 If you have had any limb(s) amputated, please specify which limb(s)

e.g. Right foot

Section 2. Cushions Used

2.1 What is the make of your current cushion?

Please use this space for your answer (brand names and/or manufacturer are acceptable)

2.2 Does your current cushion use *(Please tick **as many options** as you wish)*

Specialised foam	Air filled cells	Gel filled pouches	Alternating pressure cells	Other	Don't know
☐	☐	☐	☐	☐	☐

If **Other** please specify……

2.3 How long have you been using your current cushion?

Less than 30 days…………	☐	**12-17 months**…………	☐
1-5 months…………	☐	**18-24 months**…………	☐
6-11 months…………	☐	**More than 24 months (2 Years)**…….	☐

2

2.4 Do you consider the overall performance of your current cushion to be,

Excellent	Good	Satisfactory	Poor	Useless
☐	☐	☐	☐	☐

2.5 Why do you regard the overall performance of your current cushion to be, either **Excellent, Good, Satisfactory, Poor** or **Useless**?

Please use this space for your answer

2.6 The following options are aspects of a pressure relief cushion. How significant are these aspects to you when considering which cushion to use? *(please tick **one box on each row**)*

	Very significant	Of some significance	Significant	Of little significance	Of no significance
The cushion's ability to be fixed securely to your wheelchair…………	☐	☐	☐	☐	☐
The cushion's ability to be kept clean…………	☐	☐	☐	☐	☐
The cushion's ability to keep the pressure experienced by your skin low…………	☐	☐	☐	☐	☐
The cushion's ability to maintain your posture…	☐	☐	☐	☐	☐
The cushion's ability to prevent sweating…………	☐	☐	☐	☐	☐
The cushion's appearance…………	☐	☐	☐	☐	☐
The cushion's cost…………	☐	☐	☐	☐	☐
The cushion's weight…………	☐	☐	☐	☐	☐
The level of comfort provided by the cushion…..	☐	☐	☐	☐	☐

Please use this space if you can think of any other factors you consider when choosing which cushion to use

	Yes	No
2.7 Did you choose your current cushion?…………	☐	☐

2.7a) If **Yes**, why did you choose this particular cushion?

Please use this space for your answer

3

2.8 Have you ever used a different make/type of cushion?............................ Yes ☐ No ☐

2.8a) <u>If Yes</u>, why did you stop using your last cushion?

Please use this space for your answer

2.9 If you have used a cushion(s) which was the wrong size for you, how long in total have you had to use this cushion(s)?
(*please tick* ***one box***)

Never used a cushion of the wrong size....	☐	**4-6 months.........................**	☐
Less than 2 weeks..............................	☐	**7-9 months...........................**	☐
2-4 weeks..	☐	**10-12 months.......................**	☐
1-3 months..	☐	**More than 1 Year.................**	☐

2.9a) If you have used a cushion the wrong size for you, how much of a problem did this pose for your skin?

Major difficulties	Some difficulties	Inconvenient	Small inconvenience	Not a problem	Don't know
☐	☐	☐	☐	☐	☐

2.10 If you have used a cushion(s) which had the wrong seat surface contour shape for you, how long in total have you had to use this cushion(s)?
(*please tick* ***one box***)

Never used a cushion of the wrong shape	☐	**4-6 months.........................**	☐
Less than 2 weeks..............................	☐	**7-9 months...........................**	☐
2-4 weeks..	☐	**10-12 months.......................**	☐
1-3 months..	☐	**More than 1 Year.................**	☐

2.10a) If you have used a cushion with the wrong seat surface contour shape for you, how much of a problem did this pose for your skin?

Major difficulties	Some difficulties	Inconvenient	Small inconvenience	Not a problem	Don't know
☐	☐	☐	☐	☐	☐

Section 3. Practices and Behaviour

3.1 On average, how much time do you spend in a wheelchair **per day**?

Less than 60 minutes.................	☐	**7-8 hours..................................**	☐
1-2 hours...................................	☐	**More than 8 hours.....................**	☐
3-4 hours...................................	☐	**Varies significantly from day to day**	☐
5-6 hours...................................	☐	**Don't know.............................**	☐

3.2 On average, how much time do you spend **per day** sat in each of the following chairs?
(*please tick* ***one box on each row***)

	Never use	Varies greatly	Less than 60 minutes	1-2 hours	3-4 hours	5-6 hours	7-8 hours	More than 8 hours
A dining chair.............	☐	☐	☐	☐	☐	☐	☐	☐
An office chair............	☐	☐	☐	☐	☐	☐	☐	☐
A car seat...................	☐	☐	☐	☐	☐	☐	☐	☐
An armchair..............	☐	☐	☐	☐	☐	☐	☐	☐
A sofa.......................	☐	☐	☐	☐	☐	☐	☐	☐

Please use this space if you can think of any other types of chair that you sit on

3.3 How often do you use a pressure relief cushion with the following chairs?
(*please tick* ***one box on each row***)

	Don't sit on these chairs	All the time	Frequently	Occasionally	Very Rarely	Never
A dining chair...............................	☐	☐	☐	☐	☐	☐
An office chair..............................	☐	☐	☐	☐	☐	☐
A car seat......................................	☐	☐	☐	☐	☐	☐
An armchair...................................	☐	☐	☐	☐	☐	☐
A sofa...	☐	☐	☐	☐	☐	☐

Please use this space if you can think of any other types of chair that you sit on with a pressure relief cushion

3.4 When you are not sat in your wheelchair but sat on another chair/seat, what do you use for pressure relief? *(Please tick* ***as many options*** *as you wish)*

The pressure relief cushion you normally use in your wheelchair.....................	☐
A second pressure relief cushion, which is the same type of cushion as you use with your wheelchair...	☐
A second pressure relief cushion but a different type to the cushion you use in your wheelchair..	☐
The chair/seat's own ordinary padding/cushioning.....................................	☐
The chair/seat has built in pressure relieving features.................................	☐
A piece of cut foam...	☐
An ordinary cushion...	☐
An ordinary pillow...	☐
A sheepskin...	☐

Please use this space if you can think of any other forms of pressure relief that you use

3.5 Do you find that your pressure relief cushion, when used with your wheelchair, creates difficulties when transferring into and out of your wheelchair?

Major difficulties	Some difficulties	Inconvenient	Small inconvenience	Not a problem	Don't know
☐	☐	☐	☐	☐	☐

3.6 An example of a pressure relieving routine, to alleviate pressure on the skin, would be leaning forward for 60-90 seconds every half hour, what pressure relieving measures do you take? *(Please tick* ***as many options*** *as you wish)*

- **Don't do any pressure relieving....** ☐
- **Leaning forward......................** ☐
- **Leaning to your right................** ☐
- **Leaning to your left..................** ☐
- **Tilting backwards.....................** ☐
- **Raising yourself up...................** ☐
- **Other...................................** ☐

If **Other** please specify……

3.7 If you follow a pressure relieving routine, in an average day would you say that you stick to this routine, (*please tick* ***one box****)*

- **Don't follow a set routine..........** ☐
- **All of the time (do every one)......** ☐
- **Frequently (do most)................** ☐
- **Occasionally (miss out about half)** ☐
- **Very Rarely (miss most).............** ☐
- **Don't know.............................** ☐

3.8 In an average day, how often would you say you inspect your skin?

- **Don't follow a set routine...........** ☐
- **First thing in the morning..........** ☐
- **Last thing at night....................** ☐
- **Every few hours.......................** ☐
- **When it feels uncomfortable.........** ☐
- **Other...................................** ☐
- **After sitting in a wheelchair for a prolonged length of time (more than 4 hours)...** ☐

If **Other** please specify……

Section 4. Skin Care

4.1 Are you worried that the performance of your cushion may lead to problems with your skin?

Very worried	Worried	Concerned	Not worried at all	Never think about it
☐	☐	☐	☐	☐

4.2 What is the longest length of time you consider safe to spend, in a single sitting, on a pressure relief cushion before risking skin damage?

- **Less than 60 minutes..............** ☐
- **1-2 hours.............................** ☐
- **3-4 hours.............................** ☐
- **5-6 hours.............................** ☐
- **7-8 hours.............................** ☐
- **More than 8 hours...................** ☐

4.3 Do you limit the time you spend in a wheelchair due to concerns about skin care?.. Yes ☐ No ☐

The remainder of this section is based on experience with pressure ulcers. If you have not experienced a pressure ulcer please tick here ☐ and turn to section 5.

4.4 Where on your body did the pressure ulcer(s) occur?

	Occurred Once	Twice	3 times	4 times	5 times or more
Right Buttock........	☐	☐	☐	☐	☐
Left Buttock........	☐	☐	☐	☐	☐
Back of the Right Thigh........	☐	☐	☐	☐	☐
Back of the Left Thigh........	☐	☐	☐	☐	☐
Base of the spine........	☐	☐	☐	☐	☐
Right Hip........	☐	☐	☐	☐	☐
Left Hip........	☐	☐	☐	☐	☐
Genitals........	☐	☐	☐	☐	☐
Head........	☐	☐	☐	☐	☐
Torso........	☐	☐	☐	☐	☐
Elbows........	☐	☐	☐	☐	☐
Heels........	☐	☐	☐	☐	☐
Ankles........	☐	☐	☐	☐	☐
Other........	☐	☐	☐	☐	☐

If **Other** please specify……

4.5 Are you currently experiencing a pressure ulcer on the seat area of your body *(the area in contact with a pressure relief cushion i.e. the buttocks and the back of the thighs)*?........................ Yes ☐ No ☐

4.5a) **<u>If Yes</u>**, could you please indicate the extent of the ulcer by ticking the box which most closely describes your ulcer

A Red mark that does not go away when pressed	The surface of the skin is broken	The ulcer is deep into the skin	The ulcer is very deep with damage to tendons/bone
☐	☐	☐	☐

4.6 If you have experienced a pressure ulcer on the seat area of your body in the past, could you please give an approximate date when you first discovered the ulcer, how much damage occurred and how long it took to heal.

	Date first identified	A Red mark that did not go away when pressed	The surface of the skin was broken	The ulcer was deep into the skin	The ulcer was very deep with damage to tendons/bone	Time taken to heal
e.g.	*6/98*	☐	✓	☐	☐	*2 months*
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	

4.7 If you have experienced a pressure ulcer(s) on the seat area of your body, how often was it thought that the cushion you were using may have contributed to the development of a pressure ulcer?

All of the time (every time)........ ☐ **Very Rarely (some of the times)....** ☐
Frequently (most times)............ ☐ **Never....................................** ☐
Occasionally (about half the time) ☐ **Don't know.............................** ☐

Please use this space to describe how it was thought that the cushion may have contributed to the development on an ulcer

4.8 If you have experienced a pressure ulcer on the seat area of the body and the cushion was not identified as the cause of the pressure ulcer, how often was the ulcer the result of? *(please tick **one box on each row**)*

	All the time	Frequently	Occasionally	Very Rarely	Never
Prominent seams in clothing..........................	☐	☐	☐	☐	☐
An excessively long period left sat on the cushion	☐	☐	☐	☐	☐
A transfer to or from a wheelchair..................	☐	☐	☐	☐	☐
Missed small objects e.g. coins.......................	☐	☐	☐	☐	☐
Pressure relief routine not performed regularly enough	☐	☐	☐	☐	☐
Pressure relief routine not providing enough respite from pressure.................................	☐	☐	☐	☐	☐

Please use this space if you can think of any other occasions when a pressure ulcer occurred on the seat area of the body and the cushion was not identified as the cause.

4.9 If you developed a pressure ulcer as a consequence of poor posture whilst sitting in your wheelchair, was the ulcer the result of *(please tick **one box on each row**)*

	All the time	Frequently	Occasionally	Very Rarely	Never
Leaning to the right increased the pressure on your right side..	☐	☐	☐	☐	☐
Leaning to the left increased the pressure on your left side..	☐	☐	☐	☐	☐
Slouching/ Sliding forward reduced the area of your body in contact with the cushion...........	☐	☐	☐	☐	☐
Slouching/ Sliding forward pressed your genitals against the pummel of your cushion..............	☐	☐	☐	☐	☐

Please use this space if you developed a pressure ulcer due to poor posture not described above

4.10 Have you experienced a pressure ulcer on the seat area of your body shortly after putting on a lot of weight ?... Yes ☐ No ☐

4.11 Have you experienced a pressure ulcer on the seat area of your body shortly after losing a lot of weight?... Yes ☐ No ☐

Section 5. Sitting Posture in a Wheelchair

5.1 Have you ever experience any problems as a result of poor posture whilst sitting in a wheelchair eg sore back?

Please use this space for your answer

5.2 Can you tell for yourself if you are sitting right back in your wheelchair?

All the time	Most of the time	About half the time	Some of the time	Never
☐	☐	☐	☐	☐

5.3 Can you tell for yourself if you are sitting upright in your wheelchair?

All the time	Most of the time	About half the time	Some of the time	Never
☐	☐	☐	☐	☐

5.4 Can you tell for yourself if you are sitting centrally in your wheelchair so that you are not twisted with one knee pointing forward, further than the other?

All the time	Most of the time	About half the time	Some of the time	Never
☐	☐	☐	☐	☐

5.5 When sat in your wheelchair do your thighs stay level/parallel to the floor?

All the time	Most of the time	About half the time	Some of the time	Never
☐	☐	☐	☐	☐

5.6 When sat in your wheelchair do you manage to keep the full length of your thighs in contact with the cushion?

All the time	Most of the time	About half the time	Some of the time	Never
☐	☐	☐	☐	☐

5.7 When do you check your posture to make sure that it is still all right? *(Please tick **as many options** as you wish)*

Every couple of hours....................... ☐ **After a spasm..........................** ☐
Occasionally (maybe once a day)........ ☐ **After carrying out pressure relief..** ☐
Just after transferring into the wheelchair ☐ **After propelling your wheelchair...** ☐
When you remember....................... ☐ **Never Check...........................** ☐
When you feel uncomfortable........... ☐ **Other.....................................** ☐

If **Other** please specify......

5.8 How often is the adjustment of your footplate checked?

Daily	☐	Whenever it's noticed that it is in the wrong position	☐
Weekly	☐	Each time the wheelchair is used	☐
Monthly	☐	Don't know	☐
Never	☐	Other	☐

If **Other** please specify……

5.9 What sitting position do you typically take up?
*(please tick **one box on each row**)*

	All the time	Frequently	Occasionally	Very Rarely	Never
Slide forward and develop a slouch	☐	☐	☐	☐	☐
Shift your weight to the right so you develop a lean to the right	☐	☐	☐	☐	☐
Shift your weight to the left so you develop a lean to the left	☐	☐	☐	☐	☐
Tilt forward so your head falls forward and your shoulders round over	☐	☐	☐	☐	☐

Please use this space if you can think of any other positions you take up when you move out of a good postural position

5.10 Do you ever find yourself in a slouched sitting position? Yes ☐ No ☐

5.10a) If Yes, When you slouch do you? *(please tick **one box on each row**)*

	All the time	Frequently	Occasionally	Very Rarely	Never
Slide forward over the surface of the cushion, with the cushion fixed remaining in place	☐	☐	☐	☐	☐
Slide forward with the cushion sliding forward with you	☐	☐	☐	☐	☐

5.11 On average how long do you spend in a good postural position before slipping into a poor position?

Less than 10 minutes	☐	1½ to 2 hours *(90 to 119 minutes)*	☐
10 to 29 minutes	☐	2 to 3 hours *(120 to 179 minutes)*	☐
30 to 44 minutes	☐	3 to 4 hours *(180 to 240 minutes)*	☐
45 to 59 minutes	☐	More than 4 hours	☐
1 to 1½ hours *(60 to 89 minutes)*	☐	It varies greatly	☐
		Don't know	☐

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5.12 Are you able to sit upright and central in your wheelchair, without leaning or slouching, what might be described as a good postural position? Yes ☐ No ☐

5.12a) If Yes, do you lose a good postural position because,
*(please tick **one box on each row**)*

	All the time	Frequently	Occasionally	Very Rarely	Never
You gradually drift into a poor position	☐	☐	☐	☐	☐
You look for a more comfortable position	☐	☐	☐	☐	☐
Self propelling the wheelchair throws your position	☐	☐	☐	☐	☐
Spasms alter your position	☐	☐	☐	☐	☐
Fidgeting	☐	☐	☐	☐	☐

Please use this space if you can think of any other reasons for losing a good postural position

Section 6. Utility/Practicality of Cushion

6.1 How often is your cushion removed from your wheelchair?

Less than once a year	☐	3-5 times a week	☐
1-2 times a year	☐	1-2 times a day	☐
3-5 times a year	☐	3-5 times a day	☐
1-2 times a month	☐	More than 5 times a day	☐
1-2 times a week	☐	Varies from day to day	☐

6.2 Why is your cushion removed from your wheelchair?
*(please tick **one box on each row**)*

	All the time	Frequently	Occasionally	Very Rarely	Never
To use on a different chair	☐	☐	☐	☐	☐
To change the cushion cover	☐	☐	☐	☐	☐
To check gel sacks	☐	☐	☐	☐	☐
To collapse your wheelchair	☐	☐	☐	☐	☐
To check for damage	☐	☐	☐	☐	☐
To clean it	☐	☐	☐	☐	☐
To check air pressure	☐	☐	☐	☐	☐

Please use this space if you can think of any other reasons for removing your cushion from your wheelchair

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6.3 Do you fit and remove your cushion, from your wheelchair, by yourself?

All the time	Frequently	Occasionally	Very Rarely	Never
☐	☐	☐	☐	☐

6.4 How easy is it to fix your cushion securely to the seat of your wheelchair?

Very easy	Simple	Manageable	Difficult	Very difficult	It is not a task I'm involved with
☐	☐	☐	☐	☐	☐

6.5 Once the cushion is secured to the seat of the wheelchair, how often do you find that the cushion is loose and can slide around?

All the time	Frequently	Occasionally	Very Rarely	Never
☐	☐	☐	☐	☐

6.6 Once the cushion is secured to the seat of the wheelchair do you find that it is knocked loose during transfers?

All the time	Frequently	Occasionally	Very Rarely	Never
☐	☐	☐	☐	☐

6.7 How often is your cushion cleaned?

More than Once a day	Daily	Weekly	Monthly	When it is needed	Don't know	Other
☐	☐	☐	☐	☐	☐	☐

If **Other** please specify……

6.8 Do you clean your cushion yourself?.. Yes ☐ No ☐

6.9 How easy is your cushion to clean?

Very easy	Easy	Manageable	Difficult	Very difficult	It is not a task I'm involved with
☐	☐	☐	☐	☐	☐

6.10 The following options are examples of how a cushion may be damaged, how often has your cushion been damaged in these ways?
(*please tick **one box on each row***)

	All the time	Frequently	Occasionally	Very Rarely	Never
Chunks of foam breaking off………..……………..	☐	☐	☐	☐	☐
Air cells punctured by cigarette burns………….	☐	☐	☐	☐	☐
Air cells punctured by a pets claws………………	☐	☐	☐	☐	☐
Gel packs splitting………………………………..	☐	☐	☐	☐	☐

Please use this space if your cushion has been damaged in another way

6.11 How long do you think your cushion should last before it will need replacing?

Less than 5 months	6 – 11 months	12 – 17 months	18 - 24 months	More than 2 years
☐	☐	☐	☐	☐

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6.12 What do you use to cover your cushion? (*please tick **one box on each row***)

	All the time	Frequently	Occasionally	Very Rarely	Never
Nothing, the cushion is left uncovered…………..	☐	☐	☐	☐	☐
The cover that comes with the cushion…………	☐	☐	☐	☐	☐
A blanket to wrap around the cushion…………..	☐	☐	☐	☐	☐
A cotton sheet to wrap around the cushion……..	☐	☐	☐	☐	☐
An ordinary pillow case...…………………………	☐	☐	☐	☐	☐
A homemade cover………………….……………..	☐	☐	☐	☐	☐
A cover from another cushion which has been altered to fit your cushion…..…………………..	☐	☐	☐	☐	☐
A cover from another cushion which has NOT been altered to fit your cushion……………..….	☐	☐	☐	☐	☐

Please use this space if you can think of any other covering you use on a cushion

6.13 Do you change your cushion cover yourself?... Yes ☐ No ☐

6.14 Do you agree with the following statements about changing cushion covers?
(*please tick **one box on each row***)

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
The cushion is bulky, so it is difficult to insert into the cover……………………………………..	☐	☐	☐	☐	☐
The next cover is often not ready to put on as its away being cleaned or repaired…….………..	☐	☐	☐	☐	☐
The cover opening fastenings (zipper, buttons, press studs) are difficult………………………..	☐	☐	☐	☐	☐
To fit the cover the cushion has to be removed from the wheelchair……………………………..	☐	☐	☐	☐	☐
The cover is difficult to adjust so that the surface is not wrinkled/creased………………...	☐	☐	☐	☐	☐
The cushion cover is easy to change (put on/take off)	☐	☐	☐	☐	☐

Please use this space if you can think of anything else which makes changing a cushion cover difficult

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6.15 The following options are possible ways a cushion cover may contribute to the development of a pressure ulcer. How significant do you consider the following options to be in the formation of a pressure ulcer? (*please tick **one box on each row***)

	Very significant	Of some significance	Significant	Of little significance	Of no significance
The cover becomes wrinkled or creased...........	☐	☐	☐	☐	☐
The texture of the cover material is too rough....	☐	☐	☐	☐	☐
The weave, or cloth pattern, of the cover is too pronounced..	☐	☐	☐	☐	☐
The cover material holds too much moisture......	☐	☐	☐	☐	☐
The cover is stretched too tight across the cushion affecting the cushions ability to disperse the weight of the body.....................	☐	☐	☐	☐	☐

Please use this space if you can think of any other ways a cushion cover may cause a pressure ulcer

6.16 Have you ever used a pressure relief cushion which included a gel pack? Yes ☐ No ☐

6.16a) <u>**If Yes**</u>, In your experience how long does it take for the gel to be pushed to the sides of the pack so that there is no-longer enough gel left under you to provide sufficient pressure relief?

A couple of minutes...................	☐	**There is always enough gel...........**	☐
A couple of hours.......................	☐	**It depends on how active I'm being..**	☐
Most of the day........................	☐	**Don't know....................................**	☐

6.16b) <u>**If Yes**</u>, In your experience how often do you check your cushion to make sure there is sufficient gel under you to provide pressure relief? (*Please tick **as many options** as you wish*)

Never check...............................	☐	**Once a week..............................**	☐
Every hour..................................	☐	**After every period of activity..........**	☐
Every few hours..........................	☐	**It varies from day to day.............**	☐
Once a day..................................	☐	**Don't know.................................**	☐
		Other...	☐

If **Other** please specify......

6.16c) <u>**If Yes**</u>, In your experience what movements or actions do you make which have the effect of driving the gel out from underneath you, towards the sides of the pack? (*please tick **one box on each row***)

	All the time	Frequently	Occasionally	Very Rarely	Never
It just drifts to the sides over time...................	☐	☐	☐	☐	☐
Following a pressure relieving routine..............	☐	☐	☐	☐	☐
Propelling the wheelchair.................................	☐	☐	☐	☐	☐
Simple fidgeting..	☐	☐	☐	☐	☐
Spasms..	☐	☐	☐	☐	☐

Please use this space if you can think of any other movements which drives the gel out from underneath you towards the side of the pack

6.17 Have you ever used a cushion which is made of air filled cells?................ Yes ☐ No ☐

6.17a) <u>**If Yes**</u>, In your experience how often does the air pressure have to be checked? (*Please tick **as many options** as you wish*)

Every hour.................................	☐	**A couple of times a month...........**	☐
Every few hours..........................	☐	**After every period of activity..........**	☐
Once a day..................................	☐	**It varies from day to day.............**	☐
Once a week................................	☐	**Never check...............................**	☐
A couple of times a week..............	☐	**Don't know.................................**	☐
		Other...	☐

If **Other** please specify......

6.17b) <u>**If Yes**</u>, In your experience has this cushion ever deflated so much that you end up sitting on the solid base without your noticing?........... Yes ☐ No ☐

6.17c) <u>**If Yes**</u>, In your experience how difficult is it to control the level of air pressure?

Very easy	Easy	Manageable	Difficult	Very difficult	It is not a task I'm involved with
☐	☐	☐	☐	☐	☐

Any Additional Information/Comments

Please add any other comments you would like to make about your experiences with pressure relief cushions

You have reached the end of the questionnaire.

Thank you very much for participating in this survey, your contribution is greatly appreciated.

Please return the completed questionnaire to:

Philip Lance,
Buckinghamshire Chilterns University College
Research Centre for Health Studies
Gorelands Lane
Chalfont St. Giles
Buckinghamshire
HP8 4AD

Appendix M: Results of the SCI Patient Questionnaire

M.1 Results on Respondents Physical Characteristics

M.1.1 Physical Features

Table M-1 Gender (n = 41) *

Gender	
Male	Female
25 (61%)	14 (34%)

*2 missing

(see Q1.1)

Table M-2 Age (n = 41) *

Age (years)							
< 20	20-25	26-35	36-45	46-55	56-65	66-75	>75
0 (0%)	0 (0%)	5 (12%)	6 (15%)	12 (29%)	10 (24%)	6 (15%)	1 (2%)

*1 missing

(see Q1.2)

Table M-3 Height (n = 41) *

Height (ft & inches)						
< 5'2"	5'2"-5'7" (mean=5'4½")	5'8"-5'9" (mean=5'8½")	5'10"-5'11" (mean=5'10½")	6'0"-6'1" (mean=6' ½")	6'2"-6'5" (mean=6'3½")	>6'6"
0 (0%)	12 (29%)	7 (17%)	13 (31%)	6 (15%)	2 (5%)	0 (0%)

*1 missing

(see Q1.3)

Table M-4 Weight (n = 41) *

Weight (stones & pounds)																
< 8st 13lb	9st - 9st 6lb (mean 9st 3lb)	9st 7lb – 10st (mean 9st 10lb)	10st - 10st 6lb (mean 10st 3lb)	10st 7lb – 11st (mean 10st 10lb)	11st – 11st 6lb (mean 11st 3lb)	11st 7lb – 12st (mean 11st 10lb)	12st – 12st 6lb (mean 12st 3lb)	12st 7lb – 13st (mean 12st 10lb)	13st – 13st 6lb (mean 13st 3lb)	13st 7lb – 14st (mean 13st 10lb)	14st – 14st 6lb (mean 14st 3lb)	14st 7lb – 15st (mean 14st 10lb)	15st – 15st 6lb (mean 15st 3lb)	15st 7lb – 16st (mean 15st 10lb)	16st -16st 6lb (mean 16st 3lb)	Don't know
3 (7%)	2 (5%)	3 (7%)	3 (7%)	4 (10%)	1 (2%)	5 (12%)	2 (5%)	3 (7%)	2 (5%)	3 (7%)	2 (5%)	1 (2%)	1 (2%)	3 (7%)	1 (2%)	1 (2%)

*1 missing

(see Q1.4)

Table M-5 Body Mass Index (n = 41) *

Body Mass Index (BMI) of respondents (kg/m^2)#					
Under weight < 18.5	Ideal weight 18.5 - 25	Over weight 25 – 30	Obese 30 – 40	Very obese >40	Don't know
1 (2%)	21 (51%)	11 (27%)	6 (15%)	0 (0%)	1 (2%)

*1 missing. # BMI calculated using mean values of height and weight.

Table M-6 Dominant side (n = 41) *

Dominant side	
Left handed	Right handed
7 (17%)	31 (76%)

*3 missing

(see Q1.6)

M.1.2 Injury

Table M-7 Level of injury (n = 41)

Level of injury					
Tetraplegic (n=26)			Paraplegic (n=15)		
C1 – C4	C5 – C6	C7 – T6	T7 – L1	L2 – L5	S1 –S5
7 (17%)	8 (20%)	11 (27%)	14 (34%)	1 (3%)	0 (0%)

(see Q1.12)

Table M-8 Extent of injury (n = 41) *

Extent of injury		
Complete	Incomplete	Don't know
25 (61%)	13 (32%)	2 (5%)

*1 missing

Table M-9 Retention of some sensation in the seat area of the body (n = 41)

Retention of sensation	
With sensation	Without sensation
13 (32%)	28 (68%)

(see Q1.9)

Table M-10 Length of time with injury (n = 41)

Length of time with injury (Years)						
< ½	½ – 1	1 – 2	3 - 4	5 - 9	10 – 20	> 20
0 (0%)	0 (0%)	0 (0%)	3 (7%)	4 (10%)	14 (34%)	20 (49%)

(see Q1.11)

M.1.3 Physical Condition

Table M-11 Condition of the skin covering the respondent's seat area of the body (n = 41) *

Skin condition#							
Healthy	Tissue paper	Dry	Swollen/ puffy	Clammy (raised temp.)	Discol-oured	Damaged (broken cracked)	Don't know
32 (78%)	1 (2%)	1 (2%)	0 (0%)	1 (2%)	3 (7%)	1 (2%)	2 (5%)

*1 missing. # Categories based on the *Waterlow Pressure Ulcer Risk Assessment Score* categories of skin condition (Waterlow 1996). Respondents completed this question based on their own understanding of their skin condition.

(see Q1.8)

Table M-12 Medical conditions which have an affect on skin condition** (n = 41) *

Medical condition								
No such condition to report	Diabetes	Thyroid	Neurosarcoidosis	Hormone Replacement Therapy (HRT)	Allergies (soap)	Folliculitis	Thrush	Propantheline bromide for sweating
13 (32%)	4 (10%)	2 (5%)	1 (2%)	1 (2%)	1 (2%)	1 (2%)	1 (2%)	1 (2%)

*17 missing. **One respondent reported having more than one condition

(see Q1.7)

Table M-13 Respondents experiencing excessive sweating (n = 41) *

Sweating pattern	
Normal sweating patterns	Excessive sweating
28 (68%)	11 (27%)

*2 missing

(see Q1.10)

M.2 Results on Respondents Pressure Ulcer Histories

M.2.1 Pressure Ulcer Occurrence

Table M-14 Respondents experience of pressure ulcers at the time of completing the questionnaire

Groups	Experience with pressure ulcer		
	Currently experiencing a pressure ulcer	Have previously experienced pressure ulcers	Never had a pressure ulcer
All respondents (n=41)*	2	22	14

* 3 missing

(see Q4.5)

Table M-15 Groups of respondents who have experienced pressure ulcers

Groups					
Level of Paralysis (n=41)		Gender (n=39)#		Dominant side (n=38)##	
Tetraplegic (n=26)	Paraplegic (n=15)	Male (n=25)	Female (n=14)	Left handed (n=7)	Right handed (n=31)
15 (58%)	9 (60%)	16 (64%)	7 (50%)	5 (71%)	18 (58%)

2 respondents did not specify whether they are male or female

3 respondents did not specify whether they are left of right handed

Table M-16 The number of individual pressure ulcers experienced by the respondents

Groups					
Level of paralysis (n=41)		Gender (n=39)#		Dominant side (n=38)##	
Tetraplegic (n=26)	Paraplegic (n=15)	Male (n=25)	Female (n=14)	Left handed (n=7)	Right handed (n=31)
73 (60%)	49 (40%)	76 (62%)	46 (38%)	36 (30%)	85 (70%)

Of the 24 who reported experiencing at least one pressure ulcer, 23 respondents specified whether they were male or female;

Of the 24 who reported experiencing at least one pressure ulcer, 23 respondents specified whether they were left of right handed

Table M-17 The respondents, divided by height, who have experienced pressure ulcers (n=41)*

Groups						
< 5'2" (n=0)	5'2"-5'7" (n=12)*	5'8"-5'9" (n=7)	5'10"-5'11" (n=13)	6'0"-6'1" (n=6)	6'2"-6'5" (n=2)	>6'6" (n=0)
0 (0%)	8 (67%)	6 (86%)	4 (31%)	5 (83%)	1 (50%)	0 (0%)

* 1 missing

Table M-18 The respondents, divided by weight, who have experienced pressure ulcers (n=41)*

Groups																
< 8st 13lb (n=3)	9st - 9st 6lb (n=2)	9st 7lb – 10st (n=3)	10st - 10st 6lb (n=3)	10st 7lb – 11st (n=4)	11st – 11st 6lb (n=1)	11st 7lb – 12st (n=5)	12st – 12st 6lb (n=2)	12st 7lb – 13st (n=3)	13st – 13st 6lb (n=2)	13st 7lb – 14st (n=3)	14st – 14st 6lb (n=2)	14st 7lb – 15st (n=1)	15st – 15st 6lb (n=1)	15st 7lb – 16st (n=3)	16st -16st 6lb (n=1)	Don't know (n=1)
3 (100%)	2 (100%)	2 (67%)	3 (100%)	3 (75%)	0 (0%)	1 (20%)	1 (50%)	1 (34%)	1 (50%)	1 (34%)	1 (50%)	1 (100%)	0 (0%)	3 (100%)	0 (0%)	1 (100%)

* 1 missing

Table M-19 The respondents, divided by BMI, who have experienced pressure ulcers (n=41)*

Groups					
Under weight (n=1)	Ideal weight (n=21)	Over weight (n=11)	Obese (n=6)	Very obese (n=0)	Don't know (n=1)
1 (100%)	13 (62%)	4 (36%)	4 (67%)	0 (0%)	1 (100%)

*1 missing

M.2.2 Pressure Ulcer Anatomical Site Distribution

Table M-20 Number of occasions a pressure ulcer has occurred on the right buttock

Groups	Number of occasions					
	Never	Once	Twice	3 times	4 times	5 times
All respondents (n=41)	30 (73%)	3 (7%)	2 (5%)	3 (7%)	1 (2%)	2 (5%)
Tetraplegics (n=26)	19	2	1	2	1	1
Paraplegics (n=15)	11	1	1	1	0	1
Right handed (n=31)	23	2	1	3	0	2
Left handed (n=7)	4	1	1	0	1	0
Male (n=25)	18	1	2	3	1	0
Female (n=14)	10	2	0	0	0	2

(see Q4.4)

Table M-21 Number of occasions a pressure ulcer has occurred on the left buttock

Groups	Number of occasions					
	Never	Once	Twice	3 times	4 times	5 times
All respondents (n=41)	36 (88%)	1 (2%)	2 (5%)	0 (0%)	1 (2%)	1 (2%)
Tetraplegics (n=26)	23	1	1	0	1	0
Paraplegics (n=15)	13	0	1	0	0	1
Right handed (n=31)	28	1	1	0	0	1
Left handed (n=7)	5	0	1	0	1	0
Male (n=25)	22	0	2	0	1	0
Female (n=14)	12	1	0	0	0	1

(see Q4.4)

Table M-22 Number of occasions a pressure ulcer has occurred on the back of the right thigh

Groups	Number of occasions					
	Never	Once	Twice	3 times	4 times	5 times
All respondents (n=41)	38 (93%)	2 (5%)	1 (2%)	0 (0%)	0 (0%)	0 (0%)
Tetraplegics (n=26)	23	2	1	0	0	0
Paraplegics (n=15)	15	0	0	0	0	0
Right handed (n=31)	30	1	0	0	0	0
Left handed (n=7)	5	1	1	0	0	0
Male (n=25)	23	1	1	0	0	0
Female (n=14)	13	1	0	0	0	0

(see Q4.4)

Table M-23 Number of occasions a pressure ulcer has occurred on the back of the left thigh

Groups	Number of occasions					
	Never	Once	Twice	3 times	4 times	5 times
All respondents (n=41)	39 (95%)	2 (5%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Tetraplegics (n=26)	24	2	0	0	0	0
Paraplegics (n=15)	15	0	0	0	0	0
Right handed (n=31)	30	1	0	0	0	0
Left handed (n=7)	6	1	0	0	0	0
Male (n=25)	24	1	0	0	0	0
Female (n=14)	13	1	0	0	0	0

(see Q4.4)

Table M-24 Number of occasions a pressure ulcer has occurred on the base of the spine

Groups	Number of occasions					
	Never	Once	Twice	3 times	4 times	5 times
All respondents (n=41)	28 (68%)	8 (20%)	1 (2%)	0 (0%)	1 (2%)	3 (7%)
Tetraplegics (n=26)	19	4	1	0	0	2
Paraplegics (n=15)	9	4	0	0	1	1
Right handed (n=31)	21	6	1	0	1	2
Left handed (n=7)	4	2	0	0	0	1
Male (n=25)	14	8	1	0	1	1
Female (n=14)	12	0	0	0	0	2

(see Q4.4)

Table M-25 Number of occasions a pressure ulcer has occurred on the right hip

Groups	Number of occasions					
	Never	Once	Twice	3 times	4 times	5 times
All respondents (n=41)	40 (98%)	0 (0%)	1 (2%)	0 (0%)	0 (0%)	0 (0%)
Tetraplegics (n=26)	25	0	1	0	0	0
Paraplegics (n=15)	15	0	0	0	0	0
Right handed (n=31)	31	0	0	0	0	0
Left handed (n=7)	6	0	1	0	0	0
Male (n=25)	24	0	1	0	0	0
Female (n=14)	14	0	0	0	0	0

(see Q4.4)

Table M-26 Number of occasions a pressure ulcer has occurred on the left hip

Groups	Number of occasions					
	Never	Once	Twice	3 times	4 times	5 times
All respondents (n=41)	38 (93%)	2 (5%)	1 (2%)	0 (0%)	0 (0%)	0 (0%)
Tetraplegics (n=26)	25	0	1	0	0	0
Paraplegics (n=15)	13	2	0	0	0	0
Right handed (n=31)	29	2	0	0	0	0
Left handed (n=7)	6	0	1	0	0	0
Male (n=25)	22	2	1	0	0	0
Female (n=14)	14	0	0	0	0	0

(see Q4.4)

Table M-27 Number of occasions a pressure ulcer has occurred on certain location

Groups		Number of occasions					
		Never	Once	Twice	3 times	4 times	5 times
Head	Tetra	26	0	0	0	0	0
	Para	15	0	0	0	0	0
Torso	Tetra	26	0	0	0	0	0
	Para	14	0	1	0	0	0
Elbows	Tetra	25	0	1	0	0	0
	Para	14	0	0	0	0	1
Genitals	Tetra	25	1	0	0	0	0
	Para	15	0	0	0	0	0
Heels	Tetra	23	0	3	0	0	0
	Para	12	2	1	0	0	0
Ankles	Tetra	23	0	1	1	0	1
	Para	13	1	0	1	0	0

(see Q4.4)

Table M-28 Other location where a pressure ulcer has developed

Other location	Groups					
	Tera (n=26)	Para (n=15)	R.handed (n=31)	L.handed (n=7)	Male (n=25)	Female (n=14)
Top of the knee		1	1			1
Side of the foot	1		1			1
In intergluteal cleft	1		1		1	

* Of the 41 respondents, 3 reported other locations where they developed a pressure ulcer **(see Q4.4)**

M.2.3 Pressure Ulcer Causes

Table M-29 The frequency cushions are thought to have contributed to the development of a pressure ulcer on the seat area of the body#

Groups	Frequency the cushion was thought to have contributed					
	All the time (every time)	Frequently (most times)	Occasionally (about half the time)	Very rarely (some of the time)	Never	Don't know
Respondents with PU's (n=22)*	4 (18%)	2 (9%)	0 (0%)	2 (9%)	6 (27%)	4 (18%)
Tetraplegics (n=14)*	2	2	0	1	3	2
Paraplegics (n=8)	2	0	0	1	3	2

Of the 24 respondents who had experienced pressures, 22 had experienced a pressure ulcer on the seat area of the body **(see Q4.7)**

* 4 missing

Table M-30 How often the respondents pressure ulcers were identified as being caused by something other than the cushion (n=22)

Cause other than cushion (description drawn directly from questionnaire)	Frequency a cause is identified				
	All the time	Frequently	Occasion-ally	Very rarely	Never
"*Prominent seams in clothing*"*	0 (0%)	1 (5%)	1 (5%)	2 (9%)	5 (23%)
"*Being left for an excessively long period on the cushion*"**	2 (9%)	1 (5%)	3 (14%)	1 (5%)	3 (14%)
"*An unsafe transfer*"***	5 (23%)	1 (5%)	4 (18%)	2 (9%)	2 (9%)
"*Missed small objects eg coins*"****	0 (0%)	0 (0%)	1 (5%)	1 (5%)	6 (27%)
"*Pressure relief routine not performed regularly enough*"****	2 (9%)	0 (0%)	1 (5%)	2 (9%)	3 (14%)
"*Pressure relief routine not providing enough respite from pressure*"****	2 (9%)	0 (0%)	3 (14%)	0 (0%)	3 (14%)

* 13 missing; ** 12 missing; *** 8 missing; **** 14 missing **(see Q4.8)**

Table M-31 How often the respondents pressure ulcers were identified as being caused by something other than the cushion, divided by level of injury

Cause other than cushion (description drawn directly from questionnaire)	Frequency a cause is identified									
	All the time		Frequently		Occasion-ally		Very rarely		Never	
	Tetra (n=14)	Para (n=8)	Tetra (n=14)	Para (n=8)	Tetra (n=14)	Para (n=8)	Tetra (n=14)	Para (n=8)	Tetra (n=14)	Para (n=8)
"*Prominent seams in clothing*"*	0	0	1	0	0	1	1	1	4	1
"*Being left for an excessively long period on the cushion*"**	1	1	1	0	3	0	1	0	2	1
"*An unsafe transfer*"***	2	3	1	0	3	1	2	0	1	1
"*Missed small objects eg coins*"****	0	0	0	0	1	0	0	1	5	1
"*Pressure relief routine not performed regularly enough*"****	1	1	0	0	0	1	2	0	3	0
"*Pressure relief routine not providing enough respite from pressure*"****	1	1	0	0	2	1	0	0	3	0

* 13 missing; ** 12 missing; *** 8 missing; **** 14 missing

Table M-32 Other occasions when pressure ulcers have been identified as being caused by something other than the cushion

Causes other than cushion	Groups		
	Respondents (n=22)*	Tetrapelgics (n=14)	Paraplegics (n=8)
Infections, UTI's, sepsis	1 (2%)	1	
Not turning in bed	1 (2%)	1	
Seams in clothing cut into skin when lifted out of wheelchair	1 (2%)	1	
Colliding with wheel during a transfer	1 (2%)		
Poor transfer	2 (5%)	1	1
Fell onto floor during a transfer from a car	1 (2%)		1
Prolonged stay in bed (due to a deep vain thrombosis, TB)	1 (2%)	1	1
Wrong foot rest height	1 (2%)	1	
Poor posture	1 (2%)	1	
Significant weight loss (due to over-active thyroid	1 (2%)	1	
Poor blood circulation due to SCI	1 (2%)	1	
Loss of physical fitness	1 (2%)		1

* Of these 22 respondents, 13 reported the cause to have been something other than those previously addressed in table I-30. **(see Q4.8)**

Table M-33 Respondents who have developed a pressure ulcers shortly after a rapid change in body shape

Groups	Developed a pressure ulcer			
	After rapid weight gain		After rapid weight loss	
	Yes	No	Yes	No
Respond. with PU's (n=24)*	1	22	3	20
Tetraplegic (n=15)*	1	13	2	12
Paraplegic (n=9)	0	9	1	8

* 1 missing **(see Q4.10 and 4.11)**

Table M-34 How frequently respondents develop a pressure ulcer on the right side of the body from leaning to the right

Groups	Leaning to the right causes a pressure ulcer				
	All the time	Frequently	Occasion-ally	Very rarely	Never
Respondents with PU's (n=22)*	0 (0%)	0 (0%)	0 (0%)	0 (0%)	6 (25%)
Tetraplegics (n=14)**	0	0	0	0	3
Paraplegics (n=8)***	0	0	0	0	3
Left handed (n=5)***	0	0	0	0	0
Right handed (n=16)****	0	0	0	0	6

* 16 missing; ** 11 missing; *** 5 missing; **** 10 missing **(see Q4.9)**

Table M-35 How frequently respondents develop a pressure ulcer on the left side of the body from leaning to the left

Groups	Leaning to the left causes a pressure ulcer				
	All the time	Frequently	Occasion-ally	Very rarely	Never
Respondents with PU's (n=22)*	0 (0%)	1 (4%)	0 (0%)	0 (0%)	5 (21%)
Tetraplegics (n=14)**	0	0	0	0	3
Paraplegics (n=8)***	0	1	0	0	2
Left handed (n=5)***	0	0	0	0	0
Right handed (n=16)****	0	1	0	0	5

* 16 missing; ** 11 missing; *** 5 missing; **** 10 missing **(see Q4.9)**

Table M-36 How frequently respondents develop a pressure ulcer slouching/sliding forward reducing the area of the body in contact with the cushion

Groups	Slouching/sliding causes a PU by reducing contact area				
	All the time	Frequently	Occasion-ally	Very rarely	Never
Respondents with PU's (n=22)*	0 (0%)	2 (8%)	0 (0%)	0 (0%)	5 (21%)
Tetraplegics (n=14)**	0	1	0	0	3
Paraplegics (n=8)***	0	1	0	0	2
Left handed (n=5)***	0	0	0	0	0
Right handed (n=16)****	0	2	0	0	5

* 15 missing; ** 10 missing; *** 5 missing; **** 9 missing **(see Q4.9)**

Table M-37 How frequently respondents develop a pressure ulcer by slouching/sliding forward pressing the genitals against the pummel of the cushion

Groups	Slouching/sliding causes a PU by pressing genitals against cushion pummel				
	All the time	Frequently	Occasion-ally	Very rarely	Never
Respondents with PU's (n=22)*	0 (0%)	0 (0%)	0 (0%)	0 (0%)	6 (25%)
Tetraplegics (n=14)**	0	0	0	0	3
Paraplegics (n=8)***	0	0	0	0	3
Left handed (n=5)***	0	0	0	0	0
Right handed (n=16)****	0	0	0	0	6

* 16 missing; ** 11 missing; *** 5 missing; **** 10 missing **(see Q4.9)**

Table M-38 Other ways poor posture lead to the development of a pressure ulcer

Other way posture lead to pressure ulcer	Groups		
	Respondents(n=41)*	Tetra (n=26)	Para (n=15)
Leaning on left arm rest led to pressure ulcer on left elbow	1	1	
Leaning on the left to compensate for a spasm on the right hand side of the trunk	1	1	

* Of the 41 respondents, 2 reported other ways posture lead to a pressure ulcer **(see Q4.9)**

M.3 Results on Cushions Used by Respondents

M.3.1 Cushions Used

Table M-39 Make of cushion currently used by respondents (n=41)

Make of cushion										
Flo-tech	Foam	Jay 2	Pindot	ROHO	Stimulite	Sumed ErgoNest	Tempurmed	Unspecified	Varilite	Vicair
1 (2%)	1 (2%)	17 (41%)	2 (5%)	13 (32%)	1 (2%)	1 (2%)	1 (2%)	1 (2%)	1 (2%)	2 (5%)

(see Q2.1)

Table M-40 Cushions used by SCI groups, paraplegics and tetraplegics

Groups	Make of cushion		
	Jay	ROHO	Other#
Tetraplegics (n=26)*	9 (35%)	10 (38%)	6 (23%)
Paraplegics (n=15)	8 (53%)	3 (20%)	4 (27%)

* 1 missing

\# Other = Flo-tech, Foam, Pindot, Stimulate, Sumed ErgoNest, Tempurmed, Unspecified, Varilite, Vicair

Table M-41 Length of time the respondent's have been using their current cushion (n=41)

Cushion	Length of use (months)					
	< 1	1 - 5	6 - 11	12 – 17	18 – 24	> 24
Jay	1	2	3	2	1	8
ROHO	0	0	0	1	4	8
Other	0	4	1	1	1	4

(see Q2.3)

Table M-42 How concerned respondents are that the performance of their cushion may lead to problems with their skin

Groups		Degree of concern with cushion performance				
		Very worried	Worried	Concerned	Not worried at all	Never think about it
All respondents (n=41)*		6 (15%)	5 (12%)	9 (22%)	10 (24%)	9 (22%)
Male (n=25)		4	5	5	6	5
Female (n=14)**		2	0	3	4	4
Tetraplegics (n=26)	Jay users (n=9)**	0	2	3	1	2
	ROHO users (n=10)	3	2	3	1	1
	Other users (n=7)**	1	1	1	2	1
Paraplegics (n=15)	Jay users (n=8)	1	0	0	5	2
	ROHO users (n=3)	0	0	0	1	2
	Other users (n=4)	1	0	2	0	1

* 2 missing; ** 1 missing **(see Q4.1)**

M.3.2 Cushion Selection

Table M-43 Respondents who chose their current cushion (n=41)*

Groups	Selected their own current cushion			
	Yes (n=25)			No (n=15)
Cushion chosen	Jay	ROHO	Other	n/a
All respondents (n=41)*	11 (27%)	7 (17%)	7(17%)	15 (37%)
Tetraplegic (n=26)*	6	6	5	8
Paraplegic (n=15)	5	1	2	7

* 1 missing **(see Q2.7)**

Table M-44 Reasons why respondents chose their cushion

Reason for choice	Groups						
	All respondents (n=25)*	Tetraplegics (n=17)			Paraplegics (n=8)		
		Jay (n=6)	ROHO (n=6)	Other (n=5)	Jay (n=5)	ROHO (n=1)	Other (n=2)
Its what I'm used to, happy with	7 (17%)	2	1	1	2		1
Recommended by Spinal Injuries Centre/ staff	6 (15%)	2	2	1			1
Pressure relieving qualities	4 (10%)		1	1	1	1	
For comfort	4 (10%)	1	2			1	
For posture	2 (5%)	1	1				
Light weight	2 (5%)			1	1		
For body shape	2 (5%)			1	1		
Easy to adjust	1 (2%)			1			

* Of the 25 respondents who had chosen their current cushion all 25 gave their reasons for making that choice. Some of the respondents reported more than one reason **(see Q2.7a)**

Table M-45 Respondents who have used a different make/type of cushion

Groups	Used a different make/type of cushion	
	Yes	No
All respondents (n=41)	34	7
Tetraplegic (n=26)	20	6
Paraplegic (n=15)	14	1

(see Q2.8)

Table M-46 Reasons why respondents stopped using their previous cushion

Reasons for ceasing to use previous cushion	Respondents (n=34)*	Groups					
		Tetraplegics (n=20)			Paraplegics (n=14)		
		Jay (n=5)	ROHO (n=8)	Other (n=7)	Jay (n=7)	ROHO (n=4)	Other (n=3)
Insufficient pressure relieving qualities	8 (24%)	2	4	1		1	
Recommended to change (seating clinic/staff)	5 (15%)		2			2	1
Poor posture support	5 (15%)			3	2		
Too heavy, chose lighter cushion	4 (12%)			2	2		
Bottoming out	3 (9%)					1	2
Better cushions came onto market	3 (9%)	2	1				
Developed a pressure ulcer	2 (6%)	1	1				
Punctures easily	2 (6%)	1			1		
Uncomfortable	1 (3%)						1
Sweating problems	1 (3%)				1		
Needed wider cushion	1 (3%)						1
Gel too runny	1 (3%)			1			
Ruptured gel pack	1 (3%)				1		

* Of the 34 respondents who had stopped using their previous cushion all 34 gave their reasons why. Some of the respondents reported more than one reason as to why they stopped **(see Q2.8a)**

Table M-47 How respondents regard certain aspects when considering which cushion to use (n=41)

Aspect considered when deciding which cushion to use (description as used in questionnaire)	Significance of an aspect of a cushion				
	Very significant	Of some significance	Significant	Of little significance	Of no significance
"*The cushion's ability to be fixed securely to a wheelchair*"	13 (32%)	8 (20%)	6 (15%)	7 (17%)	7 (17%)
"*The cushion's ability to be kept clean*"*	17 (42%)	10 (24%)	8 (20%)	5 (12%)	0 (0%)
"*The cushion's ability to keep the pressure experienced by your skin low*"	40 (98%)	1 (2%)	0 (0%)	0 (0%)	0 (0%)
"*The cushion's ability to maintain the seated posture*"	31 (76%)	8 (19%)	1 (2%)	1 (2%)	0 (0%)
"*The cushion's ability to prevent sweating*"**	14 (34%)	11 (27%)	9 (22%)	1 (2%)	3 (7%)
"*The cushion's appearance*"***	6 (15%)	6 (15%)	11 (26%)	9 (22%)	7 (17%)
"*The cushion's cost*"***	9 (22%)	5 (12%)	8 (20%)	8 (20%)	9 (22%)
"*The cushion's weight*"***	11 (27%)	13 (32%)	4 (10%)	8 (20%)	3 (7%)
"*The level of comfort provided by the cushion*"	31 (76%)	6 (15%)	2 (5%)	0 (0%)	2 (5%)

* 1 missing; ** 3 missing; *** 2 missing **(see Q2.6)**

Table M-48 How respondents, divided by level of injury, regard certain aspects when considering which cushion to use

Aspect considered when deciding which cushion to use (description as used in questionnaire)	Significance of an aspect of a cushion: Very significant		Of some significance		Significant		Of little significance		Of no significance	
	Tetra (n=26)	Para (n=15)	Tetra (n=26)	Para (n=15)	Tetra (n=26)	Para (n=15)	Tetra (n=26)	Para (n=15)	Tetra (n=26)	Para (n=15)
"*The cushion's ability to be fixed securely to a wheelchair*"	9	4	5	3	3	3	4	3	5	2
"*The cushion's ability to be kept clean*"	9	8	6	4	7	1	3	2	0	0
"*The cushion's ability to keep the pressure experienced by your skin low*"	26	14	0	1	0	0	0	0	0	0
"*The cushion's ability to maintain the seated posture*"	19	12	6	2	1	0	0	1	0	0
"*The cushion's ability to prevent sweating*"**	8	6	7	4	5	4	1	0	3	0
"*The cushion's appearance*"***	3	3	2	4	8	3	6	3	5	2
"*The cushion's cost*"***	5	4	2	3	5	3	7	1	5	4
"*The cushion's weight*"***	7	4	7	6	2	2	6	2	3	0
"*The level of comfort provided by the cushion*"	19	12	4	2	1	1	0	0	2	0

* 1 missing; ** 3 missing; *** 2 missing

Table M-49 How respondents, divided by cushion use, regard certain aspects when considering which cushion to use

Aspect considered when deciding which cushion to use (description as used in questionnaire)	Significance of an aspect of a cushion: Very significant			Of some significance			Significant			Of little significance			Of no significance		
	Jay (n=17)	ROHO (n=13)	Other (n=11)	Jay (n=17)	ROHO (n=13)	Other (n=11)	Jay (n=17)	ROHO (n=13)	Other (n=11)	Jay (n=17)	ROHO (n=13)	Other (n=11)	Jay (n=17)	ROHO (n=13)	Other (n=11)
"*The cushion's ability to be fixed securely to a wheelchair*"	5	3	5	5	1	2	4	1	1	3	3	1	0	5	2
"*The cushion's ability to be kept clean*"*	7	3	7	6	3	1	2	4	2	2	2	1	0	0	0
"*The cushion's ability to keep the pressure experienced by your skin low*"	16	13	11	1	0	0	0	0	0	0	0	0	0	0	0
"*The cushion's ability to maintain the seated posture*"	14	10	7	2	2	4	0	1	0	1	0	0	0	0	0
"*The cushion's ability to prevent sweating*"**	8	2	4	4	4	3	2	4	3	1	0	0	2	1	0
"*The cushion's appearance*"***	2	2	2	3	1	2	6	2	3	5	2	2	1	4	2
"*The cushion's cost*"***	4	2	3	3	2	0	7	0	1	0	6	2	2	2	5
"*The cushion's weight*"***	5	2	4	7	3	3	2	2	0	2	3	3	0	2	1
"*The level of comfort provided by the cushion*"	12	10	9	3	2	1	1	1	0	0	0	0	1	0	1

* 1 missing; ** 3 missing; *** 2 missing

Table M-50 Other factors respondents consider significant when considering which cushion to use

Other pressure reliving movements	All respond. (n=41)*	Tetraplegics (n=8)			Paraplegics (n=6)		
		Jay (n=3)	ROHO (n=2)	Other (n=3)	Jay (n=1)	ROHO (n=2)	Other (n=3)
Easy to adjust/vary pressure	4 (10%)		1	2			1
Easy to transfer	4 (10%)	1		1		1	1
Dimensions (width & depth)	2 (5%)	1					1
Reliability	2 (5%)			1		1	
Seating clinic results (pressure mapping)	2 (5%)		1				1
Durable covers	1 (2%)				1		
Easy to repair	1 (2%)					1	
Handle on the front	1 (2%)	1					
Replaceable covers	1 (2%)				1		
Velcro fasteners on covers	1 (2%)				1		

* 27 missing, 14 respondents provided other factors. Some respondents reported more than one factor

(see Q2.6)

Table M-51 How the respondents rate the overall performance of their current cushion (n=41)

Groups		How overall performance is regarded				
		Excellent	Good	Satisfactory	Poor	Useless
All respondents (n=41)		18 (44%)	14 (34%)	7 (%)	2 (5%)	0 (0%)
Tetra (n=26)	Jay users (n=9)	5	3	1	0	0
	ROHO users (n=10)	5	2	2	1	0
	Other users (n=7)	4	1	2	0	0
Para (n=15)	Jay users (n=8)	2	6	0	0	0
	ROHO users (n=3)	0	2	1	0	0
	Other users (n=4)	2	0	1	1	0

(see Q2.5)

Table M-52 Reasons why respondents regard their cushion's overall performance as "*Excellent*"*

Reason for regarding cushion as "*Excellent*"	Respond. (n=18)*	Tetraplegics (n=14)			Paraplegics (n=4)		
		Jay (n=5)	ROHO (n=5)	Other (n=4)	Jay (n=2)	ROHO (n=0)	Other (n=2)
No skin problems	13	5	4	2	1		1
Pressure relief	5		1	2	1		1
Maintains good posture	4		2	1	1		
Comfortable	2		1		1		
Provides stability	1				1		
Easy to transfer	1	1					
Easy to use	1		1				
Easy to maintain	1		1				
Reliable	1			1			
Fits purpose	1			1			

* 18 respondents regard their cushion as "*Excellent*". Some of the respondents reported more than one reason as to why their current cushion was "*Excellent*"

(see Q2.5)

Table M-53 Reasons why respondents regard their cushion's overall performance as "*Good*"*

Reason for regarding cushion as "*Good*"	Respond. (n=14)*	Tetraplegics (n=6)			Paraplegics (n=8)		
		Jay (n=3)	ROHO (n=2)	Other (n=1)	Jay (n=6)	ROHO (n=2)	Other (n=0)
No skin problems	5	1			3	1	
Causes discomfort	2			1	1		
Comfortable	2	1			1		
Light weight	2		1		1		
Poor maintenance	2		1			1	
Prone to punctures	2		1			1	
Too heavy	1	1					
Easy to maintain	1				1		
Easy to clean	1				1		
Easy to store	1				1		
Easy to maintain	1				1		
Keeps bottom cool	1				1		
Limits sweating	1				1		
Maintains good posture	1				1		
Poor stability	1					1	
Suits needs	1	1					
Too heavy	1	1					

* 14 respondents regard their cushion as "*Good*". Some of the respondents reported more than one reason as to why their cushion is "*Good*". **(see Q2.5)**

M.3.3 Cushion Provision

Table M-54 The length of time a respondent has had to wait for a new cushion after they are found to be using a cushion of the wrong size

Groups	Length of wait						
	Always have the right size	< 2 weeks	2 – 4 weeks	1 – 3 months	4 – 6 months	7 – 12 months	> 12 months
All respondents (n=41)*	27 (66%)	4 (10%)	2 (5%)	1 (2%)	0 (0%)	0 (0%)	4 (10%)
Tetraplegics (n=26)*	16	4	1	1	0	0	1
Paraplegics (n=15)	11	0	1	0	0	0	3

* 3 missing **(see Q2.9)**

Table M-55 The extent of the problem the use of an incorrect sized cushion posed for the skin

Groups	Extent of difficulties				
	Major difficulties	Some difficulties	Inconven-ient	Small inconven-ience	Not a problem
Respondents (n=11)# *	2 (20%)	3 (30%)	2 (20%)	1 (10%)	2 (20%)
Tetraplegics (n=7)	1	1	2	1	2
Paraplegics (n=4) *	1	2	0	0	0

\# Out of the 41 respondents, 11 have used a cushion not of the correct size **(see Q2.9a)**

* 1 missing

Table M-56 The length of time a respondent has had to wait for a new cushion after they are found to be using a cushion with the wrong surface contour shape

Groups	Length of wait						
	Always have the right shape	< 2 weeks	2 – 4 weeks	1 – 3 months	4 – 6 months	7 – 12 months	> 12 months
All respondents (n=41)*	22 (54%)	1 (2%)	0 (0%)	1 (2%)	1 (2%)	1 (2%)	5 (12%)
Tetraplegics (n=26)**	15	1	0	0	0	0	2
Paraplegics (n=15)***	7	0	0	1	1	1	3

* 10 missing; ** 8 missing; *** 2 missing **(see Q2.10)**

Table M-57 The extent of the problem the use of an incorrect shaped cushion posed for the skin

	Extent of difficulties				
	Major difficulties	Some difficulties	Inconven-ient	Small inconven-ience	Not a problem
Respondents (n=9)#	5 (55%)	2 (22%)	0 (0%)	1 (11%)	1 (11%)
Tetraplegics (n=3)	1	1	0	0	1
Paraplegics (n=6)	4	1	0	1	0

Out of the 41 respondents, 9 have used a cushion with an incorrect surface contour shape **(see Q2.10a)**

M.3.4 Cushions with Air Cells

Table M-58 Respondents who have used cushions with air cells

Groups	Used cushion with air cells	
	Yes	No
All respondents (n=41)	22 (54%)	19 (46%)
Tetraplegic (n=26)*	15 (58%)	11 (42%)
Paraplegic (n=15)	7 (47%)	8 (53%)

(see Q6.17)

Table M-59 Occasions when respondents check the air pressure in the air cells of their cushion

Groups	Occasions when air pressure is checked									
	It varies form day to day	After every period of activity	Every hour	Every few hours	Once a day	Once a week	A couple of times a week	A couple of times a month	Never check	Check at other times
Respondents (n=22)#*	5 (23%)	0 (0%)	0 (0%)	1 (5%)	4 (18%)	2 (9%)	0 (0%)	5 (23%)	1 (5%)	3 (14%)
Tetraplegics (n=15)	3 (20%)	0 (0%)	0 (0%)	0 (0%)	3 (20%)	1 (7%)	0 (0%)	5 (33%)	1 (7%)	2 (13%)
Paraplegics (n=7)*	2 (29%)	0 (0%)	0 (0%)	1 (14%)	1 (14%)	1 (14%)	0 (0%)	0 (0%)	0 (0%)	1 (14%)

19 respondents have not used cushion with air cells **(see Q6.17a)**

* 1 missing

Table M-60 Other occasions the respondents, who have used cushions with air cells, would check air pressure

	Groups		
	Respondents(n=22)*	Tetraplegics (n=15)	Paraplegics (n=7)
"*Quite often*"	1		1
When travelling by air	1	1	
Twice a day	1		1
Depends on temperature	1		1
Depends on usage	1	1	
Start and end of day	1	1	

* Of the 22 respondents who have used a cushion with air cells, 5 gave other times when they check the air pressure. Some of the respondents reported more than one occasion **(see Q6.17a)**

Table M-61 The extent to which respondents experience difficulties with controlling the level of air pressure in the air cells of their cushion

Groups	Difficulty involved with controlling the level of air pressure					
	Its not a task I'm involved with	Very easy	Easy	Manageable	Difficult	Very difficult
Respondents (n=22)#*	3 (14%)	0 (0%)	3 (14%)	7 (33%)	3 (14%)	3 (14%)
Tetraplegics (n=15)*	3 (20%)	0 (0%)	3 (20%)	4 (27%)	2 (13%)	1 (7%)
Paraplegics (n=7)***	0 (0%)	0 (0%)	0 (0%)	3 (50%)	1 (16%)	2 (33%)

19 respondents have not used cushion with air cells **(see Q6.17c)**

* 3 missing; ** 2 missing; *** 1 missing

Table M-62 Respondents who have sat on an air filled cushion which has deflated so much that they have ended up sat on the soiled base without noticing

Groups	Sat on a cushion which has deflated	
	Yes	No
Respondents (n=22)#	12 (55%)	10 (45%)
Tetraplegic (n=15)	6	9
Paraplegic (n=7)	6	1

19 respondents have not used cushion with air cells **(see Q6.17b)**

M.3.5 Cushions with Gel Packs

Table M-63 Respondents who have used cushions with gel packs

Groups	Used cushion with gel packs	
	Yes	No
All respondents (n=41)	35 (85%)	6 (15%)
Tetraplegic (n=26)	22 (85%)	4 (15%)
Paraplegic (n=15)	13 (87%)	2 (13%)

(see Q6.16)

Table M-64 The time it takes for the gel to be pushed to the sides of the pack, so that there is no-longer enough gel under the user to provide sufficient pressure relief, "*bottomed out*"

Groups	Time taken for gel to move					
	There is always enough gel	It depends on how active I'm being	A couple of minutes	A couple of hours	Most of the day	Don't know
Respondents (n=35) #	8 (23%)	8 (23%)	2 (6%)	5 (14%)	5 (14%)	7 (20%)
Tetraplegics (n=22)	6 (27%)	4 (18%)	0 (0%)	5 (23%)	4 (%)	3 (%)
Paraplegics (n=13)	2 (15%)	4 (31%)	2 (15%)	0 (0%)	1 (8%)	4 (31%)

6 respondents have not used a cushion using gel **(see Q6.16a)**

Table M-65 How often gel moves due to differing movements/actions (n=35) #

Various movements/actions (description as used in questionnaire)	Frequency gel is displaced				
	All the time	Frequently	Occasion-ally	Very rarely	Never
"*It just drifts to the sides over time*"*	9 (26%)	9 (26%)	6 (17%)	2 (6%)	2 (6%)
"*Following a pressure relieving routine*"*	3 (9%)	7 (20%)	4 (11%)	6 (17%)	8 (23%)
"*Propelling the wheelchair*"*	3 (9%)	8 (23%)	6 (17%)	6 (17%)	5 (14%)
"*Simple fidgeting*"**	6 (17%)	6 (17%)	5 (14%)	5 (14%)	8 (23%)
"*Spasms*"***	2 (6%)	6 (17%)	5 (14%)	6 (17%)	10 (29%)

6 respondents have not used a cushion using gel **(see Q6.16c)**

* 7 missing; ** 5 missing; ** 6 missing

Table M-66 How often gel moves due to differing movements/actions, divided by level of injury#

Various movements/actions (description as used in questionnaire)	Frequency gel is displaced									
	All the time		Frequently		Occasion-ally		Very rarely		Never	
	Tetra (n=22)	Para (n=13)	Tetra (n=22)	Para (n=13)	Tetra (n=22)	Para (n=13)	Tetra (n=22)	Para (n=13)	Tetra (n=22)	Para (n=13)
"*It just drifts to the sides over time*"*	4	5	7	2	3	3	1	1	1	1
"*Following a pressure relieving routine*"*	2	1	6	1	3	1	2	4	4	4
"*Propelling the wheelchair*"*	2	1	3	5	4	2	4	2	4	1
"*Simple fidgeting*"**	4	2	4	2	5	0	2	3	4	4
"*Spasms*"***	2	0	4	2	5	0	3	3	4	6

Groups based on current cushion use, ie Jay users, were not considered as the questionnaire did not extract data to know whether the respondents were referring to experience based on their current cushion or previously used cushions

* 7 missing; ** 5 missing; ** 6 missing

Table M-67 Other movements/actions which pushed gel to the sides

	Groups		
	Respondents(n=35)*	Tetraplegics (n=22)	Paraplegics (n=13)
Sideways movements, such as picking up tennis balls	1		1
When gel heats up it moves from most needy areas	1		1
Gel is moved by gravity when the chair is tilted	1	1	
Just sitting seems to	1	1	

* Of the 35 respondents who have used a cushion with gel, 4 gave other movements/actions which pushes gel.

(see Q6.16c)

Table M-68 Occasions when respondents check the distribution of gel in the gel pack

Groups	Occasions when gel is checked								
	It varies form day to day	After every period of activity	Every hour	Every few hours	Once a day	Once a week	Check at other times	Never check	Don't know
Respondents (n=35)#*	3 (9%)	3 (9%)	0 (0%)	4 (11%)	11 (31%)	3 (9%)	3 (9%)	4 (11%)	3 (9%)
Tetraplegics (n=22)	2 (9%)	1 (5%)	0 (0%)	4 (18%)	7 (32%)	2 (9%)	2 (9%)	2 (9%)	2 (9%)
Paraplegics (n=13)*	1 (7%)	2 (15%)	0 (0%)	0 (0%)	4 (31%)	1 (7%)	1 (7%)	2 (15%)	1 (7%)

\# 6 respondents have not used a cushion with gel

* 1 missing

(see Q6.16b)

Table M-69 Other occasions when respondent check the distribution of gel

Other occasions when gel is checked	Groups		
	Respondents(n=35)*	Tetra (n=22)	Para (n=13)
When remember to	1		1
Start to feel uncomfortable, in particular when the gel bunches up in the genital area	1		1
When cushion is cleaned	1	1	
Twice a day	1	1	
When visiting the toilet	1	1	

* Of the 35 respondents who have used a cushion with gel, 5 reported other occasions when they check the distribution of gel

(see Q6.16b)

M.4 Results on Sitting Posture in a Wheelchair

M.4.1 Sitting Position

Table M-70 Problems experienced by the respondents as a result of poor sitting position

Problem experienced	Groups						
	All respondents (n=41)*	Tetraplegics (n=12)			Paraplegics (n=5)		
		Jay (n=4)	ROHO (n=2)	Other (n=6)	Jay (n=2)	ROHO (n=2)	Other (n=1)
Back pain	10 (24%)	3	1	3	1	1	1
Shoulder pain	6 (15%)	2	1	1	2		
Neck pain	5 (12%)	1	1	2	1		
Scoliosis	4 (10%)	1		1	1	1	
Hip pain	1 (2%)			1			
Scrotum pain	1 (2%)				1		
Sore thighs	1 (2%)			1			
Increase in spasms	1 (2%)		1				
Rounded shoulders	1 (2%)	1					
Pressure ulcer high up spine due to wheelchair back causing "*friction burns*"	1 (2%)						1

* Of the 41 respondents 17 reported experiencing a problem as a result of poor posture. Some of the respondents reported more than one problem. **(see Q5.1)**

Table M-71 Respondents able to sit in a "*normal sitting*" position

Groups	Able to sit in "*normal sitting*" position	
	Yes	No
All respondents (n=41)*	30 (73%)	7 (17%)
Tetraplegic (n=26)**	19	4
Paraplegic (n=15)***	11	3

* 4 missing; ** 3 missing; *** 1 missing **(see Q5.12)**

Table M-72 How often the respondents adopt certain seated positions (n=41)

Sitting position	Frequency certain seated positions are adopted				
	All the time	Frequently	Occasion-ally	Very rarely	Never
Slouch*	4 (10%)	9 (22%)	10 (24%)	3 (7%)	6 (14%)
Lean to the right**	2 (5%)	2 (5%)	9 (22%)	3 (7%)	10 (24%)
Lean to the left***	2 (5%)	3 (7%)	5 (12%)	6 (15%)	12 (29%)
*Tilt forward*****	4 (10%)	8 (20%)	3 (7%)	5 (12%)	10 (24%)

* 9 missing; ** 15 missing; *** 13 missing; **** 11 missing **(see Q5.9)**

Tilt forward = Tilt forward so that the head falls forward and the shoulders round over

Table M-73 How often respondents, divided by level of injury, adopt certain sitting positions

Sitting position	Frequency certain seated positions are adopted									
	All the time		Frequently		Occasion-ally		Very rarely		Never	
	Tetra (n=26)	Para (n=15)	Tetra (n=26)	Para (n=15)	Tetra (n=26)	Para (n=15)	Tetra (n=26)	Para (n=15)	Tetra (n=26)	Para (n=15)
Slouch*	3	1	7	2	5	5	2	1	3	3
Lean to the right**	1	1	2	0	5	4	2	1	5	5
Lean to the left***	1	1	3	0	2	3	4	2	6	6
*Tilt forward*****	4	0	6	2	1	2	3	2	4	6

* 9 missing; ** 15 missing; *** 13 missing; **** 11 missing

Table M-74 How often respondents, divided by cushions used, adopt certain sitting positions

Sitting position	Frequency certain seated positions are adopted														
	All the time			Frequently			Occasion-ally			Very rarely			Never		
	Jay (n=17)	ROHO (n=13)	Other (n=11)	Jay (n=17)	ROHO (n=13)	Other (n=11)	Jay (n=17)	ROHO (n=13)	Other (n=11)	Jay (n=17)	ROHO (n=13)	Other (n=11)	Jay (n=17)	ROHO (n=13)	Other (n=11)
Slouch*	1	2	1	6	1	2	4	3	3	1	1	1	3	1	2
Lean to the right**	1	1	0	1	0	1	5	2	2	1	1	1	4	2	4
Lean to the left***	0	2	0	1	1	1	4	0	1	1	3	2	5	2	5
*Tilt forward*****	1	3	0	3	1	4	3	0	0	1	2	2	5	2	3

* 9 missing; ** 15 missing; *** 13 missing; **** 11 missing

Table M-75 Other sitting positions adopted by respondents

Other sitting positions	Groups		
	Respondents(n=41)*	Tetra (n=26)	Para (n=15)
Sit with an inclined back rest	3	3	
They sit with their feet off the footplates and their body stretched out	1		1
Can't maintain an upright position without support and so their body wants to roll into a ball	1		1
When driving unless they are sat exactly in the middle of the drivers seat they will lean either left or right	1	1	

* Of the 41 respondents, 6 reported other sitting positions

(see Q5.9)

M.4.2 Shifting Position

Table M-76 Average time spent in a good postural position before slipping into a poor position

Groups		Varies greatly	< 10	10 -29	30 - 59	60 - 89	90 – 119	120 – 179	180 - 240	> 240	Never	Don't know
		Average Time (minutes)										
All respondents (n=41)*		12 (29%)	1 (2%)	2 (5%)	1 (2%)	3 (7%)	2 (5%)	3 (7%)	1 (2%)	5 (12%)	1 (2%)	7 (17%)
Tetraplegics (n=26)	Jay users (n=9)	4	0	0	0	0	1	1	0	1	0	2
	ROHO users (n=10)	2	0	1	1	1	1	0	0	2	0	2
	Other users (n=7)**	3	0	1	0	1	0	1	0	0	0	0
Paraplegics (n=15)	Jay users (n=8)***	1	0	0	0	1	0	0	1	1	0	2
	ROHO users (n=3)	1	0	0	0	0	0	1	0	0	0	1
	Other users (n=4)	1	1	0	0	0	0	0	0	1	1	0

* 3 missing; ** 1 missing; *** 2 missing **(see Q5.11)**

Table M-77 How often the respondents are displaced from a "*good postural position*" due to certain movements/actions (n=30)*

Various movements/actions (description as used in questionnaire)	Frequency respondents are moved from a good sitting position				
	All the time	Frequently	Occasion-ally	Very rarely	Never
"*You gradually drift into a poor position*"**	5 (17%)	8 (27%)	7 (23%)	2 (7%)	5 (17%)
"*You look for a more comfortable position*"***	2 (7%)	4 (13%)	8 (27%)	3 (10%)	5 (17%)
"*Self propelling the wheelchair throws your position*"****	1 (3%)	4 (13%)	9 (30%)	5 (17%)	5 (17%)
"*Spasms alter your position*"*****	2 (7%)	4 (13%)	9 (30%)	5 (17%)	5 (17%)
"*Fidgeting*"****	2 (7%)	4 (13%)	6 (20%)	5 (17%)	7 (23%)

* 30 of the 41 respondents are able to sit in a "*good postural position*", (table I-71)

** 3 missing; *** 8 missing; **** 6 missing; ***** 5 missing **(see Q5.12a)**

Table M-78 How often respondents, divided by level of injury, are displaced from a "*good postural position*" due to certain movements/actions

Various movements/actions (description as used in questionnaire)	Frequency respondents are moved from a good sitting position: All the time, Tetra (n=19)	All the time, Para (n=11)	Frequently, Tetra (n=19)	Frequently, Para (n=11)	Occasion-ally, Tetra (n=19)	Occasion-ally, Para (n=11)	Very rarely, Tetra (n=19)	Very rarely, Para (n=11)	Never, Tetra (n=19)	Never, Para (n=11)
"*You gradually drift into a poor position*"**	3	2	8	0	4	3	1	1	2	3
"*You look for a more comfortable position*"***	2	0	2	2	4	4	1	2	4	1
"*Self propelling the wheelchair throws your position*"****	1	0	1	3	6	3	4	1	3	2
"*Spasms alter your position*"*****	2	0	3	1	5	4	5	0	1	4
"*Fidgeting*"****	2	0	3	1	4	2	2	3	5	2

* 30 of the 41 respondents are able to sit in a "*good postural position*", (table I-71)

** 3 missing; *** 8 missing; **** 6 missing; ***** 5 missing

Table M-79 How often respondents, divided by cushions used, are displaced from a "*good postural position*" due to certain movements/actions

Various movements/actions (description as used in questionnaire)	Frequency respondents are moved from a good sitting position: All the time, Jay (n=13)	All the time, ROHO (n=10)	All the time, Other (n=7)	Frequently, Jay (n=13)	Frequently, ROHO (n=10)	Frequently, Other (n=7)	Occasion-ally, Jay (n=13)	Occasion-ally, ROHO (n=10)	Occasion-ally, Other (n=7)	Very rarely, Jay (n=13)	Very rarely, ROHO (n=10)	Very rarely, Other (n=7)	Never, Jay (n=13)	Never, ROHO (n=10)	Never, Other (n=7)
"*You gradually drift into a poor position*"**	2	1	2	4	3	1	3	4	0	1	1	0	2	1	2
"*You look for a more comfortable position*"***	1	1	0	2	1	1	4	2	2	3	0	0	1	3	1
"*Self propelling the wheelchair throws your position*"****	0	1	0	3	1	0	4	2	3	3	1	1	1	3	1
"*Spasms alter your position*"*****	0	2	0	3	0	1	4	2	3	2	3	0	2	2	1
"*Fidgeting*"****	1	1	0	3	1	0	1	0	5	3	2	0	3	4	0

* 30 of the 41 respondents are able to sit in a "*good postural position*", (table I-71)

** 3 missing; *** 8 missing; **** 6 missing; ***** 5 missing

Table M-80 Other reasons why respondents slip from a good postural position

Other reasons for slipping from good postural position	Respondents (n=30)*	Groups					
		Tetraplegics (n=10)			Paraplegics (n=0)		
		Jay (n=3)	ROHO (n=6)	Other (n=1)	Jay (n=0)	ROHO (n=0)	Other (n=0)
Discomfort/ pain	3 (7%)	1	1	1			
Lifting/moving objects	1 (2%)		1				
Cleaning	1 (2%)		1				
Unloading shopping	1 (2%)		1				
Cushion slipping forward	1 (2%)	1					
Working at computer/writing desk	1 (2%)	1					
Picking stuff up from the floor	1 (2%)		1				
Transferring from car	1 (2%)		1				
Bumps on road	1 (2%)		1				
Spasms	2 (5%)		2				

* 10 of the 30 respondents who can sit in a "*good postural position*" provided other reasons. Some of the respondents reported more than one reason **(see Q5.12a)**

Table M-81 Respondents who slouch

Groups	Slouch	
	Yes	No
All respondents (n=41)*	29 (71%)	11 (27%)
Tetraplegic (n=26)*	19 (73%)	6 (23%)
Paraplegic (n=15)	10 (67%)	5 (33%)
Jay (n=17)*	12 (71%)	4 (24%)
ROHO (n=13)	10 (77%)	3 (23%)
Other (n= 11)	7 (64%)	4 (36%)

* 1 missing **(see Q5.10)**

Table M-82 How frequently respondents slide over the surface of the cushion, with the cushion remaining in place

Groups		Slide forward over the surface of the cushion				
		All the time	Frequently	Occasion -ally	Very rarely	Never
All respondents (n=41)#*		13 (32%)	2 (5%)	5 (12%)	2 (5%)	3 (%)
Tetra (n=26)#	Jay users (n=9)**	4	0	1	0	2
	ROHO users (n=10)***	1	1	1	2	0
	Other users (n=7)	4	0	0	0	0
Para (n=15)#	Jay users (n=8)**	1	1	1	0	0
	ROHO users (n=3)	1	0	1	0	1
	Other users (n=4)	2	0	1	0	0

\# 11 respondents (6 tetras, 5 paras) reported that they never slouch **(see Q5.10a)**
* 4 missing; ** 1 missing; *** 2 missing

Table M-83 How frequently users slide forward, sliding the cushion forward as well

Groups		Slide forward with the cushion: All the time	Frequently	Occasion -ally	Very rarely	Never
All respondents (n=41)#*		2 (5%)	0 (0%)	5 (12%)	1 (2%)	10 (24%)
Tetra (n=26)#	Jay users (n=9)**	0	0	1	0	4
	ROHO users (n=10)***	2	0	3	0	1
	Other users (n=7)****	0	0	0	0	2
Para (n=15)#	Jay users (n=8)***	0	0	1	0	2
	ROHO users (n=3)****	0	0	0	0	1
	Other users (n=4)****	0	0	0	1	0

11 respondents (6 tetras, 5 paras) reported that they never slouch **(see Q5.10a)**

* 12 missing; ** 4 missing; *** 1 missing; **** 2 missing

M.4.3 Checking Position

Table M-84 Occasions when the adjustment of the footplate is checked

Groups		Occasions to check footplate: Each time the wheelchair is used	Whenever it's noticed that it is in the wrong position	Daily	Weekly	Monthly	Never check	Other
All respondents (n=41)*		0 (0%)	21 (51%)	2 (5%)	1 (2%)	0 (0%)	13 (32%)	2 (5%)
Tetra (n=26)	Jay users (n=9)	0	5	0	0	0	3	1
	ROHO users (n=10)**	0	5	1	0	0	2	1
	Other users (n=7)	0	3	0	1	0	3	0
Para (n=15)	Jay users (n=8)**	0	3	1	0	0	3	0
	ROHO users (n=3)	0	2	0	0	0	1	0
	Other users (n=4)	0	3	0	0	0	1	0

* 2 missing; ** 1 missing **(see Q5.8)**

Table M-85 Other occasions when respondents check the adjustment of their footplate

Other occasions when respondents check their footplate	Groups: Respondents(n=41)*	Tetra (n=26)	Para (n=15)
Footplate fixed into permanent position	2	1	1
Seldom and depends on carer	1	1	

* Of the 41 respondents, 3 reported other occasions when they check their footplate **(see Q5.8)**

Table M-86 Occasions when users check that their sitting position is still "*all right*" *

Groups		Every couple of hours	Occasionally (maybe once a day)	Just after transferring into the wheelchair	When you remember	When you feel uncomfortable	After a spasm	After carrying out pressure relief	After propelling your wheelchair	Never check
All respondents (n=41)		8 (20%)	3 (7%)	17 (41%)	8 (20%)	22 (54%)	11 (27%)	11 (27%)	6 (15%)	0 (0%)
Tetra (n=26)	Jay users (n=9)	3	0	5	1	6	4	2	1	0
	ROHO users (n=10)	2	1	5	1	5	4	3	2	0
	Other users (n=7)	1	1	2	2	2	1	3	3	0
Para (n=15)	Jay users (n=8)	2	1	2	2	4	2	1	0	0
	ROHO users (n=3)	0	0	1	2	2	0	0	0	0
	Other users (n=4)	0	0	2	0	3	0	2	0	0

(Column headers above are grouped under "Occasions to check posture".)

* All 41 respondents check their posture on at least one of these occasions. Some of the respondents check on more than one of these occasions **(see Q5.7)**

Table M-87 Other occasions when respondents check their sitting position

Other occasions when respondents check their posture	Groups		
	Respondents(n=41)*	Tetra (n=26)	Para (n=15)
Depends on helper/carer	2	2	
Continuously checking	1	1	

* Of the 41 respondents, 3 reported other occasions when they check their posture **(see Q5.7)**

Table M-88 How often the respondents can tell for themselves whether or not they are sitting in a particular position (n=41)

Sitting position	Aware of sitting position				
	All the time	Most of the time	About half the time	Some of the time	Never
Sat right back in wheelchair	21 (51%)	15 (37%)	0 (0%)	4 (10%)	1 (2%)
Sat upright in wheelchair	20 (49%)	13 (32%)	1 (2%)	7 (17%)	0 (0%)
Sat centrally in wheelchair so that the body is not twisted with one knee pointing further forward than the other	23 (56%)	11 (27%)	1 (2%)	4 (10%)	2 (5%)
Sat with thighs parallel to the floor	17 (42%)	14 (34%)	3 (7%)	5 (12%)	2 (5%)
Sat with the full length of the thighs in contact with the cushion	20 (49%)	9 (22%)	5 (12%)	4 (10%)	3 (7%)

(see Q5.2)
(see Q5.3)
(see Q5.4)
(see Q5.5)
(see Q5.6)

Table M-89 How often the **tetraplegic** respondents can tell for themselves whether or not they are sitting in a particular position (n=26)

Sitting position	Aware of sitting position				
	All the time	Most of the time	About half the time	Some of the time	Never
Sat right back in wheelchair	11 (42%)	11 (42%)	0 (0%)	4 (15%)	0 (0%)
Sat upright in wheelchair	10 (38%)	10 (38%)	0 (0%)	6 (23%)	0 (0%)
Sat centrally in wheelchair so that the body is not twisted with one knee pointing further forward than the other	12 (46%)	9 (35%)	1 (4%)	3 (12%)	1 (4%)
Sat with thighs parallel to the floor	8 (31%)	12 (46%)	2 (8%)	3 (12%)	1 (4%)
Sat with the full length of the thighs in contact with the cushion	11 (42%)	6 (23%)	4 (15%)	3 (12%)	2 (8%)

Table M-90 How often the **paraplegic** respondents can tell for themselves whether or not they are sitting in a particular position (n=15)

Sitting position	Aware of sitting position				
	All the time	Most of the time	About half the time	Some of the time	Never
Sat right back in wheelchair	10 (67%)	4 (27%)	0 (0%)	0 (0%)	1 (7%)
Sat upright in wheelchair	10 (67%)	3 (20%)	1 (7%)	0 (0%)	1 (7%)
Sat centrally in wheelchair so that the body is not twisted with one knee pointing further forward than the other	11 (73%)	2 (13%)	0 (0%)	1 (7%)	1 (7%)
Sat with thighs parallel to the floor	9 (60%)	2 (13%)	1 (7%)	2 (13%)	1 (7%)
Sat with the full length of the thighs in contact with the cushion	9 (60%)	3 (20%)	1 (1%)	1 (1%)	1 (1%)

M.5 Results on Cushion’s Practicality

M.5.1 Daily Use

Table M-91 Respondents who clean their own cushion

Groups	Clean cushion	
	Yes	No
All respondents (n=41)*	28 (68%)	13 (32%)
Tetraplegic (n=26)*	13 (50%)	13 (50%)
Paraplegic (n=15)	15 (100%)	0 (0%)
Jay (n=17)*	13 (76%)	4 (24%)
ROHO (n=13)	5 (38%)	8 (62%)
Other (n= 11)	10 (91%)	1 (9%)

(see Q6.8)

Table M-92 The degree of difficulty experienced by whoever cleans the cushion

Groups		Ease of cleaning					
		Don't know. Its not a task I'm involved with	Very easy	Easy	Manage-able	Difficult	Very difficult
All respondents (n=41)		6 (15%)	10 (24%)	11 (27%)	12 (29%)	2 (5%)	0 (0%)
Tetra (n=26)	Jay users (n=9)	2	0	3	4	0	0
	ROHO users (n=10)	4	3	1	2	0	0
	Other users (n=7)	0	4	2	1	0	0
Para (n=15)	Jay users (n=8)	0	2	3	3	0	0
	ROHO users (n=3)	0	0	1	1	1	0
	Other users (n=4)	0	1	1	1	1	0

(see Q6.9)

Table M-93 Frequency cushions are remove from their wheelchairs

Groups		Frequency cushions are removed from wheelchairs									
		Varies form day to day	More than 5 times a day	3–5 times a day	1–2 times a day	3–5 times a week	1–2 times a week	1–2 times a month	3–5 times a year	1–2 times a year	Less than once a year
All respondents (n=41)*		4 (10%)	2 (5%)	5 (12%)	12 (29%)	3 (7%)	6 (15%)	6 (15%)	1 (2%)	1 (2%)	0 (0%)
Tetra (n=26)	Jay users (n=9)*	0	1	0	2	0	2	3	0	1	0
	ROHO users (n=10)	1	0	0	3	2	1	1	1	0	0
	Other users (n=7)	1	0	1	2	0	2	1	0	0	0
Para (n=15)	Jay users (n=8)	1	1	2	3	0	0	1	0	0	0
	ROHO users (n=3)	0	0	2	0	0	1	0	0	0	0
	Other users (n=4)	1	0	0	2	1	0	0	0	0	0

* 1 missing

(see Q6.1)

Table M-94 How often cushions are removed from wheelchairs for particular reasons (n=41)

Reason for removal (description as used in questionnaire)	Frequency cushions are removed				
	All the time	Frequently	Occasion-ally	Very rarely	Never
"*To use on a different chair*"*	0 (0%)	2 (5%)	7 (17%)	5 (12%)	15 (37%)
"*To change the cushion cover*"**	2 (5%)	7 (17%)	13 (32%)	7 (17%)	3 (7%)
"*To check gel sacks*"*	2 (5%)	3 (7%)	6 (15%)	5 (12%)	13 (32%)
"*To collapse your wheelchair*"***	9 (22%)	7 (17%)	6 (15%)	4 (10%)	7 (17%)
"*To check for damage*"****	1 (2%)	4 (10%)	8 (20%)	13 (32%)	5 (12%)
"*To clean it*"*****	5 (12%)	12 (29%)	14 (34%)	6 (15%)	0 (0%)
"*To check air pressure*"*	5 (12%)	4 (10%)	0 (0%)	2 (5%)	18 (44%)

* 12 missing; ** 9 missing; *** 8 missing; **** 10 missing; ***** 4 missing

(see Q6.2)

Table M-95 How often respondents, divided by level of injury, remove their cushion for particular reasons

Reason for removal (description as used in questionnaire)	Frequency cushions are removed									
	All the time		Frequently		Occasion-ally		Very rarely		Never	
	Tetra (n=26)	Para (n=15)	Tetra (n=26)	Para (n=15)	Tetra (n=26)	Para (n=15)	Tetra (n=26)	Para (n=15)	Tetra (n=26)	Para (n=15)
"*To use on a different chair*"*	0	0	2	0	7	0	2	3	5	10
"*To change the cushion cover*"**	2	0	3	4	7	6	5	2	2	1
"*To check gel sacks*"*	2	0	0	3	3	3	4	1	7	6
"*To collapse your wheelchair*"***	5	4	4	3	4	2	4	0	2	5
"*To check for damage*"****	1	0	3	1	5	3	7	6	2	3
"*To clean it*"*****	5	0	10	2	6	8	3	3	0	0
"*To check air pressure*"*	4	1	4	0	0	0	1	1	8	10

* 12 missing; ** 9 missing; *** 8 missing; **** 10 missing; ***** 4 missing

Table M-96 How often respondents, divided by cushions used, remove their cushion for particular reasons

Reason for removal (description as used in questionnaire)	Frequency cushions are removed														
	All the time			Frequently			Occasion-ally			Very rarely			Never		
	Jay (n=17)	ROHO (n=13)	Other (n=11)	Jay (n=17)	ROHO (n=13)	Other (n=11)	Jay (n=17)	ROHO (n=13)	Other (n=11)	Jay (n=17)	ROHO (n=13)	Other (n=11)	Jay (n=17)	ROHO (n=13)	Other (n=11)
"*To use on a different chair*"*	0	0	0	2	0	0	3	2	2	3	2	0	5	4	6
"*To change the cushion cover*"**	1	1	0	4	3	0	6	3	4	2	2	3	1	1	1
"*To check gel sacks*"*	1	0	1	3	0	0	4	1	1	4	1	0	2	5	6
"*To collapse your wheelchair*"***	5	1	3	1	4	2	2	2	2	3	1	0	3	1	3
"*To check for damage*"****	1	0	0	1	2	1	3	3	2	8	2	3	1	1	3
"*To clean it*"*****	2	2	1	5	4	3	6	2	6	3	2	1	0	0	0
"*To check air pressure*"*	0	5	0	0	3	1	0	0	0	1	1	0	11	1	6

* 12 missing; ** 9 missing; *** 8 missing; **** 10 missing; ***** 4 missing

Table M-97 Other reasons why cushions are removed from their wheelchairs

Other reasons for removing cushion	All respondents (n=41)*	Groups					
		Tetraplegics (n=4)			Paraplegics (n=7)		
		Jay (n=0)	ROHO (n=3)	Other (n=1)	Jay (n=3)	ROHO (n=1)	Other (n=3)
To put into car	5 (12%)				3	1	1
To switch to different cushion	2 (5%)					1	1
To clean wheelchair	1 (2%)						1
Wheelchair sent away for service/repair	1 (2%)		1				
Cushion away for puncture repair	1 (2%)		1				
To air cushion over night	1 (2%)						1
To go swimming (to stop cushion getting wet)	1 (2%)			1			
Being caught in hoist sling	1 (2%)		1				
To check cushion position on wheelchair	1 (2%)			1			

* 30 missing, 11 respondents provided other reasons. Some of the respondents reported more than one reason

(see Q6.2)

Table M-98 How frequently users fit/remove their cushion from their wheelchair, by themselves

Groups		Fitting/removing cushion by themselves				
		All the time	Frequently	Occasion-ally	Very rarely	Never
All respondents (n=41)		21 (51%)	5 (12%)	1 (2%)	1 (2%)	13 (32%)
Tetraplegics (n=26)	Jay users (n=9)	2	1	1	0	5
	ROHO users (n=10)	2	0	0	1	7
	Other users (n=7)	5	2	0	0	0
Paraplegics (n=15)	Jay users (n=8)	6	1	0	0	1
	ROHO users (n=3)	3	0	0	0	0
	Other users (n=4)	3	1	0	0	0

(see Q6.3)

Table M-99 How easy users find the task of securing their cushion to their wheelchair

Groups		Degree of ease					
		Its not a task I'm involved with	Very easy	Easy	Manage-able	Difficult	Very difficult
All respondents (n=41)*		6 (15%)	15 (37%)	6 (15%)	7 (17%)	1 (2%)	3 (7%)
Tetraplegics (n=26)	Jay users (n=9)	2	0	3	3	0	1
	ROHO users (n=10)**	4	1	1	1	0	1
	Other users (n=7)	0	5	1	0	1	0
Paraplegics (n=15)	Jay users (n=8)	0	5	0	3	0	0
	ROHO users (n=3)***	0	1	0	0	0	1
	Other users (n=4)	0	3	1	0	0	0

* 3 missing; ** 2 missing; *** 1 missing **(see Q6.4)**

Table M-100 How frequently is the cushion unsecured and loose, free to slide around

Groups		Unsecured, loose free to slide around				
		All the time	Frequently	Occasion-ally	Very rarely	Never
All respondents (n=41)*		0 (0%)	7 (17%)	4 (10%)	16 (39%)	10 (24%)
Tetraplegics (n=26)	Jay users (n=9)	0	2	2	3	2
	ROHO users (n=10)**	0	3	1	1	2
	Other users (n=7)	0	0	1	1	5
Paraplegics (n=15)	Jay users (n=8)	0	2	0	5	1
	ROHO users (n=3)***	0	0	0	2	0
	Other users (n=4)	0	0	0	4	0

* 4 missing; ** 3 missing; *** 1 missing **(see Q6.5)**

Table M-101 How frequently a secured cushion is knocked loose during a transfer

Groups		Knocked loose during transfers				
		All the time	Frequently	Occasion-ally	Very rarely	Never
All respondents (n=41)*		3 (7%)	9 (22%)	11 (27%)	7 (17%)	7 (17%)
Tetraplegics (n=26)	Jay users (n=9)	1	3	2	2	1
	ROHO users (n=10)**	1	3	2	1	1
	Other users (n=7)	0	1	1	1	4
Paraplegics (n=15)	Jay users (n=8)***	1	1	2	2	1
	ROHO users (n=3)***	0	1	1	0	0
	Other users (n=4)	0	0	3	1	0

* 4 missing; ** 2 missing; *** 1 missing **(see Q6.6)**

Table M-102 How frequently cushions are subject to certain forms of damage (n=41)

Form of damage (description as used in questionnaire)	Frequency certain forms of damage occur				
	All the time	Frequently	Occasion-ally	Very rarely	Never
"*Chunks of foam breaking off*"*	0 (0%)	0 (0%)	2 (5%)	4 (10%)	26 (63%)
"*Gel packs splitting*"**	0 (0%)	1 (2%)	6 (15%)	9 (22%)	19 (46%)
"*Air cells punctured by cigarette burns*"***	0 (0%)	0 (0%)	0 (0%)	0 (0%)	34 (83%)
"*Air cells punctured by pet's claws*"***	0 (0%)	0 (0%)	0 (0%)	1 (2%)	33 (81%)

* 9 missing; ** 6 missing; *** 7 missing **(see Q6.10)**

Table M-103 Other forms of damage cushions are subject to

Other forms of damage	Groups						
	All respond. (n=41)*	Tetraplegics (n=6)			Paraplegics (n=5)		
		Jay (n=1)	ROHO (n=4)	Other (n=1)	Jay (n=1)	ROHO (n=3)	Other (n=1)
General wear and tear (splitting/punctures)	3 (7%)		1	1		1	
Detritus falling between legs (broken glass)	2 (5%)		1			1	
Cushion cover wearing/tearing	2 (5%)		1		1		
Transfers wearing the front of the cushion	1 (2%)	1					
Large point pressure on cushion during transfers	1 (2%)					1	
Worn gel pack seams	1 (2%)	1					
Valves being pulling out (being used as handles)	1 (2%)					1	
Cells pinched by hoist sling	1 (2%)		1				
Foam hardening & setting / losing "*spring back*"	1 (2%)						1

* 30 missing, 11 respondents provided other forms of damage. Some of the respondents reported more than one form of damage **(see Q6.10)**

M.5.2 Cushion Use on Chairs as well as Wheelchairs

Table M-104 The average length of time a respondent spends in their wheelchair per day

Groups		Length of time (hours)				
		< 5	5 – 6	7 – 8	> 8	Varies greatly
All respondents (n=41)		0 (0%)	2 (5%)	2 (5%)	33 (81%)	4 (10%)
Tetra (n=26)	Jay users (n=9)	0	0	0	9	0
	ROHO users (n=10)	0	2	1	6	1
	Other users (n=7)	0	0	1	4	2
Para (n=15)	Jay users (n=8)	0	0	0	7	1
	ROHO users (n=3)	0	0	0	3	0
	Other users (n=4)	0	0	0	4	0

(see Q3.1)

Table M-105 Average time spent sat per day on different chairs (n=41)

Type of Chair	Time spent sat on different chairs (hours)							
	Don't sit on these chairs	Varies greatly	< 1	1 - 2	3 – 4	5 - 6	7 – 8	> 8
A dining chair*	37 (90%)	1 (2%)	0	1 (2%)	0	0	0	0
An office chair**	38 (93%)	0	0	0	0	0	0	0
A car seat***	10 (24%)	13 (32%)	8 (20%)	8 (20%)	1 (2%)	0	0	0
An armchair*	29 (71%)	4 (10%)	1 (2%)	2 (5%)	1 (2%)	2 (5%)	0	0
A sofa*	29 (71%)	3 (7%)	3 (7%)	2 (5%)	2 (5%)	0	0	0

* 2 missing; ** 3 missing; *** 1 missing **(see Q3.2)**

Table M-106 Other chairs used by respondents

Other chairs	Groups		
	Respondents(n=41)*	Tetra (n=26)	Para (n=15)
A fishing chair when fishing	1		1
A gym ball	1	1	
An adjustable electric chair	1	1	
Shower-chair	2	2	
Toilet seat	2	2	

* Of the 41 respondents, 5 reported other chairs that they use. Some of the respondents reported using more than one different type of chair **(see Q3.2)**

Table M-107 How frequently respondents use their cushion when sitting on different types of chairs (n=41)

Type of Chair	Frequency respondents use their cushion on different chairs											
	Don't sit on these chairs		All the time		Frequently		Occasion-ally		Very rarely		Never	
	Tetra (n=26)	Para (n=15)	Tetra (n=26)	Para (n=15)	Tetra (n=26)	Para (n=15)	Tetra (n=26)	Para (n=15)	Tetra (n=26)	Para (n=15)	Tetra (n=26)	Para (n=15)
A dining chair*	23	14	0	0	0	0	0	0	0	0	1	1
An office chair**	23	15	0	0	0	0	0	0	0	0	0	0
A car seat***	9	1	3	3	1	1	0	2	1	1	11	7
An armchair*	19	10	0	1	0	0	1	0	0	0	4	4
A sofa*	20	9	1	0	0	0	0	0	0	0	3	6

* 2 missing; ** 3 missing; *** 1 missing **(see Q3.3)**

M.5.3 Pressure Relieving whilst Sat in a Wheelchair

Table M-108 The pressure relieving movements made by respondents

Groups		Pressure relieving movements						
		No move-ment	Leaning forward	Leaning to right	Leaning to left	Tilting backwards	Raising self up	Other move-ments
All respondents (n=41)*		6 (15%)	13 (32%)	10 (24%)	10 (24%)	2 (5%)	26 (63%)	6 (15%)
Tetra (n=26)	Jay users (n=9)	0	4	3	3	0	5	2
	ROHO users (n=10)	3	5	2	2	1	4	1
	Other users (n=7)	0	4	5	5	1	7	0
Para (n=15)	Jay users (n=8)	1	0	0	0	0	6	1
	ROHO users (n=3)	1	0	0	0	0	1	1
	Other users (n=4)	1	0	0	0	0	3	1

* 35 respondents reported that they regularly make a pressure relieving movement. Some of the respondents reported making more than one type of movement **(see Q3.6)**

Table M-109 Other pressure relieving movements made by respondents

Other pressure reliving movements	Groups						
	All respond. (n=41)*	Tetraplegics (n=3)			Paraplegics (n=3)		
		Jay (n=2)	ROHO (n=1)	Other (n=0)	Jay (n=1)	ROHO (n=1)	Other (n=1)
Frequent wriggling/general movement	2 (5%)	1				1	
Changing position when uncomfortable	1 (2%)				1		
Tilt function on wheelchair	1 (2%)		1				
Use a Standing frame	1 (2%)	1					
Frequent pushing gel back under "IT's" (ischial tuberosities)	1 (2%)						1

* 35 missing, 6 respondents reported making other pressure relieving movements **(see Q3.6)**

Table M-110 The extent to which respondents comply with their pressure relieving routine on an average day

Groups		Frequency routine performed				
		Don't follow a set routine	All the time (do every one)	Frequently (do most)	Occasionally (miss out about half)	Vary rarely (miss most)
All respondents (n=41)*		27 (66%)	3 (7%)	3 (7%)	6 (15%)	0 (0%)
Tetras (n=26)	Jay users (n=9)	5	1	2	1	0
	ROHO users (n=10)**	8	1	0	0	0
	Other users (n=7)	5	1	0	1	0
Paras (n=15)	Jay users (n=8)	6	0	0	2	0
	ROHO users (n=3)	2	0	0	1	0
	Other users (n=4)**	1	0	1	1	0

* 2 missing; ** 1 missing **(see Q3.7)**

M.5.4 Use of Covers

Table M-111 How frequently the respondents use certain types of cushion covers (n=41)

Type of Cover (description as used in questionnaire)	Frequency certain covers are used				
	All the time	Frequently	Occasion-ally	Very rarely	Never
"*Nothing, the cushion is left uncovered*"*	4 (10%)	0 (0%)	1 (2%)	4 (10%)	23 (56%)
"*The cover that comes with the cushion*"**	33 (80%)	1 (2%)	0 (0%)	0 (0%)	3 (7%)
"*A blanket to wrap around the cushion*"***	0 (0%)	0 (0%)	0 (0%)	1 (2%)	29 (71%)
"*A cotton sheet to wrap around the cushion*"***	1 (2%)	1 (2%)	0 (0%)	2 (5%)	26 (63%)
"*An ordinary pillow case*"***	0 (0%)	1 (2%)	0 (0%)	2 (5%)	27 (66%)
"*A homemade cover*"***	1 (2%)	1 (2%)	0 (0%)	0 (0%)	28 (68%)
"*A cover from another cushion which has been altered to fit your cushion*"***	0 (0%)	0 (0%)	0 (0%)	1 (2%)	29 (71%)
"*A cover from another cushion which has **NOT** been altered to fit the cushion*"****	0 (0%)	0 (0%)	1 (2%)	2 (5%)	26 (63%)

* 9 missing; ** 4 missing; *** 11 missing; **** 12 missing **(see Q6.12)**

Table M-112 Other types of covers used by the respondents

Other types of cover	Groups						
	All respond. (n=41)*	Tetraplegics (n=0)			Paraplegics (n=5)		
		Jay (n=0)	ROHO (n=0)	Other (n=0)	Jay (n=2)	ROHO (n=1)	Other (n=2)
A towel when swimming	1 (2%)				1		
A *Sorbo* thin low friction cover	1 (2%)				1		
An *Airtex* breathable cover	1 (2%)					1	
A sheep skin	1 (2%)						1
A fur covered cover	1 (2%)						1

* 36 missing, 5 respondents reported using other types of cover **(see Q6.12)**

Table M-113 How significant certain aspects of a cover are considered to be, in the development of pressure ulcers (n=41)

Aspect of Cover (description as used in questionnaire)	Significance of an aspect of a cover				
	Very significant	Of some significance	Significant	Of little significance	Of no significance
"*The cover becomes wrinkled or creased*"*	14 (34%)	15 (37%)	3 (7%)	5 (12%)	1 (2%)
"*The texture of the cover material is too rough*"**	13 (32%)	11 (27%)	3 (7%)	8 (20%)	1 (2%)
"*The weave, or cloth pattern, of the cover is too pronounced*"**	13 (32%)	13 (32%)	2 (5%)	6 (15%)	2 (5%)
"*The cover material holds too much moisture*"**	11 (27%)	10 (24%)	8 (20%)	6 (15%)	1 (2%)
"*The cover is stretched too tight across the cushion affecting the cushions ability to disperse the weight of the body*"***	17 (41%)	9 (22%)	2 (5%)	5 (12%)	4 (10%)

* 3 missing; ** 5 missing; *** 4 missing **(see Q6.15)**

Table M-114 How significant the respondents, divided by level of injury, consider certain aspects of a cover in the development of pressure ulcers

Aspect of Cover (description as used in questionnaire)	Significance of an aspect of a cover									
	Very significant		Of some significance		Significant		Of little significance		Of no significance	
	Tetra (n=26)	Para (n=15)	Tetra (n=26)	Para (n=15)	Tetra (n=26)	Para (n=15)	Tetra (n=26)	Para (n=15)	Tetra (n=26)	Para (n=15)
"*The cover becomes wrinkled or creased*"*	10	4	10	5	2	1	2	3	0	1
"*The texture of the cover material is too rough*"**	6	7	10	1	1	2	5	3	0	1
"*The weave, or cloth pattern, of the cover is too pronounced*"**	9	4	8	5	0	2	4	2	1	1
"*The cover material holds too much moisture*"**	7	4	6	4	5	3	4	2	0	1
"*The cover is stretched too tight across the cushion affecting the cushions ability to disperse the weight of the body*"***	12	5	6	3	0	2	2	3	3	1

* 12 missing; ** 9 missing; *** 8 missing; **** 10 missing; ***** 4 missing

Table M-115 How significant the respondents, divided by cushion use, consider certain aspects of a cover in the development of pressure ulcers

Aspect of Cover (description as used in questionnaire)	Significance of an aspect of a cover														
	Very significant			Of some significance			Significant			Of little significance			Of no significance		
	Jay (n=17)	ROHO (n=13)	Other (n=11)	Jay (n=17)	ROHO (n=13)	Other (n=11)	Jay (n=17)	ROHO (n=13)	Other (n=11)	Jay (n=17)	ROHO (n=13)	Other (n=11)	Jay (n=17)	ROHO (n=13)	Other (n=11)
"*The cover becomes wrinkled or creased*"*	2	5	7	9	4	2	2	0	1	2	3	0	0	0	1
"*The texture of the cover material is too rough*"**	3	4	6	5	3	3	3	0	0	4	3	1	0	0	1
"*The weave, or cloth pattern, of the cover is too pronounced*"**	4	3	6	6	4	3	1	0	1	4	2	0	0	1	1
"*The cover material holds too much moisture*"**	4	4	3	2	2	6	6	1	1	3	3	0	0	0	1
"*The cover is stretched too tight across the cushion affecting the cushions ability to disperse the weight of the body*"***	7	5	5	4	3	2	1	0	1	2	2	1	1	1	2

* 12 missing; ** 9 missing; *** 8 missing; **** 10 missing; ***** 4 missing

One reported a different way in which a cushion cover may cause a pressure ulcer:

- One respondent (paraplegic other cushion user) reported that when heat builds up they "*stick*" to their cushion cover **(see Q6.12)**

Table M-116 The number of respondents who change their cushion covers themselves

Groups	Change covers themselves	
	Yes	No
All respondents (n=41)*	25 (61%)	13 (32%)
Tetraplegic (n=26)*	11 (42%)	12 (46%)
Paraplegic (n=15)	14 (93%)	1 (7%)
Jay (n=17)	12 (71%)	5 (29%)
ROHO (n=13)**	5 (38%)	6 (46%)
Other (n= 11)***	8 (73%)	2 (18%)

* 3 missing; ** 2 missing; *** 1 missing

(see Q6.13)

Table M-117 The respondents who agree that changing the cover easy

Groups		Agree that covers are easy to change				
		Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
All respondents (n=41)*		6 (15%)	14 (34%)	11 (34%)	4 (10%)	1 (2%)
Tetra (n=26)	Jay users (n=9)	1	3	5	0	0
	ROHO users (n=10)**	2	3	1	1	1
	Other users (n=7)***	1	2	1	2	0
Para (n=15)	Jay users (n=8)***	1	4	1	1	0
	ROHO users (n=3)	1	1	1	0	0
	Other users (n=4)***	0	1	2	0	0

* 5 missing; ** 2 missing; *** 1 missing;

(see Q6.14)

Table M-118 How the respondents find certain aspects of changing cushion covers (n=41)

Aspect of changing cover (statements drawn directly from questionnaire)	Level of agreement with statements				
	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
*"The cushion is bulky, so it is difficult to insert into the cover"**	4 (10%)	7 (17%)	3 (7%)	15 (37%)	6 (15%)
"*The next cover is not ready to be put on as it is away being cleaned or repaired*"*	2 (5%)	1 (2%)	5 (12%)	16 (39%)	11 (26%)
"*The cover opening fastenings (zipper, buttons, press studs) are difficult*"*	1 (2%)	5 (12%)	10 (24%)	11 (27%)	8 (20%)
"*To fit the cover the cushion has to be removed from the wheelchair*"**	26 (63%)	8 (20%)	1 (2%)	0 (0%)	1 (2%)
"*The cover is difficult to adjust so that the surface is not wrinkled/creased*"*	0 (0%)	3 (7%)	4 (10%)	21 (51%)	7 (17%)

* 6 missing; ** 5 missing

(see Q6.14)

Table M-119 How the respondents, divided by level of injury, find certain aspects of changing cushion covers

Aspect of changing cover (statements drawn directly from questionnaire)	Level of agreement with statements									
	Strongly agree		Agree		Neither agree nor disagree		Disagree		Strongly disagree	
	Tetra (n=26)	Para (n=15)	Tetra (n=26)	Para (n=15)	Tetra (n=26)	Para (n=15)	Tetra (n=26)	Para (n=15)	Tetra (n=26)	Para (n=15)
*"The cushion is bulky, so it is difficult to insert into the cover"**	2	2	6	1	1	2	8	7	4	2
"*The next cover is not ready to be put on as it is away being cleaned or repaired*"*	1	1	1	0	5	0	9	7	5	6
"*The cover opening fastenings (zipper, buttons, press studs) are difficult*"*	1	0	3	2	7	3	7	4	3	5
"*To fit the cover the cushion has to be removed from the wheelchair*"**	17	9	3	5	1	0	0	0	1	0
"*The cover is difficult to adjust so that the surface is not wrinkled/creased*"*	0	0	3	0	3	1	12	9	3	4

* 6 missing; ** 5 missing

Table M-120 How the respondents, divided by cushion used, find certain aspects of changing cushion

Aspect of changing cover (statements drawn directly from questionnaire)	Level of agreement with statements														
	Strongly agree			Agree			Neither agree nor disagree			Disagree			Strongly disagree		
	Jay (n=17)	ROHO (n=13)	Other (n=11)	Jay (n=17)	ROHO (n=13)	Other (n=11)	Jay (n=17)	ROHO (n=13)	Other (n=11)	Jay (n=17)	ROHO (n=13)	Other (n=11)	Jay (n=17)	ROHO (n=13)	Other (n=11)
*"The cushion is bulky, so it is difficult to insert into the cover"**	1	2	1	3	3	1	1	0	2	10	4	1	0	1	5
"*The next cover is not ready to be put on as it is away being cleaned or repaired*"*	0	0	2	0	1	0	3	1	1	9	6	1	3	2	6
"*The cover opening fastenings (zipper, buttons, press studs) are difficult*"*	1	0	0	4	0	1	5	2	3	5	4	2	1	3	4
"*To fit the cover the cushion has to be removed from the wheelchair*"**	10	7	9	5	2	1	1	0	0	0	0	0	0	1	0
"*The cover is difficult to adjust so that the surface is not wrinkled/creased*"*	0	0	0	1	1	1	2	0	2	11	6	4	1	3	3

* 6 missing; ** 5 missing

Table M-121 Other way a cushion cover might causes difficulties when being changed

Other ways a cover can cause problems when being changed	All respondents (n=41)*	Groups					
		Tetraplegics (n=2)			Paraplegics (n=2)		
		Jay (n=0)	ROHO (n=2)	Other (n=0)	Jay (n=0)	ROHO (n=1)	Other (n=1)
The zip catches in the material and is unreliable	1 (2%)					1	
Cover is not hard wearing	1 (2%)					1	
Cost of spare covers prohibitive paying anything from £65 upwards	1 (2%)						1
Cushion is floppy and so can curl up inside the cover making it difficult to put flat on a seat	1 (2%)		1				
When the their cover has not been fitted properly it causes problems, friction, shear, creases	1 (2%)		1				

* 37 missing, 4 respondents reported other ways in which a cover might cause difficulties. Some of the respondents reported more than one way. **(see Q6.14)**

Appendix N: SCI Professional Questionnaire

Buckinghamshire Chilterns
UNIVERSITY COLLEGE

A Survey on the Use and Perception of Pressure Relief Cushions by those involved in the Care and Treatment of Spinal Cord Injury Patients

The study team:
Philip Lance,
Dr. Gwyn Weatherburn,
Prof. Jake Kaner,
Dr David Osypiw,

Please return by: 1st July 2006

Please return to Philip Lance *at*,
Buckinghamshire Chilterns University College, Research Centre for Health Studies, Chalfont Campus, Gorelands Lane, Chalfont St. Giles, Buckinghamshire, HP8 4AD
(Tel: 01494 522141)

Dear Colleague,

Thank you for taking the time to consider completing this questionnaire. This survey is completely voluntary. The information you provide is anonymous, we are interested in your answers we are not attempting to find out anything specifically about you. Please note that we will not show your questionnaire to anyone outside the study team.

Although this questionnaire appears lengthy it is anticipated that this questionnaire should not take longer than approximately 30 minutes to complete. Whilst it is desirable that all the questions relevant to you are answered, if there are any questions that you would rather not answer just leave them blank and move on to complete those questions you are comfortable with answering. The completion of this questionnaire is all that the research team is asking for. No follow up interviews or further questionnaires are planned.

The purpose of this study is to find out how pressure relief cushions are used and how they fit into the users life style. It is intended that through this study, it will be possible to identify and clarify the demands placed on the cushion by the user so that pressure relief cushion design might further develop.

*A summary report of the findings will be available to those who complete this questionnaire. To receive a copy of this summary report please complete the request slip attached to the end of this questionnaire and return to the address on the slip **separate to the questionnaire**.*

We plan to circulate the findings of this survey through publication in scientific journals and through presentations at conferences.

If you have any questions, please telephone or e-mail:

Philip Lance *switchboard **01494 522141** ext.**3477*** ***philip.lance@bcuc.ac.uk***

Should you be unable to speak with Philip Lance, in the first instance, it is possible to leave a voicemail message with Dr. Gwyn Weatherburn on 01494 605222 and Philip will phone you back

Thank you for taking the time to consider this survey.

Philip Lance

There may be various reasons why you might decide not to complete this questionnaire. We would be interested to know what these reasons are, so if you decide not to answer this questionnaire, could you please note down your reason(s).

Please use this space for your answer

and return in the pre paid envelop to,

Philip Lance,
Buckinghamshire Chilterns University College
Research Centre for Health Studies
Gorelands Lane
Chalfont St. Giles
Buckinghamshire HP8 4AD

Please try to ensure that you have returned this questionnaire by **1st July 2006**

Should you wish to add any further information, there is space left at the end of this questionnaire for your comments, see **'Any Additional Information/Comments'**

Please place a tick ☑or a cross ☒ in a box to indicate your answer

Now please begin……

This questionnaire has been designed to draw out information from a range of disciplines involved in the treatment and care of those with spinal cord injury. As such not all questions may be applicable to your profession. Where a question is not relevant to you or you do not know the answer please leave it blank and move on to the next question.

Could you please begin by indicating your role in spinal injury treatment, or care

Physiotherapist	Occupational Therapist	Medical Practitioner	Nurse	Carer	Other
☐	☐	☐	☐	☐	☐

If **Other** please specify……

Section 1. Cushions Used

1.1 Could you please list the pressure relief cushion(s) you currently come into contact with, during your duties

Please use this space for your answer (brand names and/or manufacturer are acceptable)

1.2 Which one cushion you most commonly come into contact with?

Please use this space for your answer

1.3 In your opinion, do you regard the overall performance of this cushion to be,

Excellent	Good	Satisfactory	Poor	Useless
☐	☐	☐	☐	☐

1.4 Why do you regard the overall performance of this cushion to be either **Excellent, Good, Satisfactory, Poor** or **Useless**?

Please use this space for your answer

1.5 Is there any one cushion that you would recommend above the others?……. Yes ☐ No ☐

1.5a) **If Yes**, which cushion would you recommend and why?

Please use this space for your answer

1.6 Are there any cushion(s) you would discourage the use of?…………………… Yes ☐ No ☐

1.6a) <u>If **Yes**</u>, which cushion(s) would you discourage and why?

Please use this space for your answer

1.7 The following options are aspects of a pressure relief cushion. How significant do you consider these aspects to the overall performance of a pressure relief cushion? (*please tick **one box on each row***)

	Very significant	Of some significance	Significant	Of little significance	Of no significance
The cushion's ability to be fixed securely to the wheelchair	☐	☐	☐	☐	☐
The cushion's ability to be kept clean	☐	☐	☐	☐	☐
The cushion's ability to keep the pressure experienced by the skin low	☐	☐	☐	☐	☐
The cushion's ability to maintain posture	☐	☐	☐	☐	☐
The cushion's ability to prevent sweating	☐	☐	☐	☐	☐
The cushion's appearance	☐	☐	☐	☐	☐
The cushion's cost	☐	☐	☐	☐	☐
The cushion's weight	☐	☐	☐	☐	☐
The level of comfort provided by the cushion	☐	☐	☐	☐	☐

Please use this space if you can think of any other aspects you consider when assessing the overall performance of a cushion

1.8 How often have you observed a patient using a pressure relief cushion which was the wrong size for them?

All the time ☐ **Frequently** ☐ **Occasionally** ☐ **Very Rarely** ☐ **Never** ☐

1.9 On average, how long do patients have to wait before this error is corrected? (*please tick **one box***)

Patients always have the right size………. ☐ **4-6 months**…………………… ☐
Less than 2 weeks……………………… ☐ **7-9 months**…………………… ☐
2-4 weeks……………………………… ☐ **10-12 months**………………… ☐
1-3 months…………………………… ☐ **More than 1 Year**…………… ☐

2

1.10 In your experience, how often does sitting on a pressure relief cushion of the wrong size trigger a pressure ulcer?

All the time ☐ **Frequently** ☐ **Occasionally** ☐ **Very Rarely** ☐ **Never** ☐ **Don't know** ☐

1.11 How often have you observed a patient using a pressure relief cushion, which had the wrong seat surface contour shape?

All the time ☐ **Frequently** ☐ **Occasionally** ☐ **Very Rarely** ☐ **Never** ☐

1.12 On average, how long do patients have to wait before this error is corrected? (*please tick **one box***)

Patients always have the right shape…… ☐ **4-6 months**…………………… ☐
Less than 2 weeks……………………… ☐ **7-9 months**…………………… ☐
2-4 weeks……………………………… ☐ **10-12 months**………………… ☐
1-3 months…………………………… ☐ **More than 1 Year**…………… ☐

1.13 In your experience, how often does sitting on a pressure relief cushion with the wrong seat surface contour shape trigger a pressure ulcer?

All the time ☐ **Frequently** ☐ **Occasionally** ☐ **Very Rarely** ☐ **Never** ☐ **Don't know** ☐

1.14 How often have you observed a patient using a pressure relief cushion which was positioned in the wheelchair upside down?

All the time ☐ **Frequently** ☐ **Occasionally** ☐ **Very Rarely** ☐ **Never** ☐

1.15 In your experience, how often does sitting on a pressure relief cushion positioned upside down trigger a pressure ulcer?

All the time ☐ **Frequently** ☐ **Occasionally** ☐ **Very Rarely** ☐ **Never** ☐ **Don't know** ☐

1.16 How often have you observed a patient using a pressure relief cushion which was positioned in the wheelchair facing the wrong way be it back to front or sideways?

All the time ☐ **Frequently** ☐ **Occasionally** ☐ **Very Rarely** ☐ **Never** ☐

1.17 In your experience, how often does sitting on a pressure relief cushion facing the wrong way trigger a pressure ulcer?

All the time ☐ **Frequently** ☐ **Occasionally** ☐ **Very Rarely** ☐ **Never** ☐ **Don't know** ☐

1.18 How often have you observed a patient using a pressure relief cushion which was no longer performing to its best through old age?

All the time ☐ **Frequently** ☐ **Occasionally** ☐ **Very Rarely** ☐ **Never** ☐

1.19 In your experience, how often does using a cushion which is no longer performing to its best through old age trigger a pressure ulcer?

All the time ☐ **Frequently** ☐ **Occasionally** ☐ **Very Rarely** ☐ **Never** ☐ **Don't know** ☐

3

Section 2. Practices and Behaviour

2.1 Are the following chairs often used by patients? (*please tick **one box on each row***)

	All the time	Frequently	Occasionally	Very Rarely	Never
A dining chair……	☐	☐	☐	☐	☐
An office chair……	☐	☐	☐	☐	☐
A car seat……	☐	☐	☐	☐	☐
An armchair……	☐	☐	☐	☐	☐
A sofa……	☐	☐	☐	☐	☐

Please use this space if you can think of any other types of chair that a patient might sit on

2.2 If a patient is sat in a chair other than their wheelchair, how often do they rely on the following pressure relief measures? (*please tick **one box on each row***)

	All the time	Frequently	Occasionally	Very Rarely	Never
The pressure relief cushion they normally use in their wheelchair……	☐	☐	☐	☐	☐
A second pressure relief cushion, which is the same type of cushion as the one used in their wheelchair	☐	☐	☐	☐	☐
A second pressure relief cushion, but a different type of cushion as the one used in their wheelchair	☐	☐	☐	☐	☐
The chairs own ordinary padding/cushioning…..	☐	☐	☐	☐	☐
The chairs own built in pressure relieving features	☐	☐	☐	☐	☐
A piece of cut foam……	☐	☐	☐	☐	☐
An ordinary cushion……	☐	☐	☐	☐	☐
An ordinary pillow……	☐	☐	☐	☐	☐
A sheepskin……	☐	☐	☐	☐	☐

Please use this space if you can think of any other method for pressure relief a patient might use

2.3 Have you found that patients only use their pressure relief cushions when in their wheelchairs?…… Yes ☐ No ☐ Don't know ☐

2.3a) <u>If **NO**</u>, where else do they use their pressure relief cushions? (eg in the car)?

Please use this space for your answer

2.4 Have you observed pressure relief cushions to cause patients difficulties whilst transferring into and out of their wheelchair?…… Yes ☐ No ☐

2.4a) <u>If **Yes**</u>, which is the most difficult cushion to transfer from and why?

Please use this space for your answer

2.4b) <u>If **Yes**</u>, which is the easiest cushion to transfer from and why?

Please use this space for your answer

2.5 An example of a pressure relieving routine, to alleviate pressure on the skin covering the seat area of the body, might be leaning forward for 60 to 90 seconds every half hour. What movements do your patients commonly make to relieve pressure? (*please tick **one box on each row***)

	All the time	Frequently	Occasionally	Very Rarely	Never
Leaning forward……	☐	☐	☐	☐	☐
Leaning to the right……	☐	☐	☐	☐	☐
Leaning to your left……	☐	☐	☐	☐	☐
Tilting backwards……	☐	☐	☐	☐	☐
Raising themselves up……	☐	☐	☐	☐	☐

Please use this space if you can think of any other movements a patient might make to alleviate pressure

2.6 What is the most commonly used set of timings your patients tend to follow?

For example, leaning forward for 60 to 90 seconds every half hour

2.7 In general would you say those patients who follow a pressure relieving routine, on an average day, manage to stick to their routine (*please tick **one box***)

All of the time (do every one)…… ☐
Frequently (do most)…… ☐
Occasionally (miss out about half) ☐
Very Rarely (miss most)…… ☐
Don't know…… ☐

2.8 In general, how beneficial do you regard pressure relieving routines to be in preventing pressure ulcers?

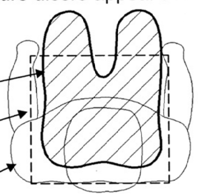
Very beneficial	Beneficial	Of some benefit	Of little benefit	Of no benefit
☐	☐	☐	☐	☐

Section 3. Skin Care

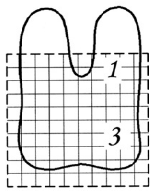
3.1 The diagram below (Dia. 1) is a plan view of a person sitting on a pressure relief cushion. From your experience, please mark the area(s) on the grid where you find that pressure ulcers develop with the numbers 1, 2 or 3, where

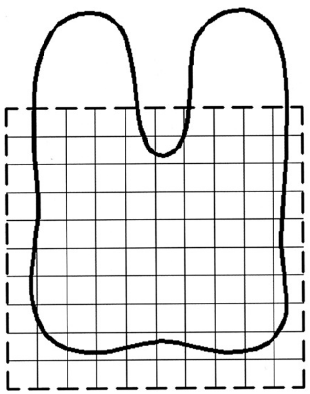
1 = Pressure ulcers appear **RARELY**
2 = Pressure ulcers appear **OCCASIONALLY**
3 = Pressure ulcers appear **FREQUENTLY**

Dia.1 Plan view of a person sat on a pressure relief cushion



An example of a completed answer





Please give your answer on this grid

3.2 In your experience, when a pressure ulcer is formed, how often is the patient (*please tick **one box on each row***)

	Very often	Frequently	Occasionally	Very Rarely	Never
Less than 9st in weight……	☐	☐	☐	☐	☐
Between 9st 1lb and 10st in weight……	☐	☐	☐	☐	☐
Between 10st 1lb and 11st in weight……	☐	☐	☐	☐	☐
Between 11st 1lb and 12st in weight……	☐	☐	☐	☐	☐
Between 12st 1lb and 13st in weight……	☐	☐	☐	☐	☐
Between 13st 1lb and 14st in weight……	☐	☐	☐	☐	☐
Between 14st 1lb and 15st in weight……	☐	☐	☐	☐	☐
Between 15st 1lb and 16st in weight……	☐	☐	☐	☐	☐
Between 16st 1lb and 17st in weight……	☐	☐	☐	☐	☐
Between 17st 1lb and 18st in weight……	☐	☐	☐	☐	☐
More than 18st……	☐	☐	☐	☐	☐

3.3 In your experience, when a pressure ulcer is formed, how often is the patient (*please tick **one box on each row***)

	Very often	Frequently	Occasionally	Very Rarely	Never
Less than 5'2" in height……	☐	☐	☐	☐	☐
Between 5'3 and 5'5" in height……	☐	☐	☐	☐	☐
Between 5'6" and 5'7" in height……	☐	☐	☐	☐	☐
Between 5'8" and 5'9" in height……	☐	☐	☐	☐	☐
Between 5'10" and 5'11" in height……	☐	☐	☐	☐	☐
Between 6'0" and 6'1" in height……	☐	☐	☐	☐	☐
Between 6'2" and 6'5" in height……	☐	☐	☐	☐	☐
More than 6'6" tall……	☐	☐	☐	☐	☐

3.4 When a pressure ulcer forms on a patients seat area of the body, how often is it thought that the cushion was **NOT** the cause but that something else may have contributed to the pressure ulcers development?

All of the time (every time)……	☐	**Very Rarely (some of the times)….**	☐
Frequently (most times)……	☐	**Never……**	☐
Occasionally (about half the time)	☐	**Don't know……**	☐

3.5 On the occasions when a pressure ulcer has formed and the cushion was not identified as the source, how often was this ulcer considered to be the result of? (*please tick **one box on each row***)

	All the time	Frequently	Occasionally	Very Rarely	Never
Prominent seams in clothing……	☐	☐	☐	☐	☐
Being left for an excessively long period on the cushion	☐	☐	☐	☐	☐
An unsafe transfer……	☐	☐	☐	☐	☐
Missed small objects e.g. coins……	☐	☐	☐	☐	☐
Pressure relief routine not performed regularly enough	☐	☐	☐	☐	☐
Poor cleanliness of the cushion……	☐	☐	☐	☐	☐
Pressure relief routine not providing enough respite from pressure……	☐	☐	☐	☐	☐

Please use this space if you can think of any other occasions where an ulcer formed and the cushion was not identified as the possible cause

3.6 Have you found that certain external events, whilst not the cause of a pressure ulcer, can be the trigger for an ulcer? (*please tick **one box on each row***)

	All the time	Frequently	Occasionally	Very Rarely	Never
An illness/infection……	☐	☐	☐	☐	☐
Travelling (eg car journey)……	☐	☐	☐	☐	☐
Rapid body weight gain……	☐	☐	☐	☐	☐
Rapid body weight loss……	☐	☐	☐	☐	☐
Pregnancy……	☐	☐	☐	☐	☐

Please use this space if you can think of any other external event which may trigger a pressure ulcer

3.7 On the occasions when poor posture was identified as a contributing factor in the development of a pressure ulcer, how often are the following options the contributing postural factor? (*please tick **one box on each row***)

	All the time	Frequently	Occasionally	Very Rarely	Never
The skin was subjected to friction when the patient slid from their ideal postural position...	☐	☐	☐	☐	☐
The skin was subjected to shear as the body was held in position unable to slide any further......	☐	☐	☐	☐	☐
The poor postural position distorted the skin creating folds and creases in the skin/tissue......	☐	☐	☐	☐	☐
The skin was subjected to an increase in direct pressure /compression as the body was in an unbalanced position................................	☐	☐	☐	☐	☐

Please use this space if you can think of any other reasons why poor posture may contribute to the development of a pressure ulcer

3.8 Could you please read the following statement (*Statement A*)

Statement A

...."Patients initially tend to opt for a cushion, for their day-to-day use, whose foremost ability is to support the patient's posture. This choice is made in favour of a cushion whose foremost ability is skin care. If an ulcer should develop, the patient then switches from their first choice cushion, strong in postural support, to a cushion whose primary ability is skin care rather than posture. The patient then uses this cushion for a short period, whilst their newly healed skin regains some of its tolerance, after which they return once again to a cushion which is primarily good at supporting posture"...

Statement A describes a pattern of events. Is this a pattern you have observed?

All the time	Frequently	Occasionally	Very Rarely	Never
☐	☐	☐	☐	☐

3.9 Have you found that most of the pressure relief cushions you have experienced tend to be either (*please tick **only one** option*)

Strong in maintaining posture but poor in skin care......................................	☐
Strong in skin care but weak in maintaining posture	☐
Strong in both maintaining posture and skin care..	☐
Weak in both maintaining posture and skin care...	☐
Satisfactory in both maintaining posture and skin care.................................	☐

Section 4. Sitting Posture in a Wheelchair

4.1 What are the most common problems you have observed patients experience, as a result of poor posture whilst sitting in a wheelchair?

Please use this space for your answer

4.2 How often have you observed patients sitting in the following seated postural positions? (*please tick **one box on each row***)

	All the time	Frequently	Occasionally	Very Rarely	Never
Slouching..	☐	☐	☐	☐	☐
Leaning forward...................................	☐	☐	☐	☐	☐
Leaning to the left.................................	☐	☐	☐	☐	☐
Leaning to the right...............................	☐	☐	☐	☐	☐

Please use this space if you can think of any other bad postural positions a patient sit in

4.3 In your experience, how greatly do the following sitting positions increase the risk of developing a pressure ulcer? (*please tick **one box on each row***)

	Major increase	Some increase	An increase	A slight increase	No increase	Don't know
Slouching......................................	☐	☐	☐	☐	☐	☐
Leaning forward.............................	☐	☐	☐	☐	☐	☐
Leaning to the right.........................	☐	☐	☐	☐	☐	☐
Leaning to the left...........................	☐	☐	☐	☐	☐	☐

4.4 When a patient slouches, how often do they? (*please tick **one box on each row***)

	All the time	Frequently	Occasionally	Very Rarely	Never	Don't know
Slide forward over the surface of the cushion, with the cushion remaining fixed in place..	☐	☐	☐	☐	☐	☐
Slide forward with the cushion sliding forward with them..........................	☐	☐	☐	☐	☐	☐

4.5 Approximately how many of your patients are able to check the following for themselves? (*please tick **one box on each row***)

	None	A few	About half	Most	All	Don't know
That they are sitting upright..............	☐	☐	☐	☐	☐	☐
That they are sat right back in their wheelchair................................	☐	☐	☐	☐	☐	☐
That they are sitting square in the wheelchair, not twisted...................	☐	☐	☐	☐	☐	☐
That they have the full length of their thighs on the cushion....................	☐	☐	☐	☐	☐	☐
That their thighs are level with the floor	☐	☐	☐	☐	☐	☐
That their footplate is set to the right height	☐	☐	☐	☐	☐	☐

4.6 How often would you say a patients posture is checked to make sure that it is still all right? *(Please tick* ***as many options*** *as you wish)*

- **Every couple of hours……………….…** ☐
- **Occasionally (maybe once a day)……..** ☐
- **Just after transferring into the wheelchair** ☐
- **When you remember…………………..** ☐
- **When you feel uncomfortable………..** ☐
- **After a spasm……………………..** ☐
- **After carrying out pressure relief..** ☐
- **After propelling your wheelchair...** ☐
- **Never Check………………………** ☐
- **Other………………………………** ☐

If **Other** please specify……

4.7 On average how long do you think a patient will spend in a good postural position before slipping into a poor position?

- **Less than 10 minutes…………….…** ☐
- **10 to 29 minutes…………………....** ☐
- **30 to 44 minutes…………………....** ☐
- **45 to 59 minutes…………………...** ☐
- **1 to 1½ hours** ***(60 to 89 minutes)*****….** ☐
- **1½ to 2 hours** ***(90 to 119 minutes)*****….** ☐
- **2 to 3 hours** ***(120 to 179 minutes)*****…..** ☐
- **3 to 4 hours** ***(180 to 240 minutes)*****.....** ☐
- **More than 4 hours…………………** ☐
- **It varies greatly……………………..** ☐
- **Don't know…………………………** ☐

4.8 How often have you found that patient's lose a good sitting postural position for the following reasons? (*please tick* ***one box on each row***)

	All the time	Frequently	Occasionally	Very Rarely	Never
They gradually drift into a poor position……..…	☐	☐	☐	☐	☐
They adjust into a poor but more comfortable position…………………………………………..	☐	☐	☐	☐	☐
Self propelling the wheelchair throws their position…………………………………………..	☐	☐	☐	☐	☐
They fidget……………...……………………....	☐	☐	☐	☐	☐
Their position is altered by spasms....……………	☐	☐	☐	☐	☐

Please use this space if you can think of any other activities which may cause a patient to lose a good postural position

4.9 If a patient is sat upon a fluid filled cushion, for example gel or air, and starts to lean to one side, the unbalanced weight of the patient pushes the fluid out from under the side being leaned on to the other side of the cushion. This uneven distribution of the fluid exaggerates the patient's lean. How exaggerated can a patient's lean become when sat on a fluid filled cushion? *(please tick* ***only one*** *option)*

- **A significant increase of the lean…** ☐
- **A definite increase of the lean……** ☐
- **Some increase in the lean…………** ☐
- **A slight increase in the lean……...** ☐
- **No increase in the lean……………..** ☐
- **Never noticed…………………...……..** ☐
- **Never been involved with fluid filled cushions…………………………..** ☐

Section 5. Utility/Practicality

5.1 The following options are possible reasons for removing a cushion from a wheelchair. In your experience, how often are cushions removed for the following reasons? *(please tick* ***one box on each row****)*

	All the time	Frequently	Occasionally	Very Rarely	Never
To collapse the wheelchair……………………..…	☐	☐	☐	☐	☐
To check for damage……...……………..………..	☐	☐	☐	☐	☐
To clean the cushion……………………………..	☐	☐	☐	☐	☐
To use the cushion on a different chair…………	☐	☐	☐	☐	☐
To change the cushion cover ………..……..……	☐	☐	☐	☐	☐
To check the cushions air cell(s) pressure………	☐	☐	☐	☐	☐
To check the cushions gel sack(s)..………………	☐	☐	☐	☐	☐

Please use this space if you can think of any other reasons for removing a cushion from a wheelchair

5.2 Out of all the patients you are involved with, approximately how many patients are able to remove and replace their pressure relief cushion from their wheelchair?

All of them	Most of them	About half	Some of them	None
☐	☐	☐	☐	☐

5.3 How difficult do those patients who remove and replace their cushions for themselves, find securing the cushion to the wheelchair?

Very easy	Easy	Manageable	Difficult	Very difficult
☐	☐	☐	☐	☐

5.4 Out of all the patients you are involved with, how many have complained that after their cushion has been secured to their wheelchair the cushion still becomes loose and slides around?

All of them	Most of them	About half	Some of them	None
☐	☐	☐	☐	☐

5.5 How often have you observed a patient knocking loose their cushion when transferring into their wheelchair?

All the time	Frequently	Occasionally	Very Rarely	Never
☐	☐	☐	☐	☐

5.6 The following options are examples of how a cushion may be damaged, how often have you observed these forms of damage? *(please tick* ***one box on each row****)*

	All the time	Frequently	Occasionally	Very Rarely	Never
Chunks of foam breaking off………..…………..	☐	☐	☐	☐	☐
Air cells punctured by cigarette burns…………	☐	☐	☐	☐	☐
Air cells punctured by a pets claws……………	☐	☐	☐	☐	☐
Gel packs splitting……………………………...	☐	☐	☐	☐	☐

Please use this space if you can think of any other forms of damage

5.7 Where a cushion has a gel pack, on average, how long would you say it takes for the gel to be pushed to the sides of the pack, so that there is no-longer enough gel under the patient to provide sufficient pressure relief?

- **There is always enough gel**……… ☐
- **A couple of minutes**……………… ☐
- **A couple of hours**………………… ☐
- **A day**……………………………… ☐
- **A couple of days**………………… ☐
- **It depends on how active the patient is** ☐
- **Don't know**……………………… ☐
- **Other**…………………………… ☐

If **Other** please specify……

5.8 How often do the following actions cause the gel in a gel pack to be pushed out from underneath the patients posterior towards the sides of the pack? *(please tick **one box on each row**)*

	All the time	Frequently	Occasionally	Very Rarely	Never
The gel just drifts to the sides over time…………	☐	☐	☐	☐	☐
The patient performing pressure relief…………	☐	☐	☐	☐	☐
The patient sliding across the pack during a transfer	☐	☐	☐	☐	☐
The patient propelling the wheelchair…………	☐	☐	☐	☐	☐
The patient fidgeting……………………………	☐	☐	☐	☐	☐
The patient spasms……………………………	☐	☐	☐	☐	☐

Please use this space if you can think of any other reasons why the gel in a gel pack might be pushed out from underneath the posterior towards the sides of the pack

5.9 Where a cushion has a gel pack, how often should a cushion be checked to make sure there is still enough gel under the patient to provide sufficient pressure relief? *(please tick **as many options** as you wish)*

- **Leave the checking to the patient**… ☐
- **Every hour**………………………… ☐
- **Every few hours**…………………… ☐
- **Once a day**………………………… ☐
- **Once a week**……………………… ☐
- **After every period of activity**……… ☐
- **It varies from day to day**………… ☐
- **Never check**……………………… ☐
- **Don't know**……………………… ☐
- **Other**…………………………… ☐

If **Other** please specify……

5.10 Have you known of the gel in a gel pack type cushion to push to the sides, to a point where the patient is left sitting on a solid base?

All the time	Frequently	Occasionally	Very Rarely	Never
☐	☐	☐	☐	☐

5.11 In your experience, how often does sitting on a pressure relief cushion which has had its gel pushed to the sides, triggers a pressure ulcer?

All the time	Frequently	Occasionally	Very Rarely	Never	Don't know
☐	☐	☐	☐	☐	☐

5.12 How often are cushions, made up from air filled cells, either over or under inflated?

All the time	Frequently	Occasionally	Very Rarely	Never
☐	☐	☐	☐	☐

5.13 Where a cushion is made up from air filled cells, on average, how long would you say it takes for the air cell to deflate so that there is no-longer enough air under the patient to provide sufficient pressure relief?

- **There is always enough air pressure** ☐
- **A couple of hours**………………… ☐
- **A full day**………………………… ☐
- **A couple of days**………………… ☐
- **A week**…………………………… ☐
- **A couple of weeks**………………… ☐
- **Cells never need re-inflating**……… ☐
- **It depends on how active the patient is** ☐
- **Don't know**……………………… ☐
- **Other**…………………………… ☐

If **Other** please specify……

5.14 Where a cushion is made up from air filled cells, how often should a cushion be checked to make sure the air pressure is correct to provide pressure relief? *(please tick **as many options** as you wish)*

- **Leave the checking to the patient**… ☐
- **Every hour**………………………… ☐
- **Every few hours**…………………… ☐
- **Once a day**………………………… ☐
- **Once a week**……………………… ☐
- **A couple of times a week**………… ☐
- **A couple of times a month**………… ☐
- **After every period of activity**……… ☐
- **It varies from day to day**………… ☐
- **Never check**……………………… ☐
- **Don't know**……………………… ☐
- **Other**…………………………… ☐

If **Other** please specify……

5.15 Do you agree with the following statements about adjusting the air pressure in air filled cell cushions? *(please tick **one box on each row**)*

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
The cushion has to be removed from the wheelchair	☐	☐	☐	☐	☐
The valves are difficult to open/close……………	☐	☐	☐	☐	☐
The valves are in a difficult position to get at…..	☐	☐	☐	☐	☐
The level of air pressure is difficult to judge……	☐	☐	☐	☐	☐
The effort involved in adjusting the air pressure in the air filled cells is such that these adjustments are not being made as often as they should……..	☐	☐	☐	☐	☐
All things considered controlling the air pressure in air cells is still easy………………	☐	☐	☐	☐	☐

Please use this space if you can think of any other difficulties involved in adjusting the air pressure in these air cells

5.16 Have you known of an air filled cell type cushion to deflate to a point where the patient is left sitting on a solid base?

All the time	Frequently	Occasionally	Very Rarely	Never
☐	☐	☐	☐	☐

5.17 In your experience, how often does sitting on a pressure relief cushion which has been incorrectly inflated, trigger a pressure ulcer?

All the time	Frequently	Occasionally	Very Rarely	Never	Don't know
☐	☐	☐	☐	☐	☐

5.18 How often have you observed the following options being used as cushion covers? (*please tick **one box on each row***)

	All the time	Frequently	Occasionally	Very Rarely	Never
Nothing, the cushion is left uncovered…………	☐	☐	☐	☐	☐
The cover that comes with the cushion…………	☐	☐	☐	☐	☐
A blanket to wrap around the cushion…………..	☐	☐	☐	☐	☐
A cotton sheet to wrap around the cushion……..	☐	☐	☐	☐	☐
An ordinary pillow case……………………………	☐	☐	☐	☐	☐
A homemade cover………………………………	☐	☐	☐	☐	☐
A cover from another cushion which has been altered to fit this cushion………………………..	☐	☐	☐	☐	☐
A cover from another cushion which has NOT been altered to fit this cushion………………..…	☐	☐	☐	☐	☐

Please use this space if you can think of any other forms of covering that might be used on a cushion

5.19 The following options are possible tasks a cushion cover might fulfil. How important do you consider these tasks to be? (*please tick **one box on each row***)

	Very important	Of some importance	Important	Of little importance	Of no importance
It protects the cushion……………………………	☐	☐	☐	☐	☐
It draws moisture from the patient………………	☐	☐	☐	☐	☐
It helps to reduce the production of sweat………	☐	☐	☐	☐	☐
It helps to keep the cushion clean……………….	☐	☐	☐	☐	☐
It hides an ugly cushion…………………………	☐	☐	☐	☐	☐
It can compliment the patient's clothing……….	☐	☐	☐	☐	☐

Please use this space if you can think of any other reasons for using a cushion cover

5.20 Do you agree with the following statements about changing cushion covers? (*please tick **one box on each row***)

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
The cushion is bulky, so it is difficult to insert into the cover……………………………………	☐	☐	☐	☐	☐
The next cover is often not ready to put on as it is away being cleaned or repaired……………..	☐	☐	☐	☐	☐
The cover opening fastenings (zipper, buttons, press studs etc) are difficult to use……………	☐	☐	☐	☐	☐
To fit the cover the cushion has to be removed from the wheelchair……………………………..	☐	☐	☐	☐	☐
The cover is difficult to adjust so that the surface is not wrinkled/creased………………...	☐	☐	☐	☐	☐
The effort involved in removing, and putting back on, a cover is such that the cover is not changed as often as it should…………………..…	☐	☐	☐	☐	☐
All things considered the cushion cover is still easy to change (put on/take off)………………..	☐	☐	☐	☐	☐

Please use this space if you can think of any other difficulties involved in changing a cover

5.21 The following options are possible ways a cushion cover may contribute to the development of a pressure ulcer. How often have you observed these circumstances? (*please tick **one box on each row***)

	All the time	Frequently	Occasionally	Very Rarely	Never
The cover becomes wrinkled or creased………..	☐	☐	☐	☐	☐
The texture of the cover material is too rough….	☐	☐	☐	☐	☐
The weave, or cloth pattern, of the cover is too pronounced……………………………………	☐	☐	☐	☐	☐
The cover material holds too much moisture…...	☐	☐	☐	☐	☐
The cover is stretched too tight across the cushion affecting the cushions ability to disperse the weight of the body……………..….	☐	☐	☐	☐	☐

Please use this space if you can think of any other ways a cushion cover may contribute to the development of a pressure ulcer

Any Additional Information/Comments

Please add here any other comments you would like to make about your experiences with pressure relief cushions

You have reached the end of the questionnaire.

Thank you very much for participating in this survey, your contribution is greatly appreciated.

Please try to ensure that you have returned this questionnaire by 1st July 2006

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Appendix O: Results of the SCI Professional Questionnaire

O.1 Results on the Respondent's Clients Pressure Ulcer Histories

O.1.1 Pressure Ulcer Occurrence

Table O-1 The frequently clients of a certain body weight develop pressure ulcers (n=31)*

Body weight	Frequency a certain body develops a pressure ulcer				
	Very often	Frequently	Occasion-ally	Very rarely	Never
Less than 9st	2 (6%)	7 (23%)	5 (16%)	2 (6%)	0 (0%)
9st 1lb – 10st	1 (3%)	8 (26%)	7 (23%)	0 (0%)	0 (0%)
10st 1lb – 11st	0 (0%)	6 (19%)	10 (32%)	0 (0%)	0 (0%)
11st 1lb – 12st	0 (0%)	5 (16%)	11 (35%)	0 (0%)	0 (0%)
12st 1lb – 13st	0 (0%)	3 (10%)	12 (39%)	1 (3%)	0 (0%)
13st 1lb – 14st	0 (0%)	3 (10%)	12 (39%)	1 (3%)	0 (0%)
14st 1lb – 15st	0 (0%)	3 (10%)	11 (35%)	2 (6%)	0 (0%)
15st 1lb – 16st	1 (3%)	2 (6%)	11 (35%)	2 (6%)	0 (0%)
16st 1lb – 17st	1 (3%)	3 (10%)	9 (29%)	3 (10%)	0 (0%)
17st 1lb – 18st	1 (3%)	3 (10%)	9 (29%)	3 (10%)	0 (0%)
More than 18st	1 (3%)	4 (13%)	8 (26%)	3 (10%)	0 (0%)

* 15 missing **(see Q3.2)**

Although no comment box was provided 9 respondents added comments on the surrounding space

Table O-2 Additional comments relating to a clients body weight

Additional comments	Groups			
	All respondents (n=31)*	Physios (n=6)	OT's (n=3)	Nurses (n=0)
Weight not a factor	3 (10%)	2	1	
Depends on other factors (chair, cushion, posture)	4 (13%)	2	2	
Different body shapes have different vulnerable areas	1 (3%)	1		
No pattern/link noticed	1 (3%)	1		

* 22 missing, 9 respondents provided additional comments **(see Q3.2)**

Table O-3 The frequently clients of a certain height develop pressure ulcers (n=31)*

Height	Frequency a certain body develops a pressure ulcer				
	Very often	Frequently	Occasion-ally	Very rarely	Never
Less than 5'2"	0 (0%)	2 (6%)	9 (29%)	3 (10%)	0 (0%)
5'3" – 5'5"	0 (0%)	2 (6%)	11 (35%)	2 (6%)	0 (0%)
5'6" – 5'7"	0 (0%)	2 (6%)	11 (35%)	2 (6%)	0 (0%)
5'8" – 5'9"	0 (0%)	3 (10%)	11 (35%)	1 (3%)	0 (0%)
5'10" – 5'11"	0 (0%)	4 (13%)	10 (32%)	1 (3%)	0 (0%)
6'0" – 6'1"	0 (0%)	4 (13%)	10 (32%)	1 (3%)	0 (0%)
6'2" – 6'5"	0 (0%)	3 (10%)	11 (35%)	1 (3%)	0 (0%)
More than 6'6"	0 (0%)	4 (13%)	10 (32%)	1 (3%)	0 (0%)

* 16 missing **(see Q3.3)**

Although no comment box was provided 8 respondents added comments on the surrounding space

Table O-4 Additional comments relating to a clients height

Additional comments	Groups			
	All respondents (n=31)*	Physios (n=6)	OT's (n=2)	Nurses (n=0)
Height not a factor	4 (13%)	3	1	
Depends on other factors (chair, cushion, posture)	3 (10%)	3		
Amputation can alter height	1 (3%)	1		
No pattern/link noticed	2 (6%)	1	1	

* 23 missing, 8 respondents provided additional comments. Some provided more than one comment **(see Q3.3)**

O.1.2 Pressure Ulcer Causes

Table O-5 How often respondents have observed a client using a cushion positioned on their wheelchair facing the wrong way, be it back-to-front or side-to-side

Groups	Frequency cushion positioned the wrong way				
	All the time	Frequently	Occasionally	Very rarely	Never
All respondents (n=31)*	0 (0%)	4 (13%)	17 (55%)	8 (26%)	1 (3%)
Physios (n=17)*	0	1	9	5	1
OT's (n=10)	0	2	6	2	0
Nurses (n=4)	0	1	2	1	0

*1 missing **(see Q1.16)**

Table O-6 How frequently does sitting on a cushion facing the wrong way trigger a pressure ulcer

Groups	Frequency ulcer triggered by cushion wrong way around					
	All the time	Frequently	Occasion-ally	Very rarely	Never	Don't know
All respondents (n=31)*	2 (7%)	4 (13%)	15 (48%)	4 (13%)	0 (0%)	5 (16%)
Physios (n=17)*	2	1	8	2	0	3
OT's (n=10)	0	1	6	1	0	2
Nurses (n=4)	0	2	1	1	0	0

*1 missing **(see Q1.17)**

Table O-7 How often respondents have observed a client using a cushion positioned on their wheelchair upside down

Groups	Frequency cushion positioned upside down				
	All the time	Frequently	Occasionally	Very rarely	Never
All respondents (n=31)*	0 (0%)	0 (0%)	12 (39%)	12 (39%)	6 (19%)
Physios (n=17)*	0	0	6	7	3
OT's (n=10)	0	0	5	3	2
Nurses (n=4)	0	0	1	2	1

*1 missing **(see Q1.14)**

Table O-8 How frequently does sitting on a cushion upside down trigger a pressure ulcer

Groups	Frequency upside down cushions trigger pressure ulcers					
	All the time	Frequently	Occasion-ally	Very rarely	Never	Don't know
All respondents (n=31)*	0 (0%)	12 (39%)	5 (16%)	2 (6%)	2 (6%)	9 (29%)
Physios (n=17)*	0	7	3	1	2	3
OT's (n=10)	0	4	1	1	0	4
Nurses (n=4)	0	1	1	0	0	2

*1 missing **(see Q1.15)**

Table O-9 How often respondents have observed a client using a cushion which, due to old age, no longer performs to its best

Groups	Frequency old cushion still used				
	All the time	Frequently	Occasionally	Very rarely	Never
All respondents (n=31)*	0 (0%)	7 (23%)	18 (58%)	4 (13%)	1 (3%)
Physios (n=17)*	0	3	9	4	0
OT's (n=10)	0	2	7	0	1
Nurses (n=4)	0	2	2	0	0

*1 missing **(see Q1.18)**

Table O-10 How frequently does using a cushion which is no longer performing to its best trigger a pressure ulcer

Groups	Frequency ulcer triggered by old cushion					
	All the time	Frequently	Occasion-ally	Very rarely	Never	Don't know
All respondents (n=31)*	0 (0%)	7 (23%)	11 (36%)	3 (10%)	0 (0%)	9 (29%)
Physios (n=17)*	0	4	4	2	0	6
OT's (n=10)	0	1	5	1	0	3
Nurses (n=4)	0	2	2	0	0	0

*1 missing **(see Q1.19)**

Table O-11 How often certain postural issues contribute to the development of a pressure ulcer (n=31)

Postural issue (description as used in questionnaire)	Frequency postural issues contribute to pressure ulcers				
	All the time	Frequently	Occasion-ally	Very rarely	Never
"*The skin was subjected to friction when the patient slide from their ideal postural position*"	1 (3%)	11 (35%)	14 (45%)	4 (13%)	1 (3%)
"*The skin was subjected to shear as the body was held in position unable to slide any further*"	0 (0%)	8 (26%)	13 (42%)	10 (32%)	0 (0%)
"*The poor postural position distorted the skin creating folds and creases in the skin/tissue*"	0 (0%)	5 (16%)	15 (48%)	9 (29%)	2 (6%)
"*The skin was subjected to an increase in direct pressure/ compression as the body was in an unbalanced position*"	0 (0%)	17 (55%)	13 (42%)	1 (3%)	0 (0%)

(see Q3.7)

Table O-12 Other ways in which posture has contributed to the development of pressure ulcers

Other ways	Groups			
	All respondents (n=31)*	Physios (n=6)	OT's (n=4)	Nurses (n=1)
Clients being asymmetric with dominance of one side in ADL (activities of daily living)	1 (3%)	1		
clients leaning on arm/back rests for support	1 (3%)		1	
clients being sat for too long in a poor position with out pressure relief	1 (3%)	1		
clients with pelvic obliquity increasing weight over one ischium	1 (3%)		1	
clients weight being on one side more than the other	1 (3%)	1		

* 26 missing, 5 respondents reported other ways in which posture has contributed to the development of a pressure ulcer

(see Q3.7)

Table O-13 How often pressure ulcers, which have developed on the seat area of the body, are thought to have be caused by something unrelated to the cushion

Groups	Frequency pressure ulcers are unrelated to cushion				
	All the time (every time)	Frequently (most times)	Occasionally (about half the time)	Very rarely (sometimes)	Never
All respondents (n=31)	0 (0%)	10 (32%)	16 (52%)	5 (16%)	0 (0%)
Physios (n=17)	0	4	11	2	0
OT's (n=10)	0	3	4	3	0
Nurses (n=4)	0	3	1	0	0

(see Q3.4)

Table O-14 How often pressure ulcers are found to have been caused by something other than the cushion (n=31)

Cause other than cushion (description as used in questionnaire)	Frequency a cause is identified				
	All the time	Frequently	Occasion-ally	Very rarely	Never
"*Prominent seams in clothing*"*	0 (0%)	4 (13%)	18 (58%)	6 (19%)	1 (3%)
"*Being left for an excessively long period on the cushion*"**	0 (0%)	8 (26%)	20 (65%)	1 (3%)	1 (3%)
"*An unsafe transfer*"	0 (0%)	15 (48%)	16 (52%)	0 (0%)	0 (0%)
"*Missed small objects eg coins*"**	0 (0%)	6 (19%)	13 (42%)	11 (35%)	0 (0%)
"*Pressure relief routine not performed regularly enough*"**	1 (3%)	7 (23%)	16 (52%)	6 (19%)	0 (0%)
"*Poor cleanliness of the cushion*"***	0 (0%)	1 (3%)	3 (10%)	16 (52%)	7 (23%)
"*Pressure relief routine not providing enough respite from pressure*"****	0 (0%)	7 (23%)	13 (42%)	7 (23%)	1 (3%)

* 2 missing; ** 1 missing; *** 4 missing; **** 3 missing **(see Q3.5)**

Table O-15 Other occasions when pressure ulcers have been identified as being caused by something other than the cushion

Causes other than cushion	Groups			
	All respondents (n=31)*	Physios (n=8)	OT's (n=8)	Nurses (n=1)
Not turning in bed	5 (16%)	3	2	
Skin conditions (spots/eczema/psoriasis)	4 (13%)	1	2	1
Incorrect sitting posture	4 (13%)	2	2	
Prolonged stay in bed	3 (10%)	1	1	1
Checking skin & keeping off red marks	3 (10%)		2	1
Showerchair	3 (10%)	1	1	1
Inadequate PR on long journeys car/plane	2 (6%)	1	1	
Falling out of chair	2 (6%)	2		
Poor Transfers	2 (6%)	1	1	
Spasticity	1 (3%)	1		
Infections, UTI's, sepsis	1 (3%)	1		
Faecal burning	1 (3%)	1		
Creases in bed sheets	1 (3%)		1	
Sitting on floor	1 (3%)	1		
From sitting on a sofa	1 (3%)	1		
Not using a cushion at all	1 (3%)		1	
Lying on catheter tube	1 (3%)		1	
Carrying out another activity eg canoeing, driving	1 (3%)		1	

* 14 missing, with 17 respondents reporting other causes. Some of the respondents reported more than one cause **(see Q3.5)**

Table O-16 How frequently certain external events trigger the development of a pressure ulcer

External event	Frequency external event triggers pressure ulcers					
	All the time	Frequently	Occasion-ally	Very rarely	Never	Don't know
An illness/inflection*	1 (3%)	15 (48%)	11 (35%)	3 (10%)	0 (0%)	1 (3%)
Travelling (eg car journey)*	0 (0%)	5 (16%)	19 (61%)	4 (13%)	1 (3%)	1 (3%)
Rapid body weight gain**	0 (0%)	3 (10%)	12 (39%)	5 (16%)	4 (13%)	3 (10%)
Rapid body weight loss***	0 (0%)	10 (32%)	15 (48%)	1 (3%)	1 (10%)	2 (6%)
Pregnancy****	0 (0%)	0 (0%)	7 (23%)	9 (29%)	5 (16%)	7 (23%)

* 1 missing; ** 4 missing; *** 2 missing; **** 3 missing; **(see Q3.6)**

Table O-17 Other external events which trigger pressure ulcers

External event	Groups			
	All respondents (n=31)*	Physios (n=5)	OT's (n=3)	Nurses (n=0)
Carrying out activities eg canoeing, driving	2 (6%)	1	1	
Not being turned enough in bed	2 (6%)	1	1	
Cuts/sores	1 (3%)	1		
Burns	1 (3%)	1		
Faecal burning	1 (3%)	1		
Spots	1 (3%)	1		
Spasticity	1 (3%)	1		
Poor posture	1 (3%)	1		
Medical conditions eg excessive bone formation	1 (3%)		1	
Aeroplane journeys	1 (3%)		1	
Usual routine disrupted	1 (3%)		1	

* 23 missing, with 8 respondents reporting other events. Some of the respondents reported more than one event **(see Q3.6)**

O.2 Results on the Cushions Used by the Respondent's Clients

O.2.1 Cushions Used

Table O-18 The make of cushion the respondents come into contact with during the course of their duties (n=31)*

Make of cushion															
Flolite	Flotech	Foam	Jay 2	Lowzone	Pindot	Qbitus	ROHO	Stimulate	STM	Strathclyde	Sumed ErgoNest	Transflo	Tempurmed	Varilite	Vicair
2 (6%)	22 (71%)	6 (19%)	29 (94%)	4 (13%)	3 (10%)	5 (16%)	31 (100%)	3 (10%)	2 (6%)	4 (13%)	2 (6%)	1 (3%)	2 (6%)	23 (74%)	25 (81%)

(see Q1.1)

Table O-19 The make of cushion the respondents most commonly come into contact with during the course of their duties (n=31)*

Make of cushion															
Flolite	Flotech	Foam	Jay 2	Lowzone	Pindot	Qbitus	ROHO	Stimulate	STM	Strathclyde	Sumed ErgoNest	Transflo	Tempurmed	Varilite	Vicair
0 (0%)	2 (7%)	0 (0%)	19 (61%)	0 (0%)	0 (0%)	0 (0%)	2 (7%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (3%)	2 (7%)

* 5 missing **(see Q1.2)**

O.2.2 Cushion Selection

Table O-20 Cushions the respondents would discourage the use of

Cushion	Groups			
	All respondents (n=31)*	Physios (n=5)	OT's (n=4)	Nurses (n=1)
Cheap foam which comes with the wheelchair	4 (13%)	4		
Lowzone foam cushion	2 (6%)	1	1	
1" foam cushions	1 (3%)		1	
The Qbitus range	1 (3%)		1	
The Synergy range	1 (3%)		1	
Old worn out foam	1 (3%)		1	
"*Doughnut*" type cushions	1 (3%)			1

* 21 missing, 10 respondents would discourage the use of a particular cushion. Some of the respondents gave more than one reason for discouraging the use of a particular cushion **(see Q1.6)**

Table O-21 Reasons why respondents would discourage the use of a particular cushion

Reason for discouraging the use of a particular cushion	Groups			
	Respondents (n=10)*	Physios (n=3)	OT's (n=4)	Nurses (n=1)
It depends on the patients individuals needs	3 (10%)	2		1
Lowzone type foam ") not enough pressure protection	2 (6%)	1	1	
Lowzone type foam limited life span	1 (3%)		1	
Thin foam (1" & 2") bottom out	1 (3%)		1	
Thin foam (1" & 2") not enough pressure protection	1 (3%)		1	
Qbitus range wear out quickly	1 (3%)		1	
Synegy range wear out quickly	1 (3%)		1	

* 2 missing, of the 10 respondents who would discourage the use of a particular cushion 8 gave a reason. Some of the respondents reported more than one reason **(see Q1.6a)**

Table O-22 Cushions respondents would recommend above the others

Cushion recommended above the others	Groups			
	All respondents (n=31)*	Physios (n=2)	OT's (n=2)	Nurses (n=0)
Jay 2	4 (13%)	2	2	0

* 0 missing, 27 respondents would not recommend a particular cushion above the others **(see Q1.5)**

Table O-23 Reasons why respondents would recommend one cushion above the others

Reason for recommending cushion	Groups			
	All respondents (n=31)*	Physios (n=7)	OT's (n=5)	Nurses (n=0)
It depends on the patients individual needs	9 (29%)	5	4	
For pressure relief	3 (10%)	2	1	
For postural support	3 (10%)	2	1	
For stability	2 (6%)	2		
For durability	2 (6%)	2		
For availability of postural support modifications	1 (3%)	1		

* 19 missing, 12 respondents gave a reason. Some of the respondents reported more than one reason for recommending a cushion but 9 out of the 12 reported that they could not recommend one cushion above the other because it depends on the needs of the patient with different cushions fitting the different needs **(see Q1.5a)**

Table O-24 How the respondents regard certain aspects of a cushion when considering a cushions overall performance (n=31)*

Aspect considered (descriptions as used in questionnaire)	Significance of an aspect of a cushion				
	Very significant	Of some significance	Significant	Of little significance	Of no significance
"*The cushion's ability to be fixed securely to a wheelchair*"	11 (35%)	7 (23%)	9 (29%)	2 (6%)	1 (3%)
"*The cushion's ability to be kept clean*"	13 (42%)	14 (45%)	2 (7%)	1 (3%)	0 (0%)
"*The cushion's ability to keep the pressure experienced by the skin low*"	28 (90%)	1 (3%)	1 (3%)	0 (0%)	0 (0%)
"*The cushion's ability to maintain posture*"	19 (61%)	7 (23%)	4 (13%)	0 (0%)	0 (0%)
"*The cushion's ability to prevent sweating*"	10 (32%)	11 (35%)	9 (29%)	0 (0%)	0 (0%)
"*The cushion's appearance*"	1 (3%)	5 (16%)	17 (55%)	6 (19%)	1 (3%)
"*The cushion's cost*"	4 (13%)	3 (10%)	13 (42%)	5 (16%)	5 (16%)
"*The cushion's weight*"	7 (23%)	12 (39%)	6 (19%)	5 (16%)	0 (0%)
"*The level of comfort provided by the cushion*"	24 (77%)	4 (13%)	2 (6%)	0 (0%)	0 (0%)

* 1 missing **(see Q1.7)**

Table O-25 Other factors professionals consider significant when considering a cushion overall performance

Factors considered significant	Groups			
	All respondents (n=31)*	Physios (n=6)	OT's (n=4)	Nurses (n=1)
Adjusting/setting of cushion	3 (10%)	1	2	
Transferring to/from	3 (10%)	1	1	1
Availability in range of sizes	2 (6%)	2		
Working life span	2 (6%)	2		
Suitability for postural correction add-ons	2 (6%)	1	1	
Height of cushion	2 (6%)	1	1	
Stable sitting base	1 (3%)		1	
Reliability/ robustness	1 (3%)	1		
General maintenance	1 (3%)	1		

* 20 missing, 11 respondents provided other factors. Some of the respondents reported more than one factor **(see Q1.7)**

Table O-26 How the respondents regard the overall performance of the cushion they most commonly come into contact with

Groups	How overall performance is regarded				
	Excellent	Good	Satisfactory	Poor	Useless
All respondents (n=31)*	9 (29%)	13 (42%)	4 (13%)	0 (0%)	0 (0%)
Physios (n=17)**	3	8	3	0	0
OT's (n=10)***	5	3	0	0	0
Nurses (n=4)	1	2	1	0	0

* 5 missing; ** 3 missing; *** 2 missing **(see Q1.3)**

Table O-27 Reasons why respondents regard the overall performance of the cushion they see most often as "*Excellent*"

Reason for regarding cushion as "*Excellent*"	Respon-dents (n=9)*	Groups					
		Jay (n=7)			ROHO (n=2)		
		Physios (n=3)	OT'S (n=3)	Nurses (n=1)	Physios (n=0)	OT'S (n=2)	Nurses (n=0)
Pressure relieving properties	7 (78%)	3	2			2	
Good working life expectancy	4 (44%)	2	2				
Postural support	4 (44%)	1	2			1	
Durable/reliable	3 (33%)	1	2				
Availability of postural support modifications	1 (11%)	1					
Beneficial for people with SCI	1 (11%)			1			
Easy to clean	1 (11%)		1				
Stable	1 (11%)	1					

* Of the 31 respondents, 9 regard the cushion the cushion they see most often as "*Excellent*". Some of the respondents reported more than one reason as to why this cushion is "*Excellent*" **(see Q1.4)**

Table O-28 Reasons why respondents regard the overall performance of the cushion they see most often as "*Good*"

Reason for regarding cushion as "*Good*"	Respon-dents (n=13)*	Groups				
		Jay (n=10)			Varilite (n=2)	Vicar (n=1)
		Physios (n=6)	OT'S (n=2)	Nurses (n=2)	Physios (n=2)	OT's (n=1)
Pressure relieving properties	9 (69%)	4	1	2	1	1
Good Postural support	3 (23%)	1	1	1		
Easier to transfer to/from	2 (15%)	2				
Poor postural support	1 (8%)					1
Stable	1 (8%)	1				
Comfortable	1 (8%)	1				
Easy to maintain	1 (8%)	1				
Durable/reliable	1 (8%)			1		
Light weight	1 (8%)				1	
Heavy/bulky	1 (8%)		1			
Sometimes bottoms out	1 (8%)		1			
Easy to use	1 (8%)				1	
Surface creases	1 (8%)				1	
Slippery in chair	1 (8%)				1	
Short life span	1 (8%)				1	

* Of the 31 respondents, 13 regard the cushion the cushion they see most often as "*Good*". Some of the respondents reported more than one reason as to why this cushion is "*Good*" **(see Q1.4)**

Table O-29 How the respondents regard the postural and skin care performance of pressure relief cushions they are most involved with

Groups	Performance of cushion				
	Strong in both maintaining posture and skin care	Satisfactory in both maintaining posture and skin care	Strong in maintaining posture but poor in skin care	Strong in skin care but weak in maintaining posture	Weak in both maintaining posture and skin care
All respondents (n=31)*	8 (26%)	9 (29%)	1 (3%)	6 (19%)	1 (3%)
Physios (n=17)**	3	7	1	4	1
OT's (n=10)***	2	2	0	1	0
Nurses (n=4)	3	0	0	1	0

* 6 missing; ** 1 missing; *** 5 missing **(see Q3.9)**

Statement A was put to the respondents:

Statement A

…."Patients initially tend to opt for a cushion, for their day-to-day use, whose foremost ability is to support the patient's posture. This choice is made in favour of a cushion whose foremost ability is skin care. If an ulcer should develop, the patient then switches from their first choice cushion, strong in postural support, to a cushion whose primary ability is skin care rather than posture. The patient then uses this cushion for a short period, whilst their newly healed skin regains some of its tolerance, after which they return once again to a cushion which is primarily good at supporting posture"…

Table O-30 How frequently the respondents have observed the pattern of events described in **Statement A**

Groups	Frequency events in **Statement A** are observed				
	All the time	Frequently	Occasionally	Very rarely	Never
All respondents (n=31)	0 (0%)	10 (32%)	6 (19%)	9 (29%)	6 (19%)
Physios (n=17)	0	3	2	9	3
OT's (n=10)	0	4	4	0	2
Nurses (n=4)	0	3	0	0	1

(see Q3.8)

O.2.3 Cushion Provision

Table O-31 How often respondents have observed a client using a cushion of the wrong size

Groups	Frequency cushion of the wrong size is used				
	All the time	Frequently	Occasionally	Very rarely	Never
All respondents (n=31)*	0 (0%)	6 (19%)	22 (71%)	2 (6%)	0 (0%)
Physios (n=17)*	0	4	10	2	0
OT's (n=10)	0	2	8	0	0
Nurses (n=4)	0	0	4	0	0

*1 missing **(see Q1.8)**

Table O-32 The average length of time a client has to wait for a new cushion after they are found to be using a cushion of the wrong size

Groups	Length of wait					
	Always have the right size	< 2 weeks	2 – 4 weeks	1 – 3 months	4 – 6 months	> 6 months
All respondents (n=31)*	0 (0%)	13 (42%)	1 (3%)	8 (26%)	1 (3%)	0 (0%)
Physios (n=17)**	0	8	1	5	0	0
OT's (n=10)***	0	2	0	3	0	0
Nurses (n=4)	0	3	0	0	1	0

* 8 missing; ** 3 missing; *** 5 missing **(see Q1.9)**

Although no comment box was provided 9 respondents added comments on the surrounding space

Table O-33 Additional comments relating to a waiting times for a new correct sized cushion

Additional comments	Groups			
	All respondents (n=31)*	Physios (n=2)	OT's (n=7)	Nurses (n=0)
Out-patients 1-3 months	6 (19%)	1	5	
In-patients less than 2 weeks	3 (10%)	1	2	
Can organise a loan	3 (10%)		3	
Depends on wheelchair service	1 (3%)	1		

* 22 missing, 9 respondents provided additional comments **(see Q1.9)**

Table O-34 How frequently does sitting on a cushion of the wrong size trigger a pressure ulcer

Groups	Frequency wrong sized cushions trigger pressure ulcers					
	All the time	Frequently	Occasion-ally	Very rarely	Never	Don't know
All respondents (n=31)*	0 (0%)	3 (10%)	16 (52%)	6 (20%)	0 (0%)	4 (13%)
Physios (n=17)**	0	2	8	4	0	2
OT's (n=10)**	0	1	5	1	0	2
Nurses (n=4)	0	0	3	1	0	0

* 2 missing; ** 1 missing **(see Q1.10)**

Table O-35 How often respondents have observed a client using a cushion with the wrong surface contour shape

Groups	Frequency cushion with the wrong contour shape is used				
	All the time	Frequently	Occasionally	Very rarely	Never
All respondents (n=31)*	0 (0%)	1 (3%)	12 (39%)	7 (23%)	4 (13%)
Physios (n=17)**	0	1	6	4	4
OT's (n=10)***	0	0	3	2	0
Nurses (n=4)	0	0	3	1	0

* 7 missing; ** 2 missing; *** 5 missing **(see Q1.11)**

Table O-36 The average length of time a client has to wait for a new cushion after they are found to be using a cushion with the wrong surface contour shape

Groups	Length of wait					
	Always have the right shape	< 2 weeks	2 – 4 weeks	1 – 3 months	4 – 6 months	> 6 months
All respondents (n=31)*	4 (13%)	7 (23%)	2 (6%)	6 (19%)	1 (3%)	0 (0%)
Physios (n=17)**	4	5	1	4	0	0
OT's (n=10)***	0	0	0	2	0	0
Nurses (n=4)	0	2	1	0	1	0

* 11 missing; ** 3 missing; *** 8 missing **(see Q1.12)**

Table O-37 How frequently does sitting on a cushion with the wrong surface contour shape trigger a pressure ulcer

Groups	Frequency wrong contour shape trigger pressure ulcers					
	All the time	Frequently	Occasion-ally	Very rarely	Never	Don't know
All respondents (n=31)*	0 (0%)	3 (10%)	11 (35%)	5 (16%)	0 (0%)	6 (19%)
Physios (n=17)**	0	1	5	4	0	4
OT's (n=10)**	0	1	3	1	0	2
Nurses (n=4)	0	1	3	0	0	0

* 6 missing; ** 3 missing **(see Q1.13)**

O.2.4 Cushions with Air Cells

Table O-38 Frequency cushions with air cells are incorrectly inflated either by over or under inflation

Groups	Frequency air cell cushions are either over or under inflated				
	All the time	Frequently	Occasionally	Very rarely	Never
All respondents (n=31)*	0 (0%)	12 (39%)	13 (42%)	5 (16%)	0 (0%)
Physios (n=17)*	0	8	6	2	0
OT's (n=10)	0	3	5	2	0
Nurses (n=4)	0	1	2	1	0

* 1 missing **(see Q5.12)**

Table O-39 The number of respondents who agree that all things considered controlling the air pressure is still easy

Ease of controlling pressure	Level of agreement with statements				
	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
All respondents (n=31)*	0 (0%)	11 (35%)	9 (29%)	8 (26%)	1 (3%)
Physios (n=17)**	0	5	5	5	1
OT's (n=10)**	0	5	2	2	0
Nurses (n=4)	0	1	2	1	0

* 2 missing; ** 1 missing **(see Q5.15)**

Table O-40 How respondents find certain aspects of adjusting air pressure (n=31)

Aspect of air pressure adjustment (description as used in questionnaire)	Level of agreement with statements				
	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
"*The cushion has to be removed from the wheelchair*"*	3 (10%)	0 (0%)	2 (6%)	12 (39%)	11 (35%)
"*The valves are difficult to open/close*"**	0 (0%)	4 (13%)	12 (39%)	13 (42%)	1 (3%)
"*The valves are in a difficult position to get at*"***	0 (0%)	4 (13%)	8 (26%)	17 (55%)	0 (0%)
"*The level of air pressure is difficult to judge*"***	3 (10%)	13 (42%)	3 (10%)	10 (32%)	0 (0%)
"*The effort involved in adjusting the air pressure in the air filled cells is such that these adjustments are not being made as often as they should*"***	2 (6%)	10 (32%)	9 (29%)	8 (26%)	0 (0%)

* 3 missing; ** 1 missing; *** 2 missing **(see Q5.15)**

Table O-41 Other difficulties clients experience when adjusting air pressure

Other occasions when air pressure is checked	Groups			
	All respondents (n=31)*	Physios (n=6)	OT's (n=3)	Nurses (n=1)
Not an objective process, difficult to judge when cushion is set correctly	5 (13%)	4	1	
To raise/adjust the position of their client so as to get their hand into the correct place to check the air pressure	1 (3%)		1	
To combine the postural position and correct pressure eg ROHO Quattro	1 (3%)	1		
There exists a "*phantom night nurse*" which hyper-inflates cushions overnight	1 (3%)	1		
Depends on the hand function of the patient and the cognitive status of the patient	1 (3%)		1	
It takes a lot of training for patients/carers to maintain their cushions	1 (3%)			1

* 21 missing, with 10 respondents reporting other difficulties. **(see Q5.15)**

Table O-42 Time taken for air cells to deflate to a point where the cushion no longer is capable of providing sufficient pressure relief

Groups	Time taken for air cells to deflate								
	There is always enough air pressure	Cells never need to be re-inflating	It depends on how active the client is	A couple of hours	A full day	A couple of days	A week	A couple of weeks	Don't know
All respondents (n=31)*	2 (6%)	0 (0%)	9 (29%)	0 (0%)	0 (0%)	1 (3%)	6 (19%)	3 (10%)	12 (39%)
Physios (n=17)**	1	0	4	0	0	1	5	1	7
OT's (n=10)**	1	0	3	0	0	0	0	2	4
Nurses (n=4)	0	0	2	0	0	0	1	0	1

* 2 missing; ** 1 missing **(see Q5.13)**

Table O-43 Other time frames for cushions with air cells to deflate to a point where the cushion no longer is capable of providing sufficient pressure relief

Other time frames for cushions to deflate	Groups			
	All respondents (n=31)*	Physios (n=0)	OT's (n=3)	Nurses (n=0)
Depends on the size of the puncture, 10secs to 1 week	2 (6%)		2	
Depends on cushion, ROHO immediately, Vicair little difference	1 (3%)		1	
Depends on valves	1 (3%)		1	

* 27 missing, 4 reported other timeframes for cushions with air cells to deflate **(see Q5.13)**

Table O-44 Frequency air pressure should be checked

Groups	Occasions when air pressure is checked									
	Leave checking to client	It varies form day to day	After every period of activity	Every hour	Every few hours	Once a day	Once a week	A couple of times a week	A couple of times a month	Never check
All respondents (n=31)*	2 (6%)	1 (3%)	1 (3%)	0 (0%)	1 (3%)	10 (32%)	9 (29%)	2 (6%)	0 (0%)	0 (0%)
Physios (n=17)**	1	1	1	0	0	5	6	1	0	0
OT's (n=10)***	1	0	0	0	1	4	2	1	0	0
Nurses (n=4)**	0	0	0	0	0	1	1	0	0	0

* 5 missing; ** 2 missing; *** 1 missing **(see Q5.14)**

Table O-45 Other occasions when clients check their air pressure

Other occasions when air pressure is checked	Groups			
	All respondents (n=31)*	Physios (n=3)	OT's (n=3)	Nurses (n=2)
Before transferring into the wheelchair	4 (13%)	1	1	2
Depends on the cushion (ROHO or Varilite)	2 (6%)	2		
When there has been a change in the skins integrity	1 (3%)		1	
When there is a significant change in external pressure eg travelling by air or hot/cold weather	1 (3%)		1	

* 23 missing, with 8 respondents reporting other occasions when to check **(see Q5.14)**

Table O-46 Frequency clients find themselves sat on the solid base of the their cushions because the air cells have deflated

Groups	Frequency deflated air cells leave clients sat on solid base				
	All the time	Frequently	Occasionally	Very rarely	Never
All respondents (n=31)	0 (0%)	0 (0%)	19 (61%)	9 (29%)	3 (10%)
Physios (n=17)	0	0	11	4	2
OT's (n=10)	0	0	7	2	1
Nurses (n=4)	0	0	1	3	0

(see Q5.16)

Table O-47 Frequency being sat on a solid base because the air cells have deflated triggers a pressure ulcer

Groups	Frequency deflated air cells trigger pressure ulcers					
	All the time	Frequently	Occasionally	Very rarely	Never	Don't know
All respondents (n=31)	1 (3%)	2 (6%)	19 (61%)	3 (10%)	1 (3%)	5 (16%)
Physios (n=17)	0	1	10	2	0	4
OT's (n=10)	0	1	6	1	1	1
Nurses (n=4)	1	0	3	0	0	0

(see Q5.17)

O.2.5 Cushions with Gel Packs

Table O-48 Time taken for enough of the gel to be pushed to the sides of the pack so that the cushion is no longer is capable of providing sufficient pressure relief

Groups	Time taken for enough gel to move						
	There is always enough gel	It depends on how active the client is	A couple of minutes	A couple of hours	A day	A couple of days	Don't know
All respondents (n=31)*	2 (6%)	15 (48%)	0 (0%)	2 (6%)	1 (3%)	0 (0%)	6 (19%)
Physios (n=17)**	1	7	0	0	1	0	5
OT's (n=10)***	1	6	0	1	0	0	0
Nurses (n=4)	0	2	0	1	0	0	1

* 5 missing; ** 3 missing; *** 2 missing **(see Q5.7)**

Table O-49 Other timeframes for the gel to be pushed to the sides so that the cushion no longer is capable of providing sufficient pressure relief

Other timeframes for gel to be pushed to the sides	Groups			
	All respondents (n=31)*	Physios (n=3)	OT's (n=6)	Nurses (n=1)
Should re-mould every time they get off their wheelchair	2 (6%)	2		
Should re-mould once per day	2 (6%)	1	1	
This happens more as cushion ages	1 (3%)		1	
If bottoming out occurs then an alternative cushion should be used	1 (3%)		1	
Depends on which cushion is used	1 (3%)		1	
Depends on how pressure reliving is carried out	1 (3%)		1	
Depends on sitting position sliding forward/sideways	1 (3%)		1	
Depends on spasms	1 (3%)			1

* 21 missing, 10 reported other timeframes for the gel to be pushed to the sides **(see Q5.7)**

Table O-50 The frequency a gel cushion should be checked for the distribution of gel

Groups	Frequency gel should be checked								
	Leave checking to the patient	After every period of activity	It varies from day to day	Every hour	Every few hours	Once a day	Once a week	Never check	Don't know
All respondents (n=31)*	5 (16%)	6 (19%)	6 (19%)	0 (0%)	2 (6%)	12 (39%)	1 (3%)	0 (0%)	3 (10%)
Physios (n=17)	5	5	4	0	2	6	1	0	1
OT's (n=10)	0	0	2	0	0	4	0	0	1
Nurses (n=4)	0	1	0	0	0	2	0	0	1

* All 31 respondents answered this question. Some of the respondents reported more than one period for checking gel **(see Q5.9)**

Table O-51 Other occasions when clients check the distribution of gel

Other occasions when air pressure is checked	Groups			
	All respondents (n=31)*	Physios (n=2)	OT's (n=5)	Nurses (n=1)
Before transferring onto the cushion	5 (16%)		4	1
After transferring off the cushion	3 (10%)	2	1	

* 23 missing, with 8 respondents reporting other occasions when to check **(see Q5.9)**

Table O-52 How often the following actions push the gel out from underneath the respondent's clients (n=31)

Actions which push gel to sides (description as used in questionnaire)	Frequency certain actions push gel				
	All the time	Frequently	Occasion-ally	Very rarely	Never
"*The gel just drifts to the sides over time*"*	2 (6%)	3 (10%)	12 (39%)	6 (19%)	1 (3%)
*"The patient performing pressure relief"***	0 (0%)	5 (16%)	6 (19%)	10 (32%)	2 (6%)
"*The patient sliding across the pack during a transfer*"***	0 (0%)	6 (19%)	14 (45%)	5 (16%)	0 (0%)
"*The patient propelling the wheelchair*"**	0 (0%)	2 (6%)	10 (32%)	9 (29%)	2 (6%)
"*The patient fidgeting*"***	0 (0%)	2 (6%)	14 (45%)	9 (29%)	0 (0%)
"*The patients spasms*"****	0 (0%)	7 (23%)	15 (48%)	4 (13%)	0 (0%)

* 7 missing; ** 8 missing; *** 6 missing; **** 5 missing **(see Q5.8)**

Table O-53 Other actions which push the gel to the sides

Other timeframes for gel to be pushed to the sides	Groups			
	All respondents (n=31)*	Physios (n=4)	OT's (n=3)	Nurses (n=0)
When clients slide forward to slouch	2 (6%)		2	
Its only an issue with wrong sized cushions	2 (6%)	1	1	
Saggy back canvas contribute to gel movement	1 (3%)	1		
Gel moves to the sides only when pack has not been fastened correctly	1 (3%)	1		
Depends on the weight and shape of the client	1 (3%)	1		

* 24 missing, 7 reported other actions which push gel to the sides **(see Q5.8)**

Table O-54 Frequency clients find themselves sat on the solid base of the their cushions because the gel has been pushed to the sides

Groups	Frequency gel movement leave clients sat on solid base				
	All the time	Frequently	Occasionally	Very rarely	Never
All respondents (n=31)*	0 (0%)	1 (3%)	14 (45%)	11 (35%)	4 (%)
Physios (n=17)*	0	0	7	7	2
OT's (n=10)	0	1	4	3	2
Nurses (n=4)	0	0	3	1	0

* 1 missing **(see Q5.10)**

Table O-55 Frequency being sat on a solid base because the gel has moved triggers a pressure ulcer

Groups	Frequency displaced gel trigger pressure ulcers					
	All the time	Frequently	Occasionally	Very rarely	Never	Don't know
All respondents (n=31)*	1 (3%)	3 (10%)	14 (45%)	3 (10%)	0 (0%)	9 (29%)
Physios (n=17)*	0	2	6	2	0	6
OT's (n=10)	0	1	5	1	0	3
Nurses (n=4)	1	0	3	0	0	0

* 1 missing **(see Q5.11)**

O.3 Results on Clients Sitting Posture in a Wheelchair

O.3.1 Sitting Position

Table O-56 Most common problems respondents have observed their clients experience

Problems experienced	Groups			
	All respondents (n=31)*	Physios (n=17)	OT's (n=10)	Nurses (n=4)
Reduced functionality	12 (39%)	6	6	
Spinal deformities (contractures – scolosis/kyphosis/lordosis)	11 (35%)	6	5	
Skin problems	11 (35%)	7	3	1
Unspecified Pain	8 (26%)	6	1	1
Back pain	7 (23%)	3	3	1
Reduced pushing ability (propelling)	6 (19%)	4	2	
Loss of balance	5 (16%)	2	3	
Sacral pressure sores	4 (13%)	3	1	
Ischial pressure sores	4 (13%)	2		2
Neck pain	4 (13%)	2	2	
Uncomfortable	2 (6%)	1		1
Shoulder pain	1 (3%)	1		
Pain in upper limbs	1 (3%)	1		
Trochanteric pressure sores	1 (3%)	1		
Worsening of neurological symptoms	1 (3%)	1		
Increase in spasm	1 (3%)		1	
Reduced respiratory function	1 (3%)	1		
Transferring	1 (3%)	1		
Feeling unsafe	1 (3%)	1		
Muscle imbalance (increased tone on one side)	1 (3%)	1		
Swollen leg	1 (3%)	1		

* 1 missing, 30 respondents reported observing problems. Some of the respondents reported more than one form of problem

(see Q4.1)

Table O-57 The increase in risk associated with the following sitting positions (n=31)

Sitting position	Level of risk related to sitting position					
	Major increase	Some increase	An increase	A slight increase	No increase	Don't know
Slouching*	11 (35%)	8 (26%)	6 (19%)	3 (10%)	0 (0%)	1 (3%)
Lean forward**	1 (3%)	0 (0%)	6 (19%)	4 (13%)	8 (26%)	7 (23%)
Lean to the left***	10 (32%)	9 (29%)	3 (10%)	5 (16%)	0 (0%)	3 (10%)
Lean to the right***	10 (32%)	9 (29%)	3 (10%)	5 (16%)	0 (0%)	3 (10%)

* 2 missing; ** 5 missing; *** 1 missing **(see Q4.3)**

Table O-58 How frequently the respondents observe their clients seated in the following positions (n=31)

Sitting position	Frequency certain seated positions are adopted				
	All the time	Frequently	Occasion-ally	Very rarely	Never
Slouching*	2 (6%)	22 (71%)	6 (19%)	0 (0%)	0 (0%)
Lean forward**	0 (0%)	6 (19%)	13 (42%)	9 (29%)	0 (0%)
Lean to the left***	1 (3%)	14 (45%)	14 (45%)	1 (3%)	0 (0%)
Lean to the right*	1 (3%)	14 (45%)	14 (45%)	1 (3%)	0 (0%)

* 1 missing; ** 3 missing **(see Q4.2)**

Table O-59 Other sitting positions observed

Other sitting positions	Groups			
	All respondents (n=31)*	Physios (n=6)	OT's (n=3)	Nurses (n=2)
Sacral sitting	4 (13%)	1	2	1
Posterior tilt	3 (10%)	2	1	
Pelvic obliquity	3 (10%)	1	1	1
Reclined	3 (10%)	2		1
Pelvic rotation	2 (6%)	1	1	
Hyper lordosis	1 (3%)	1		
Obliquity of shoulders	1 (3%)		1	
Windswept hips	1 (3%)	1		
Splaying of knees	1 (3%)		1	
Protruding chin	1 (3%)	1		
One arm hooked over pushing handle (common in tetras)	1 (3%)	1		

* 20 missing, 11 respondents reported observing other sitting positions. Some of the respondents reported more than one position **(see Q4.2)**

O.3.2 Shifting Position

Table O-60 How often the respondents clients lose a good postural position due to certain movements/actions (n=31)

Movements/actions (descriptions as used in questionnaire)	Frequency posture is lost due to a movement/action				
	All the time	Frequently	Occasion-ally	Very rarely	Never
"*They gradually drift into a poor position*"*	1 (3%)	16 (52%)	10 (32%)	0 (0%)	0 (0%)
"*They adjust into a poor but more comfortable position*"**	3 (10%)	15 (48%)	10 (32%)	1 (3%)	0 (0%)
"*Self propelling the wheelchair throws their position*"**	1 (3%)	4 (13%)	21 (68%)	3 (10%)	0 (0%)
"*Their position is altered by spasms*"**	3 (10%)	19 (61%)	7 (23%)	0 (0%)	0 (0%)
"*They fidget*"***	0 (0%)	7 (23%)	18 (58%)	1 (3%)	0 (0%)

* 4 missing; ** 2 missing; *** 5 missing **(see Q4.8)**

Table O-61 Other reasons why respondent's clients slip from a good postural position

Other reasons for slipping from good seated postural position	Groups			
	All respondents (n=31)*	Physios (n=5)	OT's (n=2)	Nurses (n=0)
Functional tasks	5 (16%)	4	1	
Transferring	2 (6%)	2		
Looking around	1 (3%)	1		
Pain	1 (3%)	1		
Reaching out	1 (3%)	1		
Pressure relief	1 (3%)	1		
Travelling over uneven/not level ground	1 (3%)	1		
Hit a bump	1 (3%)	1		
Coughing/sneezing	1 (3%)	1		
Dressing	1 (3%)		1	
Self intermittent catheterisation	1 (3%)		1	
Seeking more stability	1 (3%)		1	

* 24 missing, 7 respondents reported other activities. Some of the respondents reported more than one activity. **(see Q4.8)**

Table O-62 Average time a patient will spend in a good sitting position before slipping into a poor position

Groups	Length of time spent in a good postural position							
	It varies greatly	Less than 10 minutes	10 to 29 minutes	30 to 44 minutes	45 to 180 minutes	180 to 240 minutes	More than 240 minutes	Don't know
All respondents (n=31)*	21 (68%)	1 (3%)	2 (6%)	1 (3%)	0 (0%)	1 (%)	0 (0%)	3 (10%)
Physios (n=17)	13	1	2	0	0	1	0	0
OT's (n=10)*	6	0	0	0	0	0	0	2
Nurses (n=4)	2	0	0	1	0	0	0	1

* 2 missing

(see Q4.7)

Table O-63 When a patient slouches, how often is it the case that the patient has slid over the surface of the cushion, with the cushion remaining fixed in place

Groups	Frequency patients slide over cushion					
	All the time	Frequently	Occasion-ally	Very rarely	Never	Don't know
All respondents (n=31)*	3 (10%)	16 (52%)	9 (29%)	1 (3%)	0 (0%)	1 (3%)
Physios (n=17)	1	12	4	0	0	0
OT's (n=10)*	2	3	4	0	0	0
Nurses (n=4)	0	1	1	1	0	1

* 1 missing

(see Q4.4)

Table O-64 When a patient slouches, how often is it the case that the patient has slid forward and slid the cushion forward as well

Groups	Frequency cushion slides forward with the patient					
	All the time	Frequently	Occasion-ally	Very rarely	Never	Don't know
All respondents (n=31)*	0 (0%)	8 (26%)	16 (52%)	5 (16%)	0 (0%)	1 (3%)
Physios (n=17)	0	6	10	1	0	0
OT's (n=10)*	0	1	5	3	0	0
Nurses (n=4)	0	1	1	1	0	1

* 1 missing

(see Q4.4)

Table O-65 The extent to which the uneven distribution of fluid, within a fluid filled cushion, can exaggerate the lean of a client

Groups	The extent to which a cushion exaggerates a lean					
	A significant increase of the lean	A definite increase of the lean	Some increase in the lean	A slight increase in the lean	No increase in the lean	Never noticed
All respondents (n=31)*	2 (6%)	3 (10%)	9 (29%)	5 (16%)	1 (3%)	1 (3%)
Physios (n=17)**	1	0	6	3	1	1
OT's (n=10)**	1	0	3	1	0	0
Nurses (n=4)	0	3	0	1	0	0

* 10 missing; ** 5 missing **(see Q4.9)**

O.3.3 Checking Position

Table O-66 The proportion of clients which can check certain aspects of the sitting positions for themselves (n=31)

Check aspect of sitting (description as used in questionnaire)	Proportion of clients able to check certain aspects of the sitting position					
	All	Most	About half	A few	None	Don't know
"*That they are sitting upright*"	1 (3%)	24 (77%)	3 (10%)	3 (10%)	0 (0%)	0 (0%)
"*That they are sat right back in their wheelchair*"*	1 (3%)	18 (58%)	7 (23%)	4 (13%)	0 (0%)	0 (0%)
"*That they are sitting square in the wheelchair, not twisted*"*	2 (6%)	18 (58%)	5 (16%)	5 (16%)	0 (0%)	0 (0%)
"*That they have the full length of their thighs on the cushion*"*	0 (0%)	16 (52%)	8 (26%)	5 (16%)	0 (0%)	1 (3%)
"*That their thighs are level with the floor*"**	1 (3%)	9 (29%)	7 (23%)	9 (29%)	0 (0%)	1 (3%)
"*That their footplate is set to the right height*"***	1 (3%)	12 (39%)	9 (29%)	7 (23%)	0 (0%)	0 (0%)

* 1 missing; ** 4 missing; *** 2 missing **(see Q4.5)**

Although no comment box was provided 5 respondents added comments on the surrounding space

Table O-67 Additional comments relating to clients checking their postural position

Additional comments	Groups			
	All respondents (n=31)*	Physios (n=3)	OT's (n=2)	Nurses (n=0)
If a client is physically unable to check for themselves they should be asking others	3 (10%)	2	1	
For clients who use bucketed seats it is not possible to keep their thighs level with the floor	2 (6%)	1	1	

* 26 missing, 5 respondents provided additional comments **(see Q4.5)**

Table O-68 Occasions when clients sitting position is checked

Groups	Occasions to check posture								
	Every couple of hours	Occasionally (maybe once a day)	Just after transferring into the wheelchair	When you remember	When they feel uncomfortable	After a spasm	After carrying out pressure relief	After propelling your wheelchair	Never check
All respondents (n=31)*	12 (39%)	3 (10%)	24 (77%)	5 (16%)	19 (61%)	22 (71%)	19 (61%)	5 (16%)	1 (3%)
Physios (n=17)	10	1	13	4	10	13	11	2	1
OT's (n=10)	1	2	8	1	6	6	6	3	0
Nurses (n=4)	1	0	3	0	3	3	2	0	0

* All respondents answered, some of the respondents reported more than one occasion for checking sitting position **(see Q4.6)**

Table O-69 Other occasions when the sitting position is checked

Other occasions	Groups			
	All respondents (n=31)*	Physios (n=3)	OT's (n=3)	Nurses (n=0)
When reminded by a carer/staff	1 (3%)	1		
Every 20 mins	1 (3%)	1		
It depends on age and level of injury	1 (3%)	1		
patients are encouraged to be aware of their sitting position and request assistance as required	1 (3%)		1	
After the performance of functional activities	1 (3%)		1	
Once a patient is discharged, they have know way of knowing	1 (3%)		1	

* 25 missing, 6 respondents reported other occasions **(see Q4.6)**

O.4 Results on Cushion's Practicality

O.4.1 Daily Use

Table O-70 How frequently cushions are removed from their wheelchair for the following reasons (n=31)

Reason for removal (description as used in questionnaire)	Frequency cushions are removed				
	All the time	Frequently	Occasion-ally	Very rarely	Never
"*To collapse the wheelchair*"	14 (45%)	13 (42%)	4 (13%)	0 (0%)	0 (0%)
"*To check for damage*"*	2 (6%)	8 (26%)	14 (45%)	6 (19%)	0 (0%)
"*To clean the cushion*"**	5 (16%)	11 (35%)	10 (32%)	3 (10%)	0 (0%)
"*To use the cushion on a different chair*"*	2 (6%)	2 (6%)	19 (61%)	7 (23%)	0 (0%)
"*To change the cushion cover*"**	5 (16%)	6 (19%)	11 (35%)	7 (23%)	0 (0%)
"*To check the cushions air cell(s) pressure*"**	1 (3%)	7 (23%)	15 (48%)	5 (16%)	1 (3%)
"*To check the cushions gel sack(s)*"**	2 (6%)	8 (26%)	15 (48%)	4 (13%)	0 (0%)

* 1 missing; ** 2 missing **(see Q5.1)**

Table O-71 Other reasons for removing a cushion

Other reasons for removing a cushion	Groups			
	All respondents (n=31)*	Physios (n=3)	OT's (n=1)	Nurses (n=0)
Because it is easier to transfer from the floor into a wheelchair without the cushion being in the chair	2 (6%)	2		
In order to carry out a repair	1 (3%)	1		
To clean the wheelchair	1 (3%)	1		
To get the legs/wheelchair under a table	1 (3%)	1		
To reduce the bulk/weight of a wheelchair when lifting a wheelchair in/out of a car	1 (3%)		1	

* 27 missing, 4 respondents reported other reasons. Some of the respondents reported more than one reason **(see Q5.1)**

Table O-72 The proportion of clients which are able to remove and replace their own cushion from their wheelchair (n=31)

Groups	Proportion of clients able to fit/remove cushion by themselves				
	All of them	Most of them	About half	Some of them	None
All respondents (n=31)*	1 (3%)	5 (16%)	19 (61%)	5 (16%)	0 (0%)
Physios (n=17)	0	3	11	3	0
OT's (n=10)*	0	2	6	1	0
Nurses (n=4)	1	0	2	1	0

* 1 missing **(see Q5.2)**

Table O-73 The degree of ease the clients, which remove and replace their own cushions from their wheelchairs, find the task of securing their cushion to their wheelchair (n=31)

Groups	Degree of ease				
	Very easy	Easy	Manageable	Difficult	Very difficult
All respondents (n=31)*	0 (0%)	8 (26%)	18 (58%)	2 (6%)	1 (3%)
Physios (n=17)**	0	2	11	2	1
OT's (n=10)**	0	5	4	0	0
Nurses (n=4)	0	1	3	0	0

* 2 missing; ** 1 missing **(see Q5.3)**

Table O-74 The proportion of clients which have complained that having been secured to their wheelchair their cushion becomes loose and is free to slide around (n=31)

Groups	Proportion of clients with unsecured, loose cushions				
	All of them	Most of them	About half	Some of them	None
All respondents (n=31)	0 (0%)	5 (16%)	1 (3%)	22 (71%)	3 (10%)
Physios (n=17)	0	4	1	12	0
OT's (n=10)	0	0	0	7	3
Nurses (n=4)	0	1	0	3	0

(see Q5.4)

Table O-75 The frequency with which the respondents have observed their clients knock loose their cushion when transferring into their wheelchair (n=31)

Groups	Knocked loose during transfers				
	All the time	Frequently	Occasion-ally	Very rarely	Never
All respondents (n=31)*	0 (0%)	6 (19%)	17 (55%)	7 (23%)	0 (0%)
Physios (n=17)*	0	4	8	4	0
OT's (n=10)	0	2	6	2	0
Nurses (n=4)	0	0	3	1	0

* 1 missing **(see Q5.5)**

Table O-76 How frequently cushions are subject to certain forms of damage (n=31)

Form of damage (description as used in questionnaire)	Frequency certain forms of damage occur				
	All the time	Frequently	Occasion-ally	Very rarely	Never
"*Chunks of foam breaking off*"	0 (0%)	1 (3%)	15 (48%)	13 (42%)	2 (6%)
"*Air cells punctured by cigarette burns*"	0 (0%)	3 (10%)	15 (48%)	11 (35%)	2 (6%)
"*Air cells punctured by a pets claws*"*	0 (0%)	1 (3%)	3 (10%)	15 (48%)	11 (35%)
"*Gel pack splitting*"*	0 (0%)	3 (10%)	14 (45%)	9 (29%)	4 (13%)

* 1 missing **(see Q5.6)**

Table O-77 Other forms of damage cushions are subject to

Other forms of damage	Groups			
	All respondents (n=31)*	Physios (n=4)	OT's (n=4)	Nurses (n=1)
Run over by cars	3 (10%)	2	1	
Extreme temperatures	2 (6%)	2		
Incontinence going into cushion	2 (6%)	1		1
Abrasions on cushion from catching in wheels	1 (3%)	1		
Aging Cushions	1 (3%)		1	
Cigarette burns not just to air cells but all cushions	1 (3%)		1	
Covers wearing in corners	1 (3%)	1		
Foam hardening & setting/ losing "*spring back*"	1 (3%)	1		
Gel going solid	1 (3%)		1	
Valves being knocked releasing air	1 (3%)		1	
Valves being pulling out (being used as handles)	1 (3%)		1	
Zips breaking	1 (3%)	1		

* 22 missing, 9 respondents reported other forms of damage. Some of the respondents reported more than one form of damage **(see Q5.6)**

O.4.2 Cushions used on Chairs as well as Wheelchairs

Table O-78 How often the following types of chairs are used by clients (n=31)

Type of chair/seat	Frequency different types of chairs are used				
	All the time	Frequently	Occasion-ally	Very rarely	Never
A dining chair*	0 (0%)	2 (6%)	5 (16%)	15 (48%)	4 (13%)
An office chair*	0 (0%)	1 (3%)	6 (19%)	16 (52%)	3 (10%)
A car seat**	6 (19%)	23 (74%)	0 (0%)	0 (0%)	0 (0%)
An arm chair**	1 (3%)	11 (35%)	15 (48%)	2 (6%)	0 (0%)
A sofa**	1 (3%)	11 (35%)	17 (55%)	0 (0%)	0 (0%)

* 5 missing; ** 2 missing **(see Q2.1)**

Table O-79 Other types of chairs/seats used by clients

Other chairs/seats	Groups			
	All respondents (n=31)*	Physios (n=7)	OT's (n=6)	Nurses (n=1)
Aeroplane	7 (23%)	4	3	
Shower chair	5 (16%)	3	1	1
Sports chair	3 (10%)	3		
Chair lift	2 (6%)	1	1	
Minibus/coach seat	2 (6%)	2		
Sun lounger	2 (6%)	2		
Toilet	2 (6%)		2	
Bath	1 (3%)	1		
Bean bag	1 (3%)	1		
Chaise longue	1 (3%)	1		
Glider seat	1 (3%)	1		
Handbike	1 (3%)	1		
Sailing boat	1 (3%)	1		
Train seat	1 (3%)	1		

* 17 missing, 14 respondents reported other types of chairs/seats. Some of the respondents reported more than one type of chair/seat **(see Q2.1)**

Table O-80 Respondents who have found that their clients only use their cushion when in their wheelchair

Groups	Use their cushion only when in their wheelchair	
	Yes	No
All respondents (n=31)*	12 (39%)	18 (58%)
Physios (n=17)*	7	9
OT's (n=10)	3	7
Nurses (n=4)	2	2

* 1 missing **(see Q2.3)**

Table O-81 Occasions, other than when in their wheelchairs, clients use their pressure relief cushion

Other occasions	Groups			
	All respondents (n=31)*	Physios (n=9)	OT's (n=7)	Nurses (n=2)
Car	13 (42%)	6	6	1
Aeroplane	12 (39%)	7	3	2
Sat on floor/ground	5 (16%)	3	1	1
Sailing	3 (10%)	2	1	
Sofa/settee	3 (10%)		2	1
Bath	2 (6%)	2		
Handbikes	2 (6%)	2		
Armchair	1 (3%)			1
Cinema seat	1 (3%)			1
Deck chair	1 (3%)	1		
Restaurant chair	1 (3%)			1
Sports chair	1 (3%)	1		

* All 18 respondents who reported that their clients use their cushions outside of their wheelchairs provided examples of occasions when their clients use their cushion. Some of the respondents reported more than one occasion **(see Q2.3)**

Table O-82 The frequency patients use a particular form of pressure relief when sat in a chair other than their wheelchair (n=31)

PR measure (description as used in questionnaire)	Frequency RP measure is used					
	All the time	Frequently	Occasion-ally	Very rarely	Never	Don't know
"*The pressure relief cushion they normally use in their wheelchair*"*	0 (0%)	5 (16%)	14 (45%)	7 (23%)	1 (3%)	1 (3%)
"*A second pressure relief cushion, which is the same type of cushion as the one used in their wheelchair*"*	0 (0%)	2 (6%)	10 (32%)	10 (32%)	5 (16%)	1 (3%)
"*A second pressure relief cushion, but a different type of cushion as the one used in their wheelchair*"**	0 (0%)	0 (0%)	7 (23%)	15 (48%)	6 (19%)	1 (3%)
"*The chair's own ordinary padding/ cushioning*"***	5 (16%)	16 (52%)	7 (23%)	0 (0%)	1 (3%)	1 (3%)
"*The chair 's own built in pressure relieving features*"**	3 (10%)	10 (32%)	8 (26%)	6 (19%)	1 (3%)	1 (3%)
"*A piece of cut foam*"**	0 (0%)	2 (6%)	7 (23%)	14 (45%)	5 (16%)	1 (3%)
"*An ordinary cushion*"**	0 (0%)	0 (0%)	9 (29%)	16 (52%)	3 (10%)	1 (3%)
"*An ordinary pillow*"**	0 (0%)	0 (0%)	6 (19%)	17 (55%)	5 (16%)	1 (3%)
"*A sheepskin*"***	0 (0%)	4 (13%)	11 (35%)	11 (35%)	1 (3%)	1 (3%)

* 3 missing; ** 2 missing; *** 1 missing **(see Q2.2)**

Table O-83 Other forms of pressure relief

Other forms of pressure relief	Groups			
	All respondents (n=31)*	Physios (n=4)	OT's (n=0)	Nurses (n=0)
Inflatable cushions	1 (3%)	1		
Rubber ring	1 (3%)	1		
The motion of the vehicle when in a car	1 (3%)	1		
Gel pad removed form a Jay cushion	1 (3%)	1		

* 27 missing, 4 respondents reported other reasons. Some of the respondents reported more than one reason **(see Q2.2)**

O.4.3 Pressure Relieving whilst Sat in a Wheelchair

Table O-84 How beneficial the respondents regard pressure relieving routines to be in preventing pressure ulcers (n=31)

Groups	Degree of benefit				
	Very beneficial	Beneficial	Of some benefit	Of little benefit	Of no benefit
All respondents (n=31)	21 (68%)	6 (19%)	4 (13%)	0 (0%)	0 (0%)
Physios (n=17)	10	5	2	0	0
OT's (n=10)	7	1	2	0	0
Nurses (n=4)	4	0	0	0	0

(see Q2.8)

Table O-85 How frequently patients make certain movements to relieve pressure (n=31)

Type of movement	Frequency certain movements are made to relieve pressure				
	All the time	Frequently	Occasion-ally	Very rarely	Never
Leaning forward	7 (23%)	20 (65%)	2 (6%)	2 (6%)	0 (0%)
Leaning to their right	5 (16%)	17 (55%)	8 (26%)	1 (3%)	0 (0%)
Leaning to their left	5 (16%)	17 (55%)	8 (26%)	1 (3%)	0 (0%)
Tilting backwards	6 (19%)	12 (39%)	11 (35%)	2 (6%)	0 (0%)
Raising themselves up	3 (10%)	14 (45%)	5 (16%)	8 (26%)	1 (3%)

(see Q2.5)

Table O-86 Other movements made to relieve pressure

Other movements made to relieve pressure	Groups			
	All respondents (n=31)*	Physios (n=5)	OT's (n=5)	Nurses (n=0)
Advise not to lift/raise up (damaging to shoulders)	3 (10%)	2	1	
Incomplete injuries may stand up	2 (6%)		2	
Lying down	2 (6%)	1	1	
Fidgeting	1 (3%)	1		
Hooking arm around pushing handle and rotating to the side	1 (3%)		1	
Keeping active	1 (3%)		1	
Pushing down through legs	1 (3%)	1		
Standing (use standing frames/chairs)	1 (3%)	1		

* 21 missing, 10 respondents reported other movements. Some of the respondents reported more than one movement.

(see Q2.5)

Table O-87 Most commonly used pressure relief routine timings followed by clients

Sets of timings	Groups			
	All respondents (n=31)*	Physios (n=17)	OT's (n=10)*	Nurses (n=4)
2 mins every hour	9 (29%)	4	3	2
Depends on individual	5 (16%)	2	3	
15-30 secs every 15 mins	3 (10%)	2	1	
60-90 secs every 30 mins	3 (10%)	3		
1-2 mins every hour	3 (10%)	2		1
30 secs every 15 mins	2 (6%)	1	1	
20 secs every 20 mins	2 (6%)	1		1
10 secs every 15 mins	1 (3%)	1		
10 secs every 30 mins	1 (3%)	1		
30 secs every 30 mins	1 (3%)		1	

* 1 missing **(see Q2.6)**

Table O-88 The frequency with which patients, on an average day, manage to comply with their pressure routine (n=31)

Groups	Frequency pressure relief routines are complied with				
	All the time (do every one)	Frequently (do most)	Occasionally (miss out about half)	Very rarely (miss most)	Don't know
All respondents (n=31)	0 (0%)	18 (58%)	9 (29%)	3 (10%)	1 (3%)
Physios (n=17)	0	10	4	2	1
OT's (n=10)	0	6	3	1	0
Nurses (n=4)	0	2	2	0	0

(see Q2.7)

O.4.4 Transferring into and out of Wheelchairs

Table O-89 Respondents who have observed clients experiencing difficulties when transferring into and out of their wheelchair

Groups	Experience difficulty	
	Yes	No
All respondents (n=31)	31 (100%)	0
Physios (n=17)	17	0
OT's (n=10)	10	0
Nurses (n=4)	4	0

(see Q2.4)

Table O-90 The most difficult cushion to transfer from

Pressure relief cushion	Groups			
	All respondents (n=31)*	Physios (n=15)	OT's (n=9)	Nurses (n=4)
ROHO	26 (84%)	13	9	4
Jay 2	7 (23%)	5	2	0
Flotech	2 (6%)	1	1	0
Vicair	2 (6%)	2	0	0
Varilite	1 (3%)	1	0	0

* 3 missing, 28 respondents reported which cushion they consider to be the most difficult to transfer from. Some of the respondents listed more than one cushion **(see Q2.4a)**

Table O-91 Aspect of cushion which is a cause of difficulty when transferring

Aspect of cushion	Groups			
	All respondents (n=31)*	Physios (n=16)	OT's (n=8)	Nurses (n=4)
Unstable surface/ difficult to balance on	15 (48%)	9	4	2
Lacks firm surface, hands bottom out when pushing down	7 (23%)	1	5	1
High contours/deep seat well	5 (16%)	3	1	1
Difficult to slide bottom forward	4 (13%)	2	1	1
Cushion tendency to move around when transferring	4 (13%)	1	2	1
Depends on individual	3 (10%)	3		
Depends on postural correction add-ons	2 (6%)	2		
Cushion too high in chair	2 (6%)	2		
Poor cover, too "*sticky*"	1 (3%)	1		
Folds in two when pressed down	1 (3%)	1		
Difficult to position sliding board	1 (3%)	1		

* 3 missing, 28 respondents reported an aspect of a cushion which causes their clients difficulties when transferring. Some of the respondents listed more than one aspect **(see Q2.4a)**

Table O-92 The easiest cushion to transfer from

Pressure relief cushion	Groups			
	All respondents (n=31)*	Physios (n=11)	OT's (n=6)	Nurses (n=4)
Jay 2	9 (29%)	4	2	3
Foam	5 (16%)	4	1	0
Varilite	4 (13%)	3	1	0
Vicair	2 (6%)	0	1	1
Strathclyde	1 (3%)	0	1	0

* 10 missing, 21 respondents reported which cushion they consider to be the easiest to transfer from **(see Q2.4b)**

Table O-93 Aspect of cushion which makes transferring easier

Aspect of cushion	Groups			
	All respondents (n=31)*	Physios (n=16)	OT's (n=9)	Nurses (n=3)
No contouring/ flat surface	10 (32%)	6	4	
Firm base/ stable	10 (32%)	3	4	3
Dependent on individual	5 (16%)	3	2	
Cushion securely fixed	3 (10%)	1	1	1
Smooth surface	2 (6%)	2		
Free of postural add-ons, wedges	1 (3%)		1	
Cushion low in height	1 (3%)		1	

* 3 missing, 28 respondents reported an aspect of a cushion which makes transferring easier for their clients. Some of the respondents listed more than one aspect **(see Q2.4b)**

O.4.5 Use of Covers

Table O-94 How important the respondents regard certain tasks a cushion cover might fulfil (n=31)

Tasks a cover might fulfil (description as used in questionnaire)	How important a task is considered				
	Very important	Of some importance	Important	Of little importance	Of no importance
"*It protects the cushion*"	12 (39%)	9 (29%)	9 (29%)	1 (3%)	0 (0%)
"*It draws moisture from the patient*"*	11 (35%)	6 (19%)	12 (39%)	1 (3%)	0 (0%)
"*It helps to reduce the production of sweat*"*	12 (39%)	7 (23%)	10 (32%)	1 (3%)	0 (0%)
"*It helps to keep the cushion clean*"	9 (29%)	11 (35%)	9 (29%)	2 (6%)	0 (0%)
"*It hides an ugly cushion*"*	1 (3%)	5 (16%)	12 (39%)	7 (23%)	5 (16%)
"*It can compliment the patient's clothing*"**	0 (0%)	5 (16%)	4 (13%)	9 (29%)	11 (35%)

* 1 missing; ** 2 missing

(see Q5.19)

Table O-95 Additional reasons for using a cover

Additional reasons for using a cover	Groups			
	All respondents (n=31)*	Physios (n=4)	OT's (n=2)	Nurses (n=0)
A carrying handle on the cover helps with moving the cushion eg in/out of car	1 (3%)	1		
It helps provide comfort	1 (3%)	1		
Most clients want dark coloured covers for discretion	1 (3%)		1	
To help control the temperature	1 (3%)	1		
To help "*stabilise the cushion to wheelchair*"	1 (3%)	1		
To help their clients to slide over the cushion when transferring	1 (3%)	1		
To prevent the client from sticking to the cushion preventing friction and shear forces.	1 (3%)		1	
To stop the client from sliding	1 (3%)	1		

* 25 missing, 6 respondents reported additional reasons for using a cover. Some of the respondents provided more than one reason

(see Q5.19)

Table O-96 How frequently the respondents observe their clients using certain types of cushion covers (n=31)

Type of Cover (description as used in questionnaire)	Frequency certain covers are observed in use				
	All the time	Frequently	Occasion-ally	Very rarely	Never
"*Nothing, the cushion is left uncovered*"	2 (6%)	15 (48%)	11 (35%)	3 (10%)	0 (0%)
"*The cover that comes with the cushion*"	11 (35%)	18 (58%)	1 (3%)	0 (0%)	1 (3%)
"*A blanket to wrap around the cushion*"*	0 (0%)	1 (3%)	2 (6%)	10 (32%)	16 (52%)
"*A cotton sheet to wrap around the cushion*"	0 (0%)	3 (10%)	5 (16%)	9 (29%)	14 (45%)
"*An ordinary pillow case*"	0 (0%)	6 (19%)	10 (32%)	12 (39%)	3 (10%)
"*A homemade cover*"**	0 (0%)	2 (6%)	8 (26%)	14 (45%)	6 (19%)
"*A cover from another cushion which has been altered cover to fit this cushion*"*	0 (0%)	2 (6%)	12 (39%)	11 (35%)	4 (13%)
"*A cover from another cushion which has **NOT** been altered cover to fit this cushion*"**	0 (0%)	3 (10%)	12 (39%)	9 (29%)	6 (19%)

* 2 missing; ** 1 missing **(see Q5.18)**

Table O-97 Other types of cover in use

Other types of cover	Groups			
	All respondents (n=31)*	Physios (n=2)	OT's (n=4)	Nurses (n=0)
Sheepskin	4 (13%)	2	2	
A "*designer*" leather cover made to match the chair	1 (3%)		1	
Towels	1 (3%)		1	
Incontinent pads	1 (3%)		1	

* 25 missing, 6 respondents reported other types of cover. Some of the respondents listed more than one type of cover **(see Q5.18)**

Table O-98 The number of respondents who agree changing cushion covers is easy

Changing cover is easy	Level of agreement with statements				
	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
All respondents (n=31)*	4 (13%)	12 (39%)	10 (32%)	3 (10%)	1 (3%)
Physios (n=17)	2	9	4	2	0
OT's (n=10)*	1	2	5	1	0
Nurses (n=4)	1	1	1	0	1

* 1 missing **(see Q5.20)**

Table O-99 The number of respondents who agree that the effort involved in changing a cover is such that the cover is not changed as often as it should

Changing cover performed as often as should be	Level of agreement with statements				
	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
All respondents (n=31)*	0 (0%)	5 (16%)	11 (35%)	11 (35%)	3 (10%)
Physios (n=17)	0	2	6	7	2
OT's (n=10)	0	1	5	2	1
Nurses (n=4)	0	2	0	2	0

* 1 missing

(see Q5.20)

Table O-100 How respondents find certain aspects of changing cushion covers (n=31)

Aspect of changing cover (description as used in questionnaire)	Level of agreement with statements				
	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
*"The cushion is bulky, so it is difficult to insert into the cover"**	1 (3%)	13 (42%)	8 (26%)	7 (23%)	1 (3%)
"*The next cover is not ready to be put on as it is away being cleaned or repaired*"**	2 (6%)	9 (29%)	14 (45%)	3 (10%)	1 (3%)
"*The cover opening fastenings (zipper, buttons, press studs) are difficult*"*	0 (0%)	11 (35%)	8 (26%)	10 (32%)	1 (3%)
"*To fit the cover the cushion has to be removed from the wheelchair*"*	14 (45%)	13 (42%)	2 (6%)	1 (3%)	0 (0%)
"*The cover is difficult to adjust so that the surface is not wrinkled/creased*"**	0 (0%)	3 (10%)	10 (32%)	15 (48%)	1 (3%)

* 1 missing; ** 2 missing

(see Q5.20)

Table O-101 Additional difficulties involved with changing a cushion cover

Additional difficulties involved with changing a cover	Groups			
	All respondents (n=31)*	Physios (n=4)	OT's (n=2)	Nurses (n=0)
The hand function of the patient may not be sufficient for this task	2 (6%)		2	
It can be difficult getting the cover on the right way around	1 (3%)	1		
That there is no replacement available when needed	1 (3%)	1		
The covers when washed are not dry when needed	1 (3%)	1		
They "*shrink after being dry cleaned by well meaning people!!*"	1 (3%)	1		

* 25 missing, 6 respondents provided additional difficulties involved with changing a cover

(see Q5.20)

Table O-102 How frequently the respondents have observed the following aspects of a cushion cover contribute to the development of a pressure ulcer (n=31)

Aspects of a cover (description as used in questionnaire)	Frequency a certain aspect might lead to a pressure ulcer				
	All the time	Frequently	Occasion-ally	Very rarely	Never
"*The cover becomes wrinkled or creased*"*	0 (0%)	5 (16%)	15 (48%)	6 (19%)	3 (10%)
"*The texture of the cover material is too rough*"**	0 (0%)	0 (0%)	5 (16%)	14 (45%)	11 (35%)
"*The weave, or cloth pattern, of the cover is too pronounced*"**	0 (0%)	0 (0%)	3 (10%)	16 (52%)	11 (35%)
"*The cover material holds too much moisture*"**	0 (0%)	0 (0%)	10 (32%)	14 (45%)	6 (19%)
"*The cover is stretched too tight across the cushion affecting the cushions ability to disperse the weight of the body*"**	0 (0%)	1 (3%)	15 (48%)	10 (32%)	4 (13%)

* 2 missing; ** 1 missing

(see Q5.21)

Table O-103 Additional ways in which a cover might cause a pressure ulcer

Additional ways in which a cover might cause a pressure ulcer	Groups			
	All respondents (n=31)*	Physios (n=2)	OT's (n=3)	Nurses (n=0)
Cover being the wrong size for the cushion	3 (10%)	1	2	
When a cover is not kept clean food or other substances harden on the cover and this in turn can lead to a pressure ulcer	1 (3%)		1	
A cover might be "*too slidy – causing shearing*"	1 (3%)		1	

* 26 missing, 5 respondents provided additional ways in which a cover might cause a pressure ulcer. Some of the respondents provided more than one way

(see Q5.21)

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