School of Nursing and Midwifery

Determining the Effectiveness of Inelastic Short Stretch Bandages in Sustaining Sub-bandage Graduated Compression

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DECLARATION

I declare that this assignment is my own work and has not been submitted in any form for another unit, degree or diploma at any university or other institute of tertiary education. Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references is given. I warrant that any disks and/or computer files submitted as part of this assignment have been checked for viruses and reported clean.

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Abstract

The aim of this study was to determine whether sub-bandage graduated compression of 30-40mmHg at the ankle was sustained and comfortable when wearing inelastic short stretch bandage systems over a 72 hour bandage wear time period.

Thirty two healthy participants were used to determine the compression levels achieved by wearing a three layer inelastic compression bandage system on one leg as compared to a four layer inelastic compression bandage system on the other leg. An experienced bandager applied all bandage systems to all participants. Sub-bandage measurements were taken at spaced intervals at the ankle and the calf over the 3 day bandage wear time period by means of a non-invasive portable pneumatic monitor worn under the bandage systems. In addition, participants recorded their level of comfort against specific activities of daily living using a linear 10 point scale over the 3 days.

On application, the three layer bandage system obtained a mean ankle sub-bandage pressure of 48.12mmHg on standing which reduced to 28.75mmHg at 72 hour wear time. A mean standing ankle sub-bandage pressure of 65.74mmHg was recorded on application for the four layer bandage system, which reduced to 35.03mmHg after 72 hour bandage wear time. The compression bandages caused discomfort for the participants throughout the day, both when resting/sleeping as well as during periods of mobility.

Participants also reported difficulties in finding shoes to accommodate the compression bandage systems.

On the basis of this study's results it is recommended that a three layer bandage system should be changed at least every 48 hours and a four layer bandage system should be changed at least every 72 hours to maintain optimal sub-bandage ankle pressures of 30-40mmHg. The results also highlighted the need for an assessment tool that can be used in clinical practice to evaluate the effects that treatment interventions have on the quality of life of patients.

Contents

List of Tables

Page

List of Figures

Page

Chapter 1

Introduction

Chronic venous leg ulcers are a major cause of morbidity, health care costs and decreased quality of life. Chronic venous leg ulcers are estimated to affect 1.1/1000 of the Western Australian population (Stacey & Barker, 1990) and these findings are comparable with other international studies (Callam, 1992; Margolis, Bilker, Santanna & Baumgarten, 2002). Venous leg ulcers account for 80-90% of all chronic wounds (Shai & Halevy, 2005) at an estimated cost in Australia of $500 million per annum (Gruen, Chang & MacLellan, 1996). Reported recurrence rates are between 48% (McDaniel et al, 2002) and 68% (Finlayson, Edwards & Courtney, 2008), which reflects the true chronicity of these wounds.

Graduated compression is broadly referred to as the ‘gold standard’ in the management and prevention of venous leg ulcers (Morison & Moffatt, 1994; Stacey et al., 2002). The degree of compression generally considered necessary is 30-40mmHg at the ankle and reducing by 50% just below the knee (Sieggreen & Kline, 2004). A systematic review by Cullum, Nelson, Fletcher and Sheldon (2001) concluded that compression treatment increases the healing of venous leg ulcers compared with no compression and higher compression is more effective than low compression.

Despite these generally accepted recommendations for clinical practice there are very few studies in the literature that have examined the sub-bandage pressures achieved and maintained over time with compression bandaging. The testing of sub-bandage pressures achieved with compression bandages has commonly been conducted by applying bandages to static models such as cylinders and cones (Melhuish, Clark, Harding & Williams, 2005; Ruckley, Dale, Brown, Gibson, Lee & Prescott, 2003). The relationship between sustained sub-bandage pressure and venous leg ulcer healing appears in many instances to be based on assumptions rather than having been empirically established. If the concept of graduated compression bandaging of 30-40mmHg is considered therapeutic treatment for venous leg ulcer management, then it is fundamental for the implementation of best practice to determine the sub-bandage pressures achieved with different bandage systems used in clinical practice. Of equal importance is the need to determine whether they consistently obtain and sustain the recommended pressures for the duration of bandage wear time.

The bandage systems used in the treatment of venous leg ulcers need to be well tolerated and impose the least negative impact on the quality of life of individuals, as this will encourage adherence to treatment regimes. There have been several published studies on the impact that leg ulcers have on quality of life (Hammer, Cullum & Roe,1994; Hareendan, Bradbury, Budd, Geroulakos, Hobbs, Kenkre & Symonds, 2005). In addition, there have emerged questionnaires that focus on the attributes of health associated quality of life problems specific to chronic leg ulceration (Lamping, Schroter, Kurz, Kahn & Abenhaim, 2003; Price & Harding, 2000). However, there were found to be no studies that specifically assessed the effect compression bandages have on individual’s participation in activities of daily living. Such findings are of particular importance as such knowledge can guide clinical decision making in the selection of compression bandages, especially when there is very little difference in terms of sustained sub-bandage pressures and hence potential healing rates (Palfreyman, Nelson, Lochiel & Michaels, 2006).

Background

Silver Chain is the largest domiciliary nursing service in Western Australia and wound management contributes to a substantial component of nursing time. Prevalence studies in Silver Chain have shown that chronic venous leg ulcers contribute to 50% of all wounds managed by nurses (Carville, 2000; Carville & Smith, 2004). Clinical protocols and procedures within Silver Chain define the assessment criteria required for patients with lower leg wounds. Compression therapy guidelines outline the types of compression bandages that can be used in accordance with the patient's clinical assessment findings and their ankle/brachial pressure index.

Inelastic short stretch bandages have been favoured in Western Australia community practice because of safety and comfort elements reported to be associated with these bandages in terms of them exerting high working pressures and low resting pressures (Krasner, Rodeheaver & Sibbald, 2007). Manufacturers' information sheets recommend that inelastic short stretch bandages should be changed daily and applied singularly over a protective padding bandage when using the continuous spiral method of application (BSN Medical, n.d.). These manufacturers' guidelines have been modified in clinical practice to establish the three layer inelastic bandage system. In this system, the first contact bandage layer is a protective padding bandage which is applied from the base of the toes to below the knee and serves to absorb exudate and cushion bony prominences, which are subject to higher levels of pressure. The padding layer is then covered with an inelastic short stretch bandage. The inelastic bandage is applied from the base of the toes and around the foot twice then a single figure of 8 around the ankle and heel to anchor the bandage, before continuing up the leg in a spiral at 90-100% tension and with 50% overlap of the preceding layer to two finger widths below the popiteal fossa. The third layer is a straight retention tubular elasticated bandage which assists to hold the bandage system in place.

In Western Australia the practice of applying two inelastic short stretch bandages evolved some 20 years ago and is still widely practiced today. The first contact protective padding bandage is then covered with an inelastic short stretch bandage as outlined above for the three layer bandage system. The third layer is the second inelastic short stretch bandage which is applied over the first inelastic bandage with 90-100% tension in a continuous spiral with 50% overlap of the preceding layer from base of the toes to two finger widths below the posterior knee. The fourth layer is a straight retention tubular elasticated bandage applied over the length of the compression bandages. Both the three layer and four layer inelastic bandage systems are generally applied third daily subject to wound exudate levels and the degree of oedema. Despite these methods having been accepted practice in Western Australia for venous leg ulcer management for 20 years there have been no studies conducted that have investigated the sustainability of sub-bandage pressures in active individuals who wear either bandage system.

In vivo studies have found single inelastic bandages applied using the spiral method of application produced similar pressures and gradients when compared to two inelastic bandages applied using the Putter method of application (which follows the natural curvature of the lower leg).These studies, reported gaiter pressures below 40mmHg but rising as high as 75mmHg on standing (Lee, Dale, Ruckley, Gibson, Prescott & Brown, 2006). Higher pressures on standing were also reported by Partsch (2005) in regard to application of double layer inelastic short stretch bandages. He reported resting pressures of 60mmHg at the ankle and rising to as high as 88mmHg on standing. However, neither of these studies reported on sub-bandage pressure over time and subsequent to activities of daily living. Furthermore, inelastic short stretch bandage pressures have been shown to decline by 56% at the ankle when resting pressures were measured and 59% at the ankle when working pressures were tested after 3 hours of application (Larsen & Futtrup, 2004). Although, these pressure measurements were taken using the Kikhume® monitor which is not designed to measure pressures in the dynamic leg over time.

As the application of graduated compression bandaging of 30-40mmHg is considered ‘gold standard’ in the treatment of venous leg ulcers (Moffatt & Harper, 1997; Stacey et al., 2002) it would appear necessary that we understand what sub-bandage pressures are achieved at application and over time when worn during normal daily activity. Of equal importance is an understanding of factors that influence compression bandage tolerance.

Project Aim

The aim of this study was to determine whether sub-bandage graduated compression was sustained and comfortable when wearing inelastic short stretch bandages applied using the spiral method.

Objectives

The specific objectives of the study were to:

- Determine the sub-bandage pressure readings obtained over 72 hours when a single inelastic short stretch compression bandage was applied to a padded lower limb using the spiral method of application as part of a three layer bandage system.
- Determine the sub-bandage pressure readings obtained over 72 hours when two inelastic short stretch compression bandages were applied to a padded lower limb using the spiral method of application as part of a four layer bandage system.
- Compare the sub-bandage pressure readings of the three layer bandage system to the four layer bandage system over 72 hours bandage wear time.
- Evaluate the daily comfort levels and bandage integrity associated with wearing inelastic short stretch bandages as part of the three layer bandage system as compared to the four layer bandage system over a 72 hour period.

Significance of the Project

Silver Chain nurses working in the metropolitan area treat approximately 500 clients at any given time for venous leg ulcers. Inelastic short stretch bandage systems have been widely favoured in community practice for the treatment of venous leg ulcers yet to date there have been no previous studies that have compared the sub-bandage pressures obtained or sustained in the three and four layer inelastic short stretch compression bandaging systems. Nor have there been any studies that have measured the comfort levels of clients' associated with the wearing of these bandage systems over time and during activities of daily living. It is anticipated that the study will inform best practice in the nursing management of venous leg ulcers in the community and will lead to improved clinical outcomes for a large number of clients.

Chapter 2

Literature Review

Introduction

An extensive literature review was conducted using the key words: leg ulcers, venous leg ulcers, chronic venous insufficiency, compression bandages, compression therapy, inelastic short stretch bandages, sub-bandage pressure, and treatment of venous leg ulcers, quality of life and activities of daily living. Electronic sources included CINAHL, Ovid, InterNurse, Science Direct, Proquest, Pubmed and Cochrane Library (2000-2010). A hand search of reports, journals and relevant text books was also completed.

Epidemiology of Venous Leg Ulcers

In Australia, chronic leg ulcers affect 0.6-3% of those aged over 60 years, increasing to over 5% of those aged greater than 80 years (Adam, Naik, Hartshorne, Bello & London, 2003) at an estimated cost of $500 million per annum (Gruen et al., 1996). The number of elderly Australians with leg ulcers is estimated to double over the next 19 years (Australian National Institute, 2005). In Western Australia, leg ulcers were found to be 1.1 per 1000 population (0.11% point prevalence) (Baker & Stacey, 1994) and leg ulcer patients reported an average ulcer duration of 12 months (Adam et al, 2003; Stacey & Baker, 1994), 60-70% have recurrent ulcers (Adam et al, 2003), 24% are hospitalised with ulcers, most suffer the condition for 15 years or more and 45%

of patients were housebound (Baker, Stacey, Singh, Hoskins & Thompson, 1992) and reliant on community wound care services.

The Australian data is comparable to other international studies. Margolis et al. (2002) reported an annual prevalence of venous leg ulcers at 1.69% in people aged between 65 and 95 years. Venous leg ulcers account for 80-90% of all chronic wounds (Shai & Halevy, 2005) with treatment costs estimated at 1% to 2% of the total annual health care budget (Ruckley, 1997).

Venous leg ulcers are reported to be more prevalent in women than men (Callam, 1992) although, with increasing age, this ratio begins to equalize (Margolis et al., 2002; Reichenberg & Davis, 2005). Venous leg ulcers occur more commonly in the elderly, the peak prevalence occurring between ages 60 and 80 years (Callum et al., 1985; Parquette & Falanga, 2002). However, 72% of persons have their first leg ulcer by the age of 60 years. Twenty-two percent of people have their first ulcer by 40 years and 13% before 30 years (Valencia, Falabella, Kirsner & Eaglstein, 2001).

Advancing age, history of deep vein thrombosis, valvular incompetence, trauma to the legs, family history of leg ulcers, obesity, occupations involving prolonged standing, and multiple pregnancies are risk factors that have been associated with chronic venous insufficiency (Chuckwuemeka, Etufugh, & Phillips, 2007; Moffat, Martin & Smithdale, 2007; Reichenburg & Davis, 2005). Another factor that has been reported is exogenous hormone use (Beebe-Dimer et al., 2005) however further research is needed before a definitive relationship can be identified.

Reported healing rates whilst using compression therapy vary between 30%-60% at 24 weeks and with up to 12 months therapy the rates range between 70%-85%. However, a subset of patients (up to 20%), have ulcers for more than 5 years (Price & Harding, 1996). According to Margolis, Berlin and Strom (2000) successful healing within 24 weeks using compression therapy is more likely to occur amongst individuals whose leg ulcers measure less than $5cm^2$ and are less than 6 months duration. Recurrence rates between 48% (McDaniel et al., 2002) and 68% (Finlayson et al., 2000) have been reported. Prolonged ulcer duration (Barwell, Ghauri, Taylor, Deacon, Wakely, Poskitt & Whyman, 2000), the presence of deep venous ulcer disease (McDaniel et al., 2002) and duration of venous disease (Nelson, Harper, Prescott, Gibson, Brown & Ruckley, 2006) have been identified as risk factors for leg recurrence.

Structure and Function of the Venous System

The venous system of the lower extremities consists of three major components; deep veins, superficial veins and perforator veins. The deep system includes the posterior and anterior tibial and the peroneal veins, which are located in the deep tissue adjacent to the calf muscle. The superficial venous system consists of the greater saphenous vein (which originates in the medial malleolus region, and empties into the deep vein in the thigh) and the lesser saphenous vein (which runs from the lateral malleolus and empties into the deep vein at the knee). These two vessels lie outside the muscle just below the superficial fascia, with multiple tributaries located within the superficial tissues. The perforator veins are located at frequent intervals along the length of the veins. They pass through the fascia and muscle layers and connect the two systems, transporting blood from the superficial system into the deep system, from which point the blood is forced back to the heart ready for re-oxygenation via the lungs and filtration through the kidneys (Doughty & Holbrook, 2007; Valencia et al., 2001).

One-way valves are located within each of the perforator veins and at various intervals along the deep and superficial veins to support the unidirectional flow of blood toward the heart. These valves in the perforator veins prevent reflux of blood from the high pressure deep system to the low pressure superficial system and therefore play an essential role in normal venous function (Doughty & Holbrook, 2007; Moffatt et al., 2007).

Two important factors that facilitate venous return from the leg are the calf and foot muscle pumps. The foot pump (contraction of the plantar muscles during movement) squeezes and empties the veins in the foot. During ambulation, the calf muscles (gastrocnemius and soleus muscles) contracts, compressing the deep vein and forcing blood toward the heart. When an individual is standing upright, the gravitational force creates a column of hydrostatic pressure that is equal to the weight of the column of blood from the foot to the right side of the heart, and is around 80-100mmHg (Partsch, 2003). Upon ambulation the calf contracts, the deep veins are compressed and pressure rises transiently in the deep system to around 120-300mmHg (Doughty & Holbrook, 2007), propelling blood in the direction of the heart. The valves in the superficial, deep and perforator veins close when the pressure rises in the deep system, preventing retrograde flow and transmission of high pressure to the superficial system. As the calf muscles relaxes, the deep veins empty causing the pressure within to drop to 10-20mmHg which is below that of the superficial veins. The venous valves then open, and the resulting pressure gradient, draws blood from the superficial veins into the deep veins, via the perforators (Chukwuemeka et al., 2007; Moffatt et al., 2007; Valencia et al., 2001).

Pathophysiology of Venous Disease

In the diseased venous system or if there is impaired calf muscle pump function, venous pressure in the deep system upon ambulation may either fall minimally or not at all. This sustained ambulatory pressure is termed ambulatory hypertension. The pathophysiological mechanisms that occur include dysfunction of the valves in the superficial and/or perforator veins, dysfunction of valves in the deep system, deep venous outflow obstruction and calf muscle pump dysfunction (Valencia et al., 2001).

Loss of valvular competence in the superficial veins causes significant reflux in the superficial venous system and impairment of venous return will lead to accumulation of blood in the veins causing them to become distended, resulting in the formation of varicosities. If the function of the perforator valves is impaired, the action of the calf muscle pump will tend to cause blood to flow in the reverse direction into the superficial system increasing the possibility of damage to the superficial vessels (Doughty & Holbrook, 2007; Thomas, 1998). Similarly, if the valves in the deep system become incompetent due to primary degeneration or the results of deep vein thrombosis, blood will oscillate up and down those segments because of lack of functional valves. The resulting retrograde flow in the veins leads to reflux of blood from the deep system into the superficial system and a reduced fall in venous pressure during ambulation (Partsch, 2003).

Venous outflow obstruction may be the result of occluded or partially occluded veins subsequent to deep vein thrombosis or vein trauma. This often leads to valvular dysfunction and distension of the perforator veins because of unrelieved pressure produced by the calf pump. The pressure and blood flow is redirected to the superficial veins causing distension and dysfunction of these veins. If this occurs, there will be a large rise in the pressure in the superficial system, which may force proteins and red blood cells out of the capillaries and into the surrounding tissue (Thomas, 1998; Tran & Meissner, 2002).

Calf muscle pump dysfunction may be caused by an inability of the calf muscle to pump blood because of neuromuscular paralysis or trauma, an obstruction in the blood flow by deep or superficial vein thrombosis, an anatomical or pathological fistula between the arterial and venous system and prolonged back pressure on the valves (associated with pregnancy, obesity, pelvic tumours or prolonged standing). In the majority of cases, calf muscle pump dysfunction is caused by valve incompetence (Moffat et al., 2007). Regardless of the aetiology of the calf muscle pump dysfunction, without an efficient muscle contraction, the deep veins are incompletely emptied, resulting in high pressures and resistance to blood draining from the superficial veins. The resistance to flow creates congestion and distension of the superficial and perforator veins, valvular dysfunction and transmission of high pressures to the deep system (Doughty & Holbrook, 2007; Reichenburg & Davis, 2005).

Chronic venous hypertension causes pressure within the capillaries to rise above normal limits. Capillary walls are thin and not designed to withstand high pressures. The capillary pores are normally too small to allow large molecules and blood cells to pass into the surrounding tissue. A rise in capillary pressure causes them to swell, stretching their delicate walls, so increasing the size of the pores and forcing blood products and fluid to leak out into the surrounding tissue resulting in the formation of oedema (Moffatt et al., 2007; Partsch, 2003).

Pathophysiology of Venous Leg Ulcers

Browse and Burnand's (1982) fibrin cuff theory proposed that venous hypertension causes distension of capillary walls and widens capillary pores, with subsequent leakage of macromolecules such as fibrinogen into the dermis and subcutaneous tissue. The leaked fibrinogen then polymerises to form pericapillary fibrin cuffs into the extravascular space. It was proposed that these fibrin cuffs act as barriers and impede the exchange of nutrients and oxygen leading to ischaemia, cell death and ulceration. Neumann, Van den Broek, Brerma & Veraat (1996) dismissed this theory as they found that pericapillary cuffs were not a barrier to the diffusion of nutrients and oxygen. In addition, they found the cuffs are generally distributed in an irregular manner and that ulcers healed in the presence of these cuffs.

Coleridge-Smith, Thomas, Scurr and Dormandy (1988) introduced the white cell trapping theory and proposed that with venous hypertension, there is decreased pressure gradient between the arterial and venous system with resultant reduction in capillary bed perfusion pressure and capillary instability. This leads to erythrocyte aggregation and leukocyte plugging of capillaries resulting in local ischaemia. These leukocytes are thought to release mediators such as cytokines, proteolytic enzymes and free radicals which damage vascular structure and increase vascular permeability leading to leakage of macromolecules into the pericapillary tissues. In addition, these leukocytes release tumour necrosis factor α, which inhibits fibrinolytic activity, resulting in further deposition of fibrin into the capillaries.

Pardes, Tonneson, Falanga, Eagstein and Clark (1990) demonstrated that fibrinogen and fibrin can down regulate procollagen type I synthesis by dermal fibroblast cultures. It was hypothesised that the deposition of fibrin and fibrinogen in the intravascular space may inhibit the ability of the dermal fibroblasts to synthesis collagen and subsequently impair adequate repair of ulcerated tissue. In addition, individuals with venous disease have shown fibrinolytic and coagulation abnormalities (Falanga, 1993), which may be a contributing factor to the development of venous leg ulcers.

The growth factor trap theory initially proposed by Falanga and Eaglestein (1993) suggests that macromolecules such as fibrinogen and α-macroglobulin leak into the dermis and subcutaneous tissue in venous hypertension, trapping growth factors and other substances which are necessary for the maintenance of tissue repair and integrity. This theory was further supported by the fact that venous ulcers contain large quantities of growth factors; particularly transforming growth factor β, within pericapillary fibrin cuffs (Higley, Ksander, Gerhardt & Falanga, 1995) and fluid from venous ulcers were found to inhibit proliferation and growth of fibroblasts, keratinocytes and endothelial cells necessary for healing (Trengrove, Stacey, Macauley, Bennett, Burslem, Murphy & Schultz, 1999).

Kalra and Gloviczki (2003) suggest that venous ulceration may be caused by a combination of these theorised processes. They propose that red blood cells and fibrinogen breaks down in the dermis releasing chemoattractants for white blood cells. These activated white blood cells release inflammatory mediators and growth factors resulting in tissue inflammation and dermal fibrosis. The inflammatory and fibrotic changes in the tissues cause them to become more susceptible to ulceration.

Studies examining wound fluid and extracellular matrix in chronic, non-healing venous leg ulcers have shown significantly increased levels of matrix metalloproteinase (MMPs); enzymes which destroys extracellular matrix, and reduced levels of tissue inhibitors of MMPs (TIMPs) (Rayment, Upton & Shooter, 2008; Subramaniam, Pech & Stacey, 2008). It has been hypothesised that the imbalance between MMPs and TIMPs on extracellular matrix degradation results in a significant tissue remodelling (Raffetto & Khalil, 2008), degenerative and structural changes in the vein wall, leading to venous dilation and valve dysfunction and the progression to venous leg ulceration (Jacob, Badier-Commander, Fontaine, Benazzoug, Feidman & Michel, 2001; Raffetto & Khalil, 2008). The involvement of MMPs and TIMPs in venous leg ulceration is an area of continuous scientific interest, including the effect that MMP modulators may have in the management of venous disease (Lim, Shalhoub, Gohel, Shepherd & Davis, 2010).

Elevated iron (ferritin) levels and increased concentrations of metabolites from oxidative stress were observed in non-healing chronic leg ulcers (Yeoh-Ellerton & Stacey, 2003). It has been suggested that local iron overload may induce MMP hyper- activation (Herouy, Mellious & Banderir et al., 2001; Zamboni, Isso

& Tognazzo, 2006). However, the observed MMP activity and increased iron levels do not readily explain why only some individuals with chronic venous insufficiency get leg ulcers. It has therefore been hypothesised that such individual differences could be genetically determined (Wallace & Stacey, 2008; Zamboni et al., 2006).

Emerging theories and contemporary research findings propose that functional polymorphisms (those which alter the level of gene expression or protein function) in particular genes or genes involved in their regulation may be risk factors for the development of venous leg ulcers (Wallace & Stacey, 2008; Zamboni et al., 2006). This is an area of continual investigation.

Clinical Characteristics of Venous Leg Ulcers

Venous leg ulcers are characteristically located in the gaiter region (the area from mid calf to medial malleolus) of the lower leg. Trauma or infection may localise ulcers laterally or in more proximal locations. They may be single or multiple in numbers and the dimensions can range in size from small to very large areas involving the entire circumference of the lower leg. Generally, venous ulcers are irregularly shaped, shallow wounds with granulation tissue and fibrinous material and present with moderate to high serous exudate (Chukwuemeka et al., 2007; Doughty & Holbrook, 2007).

Commonly associated findings in the surrounding skin include: oedema, varicose veins (ranging from submalleolar venous flare to various degrees of vessel dilation), and reddish brown pigmentation changes and purpura due to extravasation of red blood cells and subsequent haemosiderin deposition. Individuals with venous leg ulcers often have eczematous changes which include redness, scaling and pruitus, which is commonly referred to as venous dermatitis (Chukwuemeka et al., 2007). Atrophie blanche lesions can be found in as many as one third of individuals and are smooth, ivory white atrophic plaques of sclerosis speckled with telangiectases. In longstanding venous disease lipodermatosclerosis may be present. Classical signs include induration and sclerosis of the dermis and subcutaneous tissue with a dramatic loss of subcutaneous tissue which sharply demarcates at the proximal leg, resulting in the appearance of an inverted bottle.

Compression Bandage Classification

The mechanism by which compression bandaging aids venous ulcer healing is not completely understood. It has been hypothesised that the application of external pressure to the calf raises the hydrostatic pressure, decreases the superficial venous pressure, and improves venous return leading to a reduction in the superficial venous hypertension (Valencia et al., 2001). The filtration – diffusion equilibrium is therefore restored, and the leakage of solutes and fluids in the interstitial space is reduced (Hafner, Luthi, Hanssle, Kammerlander & Burg, 2000; Ramelet, 2002). The application of external pressure also serves to compress the superficial veins, preventing excessive extension (Agu, Baker &

Seifalian, 2004; Ramelet, 2002). Because the cross sectional area of the vessel is reduced, the velocity of venous blood flow is increased (Agu et al., 2004; Partsch, 2003). These mechanisms result in decreased oedema, softening of lipodermatosclerosis, acceleration of venous flow back to the heart, decrease in venous volume, reduction in venous reflex, increase in arterial flow, improvement in microcirculation and improvement in lymph drainage (Odunca, Clark & Williams, 2004; Partsch, 2003).

Compression bandages are broadly classified as inelastic (short stretch) or elastic (long/high stretch). Inelastic compression bandages are manufactured from combinations of cotton, viscose and polyamide textile materials which are knitted rather than woven. The compression properties are attained through employing varying levels of twist through the structure of the yarns to obtain approximately 70% bandage extensibility (Milosavljevic & Skundric, 2007). Whereas elastic compression bandages are largely composed of knitted polyamide and polyurethane materials with varying percentages of elastane fibres in order to achieve either moderate extensibility (70-140%) or high extensibility (greater than140%) (Milosavljevic & Skundric, 2007; Thomas, 1998).

Inelastic compression achieves its effect by opposing the increase in muscle volume caused by a contraction (Ramelet et al., 2002). Because the muscle must contract, the greatest amount of pressure is supplied when the individual is active therefore the bandages have been demonstrated to cause high standing and working pressures and low resting pressures (Krasner, Rodeheaver & Sibbald, 2007). The pressure applied by inelastic bandages is able to reduce the diameter in the deep veins and occlude them intermittently while walking, thus preventing venous reflux and reducing ambulatory venous hypertension. They therefore have a significant haemodynamic effect on the reduction of oedema, of venous volume, reflux and ambulatory venous hypertension (Mosti & Mattalino, 2007).

Elastic compression utilizes a recoil force of the elastic fibres to provide compression during both exercise and rest, therefore they have high sustained working and resting pressures (Krasner, Rodeheaver & Sibbald, 2007). Although the working pressures are generally less than that provided by inelastic bandages, elastic bandages are thought to be able to maintain a constant interface pressure over a longer wear time (Ramelet et al., 2002). Because pressure is constantly being applied, this form of compression may not be well tolerated.

Until recently, compression bandage systems were further classified according to the number of layers of bandages within the system and the amount of external pressure they provide. A recent consensus document from the World Union of Wound Healing Societies (2008) has recommended that compression bandage systems should be described in terms of the components, rather than the layers within the system, as the application of all bandages involves some degree of overlap. Although the rationale proposed for the use of the term ‘component’ is appreciated, the author has selected to remain with the term ‘layer’ in this thesis as it is commonly recognised in Australia. Others recommend classifying bandages according to the sub-bandage pressures achieved when measured at the medial gaiter area with the patient supine and the elastic property of the overall compression system. Although individual parts of the compression bandage systems may be elastic, the interaction between different components may result in a system that behaves as if it is inelastic (Partsch et al., 2008).

A measurement called the ‘static stiffness index’ (SSI) has been proposed which is defined as the difference in sub-bandage pressures measured in the standing and supine positions (Partsch, 2005; Stolk, Wegen van der-Franken, Neumann, 2004) A pressure increase of greater than 10mmHg when the individual moves from supine to standing has been suggested to define inelasticity (high stiffness), and an increase of less than 10mmHg corresponds to elasticity (low stiffness). Where bandages are used as a single layer, they can be defined as ‘inelastic’ or ‘elastic’ (Mosti & Mattalino, 2007; Partsch et al., 2008). Other classification criteria ranks according to sub-bandage pressures achieved and uses terms such as mild (less than 20mmHg), moderate (20-40mmHg), strong (40-60mmHg) to very strong (greater than 60mmHg) (Partsch et al., 2008).

Graduated Compression

As identified earlier, compression bandages are classified according to the amount of external pressure they provide and their extensibility. The bandage's extensibility and the amount of pressure delivered are related to Laplace's law of physics. Laplace developed a formula that defined the relationship between the internal and external pressure of a vessel, the diameter of the vessel and the resulting tension produced in the vessel wall (Moffatt et al., 2007). Thomas (2003) modified Laplace's formula to include bandage width and the number of layers applied so that it can be used in clinical practice to calculate the sub-bandage pressures of compression bandage systems. The equation used to calculate sub-bandage pressure states that sub-bandage pressure is determined by the number of layers of bandages applied, multiplied by the tension by which the bandages are applied, multiplied by a constant, all divided by the circumference of the limb and multiplied by the bandage width.

$$\text{Sub-bandage pressure} = \frac{\text{(tension) (\# of layers) (constant)}}{\text{(circumference of limb) (bandage width)}}$$

Increasing any factor in the denominator of this equation (that is, circumference of limb or bandage width) will decrease the sub-bandage pressure. Similarly, by increasing any factor in the numerator (such as tension or number of bandage layers) will increase the sub-bandage pressure (Thomas, 2003).

The concept of graduated compression is also explained by Laplace's equation which states sub-bandage pressure is directly proportional to bandage tension but is inversely proportional to the radius of the curvature of the limb to which it is applied (Doughty & Holbrook, 2007). In other words, when a bandage is applied with constant tension (50% tension for elastic versus 90-100% tension for inelastic bandages) to a normal limb proportions from toes to knee with 50% overlap of the preceding layers this will produce a gradient of pressure, with the highest pressure at the narrower radius of the ankle than the wider radius of the calf (Carville, 2005; Moffatt & Harper, 1997).

An interface pressure between 30-40mmHg measured at the medial gaiter area with a diminishing gradient of 50% below the knee is generally considered to be a safe and optimal level of compression therapy for the treatment of venous leg ulcers. The support for this represents a compromise between pressures that have been shown to reduce venous diameter, thus increasing the flow velocity and pressures which an individual can tolerate (Lee et al., 2006; Mosti, Mattaliano & Partsch, 2008). As noted by Partsch (2003), pressures in excess of 30mmHg do not result in further increase in blood velocity in the large veins or the microcirculation when the individual is in the supine position, as at this pressure the vessels are maximally emptied and venous volume cannot be further reduced. However, in the upright standing position, the pressure in the lower leg fluctuates during walking, therefore higher levels of compression of 40-50mmHg are required. An interface pressure exceeding 60mmHg has been shown to produce an 84% decrease in blood flow (Hafner et al., 2000) which could be potentially dangerous particularly in those with a co-existing arterial insufficiency. In effect the ideal compression bandage system should therefore produce sub-bandage pressures of 20-30mmHg when the individual is in the resting supine position, increase to 40-50mmHg in the standing upright position without exceeding the 60mmHg.

It has been suggested that the clinical effect of compression bandaging is partly dependent on the skill of the bandager in achieving the correct amount of sub-bandage pressure and pressure gradient from toe to knee (Feben, 2003; Moffatt et al., 2007). It also seems that inexperienced nurses apply bandages at inappropriate and widely varying pressures (Stockport, Groarke, Greenhalgh & Davis, 1997). Unfortunately, without some means of performance feedback, many clinicians cannot precisely gauge the amount of pressure being applied. Hafner et al. (2000) demonstrated significant improvement in nurses bandage technique and accuracy in obtaining sub-bandage pressures of between 35-45mmHg after four education sessions in which the bandages pressures were measured using a sub-bandage measuring device. However, Dale and colleagues (2004) recognised that although variations were recorded in pressures achieved between experienced clinicians, they produced consistent results between bandage applications.

Sub-bandage Pressure Measurements

Systemic reviews conducted by Cullum et al. (2001) and O'Meara, Cullum & Nelson (2009) concluded that compression treatment increases the healing rates of venous leg ulcers compared with no compression and that higher compression and multi-layer compression systems are more effective than low compression and single-layer systems. A further systemic review by O'Meara et al. (2009) which compared a four layer bandage system with short stretch inelastic bandages suggested that patients with venous legs ulcers treated with the four layer bandages experience faster healing than those treated with short stretch bandages. However, none of these reviews described the bandage components used nor did they report on sub-bandage pressures attained, or maintained over time, by the various bandage systems. The relationship of sub-bandage pressure to leg ulcer healing therefore appears to require further investigation.

Lee et al. (2006) compared bandage pressures on postural change and found a single inelastic short stretch bandage applied in the spiral method of application produced similar pressures and gradients when compared to two inelastic short stretch bandages applied in the Putter method of application. The resting gaiter pressures were recorded below 40mmHg but increased as much as 75mmHg on standing (Lee et al., 2006). High pressures on postural change were also reported by Partsch (2005) with regard to double layers of inelastic short stretch compression bandages. Resting pressures of 60mmHg were reported at the ankle and these pressures rose as high as 88mmHg on standing. However, neither of these studies reported on sub-bandage pressure over time.

An earlier study by Danielsen and colleagues (1998) did not find such high pressures on standing. Their study compared the sub-bandage pressures of one inelastic short stretch bandage to one elastic long stretch bandage using the spiral method of application. The inelastic short stretch bandage on application recorded a mean resting ankle pressure of 28.8mmHg, which rose to 41mmHg on standing. After 24 hours bandage wear time the resting ankle pressure reduced to 19mmHg and the mean ankle standing pressure to 31.1mmHg. Danielsen et al. (1998) reported that as the initial participants were unable to tolerate the initial application pressure when the short stretch bandage was applied at full tension; the bandages were then applied at a lower pressure. In addition once the bandage had been applied, any excess bandage below the knee was cut off. These combined factors could possibly account for the lower reported pressures in this study.

In practice high sub-bandage pressures as reported by Lee et al. (2006) and Partsch (2005), would be unlikely to be maintained as two inelastic short stretch bandages using the Putter method of application have been shown to decline by 56% at the ankle for resting pressures and 59% at the ankle for working pressures after 3 hours wear time. Although a further 6% decline was recorded at 11 hours there were no further pressure changes reported at 22 hours (Larsen & Futtrup, 2004). However, these pressure measurements were taken using the Kikhume® sub-bandage measurement device which is not designed to measure pressures in the dynamic leg over time.

Hafner, Botonaki and Burg (2000) compared the interface bandage pressures over two day wear time on the four layer elasticated bandage system, the modified four layer bandage system (using an adhesive inelastic short stretch outer bandage), two inelastic short stretch bandages with a cohesive long stretch, medium stretch and short stretch outer cohesive bandages respectively, three short stretch bandages worn simultaneously and unna boot zinc bandage. They concluded that the elastic four layer bandage system provided the smallest pressure loss of 6-8mmHg and the three short stretch bandages provided the largest pressure loss of 16.5-18.5mmHg at 48 hours. The four layer elasticated bandage system provided the smallest pressure decrease when supine. The researchers therefore recommended the use of multilayer inelastic short stretch bandages with an outer cohesive medium stretch bandage as this system showed a marked pressure decrease when the person was lying down, high working pressures and sustained compression of 41mmHg at 48 hours after the initial 10mmHg pressure loss at 6 hours. However, they did not describe the application method used for these bandage systems.

Quality of Life

There is a large variety of compression bandaging systems available and as new compression bandaging methods for the treatment of venous leg ulcers become available, clinicians need valid and reliable measures of patient outcomes to determine the best and most appropriate form of treatment for their patients. In addition to evaluating healing rates and costs of treatment, the impact of treatment interventions on an individual's quality of life needs to be included in the overall assessment.

There is a growing recognition within the literature that quality of life is a valuable outcome measure for evaluating interventions, particularly when complete healing is unlikely (Chase et al., 2000; Hareendran et al., 2005). In addition, other studies are recognising the need for symptom management as well as wound healing in the treatment of individuals with chronic venous ulcers (Walshe, 1995; Heinen, Persoon, Kerkhof & Otero, 2007). The use of quality of life tools provides a systematic approach for measuring symptoms and interventions.

Systematic reviews conducted by Persoon, Heinen, Vleuten, Rooij, Kerhof and Achterberg (2004) and Briggs and Flemming (2007) concluded that venous leg ulcers have a major impact on a patient's quality of life, with pain being the dominant effect. Other major problems include difficulties with mobility, sleep disturbance, lack of energy, limitations in work, personal care and leisure activities, worries, frustrations and lack of self esteem. In addition to these major identified problems, researchers have identified wound leakage, odour, pruitis, infection, frequent dressing changes and compression bandaging as a source of reduced quality of life (Douglas, 2001; Hamer et al.,1994; Heinen, Persoon, Kerkhof, Otero & Achterberg, 2007; Hyde et al., 1999; Walshe, 1995). Bland (1996), Heinen et al. (2007) and Hyde et al. (1999), identified pain and oedema and the need to wear larger shoes to accommodate bandages, were the major contributors to restrictions in mobility. Pain and limitations in physical, emotional and social functioning and poorer general health have been identified as more problematic in persons with leg ulcers compared with age-matched cohorts (Price & Harding,1996).

A recognised way of assessing quality of life is to use either generic or specific measures of health status. A generic measure of quality of life, the Short Form 36 Item (SF-36) Health Survey is a well-validated measure of health status used for multiple conditions (Garratt, Ruta, Abdulla, Buckingham & Russell, 1993). It has also been used to measure the impact of leg ulceration on health status (Chase et al., 2000; Price & Harding, 1996). The SF-36 consists of 36 questions describing eight domains of health that fit broadly into physical and mental status scales. As it is not disease specific, it can take into account multiple conditions and the influence of co-morbidity on health (Smith, Guest, Greenhalgh & Davis, 2000). However, as suggested by Smith et al. (2000), the generic nature of this tool means it may not focus on the area of primary interest. Franks and Moffatt (2001) state the SF-36 appears to be poor at detecting changes in patients whose leg ulcer status changes. Conversely, specific quality of life tools are restricted to the area of primary interest and therefore, miss other important influences on the quality of life, such as comorbid health problems. They do however appear to be sensitive to change in patient's ulcer status (Franks & Moffatt, 2001; Smith et al., 2000).

Several condition specific tools for chronic leg wounds have emerged in an effort to describe the burden associated with health related quality of life issues. The Cardiff Wound Impact Schedule was originally used in patients with acute wounds and was modified and tested on patients with venous leg ulcers (Price & Harding, 2000). Other tools that have been used include the Charing Cross Venous Ulcer Questionnaire (Smith et al., 2000), the Nottingham Health Profile (Franks & Moffatt, 2001), Chronic Venous Insufficiency Questionnaire (Launois et al., 1996) and more recently the Venous Insufficiency Epidemiological and Economical Quality of Life and Symptom Questionnaire (VEINES-QOL/Sym) which is a patient based self-assessment tool designed to evaluate the health related quality of life issues associated with venous leg ulcers (Lamping et al., 2003). Despite the development of these tools, there appears to be no studies reported in the literature that have utilised these tools to evaluate the impact particular treatment interventions have on health related quality of life outcomes. As noted by Palfreyman, Nelson, Lochiel and Michaels (2006) this is a deficit of particular importance as this knowledge could guide compression bandage selection decisions, particularly where these regimens appear to produce very little difference in terms of healing rates. This study is intended to add to the body of evidence for selecting compression bandage systems.

Chapter 3

Methodology

Study Design

This study employed a quasi experimental research method, which used the same subjects to test compression levels achieved with the wearing of a three layer as compared to a four layer compression bandage system. Each participant had one of their legs randomised to the three layer bandage system while their other leg had the four layer bandage system applied. The allocation of study numbers to determine which leg the three layer bandage system was applied to was done using the Excel Microsoft random number function.

Sample

A convenience sample of 32 Silver Chain domiciliary nurses, were invited to participate in the study. A decision to use healthy volunteers was made in order to eliminate any possible artefact that could be associated with venous disease. This would allow a bench mark to be determined for future studies on individuals with venous ulceration. As one other published study comparing pressures achieved with different types of compression bandages over 48 hours found a significant difference between bandage types with just 10 people, a statistician advised a sample size of 30 subjects. However, an additional 4 nurses were invited to participate to accommodate for natural attrition rates.

Inclusion/Exclusion Criteria

Silver Chain domiciliary nurses were invited to participate in the study if they had an ankle/brachial pressure index between 0.8-1.2 and an ankle circumferential measurement of 18-25cm. Manufacturers recommend an ankle measurement of 18-25cm when using 10cm width inelastic short stretch bandages (BSN medical®). Exclusion criteria included a history of peripheral arterial occlusive disease, neuropathy of the lower limb, microvascular disease of the feet, decompensated cardiac insufficiency, history of known allergies to bandage material or hydrocolloid dressings, the presence of a wound on the lower limb or any mobility restrictions.

Recruitment

Study information sessions were provided to the target population at the Silver Chain metropolitan service centres which outlined the aim and objectives of the project, and the methodology to be employed. Information regarding the study was also disseminated through the Silver Chain Clinical Update Bulletin. Silver Chain nurses were provided with a Study Information Sheet (Appendix I) at the service centre study information sessions and with an opportunity to ask questions prior to providing signed Consent (Appendix II).

On participant recruitment into the study, an appointment at a Silver Chain clinic for the assessment and bandage application procedure was negotiated. Participants were provided with an explanation on how to complete the data and survey forms and they were also taught how to use the sub-bandage pressure monitor. Participants were required to record the sub-bandage pressures obtained at intervals over the 72 hour wear period as outlined below.

Data Collection Procedure

A Data Collection form (Appendix IV) was completed for each participant. The data collected included demographic details, assessment measurements and the pressure values obtained on bandage application. A Final Data Collection form (Appendix V) was completed to assess bandage integrity and collect the pressure measurements for each of the three different postures at 72 hours. As there was only one experienced bandager completing the initial and final assessments and applying all bandage systems to all participants, the time taken to complete all data collection was 20 weeks. Participants recorded their sub-bandage pressure data at intervals during wear of upon rising; between 1200-1400; and 2000-2200 each day and rated their comfort levels and the ease of completing activities using a 10 point linear scale at the end of each day (Appendix VI).

Sub-bandage Monitoring Device

The sub-bandage pressures were measured using the portable pneumatic Picopress® monitor. Accuracy, linear response at different pressures and reproducibility of the monitor have been verified in the laboratory and in vivo tests (Mosti & Rossari, 2009). The system is equipped with 2cm diameter ultra flat inflatable sensor cells, and, before measurement, 2cc of air was inflated into the sensor cells by means of an electronically controlled syringe. These sensors were applied directly to the participants' skin, under the padding bandage. One sensor was applied at 2cm above the medial malleolus and the second sensor was applied below the calf on each of the lower legs. The continuous polyvinyl chloride (PVC) tubing to which the sensors are attached was taped on to hydrocolloid dressings that were applied along the length of the participants' legs to prevent skin trauma from the tubing. The tubing was then attached to the monitor as required to obtain the sub-bandage pressure readings. Calibration and sub-bandage pressure measurements can be carried out under the bandage systems which therefore allowed a series of sequential measurements over the 72 hour bandage wear time period.

Bandage Systems

All roller bandages used were 10cm width bandages. The three layer bandage system consisted of one layer of padding bandage applied in a continuous spiral from the base of the toes to two finger widths below the popiteal fossa. Additional padding was applied around bony prominences and the dorsal arch of the foot if required. With the foot in a 90° position, the contact padding layer was then covered with an inelastic short stretch bandage starting laterally at the base of the toes, and was applied around the foot twice then turning around the ankle and heel in a figure of 8 with returns enclosing the heel. The spiral application was continued up the leg and the bandage was applied with 90-

100% tension and with 50% over lap of each preceding layer, to two finger widths below the popiteal fossa. The third, outer bandage was a straight retention tubular elasticated bandage applied over the length of the compression bandage.

The four layer bandage system consisted of one layer of padding bandage applied as for the three layer bandage system. Additional padding was also applied around bony prominences and the dorsal arch of the foot if required. With the foot in a 90° position, the padding contact layer was then covered with an inelastic short stretch bandage as outlined above for the three layer system. The third bandage was the second inelastic short stretch bandage which was applied over the first inelastic bandage with 90-100% tension in a continuous spiral with 50% over lap of the preceding layer from the base of the toes to two finger widths below the posterior knee. The fourth, outer layer was a straight retention tubular elasticated bandage applied over the length of the compression bandages.

The same experienced bandager applied all bandage systems to all participants with the participants sitting in a chair.

Measurements

Measurements of the participants' ankle/brachial index, and the length of lower leg from the base of the heel to two finger widths below the knee were recorded. The ankle and calf circumference measurements were also recorded. Pressure measurements were taken within 5 minutes of bandage application, by means of the non invasive sub-bandage pressure apparatus (PicoPress®), worn under the compression bandages. Application of the apparatus sensors were positioned at two points on the leg: the ankle (2cm) above the medial malleolus and mid- calf (11cm approximately from the ankle). The initial pressures were recorded for each of three different postures (I) standing with weight equally distributed on both legs; (II) sitting with feet on the floor and knees at right angles; and, (III) horizontal with participant lying on the bed with head and shoulders supported on pillows. Participants were taught to record the standing pressures obtained after walking for 3 minutes, at three spaced intervals over the day and on three consecutive days. Times for pressure monitoring were: upon rising; between 1200-1400; and 2000-2200 (see Appendix III). Standing pressures after walking were selected as a point of measure as short stretch bandages have been demonstrated to have high working (walking) pressures and lower resting pressures (Krasner et al., 2007). Each subject underwent training and were observed in practice on how to use and read the digital pressure monitor and complete the required data forms.

The participants responded with yes/no answers to a set of statements designed to ascertain the impact of wearing bandages whilst undertaking specific activities of daily living. The set of statements were developed as a pilot tool for this study in consultation with a clinical expert in wound management based on previous feedback received from patients receiving compression bandaging for the treatment of their venous leg ulcerations.

Against each statement, the participants then rated their comfort or ease score using a linear 10 point scale. A score of 5 or below equated to negative verbal feedback and negative written comments from participants in regards to their experience when undertaking specified activities. A score of 6 or greater equated to positive verbal feedback and positive written comments from participants and indicated the bandages had little or no impact on the individual performing that activity.

Data Analysis

Statistical analyses were carried out using the Statistical Package for the Social Sciences (SPSS), version 14. Descriptive statistics were used to summarise the data. The means (standard deviation) and medians (range) and frequency distribution of pressure measurements for both bandage systems were determined. The Kolmogorov-Smirnov test and Shapiro-Wilk test were applied to determine whether the distribution deviated from a normal distribution. Neither the distribution of individual sub-bandage pressures at a given time of measurement or the difference between the maximum and minimal sub-bandage pressures of each of the bandage systems differed significantly from a normal distribution ($p=<0.05$), so the mean values were compared between the three layer and four layer bandage systems by a parametric paired samples two-tailed t test.

Descriptive statistics were used to summarise participants' responses from the quality of life survey and determine the frequency distributions of the comfort scores. The Kolmogorov-Smirnov test and Shapiro-Wilk test were again applied to determine whether the distributions varied from a normal distribution. Variances in distribution on individual ratings against the various activities of daily living over the 3 days were significant (p=>0.05), therefore non-parametric testing using the Wilcoxon signed-rank test was used to analyse the comfort measurement differences between the two bandage systems.

Ethical Procedures

Permission to conduct the study was sought from Curtin University's School of Nursing and Midwifery Ethics Review Committee and Silver Chain's Human Research Ethics Committees. Participation was voluntary and participants were informed of their right to withdraw at any time without consequence. The participant's rights to confidentiality, anonymity and privacy were maintained by not using any names instead a de-identified study number was used on all of the data collection forms. All data collected was only accessible by the researcher and study supervisors. In accordance with the national research guidelines, all study records will be stored for 5 years in a secure locked cabinet and then will be destroyed.

Chapter 4

Results

Introduction

Thirty four participants were recruited to the study, 30 of whom completed the required 72 hour bandage wear time. Four participants withdrew from the study within the first 24 hours; one due to a hypersensitivity to the hydrocolloid dressing and three due to bandage intolerance. Sixteen participants had the three layer bandage system applied to their left lower leg whilst the remaining 18 participants had the three layer bandage system randomised to their right lower leg.

Sub-bandage Pressures on Application

The participants underwent an assessment of their bilateral legs and the results are provided in Table 1.

Table 1: Participants' Lower Leg Assessments

	N	Minimum	Maximum	Mean	Std. Deviation
Left Ankle Brachial Index	34	.90	1.20	1.0747	.07308
Right Ankle Brachial Index	34	.90	1.20	1.0988	.06918
Left Ankle Measurement (cm)	34	20.5	25.0	22.235	1.4208
Right Ankle Measurement (cm)	34	20.5	25.0	22.191	1.4513
Left Calf Measurement (cm)	34	32.5	44.0	37.412	3.0784
Right Calf Measurement (cm)	34	32.5	44.0	37.412	3.0784
Length Left Lower Leg (cm)	34	37.0	46.0	41.015	2.5151
Length Right Lower Leg (cm)	34	37.0	46.0	41.015	2.5151
Valid N (listwise)	34				

The pressures obtained for the three layer inelastic bandage system for each layer and postural change, are given in Table 2. In all cases and with each postural change the pressures were always higher at the ankle than the calf. The pressure difference with the application of the outer elasticated retention bandage was only minimal to obtain an overall mean standing ankle pressure of 48.12mmHg (range 32mmHg – 65mmHg) and the mean standing calf pressure of 34.24mmHg (range 23mmHg-43mmHg).

Table 2: Application Pressures (mmHg) for the 3 Layer Bandage System							
Bandage	Measure Point	Posture	N	Minimum	Maximum	Mean	Std. Deviation
1 Inelastic Short Stretch Bandage	Ankle	Lying	34	22	47	33.00	6.252
	Calf		34	22	38	29.56	4.258
	Ankle	Sitting	34	32	56	45.79	5.353
	Calf		34	29	40	34.76	3.182
	Ankle	Standing	34	31	61	46.38	6.504
	Calf		34	22	44	33.41	5.182
1 Inelastic Short Stretch Bandage With Elasticated Tubular Bandage	Ankle	Lying	34	22	47	34.32	5.798
	Calf		34	23	39	30.56	4.258
	Ankle	Sitting	34	34	56	46.59	5.996
	Calf		34	27	51	37.38	5.716
	Ankle	Standing	34	32	65	48.12	6.419
	Calf		34	23	43	34.24	5.129
Valid N (listwise)			34				

Table 3 provides the sub-bandage pressures obtained for each accumulative layer with each postural change within the four layer inelastic bandage system on application. As with the three layer bandage system, in all of the cases and with each additional layer and posture change, the pressures were highest at the ankle than at the calf. The pressure obtained at the ankle from one inelastic short stretch bandage over padding on standing, constituted approximately 66% of the total pressure accumulation within the system. The external elasticated tubular retention bandage when applied over the two inelastic short stretch bandages provided only an additional 3-5mmHg to the four layer bandage system.

Table 3: Application Pressures (mmHg) for the 4 Layer Bandage System							
Bandage	Measure Point	Posture	N	Minimum	Maximum	Mean	Std. Deviation
1 Inelastic Short Stretch Bandage	Ankle	Lying	34	22	44	32.68	5.180
	Calf		34	20	36	27.82	4.034
	Ankle	Sitting	34	34	54	42.82	4.865
	Calf		34	28	40	34.32	3.346
	Ankle	Standing	34	36	53	43.38	4.678
	Calf		34	21	43	30.97	5.529
2 Inelastic Short Stretch Bandages	Ankle	Lying	34	42	60	51.53	4.280
	Calf		34	37	53	43.94	4.185
	Ankle	Sitting	34	48	73	59.06	7.084
	Calf		34	41	57	48.47	4.548
	Ankle	Standing	34	51	76	62.03	6.842
	Calf		34	40	62	48.88	5.804
2 Inelastic Short Stretch Bandages with Elasticated Tubular Bandage	Ankle	Lying	34	45	67	54.65	5.548
	Calf		34	36	59	47.44	5.478
	Ankle	Sitting	34	52	81	65.26	6.921
	Calf		34	44	62	53.00	4.805
	Ankle	Standing	34	52	81	65.74	7.501
	Calf		34	44	68	53.35	6.261
Valid N (listwise)			34				

Table 4: Sub-bandage Pressure (mmHg) Differences Between the Bandage Systems on Application							
Posture	Measure Point	Bandage System	N	Minimum	Maximum	Mean	Mean Pressure Difference
Lying	Ankle	4 Layer	34	45	67	54.65	20.33mmHg
		3 Layer	34	22	47	34.32	
Lying	Calf	4 Layer	34	36	59	47.44	16.88mmHg
		3 Layer	34	23	39	30.56	
Sitting	Ankle	4 Layer	34	52	81	65.26	18.67mmHg
		3 Layer	34	34	56	46.59	
Sitting	Calf	4 Layer	34	44	62	53.00	15.63mmHg
		3 Layer	34	27	51	37.38	
Standing	Ankle	4 Layer	34	52	81	65.74	17.62mmHg
		3 Layer	34	32	65	48.12	
Standing	Calf	4 Layer	34	44	68	53.35	21.11mmHg
		3 Layer	34	23	43	32.24	
Valid N (listwise)			34				

As outlined in Table 4, the mean lying ankle and the mean standing calf pressures provided the greatest pressure difference between the four layer and three layer bandage systems; with each posture change all the ankle and calf measure points within the four layer bandage system provided significantly higher sub-bandage pressures compared to the three layer bandage system on application. Despite the mean standing ankle pressures providing these least pressure difference between the two bandage systems, the standing ankle pressures obtained in the four layer bandage system were still significantly higher (mean = 65.74, SD = 7.501) than the pressures obtained in the three layer bandage system (mean = 48.12, SD = 6.419), (t = -11.705, DF = 33, p = 0.000). The standing calf pressures obtained in the four layer bandage system were also significantly higher (mean = 53.35, SD = 6.261) than the calf pressures obtained in the three layer bandage system (mean = 34.24, SD = 5.129), (t = -15.155, DF = 33, p = 0.000).

Sub-bandage Pressures Over 24 Hour Wear Time

Table 5: Sub-bandage Pressures (mmHg) for the 3 Layer Bandage System over 24 Hour Bandage Wear Time

Bandage Wear Time	Measure Point	N	Minimum	Maximum	Mean	Std. Deviation	Mean Pressure Difference Since Application
4-6 hours	Ankle	34	29	48	38.41	4.453	9.71mmHg
4-6 hours	Calf	34	17	36	26.71	5.024	7.53mmHg
12-14 hours	Ankle	34	31	40	36.62	2.606	11.5mmHg
12-14 hours	Calf	34	14	33	23.53	4.705	10.71mmHg
22-24 hours	Ankle	34	24	48	34.47	5.674	13.65mmHg
22-24 hours	Calf	34	12	31	21.59	4.749	12.65mmHg
Valid N (listwise)		34					

Table 5 presents the sub-bandage pressures obtained over the first 24 hour bandage wear time for the three layer bandage systems. The largest sub-bandage mean ankle and mean calf pressure decline occurred within the first 4-6 hours of bandage wear time, reducing by 20% and 22% respectively. This represented a significant pressure reduction within the first 4-6 hours wear time (mean = 38.41, SD = 4.453) compared to the pressures obtained on application (mean = 48.12, SD = 6.419), (t = 12.28, DF = 33, p = 0.000) as did the mean calf pressures after 4-6 hours wear time (mean = 26.71, SD = 5.024) compared to those pressures obtained on application (mean = 34.24, SD = 5.129), (t = 9.206, DF = 33, p = 0.001). Though the sub-bandage pressures at the ankle and calf continued to decline over the first 24 hour period, the reductions in pressure were not as considerable in comparison to the first 4-6 hours. At 24 hours, the mean ankle pressure was 34.47mmHg (28% reduction since application) and the mean calf pressure was 21.59mmHg (37% decline since application).

Table 6: Sub-bandage Pressures (mmHg) for the 4 Layer Bandage System Over 24 hour Bandage Wear Time

Bandage Wear Time	Measure Point	N	Minimum	Maximum	Mean	Std. Deviation	Mean Pressure Difference Since Application
4-6 hours	Ankle	34	41	66	52.38	6.862	13.36mmHg
4-6 hours	Calf	34	24	48	39.41	5.679	13.94mmHg
12-14 hours	Ankle	33	34	60	46.79	6.494	18.95mmHg
12-14 hours	Calf	33	21	44	33.33	6.411	20.02mmHg
22-24 hours	Ankle	30	34	53	43.97	5.021	21.77mmHg
22-24 hours	Calf	30	21	36	28.87	3.884	24.43mmHg
Valid N		30					

Table 6 demonstrates the most significant sub-bandage ankle pressure decline in the four layer bandage system occurred within the first 4-6 hours (mean = 52.38, SD = 6.862) when compared to the pressures obtained on application (mean = 65.74, SD = 7.501), (t = 13.214, DF = 33, p = 0.000). The calf sub-bandage pressures from application (mean = 53.35, SD = 6.261) also reduced considerably after 4-6 hour wear time (mean = 39.41, SD = 5.679), (t = 16.553, DF = 33, p = 0.000). The mean ankle pressure reduced by 13.36mmHg (20%) and the mean calf pressure by 13.94mmHg (26%) within 4-6 hours wear time. Although the sub-bandage ankle and calf pressures as shown in Table 6 continued to decline over the first 24 hour period, the pressure reductions were not as significant as the first 4-6 hour wear time.

Despite the pressure reduction in the four layer bandage system being higher than that of the three layer bandage system, the ankle sub-bandage pressures in the four layer bandage system were still significantly higher (mean = 43.97, SD = 5.021) than that of the three layer bandage system (mean = 33.97, SD = 5.586), (t = -7.585, DF = 29, p = 0.000), as were the calf sub-bandage pressures in the four layer bandage system (mean = 28.87, SD = 3.884) compared to the three layer bandage system (mean = 21.23, SD = 4.606), (t = -8.216, DF = 29, p = 0.000) after 24 hour bandage wear time.

Sub-bandage Pressures at 28 – 48 Hour Wear Time

There was only a minimal sub-bandage mean ankle pressure decrease of 2.26mmHg in the three layer bandage system from 24 hour to 48 hour bandage wear time (Table 7). Even though the mean ankle pressure continued to decline from 24 hour to 48 hour wear time, it should be noted that there were some slight ankle pressure increases in some of the participants between the times of 22-24 hours and 46-48 hours. Despite these pressure increases, the ankle pressures at 48 hours (mean = 32.21, SD = 3.951) were still notably lower than those recorded at 24 hours (mean = 34.48, SD = 5.762), ($t = 2.984$, DF= 32, $p = 0.005$). In addition, there was an overall substantial calf pressure decrease from 24 hour bandage wear time (mean = 21.70, SD = 4.779) to 48 hour bandage wear time (mean =17.12, SD = 3.199), ($t = 6.306$, DF = 32, $p= 0.000$). In comparison to the pressures obtained on application, the mean ankle pressure had decreased by 15.91mmHg (33%) and the mean calf pressure had reduced by 17.12mmHg (50%) after 48 hours wear time.

Table 7: Sub-bandage Pressures (mmHg) for the 3 Layer Bandage System Over 28- 48 Hour Bandage Wear Time							
Bandage Wear Time	Measure Point	N	Minimum	Maximum	Mean	Std. Deviation	Mean Pressure Difference Since Application
28-30 hours	Ankle	33	22	41	33.79	4.211	14.33mmHg
28-30 hours	Calf	33	11	28	18.94	4.589	15.30mmHg
34-36 hours	Ankle	33	20	40	32.00	4.345	16.12mmHg
34-36 hours	Calf	33	11	25	17.64	3.815	16.60mmHg
46-48 hours	Ankle	33	24	40	32.21	3.951	15.91mmHg
46-48 hours	Calf	33	11	24	17.12	3.199	17.12mmHg
Valid N (listwise)		33					

Table 8: Sub-bandage Pressures (mmHg) for the 4 Layer Bandage System Over 28- 48 hour Bandage Wear Time							
Bandage Wear Time	Measure Point	N	Minimum	Maximum	Mean	Std. Deviation	Mean Pressure Difference Since Application
28-30 hours	Ankle	30	33	49	41.37	4.311	24.37mmHg
28-30 hours	Calf	30	18	36	26.03	5.417	27.32mmHg
34-36 hours	Ankle	30	29	52	39.93	5.860	25.81mmHg
34-36 hours	Calf	30	16	33	23.43	5.042	29.92mmHg
46-48 hours	Ankle	30	32	48	38.87	4.562	26.87mmHg
46-48 hours	Calf	30	17	26	20.50	2.529	32.85mmHg
Valid N (listwise)		30					

The sub-bandage pressures obtained over the 28-48 hour bandage wear time for the four layer bandage system (Table 8). Similarly to the three layer bandage system, small sub-bandage pressure increases were also noted with the four layer bandage system in some of the participants at 22-24 hours and 46-48 hours. Although the sub-bandage pressure decreases from 28-48 hour wear time were not as high as compared to the first 24 hours, the overall mean sub-bandage ankle pressure decrease from 24 hours (mean = 43.97, SD = 5.021) to 48 hour bandage wear time (mean = 38.87, SD = 4.562) was still significant ($t = 6.057$, $DF = 29$, $p = 0.000$), as were the overall mean calf pressure decreases from 24 hours (mean = 28.87, SD = 4.562) to 48 hour bandage wear time (mean = 20.50, SD = 2.529), (t = 16.527, DF = 29, p = 0.000). Overall, the sub–bandage mean ankle pressure in the four layer bandage system reduced by 5.1mmHg and the sub-bandage mean calf pressure reduced by 8.37mmHg from the period of 24 hours to 48 hours. In total, the mean ankle pressure had decreased by 26.87mmHg (41%) and the mean calf pressure had reduced by 32.85mmHg (62%) after 48 hours of bandage wear time.

Despite the four layer bandage system having larger sub-bandage ankle pressure decreases between 24 hour to 48 hour bandage wear time, the mean ankle sub-bandage pressure in the four layer bandage system still remained significantly higher (mean = 38.87, SD = 4.562) compared to the three layer bandage system (mean = 31.60, SD = 3.597), (t = -7.006, DF = 29, p = 0.000). The calf sub-bandage pressure in the four layer bandage system also remained considerably higher (mean = 20.50, SD = 2.529) compared to the three layer bandage system (mean = 16.83, SD = 2.984), (t = -5.140, DF = 29, p = 0.000) after 48 hour bandage wear time.

Sub-bandage Pressures at 52-72 Hours Wear Time

Both the ankle and calf sub-bandage pressures in the three layer bandage system declined minimally from 52 hours to 72 hours wear time recording only a further 2mmHg reduction in the mean ankle pressure and a further 1.97mmHg pressure reduction in the mean calf pressure (Table 9). Despite these minimal pressure decreases, the ankle sub-bandage pressure at 72 hours (mean = 28.75, SD = 2.995) were considerably lower compared to the pressures recorded at 48 hours (mean = 32, SD = 3.818), (t =7.945, DF = 31, p = 0.000). A notable reduction in the calf sub-bandage pressures at 72 hours (mean =14.56, SD = 2.639) was also noted in comparison to the pressures recorded at 48 hours wear time (mean = 17.19, SD = 3.227), (t = 17.055, DF = 31, p = 0.000).

Table 9: Sub-bandage Pressures (mmHg) for the 3 Layer Bandage System Over 52-72 hour Bandage Wear Time

Bandage Wear Time	Measure Point	N	Minimum	Maximum	Mean	Std. Deviation	Mean Pressure Difference Since Application
52-54 hours	Ankle	32	23	36	30.94	3.627	17.18mmHg
52-54 hours	Calf	32	11	23	16.53	2.973	17.71mmHg
58-60 hours	Ankle	32	24	35	30.06	3.079	18.06mmHg
58-60 hours	Calf	32	10	22	15.50	2.918	18.74mmHg
72 hours	Ankle	32	23	34	28.75	2.995	19.37mmHg
72 hours	Calf	32	10	20	14.56	2.639	19.68mmHg
Valid N (listwise)		32					

Table 10: Sub-bandage Pressures (mmHg) for the 4 Layer Bandage System Over 52-72 hour Bandage Wear Time							
Bandage Wear Time	Measure Point	N	Minimum	Maximum	Mean	Std. Deviation	Mean Pressure Difference Since Application
52-54 hours	Ankle	30	32	47	38.13	4.117	27.61mmHg
52-54 hours	Calf	30	16	25	19.50	2.529	33.85mmHg
58-60 hours	Ankle	30	33	40	36.33	2.106	29.41mmHg
58-60 hours	Calf	30	13	21	17.83	2.086	35.52mmHg
72 hours	Ankle	30	32	40	35.03	1.991	30.71mmHg
72 hours	Calf	30	12	20	16.53	2.030	36.82mmHg
Valid N (listwise)		30					

As outline in Table 10, both the ankle and calf pressures of the four layer bandage system declined minimally from 52 hours to 72 hours bandage wear time resulting in a further 3.1mmHg decline in the mean ankle pressure and a further 2.97mmHg loss in the mean calf pressure. Despite these minimal pressure declines, the ankle pressure at 72 hours (mean = 35.03, SD = 1.991) reduced considerably compared to the pressures recorded at 48 hours (mean = 38.87, SD = 4.562), (t = 6.242, DF = 29, p =0.000). The calf pressures also significantly declined at 72 hours (mean =16.53, SD = 2.030) in comparison the pressures recorded at 48 hours (mean = 20.50, SD = 2.529), (t = 8.467, DF = 29, p = 0.000).

Although the four layer bandage system continued to have larger pressure decreases compared to the three layer bandage system, the ankle sub-bandage pressure at 72 hours of the four layer bandage system remained significantly higher (mean = 35.03, SD = 1.991) compared to the three layer bandage system (mean = 28.53, SD = 2.956), (t = -10.345, DF = 29, p = 0.000). The calf sub-bandage pressure at 72 hours of the four layer bandage system remained notably higher (mean = 16.53, SD = 2.030) compared to the three layer bandage system (mean = 14.30, SD = 2.480), (t = -4.468, DF = 29, p = 0.000).

Table 11: Sub-bandage Pressures (mmHg) at 72 hours For The 3 Layer and 4 Layer Bandage Systems Compared to Application Pressures

Posture	Measure Point	Bandage System	N	Minimum	Maximum	Mean	Mean Pressure Difference from Application
Lying	Ankle	4 Layer	30	20	35	26.97	27.68mmHg
		3 Layer	32	18	27	22.00	12.32mmHg
Lying	Calf	4 Layer	30	14	22	18.13	29.31mmHg
		3 Layer	32	12	18	15.00	15.56mmHg
Sitting	Ankle	4 Layer	30	30	45	36.67	28.59mmHg
		3 Layer	32	26	36	30.53	16.06mmHg
Sitting	Calf	4 Layer	30	11	26	18.03	34.97mmHg
		3 Layer	32	10	23	16.22	21.16mmHg
Standing	Ankle	4 Layer	30	32	40	35.03	30.71mmHg
		3 Layer	32	23	34	28.75	19.37mmHg
Standing	Calf	4 Layer	30	12	20	16.53	36.82mmHg
		3 Layer	32	10	20	14.56	17.68mmHg
Valid N (listwise)			30				

Table 11 presents the final sub-bandage pressures recorded for each bandage system at each posture change with the mean sub-bandage pressure difference at 72 hours compared to the pressures obtained from application. Both bandage systems had significant pressure reductions over the 72 hours with each posture change. Overall, the mean sub-bandage ankle pressures in the four layer bandage system reduced over the 72 hour bandage wear time by 51% in the lying position, 44% in sitting posture and 47% in the standing position. Higher mean sub-bandage calf pressure reductions at 72 hours were also found. The mean sub-bandage calf pressures in the four layer bandage system decreased by 62% in the lying position, 66% in the sitting posture and 69% in the standing position.

In total, the mean sub-bandage ankle pressures in the three layer bandage system declined over the 72 hour wear time by 36% in the lying position, 34% in the sitting posture and 40% in the standing position. The mean sub-bandage calf pressures in the three layer bandage system reduced by 51% in the lying position, 57% in the sitting posture and 55% in the standing position after 72 hours. Although the inelastic four layer bandage system recorded the greatest pressure reductions, the sub-bandage pressures at 72 hour wear time remained significantly higher than those in the inelastic three layer bandage system.

Table 12: Bandage Slippage (cms) at 72 Hours					
	N	Minimum	Maximum	Mean	Std. Deviation
3 Component Bandage System	32	1	7	5.22	1.497
4 Component bandage System	30	1	6	5.10	1.322
Valid N (listwise)	30				

Bandage slippage was problematic for both bandage systems with all participants experiencing some degree of slippage ranging between 1cm – 7cm below the knee at 72 hour bandage wear time. Twenty five participants reported problems of bandage slippage on their feedback survey form after 48 hour wear time for both bandage systems. As shown in Table 12, bandage slippage was slightly greater in the three layer bandage system reporting a mean bandage slippage of 5.22cm below the knee compared to 5.10cm for the four layer bandage system however, the difference between the two bandage systems was insignificant.

Table 13: Trauma From the Three Layer Bandage System					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	33	97.1	97.1	97.1
	Yes	1	2.9	2.9	100.0
	Total	34	100.0	100.0	

Table 14: Trauma From the Four Layer Bandage System					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	29	85.3	85.3	85.3
	Yes	5	14.7	14.7	100.0
	Total	34	100.0	100.0	

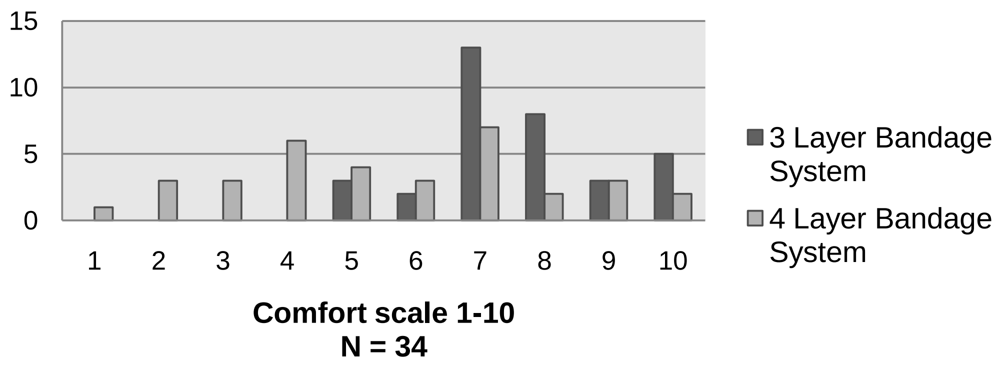
On bandage removal the participant's lower legs were assessed for any bandage associated trauma. Table 13 demonstrates, one participant had trauma recorded for the three layer bandage system and this was a hypersensitivity reaction caused by the hydrocolloid dressings rather than trauma associated with the bandages. Otherwise none of the other participants had bandage associated trauma caused by the three layer bandage system. In contrast, five participants had bandage trauma recorded at bandage removal (Table 14) for the four layer bandage system. One participant had a hypersensitivity reaction caused by the hydrocolloid dressing, while the remaining four participants experienced slight bruising at the medial aspect of dorsal ankle arch. Overall, there was more considerable bandage trauma associated with the four layer bandage system (mean = 1.15, SD = 0.359) compared to the three layer bandage system (mean = 1.03, SD = 0.171), ($t = -2.098$, DF = 33, $p = 0.04$).

Comfort Levels of the Bandage Systems

Table 15 presents the participants' responses to the statement the 'bandage system was comfortable throughout the day' over the 3 day wear time. The participants rated their comfort score (Figure 1), using a linear 10 point scale. A score of 5 or below equates to some discomfort whereas a score of 6 or greater equates to no discomfort. As shown in Figure 1, 31 (91%) of the participants had favourable comfort scores between 6 and 10 whilst the remaining 3 (9%) of participants rated their scores 5 to obtain an overall mean comfort score of 7.62 for the three layer bandage system.

Table 15: Participant Responses To The Comfort of the Bandage Systems Throughout the Day Over 3 Days						
Day	Bandage System	N	Yes	Percentage	No	Percentage
1	3 Layer	34	33	97.1%	1	2.9%
	4 Layer	34	17	50.0%	17	50%
2	3 Layer	33	30	90.9%	3	9.1%
	4 Layer	30	14	46.7%	16	53.3%
3	3 Layer	32	29	90.6%	3	9.4%
	4 Layer	30	20	66.7%	10	33.3%

Figure 1: Comfort Levels Of The Bandage Systems Throughout The Day On Day 1



For the four layer bandage system, 17(50%) participants rated their comfort score unfavourably between 1 and 5, with the remaining 17 (50%) participants having rated their comfort levels as satisfactorily between 6 and 10 to obtain an overall mean score of 5.59. Therefore, the four layer bandage system was significantly more uncomfortable (mean = 5.59, SD = 2.44) than the three layer bandage system (mean = 7.62, SD = 1.41), (t = 5, DF = 34, p = 0.000) throughout the day on day 1.

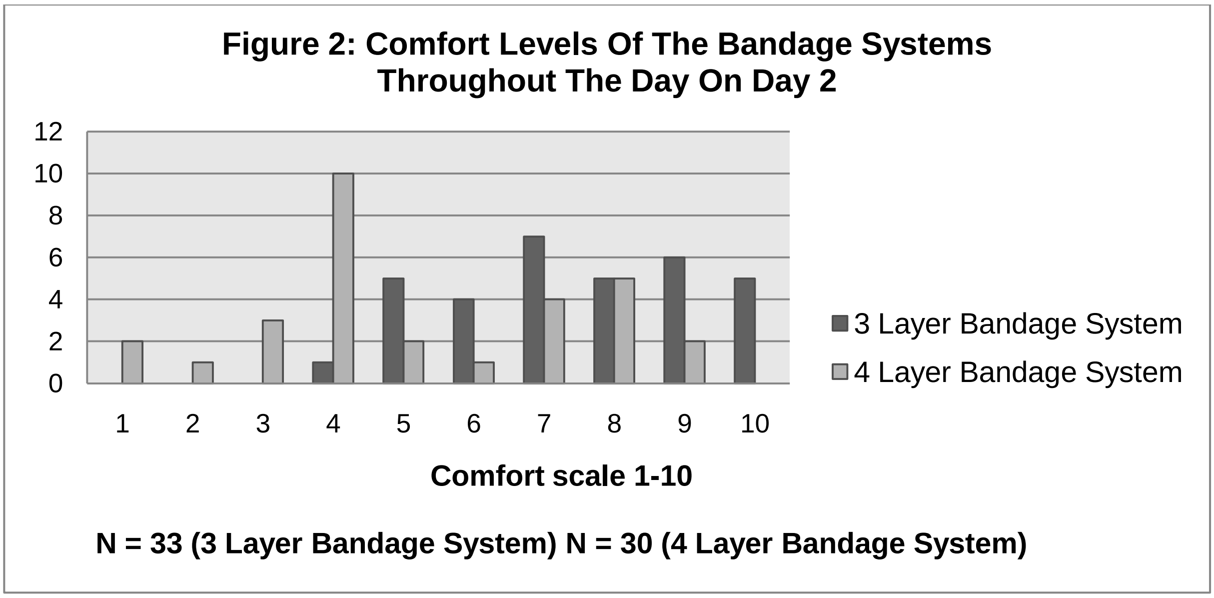
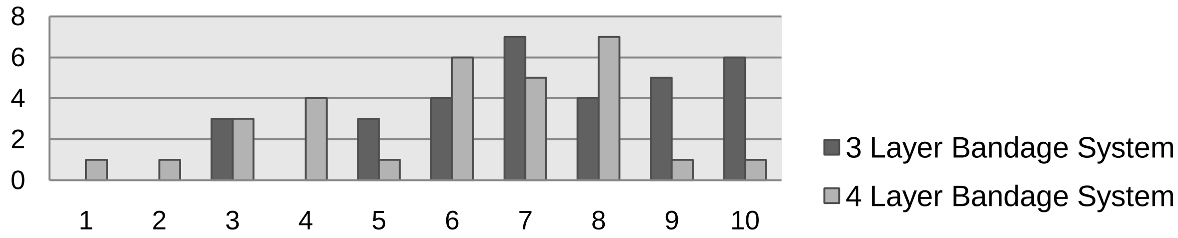


Figure 2 highlights the fact that there was a slight increase in the number of participants who rated their scores unfavourably between 4 and 5 for the three layer bandage system. However, as 27 (82%) of the participants continued to rate their comfort levels favourably between 6 and 10 to obtain an overall mean score of 7.45, there were no significant differences between participant scores throughout the day from day one (mean = 7.62, SD = 1.41) compared to those on day 2 (mean = 7.45, SD = 1.77) (t = 8, DF = 33, p =0.34).

The number of participants who rated their comfort level low between 1 and 5 for the four layer bandage system increased on day 2 to 18 (60%) which resulted in a decline in the mean score to 5.17. Therefore the participant comfort levels had notably worsened on day 2 (mean = 5.17, SD = 2.32) compared to day 1 (mean = 5.59, SD = 2.44) (t = 6.75, DF = 30, p = 0.48). As a result, the four layer bandage system remained considerably more uncomfortable (mean = 5.17, SD = 2.321), than the three layer bandage system (mean = 7.53, SD = 1.769), (t = 0, DF = 30, p = 0.000) throughout the day on day 2.

Figure 3: Comfort Levels Of The Bandage Systems Throughout The Day On Day 3



N = 32 (3 Layer Bandage System), N = 30 (4 Layer Bandage System)

The comfort scores for the three layer bandage system on day 3 were similar to the previous two days of bandage wear time. There were 26 (81%) participants who continued to rate their comfort level positively between 6 and 10 whilst the remaining 6 (19%) participants scored their comfort levels between 3 and 5 to obtain a mean comfort score on day 3 of 7.31.

On day three, the number of participants who agreed that the four layer bandage system was comfortable throughout the day (Table 15) increased to 20 (67%) and rated their comfort scores between 6 and 10. Ten (33%) participants disagreed with this statement and continued to rate the comfort levels low between 1 and 5 to obtain a mean comfort score of 5.97. The participants' comfort levels in the four layer bandage system were significantly more comfortable on day 3 (mean = 5.97, SD = 2.22) compared to day 2 (mean

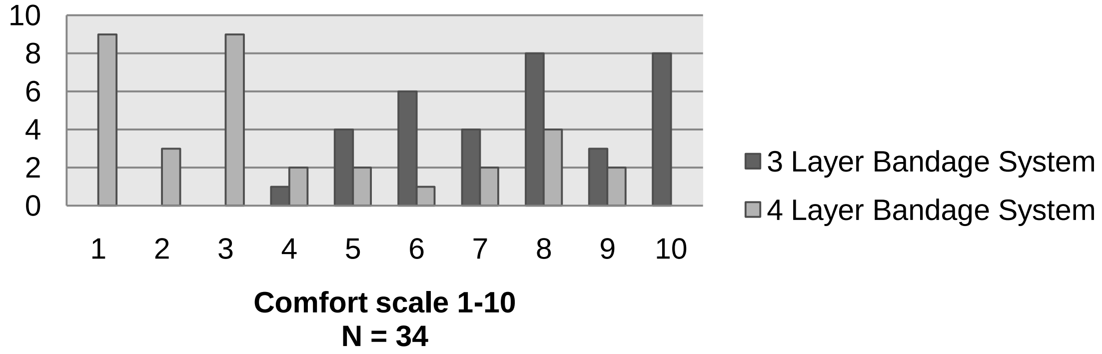
= 5.17, SD = 2.32) (t = 6, DF = 30, p = 0.007). Despite this increase in participant comfort, the four layer bandage system remained considerably more uncomfortable throughout the day for participants (mean = 5.97, SD = 2.22) in comparison to the three layer bandage system (mean = 7.31, SD = 2.117), (t = 0, DF = 30, p = 0.000) on day 3.

Table 16: Participant Responses To The Comfort Of The Bandage Systems While Resting/Sleeping Over 3 Days

Day	Bandage System	N	Yes	Percentage	No	Percentage
1	3 Layer	34	33	97.1%	1	2.9%
	4 Layer	34	9	26.5%	25	73.5%
2	3 Layer	33	29	87.9%	4	12.1%
	4 Layer	30	11	36.7%	19	63.3%
3	3 Layer	32	27	84.4%	5	15.6%
	4 Layer	30	12	40%	18	60%

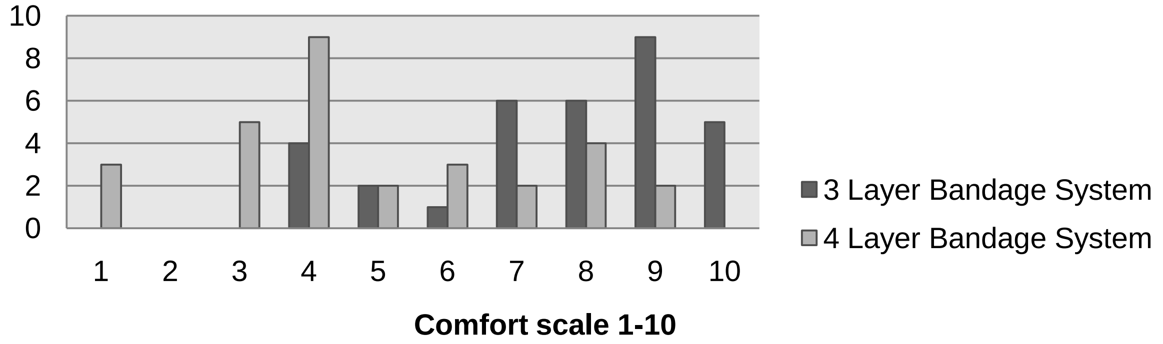
Thirty three participants (97%) on day 1 (Table 16) agreed the three layer bandage system was comfortable while resting/sleeping, whilst only 1 (3%) participant disagreed with this statement. As shown in Figure 4, 5 (15%) of the participants rated their comfort as low between 4 and 5 whilst the remaining 29 (85%) of participants rated their comfort favourably, between 6 and 10, to obtain a mean score of 7.62.

Figure 4: Comfort Levels Of The Bandage Systems While Resting/Sleeping On Day 1



In comparison, only 9 (26%) participants (Table 16) on day 1 agreed the four layer bandage system was comfortable while resting/sleeping and they rated their comfort score (Figure 4), between 6 and 9, whilst the remaining 25 (74%) participants disagreeing with this statement and rated their comfort scores negatively between 1 and 5, to obtain a mean comfort score of 3.82. In general the four layer bandage system was significantly more uncomfortable (mean = 3.82, SD= 2.69) compared to the three layer bandage system (mean = 7.62, SD = 1.83), (t = 0, DF = 34, p = 0.000) at rest on day 1 of bandage wear time.

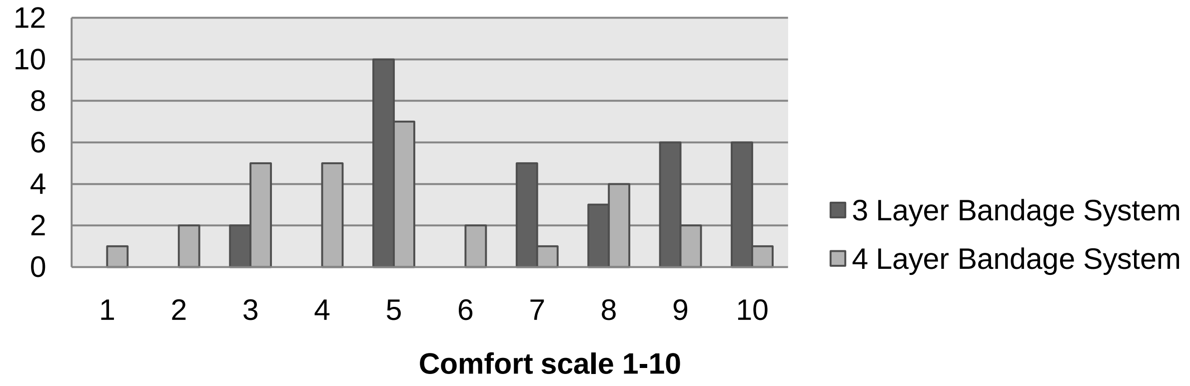
Figure 5: Comfort Levels Of The Bandage Systems While Resting/Sleeping On Day 2



N = 33 (3 Layer Bandage System), N = 30 (4 Layer Bandage System)

On day 2, the participant scores (Figure 5) for the three layer bandage system was similar to day 1. Six (18%) participants continued to rate their comfort scores between 4 and 5 and the remaining 27 (82%) participants rating their comfort score between 6 and 10 to obtain a mean score of 7.67. Similarly, the participant comfort scores for the four layer bandage system while resting/sleeping on day 2 were comparable to day 1. The majority (63%) of participants continued to rate the comfort score between 1 and 5 and the remaining 11 (37%) of participants scored 6 and 9 to obtain a mean score of 4.87. Therefore on day 2, the four layer bandage system remained considerably more uncomfortable (mean = 4.87, SD = 2.32) compared to the three layer bandage system (mean = 7.67, SD = 1.92), (t = 0, DF = 30, p = 0.000) at rest.

Figure 6: Comfort Levels Of The Bandage Systems While Resting/Sleeping On Day 3



N = 32 (3 Layer Bandage System), N = 30 (4 Layer Bandage System)

By day 3, the number of participants who rated their comfort scores unfavourably between 3 and 5 while resting/sleeping for the three layer bandage system increased to 12 (37%) this was not reflected in the mean score of 7.16 as the majority of participants (63%) continued to rate their scores between 7 and 10.

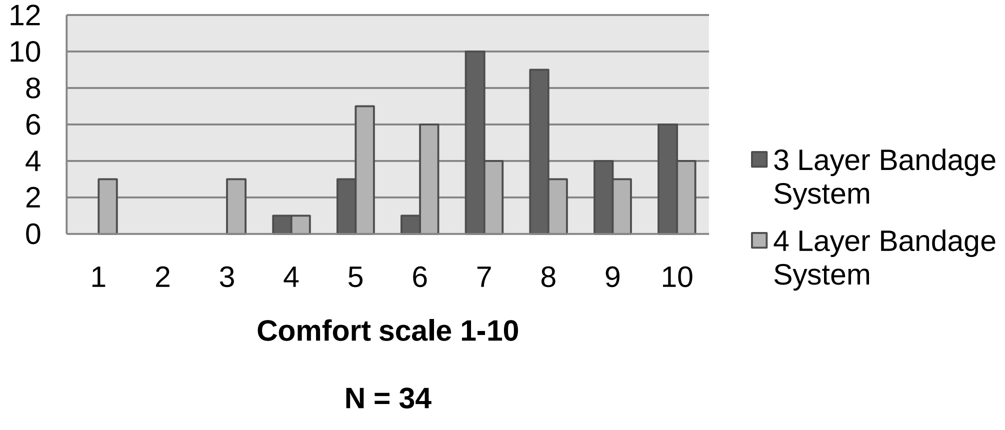
In contrast, as shown in Figure 6, the comfort scores for the four layer bandage system while resting/sleeping improved slightly by day three. Although twenty (67%) continued to rate their comfort scores between 1 and 5, the remaining 33% of participants rated their scores between 6 and 10 to obtain an overall mean score of 5.13. Therefore, the four layer bandage system was comparatively more comfortable on day 3 (mean = 5.13, SD = 2.33) compared to day 1 (mean = 3.82, SD = 2.69), (t = 11.05, DF = 30, p = 0.27). Despite the improvement in the participants comfort score on day 3, the four layer bandage system still remained significantly more uncomfortable (mean = 5.13, SD = 2.33) compared to the three layer bandage system (mean = 7.16, SD = 2.22), (t = 0, DF = 30, p = 0.000) at rest.

Table 17: Participant Responses To The Comfort Of The Bandage Systems While Walking Over 3 Days

Day	Bandage System	N	Yes	Percentage	No	Percentage
1	3 Layer	34	33	97.1%	1	2.9%
	4 Layer	34	22	64.7%	12	35.3%
2	3 Layer	33	31	93.9%	2	6.1%
	4 Layer	30	18	60%	12	40%
3	3 Layer	32	27	84.4%	5	15.6%
	4 Layer	30	20	66.7%	10	33.3%

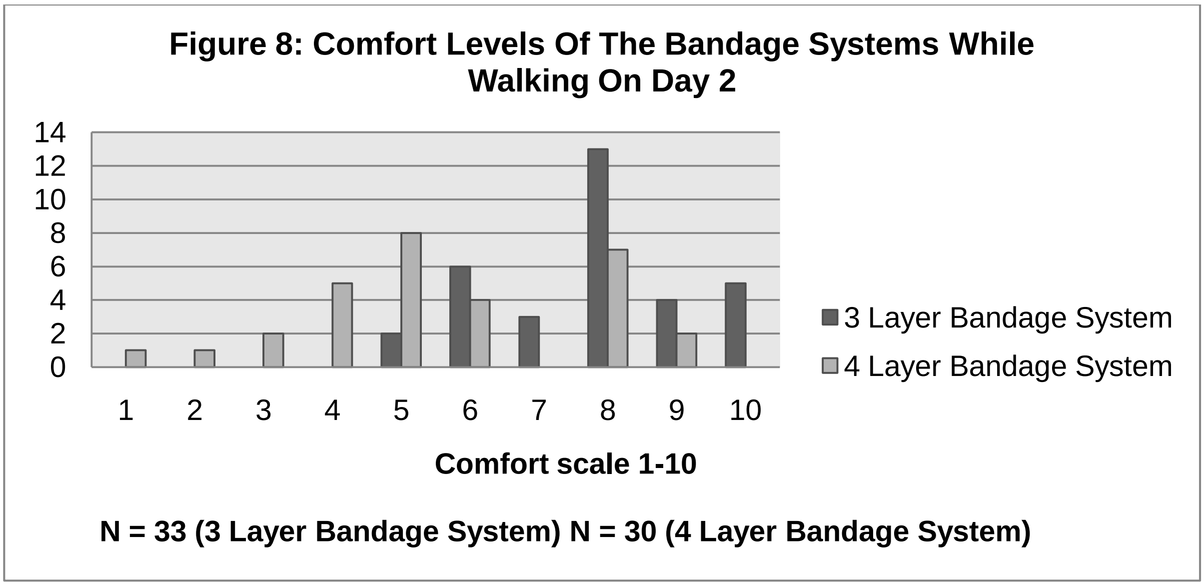
Table 17 provides the participants' responses to the statement the 'bandage system were comfortable whilst walking' over the 3 day wear time.

Figure 7: Comfort Levels Of The Bandage Systems While Walking On Day 1



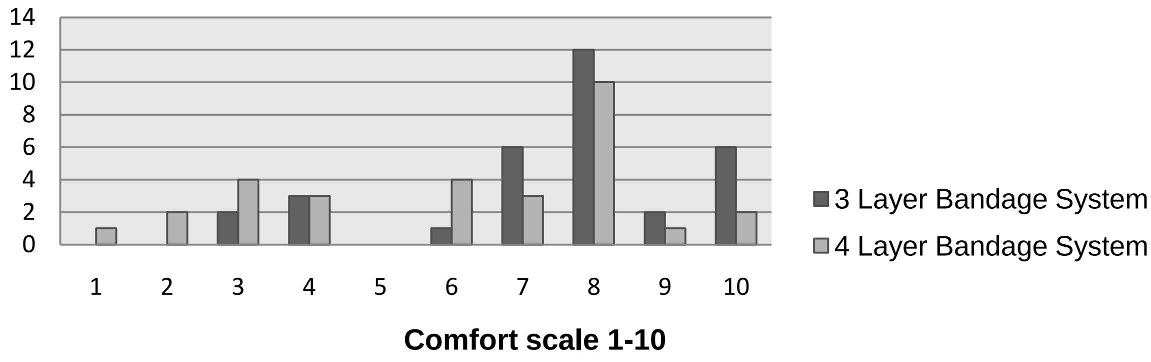
As shown in Figures 7 to 9, the three layer bandage system was consistently comfortable while walking over the 3 day bandage wear time. On day 1, 30 (88%) participants rated their comfort positively between 6 and 10, whilst only four (12%) participants rated their comfort level between 4 and 5 to obtain an overall mean comfort score of 7.74. Results were very similar on day 2 with 31 (94%) of the participants continuing to rate their comfort levels between 6 and 10 resulting in an overall mean comfort score of 7.79. By day 3, five (16%) participants disagreed that the bandage system was comfortable while walking (Table 17) and rated their comfort levels between 3 and 5. However this had very little impact on the overall mean comfort score of 7.50 as the remaining 27 (84%) participants still rated their comfort levels favourably between 6 and 10.

On day one, 14 (41%) of the participants rated their comfort score for the four layer bandage system poorly between 1 and 5 while the remaining 20 (59%) rated their comfort level positively between 6 and 10 resulting in an overall mean comfort score of 6.06. Therefore the four layer bandage system was considerably more uncomfortable (mean = 6.06, SD = 2.58) than the three layer bandage system (mean = 7.74, SD = 1.58), (t = 0, DF = 34, p = 0.000) on day 1 while walking.



In general, the comfort level in the four layer bandage system while walking on day 2 was considerably less (mean = 5.57, SD = 2.10) compared to day 1 (mean = 6.06, SD = 2.58), (t = 6.88, DF = 30, p = 0.10), with 17 (57%) of the participants rating their comfort level between 1 and 5, while the remaining 13 (43%) participants comfort scores remained positively between 6 and 10. This reflected in the four layer bandage system being significantly more uncomfortable on day 2 (mean = 5.57, SD = 2.10) compared to the three layer bandage system (mean =7.79, SD = 1.45), (t = 0, DF = 30, p = 0.000).

Figure 9: Comfort Levels Of The Bandage Systems While Walking On Day 3



N = 32 (3 Layer Bandage System) N = 30 (4 Layer Bandage System)

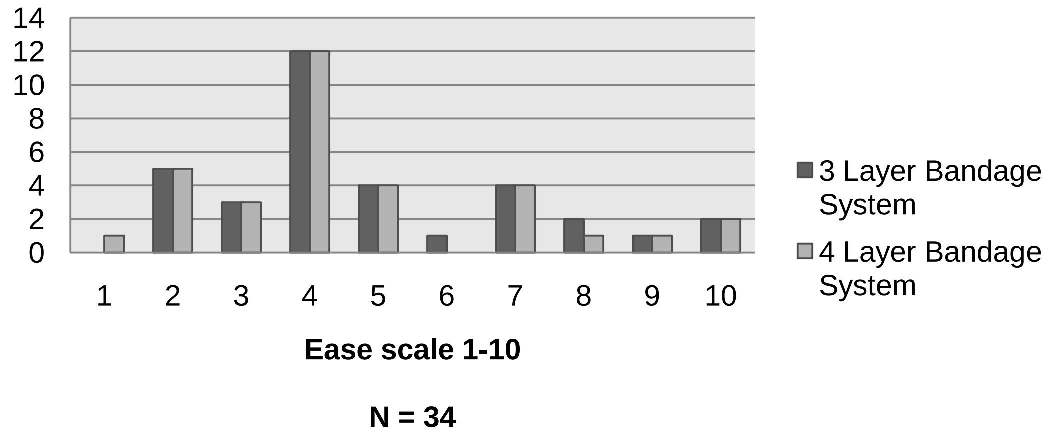
By day three, 20 (67%) of the participants agreed the four layer bandage system was comfortable while walking (Table 17) and rated their comfort between 6 and 10 (Figure 9), while the remaining 10 (33%) disagreed and continued to rate their comfort between 1 and 4, which resulted in a mean comfort score of 6.10. Despite this minor increase in the overall mean comfort score, the four layer bandage system still remained noticeably more uncomfortable while walking (mean = 6.10, SD = 2.55) compared to the three layer bandage system (mean = 7.50, SD = 2.02), (t = 0, DF = 30, p = 0.000).

Attending to Activities of Daily Living

Table 18 presents the participants' responses to the statement, 'the task of attending to showering/hygiene needs was easy' while wearing the compression bandage systems over the 3 day wear time.

Table 18: Participant Responses To The Ease Of Attending To Hygiene Needs While Wearing The Bandage Systems Over 3 Days						
Day	Bandage System	N	Yes	Percentage	No	Percentage
1	3 Layer	34	9	26.5%	25	73.5%
	4 Layer	34	8	23.5%	25	76.5%
2	3 Layer	33	15	45.5%	18	54.5%
	4 Layer	30	11	36.7%	19	63.3%
3	3 Layer	32	16	50%	16	50%
	4 Layer	30	13	43.3%	17	56.7%

Figure 10: Ease Of Attending Hygiene Needs While Wearing the Compression Bandage Systems On Day 1

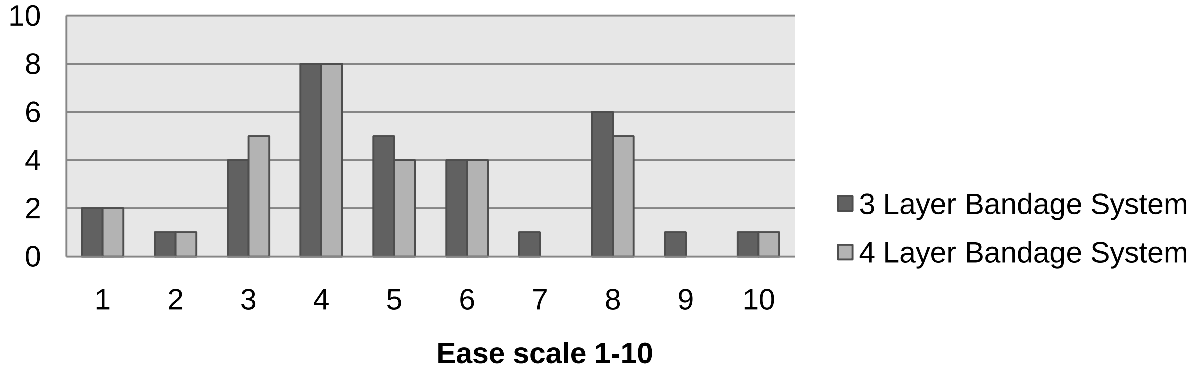


On day one, 9 (26%) of the participants agreed it was easy to attend to their showering/hygiene needs whilst wearing the three layer bandage system (Table 18) and rated the ease of doing the task favourably between 6 and 10 (Figure 10). However, the remaining 25 (74%) disagreed and as shown in

Figure 10, rated the task as difficult between 2 and 5, to obtain a mean score of 4.88.

Similar results were found with the four layer bandage system, 8 (24%) of the participants agreed it was easy to attend to their showering/hygiene needs while the remaining 25 (76%) of the participants disagreed (Table 18) rating the task as difficult between 1 and 5 (Figure 10), which resulted in mean rating of 4.64.

Figure 11: Ease Of Attending Hygiene Needs While Wearing The Compression Bandage Systems On Day 2

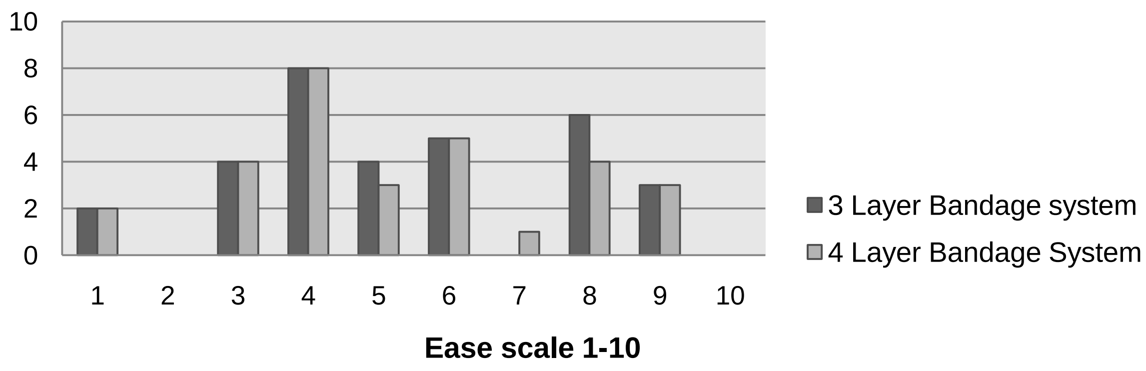


N = 33 (3 Layer Bandage System), N = 30 (4 Layer Bandage System)

As shown in Figure 11, 13 (39%) of the participants rated the ease of showering/attending to hygiene needs whilst wearing the three layer bandage system favourably between 6 and 10, however as 20 (61%) of the participants still rated the task as difficult (between 1 and 5) this resulted in minimal increase in the mean score to 5.18. Therefore the participant scores over the 2 day bandage wear time for the three layer bandage system were comparable.

Twenty (67%) of the participants on day 2 still rated the task of attending to showering/hygiene needs whilst wearing the four layer bandage system as difficult between 1 and 5. The remaining 10 (33%) participants' scores fell between 6 and 10, resulting in a mean score of 4.83. Although there was a slight increase between day 1 and day 2, the difference was insignificant. There were also no major differences found between the two compression bandage systems in terms of how difficult participants found it to shower and attend to their hygiene needs over the 2 days bandage wear time.

Figure 12: Ease of Attending Hygiene Needs While Wearing The Compression Bandage Systems On Day 3



N = 32 (3 Layer Bandage System) N= 30 (4 Layer Bandage System)

On day 3, 18 (56%) of the participants continued to indicate they found the task of attending to showering/hygiene needs whilst wearing the three layer bandage system difficult between 1 and 5, whilst the remaining 14 (44%) participants rated the ease of this task as between 6 and 9 resulting in a mean score of 5.34. Even though the increase in the mean score on day 3 compared to day two was small, by the third day participants wearing the three layer bandage system found attending to their showering/hygiene needs considerably easier (mean = 5.34, SD = 2.27) than on day 1 (mean = 4.88, SD = 2.27), (t = 7, DF = 32, p= 0.038).

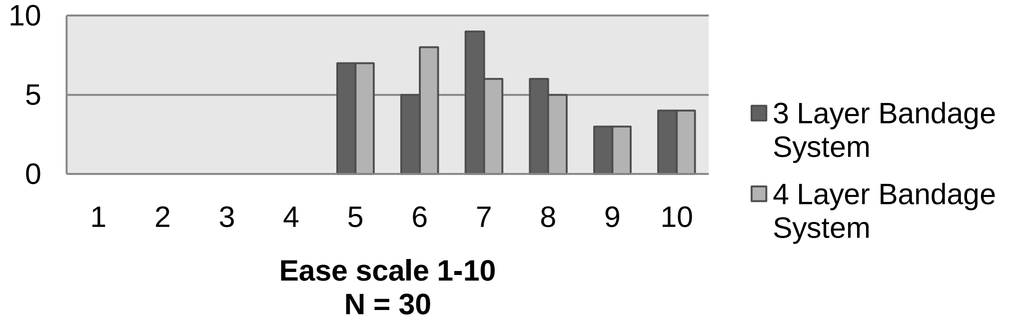
By day 3, 13 (43%) of the participants wearing the four layer bandage system, rated the task of attending to showering/hygiene needs between 6 and 10. The remaining 17 (57%) continued to rate the ease of the task between 1 and 5 resulting in a mean score of 5.23. This represented a considerable improvement on day 3 (mean = 5.23, SD = 2.25) compared to day 1 (mean = 4.64, SD = 2.32) (t = 6, DF = 32, p = 0.018).

Table 19: Participant Responses To The Ease Of Dressing While Wearing The Bandage Systems Over 3 Days

Day	Bandage System	N	Yes	Percentage	No	Percentage
1	3 Layer	34	31	91.2%	3	8.8%
	4 Layer	34	31	91.2%	3	8.8%
2	3 Layer	33	33	100%	0	0%
	4 Layer	30	30	100%	0	0%
3	3 Layer	32	31	96.9%	1	3.1%
	4 Layer	30	28	93.3%	2	6.7%

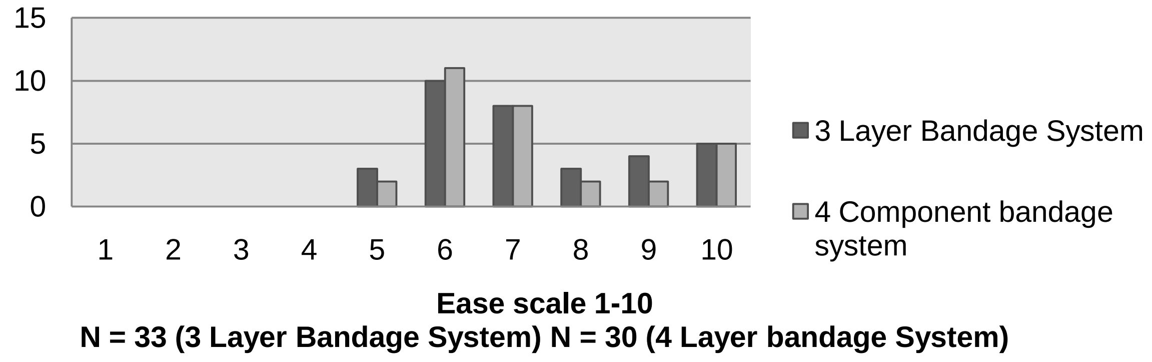
Table 19 shows the participants' responses to the statement, 'getting dressed while wearing the bandage system was easy' for the 3 day bandage wear time.

Figure 13: Ease Of Dressing While Wearing The Compression Bandage Systems On Day 1



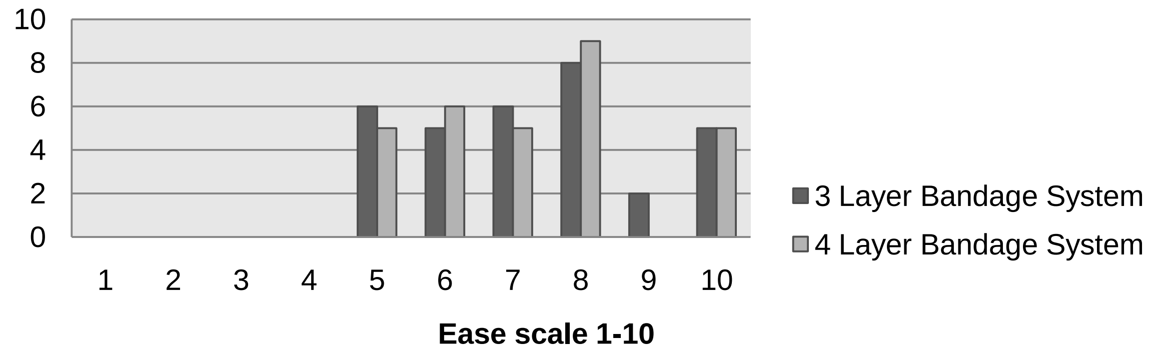
As shown in Figure 13, 27 (79%) of the participants wearing the three layer bandage system rated dressing as relatively easy between 6 and 10, on day 1, while the remaining 7 (21%) participants found the task slightly more difficult with a rating of 5, giving a mean score of 7.15. Similarly, 26 (79%) participants wearing the four layer bandage system rated dressing as easy between 6 and 10, while the remaining 7 (21%) indicated they were having some difficulty with a rating of 5, which resulted in a mean score of 7.03.

Figure 14: Ease Of Dressing While Wearing The Compression Bandaging Systems On Day 2



As shown in Figure 14, participants' ratings for both bandage systems were again similar on day 2, with the proportion of the number of participants finding dressing relatively easy having increased. For the three layer bandage system, just 3 (9%) of the participants continued to rate the ease at 5 while the remaining 30 (91%) participants rated the task between 6 and 10 to give a mean score of 7.30. Similarly only 2 (7%) of the participants rated the four layer bandage system as making dressing somewhat difficult, whereas the other 28 (93%) rated it as relatively easy, between 6 and 10, which resulted in a mean score of 7.20.

Figure 15: Ease Of Dressing While Wearing The Compression Bandage Systems On Day 3



N = 32 (3 Layer Bandage System) N = 30 (4 Layer Bandage System)

The results were again similar for both the three layer and four layer bandage systems on day 3 however, there was a small increase in the numbers of participants indicating that they were having some difficulty dressing compared to day 2. Six (19%) participants rated the three layer bandage system as effecting dressing somewhat negatively with a rating of 5, while the other 26 (81%) participants continued to rate the task between 6 and 10, resulting in a mean score of 7.31. Likewise, 25 (83%) participants continued to indicate dressing was relatively easy whilst wearing the four layer bandage system, while the remaining 5 (17%) participants gave a rating of 5, to obtain an overall mean score of 7.27.

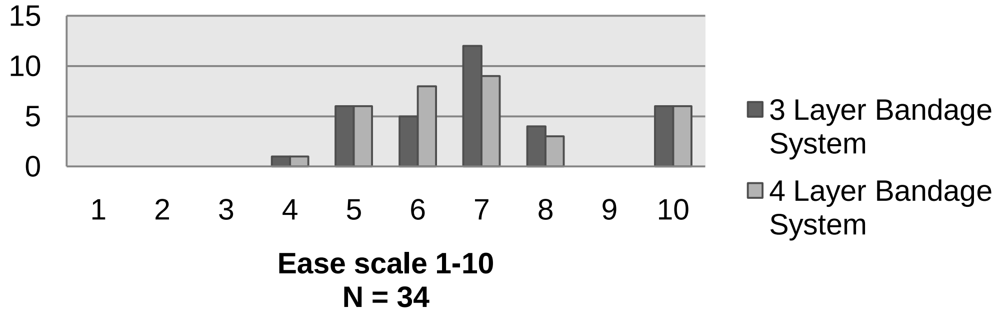
Although there was a slight decrease in the numbers of participants rating the task as relatively easy on day 3 as compared to day 1, this was obviously compensated by others rating the task easier, as indicated by the higher mean scores on day 3. For both the three and four layer bandage systems there was a small increase in the mean ratings for ease of dressing over the three day wear time, however neither in the three layer bandage system from day 1 (mean = 7.15, SD = 1.62) to day 3 (mean 7.31, SD = 1.67) (t = 7.69, DF = 32, p = 0.46) or the four layer bandage system on day 1 (mean = 7.03, SD = 1.67) compared to day 3 (mean = 7.27, SD = 1.64) (t = 7.67, DF = 30, p = 0.42) was this increase statistically significant.

Table 20: Participant Responses To The Ease of Finding Clothes To Wear Over The Compression Bandage Systems Over 3 Days

Day	Bandage System	N	Yes	Percentage	No	Percentage
1	3 Layer	34	31	91.2%	3	8.8%
	4 Layer	34	31	91.2%	3	8.8%
2	3 Layer	33	31	93.9%	2	6.1%
	4 Layer	30	28	93.3%	2	6.7%
3	3 Layer	32	27	84.4%	5	15.6%
	4 Layer	30	26	86.7%	4	13.3%

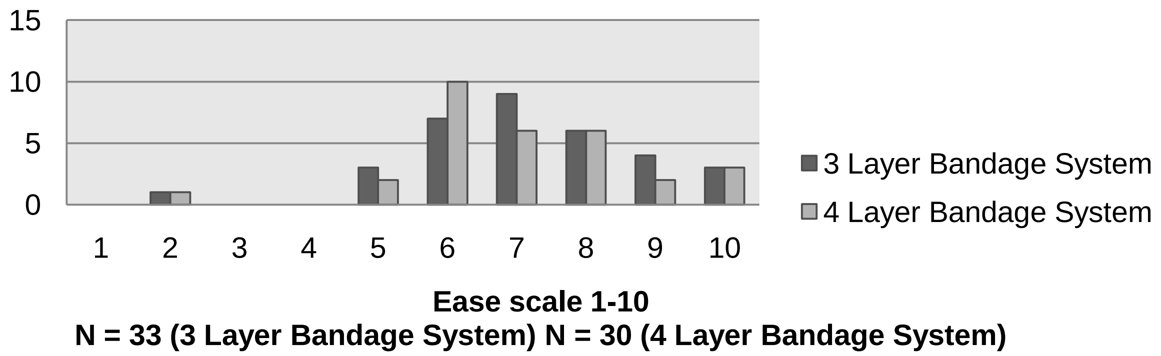
On day 1, 31(91%) of the participants (Table 20) agreed that the task of finding clothes to wear over the three layer bandage system was easy, while the remaining 3(9%) disagreed with this statement. Twenty-seven (79%) of the participants (Figure 16) rated the task as relatively easy, between 6 and 10, while the remaining 7 (21%) participants rated it as relatively difficult, between 4 and 5, giving a mean score of 7.06.

Figure 16: Ease Of Finding Clothes To Wear Over The Compression Bandage Systems On Day 1



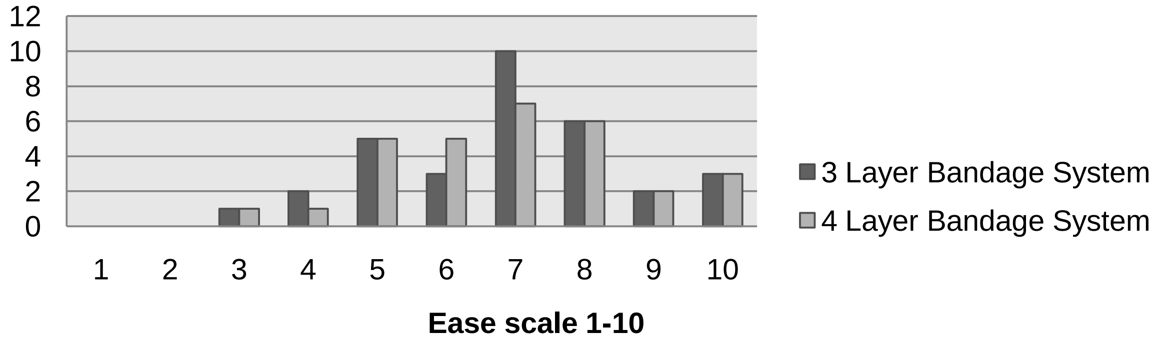
Similar results were found with the four layer bandage system. Thirty (91%) participants agreed finding clothes to wear over the four layer bandage system was easy (Table 20), with the remaining 3 (9%) participants disagreeing with this statement. The majority of participants (79%) rated the ease of the task between 6 and 10, with the remaining 7 (21%) participants giving ratings between 4 and 5 (Figure 16) to obtain a mean score of 7.15.

Figure 17: Ease Of Finding Clothes To Wear Over The Compression Bandage Systems On Day 2



Results on day 2 were comparable to day 1 with 31 (94%) participants continuing to agree that finding clothes to wear over the three layer bandage system was easy (Table 20). Four (12%) of the participants (Figure 17) rated it as relatively difficult with scores between 2 and 4, while the remaining 29 (88%) continued to find it relatively easy, ratings between 6 and 10, resulting in a mean score of 7.15. Similarly, 28 (93%) of the participants' continued to agree that finding clothes to wear over the four layer bandage system on day 2 was easy (Table 20). Three (10%) participants rated the task as relatively difficult, between 2 and 5, and the other 27 (90%) participants as relatively easy between 6 and 10 (Figure 17). There were no noteworthy differences between the three layer bandage system (mean = 7.30, SD = 1.61) and the four layer bandage system (mean = 7.20, SD = 1.58) (t = 1.5, DF = 30, p = 0.18) for the task of finding clothes to wear.

Figure 18: Ease Of Finding Clothes To Wear Over The Compression Bandage Systems On Day 3



N = 32 (3 Layer Bandage System) N = 30 (4 Layer Bandage System

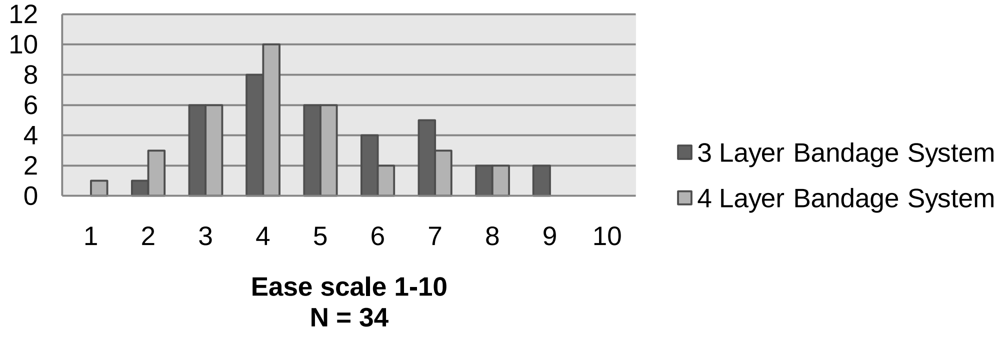
As shown in Table 20, on day 3, the number of participants who agreed the task of finding clothes to wear over the three layer bandage system reduced to 27 (84%) and the number who disagreed with this statement increased to 5 (16%). Although there was a small increase in participants to 8 (25%) who rated the task between 3 and 5, indicating they were having some difficulty in finding clothes to wear over the three layer bandage system, as 24 (75%) of the participants continued to rate the task as relatively easy between 6 and 10, (Figure 18), this resulted in a mean score of 6.87. Similarly, the number of participants who agreed the task of finding clothes to wear over the four layer bandage system was easy, also reduced to 26 (87%) and the number who disagreed with this statement increased to 4 (13%). The number of participants who rated the task as relatively difficult between 3 and 5 increased to 7 (23%), however as 23 (77%) participants still rated the task as relatively easy, this resulted in a mean score of 6.90. Therefore, the participant scores for both bandage systems in terms of finding clothes to wear over the bandage systems remained consistently easy over the three days.

Table 21: Participant Responses To The Ease Of Finding Footwear To Fit Over the Compression Bandage Systems Over 3 Days

Day	Bandage System	N	Yes	Percentage	No	Percentage
1	3 Layer	34	13	38.2%	21	61.8%
	4 Layer	34	8	23.5%	26	76.5%
2	3 Layer	33	13	39.4%	20	60.6%
	4 Layer	30	8	26.7%	22	73.3%
3	3 Layer	32	14	43.8%	18	56.2%
	4 Layer	30	9	30%	21	70%

On day 1, 13 (38%) participants agreed that finding footwear to wear with the three layer bandage system was easy, recording ratings (Figure 19) between 6 and 9 on the ease scale, while the remaining 21 (62%) participants disagreed, rating the ease between 2 and 5 to give an overall mean score of 5.15.

Figure 19: Ease Of Finding Footwear To Fit Over The Compression Bandage Systems On Day 1



In comparison, 26 (76%) participants on day one found the task of finding footwear to fit over the four layer bandage system relatively difficult, giving ratings between 1 and 5, while the remaining 8 (24%) participants rated the ease of the task between 6 and 8 and the resulting mean rating was 4.38. Therefore, finding footwear to fit over the four layer bandage system was significantly more difficult (mean = 4.38, SD = 1.71) compared to the three layer bandage system (mean = 5.15, SD = 1.73) (t = 0, DF = 34, p = 0.02).

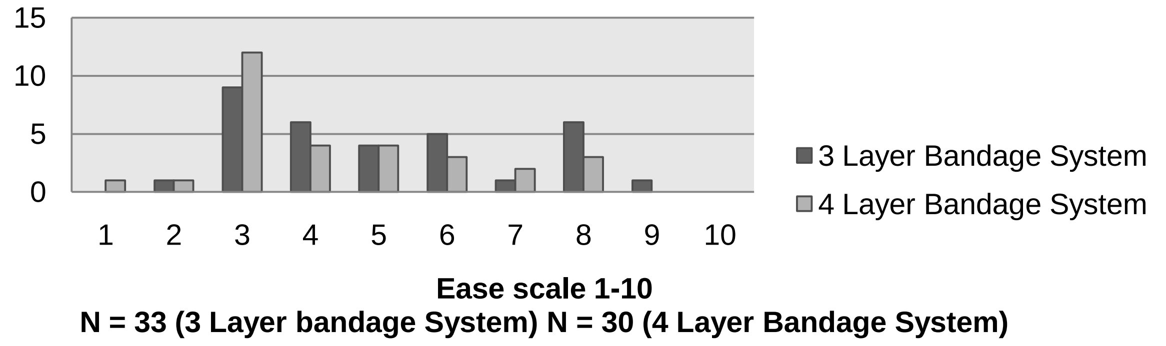
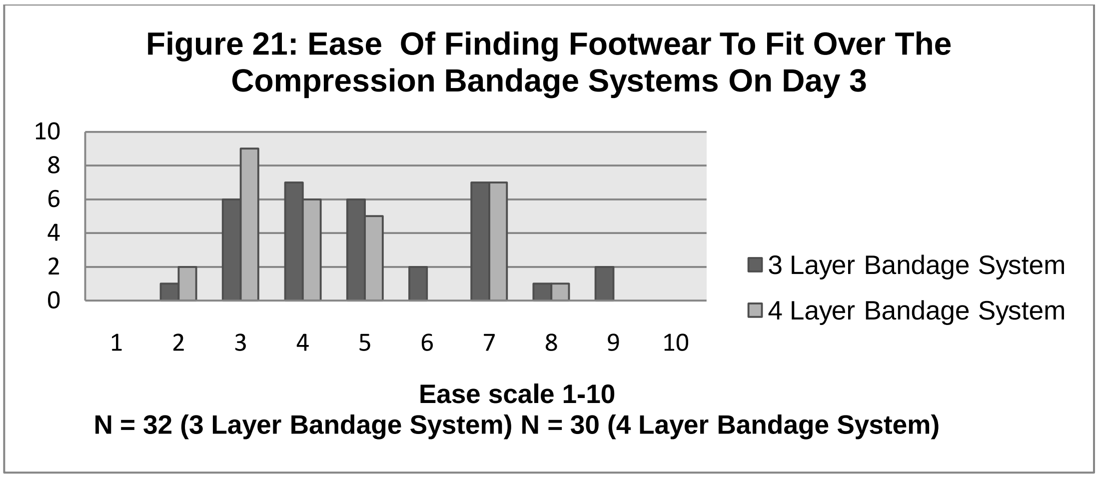


Figure 20: Ease Of Finding Footwear To Fit Over The Compression Bandage Systems On Day 2

Similar results were recorded on both days 2 and 3 for the three layer bandage system when 20 (62%) continued to rate the task of finding footwear as difficult (between 2 and 5), whereas the remaining 12 (38%) participants rated the task as easier (between 6 and 9) and the mean ratings were 5.06 and 5.16 respectively. Therefore there were no noteworthy differences between participant scores over the 3 day bandage wear time.

Equally, the results on day 2 for the four layer bandage system were comparable to day 1. Twenty two (73%) participants continued to score the task as relatively difficult (between 1 and 5), while the remaining 8 (27%) of participants rated the task as easier (between 6 and 8). Finding footwear to fit over the four layer bandage system on the second day was still significantly more difficult (mean = 4.37, SD = 1.88) than over the three layer bandage system (mean = 5.06, SD = 2.01), (t = 0, DF = 30, p = 0.17).

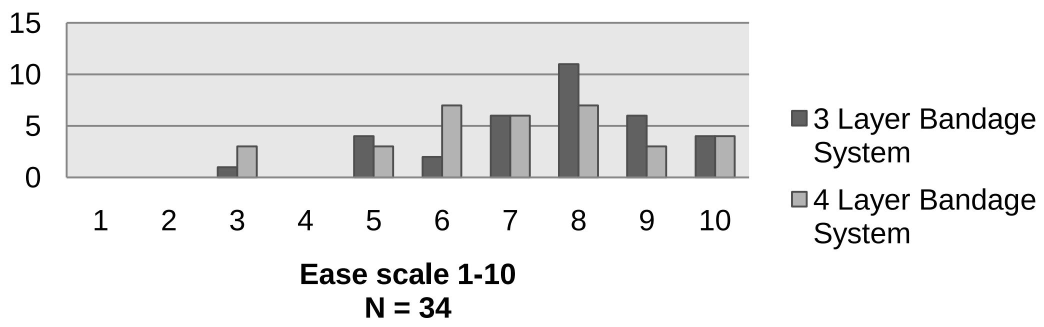


By day 3 more participants were finding it easy to find footwear to fit over the four layer bandage system with 22 (73%) rating the task between 2 and 5 and the remaining 8 (27%) rating it between 7 and 8. Nevertheless, the mean rating (4.57) was only marginally higher than on day 2. Despite this slight increase there were no significant differences between the participants score on day 3 compared to the previous 2 days of bandage wear time and finding footwear to fit over the four layer bandage system still remained considerably more difficult (mean = 4.57, SD = 1.77) compared to the three layer bandage system (mean = 5.16, SD = 1.87) (t = 0, DF = 30, p = 0.17).

Table 22: Participant Responses to the Ease of Completing Home Duties While Wearing the Compression Bandage Systems Over 3 Days						
Day	Bandage System	N	Yes	Percentage	No	Percentage
1	3 Layer	34	33	97.1%	1	2.9%
	4 Layer	34	31	91.2%	3	8.8%
2	3 Layer	33	33	100%	0	0%
	4 Layer	30	27	90%	3	10%
3	3 Layer	32	29	90.6%	3	9.4%
	4 Layer	30	3	86.7%	4	13.3%

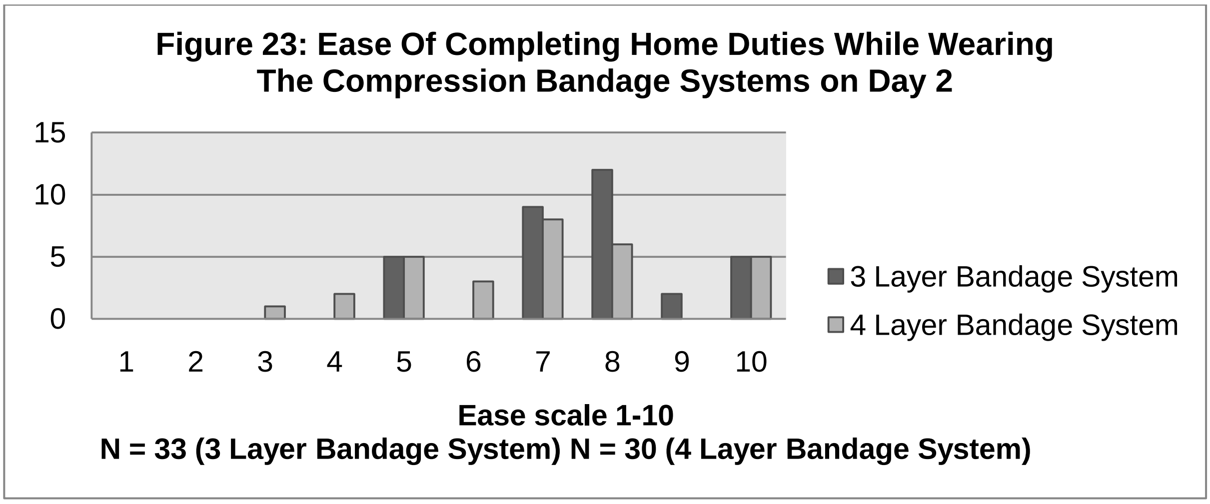
On day 1, 33 (97%) of the participants agreed that completing home duties while wearing the three layer bandage system was easy, with only 1 participant disagreeing with this statement. Twenty-nine (85%) rated completing home duties as relatively easy (Figure 22) between 3 and 5 making the mean rating of 7.62.

Figure 22: Ease Of Completing Home Duties While Wearing The Compression Bandage Systems On Day 1



Thirty one (91%) participants on day 1 agreed that completing home duties whilst wearing the four layer bandage system was easy, with only 3 (9%)

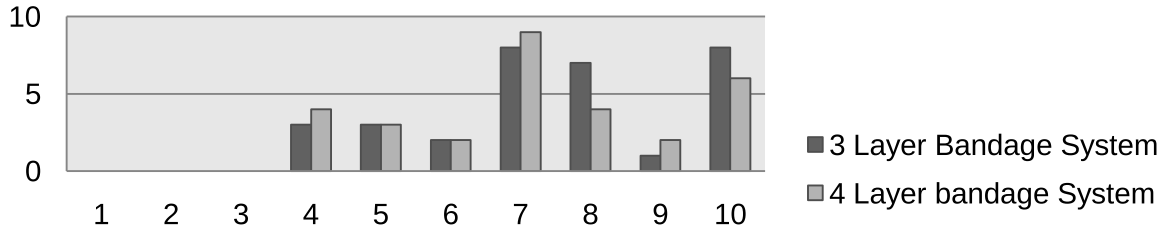
disagreeing with this statement. Twenty seven (79%) participants rated completing home duties between 6 and 10 (relatively easy) while the remaining 7 (21%) judged it as relatively difficult (between 3 and 5), to give a mean rating of 7.2 (Figure 22). On day 1, the participants found completing home duties whilst wearing the three layer bandage system significantly more easier (mean = 7.62, DF = 1.67) than wearing the four layer bandage system (mean = 6.94, DF = 1.95) (t = 0, DF = 34, p = 0).



On day 2, all of the participants (100%) agreed it was easy completing home duties while wearing the three layer bandage system (Table 22). Similar results were recorded for the three layer bandage system on day 2 in that 28 (85%) continued to rate completing home duties between 6 and 10 (relatively easy) with only 5 (15%) participants (Figure 23) giving a score of less than 6 and this resulted in a mean score of 7.64.

Twenty two (73%) participants on day 2, continued to rate home duties whilst wearing the four layer bandage system relatively easy (between 6 and 10), with the remaining 8 (27%) rating the task as relatively difficult (between 3 and 5) and the mean rating being 6.93. There were no significant differences noted between the participants' ratings over the first 2 days of bandage wear time, thus meaning that completing home duties on the second day remained significantly more difficult whilst wearing the four layer bandage system (mean = 6.93, SD = 1.93) than the three layer bandage system (mean = 7.64, SD = 1.50) (t = 0, DF = 30, p = 0.007).

Figure 24: Ease Of Completing Home Duties While Wearing The Compression Bandaging Systems On Day 3



Ease scale 1-10
N = 32 (3 Layer Bandage System) N = 30 (4 Layer Bandage System)

On day 3, 29 (91%) participants agreed that completing home duties while wearing the three layer bandage system was easy, while the remaining 3 (9%) disagreed with this statement (Table 22). Now 6 (19%) were rating completing home duties as relatively difficult (between 4 and 5), whilst the remaining 26 (81%) continued to rate it as relatively easy (between 6 and 10) (Figure 24). Although the mean score on day 3 reduced to 7.50, this reduction was insufficient for the difference in ratings over the 3 day bandage wear time for the three layer bandage system.

There was a slight positive shift in the participant ratings on day 3 for the four layer bandage system (Figure 24) where 23 (77%) of participants rated the task relatively easy (6 to 10) while the remaining 7 (23%) of participants rated it between 4 and 5, and the mean score was 7.20. Even with this small increase, completing home duties still remained consistently more difficult whilst wearing the four layer bandage system (mean = 7.20, SD = 1.990) than the three layer bandage system (mean = 7.50, SD = 1.934) (t = 0, DF = 30, p = 0.16).

Chapter 5

Discussion

Introduction

Compression bandages used to treat venous leg ulcers should achieve and sustain effective levels and gradients of pressure and minimise trauma. The inelastic bandage systems used in this study were chosen as they are widely used in the domiciliary health care setting in Western Australia for venous leg ulcer compression. However without detailed information on sub-bandage pressures provided by these bandages it's difficult to draw conclusions from previously published reports on compression therapy. The literature revealed studies which have included bandages of differing properties and used in a variety of combinations with different application techniques. Most studies were found to have only reported on pressures obtained on application rather than therapeutic pressures achieved over bandage wear time. This study sought to address this knowledge deficit.

Sustained Graduated Compression

A significant outcome of this study was evidence that graduated compression was achieved and sustained, under compression bandages. Although the ascending pressure gradient between the ankle and the calf (whilst the participant was standing) did not always measure 50% higher at the ankle until approximately 48 hours bandage wear time, in all cases and with each postural change, the pressures were always higher at the ankle than the calf. Overall the ankle pressures were higher when standing compared to sitting and generally higher when sitting as compared to resting in the supine position. Even with the use of an outer elasticated tubular retention bandage, the pressure difference between lying and standing was always greater than 10% on application and at the end of the 72 hour bandage wear time. Thus both bandage systems can conclusively be classified as inelastic according to the static stiffness index (Mosti et al., 2008).

Bandage Integrity

In practice, it is typically thought that the use of an outer elasticated tubular retention bandage will assist with keeping the compression bandages *in situ* as well as contribute to the maintenance of the sub-bandage pressures. However, this study found the use of the elasticated tubular bandage over inelastic short stretch compression bandages had a very minimal influence on the overall sub-bandage pressures at application. Furthermore they contributed only an additional 1-2mmHg in the three layer bandage system and 3-5mmHg in the four layer bandage system over time. In fact, the inelastic compression bandages were found to slip when worn beneath the elasticated retention bandage, recording a mean slippage of 5.22cm for the three layer bandage system and 5.10cm for the four layer bandage system after 72 hours bandage wear time. As many as 83% of the participants commented on bandage slippage being problematic after 48 hours wear time. The continued use of this bandage in combination with inelastic short stretch bandages therefore requires further evaluation.

It is conventionally taught that compression therapy for the treatment of chronic venous ulceration should deliver a pressure of 30-40mmHg at the ankle with a 50% diminishing ascending gradient below the popliteal fossa. The support for this within the literature represents a compromise between pressures that have been shown to have an effect on limb volume and blood flow, and pressures which an individual will tolerate (Lee et al., 2005; Mosti et al., 2008). Authors seldom discuss the posture to which these pressures apply. As recommended by Partsch (2003), ankle pressures should not exceed 30mmHg when in the resting supine position, however, higher pressures of 40-50mmHg are required in the standing position to accommodate fluctuations during walking.

In this study, the three layer bandage system produced a mean ankle resting pressure of 34.32mmHg on application which rose to 48.12mmHg on standing. Higher pressure differences were more apparent with the four layer bandage system. The resting mean ankle pressures were found to be above the recommended 30mmHg, and measured a mean 54.65mmHg (range 45-67mmHg) which rose as high as a mean 65.74mmHg (range 52-81mmHg) on standing. This could be considered dangerous as pressures greater than 60mmHg have been shown to produce an 84% decrease in blood flow (Hafner et al., 2000). The bandages however, had a significant pressure decline of 13.36mmHg within the first 4 to 6 hours; therefore these elevated pressures were not maintained.

A rapid pressure loss after a few hours of wear time is the main disadvantage associated with inelastic short stretch bandages (Hafner et al., 2000). Previous studies have suggested a pressure loss as high as 59% after 3 hours wear time (Larsen & Futtrup, 2004) and these authors recommend daily bandage application. Reduction in sub-bandage pressure was also found in this study, although not as significant as previously reported. Both the three and four layer inelastic bandage systems showed a 20% reduction in the mean ankle pressures within the first 4-6 hours of wear time. Although the sub-bandage pressures continued to decline with both bandage systems throughout the wear time period, the pressures appeared to stabilise after 24 hours of wear time as there were no further rapid pressure losses noted.

The sub-bandage mean ankle pressure for the three layer bandage system at 48 hours declined to 32.21mmHg (range 24-40mmHg) and the mean calf pressure reduced to 17.12mmHg (range 11-24mmHg). By 72 hours the ankle sub-bandage pressures declined by a total of 40% since application, recording mean pressure of 28.75mmHg (range 23-34mmHg). The calf sub-bandage pressures reduced by 57% after 72 hours wear time, resulting in mean pressure of 14.56mmHg (range 10-20mmHg), well below the recommended guidelines.

Although the four layer bandage system pressures remained considerably higher than the three layer bandage system throughout the 3 day wear time, the pressure reductions were significantly greater. The sub-bandage mean ankle pressure for the four layer bandage system at 48 hours declined to 38.87mmHg (32-48mmHg) and the mean calf pressure reduced to 20.50mmHg (17-26mmHg). By 72 hours the ankle sub-bandage pressures reduced by a total of 47% since application, recording mean pressures of 35.03mmHg (range 32-40mmHg). The calf sub-bandage pressures declined by 69% after 72 hours wear time, resulting in a mean pressure of 16.53mmHg (range 12-20mmHg). Therefore, if the goal in compression therapy is to maintain ankle sub-bandage pressures of 30-40mmHg, the three layer bandage system would require second daily application (48 hour) and the four layer bandage system would require re-application at least third daily (72 hour).

Effects of Bandages on Activities of Daily Living

The impact of venous leg ulceration on quality of life is well documented within the literature. Pain, immobility, sleep disturbance and difficulties associated with finding footwear to fit, have been identified as major impacts to physical functioning (Heinen et al., 2007; Persoon et al., 2004). The findings of this study are consistent with these studies' results. Discomfort in particular was a significant finding for all participants in this study. Participants experienced discomfort throughout the day, whilst resting/sleeping, and interestingly, during periods of mobility. Difficulties associated with the need to find suitable footwear to accommodate the compression bandages also had a significant impact on otherwise healthy, independent participants. As many as 73% to 79% of participants rated the task of finding footwear to accommodate the four layer inelastic bandage system difficult, producing mean ease scores of between 4.36 and 4.57 on a scale of 1-10, where 10 represents no difficulty over the 3 day bandage wear time. Although the three layer bandage system rated considerably better, 62% of participants rated the task as difficult with mean scores between 5.06 and 5.16 over the 3 days. These results are entirely consistent with the issues reported in previous studies of compression bandages. Heinen et al. (2007) found as many as 60% of patients reported problems with footwear because of the volume of bandages, of which 44% of patients resorted to wearing larger sized slippers or mules.

Pain related to venous leg ulceration has been documented as a major symptom. The pain experienced by individuals has been largely attributed to the wound with reported variations in pain type and intensity throughout the day. Pain scores associated with venous leg ulceration have been reported to be 4.2 to 4.9, on a range of 0-10, where a score of 0 represents no pain (Heinen et al., 2007; Persoon et al., 2004). Factors exacerbating leg ulcer pain include swelling (Krasner, 1998), weather or seasonal influences (Hyde et al., 1999), mobility and underlying co-morbidities (Persoon et al., 2004). Some other authors have also suggested compression bandages may be a contributing factor (Bland 1996; Ebbeskog, 2001; Heinen et al., 2007). In this study, bandage discomfort in the non-ulcerated participant whilst wearing the four layer bandage system was problematic for 50% of participants. On a scale of 1-10, where 10 represents no discomfort, these study participants' scored between 5.17 and 5.97 over the 3 day wear time. Although the three layer bandage system rated significantly better with mean comfort scores between 7.31 and 7.62, 18-19% of participants still found the bandages uncomfortable throughout the day. Interestingly, the intensity of the sub-bandage pressure did not seem to influence the participant comfort scores, for even when the sub-bandage ankle pressures reduced by 41% at the end of day 2, there were no significant differences in participant comfort scores and in some instances, the comfort scores worsened.

The reported levels of comfort worsened during times of rest or sleep for the four layer bandage system particularly over the first two nights. Comfort levels of 3.82 and 4.87 respectively were reported. Although there was a significant improvement by day 3, with mean score of 5.13, 67% continued to report poor comfort scores of between 1 and 5, demonstrating that this was an area of considerable concern for the four layer inelastic bandage system. Although the participant comfort score for the three layer bandage system was significantly better, recording between 7.16 and 7.62 over the 72 hours wear time, there were still as many as 15% to 33% of participants who reported discomfort during times of rest and sleep with this bandage system. Sleep disturbance in previous studies has been identified as problematic in at least two-third of patients with leg ulceration (Hyland et al., 1994) and was found to be related to pain, uncomfortable sleeping positions (Douglas, 2001; Hyde et al.,1999) and, itching and wound leakage (Heinen et al., 2007). Although Franks and Moffatt (1998) found patient scores on the sleep-subscale of the Nottingham Health Profile are not significantly higher than those in an age-matched normal group. This study however, found compression bandages can contribute to pain related issues associated with sleep disturbance.

Several studies have identified impaired mobility as a significant problem associated with leg ulceration. Limitations in mobility have been largely recognised as a result of aggravating leg ulcer pain, swollen legs, fear of falling or hurting their leg and the need to wear larger shoes to accommodate the compression bandages (Hammer et al., 1994; Heinen et al., 2007; Persoon et al., 2004). In addition, immobility scores in leg ulcer patients' samples are significantly higher than age/sex – matched normal values (Franks & Moffatt, 1998; Price & Harding, 1996). In this study, participant comfort scores were significantly higher while walking compared to scores obtained for resting or sleeping and were slightly better in comparison to the overall participant comfort scores throughout the day. It was demonstrated that 84%-94% of participants provided positive comfort scores for the three layer bandage system to obtain a mean comfort score of between 7.50 and 7.74 over the 3 days, in contrast 33%-41% of the participants found the four layer bandage system uncomfortable whilst walking. Pain was a particular problem over the medial aspect on the dorsal arch of the foot in the four layer bandage which resulted in mean comfort scores between 5.57 and 6.10 throughout the 72 hour bandage wear time.

The limitations in mobility associated with venous leg ulceration has been identified as a contributing factor to the difficulties associated with participation in daily activities such as housekeeping and shopping in as many as 48% of patients (Douglas, 2001; Heinen et al., 2007). In this study, the task of completing home duties was largely rated positively by participants with mean ease scores between 7.50 and 7.62 for the three layer bandage system and mean ease scores between 6.93 and 7.20 for the four layer bandage system over the 3 day bandage wear time. However, it should be noted that 15% to 19% of participants had difficulties maintaining home duties whilst wearing the three layer bandage system and as many as 18% to 27% of participants rated the task of completing home duties as difficult, between 3 and 5, on a scale of 1-10, where 10 represents no difficulty whilst wearing the four layer bandage system. Therefore wearing of compression bandaging, particularly the four layer inelastic system, may contribute to the discomfort associated with mobility and as a result affect activities of daily living, including home duties in some individuals.

Leg ulceration has been identified as an obstacle for patients in maintaining personal hygiene activities (Douglas 2001; Ebbeskog, 2001). Persoon et al. (2004) largely attributed this problem to impaired mobility. In this study, 71% of participants found attending hygiene needs difficult on day 1 whilst wearing the three layer bandage system and 76% of participants found this task difficult whilst wearing the four layer bandage system. Participants reported mean scores of 4.88 and 4.64 respectively on a scale of 1-10, where 10 represent no difficulty. Although the results on day 2 were similar to day 1, by day 3 there was a significant improvement in participants' scores compared to day 1 for both bandage systems whereby the mean ease score for the three layer bandage system was 5.34 and the four layer bandage system was 5.23, suggesting participants over time were able to adapt their personal hygiene activities to meet their needs. Participants did not report difficulties in finding clothes to wear over the compression bandaging systems, nor problems associated with getting dressed.

Limitations

The study only included a small number of healthy, active participants without a history of venous insufficiency or current leg ulceration. Sub-bandage pressures achieved on application could be lower in those with venous disease, and further research is necessary to determine the clinical effectiveness of these bandage systems in patients with venous leg ulcerations.

Although there are a variety of compression bandage systems used in clinical practice for the management of venous leg ulcers, this study was not designed to include these other bandage systems. Establishing the sub-bandage pressures obtained and sustained by these other systems as well as determining their effects on the activities of daily living will require further investigation.

Of the 34 participants recruited to the study, only two were male. The sub-bandage pressure, ease and comfort scores may have subsequently been different if there were more male participants. Although, the results of previous published studies concerning the relationship between gender and physical functionality difficulties including pain are inconclusive (Persoon et al., 2004). In addition, this study was only designed to capture the short term effects exerted by inelastic compression bandage systems on physical functioning and did not include the impacts on longer periods of use or psychological and social aspects of life. Larger, more detailed studies would be required to include these domains in order to obtain a clearer indication of the effects that these treatment regimes have on quality of life.

Recommendations

This study was conducted on healthy participants with no history or evidence of venous disease, therefore the recommendations can only be related specifically to this cohort of individuals. The principle recommendation is to repeat this study on individuals with venous disease and those with venous ulcerations. However, the recommendations that result from this study could be extrapolated to individuals with venous leg ulcerations when compression bandaging is used with all due care until further studies on individuals with venous leg ulceration can be conducted.

There are seven recommendations made by the author in response to the study findings and they are:

(1) The three layer inelastic bandage system should be reapplied at least every 48 hours.

(2) The four layer inelastic bandage system should be reapplied at least every 72 hours.

(3) As high sub-bandage pressures were found with the four layer inelastic bandage system, particularly on application and within the first 24 hours wear time, this bandage system should be avoided in any individual suspected to have any degree of co-existing arterial insufficiency or peripheral neuropathy.

(4) In the event that an individual is unable to tolerate the inelastic four layer bandage system, the three layer inelastic bandage system should be trialled as an alternative or attempts should be made to assess the individuals' tolerance to alternative bandage systems.

(5) Further evaluation of sub-bandage pressures obtained and sustained in the inelastic compression bandage systems is necessary in patients with venous insufficiency and in patients with venous leg ulcerations.

(6) Evaluation of the sub-bandage pressures obtained and sustained performance of the multi-layered compression bandage systems and the elasticated bandage systems available is necessary in order to provide guidance for clinical application and standardise the compression therapy systems used in practice.

(7) The development of a well-validated and reliable symptom assessment tool is needed in clinical practice to assess the needs of individuals with venous leg ulcers and to evaluate the effects that treatment interventions have on the quality of life of individuals whilst involved in activities of daily living.

Conclusion

This study succeeded in giving insight into the sustainability of sub-bandage pressures in the inelastic short stretch bandage systems. In addition, this study has also provided insight into the associated issues of wearing inelastic compression bandages whilst performing activities of daily living. These problems are likely to be related. The participant discomfort associated with the inelastic compression bandage systems impacted on sleep disturbance, mobility and daily activities. Proper footwear is important to enhance mobility to stimulate the calf muscle.

The problems associated with wearing inelastic bandages in this study were similar to previous reported studies examining the impact venous leg ulcerations have on quality of life. Although there is a possible likelihood that treatment regimes in the form of inelastic compression bandages could possibly contribute to the problems experienced by individuals with venous leg ulcers, further studies are needed to validate this assumption.

Chapter 6

Conclusion

The inelastic three layer compression bandage system is suitable for the management of patients with venous insufficiency as it produces high standing pressures and shows a significant pressure decrease when the individual is in the supine position. Although this bandage system was well tolerated by the participants in this trial, the main disadvantage was the significant sub-bandage pressure decline observed within the first 24 hour wear time. Therefore this bandage system would require re-application after 48 hours wear time. The inelastic four layer compression bandage system on the other hand, was observed to maintain the therapeutic sub-bandage pressure range up to 72 hours wear time. However, this compression bandage system was not well tolerated by the participants in this study as it impacted on aspects of their physical functioning whilst participating in activities of daily living.

The data also indicates that we should be cautious of the initial pressures obtained in the four layer inelastic bandage system, and therefore this system should be avoided in individuals suspected of mixed venous arterial disease and those with peripheral neuropathy. Further research is necessary to determine whether the same findings would be mirrored in patients with venous insufficiency and leg ulceration. It is important that health professionals who apply compression therapy understand the physical properties and the potential effects achieved with the bandage systems used in clinical practice. Further studies are necessary to determine the sub-bandage pressures achieved by different bandage materials and various methods of application.

Although the impact of venous leg ulceration on quality of life are well documented within the literature, this study succeeded in giving insight into the physical functioning difficulties incurred by healthy participants with no venous ulceration, when wearing compression bandages. The results highlight the need for a well-validated and reliable symptom assessment tool that can be used in clinical practice to not only assess the needs of individuals with chronic wounds, but one which can also be used to evaluate the effects that treatment interventions have on the quality of life of patients. Such assessments would support clinical rationales for leg ulcer management choices. Current quality indicators and guidelines focus on wound healing and recurrence rates, measures which are primary concern in acute wounds. However, venous leg ulceration is a chronic condition and thus greater attention needs to be paid to the impact of treatment on the individual’s quality of life and ability to complete everyday activities. Systematic assessment and appropriate interventions for the management of ulcer-related problems, in particular pain should be incorporated into treatment plans and evaluated regularly.

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Declaration:

Every reasonable effort has been made to acknowledge the owners of copyright material. I would be pleased to hear from any copyright owner who has been omitted or incorrectly acknowledged.

Appendix I

Curtin University of Technology School of Nursing and Midwifery

PROJECT INFORMATION SHEET

Project Title: Determining the Effectiveness of Inelastic Short Stretch Bandages in Sustaining Sub-Bandage Graduated Compression

You are invited to participate in a research study. Please take time to read this information sheet and the attached consent form, which if you agree to take part, you will be asked to sign on commencement of the study.

What is this study about?

This study will compare the sub-bandage pressures obtained and sustained from the three layer and four layer inelastic, short stretch bandage systems, using the spiral method of application. The bandage pressures will be measured on application, with postural change and at set time intervals throughout the 72 hour period to determine which bandage system is most effective at sustaining graduated compression of 30-40mmHg at the ankle. The comfort of each bandage system will also be measured daily.

How will I be involved?

Should you agree to participate in this study, you will be required to have a Doppler assessment to determine your ankle/brachial index pressure. Measurements of your ankle and calf circumference will also be recorded. A sub-bandage pressure apparatus will be placed on your legs, followed by the compression bandaging. One leg will have the three layer bandage system and the other will have the four layer bandage system. You will be required to wear the compression bandaging for 72 hours and record the pressure measurements at set time intervals. During the study you will be asked to complete an evaluation form daily to measure the comfort levels of each of the bandage systems.

Benefits and Risks

In participating in this study you will be able to personally experience the effects of wearing compression therapy, so you will be able to provide accurate education and expectations of this treatment to your clients. In addition, you will be contributing to informing best practice in the nursing management of venous leg ulcers which could potentially lead to improved clinical outcomes for a large number of clients.

There is a small possibility that you may get some discomfort from the bandages and although your lower legs will be well padded there is also a possibility that you could experience some pressure associated with the sub-bandage pressure apparatus. Should this occur you will be advised to remove the bandaging and sub-bandage pressure monitor.

Voluntary Participation

It is important for you to know that you do not have to take part in this study and if you decide not to be involved, your employment now, or in the future, will in no way be affected. If after agreeing you later change your mind, you may withdraw your consent at any time and all your records will be destroyed.

How will your privacy be protected?

If you decide to take part in the study all information relating to you that is used as part of the study will be kept strictly confidential. To protect your privacy, your name will not be kept on any study data but will instead you will be allocated a confidential study number. The results of this study may be presented and reported in journal articles but will not involve the reporting of any personal information. In accordance with the national research guidelines, all study records will be stored for 5 years in a secure locked location and then will be destroyed.

Who to contact if you have any further questions about the study?

Should you decide to participate in this study or have any further queries regarding this study please either contact me, Liz Howse 0410 222 012, or my project supervisors, Associate Professor Keryln Carville or Professor Gill Lewin through 9242 0242. Your participation in this study is greatly appreciated, thank you for your support in this project.

Concerns or Complaints

The Silver Chain Human Ethics Committee has given ethics approval for the conduct of this project. If you have any concerns or complaints about the project, please contact Dawn Woods, Research Support Co-ordinator, Silver Chain, 6 Sundercombe Street, Osborne Park WA 6017, telephone 92016758.

Appendix II

Curtin University of Technology School of Nursing and Midwifery

PROJECT CONSENT FORM

Project Title: Determining the Effectiveness of Inelastic Short Stretch Bandages in Sustaining Sub-Bandage Graduated Compression

I____________________________________

(Print Full Name)

- I have read the Information Sheet about this study and any questions I have asked have been answered to my satisfaction
- I understand that participation is voluntary and I have the right to withdraw at any time without consequence
- I understand that all information collected is confidential and will not identify me in any way
- I agree that the research data collected from this study may be presented and published, provided that I am not identifiable
- I have been provided with a copy of the Information Sheet for this project and understand that I may contact the researcher if I have any further questions regarding this project

Consent

………………………………. ………………………

Signature of Participant Date

………………………………. ………………………

Signature of Researcher Date

Appendix III

Curtin University of Technology School of Nursing and Midwifery

Ongoing Data Collection Form

Recording Pressures

- Walk for 3 minutes, then while standing with legs equally apart and feet flat on the floor attached the monitor to sensor tubing.
- Turn monitor on, slowly pull plunger out, and when indicated on the monitor, push plunger in. Record the pressure obtained.

1. **Study Number: ________________________**

2. **Please tick one day only**

Day 1	Day 2	Day 3

3. **Date:** _ _/_ _/_ _ (dd/mm/yy)

4. **Record pressures obtained immediately after getting out of bed in the morning.**

   3 Layer bandage system (_______) leg 4 layer bandage system (_______) leg

   Standing: Ankle ______ mmHg Calf ______ mmHg

   Standing: Ankle ______ mmHg Calf ______ mmHg

5. **Record pressures obtained between 1200 and 1400 hours**

   3 Layer bandage system (_______) leg 4 layer bandage system (_______) leg

   Standing: Ankle ______ mmHg Calf ______ mmHg

   Standing: Ankle ______ mmHg Calf ______ mmHg

6. Record pressures obtained between 2000 and 2200 hours

3 Layer bandage system (________) leg 4 layer bandage system (________) leg

Standing: Ankle ________ mmHg Calf _______ mmHg

Standing: Ankle ________ mmHg Calf _______ mmHg

Appendix IV

Curtin University of Technology School of Nursing and Midwifery

Initial Data Collection Form

1. **Study Number:** _______________________

2. **Date:** _ _/_ _/_ _ (dd/mm/yy)

3. **Gender:** Male ☐ Female ☐

4. **Which leg randomised to three layer bandage method?**

   Right leg ☐ Left leg ☐

5. **What is the Ankle Brachial Pressure Index (ABPI)?**

   Right Leg_______ Left Leg_______

6. **Leg Dimensions:**

Right Leg: Length _______ cm Ankle Width _______ cm
Calf Width _______ cm

Left Leg: Length _______ cm Ankle Width _______ cm
Calf Width _______ cm

7. **Pressures obtained from the three layer bandage system on application**

(a) Layer 2: One spiralled comprilan bandage

Lying: Ankle _______ mmHg Calf _______ mmHg

Sitting: Ankle _______ mmHg Calf _______ mmHg

Standing: Ankle _______ mmHg Calf _______ mmHg

(b) Layer 3: One Elasticated Bandage

Lying: Ankle _______ mmHg Calf _______ mmHg

Sitting: Ankle _______ mmHg Calf _______ mmHg

Standing: Ankle _______ mmHg Calf _______ mmHg

8. **Pressures obtained from the four layer bandage system on application**

(a) Layer 2: One spiralled comprilan bandage

Lying: Ankle _______ mmHg Calf _______ mmHg

Sitting: Ankle _______ mmHg Calf _______ mmHg

Standing: Ankle _______ mmHg Calf _______ mmHg

(b) Layer 3: Two spiralled comprilan Bandage

Lying: Ankle _______ mmHg Calf _______ mmHg

Sitting: Ankle _______ mmHg Calf _______ mmHg

Standing: Ankle _______ mmHg Calf _______ mmHg

(c) Layer 4: One Elasticated Bandage

Lying: Ankle _______ mmHg Calf _______ mmHg

Sitting: Ankle _______ mmHg Calf _______mmHg

Standing: Ankle _______ mmHg Calf _______mmHg

Appendix V

Curtin University of Technology School of Nursing and Midwifery

Final Data Collection Form

1. Study Number: ______________________

2. Date: _ _/_ _/_ _ (dd/mm/yy)

3. Pressures obtained at _______hrs (72hours) after bandage application

3 Layer bandage system (_______) Leg

4 Layer bandage system (_______) Leg

(Right Leg) Lying: Ankle _______ mmHg Calf _______ mmHg
(Left Leg) Lying: Ankle _______ mmHg Calf _______ mmHg

(Right Leg) Sitting: Ankle _______ mmHg Calf _______ mmHg
(Left Leg) Sitting: Ankle _______ mmHg Calf _______ mmHg

(Right Leg) Standing: Ankle ______ mmHg Calf ______ mmHg
(Left Leg) Standing: Ankle ______ mmHg Calf ______ mmHg

What type of activities was the participant doing 30 mins prior to testing pressures? ____

4. Was the three layer bandage system still in situ at time of assessment?

Yes ☐ **No** ☐

If No, why was the bandage system removed?

____

How long was the bandage system left in situ? ____________________

If yes were photos taken? Yes ☐ **No** ☐

5. **Was the four layer bandage system still in situ at time of assessment?**

Yes ☐ **No** ☐

If No, why was the bandage system removed?

____

How long was the bandage system left in situ? _________________

If yes, were photos taken? **Yes** ☐ **No** ☐

Was there any trauma observed to the lower leg when the three layer bandage system was removed? **Yes** ☐ **No** ☐

If yes, describe: ____

Photos taken? **Yes** ☐ **No** ☐

Was there any trauma observed to the lower leg when the four layer bandage system was removed? **Yes** ☐ **No** ☐

If yes, describe: ____

Photos taken? **Yes** ☐ **No** ☐

Appendix VI

Curtin University of Technology School of Nursing and Midwifery

Feedback Survey

Study Number: ____________   Date: _ _/_ _/_ _

Study Day Number: ____________

Thank-you for taking the time to participate in this study. Please provide us with your feedback by completing all sections of this form prior to retiring to bed at the end of each day (e.g. day 1, day 2, and day 3) during the bandage study.

Please circle the degree of comfort you experienced each day with both bandage systems with 1 being the least comfort obtained to 10 being the most comfortable.

Overall Comfort Scale

	Yes	No	Comfort Scale	Comments
The three layer bandage system was comfortable throughout the day	☐	☐	1 2 3 4 5 6 7 8 9 10	
The four layer bandage system was comfortable throughout the day	☐	☐	1 2 3 4 5 6 7 8 9 10	
The three layer bandage system was comfortable while resting/sleeping	☐	☐	1 2 3 4 5 6 7 8 9 10	
The four layer bandage system was comfortable while resting/sleeping	☐	☐	1 2 3 4 5 6 7 8 9 10	
The three layer bandage system was comfortable while walking	☐	☐	1 2 3 4 5 6 7 8 9 10	
The four layer bandage system was comfortable while walking	☐	☐	1 2 3 4 5 6 7 8 9 10	

Please circle the degree of ease you experienced each day with both bandage systems while carrying out your activities of daily living with 1 being the least ease obtained to 10 being the most ease.

Comfort Associated with Activities of Daily Living

	Yes	No	Comfort Scale	Comments
Showering/attending to hygiene needs while wearing the three layer compression bandage system was easy	☐	☐	1 2 3 4 5 6 7 8 9 10	
Showering/attending to hygiene needs while wearing the four layer compression bandage system was easy	☐	☐	1 2 3 4 5 6 7 8 9 10	
Getting dressed while wearing the three layer bandage system was easy	☐	☐	1 2 3 4 5 6 7 8 9 10	
Getting dressed while wearing the four layer bandage system was easy	☐	☐	1 2 3 4 5 6 7 8 9 10	
Finding clothes to wear over the three layer bandage system was easy	☐	☐	1 2 3 4 5 6 7 8 9 10	
Finding clothes to wear over the four layer bandage system was easy	☐	☐	1 2 3 4 5 6 7 8 9 10	
Finding footwear to fit over the three layer bandage system was easy	☐	☐	1 2 3 4 5 6 7 8 9 10	
Finding footwear to fit over the four layer bandage system was easy	☐	☐	1 2 3 4 5 6 7 8 9 10	
Completing home duties while wearing the three layer bandage system was easy	☐	☐	1 2 3 4 5 6 7 8 9 10	
Completing home duties while wearing the four layer bandage system was easy	☐	☐	1 2 3 4 5 6 7 8 9 10	