SAGITTAL PLANE BLOCKAGE OF THE FOOT AND ANKLE – PREVALENCE AND ASSOCIATION WITH LOW BACK PAIN.

By

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I, Joanne Lee Gilbert, do declare that this dissertation is representative of my own work in both conception and execution.

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DEDICATION

I dedicate this to my family for all their love and support.

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ABSTRACT

There is a growing base of evidence demonstrating the important relationship between altered mechanics of the lower limb and low back pain. Sagittal plane blockage, specifically at the first metatarsophalangeal joints but also at the ankle joints, has been implicated as playing a role in the process of chronic mechanical low back pain. The purpose of this study was to determine whether a link could be found between chronic mechanical low back pain and sagittal plane blockage of the feet and ankles. The study was a blinded non-probability correlation study involving 100 subjects with chronic mechanical low back pain and one hundred and four subjects with no low back pain, between the ages of 18 and 45. The measurements that were taken included ankle dorsiflexion range of motion, hallux dorsiflexion range of motion and the difference in navicular height between the resting and neutral standing postures.

All the data was analysed using the SPSS version 9.0 statistical software package. All tests were carried out at the 5% level of significance and p-values were used for decision making. Parametric testing was used to analyze the data. Inter-group comparisons were made using the unpaired t-test and intra-group comparisons were made using the paired t-test. To test the association between mechanical low back pain and static foot measurements a chi-square test was carried out. To determine the degree of association (correlation) the contingency coefficient was computed.

The results indicated a significantly smaller amount of ankle dorsiflexion in individuals with chronic mechanical low back pain in comparison to individuals without low back pain. Individuals with chronic mechanical low back pain also exhibited significantly less ankle dorsiflexion in the right foot than the left foot and individuals without low back pain exhibited significantly less hallux dorsiflexion in the left foot than the right. The study indicated that individuals with chronic mechanical low back pain had a significantly smaller difference in navicular height between the resting and neutral standing postures in

comparison to individuals without low back pain. This indicated that they pronate less than individuals without low back pain. The study also found a significant association between chronic mechanical low back pain and the difference in navicular height between the resting and neutral standing postures for the right foot.

It is of the researcher's opinion that this study has shown that SPB may be an important factor in chronic mechanical low back pain, and that it should be investigated further.

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DEFINITIONS

Ankle equinus

An inability to achieve 10 degrees of dorsiflexion at the ankle joint in weightbearing (Dananberg, 1997:259).

Ankle joint

The ankle joint is made up of the distal tibiofibular, tibiotalar and fibulotalar joints (Hall, 1999:260), which collectively are known as the talocrural or ankle joint (Moore and Dalley, 1999:632).

Center of gravity

This is an imaginary point around which there is a balance of the weight of all the parts of the body. This point is found in the midline, just anterior to the level of the second sacral vertebra in the human body (Jenkins, 1998:405).

Chronic low back pain

For the purpose of this study chronic low back pain was classified as pain which had been present for 6 weeks or longer, or that was recurrent.

Dorsiflexion

This refers to the movement at the hallux and ankle whereby the dorsal surface of the toes is brought closer to the anterior surface of the leg (Jenkins, 1998:406).

First metatarsophalangeal joint

This joint is found between the head of the first metatarsal and the base of the first proximal phalanx (Moore and Dalley, 1999:638).

Gait

“The manner of walking”, (Jenkins, 1998:406)

Gait cycle

The movement that occurs from the heel-strike of one limb to the next heel-strike of the same limb (Jenkins, 1998:344).

Goniometer

This is an instrument which is used to measure angles and particularly to measure the range of motion angles of a joint (Anderson, Anderson and Glanze, 1998:704). For this study the goniometer used was a standard plastic 6-inch goniometer.

Hallux

The first digit of the foot or the "great toe" (Hall, 1999:265).

Hallux limitus

A mild or moderate limitation of flexion and extension of the first metatarsophalangeal joint (Hartley, 1994:308). For the purpose of this study a person was classified as having hallux limitus if their maximal hallux dorsiflexion was measured as less than 65^0.

Mechanical Low Back Pain

Mechanical low back pain may be defined as low back pain of a musculoskeletal origin (Borenstein, Wiesel and Boden, 1995:183). For the purpose of this study mechanical low back pain was taken to include lumbar facet syndrome, sacroiliac joint syndrome, myofascial syndromes and disc degeneration or herniation (Kirkaldy-Willis, Burton and Cassidy, 1992:121).

Motion restriction

This refers to a limitation of the normal range of motion of a joint (Everett, 1997:133).

Sagittal plane

Anatomic plane dividing the body into left and right sides (Pope et al. 1991:xvii).

CHAPTER ONE: Introduction

1.1 The problem and its setting

Seventy to eighty-five percent of all people suffer from back pain at some point during their lifetime (Andersson, 1999:581), with the lower back being the primary site of pain (Weiner and McCulloch, 2000:450). In Magee's opinion (1997:599) foot problems are also common, and affect at least 80% of the general population. Although the lower back and the feet seem to be two isolated regions, there are many who believe that the two regions are functionally related (Cibulka, 1999:600; Dananberg and Guiliano, 1999:116; Rothbart and Estabrook, 1988:376; Voorn, 1998:442). This connection is due to the two regions being connected to each other through the kinematic chain of the lower extremity.

Low back pain is a complex condition; it has a very high rate of recurrence (Andersson, 1999:583) and in most cases the exact cause of the pain is difficult to isolate (Weiner and McCulloch, 2000:450). This makes low back pain a difficult entity to treat. Chronic low back pain is even more difficult to treat, since there is often an emotional and psychological component involved too (Waddell and Frymoyer, 1991:84). It is generally believed that 60-70% of people with low back pain get better on their own within six weeks, and 80-90% by twelve weeks (Andersson, 1999:582). Burton et al. (1995:727) and Croft et al. (1998:1358), however, have found that a great percentage of people still have some degree of pain or disability after twelve months. There are a great number of reasons which may explain the above finding. Some of the most likely reasons might include: incomplete rehabilitation, re-injury, occurrence of a new problem, a pathology which was not diagnosed, or the fact that the cause of the low back pain was not in the lower back, and so was not treated. The last reason necessitates investigation into other causes for low back pain and into other areas that may be involved in the development of low back pain or which may be affected by low back pain.

Although a relationship between the lower extremity and low back pain is often assumed, little research has been published to demonstrate the association (Cibulka, 1999:599). Most of the evidence so far has been anecdotal (Dananberg and Guiliano, 1999:109), without scientific research to back it up. There are many like Innes (2003) who believe that it is essential to examine the lower extremity in cases of low back pain. Innes (2003) states that by ignoring the effect of the lower extremity on the lower back, the primary cause of a patient's pain may be missed, and unnecessary treatment provided to another area.

It is believed that motion restrictions in the joints of the feet can adversely affect the lower back (Dananberg, 1997:253). A motion restriction here refers to a limitation of the normal range of motion of a joint (Everett, 1997:133). This restricted movement is believed to cause changes in gait, leading to repetitive injury to the lumbar spine and resultant low back pain (Dananberg and Guiliano, 1999:113). These restrictions however do not commonly cause any symptoms in the foot or ankle, so an association between the foot and the low back pain is seldom made (Dananberg, 1997:253).

Sagittal plane blockage (SPB) refers to a rotational type of motion restriction within the sagittal plane of the foot and ankle joints (Dananberg and Guiliano, 1999:109). The pivotal motion that is supplied by the foot and ankle within the sagittal plane is essential for gait to occur efficiently (Dananberg and Guiliano, 1999:114). Walking involves a highly co-ordinated, smooth, rhythmical motion (Trew, 1997:156), with each step requiring the body to move its centre of mass over the weightbearing foot (Dananberg, 1999:144). This movement is dependent on the foot's ability to allow sagittal plane motion to occur efficiently and on time in the gait sequence (Dananberg and Guiliano, 1999:114).

If there is a blockage within the sagittal plane, the body must compensate in order for the person's center of mass to still be carried forward. This results in changes in posture (Dananberg, 1999:145) and these compensations or changes in the gait cycle are believed to cause the above mentioned

repetitive injury to the lumbar spine with resultant low back pain (Dananberg and Guiliano, 1999:113).

Dananberg and Guiliano (1999:116) believe that it is of utmost importance that gait style be examined as a cause of chronic or acute recurrent low back pain. They believe that if it is not addressed, sagittal plane blockage can become a perpetuating factor, leading to the continual recurrence of low back pain, in spite of the lower back being treated, since the cause of the back pain is not being addressed (Dananberg and Guiliano, 1999:116). This study will attempt to determine whether or not sagittal plane blockage needs to be addressed in the patient with chronic mechanical low back pain.

1.2 Aims and objectives of the study

The first aim of this study was to assess the prevalence of SPB in people with mechanical low back pain as well as in asymptomatic individuals.

Secondly, the study aimed to determine whether or not subjects with mechanical low back pain had a greater extent of SPB than subjects without low back pain.

Thirdly, the study aimed to identify whether or not the presentation of SPB in subjects with low back pain correlated with their mechanical low back pain.

1.3 Purpose and benefits of the study

The purpose of this study was to determine whether a link could be found between chronic mechanical low back pain and sagittal plane blockage of the feet and ankles. Due to a lack of literature comparing individuals with low back pain to a control group, it was felt that a study to determine the importance of SPB in the aetiology of mechanical low back pain was needed.

Due to the unknown cause of many cases of low back pain, it was important to look at other areas of the body to see if these areas play a role in low back

pain. If SPB was found to play a role in chronic mechanical low back pain, this knowledge would enable chiropractors and other practitioners to address this aspect and so provide a more holistic approach to treating patients with low back pain.

Dananberg, Shearstone and Guiliano (2000:389) have shown that manipulation of the fibula and talus is very effective in restoring ankle joint dorsiflexion in some cases of ankle equinus. An increased ankle dorsiflexion range of motion was also found by Pellow and Brantingham (2001:17) after manipulation of the ankle mortise joint and by Coetzer (1999:124) after manipulation of the talocrural and subtalar joints. If ankle equinus was found to play a role in chronic mechanical low back pain this knowledge would allow the chiropractor to be able to relieve this motion restriction, and thereby treat the cause of the condition, rather than only being able to supply treatment to the symptomatic area.

If SPB was found to play a role in the aetiology of low back pain, knowledge of this could lead to the condition being corrected, without unnecessary surgery or treatment to the back or even to other areas of the lower limb which may be affected along the kinematic chain. This could lead to more efficient and cost effective treatment for the patient.

The data collected in this study would contribute to the demographic data of sagittal plane blockage in South Africa, especially in the Durban area. This research may also provide a foundation for further studies into sagittal plane blockage and its association with chronic mechanical low back pain or even other conditions.

CHAPTER TWO: Review of the related literature

2.1. Introduction

This chapter is intended to provide an overview of the current literature that is available on low back pain, sagittal plane blockage and their relationship.

2.2. Mechanical low back pain

Mechanical low back pain is the most common cause of low back pain (Borenstein, Wiesel and Boden, 1995:183). It may be defined as low back pain of a musculoskeletal origin, either due to overuse of a normal anatomical structure (for example a muscle strain) or due to injury or deformity of a normal anatomical structure (for example a herniated intervertebral disc), (Borenstein, Wiesel and Boden, 1995:183). For the purpose of this study mechanical low back pain was taken to include facet syndrome, sacroiliac joint syndrome, myofascial syndromes and disc degeneration or herniation (Kirkaldy-Willis, Burton and Cassidy, 1992:121).

2.2.1. Incidence and prevalence

According to Andersson (1999:581) 70 to 85% of people have low back pain at some point in their lifetime (lifetime prevalence). Shekelle (1997:19) states that this figure ranges from 14% to over 50%. At any given moment it is estimated that anywhere from 10% to over 50% of people have low back pain (point prevalence), with 1.4 to 4.9% of the population without low back pain developing low back pain every year (annual incidence), (Shekelle, 1997:19).

On the South African front, van der Meulen (1997:99) found the lifetime incidence of low back pain in a formal Black township to be 57.6%. Docrat (1999:156) studied the epidemiology of low back pain in the Indian and Coloured communities of South Africa, and found the lifetime prevalence to be 78.2% in the Indian community and 76.6% in the Coloured community. The

prevalence of low back pain at the time of the respective studies was 53.1% in the Black community (van der Meulen, 1997:99), 45% in the Indian community and 32.6% in the Coloured community (Docrat, 1999:157). Docrat (1999:157) believed that the differences recorded between his study and that of van der Meulen could have been due to differences in the definitions they used for the prevalence as well as the fact that the different race groups may have had different occupational activities. Other reasons for the differences may include psychosocial aspects (Burton et al. 1995:727), economic differences or the level of education of the individuals. No statistics were available on low back pain in the white population in South Africa.

2.2.2. Chronic mechanical low back pain

Chronic mechanical low back pain is a difficult entity to define, since there is a lack of agreement about the definition as to when a case of low back pain becomes chronic (Andersson, 1999:581; Hubley-Kozey, McCulloch and McFarland, 2003:78). It may be defined as low back pain lasting for over 6 weeks (Bronfort et al. 1996:571; Cailliet, 1988:299), or which lasts for longer than 7 to 12 weeks (Andersson, 1999:581), or even as pain which persists past the expected healing period (Andersson, 1999:581). Low back pain that tends to be recurrent is also sometimes classified as chronic, due to the fact that it affects someone intermittently over an extended period of time (Andersson, 1999:581). Hestbaek et al. (2003:218-219) warn against using the term chronic based only on the duration of symptoms, for they feel that the nature of the condition is one of periodic attacks and temporary remissions and that it does not follow a linear course. For the purpose of this study, however, chronic mechanical low back pain was classified as pain of a musculoskeletal origin, which had been present for 6 weeks or longer, or that was recurrent.

Chronic mechanical low back pain is a highly complex condition. This is due to the fact that an emotional and psychological aspect frequently accompanies the pain, in the form of emotional distress and depression,

leading to chronic pain becoming a self-sustaining condition, which is very difficult to treat (Waddell and Frymoyer, 1991:84).

Andersson (1999:582) and Burton and Cassidy (1992:2) state that the majority of patients who present with low back pain get better on their own within 6 weeks. This however does depend on the aetiology of the low back pain and whether an actual pathology is present, which is causing the pain. Burton et al. (1995), however, conducted a study at an osteopathic practice and found that 1 year after initially presenting with low back pain 53% of the patients were still disabled to some extent (Burton et al. 1995:727). Croft et al. (1998) conducted a study in a general practice and found that although 90% stopped consulting a practitioner for their low back pain within three months of their initial consultation (Croft et al. 1998:1356), 25% had fully recovered 12 months later (Croft et al. 1998:1359). Hestbaek et al. (2003:216) conducted a 5 year prospective study looking at the course of low back pain in a general population sample, and also attest to the fact that low back pain is not by nature self-limiting, but rather a condition characterised by periodic attacks and remissions. Chronic low back pain may be more of a problem than initially believed.

2.2.3. Aetiology of chronic mechanical low back pain

Structures which have been shown to have the ability to cause pain include the lumbar vertebrae, muscles, thoracolumbar fascia, dura mater, epidural plexus, ligaments, sacroiliac joints, zygapophyseal joints, lumbar intervertebral discs (Bogduk, 1997:192-202) and vertebral end plates (Heggeness and Doherty, 1993:1050). These structures have this ability due to the fact that they are either innervated or have the ability to be mediators for nociceptive nerve endings (Paris, 1997:319).

Of the above structures, most are believed to be able to cause acute pain, but are thought to be uncommon sources of chronic low back pain (Bogduk, 1997:212). Structures that have been shown to be able to cause chronic low back pain include the lumbar zygapophyseal joints (or facet joints), sacroiliac

joints and lumbar intervertebral discs (Bogduk, 1997:212). Pain due to these structures is thought to make up 60% of chronic low back pain cases (Bogduk, 1997:213). Since this study included lumbar facet syndrome, sacroiliac joint syndrome, and disc degeneration or herniation (Kirkaldy-Willis, Burton and Cassidy, 1992:121) these structures will be looked at in a more detail.

In the zygapophyseal joints (also known as facet joints), the facets and capsules are innervated (Borenstein, Wiesel and Boden, 1995:15), so pain may arise from these structures. Pain may also arise from zygapophyseal joint synovial folds (previously known as menisci), which are found in the joint space, which may become entrapped between the two articular surfaces (Cramer and Darby, 1996:3). Inflammatory agents may also be produced, due to degeneration of the articular cartilage, which may stimulate nociceptors in the facet joint articular capsule, leading to pain (Cramer and Darby, 1996:3).

Pain due to intervertebral disc herniation may arise from pressure from the actual mass of herniated material, or distension within the mass causing more mechanical stimulation on the nerve root (McCulloch and Transfeldt, 1997:231), dorsal root ganglion or cauda equina (McCulloch and Transfeldt, 1997:232). The outer third of the annulus fibrosis is innervated, so pain may occur due to a tear in the outer annulus fibrosis (Bogduk, 1997:207). Pain may also occur due to chemical stimulation of nociceptors by breakdown products of internal disc disruption (Bogduk, 1997:231) or due to the inflammatory reaction, which is initiated because of the presence of the ruptured discal material (McCulloch and Transfeldt, 1997:231). It may also be due to mechanical overstimulation of the nociceptors of the intact annular fibres, in disc disruption, due to increased stress borne by the intact fibres, since the disc would still have the same load applied to it (Bogduk, 1997:207). Whichever way one looks at it, the disc is a significant factor in the aetiology of chronic mechanical low back pain.

The vertebral endplates have also been implicated as being possible causes of pain, which was previously thought to come only from the intervertebral disc (Heggeness and Doherty, 1993:1050). Kokkonen et al. (2002:2276) found a significant association between endplate degeneration and disc degeneration, but their results did not find endplate degeneration to be significantly associated with pain provocation during discography. They concluded that their results did not show endplate degeneration to be an immediate cause of low back pain (Kokkonen et al. 2002:2277).

The sacroiliac joint has been found to be a significant source of chronic low back pain (Schwarzer, Aprill and Bogduk, 1995:31). For many years the idea that the sacroiliac joint is mobile and innervated, and so a possible source of pain, has been controversial (Franke Jr. 2003:12), however the joint's capsule as well as its overlying ligaments have been shown to be innervated, making them possible sources of pain (Bernard, 1997:77-78). Although pain due to the sacroiliac joints is not common, it appears that the prevalence of pain arising from the sacroiliac joint may be between 13 and 30% or even higher (Schwarzer, Aprill and Bogduk, 1995:31), which is higher than previously thought (Franke Jr. 2003:12). Sacroiliac joint pain therefore appears to play an important role in the aetiology of chronic mechanical low back pain.

2.2.4. Biomechanics of the lumbar spine and pelvis

The spine is a complex structure, having to provide support and stability for the body, and a protective passage for the spinal cord, while at the same time allowing enough mobility and flexibility to perform a variety of tasks (McCulloch and Transfeldt, 1997:75). The basic functional unit of the spine is known as a motion segment, and it consists of two adjacent vertebral bodies with the soft tissue between them (Andersson, 1992:27). These segments allow the spine to bend forward (flexion), backward (extension), twist (axial rotation) and bend to the side (lateral flexion), as well as combinations of the above movements (Andersson, 1992:27).

The various components of the spine all play their own role in the function of the spine. The facet joints play an important role in stabilising the motion between two adjacent vertebrae, resisting torsion and translation, while facilitating sagittal plane flexion and extension (Borenstein, Wiesel and Boden, 1995:3). They are especially important in stabilising the spine during flexion (Bogduk, 1997:87). The facet joints are normally not weight bearing, except in the lower lumbar spine where they can take up to 20% of the compressive load (McCulloch and Transfeldt, 1997:81). The intervertebral discs seem to be the main load bearing units of the spine for axial compression, flexion and lateral and posterior shear (McCulloch and Transfeldt, 1997:81). They act as a shock absorber for the spine, distributing and absorbing some of the load applied to the spine. They also separate the vertebrae, allowing far more mobility to the spine than if the vertebrae were in direct contact with each other (Borenstein, Wiesel and Boden, 1995:7) and allowing the nerve roots to pass freely from the spinal cord through the intervertebral foramina (Magee, 1997:363).

The lumbar spine normally has a lordotic curve, which protects it to a large extent from compressive forces due to body weight (Bogduk, 1997:58). If the lumbar spine was straight, forces would be transmitted through the vertebral bodies and intervertebral discs, with the shock absorption of the intervertebral discs being the only protection of the vertebrae (Bogduk, 1997:58). However, the curves of the spine reduce these downward forces significantly, by helping to stagger the transmission of the forces (Moore and Petty, 1997:190).

The pelvis, with its articulations and ligaments, is often classified as being part of the legs (Vleeming et al. 1997:53), however the pelvis forms an essential connection between the spine and the lower extremity (Vleeming et al. 1997:54). The sacroiliac joints, together with the pubic symphysis, help to translate the weight from the spine to the lower limbs. At the same time they also try to reduce the force of bumps and jars, caused by contact of the feet on the ground, to the spine and upper body (Magee, 1997:434). It is important to look at the pelvis, and especially the sacroiliac joints and the hip joints, when examining the lumbar spine (Magee, 1997:362). This connection

between the spine and lower extremity will be stressed later, when we take a look at the link between the feet and the lower back.

2.3. Foot and ankle

2.3.1. Sagittal plane blockage

Sagittal plane blockage (SPB) is specifically defined as a rotational type of motion restriction of the foot or ankle within the sagittal plane (Dananberg and Guiliano, 1999:109). There are in essence 3 sites in the foot and ankle where a sagittal plane pivotal function is performed, and it is at these sites that SPB may occur. These 3 sites are firstly, the underside of the calcaneus, secondly the talocrural or ankle joint and, thirdly the first metatarsophalangeal joint (Dananberg, 1997:259). The rounded underside of the calcaneus rarely fails to provide its pivotal function (Dananberg, 1999:142), so for the purpose of this section only the ankle joint and first metatarsophalangeal joint will be concentrated on, and in particular the conditions of ankle equinus and hallux limitus.

2.3.2. Incidence and prevalence of sagittal plane blockage

The literature is scant regarding sagittal plane blockage (SPB). Howard J. Dananberg has written extensively on the subject (Dananberg, 1993; Dananberg, 1997; Dananberg, 1999; Dananberg and Guiliano, 1999; Dananberg, Shearstone and Guiliano, 2000), however a review of the literature failed to show any statistics on the incidence and prevalence of SPB in the normal population.

If one looks at the two individual conditions of ankle equinus and hallux limitus, there is also little literature on their incidence and prevalence in the normal population. Dananberg (1993:433-441) looked at gait style as an aetiology to chronic postural pain and specifically the role of hallux limitus, and he states that functional hallux limitus is a common condition, but that it is locally asymptomatic, leading to it rarely being recognised (Dananberg,

1993:433). He however fails to substantiate this statement. Evans, Averett and Sanders (2002:359-365) studied the association between hallux limitus and the accessory navicular, and state that hallux limitus "is one of the most prevalent, debilitating disorders of the first metatarsophalangeal joint" (Evans, Averett and Sanders, 2002:359). They, however, also do not give any idea of the incidence or prevalence of the condition or why they make this statement.

Concerning the ankle, Dananberg (1997:259) states that ankle equinus is "a common patho-mechanical entity", but he gives no indication of the incidence and prevalence of the condition or his reason for making this statement. Hill (1995:295-300) conducted a study to demonstrate the prevalence of ankle equinus and its linkage to common foot pathology. Of 209 patients presenting to a podiatry department in California, 174 were taken into the study and of these 168 (96.5%) showed markedly restricted ankle dorsiflexion ($<3^0$) and 165 (95%) with bilateral gastrocnemius and soleus muscle involvement (Hill, 1995:299).

2.3.3. Normative values for ankle and hallux dorsiflexion

Ankle dorsiflexion

Magee (1997:624) states that ankle dorsiflexion is usually 20^0 past the anatomic position of the foot being at right angles to the bones of the leg. He also states that 10^0 of dorsiflexion is required for normal walking (Magee, 1997:624). A review of the literature found a number of authors who agreed with this figure (Hill, 1995:297; Dananberg, 1999:144), however, the search failed to show any studies which substantiated these figures.

Ankle equinus is generally accepted by podiatrists as the inability to achieve 10^0 of dorsiflexion past 90^0 during the gait cycle (Dananberg, Shearstone and Guiliano, 2000:386; Hartley, 1994:305).

Hallux dorsiflexion

In a review of the literature, Nawoczenski, Baumhauer and Umberger (1999:370) found that in the normal population the static clinical measurements of hallux dorsiflexion ranged between 65 and 110^0 of motion, while measurements taken during gait ranged between 50 and 90^0. The slight variation in what is deemed to be normal is echoed in the fact that Hartley (1994:294) states that 80 to 90^0 of dorsiflexion is needed for normal walking, while Lichniak (1997:408) puts this figure at about 65 to 75^0. Dananberg (1999:147-148) then states that 15 to 20^0 is a normal measurement for passive dorsiflexion of the hallux in the loaded or weight-bearing position. The wide range of measurement values may be due to the wide variety of measurement techniques and tools that are used, and the lack of standardisation (Nawoczenski, Baumhauer and Umberger, 1999:370). The differences in values may also be due to the discrepancy between static measurements and the motion of the first MTP joint during gait.

Nawoczenski, Baumhauer and Umberger (1999:370-376) undertook a study to show the relationship between clinical measurements and the motion of the first MTP joint during gait. Their sample size was relatively small (33 participants), but their findings were interesting. They found that the mean dorsiflexion of the first MTP joint during gait was about 42^0. They found that the assessment of the active range of motion of the joint in weight-bearing correlated strongly with the actual motion of the joint in walking and its mean value was also the closest to the actual motion (measuring about 44^0). The heel-rise test[1] also correlated strongly with motion of the first MTP joint, however the recorded mean was not as accurate (measuring 58^0). The mean passive dorsiflexion of the hallux in the weight-bearing position that was measured was about 37^0, so less than the actual motion (Nawoczenski, Baumhauer and Umberger, 1999:374). The above values demonstrate that

[1] The heel-rise test is done while the subject is standing, they are instructed to lift one of their heels as high as possible off the floor, while keeping the entire ipsilateral hallux on the floor, and the amount of dorsiflexion achieved is measured. This measurement is used to indicate the amount of dorsiflexion available at the first metatarsophalangeal joint in a functional weight-bearing position. (Nawoczenski, Baumhauer and Umberger, 1999:372)

the differences in normal values may be due to which test was used, and show that the tests are not interchangeable (Nawoczenski, Baumhauer and Umberger, 1999:375).

Hallux limitus is defined as a mild or moderate limitation of flexion and extension of the first metatarsophalangeal (MTP) joint (Hartley, 1994:308). There is a slight discrepancy as to the degree of limitation considered to constitute hallux limitus. Dananberg (1999:147-148) states that less than 15 to 20^0 of passive dorsiflexion of the hallux in the weight-bearing position is considered to be positive for hallux limitus. Dananberg and Guiliano (1999:111), however, classified people as having hallux limitus when dorsiflexion of the hallux was significantly less than 65^0 in the unloaded state, and a diagnosis of functional hallux limitus was made if the subject had normal dorsiflexion (65^0 or more) in the unloaded state and markedly less than 65^0 dorsiflexion in the loaded state (weight-bearing).

Lichniak (1997:416) states that it is generally agreed that 65^0 of dorsiflexion is needed at the first metatarsophalangeal joint for gait to occur normally (Lichniak, 1997:416) and Hartley (1994:308) feels that 60^0 of hallux dorsiflexion during gait is considered hypomobile. For this reason, for the purpose of this study 65^0 dorsiflexion was taken to be normal and a person was classified as having hallux limitus if their maximal hallux dorsiflexion was measured as less than 65^0.

2.3.4. Aetiology of sagittal plane blockage

Before we look at the causes of SPB we need to look at what the definition of SPB encompasses. As was mentioned above, restriction in the sagittal plane is predominantly seen at either the ankle joint (as ankle equinus) or at the hallux or “great toe” (as functional hallux limitus) (Dananberg and Guiliano, 1999:109). We will therefore look at these two conditions separately.

Ankle equinus

Ankle equinus is defined as an inability to achieve 10 degrees of dorsiflexion at the ankle joint in weight-bearing (Dananberg, 1997:259). Restriction of ankle joint dorsiflexion can be divided into 2 types: structural and functional.

Structural restrictions can be due to trauma to the ankle, degeneration, true Achilles tendon shortness or fusion due to surgery (Dananberg, 1999:144). They can also occur due to bone deformity (mainly seen in the talus) or due to inflammatory disease (Magee, 1997:614).

Functional restrictions can occur due to either a congenital or an acquired tightness or contracture of the Achilles tendon or the triceps surae, or due to mechanical dysfunction or "fixation" of the fibula. In the latter case the fibula is temporarily unable to move, and does not allow the ankle to widen to accept the anterior dome of the talus during dorsiflexion, resulting in restriction (Dananberg, 1999:144). Functional restrictions may also occur due to a cavus foot or suprapedal compensation (such as iliopsoas or hamstring contracture) (Morris, Berenter and Kosai, 1994:78).

Hallux limitus

As with ankle equinus, restriction of the hallux can be structural or functional. Structural hallux limitus is a degenerative disease of the first MTP joint, and is usually associated with pain and swelling of the hallux (Dananberg, 1999:144). It may be caused by a fixed elevated position of the first ray or due to a structural metatarsus primus elevatus (referring to the first ray being above the transverse plane of the other metatarsals) (Lichniak, 1997:411,414,415). Functional hallux limitus is seen where the first MTP joint shows a normal range of motion in the non weight-bearing position, but a limited range of motion while weight-bearing. This restriction may be due to hypermobility of the first ray, a functional metatarsus primus elevatus, or due to anything which leads to a functionally raised first ray (Lichniak, 1997:414). First ray hypermobility, like the other conditions mentioned, prevents the

amount of plantarflexion that is needed at the first ray in order for the MTP joint to dorsiflex optimally (Lichniak, 1997:408), in this case due to a lack of stabilisation of the hallux and subsequent dorsiflexion when plantarflexion should be taking place.

Lichniak states that hallux limitus usually presents as an insidious gradual decrease in the range of motion of the first MTP joint, which may result in pain (Lichniak, 1997:408). Dananberg (1997:253) adds that functional hallux limitus is believed to rarely, if ever, cause symptoms of pain or swelling at this joint (Dananberg, 1997:253).

2.3.5. A brief look at structure and function

In essence, the ankle joint is made up of the distal tibiofibular, tibiotalar and fibulotalar joints (Hall, 1999:260), which collectively are known as the talocrural or ankle joint (Moore and Dalley, 1999:632). The foot is made up of 26 bones and numerous joints or articulations (Hall, 1999:265). Although it is often theoretically broken up into different regions, all the parts of the foot are functionally and integrally related (Donatelli, 1990:3). As mentioned before, the joints mainly involved in SPB are the ankle and first metatarsophalangeal (MTP) joints, so these will be the joints that are concentrated on in this section. Due to the subtalar joint also being involved in compensatory processes, this joint will also be touched on.

<u>Ankle joint</u>

This joint is a hinge type of synovial joint, which consists of a deep socket formed by the inferior aspects of the tibia and fibula, into which the superior part of the talus fits (Snell, 2000:589). The movement at the ankle occurs mainly in the sagittal plane (Hall, 1999:261) in the form of dorsiflexion and plantarflexion (Snell, 2000:589).

First Metatarsophalangeal (MTP) joint

This joint is found between the head of the first metatarsal and the base of the first proximal phalanx and is a knuckle-like condyloid type of synovial joint (Moore and Dalley, 1999:638). This is the largest of the metatarsophalangeal joints, and its articular surfaces are particularly large to accommodate the amount of dorsiflexion needed at the hallux during walking. (Moore, 1992:493)

The joint has two separate and distinct axes allowing, firstly, pure sagittal plane motion (dorsiflexion and plantarflexion) and, secondly, transverse plane motion (abduction and adduction). The motion in the transverse plane is relatively small and of no functional significance to the gait cycle, however, the motion in the sagittal plane essential for normal gait to occur (Michaud, 1993:13).

Subtalar joint

This is a plane type of synovial joint, found distal to the ankle joint, between the inferior surface of the body of the talus and the superior aspect of the calcaneus (Snell, 2000:590). This is one of the most important joints of the lower extremity, since it is responsible for conversion of the rotatory forces of the lower extremity (Donatelli, 1990:14). The main movements that occur at this joint are inversion and eversion of the foot (Moore and Dalley, 1999:638), and the movements of the midtarsal joint and the forefoot are dependent on the mechanics of this joint (Donatelli, 1990:14).

2.3.6. Biomechanics of the ankle and first ray

As with the lumbar spine, the foot and ankle also have a complex function, having to provide shock absorption and stability for the body, while at the same time being able to provide propulsion for the body (Simon et al. 1994:592).

Although the foot is divided up into the rearfoot, midfoot, and forefoot, these three regions function as a unit during walking. Changes in any of the structures will have an impact on the entire foot and ankle's function. The link lies in the muscle and connective tissue structures which bind the areas together, and not only provide an interdependency within the foot, but also an interdependency between the foot and ankle and the entire lower limb. This results in any changes in the mechanics of the foot and ankle being able to effect the function of the lower limb. (Donatelli, 1990:8)

One of the lower limb's functions is to take the forces that are imposed on it during the gait cycle, and to distribute and dissipate the forces (Simon et al. 1994:592). The forces are made up of compressive, rotatory and sheering forces, which are transmitted to the feet from the upper body due to muscular actions, the weight of the body and external forces applied to the body (Simon et al. 1994:592). The lower limb distributes and dissipates the forces through the kinematic chain of the lower limb, through muscle action and translation and rotation of the joints of the feet and ankles (Simon et al. 1994:592). If the lower limb is not able to do this and there is inadequate distribution of these forces this leads to abnormal movement occurring and subsequently to the breakdown of connective tissue and muscle (Donatelli, 1990:3). In order for the most efficient attenuation of forces, the bones, muscles, ligaments and tendons need to be co-ordinated and work as a unit (Donatelli, 1990:3).

2.4. The relationship between SPB and low back pain

2.4.1. Introduction

There is a growing base of evidence demonstrating the important relationship between altered mechanics of the lower limb and low back pain (Barbee Ellison, Rose and Sahrmann, 1990; Cibulka et al. 1998; Voorn, 1998; Cibulka, 1999; Dananberg and Guiliano, 1999). The following section will attempt to show what literature is available to either substantiate or refute the link.

2.4.2. Foot orthoses

Foot orthotic devices have been shown to help alleviate low-back pain, however the evidence has mainly been anecdotal (Dananberg and Guiliano, 1999:109). Dananberg and Guiliano (1999:109-110) undertook a study involving 32 subjects with either chronic mechanical low back pain, or an acute episode of recurrent mechanical low back pain, who had found conventional low-back treatment to be unsuccessful (Dananberg and Guiliano, 1999:109). The purpose of their study was to see if by addressing SPB (in the lower limb) they could alleviate chronic low back pain in the study participants (Dananberg and Guiliano, 1999:109). Treatment involved the use of foot orthoses and manipulation of affected joints (including the first metatarsophalangeal joint, ankle and fibular head), when appropriate (Dananberg and Guiliano, 1999:111). The treatment was considered successful with 84% of the patients experiencing improvement (Dananberg and Guiliano, 1999:112). Due to the combined use of orthotics and manipulation for the treatment it is not possible to ascertain which aspect was responsible for the improvement. However, since no treatment was given to the symptomatic lower back region, the success of the treatment appears to point to the feet being involved. The study did not, however, have any control, so there is the possibility that the natural history of the condition may have led to the improvement, or that placebo played a role in the results.

2.4.3. Pronation

Rothbart and Estabrook (1988:376) found a high correlation between excessive pronation and low back pain. Their study was done on only low back pain patients and they found 96% were excessive pronators (pronating more than 6^0 during the stance phase of gait). Their study, however, had no control and little has been published since then to support this study (to the best of the researcher's knowledge). The findings of the study do however support, albeit in an anecdotal way, that there may be some link between low back pain and excessive foot pronation.

2.4.4. Static foot measurements

Few studies have been done comparing any static measurements of the feet in people with low back pain to those without low back pain. Roncarati and McMullen (1988:158-164) published a study that involved 674 subjects and aimed to determine some of the correlates of low back pain in a general population sample. The only measurement in the feet, however, that they looked at was the Feiss line[2]. They concluded from their study that there was a negative relationship between pes cavus (high arch) and low back pain, indicating that low back pain subjects tend to have normal longitudinal arches of the feet (1988:162) and that the pes cavus individual has less incidence of low back pain (1988:163). However, Feiss line measurements are usually used to determine the degree of pes planus (flatfoot) present rather than pes cavus (Magee, 1997:636 and 638), so the reliability of their study is questionable. Roncarati and McMullen (1988:160) also state that they found less range of motion of the gastrocnemius musculature, however they do not state what joint they found this in. The authors concede that no attempt was made to select subjects from any specific groups or with specific features, and so their sample may have not have been typical of the general population.

The value of static foot evaluation as an indication of the degree of maximum pronation during the gait cycle has been questioned by some. The reason for this is due to the fact that one is using a static measurement to try to predict the amount of movement in a dynamic state, so the relationship between the two measurements has been questioned as well as the clinical relevance of the measurements. McPoil and Cornwall (1996:313) however, looked at 17 static measures of the foot and found the difference in navicular height between the resting and neutral standing postures to be a predictor of

[2] Feiss line: The apex of the medial malleolus and the plantar aspect of the first metatarsophalangeal joint are marked while the patient is not bearing weight. The navicular tubercle is then palpated, noting where it lies relative to a line joining the previously mentioned points. The patient then stands up and the navicular tubercle is again palpated and noting where it lies relative to the line mentioned above. If the tuberosity falls one third of the distance to the floor it represents first-degree flatfoot, if it falls two thirds of the distance it is second degree flatfoot and if it rests on the floor it represents third-degree flatfoot (Magee, 1997:636 and 638).

maximum rearfoot pronation. They also concluded that further research was warranted before definitive conclusions were made regarding the predictability of static foot measurements for rearfoot motion (1996:313).

2.4.5. Achilles tendon

Voorn (1998:436-443) published a case study in which he found a possible relationship between the Achilles tendon and sacroiliac dysfunction. Although it is a case study and not a clinical trial, it still raises some interesting issues. In this case study a patient presented with chronic Achilles tendinitis, which failed to resolve with conservative treatment to the area (Voorn, 1998:436). However it was later noted that he also had sacroiliac dysfunction on the ipsilateral side (Voorn, 1998:439). After treatment to both the sacroiliac area (including manipulation, mobilisation and muscle strengthening exercises) and the Achilles tendon (including ultrasound, stretching and ice) the patient's symptoms resolved completely (Voorn, 1998:440-441). The results indicate, although only anecdotally, that the sacroiliac joint dysfunction may have been involved in the Achilles tendinitis process. Voorn (1998:442) concludes that the sacroiliac dysfunction could have caused a change in the kinematic chain of the lower extremity, leading to excessive loading of the Achilles tendon and subsequently the tendinitis. One of the problems with this case study is that there were a great number of treatment interventions given, so it is impossible to know which of the interventions lead to a resolution of the symptoms. As there is no control, it is impossible to rule out that other factors may have played a role in the outcome too. The case does however raise some questions on the possible link between the low back and the lower extremity.

Although Voorn (1998) found that the sacroiliac dysfunction could have lead to the Achilles tendinitis, Cailliet (1988:179) provides a mechanism by which he feels a "tight" or hypertonic Achilles tendon or "heel cord" may cause low back pain. A "tight" Achilles tendon places an increased load on the hamstring and ultimately on the lumbosacral spine in forward flexion, with bilateral Achilles tendon limitation resulting in general lumbosacral stress and unilateral Achilles tendon limitation resulting in ultimate pelvic rotation and

lateral flexion (Cailliet, 1988:179). Unilateral “tightness” of the Achilles tendon would result in restricted ankle dorsiflexion, and if as stated above this resulted in pelvic rotation, this could result in sacroiliac dysfunction, and therefore explain how limited ankle dorsiflexion could lead to low back pain.

2.4.6. SPB Compensations

Now we need to look at the possible mechanisms by which SPB may be able to play a role in low back pain.

What SPB in essence does is to obstruct the forward transfer of the individual’s centre of body mass during the gait cycle (Dananberg, 1999:140). Due to the blockage within the sagittal plane, the body needs to compensate in order for the person’s center of mass to still be carried forward. The compensations can be divided into pedal and postural compensations, although the two occur simultaneously (Dananberg, 1993:615). The pedal compensations are the ways in which the foot and ankle compensate for the loss of motion in the sagittal plane. They may include: altered heel lift (either early, intermittent or delayed) (Dananberg, 1993:615), which may lead to lowering of the medial longitudinal arch (Dananberg, 1999:145), vertical toe-off (where heel lift is not visible until full contact occurs on the other side) (Dananberg, 1993:617), an inverted step (Dananberg, 1993:617), or abducted or adducted toe-off (Dananberg, 1993:618). At the same time compensations occur in the rest of the body. These compensations include failure to reach full knee extension, failure to reach full hip extension, flexed posture (straight lumbar spine), and forward head posture (Dananberg, 1999:145). The changes in the gait cycle may then lead to repetitive injury to the lumbar spine with resultant low back pain (Dananberg and Guiliano, 1999:113).

2.4.7. Sacroiliac joint involvement

Just as foot dysfunction has been proposed as a possible cause of low back pain, the converse may also be true. Maintenance of proper foot function is dependent on the entire kinematic chain above the foot (Subotnick, 1999:8).

The concept of the sacroiliac joint being a primary source of low back pain is gaining recognition, although it lacks universal acceptance (Bernard, 1997:79). The sacroiliac joint is, however, fundamental in the transfer of weight between the upper and lower extremities (Franke Jr. 2003:14).

The lumbosacral, sacroiliac, pubic symphysis and hip joints are all linked biomechanically, resulting in a problem in one of the joints being able to cause a compensatory change in one of the other joints (DeFranca and Levine, 1996:58). But the compensation does not necessarily stop here, since the entire lower limb is part of a kinematic chain linking it together functionally (Huson, 1997:128). With unilateral sacroiliac joint dysfunction (where the ipsilateral innominate has rotated anteriorly), the iliac crest on the affected side will be higher when standing (this is due to the relative movement of the sacroiliac joints anteriorly and superiorly to the acetabulum) (DonTigny, 1997:470). This results in a functional shortening of that limb (DonTigny, 1997:470). With limb length discrepancies the short leg most often externally rotates for increased stability (Subotnick, 1999:194). This in turn could lead to the foot and ankle being in external rotation, instead of neutral, at heelstrike, with subsequent lateral foot loading being more brief, pronation being prolonged and the amount of dorsiflexion of the ankle being decreased (Voorn, 1998:441). This may explain why a lack of normal dorsiflexion range of motion at the ankle has been implicated in some cases of chronic sacroiliac joint pain (Dananberg, 1999:147).

2.4.8. Hip joint range of motion

Barbee Ellison, Rose and Sahrmann (1990:537-541) compared the pattern of hip rotation between healthy subjects and individuals with low back pain. Their results suggested an association between an imbalance of hip rotation range of motion and low back pain (Barbee Ellison, Rose and Sahrmann, 1999:537). They found that a greater proportion of individuals with low back pain had more lateral rotation than medial rotation of the hip (Barbee Ellison, Rose and Sahrmann, 1999:541).

Cibulka et al. (1998:1009-1015) took this study one step further, but this time took only low back pain patients and compared those with sacroiliac joint dysfunction to those with unspecified low back pain. The results of the study indicated that the patients with sacroiliac joint regional pain had a greater asymmetry between hip range of motion between the right and left side, with significantly more external rotation than internal rotation on the side where the innominate had rotated posteriorly (Cibulka et al. 1998:1013). The individuals with low back pain, but no evidence of sacroiliac joint regional pain, also demonstrated more external hip rotation than internal rotation, however it was found bilaterally (Cibulka et al. 1998:1013).

2.4.9. The kinematic chain

The literature review so far has tried to show what literature is available on the link between the lower limb and low back pain. We will now try to ascertain the possible mechanism by which the relationship between these two regions may occur, and therefore we will look at the kinematic chain of the lower limb.

The human body is made up of a great number of kinematic chains (Huson, 1997:130), which consist of bones with joints or links which bind them together. The kinematic chain of the pelvis and lower extremity is a closed kinematic chain when the feet are on the floor (Huson, 1997:128). For this reason, all the links in the system are interdependent (DeFranca and Levine, 1996:58) resulting in any changes in one link or joint of the chain having immediate effects on the kinematics of other joints in the chain (Huson, 1997:130). In theory, this implies that stresses that are applied to the chain can be spread among the members of the chain, and so link them in function as well as dysfunction (DeFranca and Levine, 1996:58).

The physical link between the low back and the lower limb is supplied by the thoracolumbar fascia, which may play an important role in the transfer of forces between the spine pelvis and legs (Vleeming et al. 1995:757). The posterior layer of the thoracolumbar fascia extends from the sacral area all the way up into the thoracic region, and is continuous with the latissimus dorsi

muscle and partly with the trapezius muscle superiorly and with the gluteus maximus muscle inferiorly (Vleeming et al. 1995:754-755). This links the lumbar spine to the pelvis. From here some of the forces from the upper half of the body are transferred downwards into the rest of the lower limb through the iliotibial tract, which extends down from the gluteus maximus muscle (Vleeming et al. 1997:68) down to the lateral condyle of the tibia (Snell, 2000:513).

2.5. Conclusion

Although a link between altered mechanics of the foot and low back pain is often presumed, there is little solid proof of the link. There is a growing base of research that supports the idea that an important relationship exists between the lower limb and the low back, however more research in this sphere is needed.

There is evidence that foot orthoses, which aim to rectify gait disturbances, have been successful in the relief of chronic low back pain. This suggests that there may be an aspect to low back pain that needs to be addressed in the foot or ankle. There are conflicting reports on foot pronation and whether it is linked to low back pain or predisposes one to less chance of low back pain. Hypertonic Achilles tendons and decreased ankle dorsiflexion have been considered to have a possible relationship with low back pain.

Sagittal plane blockage (SPB) at the ankle and hallux has been implicated as a possible cause of chronic mechanical low back pain. An extensive search of the literature, however, failed to show any studies which showed the incidence or prevalence of SPB in a normal healthy group of subjects compared to patients with low back pain, so this needs to be addressed.

Dananberg (1999:146) states that by specifically addressing the appropriate site of SPB rather than the apparent symptomatic location (in this case the lower back), one can achieve rapid and long-term resolution of a patient's symptoms. The author therefore contends that a comparison of SPB in the

normal healthy population to those of low back pain sufferers is necessary, to determine the importance of the relationship between SPB and chronic mechanical low back pain.

CHAPTER THREE: Methodology

3.1. Introduction

The following chapter outlines the methods and procedures that were used in this study. A detailed description of the study design, study protocol, inclusion and exclusion criteria and measurements is given. A flow chart summarising the research process has also been included at the end of the chapter.

3.2. Study design

The design of this study was that of a blinded non-probability correlation study. Factors specifically considered from the objectives included:

Objective	Possibilities
1. To find out what the period prevalence of SPB was in individuals who took part in the study.	Present / Not present Unilateral / Bilateral Left / Right
2. The extent of restriction in SPB.	Degree Number of joints involved
3. Was there a correlation between SPB and low back pain.	Correlation / No correlation

3.3. Patient selection

One hundred subjects with chronic mechanical low back pain and one hundred and four subjects with no back pain were entered into the study. For the purpose of this study chronic mechanical low back pain was defined as pain for over 6 weeks (Cailliet, 1988:299), or recurrent low back pain which occurred over an extended period (Andersson, 1999: 581). Participants were chosen using a non-probability purposive method of sampling. Any patient

that presented to the Chiropractic Day Clinic at the Durban Institute of Technology and fitted the research criteria (criteria can be found in 3.5 and 3.6 below) were eligible for participation in this study.

3.4. Blinding

In order for the researcher to be blinded as to whether the subject had low back pain or not, the initial consultation and diagnosis were done by the student interns working in the Durban Institute of Technology Chiropractic Day Clinic. The interns participated in the initial screening process. They were instructed on the inclusion and exclusion criteria of the study and asked not to call the researcher for patients who fell outside the research criteria.

3.5. Inclusion criteria

1. Patients had to be between the age of 18 and 45, in order to try to eliminate degenerative factors that may have occurred with advanced age.
2. Patients had to have chronic (over 6 weeks) or an acute episode of recurrent mechanical low back pain or no low back pain at all or pain in an area other than the low back, but not the lower limb.
3. Patients must have understood and completed an informed consent form and received a letter of information on the study.

3.6. Exclusion criteria

1. The presence of low back pain due to causes other than mechanical, such as due to organic or pathological causes (e.g. abdominal aortic aneurysm), excluded on the basis of a case history and physical examination done by the chiropractic intern.
2. The presence of any condition which may have prevented some of the measurements of the feet being taken (e.g. a fracture of the ankle).
3. Patients who had foot pain or other lower limb pain or who had had foot surgery, which may have affected the accuracy of the measurements taken (for example, fusion of the first metatarsal joint due to surgery would

prevent movement at that joint, leading to a much smaller reading than would usually be taken on a normal joint).

4. Patients who had received any treatment of their feet or their lower back within one week of the consultation.

3.7. Procedure

The patients underwent their normal consultation, however before treatment commenced the student intern asked a patient who was eligible for the study if they were willing to participate in this study. If a patient expressed an interest in participating in the study, the researcher was called and further explanation of the study was given. If the patient was still interested in the study they were given a patient information letter (Appendix A), which explained to them what the research would entail. The researcher was available to answer any questions the patient had about the study. If the patient agreed to participate in the study, they were asked to sign a letter of consent (Appendix B) and participated in the study. The patients were told that they were not to divulge to the researcher whether they had low back pain or not. They were also told that all data captured would be dealt with in the strictest of confidence; no names would be divulged, each participant would be given an identity code, instead of their names being used, and only the researcher and her supervisor would have access to the data. The researcher then took measurements of the foot and ankle of the patient (Appendix C), thanked the patient for participating in her study, and then left the intern to commence with their consultation as normal.

3.8. Grouping of subjects

After the entire consultation the researcher consulted the patient's file in order to find out the diagnosis of the patient, so that the proper grouping could be made. Each participant was given an identity code, (A1 to A204), instead of their names being used in the research. If the patient had chronic mechanical low back pain, they were placed into Group 1. Mechanical low back pain included facet syndrome, sacroiliac joint syndrome, myofascial syndromes,

disc degeneration and herniation and central or lateral canal stenosis (Kirkaldy-Willis, Burton and Cassidy, 1992:121). If the patient had no low back pain they were placed into Group 2. Any person diagnosed with back pain due to any cause other than mechanical, or with lower limb pain was excluded from the study. The data of such a patient was not analysed and their data sheet was destroyed immediately by shredding.

3.9. Measuring instruments

The first two sets of measurements (range of ankle dorsiflexion and range of hallux dorsiflexion) were taken using a standard goniometer. The goniometer had been found to be moderately reliable when readings were taken by the same therapist over a short period of time (Elveru, Rothstein and Lamb, 1988:672). It is commonly used for measurements of the feet and ankles (Astrom and Arvidson, 1995; Gross, 1995; Garbalosa et al. 1994; Picciano, Rowlands and Worrel, 1993; Smith-Oricchio and Harris, 1990).

The second two sets of measurements (navicular height in resting standing position and navicular height in neutral standing position) were taken using a ruler.

3.10. Measurements

All the measurements were taken in weightbearing, since weightbearing measurements had been found to be more accurate than non-weightbearing measurements (Smith-Oricchio and Harris, 1990:13), and due to the importance of evaluating the patient in a functional (weightbearing) position which was applicable to activities of daily life (Lattanza, Gray and Kantner, 1988:314).

All measurements were taken 3 times and the mean of the 3 measurements recorded, as described by Garbalosa et al. (1994:202). The following measurements were taken:

1. Range of ankle dorsiflexion (weightbearing): This measurement was taken using a goniometer (Garbalosa et al., 1994:201). The patient was asked to stand on a low platform, and care was taken that the ipsilateral knee was straight (180^{o} knee extension) while the measurement was taken. this was important in order to include equinus due to the gastrocnemius, since the gastrocnemius is a two joint muscle, going over both the knee and ankle joints (Magee, 1997:625-626). The stationary arm of the goniometer was aligned along the lateral aspect of the fibula and the mobile arm along the lateral aspect of the fifth metatarsal (Garbalosa et al., 1994:201). The person was then asked to dorsiflex their ankle maximally and the acute angle recorded. The above measurement was important in order to ascertain whether the person had at least the minimum of 10^{o} of ankle dorsiflexion, which is needed for normal locomotion (Magee, 1997:624). Normal dorsiflexion is usually 20^{o} past the anatomic position (with the foot at 90^{o} to the bones of the leg), (Magee, 1997:624). A measurement of less than 10^{o} dorsiflexion is classified as talipes equinus (Magee, 1997:614).

   The accepted method for measuring ankle dorsiflexion is to maintain the subtalar joint in the neutral position and then measure the degree of dorsiflexion with the knee fully extended (Dananberg, Shearstone and Guiliano, 2000:386). It has, however, been shown that with an inexperienced tester, referencing measurements of ankle range of motion to the subtalar neutral position, will diminish their reliability (Elveru, Rothstein and Lamb, 1988:677). For this reason the ankle dorsiflexion measurements were not referenced to the subtalar neutral position, but all the patients were instructed to put their foot parallel to the edge of the platform, and careful note was taken that the person dorsiflexed their ankle straight upward with no compensatory movement to either side. This was done consistently with every patient.

2. Range of hallux dorsiflexion (weightbearing): The subjects were instructed to stand on a low platform with their weight on the leg being measured, with their hallux parallel to the edge of the platform. The examiner then

attempted to dorsiflex the hallux (Dananberg, 1999:148). The stationary arm of the goniometer was aligned along the medial aspect of the first metatarsal and the mobile arm along the hallux (Michaud, 1993:182). If the range of hallux dorsiflexion was less than 65 degrees the patient was diagnosed as having functional hallux limitus (Lichniak, 1997:416).

3. Difference in navicular height between the resting and neutral standing postures (McPoil and Cornwall, 1996:310): The height of the navicular tuberosity from the ground was measured with the patient in a relaxed standing posture[3]. The height of the navicular tuberosity from the ground was then measured again however with the subtalar joint positioned in neutral this time. In order to determine the subtalar neutral position, with the patient standing as above, the examiner used the thumb and forefinger of one hand to palpate the head of the talus on the dorsal aspect of the subject's foot. The patient was then asked to slowly rotate their trunk to the right and to the left, resulting in medial and lateral rotation of the tibia and pronation and supination of the talus (Magee, 1997:631). When talar dome congruency was felt (there was no bulge felt on either the lateral or medial side) then the subtalar joint was taken as being in neutral. The difference between the two navicular height measurements was then calculated, with the first value being subtracted from the second (McPoil and Cornwall, 1996:310). McPoil and Cornwall (1996:313) found this variable to be the only one of 17 variables able to predict maximum rearfoot pronation. McPoil and Cornwall (1996:311) found the mean difference to be 6.2 mm with a standard deviation of 4 mm and Mueller, Host and Norton (1993:200) found the mean difference to be 7.3 mm with a mean standard deviation of 3.35 mm. Both studies found their measurements to be reliable (McPoil and Cornwall, 1996:312; Mueller, Host and Norton, 1993:200-201). Mueller, Host and Norton (1993:201), due to the results of their study and due to a comparison with other studies, advocate that a navicular drop of greater than 10 mm should be considered abnormal.

[3] Standing with their normal base width and Fick angle (Magee, 1997:631).

3.11. Ethical considerations

The rights and welfare of the subject were protected in the following manner:

- The subject was not coerced into participating in the study
- Participation was voluntary and did not involve any financial benefit
- Information was given to the patient in an understandable language
- Informed consent was obtained
- The patient was free to withdraw from the study at any stage
- Confidentiality was maintained at all times

3.12. Statistical analysis of the data

3.12.1. Treatment of the data

All the data was analysed using the SPSS version 9.0 statistical software package (SPSS Inc., 444N. Michigan Ave, Chicago, Illinois, 60611, USA). All tests were carried out at the 5% level of significance and p-values were used for decision making. In general, a null hypothesis was rejected at the $\alpha = 0.05$ level of significance if $p < \alpha$ where p was the observed level of significance or probability level, otherwise if $p \geq \alpha$ the null hypothesis was accepted at the 0.05 level.

3.12.2. Methods of data analysis

Due to the large sample size, parametric testing was used to analyze the data. Inter-group comparisons were made using the independent sample t-test and intra-group comparisons were made using the paired t-test. To test the association between mechanical low back pain and static foot measurements a chi-square test was carried out. Cramer's V was then used to determine the degree of association (correlation).

3.12.2.1. Parametric tests

Test 1: Unpaired t-test (inter-group)

Hypothesis testing:

The null hypothesis (Ho) states that there is no difference between the two groups with respect to the variable of interest. The alternative hypothesis (Ha) states that there is a difference between the two groups.

Ho: There is no difference between Group 1 and Group 2

Ha: There is a difference between Group 1 and Group 2

Decision rule:

If $p < \alpha$, reject Ho

if p / α, accept Ho

Where p is the reported p-value

Test 2: Paired t-test (intra-group)

Hypothesis testing:

The null hypothesis (Ho) states that there is no difference within the group between the right and the left foot measurements. The alternative hypothesis (Ha) states that there is a difference within the group between the right and the left foot measurements.

Ho: There is no difference between the right and left foot measurements

Ha: There is a difference between the right and left foot measurements.

Decision rule:

If $p < \alpha$, reject Ho

if p / α, accept Ho

Where p is the reported p-value

Test 3: Chi-square test (association)

Hypothesis testing:

The null hypothesis (Ho) states that the two variables are independent from each other and no association exists. The alternative hypothesis (Ha) states that the two variables are associated with each other.

Ho: Variables A and B are independent and no association exists.

Ha: Variables A and B are associated with each other.

Decision rule:

If $p < \alpha$, reject Ho

if p / α, accept Ho

Where p is the reported p-value

Test 4: Cramer's V (degree of association)

Hypothesis testing:

This test is a measure of association based on chi-square. The value computed ranges between zero and 1, with zero indicating no association between the row and column variables and values close to 1 indicating a high degree of association between the variables. The null hypothesis (Ho) states that the two variables are independent from each other and no association exists. The alternative hypothesis (Ha) states that the two variables are associated with each other.

Ho: Variables A and B are independent and no association exists.

Ha: Variables A and B are associated with each other.

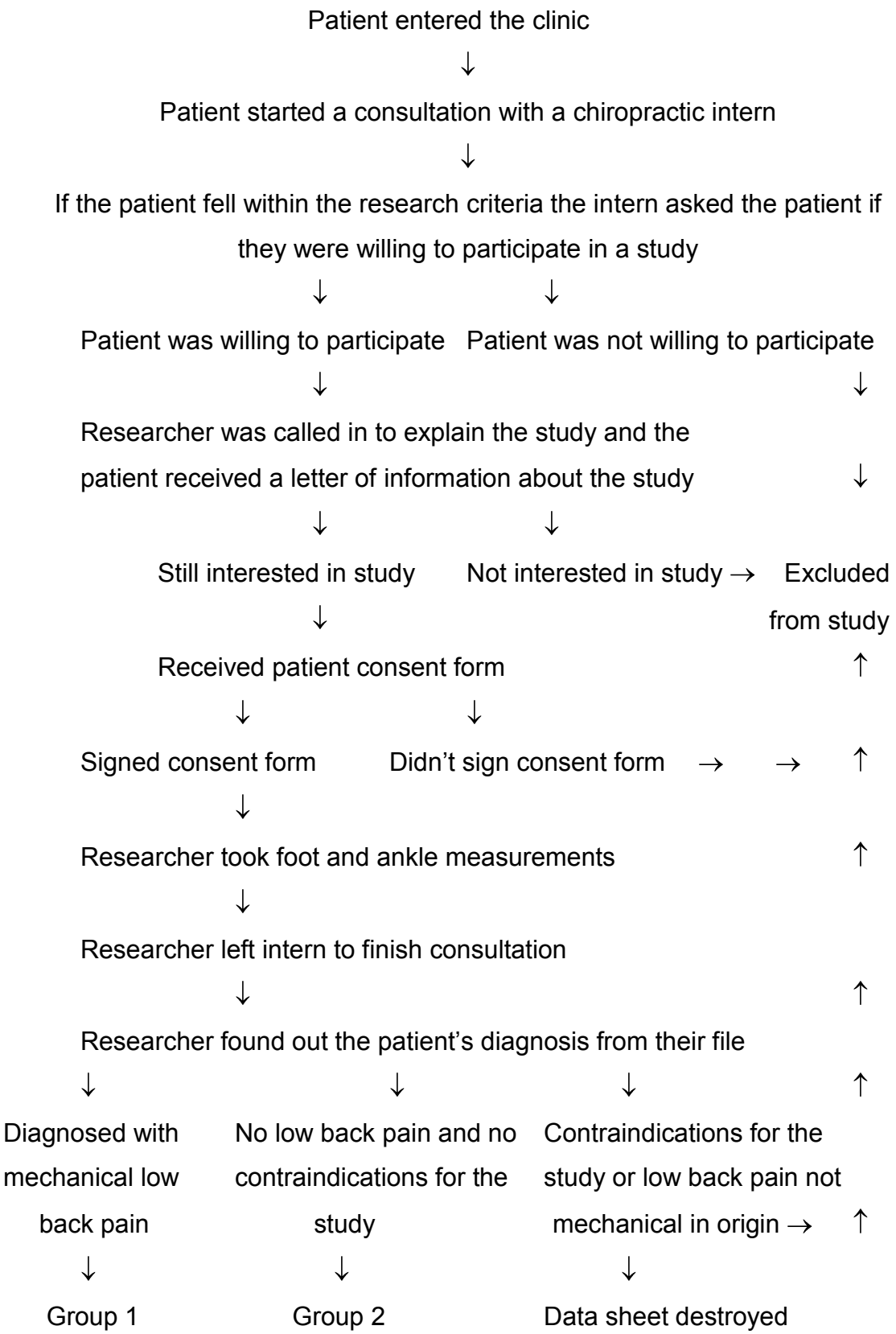
Decision rule:

If $p < \alpha$, reject Ho

if p / α, accept Ho

Where p is the reported p-value

3.13. Flow chart summarising the research process:



CHAPTER FOUR: Results

4.1. Introduction

This chapter contains the results obtained after statistical analysis of the data collected in the study. It includes demographic data as well as the researcher's objective data, namely:

- Goniometer readings of ankle dorsiflexion
- Goniometer readings of hallux dorsiflexion
- Difference in navicular height between resting and neutral standing postures

The results have been tabulated and, where appropriate, shown in the form of a graph. The demographic data has been split up into the two groups (Group 1 having chronic mechanical low back pain and Group 2 having no low back pain) for comparison purposes. The following abbreviations have been used in the tables which follow: sample size (N), mean value (MEAN), standard deviation (S.D.), level of significance (P-VALUE), t-value for independent samples t-test (T), t-value for paired samples t-test (T_d) and degrees of freedom (DF).

4.2. Criteria governing the admissibility of data

Only data collected from patients who met all of the criteria for the study was used. Information was obtained from the objective measurements taken by the researcher and from information obtained from the respective file of the participant after their consultation with the chiropractic intern. All the measurements were taken three times and the mean of the three measurements used.

4.3. Descriptive statistics

4.3.1. Explanation of the recruitment of patients

One hundred subjects with chronic mechanical low back pain and one hundred and four subjects with no back pain were entered into the study over a period of 5 ½ months. Participants were chosen using a non-probability purposive method of sampling, with any patient presenting to the Durban Institute of Technology Chiropractic Day Clinic and fitting the research criteria being eligible for participation in this study. An attempt was made to blind the researcher, with the initial consultation being done by a chiropractic intern at the Durban Institute of Technology Chiropractic Day Clinic and the researcher merely taking the objective foot measurements before finding out the patient's diagnosis.

An effort was made to try to limit the variables which may have had an influence on the study's results. For this reason the study population only involved people between the age of 18 and 45, with anyone with lower limb pain or who had had any foot surgery, which may have lead to decreased movement of the joints being measured, being excluded from the study. The interns participated in the initial screening process. They were briefed on the inclusion and exclusion criteria of the study and asked not to call the researcher for patients who fell outside the research criteria. Despite this, the table below some patients who were excluded from the study after the measurements had been taken. A total of 245 patients were seen with 41 patients excluded for the reasons below.

Table 1: Patients excluded from the study

EXCLUSION CRITERIA	NUMBER
Person > 45 years of age	1
Lower limb pain	4
Low back pain not mechanical in origin	1
Low back pain acute and not chronic	35
Total	41

4.4. Demographic data

Table 2: Age distribution of patients

AGE	GROUP 1 LBP / % OF GROUP	GROUP 2 NO LBP / % OF GROUP	TOTAL / % OF TOTAL
18-21	8 (8%)	19 (18%)	27 (13%)
22-25	21 (21%)	25 (24%)	46 (23%)
26-29	18 (18%)	22 (21%)	40 (20%)
30-33	15 (15%)	11 (11%)	26 (13%)
34-37	15 (15%)	9 (9%)	24 (12%)
38-41	8 (8%)	8 (8%)	16 (8%)
42-45	15 (15%)	10 (10%)	25 (12%)
TOTAL	100 (100%)	104 (100%)	204 (100%)

Table 3: Average age and age range of patients

AGE	GROUP 1 (LBP)	GROUP 2 (NO LBP)
AVERAGE AGE	31.23	28.82
YOUNGEST	18	18
OLDEST	45	44

Table 4: Gender distribution of patients

GENDER	GROUP 1 / % OF GROUP	GROUP 2 / % OF GROUP	TOTAL / % OF TOTAL
MALE	68 (68%)	41 (39%)	109 (53%)
FEMALE	32 (32%)	63 (61%)	95 (47%)
TOTAL	100 (100%)	104 (100%)	204 (100%)

Table 5: Race distribution of patients

RACE	GROUP 1 / % OF GROUP	GROUP 2 / % OF GROUP	TOTAL / % OF TOTAL
CHINESE	1 (1%)	0 (0%)	1 (0.5%)
BLACK	4 (4%)	12 (11)%)	16 (7.8%)
COLOURED	3 (3%)	5 (5%)	8 (3.9%)
INDIAN	28 (28%)	25 (24%)	53 (26.0%)
WHITE	64 (64%)	62 (60%)	126 (61.8%)
TOTAL	100 (100%)	104 (100%)	204 (100%)

Table 6: Occupation of patients

OCCUPATION	GROUP 1 / % OF GROUP	GROUP 2 / % OF GROUP	TOTAL / % OF TOTAL
MANAGERIAL	13 (13%)	5 (5%)	18 (9%)
SALES/ MARKETING	7 (7%)	11 (11%)	18 (9%)
MEDICAL/ PARAMEDICAL	6 (6%)	2 (2%)	8 (4%)
TECHNICIAN/ MANUAL LABOUR	16 (16%)	5 (5%)	21 (10%)
STUDENT	16 (16%)	37 (35%)	53 (26%)
SPORTSMAN	2 (2%)	3 (3%)	5 (2.5%)
DESK JOBS	16 (16%)	20 (19%)	36 (18%)
SECURITY/ LAW ENFORCEMENT	1 (1%)	2 (2%)	3 (1.5%)
EDUCATOR	9 (9%)	5 (5%)	14 (7%)
ARTIST/ MUSICIAN	1 (1%)	4 (4%)	5 (2.5%)
SELF EMPLOYED	5 (5%)	4 (4%)	9 (4%)
HOME EXECUTIVE	7 (7%)	2 (2%)	9 (4%)
UNEMPLOYED	1 (1%)	4 (4%)	5 (2.5%)
TOTAL	100 (100%)	104 (100%)	204 (100%)

4.5. Inter-group results: Independent samples t-test

The results from groups 1 and 2 were compared with regard to the measurements of ankle dorsiflexion, hallux dorsiflexion and the difference in navicular height between the resting and neutral standing postures.

4.5.1. Statistical analysis: Inter-group

Test statistic: Independent samples t-test

$$T = \frac{\bar{x} - \bar{y}}{s_p \sqrt{1/n_1 + 1/n_2}}$$

Where:

$\bar{x}$ = *The sample mean of Group 1*

$\bar{y}$ = *The sample mean of Group 2*

n_1 = *The sample size of Group 1*

n_2 = *The sample size of Group 2*

$s_p^2 = \frac{(n_1-1)s_1^2 + (n_2-1)s_2^2}{n_1 + n_2 - 2}$

S_1^2 = *The sample variance for Group 1*

S_2^2 = *The sample variance for Group 2*

The t-statistic has a t-distribution with n_1+n_2-2 degrees of freedom

The null hypothesis (Ho) states that there is no difference between the means of the two groups with respect to the variable of interest.

The alternative hypothesis (Ha) states that there is a difference between the means of the two groups.

Ho: There is no difference between the mean of Group 1 and the mean of Group 2

Ha: There is a difference between the mean of Group 1 and the mean of Group 2

Decision rule:

If $p < \alpha$, reject Ho

if p / α, accept Ho

Where p is the reported p-value

4.5.2. Results of inter-group analysis

Table 7: Ankle dorsiflexion in Groups 1 and 2

MEASUREMENT	GROUP	N	MEAN	S.D.
RIGHT ANKLE DORSIFLEXION	Group 1	100	14.97	4.53
	Group 2	104	17.14	5.21
LEFT ANKLE DORSIFLEXION	Group 1	100	15.80	4.60
	Group 2	104	17.53	6.59

Table 7 gives an indication of the amount of dorsiflexion that was available at the ankle joint of participants within the two groups. When the means are compared, it appears that the patients with chronic mechanical low back pain (Group 1) had less dorsiflexion available than participants with no low back pain (Group 2), in both the right and the left ankles.

Table 8: Results of the independent samples t-test for ankle dorsiflexion in Groups 1 and 2

MEASUREMENT	T	DF	P-VALUE
RIGHT ANKLE DORSIFLEXION	-3.159	202	0.002
LEFT ANKLE DORSIFLEXION	-2.164	202	0.032

Table 8 shows the results of the independent samples t-test comparing ankle dorsiflexion between the groups. The null hypothesis was rejected for the right ankle (p=0.002) and the left ankle (p=0.032), indicating a statistically significant difference between the two groups at the 5% significance level.

Table 9: Hallux dorsiflexion in Groups 1 and 2

MEASUREMENT	GROUP	N	MEAN	S.D.
RIGHT HALLUX DORSIFLEXION	Group 1	100	52.12	12.02
	Group 2	104	53.14	12.93
LEFT HALLUX DORSIFLEXION	Group 1	100	53.81	11.49
	Group 2	104	57.06	13.38

Table 9 gives an indication of the amount of dorsiflexion that was available at the hallux of participants within the two groups. When the means are compared, it appears that the patients with chronic mechanical low back pain (Group 1) had less dorsiflexion available than participants with no low back pain (Group 2), in the hallux of both the right and the left feet.

Table 10: Results of the independent samples t-test for hallux dorsiflexion in Groups 1 and 2

MEASUREMENT	T	DF	P-VALUE
RIGHT HALLUX DORSIFLEXION	-0.581	202	0.562
LEFT HALLUX DORSIFLEXION	-1.855	202	0.065

Table 10 shows the results of the independent samples t-test comparing hallux dorsiflexion between the groups. The null hypothesis was not rejected for the right hallux (p=0.562) or the left hallux (p=0.065) at the 5% level of significance, indicating that no statistically significant difference was found at this level between Group 1 and Group 2 for the right or left hallux.

Table 11: Difference in navicular height between the resting and neutral standing postures in Groups 1 and 2

MEASUREMENT	GROUP	N	MEAN	S.D.
RIGHT NAVICULAR DIFFERENCE	Group 1	100	3.92	4.12
	Group 2	104	5.64	4.14
LEFT NAVICULAR DIFFERENCE	Group 1	100	4.14	4.45
	Group 2	104	5.75	4.27

Table 11 gives an indication of the difference in navicular height between the resting and neutral standing postures, between patients with chronic mechanical low back pain (Group1) and participants without low back pain (Group 2). When the means are compared it appears that the patients with chronic mechanical low back pain (Group 1) had a smaller difference in navicular height in comparison to the participants with no low back pain (Group 2).

Table 12: Results of the independent samples t-test for the difference in navicular height between the resting and neutral standing postures in Groups 1 and 2

MEASUREMENT	T	DF	P-VALUE
RIGHT NAVICULAR DIFFERENCE	-2.981	202	0.003
LEFT NAVICULAR DIFFERENCE	-2.629	202	0.009

Table 12 shows the results of the independent samples t-test comparing the difference in navicular height between the resting and neutral standing postures in Groups 1 and 2 between the groups. The null hypothesis was rejected for the right foot (p=0.003) and the left foot (p=0.009), indicating a statistically significant difference at the 5% significance level between the two groups.

4.6. Intra-group results: Paired samples t-test

The right and the left foot were compared within the groups with regard to the measurements of ankle dorsiflexion, hallux dorsiflexion and the difference in navicular height between the resting and neutral standing postures.

4.6.1. Statistical analysis: Intra-group

Test statistic: Paired samples t-test

$$T_d = \frac{\bar{d}}{s_d / \sqrt{n}}$$

Where:

r = *The right foot measurement*

l = *The left foot measurement*

d = *The difference between the right and left foot measurements*

d_i = $r_i - l_i$, $i = 1, \ldots, n$

$\bar{d}$ = *The mean for the differences*

$\bar{d}$ = $1/n \sum_{i=1}^{n} d_i$

s_d^2 = *The variance for the differences*

The t-statistic has a t-distribution with n-1 degrees of freedom

The null hypothesis (Ho) states that there is no difference within the group between the means of the right and the left foot measurements.

The alternative hypothesis (Ha) states that there is a difference within the group between the means of the right and the left foot measurements.

Ho: There is no difference between the means of the right and left foot measurements

Ha: There is a difference between the means of the right and left foot measurements.

Decision rule:

If p < α, reject Ho

if p / α, accept Ho

Where p is the reported p-value

4.6.2. Results of intra-group analysis

Table 13: Ankle dorsiflexion, hallux dorsiflexion and the difference in navicular height between the resting and neutral standing postures: Group 1

GROUP 1			
MEASUREMENT	**SIDE**	**MEAN**	**S.D.**
ANKLE DORSIFLEXION	Right Left	14.97 15.80	4.53 4.60
HALLUX DORSIFLEXION	Right Left	52.12 53.81	12.02 11.49
NAVICULAR DIFFERENCE	Right Left	3.92 4.14	4.12 4.45

Table 13 gives an indication of the difference between the means of the right and left feet for all measurements within Group 1 (patients with chronic mechanical low back pain). When the means are compared it appears that patients with chronic mechanical low back pain had less dorsiflexion available in the right ankle than in the left ankle.

Table 14: Results of the paired samples t-test within Group 1, for ankle dorsiflexion, hallux dorsiflexion and the difference in navicular height between the resting and neutral standing postures

GROUP 1			
MEASUREMENT	**T_d**	**DF**	**P-VALUE**
ANKLE DORSIFLEXION	-2.119	99	0.037
HALLUX DORSIFLEXION	-1.772	99	0.079
NAVICULAR DIFFERENCE	-0.567	99	0.572

Table 14 shows the results of the paired samples t-test within Group 1. The null hypothesis was rejected for ankle dorsiflexion (p=0.037), indicating that there was a statistically significant difference, at the 5% significance level, between the means of the right and left foot measurements within Group 1. The null hypothesis was not rejected for the hallux dorsiflexion (p=0.079) and navicular difference measurements (p=0.572), indicating that there was no statistically significant difference, at the 5% significance level, between the means of the right and left foot for hallux dorsiflexion and navicular difference measurements in Group 1.

Table 15: Ankle dorsiflexion, hallux dorsiflexion and the difference in navicular height between the resting and neutral standing postures: Group 2

GROUP 2			
MEASUREMENT	**SIDE**	**MEAN**	**S.D.**
ANKLE DORSIFLEXION	Right Left	17.13 17.53	5.21 6.59
HALLUX DORSIFLEXION	Right Left	53.14 57.06	12.93 13.38
NAVICULAR DIFFERENCE	Right Left	5.64 5.75	4.14 4.27

Table 15 gives an indication of the difference between the means for the right and left feet for all measurements within Group 2 (patients with no low back pain). When the means are compared it appears that participants with no low back pain had less hallux dorsiflexion available in the right hallux than the left hallux.

Table 16: Results of the paired samples t-test within Group 2, for ankle dorsiflexion, hallux dorsiflexion and the difference in navicular height between the resting and neutral standing postures

GROUP 2			
MEASUREMENT	**T_d**	**DF**	**P-VALUE**
ANKLE DORSIFLEXION	-0.963	103	0.338
HALLUX DORSIFLEXION	-4.090	103	0.000
NAVICULAR DIFFERENCE	-0.398	103	0.692

Table 16 shows the results of the paired samples t-test within Group 2. The null hypothesis was rejected for hallux dorsiflexion (p=0.000), indicating that there was a statistically significant difference, at the 5% significance level, between the means of the right and left foot within Group 2. The null hypothesis was not rejected for the ankle dorsiflexion (p=0.338) and navicular difference measurements (p=0.692), indicating that there was no statistically significant difference, at the 5% significance level, between the means of the right and left foot for ankle dorsiflexion and navicular difference measurements in Group 2.

4.7. Association: Chi-square and Cramer's V

To test the association between mechanical low back pain and static foot measurements a chi-square test was carried out. Cramer's V was then used to determine the degree of association (correlation). In order for tests of association to be done the data needed to be grouped into categories. Due to 10^0 of dorsiflexion of the ankle being considered normal (Dananberg, 1997:259), the data was split into categories of $<10^0$ and $>10^0$ of dorsiflexion. For more clarity the measurements above 10^0 were also split into 2 groups ($10\text{-}19.99^0$ and 20^0+) to indicate normal movement ($10\text{-}19.99^0$) and greater than normal movement (20^0+). Similarly, since it is generally believed that 65^0 of hallux dorsiflexion is considered to be normal (Lichniak, 1997:416), the hallux measurements were split into $0\text{-}64.99^0$ dorsiflexion and 65^0+ dorsiflexion.

The measurement of the difference in navicular height between the resting and neutral standing postures was done in order to try to ascertain whether the participants pronated or supinated. McPoil and Cornwall (1996:313) found this variable to be the only one of 17 variables able to predict maximum rearfoot pronation. For the tests of association the results of this test were also grouped into categories. These categories were broken down into <0 mm (indicating supination), 0 mm (indicating no supination or pronation), 0.01-9.99 mm (indicating pronation) and 10 mm + (indicating greater pronation). The data is cross-classified into these categories followed by the relevant values for the chi-square test and Cramer's V.

4.7.1. Statistical analysis for chi-square

Test statistic: Chi-square

$$\chi^2 = \sum_{i=1}^{r} \sum_{j=1}^{c} \frac{(o_{ij}-e_{ij})^2}{e_{ij}}$$

Where:

o_{ij} = *The observed frequency in the i-th row, j-th column*

e_{ij} = *The expected frequency in the i-th row, j-th column*

r = *The number of rows*

c = *The number of columns*

Chi-square has a chi-square distribution with (r-1)(c-1) degrees of freedom

The null hypothesis (Ho) states that the two variables are independent from each other and no association exists.

The alternative hypothesis (Ha) states that the two variables are associated with each other.

Ho: Variables A and B are independent from each other and no association exists.

Ha: Variables A and B are associated with each other.

Decision rule:

If p < α, reject Ho

if p / α, accept Ho

Where p is the reported p-value

4.7.2. Statistical analysis for Cramer's V

Test statistic: Cramer's V

$$V = \sqrt{\frac{\frac{\chi}{n}}{\min(r -)(c -)}}$$

Where:

r = *The number of rows*

c = *The number of columns*

χ = *The chi-square statistic*

min = *Minimum*

The null hypothesis (Ho) states that the two variables are independent from each other and no association exists.

The alternative hypothesis (Ha) states that the two variables are associated with each other.

Ho: Variables A and B are independent from each other and no association exists.

Ha: Variables A and B are associated with each other.

Decision rule:

If p < α, reject Ho

if p / α, accept Ho

Where p is the reported p-value

4.7.3. Results of chi-square and Cramer's V

Table 17: Frequency table for right ankle dorsiflexion measurements expressed in categories

RIGHT ANKLE DORSIFLEXION	GROUP 1 / % OF GROUP	GROUP 2 / % OF GROUP	TOTAL / % OF TOTAL
$<10^0$	4 (4%)	1 (1%)	5 (3%)
$10\text{-}19.99^0$	82 (82%)	78 (75%)	160 (78%)
20^0+	14 (14%)	25 (24%)	39 (19%)
TOTAL	100 (100%)	104 (100%)	204 (100%)

Table 17 gives an indication of the distribution of ankle dorsiflexion measurements of the right ankle expressed in categories. Although few people exhibited less than 10^0 of dorsiflexion, the majority who did were found within Group 1. The majority of subjects in both groups were able to dorsiflex their right ankle $10\text{-}19.99^0$. The majority of participants who were able to dorsiflex their right ankle more than 20^0 were found in Group 2.

Table 18: Pearson's Chi-square and Cramer's V values for ankle dorsiflexion of the right foot

RIGHT ANKLE			
	VALUE	DF	P-VALUE
PEARSON'S CHI-SQUARE	4.926	2	0.085
CRAMER'S V	0.155		0.085

Table 18 shows that there is no association between ankle dorsiflexion of the right foot and chronic mechanical low back pain at the 5% level of significance. The null hypothesis was therefore accepted.

Table 19: Frequency table for left ankle dorsiflexion measurements expressed in categories

LEFT ANKLE DORSIFLEXION	GROUP 1 / %OF GROUP	GROUP 2 / % OF GROUP	TOTAL / % OF TOTAL
$<10^0$	7 (7%)	6 (6%)	13 (6%)
$10\text{-}19.99^0$	75 (75%)	68 (65%)	143 (70%)
20^0+	18 (18%)	30 (29%)	48 (24%)
TOTAL	100 (100%)	104 (100%)	204 (100%)

Table 19 gives an indication of the distribution of ankle dorsiflexion measurements of the left ankle expressed in categories. Although there were also few people who exhibited less than 10^0 of dorsiflexion, the number was greater than for the right foot, and a slight majority was found within Group 1. As in the right ankle, the majority of subjects in both groups were able to dorsiflex their right ankle $10\text{-}19.99^0$. The majority of participants who were able to dorsiflex their left ankle more than 20^0 were again found in Group 2.

Table 20: Pearson's Chi-square and Cramer's V values for ankle dorsiflexion of the left foot

LEFT ANKLE			
	VALUE	DF	P-VALUE
PEARSON'S CHI-SQUARE	3.342	2	0.188
CRAMER'S V	0.128		0.188

Table 20 shows that there is no association between ankle dorsiflexion of the left foot and chronic mechanical low back pain at the 5% level of significance. The null hypothesis was therefore accepted.

Table 21: Frequency table for right hallux dorsiflexion measurements expressed in categories

RIGHT HALLUX DORSIFLEXION	GROUP 1 / % OF GROUP	GROUP 2 / % OF GROUP	TOTAL / % OF TOTAL
$0\text{-}64.99^0$	86 (86%)	83 (80%)	169 (83%)
65^0+	14 (14%)	21 (20%)	35 (17%)
TOTAL	100 (100%)	104 (100%)	204 (100%)

Table 21 gives an indication of the distribution of hallux dorsiflexion measurements of the right hallux expressed in categories. Although 65^0 of hallux dorsiflexion is considered to be normal (Lichniak, 1997:416) the majority of people in both groups exhibited less than 65^0 of dorsiflexion, with a slightly greater percentage being found in Group 1.

Table 22: Pearson's Chi-square and Cramer's V values for hallux dorsiflexion of the right foot

RIGHT HALLUX			
	VALUE	DF	P-VALUE
PEARSON'S CHI-SQUARE	1.375	1	0.241
CRAMER'S V	0.082		0.241

Table 22 shows that there is no association between hallux dorsiflexion of the right foot and chronic mechanical low back pain at the 5% level of significance. The null hypothesis was therefore accepted.

Table 23: Frequency table for left hallux dorsiflexion measurements expressed in categories

LEFT HALLUX DORSIFLEXION	GROUP 1 / % OF GROUP	GROUP 2 / % OF GROUP	TOTAL / % OF TOTAL
$0\text{-}64.99^0$	83 (83%)	76 (73%)	159 (78%)
65^0+	17 (17%)	28 (27%)	45 (22%)
TOTAL	100 (100%)	104 (100%)	204 (100%)

Table 23 gives an indication of the distribution of hallux dorsiflexion measurements of the left hallux expressed in categories. Again, although 65^0 of hallux dorsiflexion is considered to be normal (Lichniak, 1997:416) the majority of people in both groups exhibited less than 65^0 of dorsiflexion, with a slightly greater percentage being found in Group 1.

Table 24: Pearson's Chi-square and Cramer's V values for hallux dorsiflexion of the left foot

LEFT HALLUX			
	VALUE	DF	P-VALUE
PEARSON'S CHI-SQUARE	2.920	1	0.088
CRAMER'S V	0.120		0.088

Table 24 shows that there is no association between hallux dorsiflexion of the left foot and chronic mechanical low back pain at the 5% level of significance. The null hypothesis was therefore accepted.

Table 25: Frequency table for the difference in navicular height between the resting and neutral standing postures for the right foot, expressed in categories

RIGHT NAVICULAR DIFFERENCE	GROUP 1 / % OF GROUP	GROUP 2 / % OF GROUP	TOTAL / % OF TOTAL
<0 mm	14 (14%)	3 (3%)	17 (8%)
0 mm	9 (9%)	3 (3%)	12 (6%)
0.01-9.99 mm	65 (65%)	86 (83%)	151 (74%)
10 mm +	12 (12%)	12 (11%)	24 (12%)
TOTAL	100 (100%)	104 (100%)	204 (100%)

Table 25 shows that in the right foot the majority of people in both groups displayed a navicular difference of 0.01-9.99 mm, indicating that they might pronate during the gait cycle. In Group 1 there were more people in the <0 mm range, indicating that more people in Group 1 might supinate, as well as there being more cases of 0 mm being measured, meaning that no pronation or supination was exhibited.

Table 26: Pearson's Chi-square and Cramer's V values for difference in navicular height between the resting and neutral standing postures for the right foot

RIGHT NAVICULAR			
	VALUE	DF	P-VALUE
PEARSON'S CHI-SQUARE	12.965	3	0.005
CRAMER'S V	0.252		0.005

Table 26 shows that there is an association between the difference in navicular height between the resting and neutral standing postures for the right foot and chronic mechanical low back pain at the 5% level of significance. The null hypothesis was therefore rejected.

Table 27: Frequency table for the difference in navicular height between the resting and neutral standing postures for the left foot, expressed in categories

LEFT NAVICULAR DIFFERENCE	GROUP 1 / % OF GROUP	GROUP 2 / % OF GROUP	TOTAL / % OF TOTAL
<0 mm	15 (15%)	8 (8%)	23 (11%)
0 mm	2 (2%)	2 (2%)	4 (2%)
0.01-9.99 mm	75 (75%)	81 (78%)	156 (77%)
10 mm +	8 (8%)	13 (12%)	21 (10%)
TOTAL	100 (100%)	104 (100%)	204 (100%)

Table 27 shows that in the left foot the majority of people in both groups also displayed a navicular difference of 0.01-9.99 mm, indicating that they might pronate during the gait cycle. In Group 1 there were again more people in the <0 mm range, indicating that more people in Group 1 might supinate. There were slightly more people in the 10 mm + range in Group 2, indicating that slightly more people might pronate more during the gait cycle.

Table 28: Pearson's Chi-square and Cramer's V values for difference in navicular height between the resting and neutral standing postures for the left foot

LEFT NAVICULAR			
	VALUE	DF	P-VALUE
PEARSON'S CHI-SQUARE	3.475	3	0.324
CRAMER'S V	0.131		0.324

Table 28 shows that there is no association between the difference in navicular height between the resting and neutral standing postures for the left foot and chronic mechanical low back pain at the 5% level of significance. The null hypothesis was therefore accepted.

4.8. Distribution of sagittal plane blockage

Table 29: Frequency table for the distribution of sagittal plane blockage (SPB) between the groups

SPB	GROUP 1 NUMBER OF JOINTS / % OF GROUP	GROUP 2 NUMBER OF JOINTS / % OF GROUP	TOTAL / % OF TOTAL
$<10^0$ ANKLE DORSIFLEXION	11 (6%)	7 (4%)	18 (5%)
$<65^0$ HALLUX DORSIFLEXION	169 (94%)	159 (96%)	328 (95%)
TOTAL	180 (100%)	166 (100%)	346 (100%)
POSSIBLE TOTAL	400	416	816

Table 29 shows that of the 816 possible joints which could have been involved 346 displayed SPB. Of these, the majority in both groups were found in the hallux.

Table 30: Frequency table for the number of joints with SPB compared to the total joints in Group 1

GROUP 1	JOINTS WITH SPB / % OF TOTAL	JOINTS WITHOUT SPB / % OF TOTAL	TOTAL / % OF TOTAL
$<10^0$ ANKLE DORSIFLEXION	11 (5.5%)	189 (94.5%)	200 (50%)
$<65^0$ HALLUX DORSIFLEXION	169 (84.5%)	31 (15.5%)	200 (50%)
TOTAL	180 (45%)	220 (55%)	400 (100%)

Table 30 shows that 5.5% of the ankle joints in Group 1 exhibited SPB, and 84.5% of the first metatarsophalangeal joints of the hallux. This lead to a total of 45% of the 400 joints exhibiting SPB.

Table 31: Frequency table for the number of joints with SPB compared to the total joints in Group 2

GROUP 2	JOINTS WITH SPB / % OF TOTAL	JOINTS WITHOUT SPB / % OF TOTAL	TOTAL / % OF TOTAL
$<10^0$ ANKLE DORSIFLEXION	7 (3%)	189 (94.5%)	208 (50%)
$<65^0$ HALLUX DORSIFLEXION	159 (76%)	31 (15.5%)	208 (50%)
TOTAL	166 (40%)	220 (55%)	416 (100%)

Table 31 shows that 3% of the ankle joints in Group 2 exhibited SPB, and 76% of the first metatarsophalangeal joints of the hallux. This lead to a total of 40% of the 416 joints exhibiting SPB.

Table 32: Frequency table for the distribution of the number of people with unilateral and bilateral SPB in the ankle

ANKLE SPB ($<10^0$ ANKLE DORSIFLEXION)	GROUP 1 / % OF GROUP	GROUP 2 / % OF GROUP	TOTAL / % OF TOTAL
Unilateral	7 (78%)	7 (100%)	14 (87.5%)
Bilateral	2 (22%)	0 (0%)	2 (12.5%)
Total	9 (100%)	7 (100%)	16 (100%)

Table 32 shows that of the cases of SPB in the ankle the majority were unilateral. Only a few cases were bilateral and these were only found in Group 1 (participants with chronic mechanical low back pain).

Table 33: Frequency table for the distribution of number of people with unilateral and bilateral SPB in the hallux

HALLUX SPB (<65^0 HALLUX DORSIFLEXION)	GROUP 1 / % OF GROUP	GROUP 2 / % OF GROUP	TOTAL / % OF TOTAL
Unilateral	17 (18%)	13 (15%)	30 (17%)
Bilateral	76 (82%)	73 (85%)	149 (83%)
Total	93 (100%)	86 (100%)	179 (100%)

Table 33 shows that of the cases of SPB in the hallux the majority were bilateral, with slightly more cases found in Group 1 (participants with chronic mechanical low back pain). Of the unilateral cases found, again slightly more cases were found in Group 1.

Table 34: Frequency table for the side of SPB in unilateral cases

SPB	GROUP 1		GROUP 2	
	RIGHT	LEFT	RIGHT	LEFT
Ankle	2	5	1	6
Hallux	10	7	10	3
Total	12	12	11	9

Table 34 shows that of the unilateral cases of SPB in the ankle Group 1 displayed 2 cases on the right and 5 cases on the left, and Group 2 displayed 1 case on the right and 6 cases on the left. For the hallux, Group 1 displayed 10 cases on the right and 7 cases on the left, while Group 2 displayed 11 cases on the right and 9 cases on the left.

Table 35: Frequency table for the breakdown of the number of joints displaying SPB in the study participants

NUMBER OF JOINTS INVOLVED	GROUP 1 / % OF GROUP	GROUP 2 / % OF GROUP	TOTAL / % OF TOTAL
0	6 (6%)	17 (16%)	23 (11%)
1	16 (16%)	12 (12%)	28 (14%)
2	72 (72%)	71 ((68%)	143 (70%)
3	4 (4%)	4 (4%)	8 (4%)
4	2 (2%)	0 (0%)	2 (1%)
Total number of people with SPB	94 (94%)	87 (84%)	181 (89%)
Total number of people in group	100 (100%)	104 (100%)	204 (100%)

Table 35 shows that the majority of participants in both groups had 2 joints displaying SPB. The next largest number in Group 1 was 1 joint involved and in Group 2 was 0 joints involved. Only 2 individuals demonstrated SPB of all 4 joints and both were found in Group 1.

4.9. Graphical presentation of the data

Figure 1: Age distribution of patients

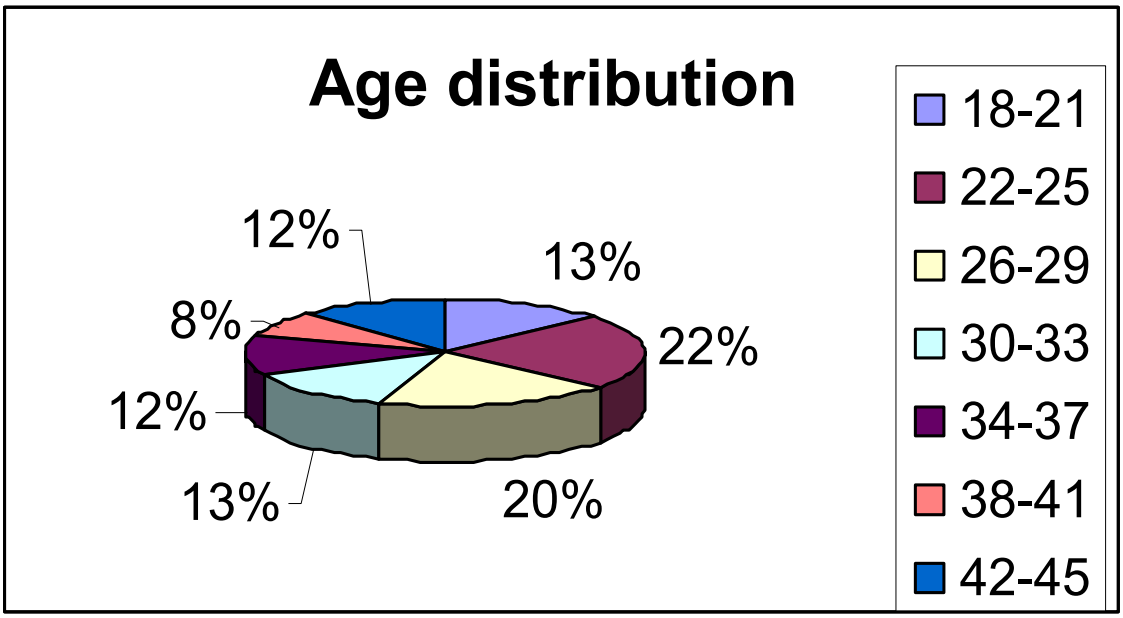


Figure 2: Gender distribution of patients

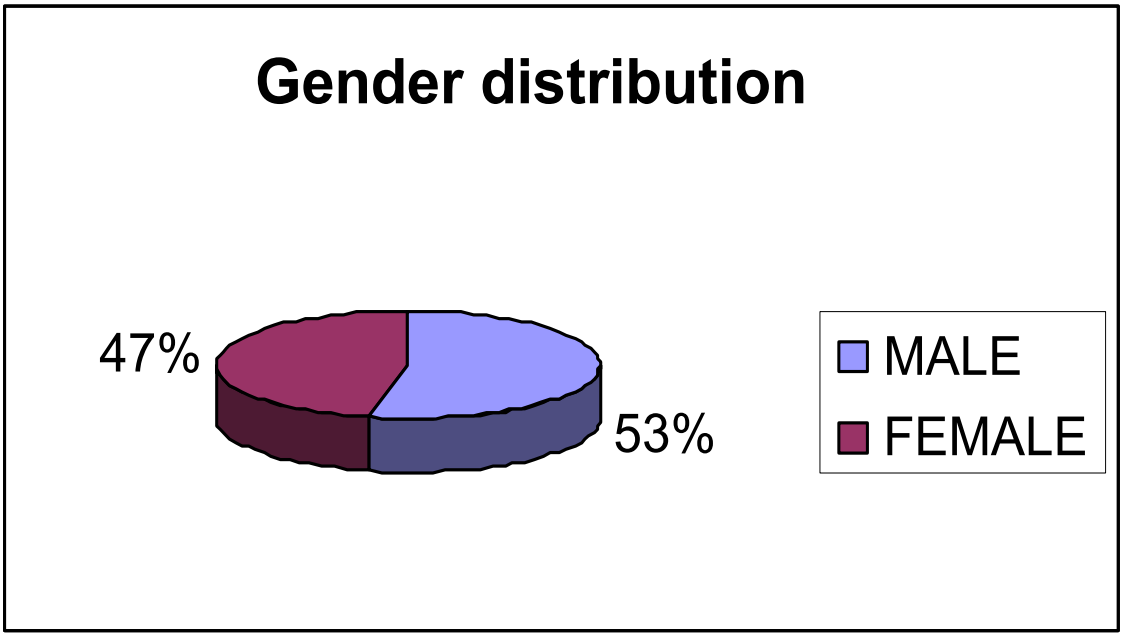


Figure 3: Race distribution of patients

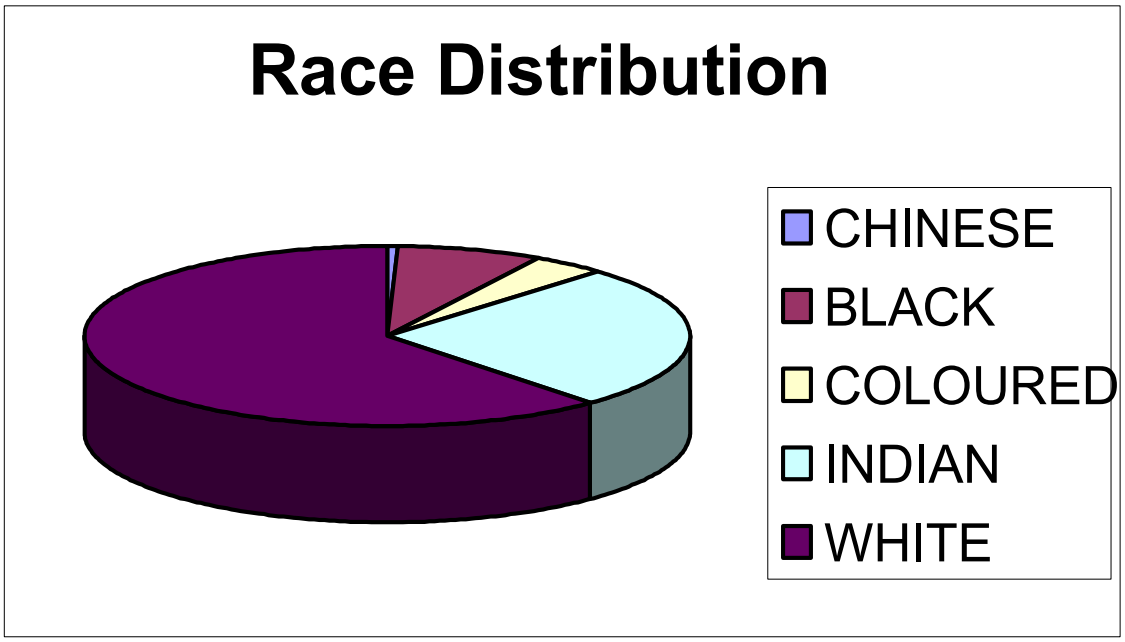


Figure 4: Occupation of patients

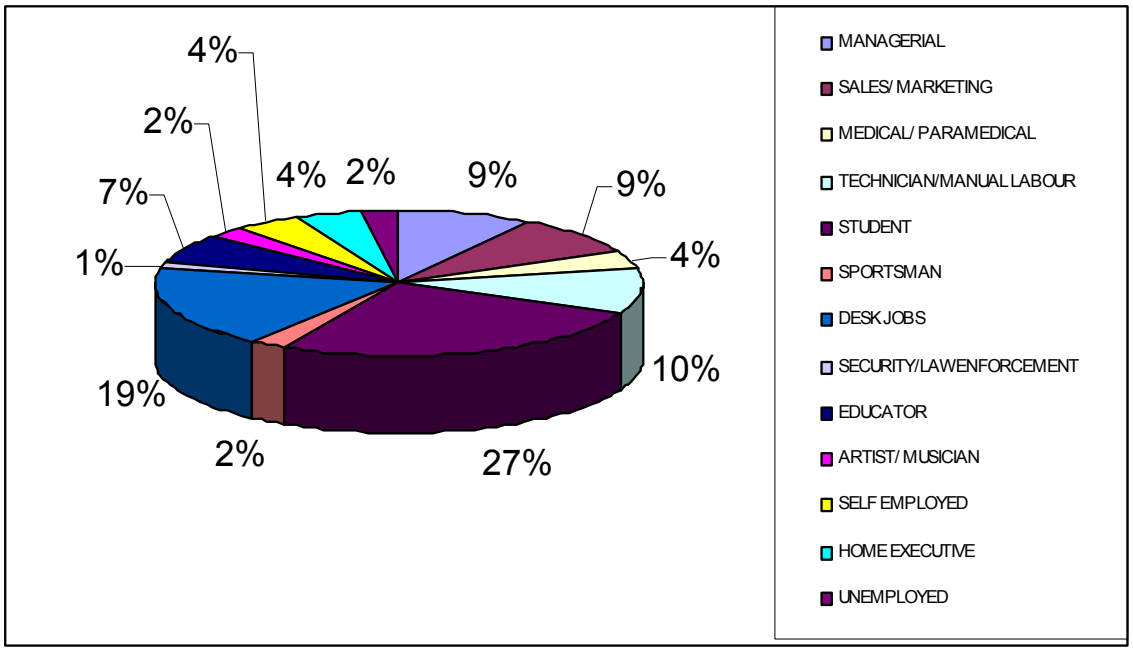


Figure 5: Ankle dorsiflexion: Inter-group comparison

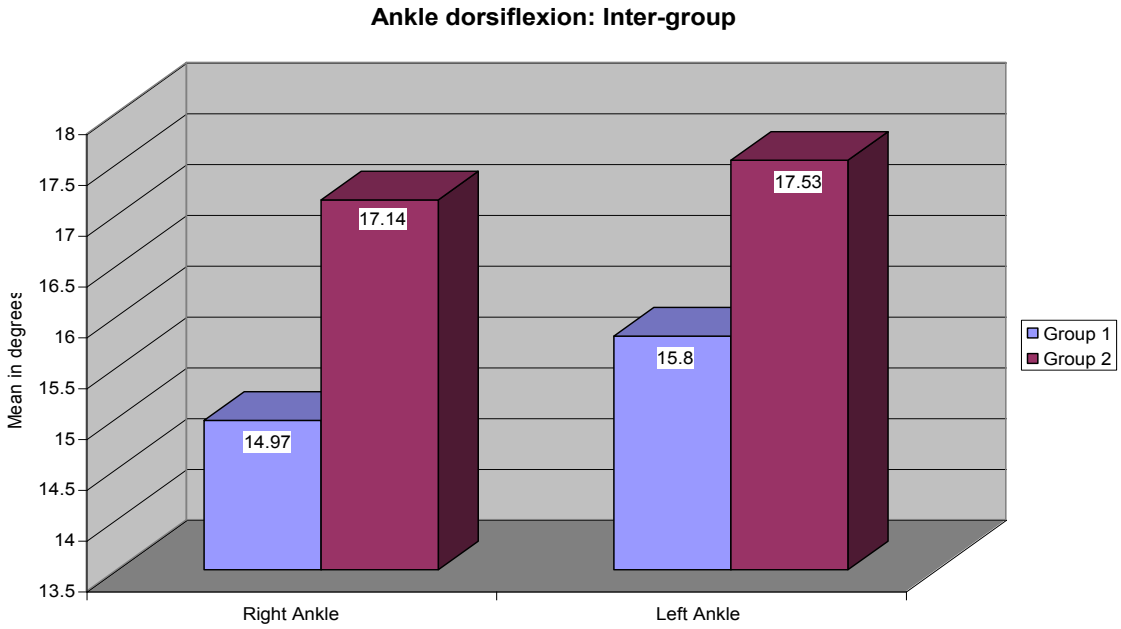


Figure 6: Ankle dorsiflexion: Intra-group comparison

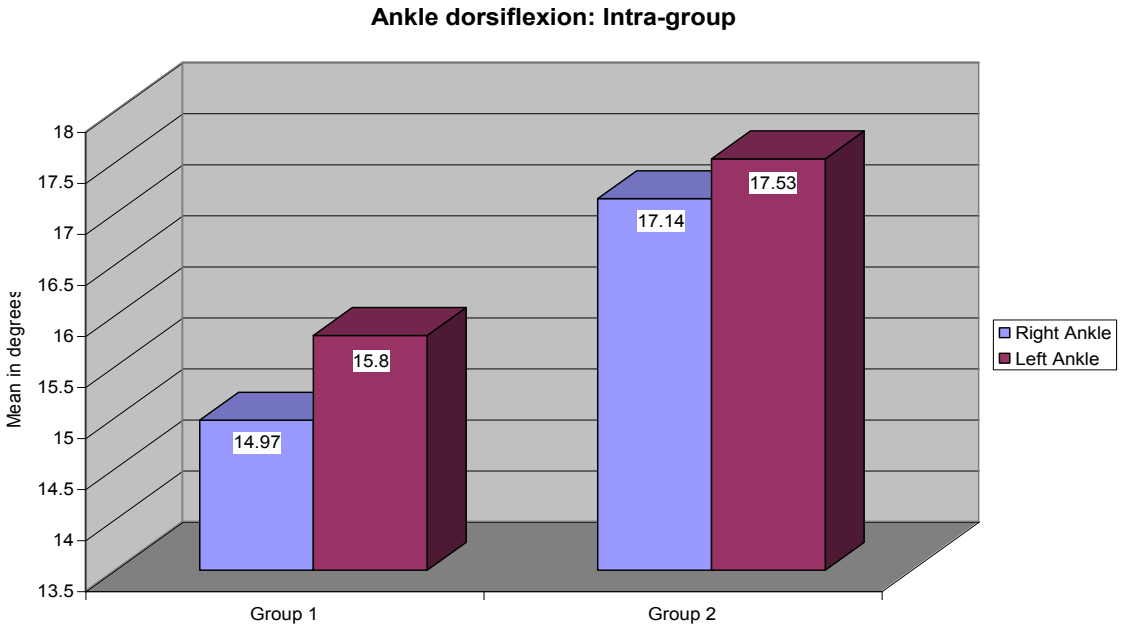


Figure 7: Hallux dorsiflexion: Inter-group comparison

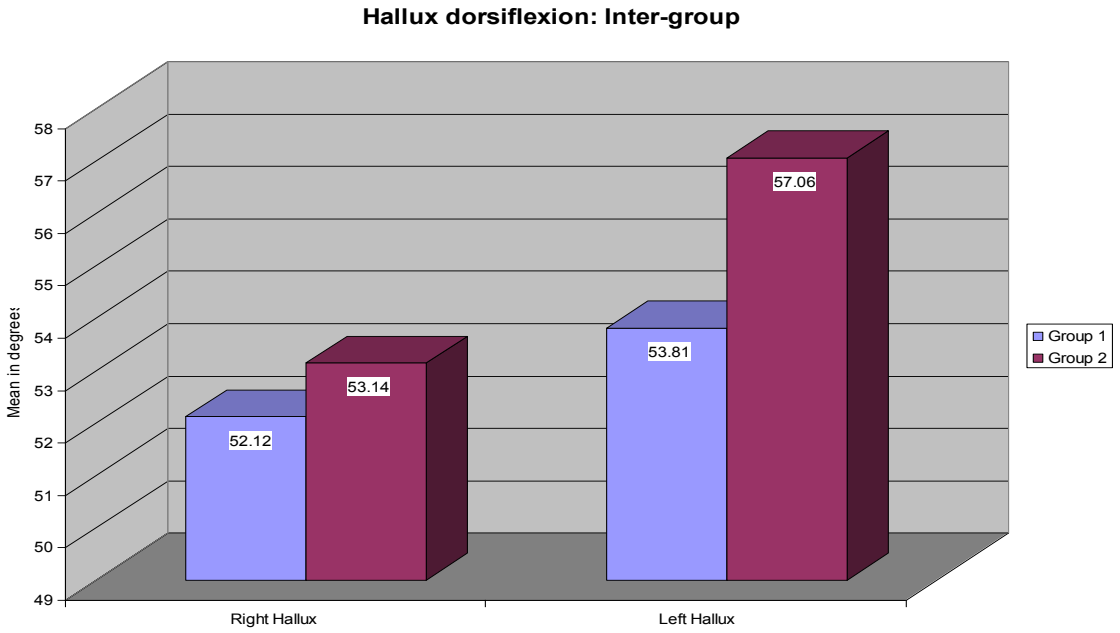


Figure 8: Hallux dorsiflexion: Intra-group comparison

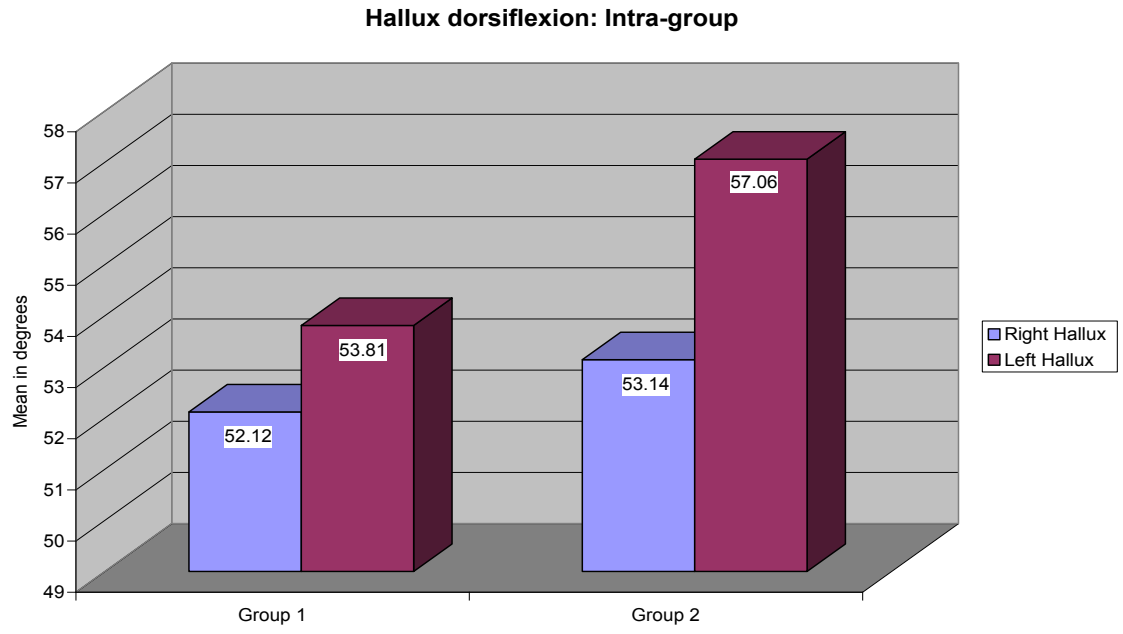


Figure 9: Difference in navicular height between the resting and neutral standing postures: Inter-group comparison

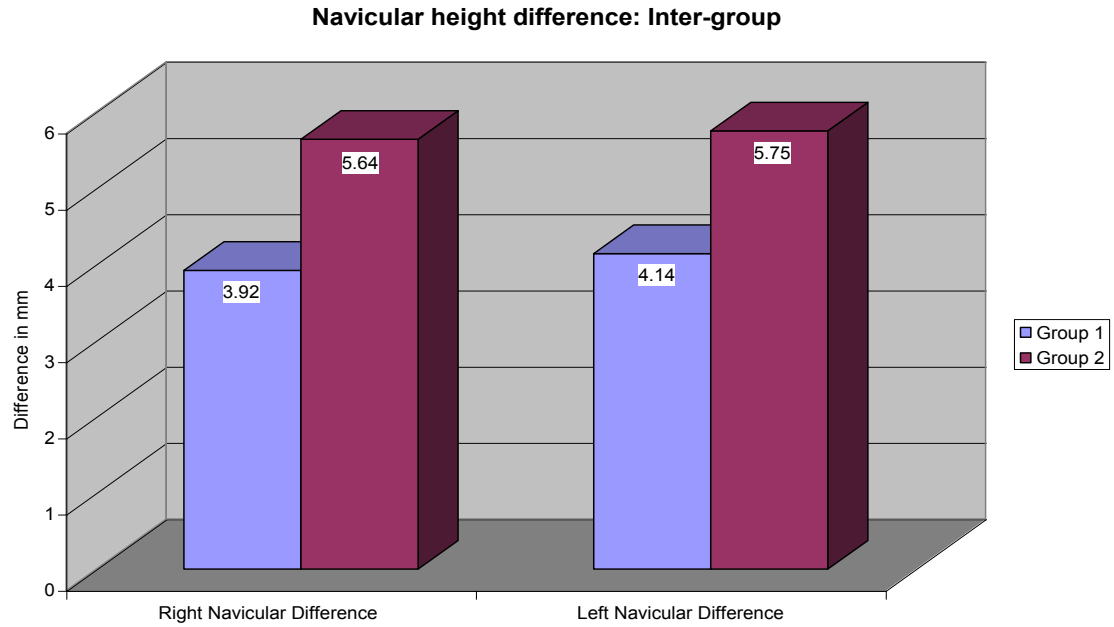


Figure 10: Difference in navicular height between the resting and neutral standing postures: Intra-group comparison

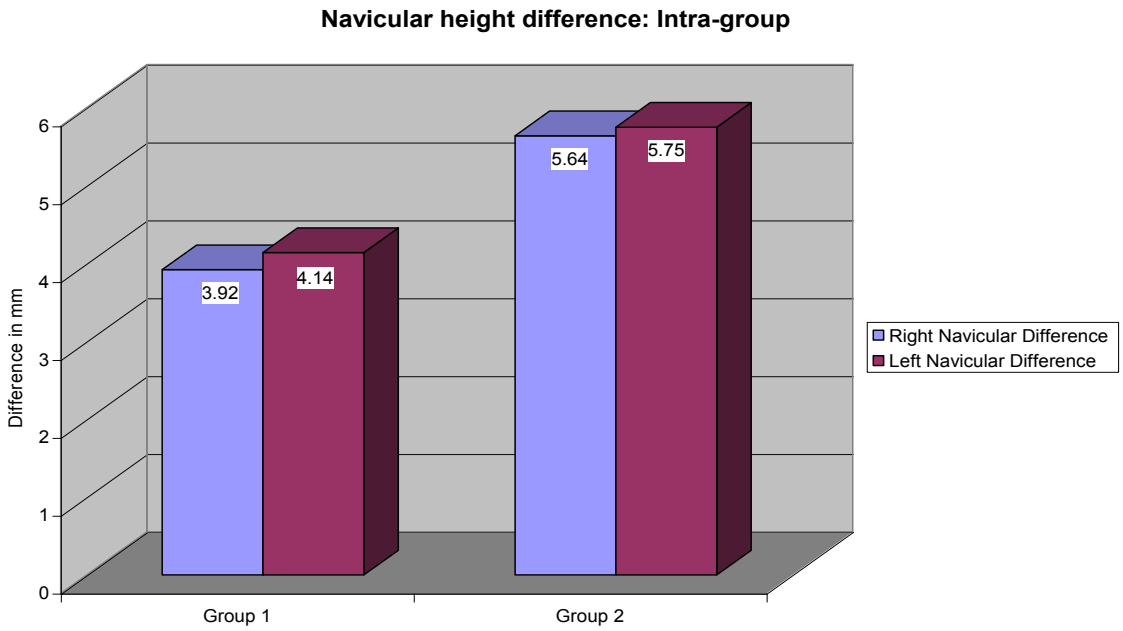


Figure 11: Distribution of SPB within the groups

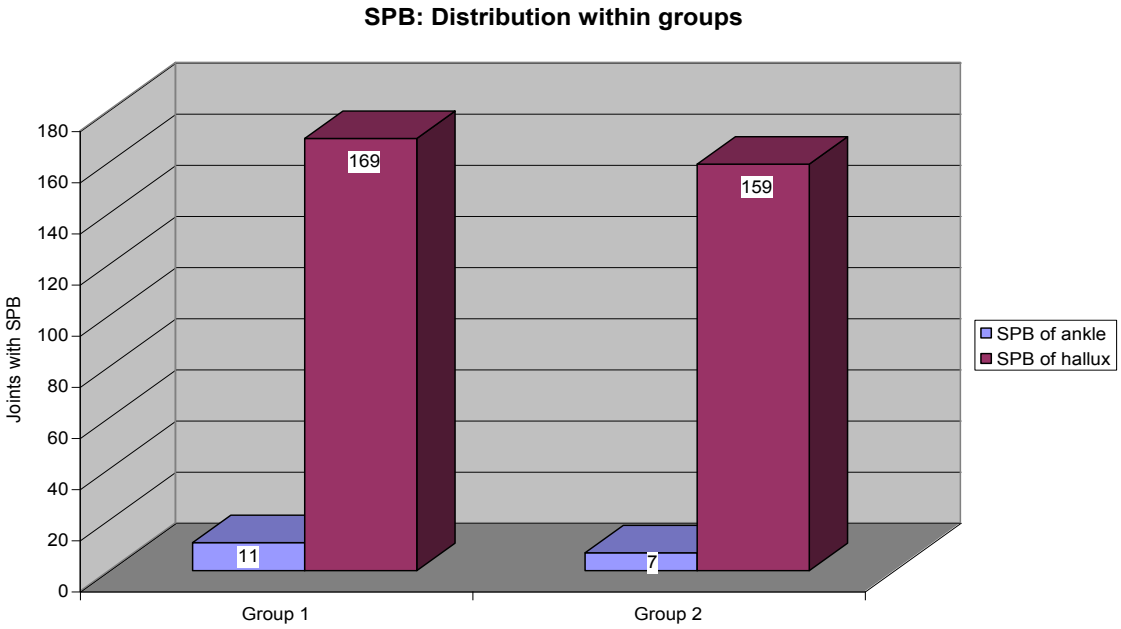


Figure 12: Distribution of SPB between the groups

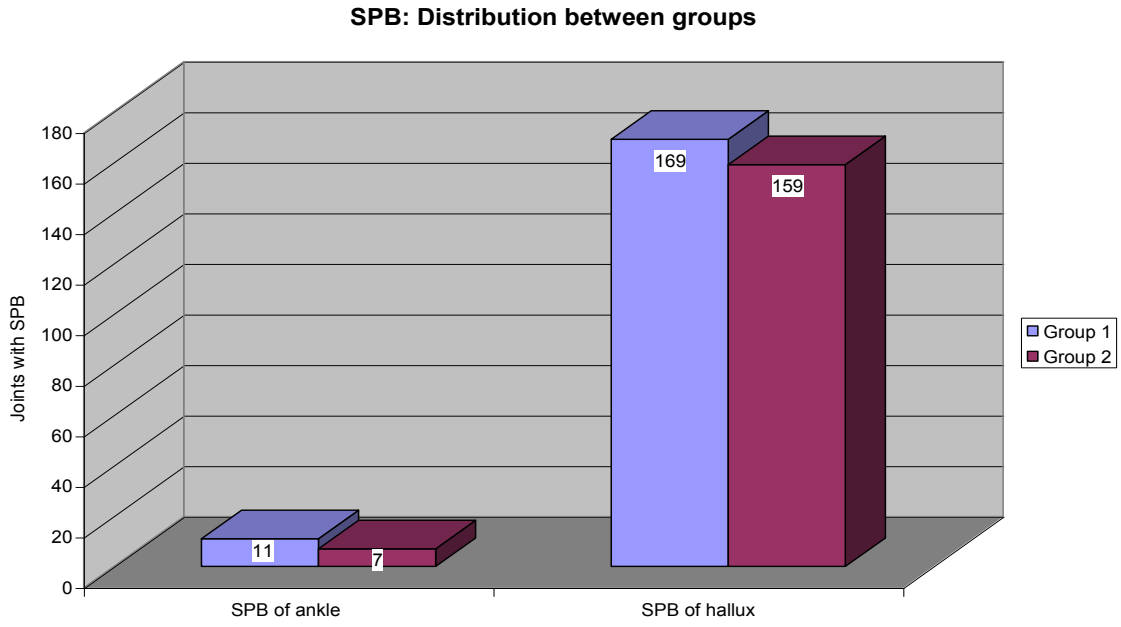


Figure 13: Presence of SPB in the ankle compared to absence of SPB within the groups

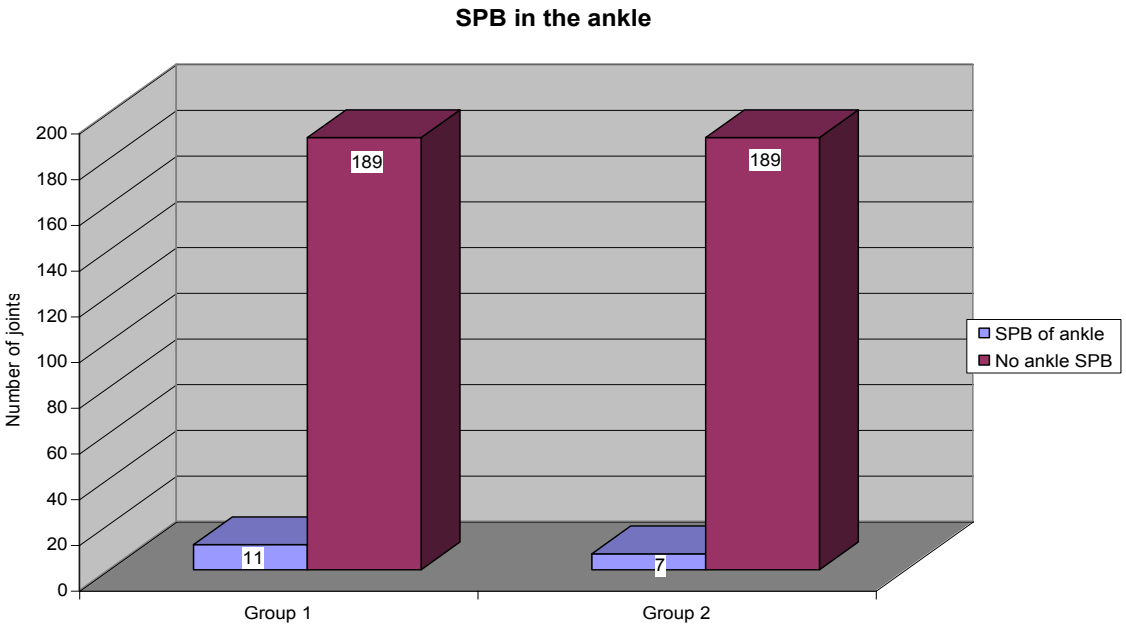


Figure 14: Presence of SPB in the hallux compared to absence of SPB within the groups

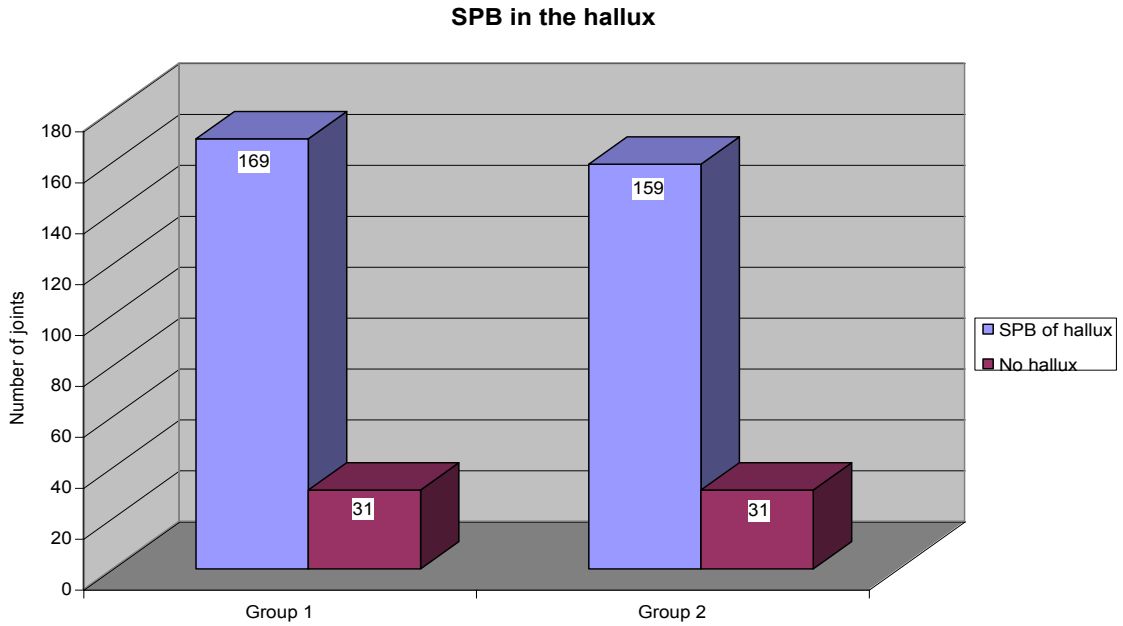


Figure 15: Unilateral versus bilateral SPB of the ankle

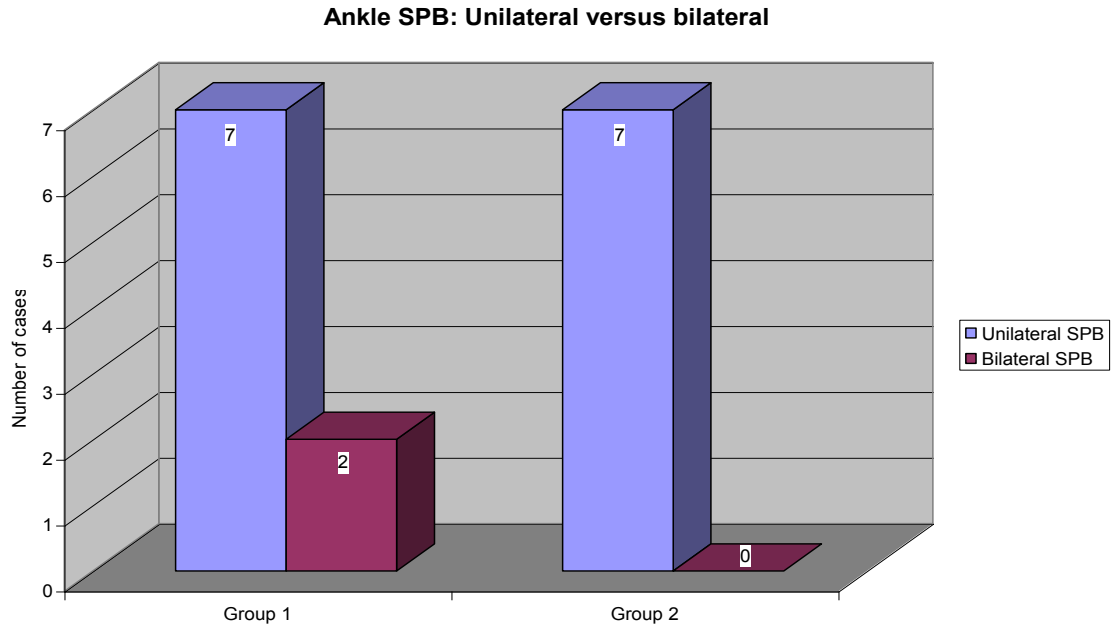


Figure 16: Unilateral versus bilateral SPB of the hallux

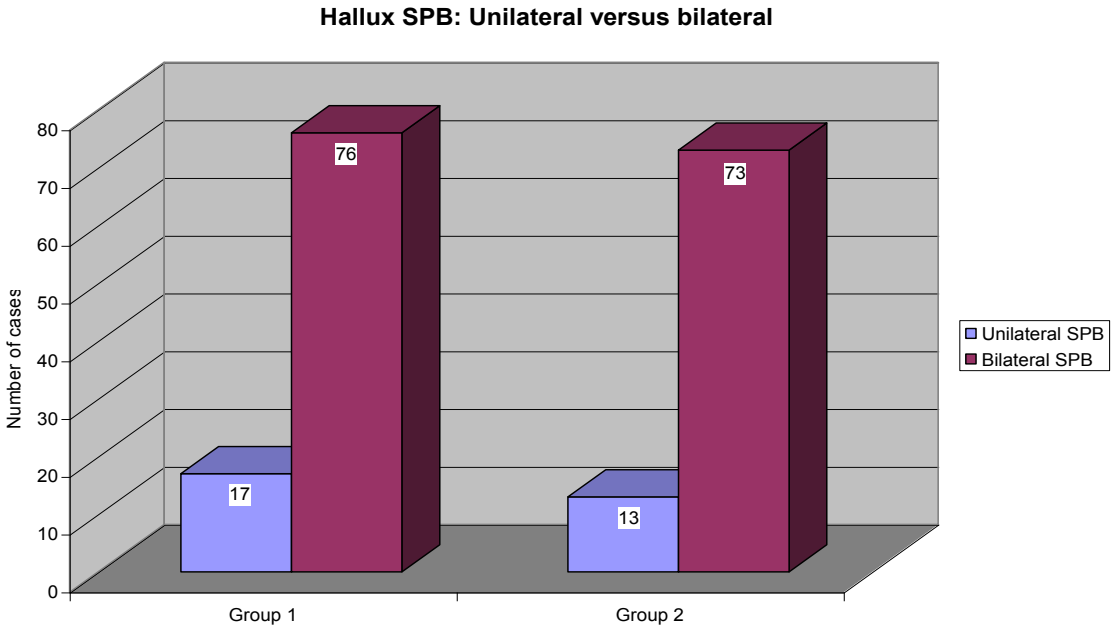


Figure 17: Distribution of unilateral SPB of the ankle: right or left

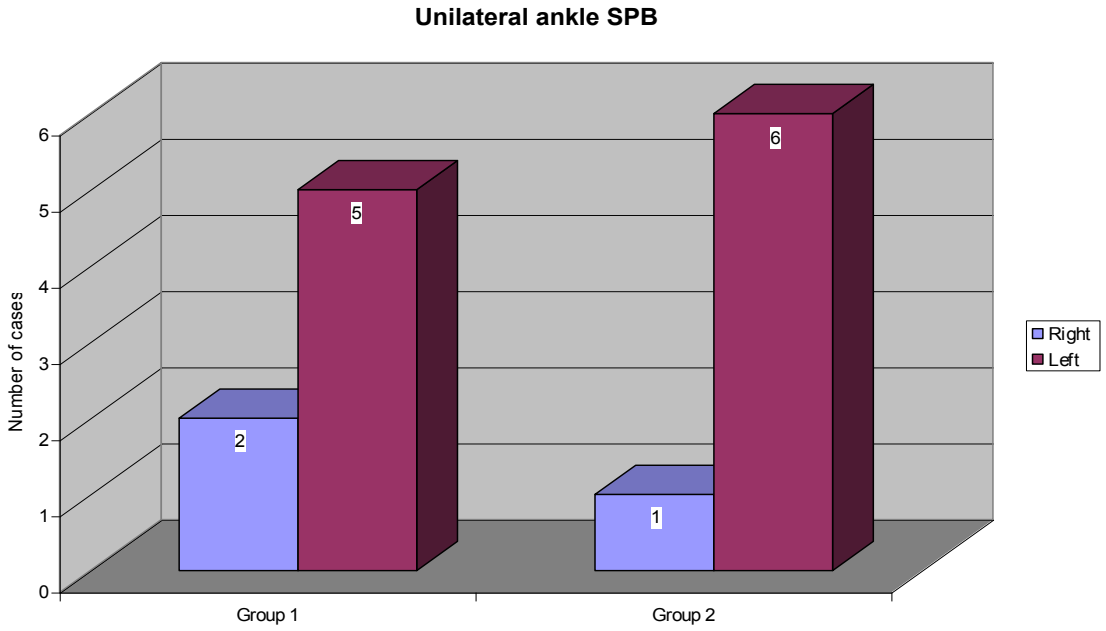


Figure 18: Distribution of unilateral SPB of the hallux: right or left

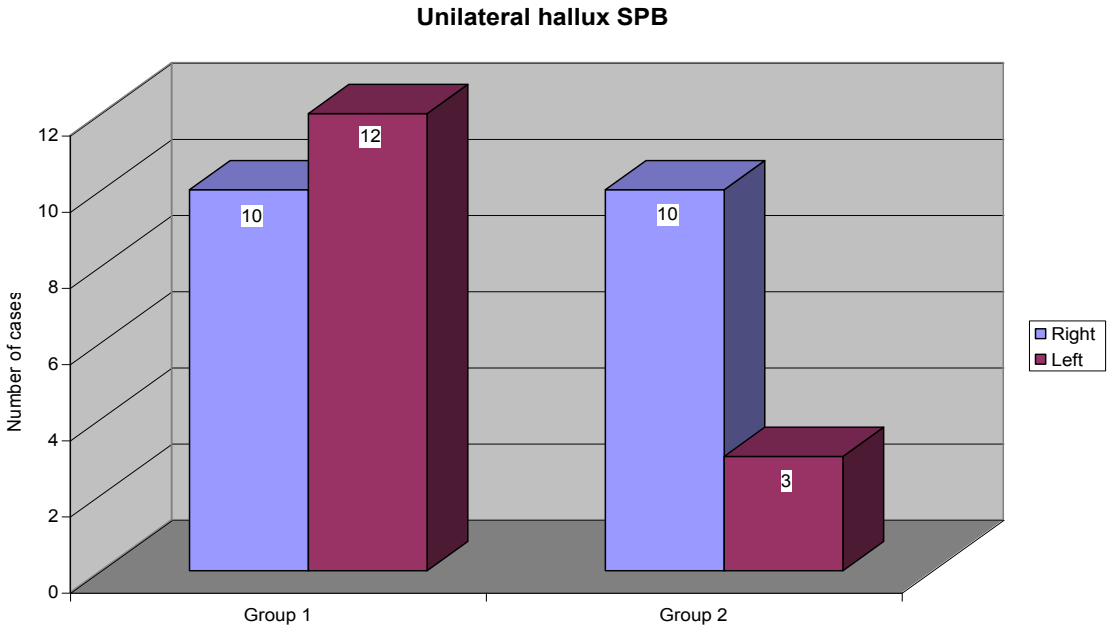


Figure 19: Distribution of the number of joints with SPB in participants in Group 1

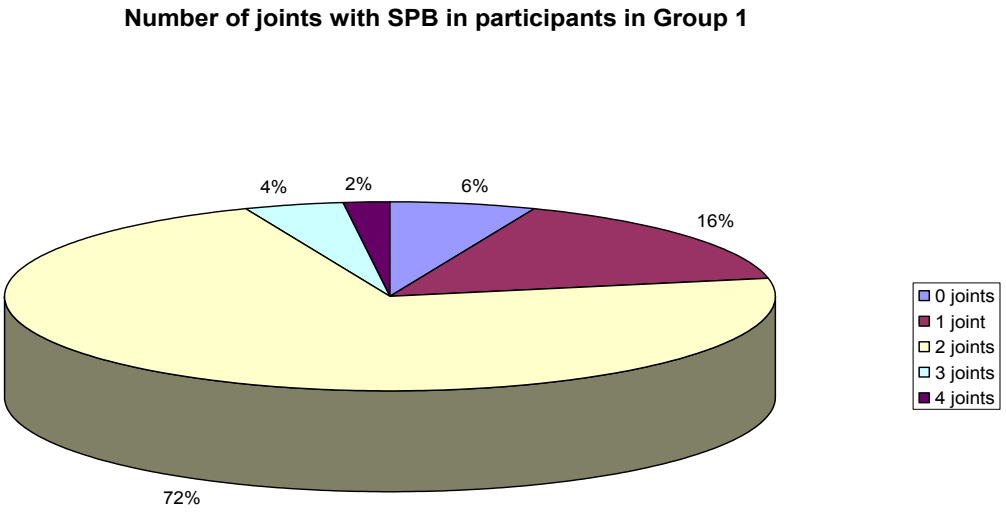
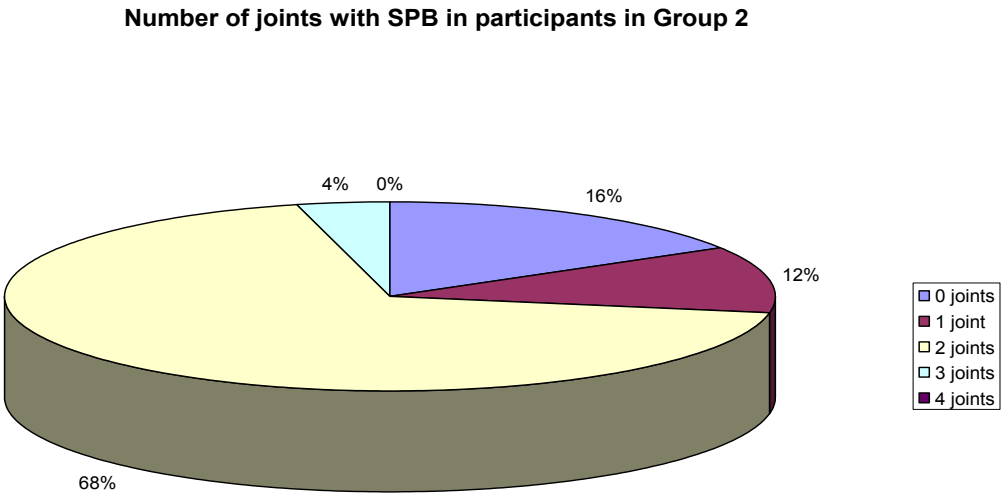


Figure 20: Distribution of the number of joints with SPB in participants in Group 2



CHAPTER FIVE: Discussion

5.1. Introduction

This chapter consists of a discussion of the results that were presented in chapter four. Firstly the demographic data will be presented, followed by the discussion on the objective data. The results of this study will be compared throughout with available literature on the subject, to determine how the results of this study compare to other studies.

5.2. Demographic data

Tables 2 and 3 show the age distribution and average age of the patients who took part in the study, as well as the oldest and youngest participants in each group. The results show a relatively even age spread, with a slight majority in both groups being found in the 22-25 years of age range. The age range in Group 1 was from 18 to 45 years of age, with an average age of 31.23. Group 2's age range was 18 to 44 years of age, with an average age of 28.82 years of age. The older average age of the group with chronic mechanical low back pain group in comparison to the asymptomatic group correlates with the findings of Roncarati and McMullen (1988:160) who found a significantly older average age in the low back pain group (on average 4.64 years older than the group with no low back pain). It has also been found that the prevalence of low back pain rises with increasing age up to 65 years of age (Andersson, 1999:584). It is therefore understandable that with a higher prevalence of the condition in the older age groups the participants in this study may have included more patients who were older than the asymptomatic patients.

With regards to gender, Table 4 shows that there were slightly more males than females overall (53% males and 47% females). However if one looks at the 2 groups separately, Group 1 had a majority of males, with 68% males and 32% females, while Group 2 had a majority of females, with 39% males

and 61% females. In general, low back pain seems to occur equally in men and women (Andersson, 1999:584). The higher proportion of males in the low back pain group may therefore not be representative of the population as a whole and may have had an influence on the results. A slight male predominance has however been found by other researchers (Roncarati and McMullen, 1988:160; Burton et al. 1995:724) and so this study is in keeping with these studies.

Table 5 shows the race distribution. The majority of the patients who took part in the study were white (61.8%) and these patients were relatively evenly distributed between the two groups. The next highest population group was the Indian population (26%), also quite evenly distributed between the groups. The higher proportion of Indian patients compared to Black patients is supported in the literature (Docrat, 1999:157). The small number of Black patients in the study may also be due to the study taking part at a chiropractic clinic, since chiropractic treatment is still relatively new within the Black population in South Africa and not yet greatly recognised by this population group.

The occupations of the individuals (Table 6) were varied, with the highest overall percentage being made up of students (26%), with individuals with desk jobs (including accountants, bankers, architects, financial advisors, IT specialists and secretaries) being the next largest group (18%), followed by technicians or manual labourers (10%). Looking at the individual groups, the most common occupation in the chronic mechanical low back pain group (Group 1) was shared amongst students, individuals with desk jobs, and technicians or manual labourers (16% for each). The group without low back pain (Group2) showed a higher proportion of students (35%), followed by individuals with desk jobs (19%) and sales and marketing positions (11%). The higher proportion of students in Group 2 may have been due to the majority of patients in this group presenting with neck pain or headaches, which may have been due to studying postures.

5.3. Results of inter-group, intra-group, chi-square and Cramer's V

5.3.1. Ankle dorsiflexion

When comparing the two groups (Table 8), the independent samples t-test showed a statistically significant difference between the mean ankle dorsiflexion in Group 1 and Group 2 at the 5% significance level for both the right foot (p=0.002) and the left foot (p=0.032). A comparison of the means of the two groups (Table 7), indicated that individuals with chronic mechanical low back pain (Group 1) had less ankle dorsiflexion available than the individuals with no low back pain (Group 2) in both the right and the left feet. This finding correlates with that of Roncarati and McMullen (1988:160) who found a decreased range of motion of the gastrocnemius musculature in low back pain subjects, compared to individuals with no low back pain. The restriction of ankle dorsiflexion range of motion could have occurred due to any of the structural or functional mechanisms described in 2.3.4. in Chapter 2 and, although the difference is statistically significant, causality can't be assumed.

When looking within the groups, the paired samples t-test showed a statistically significant difference (p=0.037), at the 5% significance level, between the means of the right and left foot in Group 1(Table 14). A comparison of the means for ankle dorsiflexion in Group 1 (Table 13) indicated that individuals with chronic mechanical low back pain had less dorsiflexion in the right ankle than the left ankle. The reason for this is unknown, however it may be due to a dominance of one foot over the other. Within Group 2 (Table 16) there was no statistically significant difference (p=0.338), at the 5% significance level, between the right and left foot. This finding suggests that individuals without low back pain do not have a significant difference, in terms of ankle dorsiflexion, between feet.

Chi-square and Cramer's V tests for the right ankle (Table 18) and for the left ankle (Table 20) indicated no association between chronic mechanical low

back pain and dorsiflexion of the right ankle (p=0.085) or the left ankle (p=0.188) at the 5% level of significance.

5.3.2. Hallux dorsiflexion

When comparing the mean hallux dorsiflexion between groups (Table 10), the independent samples t-test indicated no statistically significant difference at the 5% level of significance for either the right foot (p=0.562) or the left foot (p=0.065). This finding suggests that there is no significant difference with regard to hallux dorsiflexion, at the 5% significance level, between individuals with chronic mechanical low back pain and individuals with no low back pain. If one looks at the means (Table 9), the amount of dorsiflexion is smaller in Group 1 for both the right foot (52.12^0 for Group 1 and 53.14^0 for Group 2) and left foot (53.81^0 for Group 1 and 57.06^0 for Group 2), however this difference is not statistically significant.

When looking within the groups, the paired samples t-test for Group 1 (Table 14) showed no statistically significant difference, at the 5% significance level, between the right and left foot (p=0.079). The paired samples t-test for Group 2 however (Table 16) showed a statistically significant difference, at the 5% significance level, between the right and left foot (p=0.000). This difference indicated that, in patients with no low back pain, the right hallux demonstrated significantly less dorsiflexion than the left hallux. The reason for this is also unknown, but as mentioned before, it may be due to a dominance of one foot over the other.

Chi-square and Cramer's V tests for the right hallux (Table 22) and for the left hallux (Table 24) indicated no association between chronic mechanical low back pain and hallux dorsiflexion of the right foot (p=0.241) or the left foot (p=0.088) at the 5% level of significance.

5.3.3. Difference in navicular height between the resting and neutral standing postures

The independent samples t-test (Table 12) indicated a statistically significant difference at the 5% significance level between the two groups for the navicular difference in both the right foot (p=0.003) and the left foot (p=0.009). This difference indicated that the individuals with chronic mechanical low back pain (Group 1) had a significantly smaller difference in navicular height than the individuals with no low back pain (Group 2). This indicates that individuals with chronic mechanical low back pain tend to pronate less than individuals without low back pain.

This correlates to a certain extent with the findings of Roncarati and McMullen (1988:162) where they stated that their findings reflected that individuals with low back pain tended to have normal longitudinal arches. They however used the Feiss line measurement for their results in order to determine whether or not a person had pes cavus, while this test is normally used to indicate pes planus, so the reliability of their findings is questionable. Rothbart and Estabrook (1988:375) found that of 97 patients with low back pain 95 were excessive pronators (pronating more than 6^0), however their method used to determine this was a visual gait analysis and measuring casts associated with excessive forefoot pronation, and the reliability is questionable. The present study's findings are interesting, since excessive pronation has often been sighted as being a possible cause of low back pain. On the contrary, the findings of this study indicate that this may not necessarily be the case.

Within Group 1 (Table 14) as well as within Group 2 (Table 16) the paired samples t-test showed no statistically significant difference, at the 5% significance level, between the right and left feet with regard to the difference in navicular height between the resting and neutral standing postures (p=0.572 for Group1 and p=0.692 for Group 2). This indicates that although the mean difference in navicular height for the right foot was smaller in both groups compared to the left, this was not statistically significant.

Chi-square and Cramer's V tests for the right navicular difference (Table 26) showed an association between chronic mechanical low back pain and the difference in navicular height between the resting and neutral standing postures at the 5% level of significance (p=0.005). Chi-square and Cramer's V tests for the left navicular difference (Table 28), however, indicated no association at the 5% level of significance (p=0.324). As has been mentioned above, the fact that the difference is significant on the right and not the left may also be due to a dominance of one foot over the other, but this aspect needs to be researched further. Although it is evident that there is a statistically significant association between the right navicular difference and chronic mechanical low back pain, it is unclear what the association entails and this should be researched further.

5.4. Analysis of distribution of sagittal plane blockage

5.4.1. Distribution between ankle and hallux

Of the 816 possible joints measured for SPB, 346 displayed SPB (Table 29). This represents 42% in total, which is a relatively high percentage. Of the cases of SPB, the majority in both groups were found in the hallux, with 80% of the hallux measurements being classed as having SPB. This indicates that SPB is a relatively common occurrence with it being very common in the hallux. This substantiates Lee Evans, Averett and Sanders (2002:359) and Dananberg's statements (1993:433) that hallux limitus occurs commonly.

When broken down into the individual groups, 5.5% of the ankle joints and 84.5% of the first metatarsophalangeal joints of the hallux in Group 1 displayed SPB, with a total of 45% of the 400 joints exhibiting SPB (Table 30). In comparison, Group 2 exhibited SPB in 3% of the ankle joints and 76% of the first metatarsophalangeal joints of the hallux, leading to a total of 40% of the 416 joints exhibiting SPB (Table 31). SPB therefore was found slightly more commonly in the group with chronic mechanical low back pain than in the group without low back pain. This also correlates with Dananberg's view

(1993:433) that SPB may play a role in low back pain, however once again causality can't be assumed.

5.4.2. Unilateral versus bilateral SPB

The majority of cases of SPB in the ankle (Table 32) were unilateral (87.5%) and these were spread evenly between the two groups (7 people in each group). Only 2 cases of bilateral SPB of the ankle occurred, and these were both found in the chronic mechanical low back pain group. These numbers are far lower than those of Dananberg and Guiliano (1999:113) who found that out of the 32 participants in their study, all with chronic mechanical low back pain, 91% had SPB of the ankle with a slight majority being bilateral (47% versus 44%).

With hallux dorsiflexion (Table 33) the majority of cases were bilateral (83%), with a slight majority of cases found in the chronic mechanical low back pain group (76 versus 73). Only 17% of the total cases of SPB were unilateral SPB, and again there was a slight majority in the chronic mechanical low back pain group. This correlates with the findings of Dananberg and Guiliano (1999:113) who found that 91% of their subjects had SPB of the hallux with the majority of cases being bilateral (88% of the subjects).

The present study's results do not however appear to indicate a substantial difference between the 2 groups, and the inconsistency as to whether the majority is unilateral or bilateral is also not indicative of a pattern emerging.

5.4.3. Right versus left

Of the cases of unilateral SPB (Table 34) Group 1 and Group 2 both displayed a majority of cases on the left in the ankle and on the right in the hallux. This led to a total of 12 cases on the left and 12 on the right for Group 1 and 11 on the right and 9 on the left for Group 2. The reason for this finding is unknown, however the pattern appears to be the same in individuals with chronic mechanical low back pain and individuals with no low back pain.

5.4.4. Number of joints involved

The majority of people in both groups displayed SPB in 2 joints (72% of the people in Group 1 and 68% of the people in Group 2 (Table 35). The next largest number in Group 1 was 1 joint involved (which involved 16 people) and in Group 2 was 0 joints involved (involving 17 people). Only 2 individuals had SPB of all 4 joints and both were found in Group 1. This shows that there were more people without low back pain (Group 2) who displayed no form of SPB whatsoever than in the group with chronic mechanical low back pain (Group 1). Ninety four percent of the participants with chronic mechanical low back pain had some form of SPB. Although not as high a finding as Dananberg and Guiliano (1999:112), who found 100% of their chronic mechanical low back pain study participants had a form of SPB, this is still a high proportion. The participants without low back pain also, however, had a high majority of cases of SPB, with 84% displaying some form of SPB.

5.5. Summary

A comparison between the two groups indicated that Individuals with chronic mechanical low back pain had significantly less ankle dorsiflexion in both the right and left feet compared to individuals without low back pain. There was no significant difference between the two groups for hallux dorsiflexion, however, individuals with chronic mechanical low back pain also had a significantly smaller difference in navicular drop from a neutral to a resting posture. This indicated that this group of individuals tended to pronate less than individuals without low back pain.

Within the groups, the individuals with chronic mechanical low back pain had a significantly lesser degree of ankle dorsiflexion in the right foot compared to the left foot. Individuals without low back pain, however, had a significantly lesser degree of hallux dorsiflexion on the right in comparison to the left hallux. The navicular difference showed no significant difference within either group.

The only association found at the 5% level of significance was between chronic mechanical low back pain and the difference in navicular height between the resting and neutral standing postures for the right foot.

SPB was found in 42% of the joints measured with 80% of the hallux joints showing evidence of SPB. Of the study participants, 94% of those with chronic mechanical low back pain and 84% of those without low back pain displayed some form of SPB. This indicates that SPB is a prevalent finding in both people with chronic mechanical low back pain and those with no low back pain. The majority of individuals in both groups had 2 joints with SPB. In the ankle the majority of cases were unilateral and in the left foot, whereas the majority of cases in the hallux were found bilaterally and of the unilateral cases most were found on the right.

CHAPTER SIX: conclusion and recommendations

6.1. Introduction

In order to conclude this study it is necessary to once again look at the study's aims and objectives.

6.2. Aim 1

The first aim of this study was to assess the prevalence of SPB in people with mechanical low back pain as well as in asymptomatic individuals. In order to answer this we need to look at whether SPB was present or not, and if present, whether it was unilateral or bilateral, right or left.

6.2.1. Present or not

Of the 816 joints that were measured in the ankle and hallux, 42% showed signs of SPB. Of these, the majority of cases of SPB were found in the hallux. When comparing the two groups, it was found that the individuals with chronic mechanical low back pain (Group 1) had a slightly higher number of cases of SPB. Group 1 displayed SPB in 5.5% of the ankle joints compared to 3% in Group 2. The percentage of SPB in the hallux for Group 1 was also slightly higher, with 84.5% SPB in comparison to 76% in Group 2. The total percentage of SPB in the groups was 45% of the joints in Group 1 and 40% of the joints in Group 2.

6.2.2. Unilateral or bilateral

When looking at the distribution of the cases of SPB, the majority of cases of SPB in the ankle were unilateral (87.5%) whereas in the hallux the majority of cases were bilateral (83%). Again looking at the differences between the groups, for ankle SPB Group 1 and 2 had equal amounts of unilateral SPB (7 cases each) and only 2 cases of bilateral SPB which both occurred in the chronic mechanical low back pain group (Group 1). For the hallux, Group 1

displayed a slight majority of cases of both bilateral (76 cases versus 73) and unilateral (17 versus 13) SPB.

6.2.3. Left or right

Of the cases of unilateral SPB, Group 1 and Group 2 both displayed a majority of cases on the left in the ankle and on the right in the hallux. The total number of cases on each side was relatively even between the groups. However, looking at the actual measurements for ankle dorsiflexion, individuals with chronic mechanical low back pain (Group 1) were found to exhibit significantly less dorsiflexion in the right ankle than the left ankle. No significant difference was found between the groups with regard to hallux dorsiflexion.

6.3. Aim 2

The second aim of the study was to determine whether or not subjects with mechanical low back pain had a greater extent of SPB than subjects without low back pain. For this we need to look at the degree of restriction as well as the number of joints involved.

6.3.1. Degree

When the amount of ankle dorsiflexion available was compared between the two groups, individuals with chronic mechanical low back pain (Group 1) were found to have significantly less ankle dorsiflexion available, in both the right and left feet, than the individuals with no low back pain (Group 2). No significant difference was found between the groups with regard to hallux dorsiflexion, at the 5% significance level. Within the groups, individuals with chronic mechanical low back pain (Group 1) had a significantly lesser degree of ankle dorsiflexion on the right compared to the left and individuals without low back pain (Group 2) had a significantly lesser degree of hallux dorsiflexion on the right in comparison to the left.

6.3.2. Number of joints involved

The majority of people in both groups displayed SPB in 2 joints. The next largest number in Group 1 was 1 joint involved and in Group 2 was 0 joints involved. There were only 2 individuals who demonstrated SPB of all 4 joints and both were found in Group 1. On the whole, there were more individuals without SPB in Group 2 than Group 1(17 versus 6) and so more people with SPB in Group 1 than in Group 2 (94 individuals versus 87).

6.4. Aim 3

The third aim of the study was to identify whether or not the presentation of SPB in subjects with low back pain correlated with their mechanical low back pain.

6.4.1. Association

No association was found between chronic mechanical low back pain and sagittal plane blockage (SPB) of the hallux or ankle at the 5% level of significance.

6.5. Navicular difference

The difference in navicular height between the resting and neutral standing postures was included in an effort to find out whether individuals with chronic mechanical low back pain pronated more than individuals without low back pain. The study found that individuals with chronic mechanical low back pain had a significantly smaller difference in navicular drop from a neutral to a resting posture, at the 5% significance level. This indicated that this group of individuals tended to pronate less than individuals without low back pain.

6.6. Final conclusion

The purpose of this study was to determine whether a link could be found between chronic mechanical low back pain and sagittal plane blockage of the feet and ankles. The results of this study indicate that sagittal plane blockage is occurs commonly in individuals with chronic mechanical low back pain as well as those with no low back pain, with a slightly higher prevalence in the group with chronic mechanical low back pain.

Statistical analysis indicated a significant difference between mean ankle dorsiflexion measurements between Group 1 and Group 2. A comparison of the means indicated that individuals with chronic mechanical low back pain had less ankle dorsiflexion available than individuals without low back pain. A chi-square analysis, however, did not find an association at the 5% significance level, between chronic mechanical low back pain and SPB. Individuals with chronic mechanical low back pain exhibited significantly less ankle dorsiflexion in the right foot than the left foot and individuals without low back pain exhibited significantly less hallux dorsiflexion in the left foot than the right. The study's finding of a significant association between chronic mechanical low back pain and the difference in navicular height between the resting and neutral standing postures, also warrants further investigation.

It is of the researcher's opinion that this study has shown that SPB is a commonly occurring condition in both individuals with chronic mechanical low back pain and those with no low back pain. Although no direct association could be made between chronic mechanical low back pain and sagittal plane blockage, the slightly higher occurrence of SPB in both the ankle and hallux in individuals with chronic mechanical low back pain deserves further investigation. The data collected in this study will add to the demographic data available on sagittal plane blockage and hopefully give a better idea of its importance and distribution in the South African population, especially in the Durban area. This study was a preliminary study and hopefully will provide a foundation for further studies into sagittal plane blockage and its association with chronic mechanical low back pain or even with other conditions.

6.7. Limitations of the study and further recommendations

Examiner experience

The researcher was a 6th year chiropractic student, and inexperienced in taking static foot measurements, so researcher error may have played a role in the measurements taken.

Further studies should be done by a researcher with experience in static foot measurements, or a considerable amount of training should be done before the study, since this would increase the reliability of the study.

Methods used

Due to there being many methods of measuring ankle joint dorsiflexion, hallux dorsiflexion and navicular difference the methods used in this study may be slightly different to other studies and so make a direct comparison between studies difficult. An error may have occurred in the reading of the angle on the goniometer or the height on the ruler, since the researcher's eye was not at the level of the foot and so an error of parallax could have occurred. The ruler may also not have always been perfectly vertical and perpendicular to the ground, although an effort was made to ensure this was done.

Future studies should try to have the examiner's eye at the level of the ruler or goniometer, by placing the person on a higher platform, to avoid the error of parallax. Future studies should possibly make use of the navicular drop test, but should stay away from subtalar joint neutral measurements.

Variables and homogeneity

Due to the nature of the study there were many variables present (some participants were sportsmen, some not, some very sedentary, some very active) and although an effort was made to try to limit the variables, some compounding variables may still have played a role in the results. Future studies should possibly be aimed at a certain group of individuals, such as

runners. Although a correlation was found in the study, this does not imply causation, and this should be kept in mind.

More closely defined parameters with regard to the diagnosis of low back pain, such as only sacroiliac syndrome or only lumbar facet syndrome, may enhance the strength of the study, by limiting some variables. This study also made use of a number of interns who made the diagnosis, limiting this to one examiner may also strengthen the study by providing consistency.

Symptomatic individuals

In an effort to reduce the number of variables in the study, all individuals with lower limb pain were excluded from the study. This excluded anyone with a symptomatic hallux limitus or ankle equinus, and so may have had ruled out an important group of the population.

It is recommended that future studies also allow for individuals with lower limb pain, since SPB is not only asymptomatic in the lower limb, and this aspect should also be taken into account.

Blinding

An effort was made for the researcher to be blinded as to whether an individual had chronic mechanical low back pain or not, however with individuals in severe pain this was not always possible, and so there may have been an element of bias present in the study.

Chronicity

For the purpose of this study chronic was taken to mean pain for 6 weeks or longer or acute recurrent pain, however it may be of value to define the parameters more closely. Hestbaek et al. (2003:213) state that the term chronic should not be based solely on the duration of symptoms, so this should be taken into account in future studies. Future studies should possibly stay away from the term “chronic” in terms of low back pain and should rather concentrate on acute recurrent episodes of low back pain, and stipulate a

minimum number of episodes over a specific time period, such as 10 or more episodes of low back pain over a period of 1 year.

Objective data on severity of back pain

If objective data on the severity of the low back pain were collected, this would allow the researcher to be able to examine the correlation between the chronic mechanical low back pain and SPB in much more detail and therefore strengthen the study.

Age range

It is suggested that other age ranges be studied too, to see if an association can be found in other age groups. Future studies should possibly concentrate on an older age group (possibly between the ages of 35 and 55). This is due to the fact that sagittal plane blockage, and specifically structural hallux limitus, has been implicated as being able to result in chronic low back pain "when repeated over a sufficient number of years" (Dananberg, 1993:434). The age group used in the present study may not have had sagittal plane blockage present for enough years for symptoms to develop, so an older age group should be investigated.

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APPENDIX A: Patient information letter

Dear Participant
Thank you for taking the time to consider participation in my research study.

Title of my research study:

Sagittal plane blockage of the foot and ankle – prevalence and association with low back pain.

What is my study about?
I am looking at the link between the feet and low back pain. The aim of this study is to compare measurements of the foot in people with mechanical low back pain (usual back strain) to those with no back pain.

Why will this study be of benefit to you?
In doing this study I hope to see how important restrictions of the foot and ankle joints are in the development of low back pain. If I find that there is a link between the two, this would enable me to treat low back pain more effectively, which may be of benefit to you. The study is of no cost and on a voluntary basis. You will not receive any treatment as part of this study from the researcher and there is no monetary compensation for participating in the study, but your help would be greatly appreciated.

How many people will be involved in the study?
100 people with mechanical low back pain and 100 people with no low back pain.

What will you have to do?
I need to take a few measurements of your feet, which will take about 10 to 15 minutes, and then you can continue with the consultation with the chiropractic intern who is treating you.

Please do not tell to me whether or not you have low back pain, because I need to be unbiased when I take the measurements. After your consultation is over I will find out from your intern what their diagnosis of your condition was and whether you had low back pain or not. If you have been diagnosed with mechanical low back pain you will be placed in group 1, and if you do not have any low back pain you will be in group 2.

Is their any reason you might be excluded from the study?
If you are undergoing any other form of treatment for your back pain or if you have foot pain, you will be excluded from the study. You are free to withdraw at any stage, and refusal to participate in the study or dropping out of the study for any reason will not result in any adverse consequences. You may be informed of the findings of this research study if you indicate you would like to. All information will be dealt with in the strictest of confidence. No names will be divulged, all data will be coded and only the researcher and her supervisor will have access to the data. If you are excluded, your data from the study will be shredded.

Please don't hesitate to ask questions on any aspect of this study. If you have any queries or complaints you may contact me or my supervisor.

Yours sincerely,
Joanne Gilbert (Chiropractic intern)

Researcher (Joanne Gilbert) to be contacted at 204 2205
Supervisor (Dr J. Shaik) to be contacted at 204 2588

APPENDIX B: Informed Consent Form

Date	**:**	
Title of research project	**:**	Sagittal plane blockage of the foot and ankle – prevalence and association with low back pain.
Name of supervisor	**:**	Dr J. Shaik
Tel ☎	**:**	(031) 204 2588
Name of research student	**:**	Joanne Gilbert
Tel ☎	**:**	(031) 204 2205

PLEASE CIRCLE THE APPROPRIATE ANSWER:

1. Have you read the research information sheet? YES / NO
2. Have you had the opportunity to ask questions regarding this study? YES / NO
3. Have you received satisfactory answers to your questions? YES / NO
4. Have you had an opportunity to discuss this study? YES / NO
5. Have you received enough information about this study? YES / NO
6. Do you understand the implications of your involvement in this study? YES / NO
7. Do you understand that you are free to withdraw from this study
   a) at any time? YES / NO
   b) without having to give a reason for withdrawing? YES / NO
   c) without affecting your future health care? YES / NO
8. Do you agree to voluntarily participate in this study? YES / NO
9. Who have you spoken to? _____

Please ensure that the researcher completes each section with you. If you have answered NO to any of the above, please obtain the necessary information before signing.

Please Print in block letters:

PATIENT/SUBJECT Name……Signature…….

WITNESS Name……Signature…….

RESEARCH STUDENT Name……Signature…….

APPENDIX C: Researcher's examination sheet

Name: …… File number: …… Date: ……

Measurement:		1	2	3	mean
Range of ankle dorsiflexion (Weightbearing)	R				
	L				
Range of hallux dorsiflexion (Weightbearing)	R				
	L				
Height of the navicular from the ground in a relaxed standing posture	R				
	L				
Height of the navicular from the ground with the subtalar joint positioned in neutral	R				
	L				
The difference between the Two navicular height measurements	R				
	L				