THE EFFECTIVENESS OF MANIPULATION OF THE SUBTALAR JOINT COMBINED WITH STATIC STRETCHING OF THE TRICEPS SURAE MUSCLES COMPARED TO MANIPULATION ALONE IN THE TREATMENT OF PLANTAR FASCIITIS

By

TERRI LYNDAL BLAKE

Dissertation submitted in partial compliance with the requirements for the Master's Degree in Technology: Chiropractic at Durban Institute of Technology.

I, Terri Blake, do declare that this dissertation is representative of my own work in both conception and execution.

________________________ ________________________

Terri Blake Date

APPROVED FOR FINAL EXAMINATION BY:

________________________ ________________________

Supervisor Date
Dr C. Korporaal
M.Tech:Chiropractic(SA), CCFC(SA), CCSP(ICCSD)(USA)

DEDICATION

To Mom,
thank you for being the ultimate role model;
your sacrifices have not gone unnoticed

To Dad,
I miss you always

I love you both

ACKNOWLEDGEMENTS

Thank you to Dr Charmaine Korporaal, primarily for supervising this dissertation, but also for her seemingly unending help and advice she's provided during my period of study.

To Simon and Greg, I couldn't have asked for better friends in the world.

To Denham, my motivator and friend.

To all my classmates: it's been a privilege studying with you and I'll miss you all.

To Pat, Linda, Mrs Ireland and Kershnee for their support during my time at the clinic and throughout the research process.

To Mr Thomas, for all his help and advice with the statistical analysis.

Finally, a big thank you to all the patients who participated in this study, without whom this dissertation could not have been possible.

ABSTRACT

Plantar Fasciitis (PF) is a common injury, and one which is known to be stubborn to many forms of treatment. The purpose of this investigation was to determine the effectiveness of manipulation of the subtalar joint combined with static stretching of the Triceps Surae muscles compared to manipulation alone in the treatment of PF.

Studies have shown chiropractic manipulation to be effective in treating this overuse injury, and gastro-soleus stretching is a treatment advocated by many authors, but which has not yet been investigated in combination with manipulation.

This study consisted of 40 patients who were randomly divided into two equal groups. Group One received manipulation to restrictions in the subtalar joint, and Group Two received subtalar manipulation in addition to two static stretched of the gastro-soleus muscles.

The patients were treated 5 times over a two week period, with a sixth follow-up consultation one week later for final data collection. The subjective measurements used were the Numerical Pain Rating Scale – 101 (NRS – 101) and the Foot Function Index (FFI). Objective measurements used were the Algometer and weight-bearing dorsiflexion range of motion.

Statistical analysis was completed using the Mann-Whitney U-test for inter-group comparisons, and the Friedman's test for intra-group comparisons.

The subjective data did not show any significant differences between the two groups. However significant results were seen for intra-group comparisons of the NRS – 101, and FFI Questions One, Two, Three and Five of both groups. These findings suggest that in these instances the patients pain was reduced regardless of which treatment they received. In FFI Questions Four, Six and Nine, only Group One showed significant results. This suggests that subtalar manipulation alone appeared to be effective, and that subtalar manipulation in combination with gastro-soleus stretches

did not appear to be effective in reducing pain and disability relating to these questions. Neither group showed significant results in FFI Questions Seven and Eight.

The objective measurements showed that although no significant results were seen between the two groups, significant results were seen for intra-group comparisons of the Algometer readings and the Dorsiflexion range of motion measurements of Group One. Group Two showed no significant results. This suggests that subtalar manipulation alone appeared to be effective in reducing the pressure pain threshold and improving dorsiflexion range of motion, whereas combining manipulation with stretches did not appear to be effective.

Thus, both types of treatments may be effective in improving the subjective measurements. Group One appeared to be effective in improving the objective measurements, whereas Group Two did not. Neither group showed significant superiority over the other when compared.

TABLE OF CONTENTS

TABLES AND FIGURES

APPENDICES

DEFINITION OF TERMS

Algometer

A mechanical device capable of measuring the amount of pressure tolerated by a person on a painful spot (Fischer, 1986:835-837).

Biomechanics

Application of mechanical laws to living structures. The study and knowledge of biological function from an application of mechanical principle (Gatterman, 1990:406).

Manipulation

Passive manoeuvre in which specifically directed manual forces are applied to the vertebral and extravertebral articulations, with the object of restoring mobility to restricted areas (Gatterman, 1990:410).

Objective clinical findings

For the purposes of this study this refers to the data obtained from the weight-bearing ankle dorsiflexion measurements and algometer readings as a measure of pain pressure threshold.

Subjective clinical findings

For the purposes of this study this refers to the data obtained from patients from the Numerical Pain Rating Scale – 101 and the Foot Function Index.

CHAPTER ONE

INTRODUCTION

1.1) THE PROBLEM AND ITS SETTING

Plantar Fasciitis (PF), or commonly “the heel pain syndrome,” (Hyde and Gengenbach, 1997:477) is a frequent cause of heel pain in athletes as well as non-sports persons (Batt and Tanji, 1995:77; Ryan, 1995:891). This is a common, well-documented overuse syndrome involving an inflammatory reaction at the insertion of the plantar fascia to the calcaneus (Pollard and So, 1999:93; Ryan, 1995:891) following tensile overload to the plantar fascia (Batt and Tanji, 1995:78).

Ryan (1995:891) found that the pathophysiology of this condition is often misunderstood, and predisposing conditions are frequently not recognised. He felt that a lack of understanding of the biomechanics of PF may result in an inadequate treatment plan and failure to relieve the patients’ pain.

There are various aetiological factors resulting in PF and these are classified as being biomechanical, environmental and anatomical (Kibler, et al. 1991:66). Among the biomechanical explanations are abnormal joint biomechanics, tight posterior musculature[1], and resultant range of motion deficits (Ambrosius and Kondracki, 1992:32-34).

Conservative treatments include advice on weight loss, relative rest from activities, physical therapy modalities, orthotics, low-dye taping, and correction of footwear and strength training (Brown, 1996:881-882; Ryan, 1995:893-896).

---

[1] The posterior musculature includes the gastrocnemius and soleus muscle with the common attachment the Achilles tendon. This complex is also known as the Triceps surae muscle (Moore, 1999:586)

Although most authors support conservative treatment of PF, it still remains a time-consuming and difficult condition to treat (Reid, 1992:200).

Hypomobile joints in the foot and ankle don't effectively absorb weight-bearing stress (Brantingham, et al.1992:82). An alteration of normal biomechanics of the foot and ankle during gait will result in increased tensile strain on the plantar fascia (Brown, 1996:876) because of its continuous "bowstring" attachment between the proximal phalanges and the calcaneus (Polkinghorn, 1995:45). Correction of abnormal biomechanics is essential in the treatment of PF, and manipulative therapy can restore normal joint mechanics to decrease tension across the plantar fascia (Hyde and Gengenbach, 1997:479). Polkinghorn (1995:50) found that conservative management of PF could be effective using specific chiropractic adjusting procedures and recommended a trial period of manipulative therapy in every case of PF before further measures are considered. In their study on PF, Brantingham, et al. (1992:82) also concluded that PF could be effectively treated by chiropractors using joint manipulation. This is further supported in the placebo-controlled study carried out by Hammond (2000:80), where it was concluded that manipulative therapy is a reliable intervention in the treatment of PF.

Other biomechanical abnormalities such as muscle and flexibility imbalances will predispose an athlete to PF symptoms (Pollard and So, 1999:94). Barret and O'Malley (1999:2200), state that most causes of PF are due to poor biomechanics resulting in abnormal functional pronation. Pronation of the foot causes an increased tensile strain on the plantar fascial insertion resulting in PF (Kwong, et al.1988:119-126).

In their study of functional biomechanics of athletes with PF, Kibler, et al. (1991:68) found that a tight triceps surae muscle created a valgus (weight-bearing) heel position at heel strike, restricting supination and dorsiflexion of the hindfoot. This confirmed 2 previous studies by Taunton, et al. (1982) and Riddle and Freeman (1988:1914) who had previously concluded that tight triceps surae tethers the calcaneus in a valgus (weight bearing) position at heel strike thus leading to a functional pronation.

It can therefore be seen from the literature, that tight triceps surae results in a functional pronation and restriction of motion (Kibler, et al. 1991:68; Taunton, et al. 1982; Riddle and Freeman 1988:1914), and that this has been linked to the development of PF (Kwong, et al. 1988:119-126; Kitaoka et al. 1994:557-560).

It therefore follows that triceps surae tightness is a very common finding in patients with PF and should always be looked for and treated with triceps surae stretches (Brown, 1996:877). Stretching and strengthening programs play an important role in the treatment of PF and can correct functional risk factors, such as tight triceps surae muscles (Young, Rutherford and Niedfeldt, 2001:469). In a study by Wolgin et al. (1994:99), 29% of participants named stretching as the treatment that helped them the most compared to other conservative treatments. Ryan (1995:895) is of the opinion that Achilles tendon stretching should be the cornerstone of the rehabilitation program. Hyde and Gengenbach (1997:479) and Barret and O'Malley (1999:2201) also advocate triceps surae stretching as a beneficial adjunctive therapy in the treatment of PF.

Thus one can see that manipulative therapy has been shown to be a reliable intervention in the treatment of PF but triceps surae muscle stretches, although advocated by many authors and found to improve PF in terms of increased flexibility and reduced symptoms (Porter, et al. 2002:623), have yet to be studied in combination with manipulation.

This study is undertaken with the aim to assist chiropractors and other manual therapists by providing information on an effective, non-invasive, conservative, low-cost method of treating this common condition.

1.2) THE OBJECTIVES OF THE STUDY

The purpose of this randomized comparative clinical trial was to determine the effectiveness of manipulation combined with static stretching of the triceps surae muscles, compared to manipulation alone in the treatment of PF in terms of subjective and objective clinical findings.

1.2.1) The first objective

The first objective was to determine the effectiveness of manipulation alone compared to manipulation in conjunction with static stretching of the triceps surae muscles in terms of subjective clinical findings.

1.2.2) The second objective

The second objective was to determine the effectiveness of manipulation alone compared to manipulation in conjunction with static stretching of the triceps surae muscles in terms of objective clinical findings.

Subjective data was obtained using the Numerical Pain Rating Scale (Jensen, et al. 1986:125) (Appendix G), and the Foot Function Index Pain Subscale (Appendix H). Saag, et al. (1996:506) found the Foot Function Index to be a reliable measurement scale for use in orthopedic interventional trials.

Objective data was obtained by using an algometer to measure pain pressure threshold (Fischer, 1987:207) over the antero-medial calcaneal tubercle while passively dorsiflexing the great toe, and by measuring maximal weight-bearing ankle dorsiflexion.

1.3) THE HYPOTHESES

1.3.1) The first hypothesis

It was hypothesized that manipulation of the subtalar joint alone would be effective in the treatment of PF in terms of subjective and objective clinical findings.

1.3.2) The second hypothesis

It was hypothesized that manipulation of the subtalar joint combined with static stretch of the triceps surae muscles would be effective in the treatment of PF in terms of subjective and objective clinical findings.

1.3.3) The third hypothesis

It was hypothesized that manipulation of the subtalar joint combined with static stretch of the triceps surae muscles would be more effective than manipulation alone in the treatment of PF.

CHAPTER TWO

A REVIEW OF THE RELATED LITERATURE

2.1) INTRODUCTION

In this chapter, a detailed discussion of the available literature on PF is presented.
This includes:

a. A definition of PF,
b. A review of the relevant anatomical structures,
c. A discussion of the syndrome and the presenting symptoms of PF,
d. The aetiological factors,
e. The findings on examination and forming a diagnosis,
f. Differential diagnoses, and
g. The various available treatment protocols.

Literature surrounding hypomobility of the joints of the foot and ankle and the role of tight Triceps Surae muscles in the syndrome of PF is presented in this chapter in terms of aetiological relevance as well as the interventions available to correct these biomechanical abnormalities.

2.2) DEFINITION AND EPIDEMIOLOGY OF PLANTAR FASCIITIS

PF is the most common cause of heel pain in adults and those involved in running sports (Pollard and So, 1999:93; Barret and O'Malley, 1999:2200, Young, Rutherford and Niedfeldt, 2001:467). It is also one of the most common clinical problems encountered by an orthopedic surgeon (Gill and Kiebzak, 1996:527). Often termed "the heel pain syndrome," (Hyde and Gengenbach, 1997:477) this overuse syndrome is characterized by pain at the anteromedial calcaneal tubercle due to collagen degeneration, often misnamed "chronic inflammation" (Khan, et al. 2000), at the attachment of the plantar fascia to the calcaneus (Pollard and So, 1999:93).

There appears to be little literature on the incidence and prevalence of PF in South Africa or world-wide. A review of the literature, however, found the following:

Brown (1996:877) describes 2 groups of people likely to present with heel pain:

a. The majority being mostly women in the 40–60 year age group with obesity often present;

b. The second group is athletes, mostly runners.

This is in keeping with Reid (1992:196), who stated that patients over the age of 40 were more likely to develop PF, and Ryan (1995:891) who stated that people who are overweight and spend a lot of time standing are more likely to develop PF.

PF is seen in approximately 7 – 10 % of all running injuries (Pollard and So, 1999:93; Batt and Tanji, 1995:77).

In 2 separate South African studies by Morris (2000:103-104) and Hammond (2000:62), there were slightly more females presenting with PF than males (66,6% and 56,6% respectively), and the average age group was 50,3 years and 40 years respectively.

2.3) RELEVANT ANATOMY OF THE PLANTAR FASCIA AND SURROUNDING STRUCTURES

The plantar fascia, or plantar aponeurosis, is a thickened fibrous structure originating from the medial calcaneal tubercle and forming the longitudinal arch of the foot (Moore and Dalley, 1999:595-596 and 640). It provides static support of the longitudinal arch and dynamic shock absorption as it is intricately related to the changes in shape, position and shock-absorbing qualities of the foot (Reid, 1992:195; Moore and Dalley, 1999:640). The central part is thick and strong, and lies between thinner and weaker medial and lateral portions. It fans out from the calcaneus, dividing into 5 bands that enclose the digital tendons. Vertical septa extend from the central portion dividing the sole into medial, lateral and central compartments. The musculature of the sole of the foot is divided into 4 layers, with a neurovascular plane being present between the first and second layers, and between the third and fourth layers (Moore and Dalley, 1999: 595-596). The plantar fascia gives attachments to the overlying skin and to protect the underlying structures (Ambrosius and Kondracki, 1992:30), it assists in stabilizing the arch of the foot, and surgical release of the fascia or traumatic fascial rupture may cause flattening of the arch (Kitaoka, et al. 1994:557).

The subtalar joint lies between the inferior surface of the body of the talus and the superior surface of the calcaneus, and is surrounded by an articular capsule (Norkin and Levangie, 1992:388). The fibrous capsule is weak but is supported by medial, lateral and posterior talocalcaneal ligaments. Anteriorly, the interosseus talocalcaneal ligament supports it. The main movements occurring at this joint are inversion and eversion, the result of slight gliding and rotation that the joint permits (Moore and Dalley, 1999:637).

The two heads of the gastrocnemius muscle and the soleus muscle together form the triceps surae muscle, which attaches to the middle of the posterior surface of the calcaneus via the Achilles tendon (Moore and Dalley, 1999:586). The calcaneus is the largest and strongest bone in the foot, and the first to ossify. There are articulating facets superiorly for the talus. It articulates with the cuboid anteriorly (Moore and Dalley, 1999:515).

2.4) DISCUSSION OF THE SYNDROME AND PRESENTING SYMPTOMS

The pain from PF is usually due to collagen degeneration (similar to chronic necrosis of tendinosis), following microscopic tears and inflammation at the insertion of the plantar fascia to the calcaneus (Porter, et al. 2002:619; Ambrosius and Kondracki, 1992:30). This degeneration features loss of collagen continuity, increased ground substance, vascularity and fibroblasts. Thus it is often incorrectly termed "chronic inflammation," as fibroblasts are present rather than the inflammatory cells seen in tendonitis (Khan, et al. 2000). The degeneration is a result of overuse that overcomes the ability of the body to repair itself (Young, Rutherford and Niedfeldt, 2001:467).

The onset of pain is usually gradual, with only a small number of patients able to recall an initiating event (Pollard and So, 1999:95; Barret and O'Malley, 1999:2200; Reid, 1992:196). There is usually a history of an increase in weight-bearing activities, especially those involving running, prior to the onset of symptoms (Pollard and So, 1999:95; Young, Rutherford and Niedfeldt, 2001:467, Reid, 1992:196).

A patient classically reports the worst pain occurring in the mornings during the first steps, and the pain is usually more severe if the plantar fascia is cold or contracted. The pain is also often present at the beginning of activity but decreases as the patient warms-up (Pollard and So, 1999:95; Young, Rutherford and Niedfeldt, 2001:467; Porter, et al. 2002:620). It is aggravated by prolonged standing and is often characterized by stiffness. Pain at the end of the day may be present (Pollard and So, 1999:95; Young, Rutherford and Niedfeldt, 2001:467; Barret and O'Malley, 1999:2200; Porter, et al. 2002:620; Reid, 1992:196, Krivickas, 1997:141). The patient may start bearing weight only on the lateral aspect of the affected foot, start limping and even have pain at rest if the condition becomes very severe (Reid, 1992:196).

2.5) AETIOLOGICAL FACTORS

The common causative factors can be classified as being biomechanical, environmental or anatomical (Kibler, et al. 1991:66, Pollard and So, 1999:94). However, most authors are in agreement that the most common causes of PF are overuse activities (Young, Rutherford and Niedfeldt, 2001:467, Krivickas, 1997:141, Batt and Tanji, 1995:77), or poor biomechanics (Barret and O'Malley, 1999:2200, Hall and Messier, 1993:41), resulting in abnormal functional pronation.

Efficient pronation and supination are essential for normal foot function during the gait cycle. The foot should pronate during heel strike to absorb shock, and then should supinate from mid-stance to toe-off (Norkin and Levangie 1992:460). In this way, the loading forces are absorbed from various anatomic structures in a precise sequence. Any condition causing abnormal pronation will result in the plantar fascia absorbing more load than it is able to physiologically accommodate. Prolonged pronation of the foot will result in loading forces being supported by the plantar fascia (a secondary supporting structure) and not by the primary supporting structures (i.e. bone), resulting in an increased tensile strain on the plantar fascial insertion and causing PF (Kwong, 1988:121).

2.5.1) Biomechanical factors

Functional risk factors include tightness and weakness in the gastrocnemius and soleus muscles, Achilles tendon and intrinsic foot muscles (Young, Rutherford and Niedfeldt, 2001:467, Batt and Tanji, 1995:78), a stiff subtalar joint (Brown, 1996:876), non-weight bearing rearfoot varus, non-weight-bearing forefoot varus or functional leg length inequality (Barret and O'Malley, 1999:2200). Biomechanical factors are usually primarily responsible for PF that occurs in the elderly. This can be attributed to poor intrinsic muscle strength, acquired flat feet and reduced healing capacity of the body (Young, Rutherford and Niedfeldt, 2001:467).

2.5.1.1) Tight Achilles tendon

Over-pronation can be the result of a tight triceps surae muscle, resulting in a shortened Achilles tendon, common in symptomatic PF patients (Kwong, et al. 1988:121; Donatelli, 1990:47). In their study of functional biomechanics of athletes with PF, Kibler, et al. (1991:68) found that 41 out of 43 feet examined had triceps surae flexibility deficits. They found that the tight triceps surae created a valgus (weight-bearing) heel position at heel strike, restricting supination and dorsiflexion of the hindfoot. This confirmed 2 previous studies by Taunton, et al. (1982) and Riddle and Freeman (1988:1914) who had previously concluded that tight triceps surae tethers the calcaneus in a valgus (weight bearing) position at heel strike thus leading to a functional pronation.

2.5.1.2) Joint hypomobility

Hypomobile joints in the foot and ankle don’t effectively absorb weight-bearing stress (Brantingham, et al.1992:82) and abnormal joint mechanics can result in prolonged pronation (Kwong, et al. 1988:121). An alteration of normal biomechanics of the foot and ankle during gait will result in increased tensile strain on the plantar fascia (Brown, 1996:876) because of its continuous “bowstring” attachment between the proximal phalanges and the calcaneus (Polkinghorn, 1995:45).

2.5.2) Environmental factors

Training error, changes in training equipment, intensity or duration of exercise (Kibler, et al. 1991:67), increased mileage, addition of speed work or running up hills (Reid, 1992:196) may contribute to the overload process. Wilk, Fisher and Gutierrez (2000:22-27) presented a case study in which a triathlete suddenly developed PF in his right foot after a race. Although his training schedule was intense, he had competed in the event before with the same preparation. He had also not changed his brand of running shoe for the past 2 years, although he bought new shoes after every 480-800km. Upon inspection of the shoes it was noted that there were defects in the right shoe resulting in excessive inward tilting of the shoe. Their conclusion was that faulty running shoes can contribute to the development of an overuse injury such as PF, and careful assessment of an athlete's shoes may prevent the development such an injury.

2.5.3) Anatomical factors

Anatomical risk factors include rigid pes planus or pes cavus, anatomic leg-length inequality, lateral tibial torsion, increased femoral anteversion, talipes equinovarus, tarsal coalitions (Batt and Tanji, 1995:78, Young, Rutherford and Niedfeldt, 2001:467, Pollard and So, 1999:94, Kibler, et al. 1991:67).

2.6) DIAGNOSIS OF PLANTAR FASCIITIS AND FINDINGS ON EXAMINATION

There is usually a point of maximal tenderness at the anteromedial calcaneal tubercle, and patients may have pain along the proximal plantar fascia. Passive dorsiflexion of the toes or ankle, or having the patient stand on their toes often exacerbates the pain (Young, Rutherford and Niedfeldt, 2001:467; Reid, 1992:196, Barret and O'Malley, 1999:2201, Krivickas, 1997:141).

The diagnosis of PF is based mainly on the patient's history:

- Gradual onset of pain, usually unable to recall an initiating event (Pollard and So, 1999:95; Barret and O'Malley, 1999:2200; Reid, 1992:196).
- History of an increase in weight-bearing activities, especially those involving running, prior to the onset of symptoms (Pollard and So, 1999:95; Young, Rutherford and Niedfeldt, 2001:467, Reid, 1992:196).

- Worst pain occurring in the mornings during the first steps. Pain is present at the beginning of activity but decreases as the patient warms-up (Pollard and So, 1999:95; Young, Rutherford and Niedfeldt, 2001:467; Porter, et al. 2002:620).
- Pain aggravated by prolonged standing. Pain at the end of the day may be present (Pollard and So, 1999:95; Young, Rutherford and Niedfeldt, 2001:467; Barret and O'Malley, 1999:2200; Porter, et al. 2002:620; Reid, 1992:196, Krivickas, 1997:141).

and the clinical findings:

- Maximal tenderness at the anteromedial calcaneal tubercle (Young, Rutherford and Niedfeldt, 2001:467; Reid, 1992:196, Barret and O'Malley, 1999:2201, Krivickas, 1997:141).
- Passive dorsiflexion of the toes or ankle, or having the patient stand on their toes often exacerbates the pain (Young, Rutherford and Niedfeldt, 2001:467; Reid, 1992:196, Barret and O'Malley, 1999:2201, Krivickas, 1997:141).

Diagnostic imaging is rarely indicated during initial evaluation of PF (Young, Rutherford and Niedfeldt, 2001:467), and should rather be used to confirm the diagnosis (Barret and O'Malley, 1999:2201).

Heel spurs, as a result of mechanical stress acting through the plantar fascia onto its origin at the calcaneal tubercle, may be present (Reid, 1992:196). The presence of heel spurs on radiographical examination (i.e. bony osteophytes visible on the anteromedial calcaneus) does not guarantee that the patient suffers from PF. Williams, et al. (1987) found 75% of symptomatic subjects to have heel spurs on x-ray, while 63% of asymptomatic heels also demonstrated a heel spur. Thus, since many symptomatic individuals may not have an associated heel spur, x-ray screening for these spurs should not be a routine procedure in patients with PF (Wolgin, et al. 1994:99). In systemic conditions (e.g. Ankylosing Spondylitis, Reiter's syndrome, Rheumatoid Arthritis, or gout), the PF is more likely to be associated with a heel spur. This type of spur may be large and fluffy on x-ray, as opposed to the usually small traction spur (Reid, 1992:196).

Ultrasonography has been found to be effective in confirming the diagnosis of PF. A study was done in which ultrasound (US) scans of 20 symptomatic patients with respect to PF were compared to the US scans of 20 asymptomatic patients. It was shown that US was quick and easy to perform, and that the signs of PF on US scans of symptomatic patients (significant increase in thickness of the plantar fascia and hypoechoic with convex bulging of it's margin) were readily visible in comparison to the US scans of the asymptomatic patients (Kamel and Kotob, 2000).

Magnetic resonance imaging (MRI) has also been found to be useful in specifically confirming the diagnosis of PF, but this imaging technique is expensive and not always readily available (Berkowitz, Kier and Rudicel, 1991).

Bone scintigraphy shows increased radionuclide uptake in patients suffering from PF, and ultrasound findings correlated 100% with the bone scans findings. Unfortunately this technique is not specific, as other conditions (e.g. stress fractures and infections) will also show increased radionuclide uptake. Ultrasound also involved less time and expense with no radiation exposure (Kane, et al. 1998:95).

2.7) DIFFERENTIAL DIAGNOSES

The most common conditions that must be differentiated from PF are:

- Soft tissue conditions such as fat pad syndrome (Reid, 1992:197),

- Skeletal conditions such as stress fracture of the calcaneus (Reid, 1992:197) and Sever's disease (ages 9 – 11) (Reid, 1992:197).

- Neurological conditions such as tarsal tunnel syndrome and 1st sacral radiculopathy are slightly rarer causes of chronic heel pain (Reid, 1992:197).

2.7.1) Soft tissue causes

2.7.1.1) Fat pad syndrome

Elastic adipose tissue is present on the plantar surface of the calcaneus (heel pad), as it is in other areas, which are subject to pressure (Moore and Dalley, 1999:594). Increased body weight, ageing, poor shoes or hard walking surfaces may lead to damage of this heel pad, resulting in the calcaneus having to bear increased pressure. The patient may describe the heel pain to be worst during the initial steps in the mornings (as is the case with PF) but may continue to worsen with activity (Reid, 1992:194) while in PF, the pain often decreases with further activity. The pain will often be localized to the centre of the plantar surface of the heel (i.e. the weight-bearing region) (Brown, 1996:875) whereas in PF, the pain is localized to the antero-medial calcaneal tubercle**.**

2.7.1.2) Partial or complete rupture of plantar fascia

This is an uncommon cause of plantar heel pain, and patients will present with a history of recent trauma (Barret and O'Malley, 1999:2205). The patient may describe the pain as being "sudden" and "knife-like", and there may be visible ecchymosis (Young, Rutherford and Niedfeldt, 2001:468). Palpation may reveal a defect within the plantar fascia (Barret and O'Malley, 1999:2205). This can be differentiated from PF as patients with PF will rarely have a history of specific trauma, the pain is often insidious in onset and there will not be a palpable defect within the plantar fascia.

2.7.2) Skeletal conditions

2.7.2.1) Stress fracture of calcaneus

This condition often presents with a history of sudden increase in physical activity, and the pain is aggravated by medial to lateral compression of the calcaneus (Barret and

O'Malley, 1999:2205), and by prolonged weight-bearing (Young, Rutherford and Niedfeldt, 2001:468). Patients with PF should not report an increase in pain during medial to lateral compression of the calcaneus, only pressure to the antero-medial calcaneal tubercle will increase their pain. There may be a delay in diagnosing this condition as the radiological signs take time to become apparent, but a stress fracture should be suspected if a patient presents with non-specific pain which is difficult to localize, fails to respond after being treated for a diagnosed PF or tendonitis (Reid, 1992:179).

2.7.2.2) Sever's Disease (Calcaneal apophysitis)

In early adolescence, posterior heel pain may be attributed to an apophysitis of the calcaneal apophysis due to increased shearing stress by the Gastrocnemius muscle following repetitive landing (e.g. gymnasts) or a sudden growth spurt. This can be differentiated from PF as it is a condition affecting younger athletes, and the pain is primarily located over the posterior calcaneus. X-rays will demonstrate fragmentation and altered density of the calcaneal apophysis (Reid, 1992:190).

2.7.3) Neurologic causes

2.7.3.1) Entrapment of L5/S1 nerve root

Nerve root entrapment will result in the patient complaining of pain over the lower back, radiating down the posterior buttock, posterior thigh and calf, and lateral foot. There may be diminished sensation along the lateral foot, weakness in the gastrocnemius muscle, and reduced deep tendon reflex of the Achilles tendon. A neurological examination, including the straight-leg raising test, should indicate a nerve root disorder. Lumbar x-rays, MRI or CT scanning may all show evidence of disc pathology or stenosis of the vertebral or lateral canal (Reid, 1992:815, Barret and O'Malley, 1999:2204).

2.7.3.2) Tarsal tunnel syndrome

This is a compression neuropathy of the posterior tibial nerve within the tarsal tunnel as a result of anatomic variations, trauma, tumors, pregnancy or weight gain, all of which may limit the size of the tarsal tunnel. The tarsal tunnel is a fibro-osseous structure bound by the flexor retinaculum medially, the posterior surface of the talus and calcaneus laterally, and the medial malleolus (Barret and O'Malley, 1999:2204 and Moore and Dalley, 1999: 636). The patient may complain of "burning" pain and paraesthesia along the plantar aspect of the foot, and occasionally the medial plantar surface of the heel. Sensation may be reduced in the area of distribution (which is not the case with PF), but muscle weakness is difficult to detect. A positive Tinel's sign over (i.e. tingling or parasthesia) (Magee, 1997:638) and a nerve conduction study to abductor digiti minimi and abductor hallicus can confirm this diagnosis (Reid, 1992:262).

2.7.3.3) Entrapment of lateral plantar nerve (nerve to abductor digiti quinti muscle)

The nerve may be entrapped between the abductor hallucis muscle and the quadratus plantae muscle (Barret and O'Malley, 1999:2204). The patient may describe the pain as "burning" (Young, Rutherford and Niedfeldt, 2001:468) over the medial aspect of the sole (Pollard and so, 1999:95; Barret and O'Malley, 1999:2204), which tends to be more medial to the calcaneal tubercle, which is painful in patients with PF.

2.7.4) Systemic disorders

For example: Rheumatoid arthritis, Ankylosing spondylitis, Reiter's syndrome, gout, Bechet's syndrome, Systemic Lupus Erythematosus, Gonorrhea and Tuberculosis. Patients with systemic disease will usually present with joint pain and signs of inflammation in other areas of body, although symptoms can sometimes begin in the heel (Brown, 1996:881; Barret and O'Malley, 1999:2206).

A thorough history and examination will usually reveal signs and symptoms of systemic disease, although these diseases rarely cause heel pain (Barret & O'Malley, 1999:2206).

2.8) TREATMENT PROTOCOLS

PF is a self-limiting condition but unfortunately it can take between six to eighteen months before symptoms are resolved. Early recognition and implementation of a treatment plan usually leads to a shorter course of treatment and increased chances of success with a conservative approach (Young, Rutherford and Niedfeldt, 2001:469).

2.8.1) Conservative management of PF

In a retrospective review of 100 patients who were treated conservatively for their PF, 82 reported complete resolution, 15 reported fair improvement and 3 reported poor results. The patients who continued to suffer from PF were those who were overweight, had bilateral symptoms and had a longer duration of symptoms before treatment was sought. Patients may have received either a single intervention or a combination of stretching, heel cups, NSAID's, ice, steroid injection, heat, night splints, strapping, or advice on new footwear and walking programs (Wolgin, et al. 1994:102).

Similar results were obtained in a study by Davis, Severund and Baxter (1994:53) in which 89,5% of the patients were treated successfully using a combination of anti-inflammatory medications, Achilles tendon stretches, relative rest, heel cups and occasionally injections.

In a later study (Gill, and Giebzak, 1996:531), conservative treatments were found to be unpredictable and minimally effective when patients were asked directly about a variety of interventions. The treatments that were evaluated were rest, steroid injection, NSAID's, ice, heat, changing shoes, heel cups (plastic, foam and Tuli's) and a short-leg cast. Unfortunately other conservative interventions such as stretching, manipulation, night splints, ultrasound and taping techniques were not considered, and patient compliance was not investigated.

2.8.1.1) Correction of environmental factors

As far as possible, any environmental factors should be identified and modified in order to prevent the aggravation of PF. This may include evaluation of running shoes, terrain on which the patient exercises, etc. (Young, Rutherford and Niedfedlt, 2001:469). Shoes should be properly fitted as shoes that are too small or too narrow (especially women's pointed shoes) aggravate many types of foot pain and a change of footwear may be all that is needed for resolution of symptoms (Meyer, 1996:123). Running shoes also tend to lose their shock absorbing capacity with age (Reid, 1992:1151), thus the footwear of athletes and patients suffering from PF should be thoroughly evaluated as a better or newer pair of shoes may contribute greatly to decreasing the patients' pain.

2.8.1.2) Rest

Rest has been found effective but unfortunately athletes, and those involved in occupations requiring long periods of standing, may not be compliant if told to stop all activity. "Relative rest", i.e. substituting alternative activities for those activities aggravating their PF, may be more successful in maintaining patient compliance during the treatment period (Young, Rutherford and Niedfeldt, 2001:468).

2.8.1.3) Ultrasound and Ice

In the acute phase, a significant inflammatory reaction may be present and modalities such as ice and ultrasound may be helpful (Batt and Tanji, 1995:83). Ice is a commonly used anti-inflammatory agent in the treatment of PF and can be applied in the form of an ice massage, ice bath or ice pack. Ice is usually applied for 10-15 minutes and is usually done after periods of exercise, stretching, strengthening or after a day's work (Young, Rutherford and Niedfeldt, 2001:473).

2.8.1.4) Stretching

Tight triceps surae musculature is a significant contributing factor in patients suffering from PF, and authors consistently agree that Achilles tendon stretching plays a very important role in treatment (Young, Rutherford and Niedfeldt, 2001:469; Barret and O'Malley, 1999:2201; Batt and Tanji, 1995:83; Reid, 1992:197). It therefore follows that since triceps surae tightness is a very common finding in patients with PF, it should always be looked for and treated with Triceps Surae stretches (Brown, 1996:877).

In a clinical trial by Porter, et al. (2002:623) two types of Achilles stretches were compared in the treatment of PF. It was found that, although there was no difference between the two groups, both groups improved significantly in terms of increased flexibility and reduced symptoms. The establishment of a correlation between increased flexibility and decreased symptoms confirms that Achilles tendon stretching is a necessity in the treatment of PF.

In one study (Wolgin, et al. 1994:99), Achilles tendon stretching was the found to be the treatment that helped patients the most (29%) compared to a range of other conservative treatments. Rest was the next most effective form of treatment (25%). Similar results were obtained in a study by Davis, Severund and Baxter (1994:534), in which patients reported that the stretching program was the most helpful treatment.

2.8.1.5) Manipulation

Correction of abnormal biomechanics is essential in the treatment of PF, and manipulative therapy can restore normal joint mechanics to decrease tension across the plantar fascia (Hyde and Gengenbach, 1997:479). A complete biomechanical examination should be performed on all patients with PF, including checking the range of motion of the first metatarso-phalangeal, midtarsal, subtalar and talocrural joints in order to correct any abnormal biomechanics (Barret and O'Malley, 1999:2202).

Polkinghorn (1995:50) found that conservative management of PF could be effective using specific chiropractic adjusting procedures and recommend a trial period of manipulative therapy in every case of PF before further measures are considered. He treated 3 patients with chiropractic adjustments based on the individual fixations present in each case but noted that posterior calcaneal restriction was common to each patient. The patients were treated over a period of 1-2 months and had complete resolution of symptoms with no recurrence at follow-up visits at 12-18 months.

In their study on PF, Brantingham, et al. (1992:82) also concluded that PF could be effectively treated by chiropractors using joint manipulation. They reviewed the files of 29 patients and all had demonstrated evidence of foot joint dysfunction. All patients received foot manipulation in addition to various other conservative treatments, and 22 of the patients reported greater than 75% reduction in pain after an average of 8 treatments.

Pollard and So (1999:94) presented a case report in which a patient suffering from PF was symptom free after 5 weeks, and was treated using a range of conservative therapies including adjustments to the talocrural joint and talocalcaneal joint.

The above authors all concluded that PF could be effectively managed by chiropractors using specific manipulative techniques to restore normal joint motion.

This is further supported by two studies carried out at the Durban Institute of Technology (formerly Technikon Natal):

- In her placebo controlled study, Hammond (2000) concluded that manipulative therapy is a reliable intervention in the treatment of PF.
- Morris (2000) studied the relative effectiveness of anterior night splints and a combination of anterior night splints and manipulation of the foot and ankle joints in the treatment of PF, and concluded that manipulation of the foot and ankle

joints used in combination with anterior night splints contributes greatly to the improvement and overall recovery of the patient with PF.

2.8.1.6) Orthotics and strapping

Types of mechanical corrections often used include taping, over-the-counter arch supports, custom orthotics and heel cups (Young, Rutherford and Niedfeldt, 2001:472). Orthotics are often the mainstay of treatment and are usually designed to correct any overpronation (Barret and O'Malley, 1999:2302). A simple heel cushion is often used to absorb some of the shock at heel strike, assist with weight redistribution and will reduce the pull of the Achilles tendon by placing it in a slightly shortened position (Batt and Tanji, 1995:83). Taping the plantar surface of the foot to reduce the stress along the plantar fascia can also provide rapid relief (Ryan, 1995:893). "Low-dye" strapping is the taping technique of choice on patients with PF (Reid, 1992:199).

2.8.1.7) Splinting

Most people tend to sleep with the feet in a plantar-flexed position, thus maintaining a position in which the plantar fascia and Achilles tendon are relaxed and allowed to shorten (Young, Rutherford and Niedfeldt, 2001:472, Wapner and Sharkey 1991:136).

Night splints are designed to keep the ankle in a neutral position overnight, i.e. in dorsiflexion, and thus allows for a degree of passive stretching of the calf muscles and plantar fascia overnight. This neutral position also allows for healing, as well as reducing the discomfort associated with the initial steps in the morning. Because the splints are moulded from plaster, fibreglass or plastic, some mild discomfort may be experienced which may interfere with the patients' ability to sleep (Young, Rutherford and Niedfeldt, 2001:472, Wapner and Sharkey 1991:136). Wapner and Sharkey (1991:136) found night splinting to be 100% successful in 11 out of 15 symptomatic patients in less than 4 months, with no recurrence of symptoms at 9 months. Ryan (1995:897) reported that since he incorporated night splinting as part of the treatment for PF 5 years previously, he has not needed to administer a single corticosteroid injection for PF for any of his patients at his institution.

Morris (2000) studied the relative effectiveness of anterior night splints and a combination of anterior night splints and manipulation of the foot and ankle joints in the treatment of PF, and concluded that manipulation of the foot and ankle joints used in combination with anterior night splints contributes greatly to the improvement and overall recovery of the patient with PF.

A fourth study (Probe, et al. 1999:195) found night splinting to be no more effective in combination with Achilles tendon stretches, anti-inflammatory medication and shoe recommendations, when compared to Achilles tendon stretches, anti-inflammatory medication and shoe recommendations alone.

2.8.2) Anti-inflammatory medication

The use of anti-inflammatory drugs in cases of chronic inflammation is controversial (Khan, et al. 2000; Stanley, Weaver 1998:381). Non-steroidal anti-inflammatory drugs (NSAID's) are convenient and easy to administrate if taken orally. Disadvantages include risk of gastro-intestinal damage resulting in bleeding and perforation. Patients are also more susceptible to these side effects during the initial 30 days of NSAID treatment, and factors such as age, smoking and alcohol use also increase the risk of side effects (McCarthy, 1998:7S).

2.8.3) Corticosteroid injections

Corticosteroid injections, although more effective if administered early, are usually reserved for chronic cases unresponsive to conservative care due to the high risks involved. These risks include rupture of the plantar fascia and fat pad atrophy (Young, Rutherford and Niedfeldt, 2001:473).

Sellman (1994:376) treated 37 patients that presented with rupture of the plantar fascia. All these patients previously were diagnosed with PF and were given corticosteroid injections into the calcaneal origin of the fascia. Two patients suffered from metatarsal stress fractures as a result of the fascial rupture. All patients were then treated conservatively, but took between 6 and 12 months for recovery. The author felt that there was a direct relationship between the corticosteroid injection and the plantar fascia rupture, and thus possible foot complications as a result of the rupture. An earlier study (Leach, Jones and Silva, 1978:538) had also reported plantar fascial rupture in 6 patients with a history of PF, 5 of which had been treated with local steroid injections.

2.8.4) Surgical intervention

Surgery may be considered in cases that fail to respond to conservative therapy. Plantar fasciotomy may be performed, but may result in flattening of the longitudinal arch, heel hypoasthesia and complications associated with rupture of the plantar fascia and complications associated with anaestheisa (Young, Rutherford and Niedfeldt, 2001:473).

Fourteen out of fifteen patients were able to return to full activity at a 6-month follow-up after surgery (Leach, et al. 1986), but there was no long-term follow up. In a case report by Jerosch (2000:511), an endoscopic release of the plantar fascia and removal of a heel spur resulted in the patient being pain-free for 3 months, after which the heel pain returned, and a stress-reaction was visible on the calcaneus on MRI. He concluded that, although the surgical procedure was not difficult, strict indications should always be maintained. Only 20 out of 41 patients (48,8%) were totally satisfied with the results of a partial fascial release and decompression of the nerve to abductor digiti minimi (Davies, Weiss and Saxby, 1999:806), although only 4 patients failed to note improvement in their daily activities. One patient developed reflex sympathetic dystrophy, and another suffered from a pulmonary embolus, both as a direct result of the surgery.

They (Davies, Weiss and Saxby, 1999:806) concluded that surgery should only be considered after extensive conservative therapy has failed, and that the patient be warned of any possible side effects and limitations of the procedure, and if surgical intervention is then decided upon, it has an acceptable success rate.

2.8.5) A typical rehabilitation program

A typical rehabilitation program should start by identifying and correcting training errors, faulty footwear and other modifiable environmental factors. A period of relative rest should be implemented and the patient should be instructed on the correct use of ice following activity.

Biomechanical factors are identified next and the appropriate stretching, strengthening, mobilization and manipulative techniques employed to correct the respective tight, weak and restricted areas. If there is no satisfactory improvement, night splints, orthotics or other appropriate mechanical intervention may be considered.

NSAID's, corticosteroids and, if deemed necessary, surgery are considered if there is still no improvement after good quality conservative care for an appropriate time. This is based on the findings of Young, Rutherford and Niedfeldt, 2001:474, Ryan, 1995:893, Brown, 1996:881, and Batt and Tanji, 1995:83.

2.8.6) The need for a study to determine the effectiveness of manipulation combined with static stretching of the triceps surae muscles, compared to manipulation alone in the treatment of Plantar Fasciitis

From the above literature review we can conclude that the management of PF requires a conservative intervention that is effective, low-cost and within the scope of practitioners of manual therapy who are confronted with this condition regularly.

Since manipulative therapy has been shown to be a reliable intervention in the treatment of PF, and triceps surae muscle stretches, advocated by many authors and found to improve PF in terms of increased flexibility and reduced symptoms, are both cost-effective, conservative interventions used regularly by manual therapists, it was of the researcher's opinion that a study combining the two was necessary.

CHAPTER 3

MATERIALS AND METHODS

3.1) INTRODUCTION

In this chapter

a. A detailed description of the design of the study,

b. The interventions,

c. The methods employed in data collection,

d. As well as the statistical methods used for the analysis and interpretation of the data

will be discussed.

A description of each treatment group is given, as well as the criteria for acceptance or exclusion of patients.

3.2) SAMPLING PROCEDURE

Non-probability purposive sampling was used and the study was limited to symptomatic patients with respect to PF residing in the Kwazulu-Natal province.

Extensive advertising was used to recruit patients for this study:

- Posters (Appendix A) were placed around the Durban Institute of Technology campuses, local sports clubs and sports shops, local libraries, gyms; and
- Advertisements were placed in local newspapers.

Interested subjects who responded to the adverts were screened telephonically to ensure suitability for their inclusion in this study in terms of age, and to ensure that they had signs and symptoms indicating a strong possibility that they did indeed suffer from PF.

The study was limited to the first 40 patients that completed the research. The patients were randomly allocated into two groups of twenty. Forty pieces of paper were used, with twenty pieces having the words “Group One” written on them, and twenty having the words “Group Two” written on them. All the pieces of paper were tightly folded and placed in a box. After shaking the box thoroughly, the researcher withdrew each piece of paper individually and wrote the group number on a list that corresponded with patient numbers from one to forty.

The patients in Group One received only manipulation to the subtalar joint, while the patients in Group Two received manipulation to the subtalar joint and stretches to the Gastrocnemius and Soleus muscles.

3.3) INCLUSION AND EXCLUSION CRITERIA

After the initial telephonic screen, an initial consultation was held during which the diagnosis of PF was made based on the findings of a complete history (Appendix B), physical examination (Appendix C) and foot and ankle regional examination (Appendix D). During this time the patients were screened further according to the following inclusion and exclusion criteria:

3.3.1) Inclusion criteria

1) Participants had to be between the ages of 14-60 years.

This is based on the findings of Brantingham et al. (1992:76), Brown (1996:877), Gill and Kiebzak (1996:529), who found the average age range of patients suffering from PF to be 36 years, 40-60 years, and 30-65 years respectively.

2) The diagnosis of PF was based on maximal pain located at the antero-medial aspect of the plantar surface of the calcaneus (Young, Rutherford and Niedfeldt, 2001:467; Reid, 1992:196, Barret and O'Malley, 1999:2201, Krivickas, 1997:141).

They would also have to display at least 3 of the following:

1) Aggravation of pain by passive dorsiflexion of the great toe;

2) Aggravation of pain when the patient stands on their toes;

3) Pain that is worse in the morning during the initial steps, but which decreases after walking continues.

4) Aggravation of pain during direct palpation of the antero-medial calcaneal tubercle during passive dorsiflexion the great toe.

These diagnostic criteria were based on the findings of Brown (1996:877-878), Reid (1992:196), Barret and O'Malley (1999:2200), and Pollard and So (1999:95).

3) All participants received a letter (Appendix E) informing them about the study. They then had to complete and have understood the informed consent form (Appendix F).

4) All participants had to demonstrate reduced ankle dorsiflexion range of motion on the affected foot. Pope, Herbert and Kirwan (1998:169) measured the effects of ankle dorsiflexion range of motion and calf muscle stretching on injury risk in 1093 asymptomatic army recruits. They found the mean range of motion of ankle dorsiflexion to be 45º. Since the measuring tool used in this study is the same as that used in their study, ankle dorsiflexion of less than 45º will be regarded as reduced. The angle calculated using this technique will tend to overestimate the actual dorsiflexion range of motion by approximately 10º (Montgomery, et al. 1989) as the axis of ankle rotation is not at the posterior aspect of the heel, which is the point of reference used in the calculation.

5) All participants must have had an identifiable subtalar joint restriction in at least one direction, based on the findings of motion palpation according to Schafer and Faye (1990:410-414). The plantar flexors control movement of the ankle indirectly through the calcaneus via the subtalar joint, thus the functional integrity of this joint is important as it

will always be involved during gastro-soleus muscle action (Reid, 1992:201). Polkinghorn (1995:50) found restriction of the subtalar joint to be a common denominator in patients with PF. In a retrospective study by Brantingham, et al. (1992:76) on PF, the patients received adjustments to the talocrural, subtalar, midtarsal and intermetatarsal joints, but they made no mention of the most common motion palpation findings. Morris (2000:76) found the 3 most common joints to be restricted in PF patients to be the talocrural, subtalar and midtarsal joints.

3.3.2 Exclusion Criteria:

1) Participants were excluded if they received any form of therapy, manual or medicinal (Poul, et al. 1993), for their PF during the course of the research period.

2) Participants with a history of foot and/or ankle fracture, dislocation, surgery, peripheral neuropathy, nerve root entrapment, fixed foot deformity or any other condition other than PF causing foot pain were excluded from the study.

3) Participants suffering from systemic disease, such as metabolic arthritides, causing foot pain were excluded from the study.

4) Participants who were contraindicated to manipulative therapy (Bergmann, Peterson and Lawrence, 1993:132-133) were excluded from the study.

5) Participants were asked not to change their lifestyle, daily activities, and regular medication or exercise programs in any way to avoid being excluded from the study.

3.4) INTERVENTIONS

Participants were informed as to which group they were part of and thus which treatment they would be receiving.

Group One received only manipulation to the restricted articulations in the subtalar joint found by motion palpation (Schafer and Faye, 1990:402-403):

> Long axis extension:
> The patient is seated with the hip and knee flexed to a right angle. The examiner sits with their back against the patient's thigh while gripping the patient's heel and talus with both hands, just distal to the mortise joint. Push the patient's foot away until a separation is felt at the subtalar joint. A dynamic impulse is the applied.
>
> Medial and lateral side tilt:
> Cup the calcaneus with both hands while the patient is supine. Apply eversion and inversion forces to test medial and lateral side tilt. Apply a dynamic impulse in the direction of restriction.
>
> Posterior to Anterior talocalcaneal glide:
> The examiner stands perpendicular to the limb being examined, grasping the distal aspect of the patient's leg with the cephalad hand, and cupping the patient's heel with the caudad hand while the patient is supine. Pull upward with the caudad hand while maintaining pressure over the patient's leg. Anterior to posterior glide is assessed similarly, with the forces reversed.

Group Two also received manipulations to the subtalar joint. In addition they received 2 static stretches held for 20 seconds each to the gastrocnemius and soleus muscles as described by Travell and Simons (1983:415 and 449):

Gastrocnemius muscle stretch:

The patient lies prone with the feet extended off the end of the examination table so that the knee remains straight as the examiner applies firm pressure to the ball of the foot to take up slack while dorsiflexing the foot at the ankle.

Soleus muscle stretch:

The patient lies prone with the knee flexed and the ankle passively dorsiflexed. Increased pressure is gradually applied to dorsiflex the foot fully.

Pope, Herbert and Kirwan (1998:197) found the accepted stretching protocols to be 2 stretches of 20 seconds each to the gastrocnemius and soleus muscles. Arnheim and Prentice (1993:44) and Vegso (1995:477) are in agreement with holding the stretch for 20 seconds.

Each patient was treated 5 times within a 2-week period, with a 6th follow-up consultation no longer than 1 week after the 5th consultation during which final data was collected. No treatment was given during the 6th consultation. This is in keeping with a similar protocol used by Hammond (2000).

3.5) MEASUREMENTS

3.5.1) The Location of the Data

This study incorporated both primary and secondary data.

3.5.1.1) The Primary Data

a) The Subjective Data

1. The Numerical Pain Rating Scale – 101 (NRS 101) (Appendix G); and
2. the Foot Function Index (FFI) (Appendix H) were used to record the patients' perception of the severity of their foot pain.

These questionnaires were completed by all patients during the first, fourth and sixth visits.

b) The Objective Data

The algometer was used to measure the patients' pain threshold, and the weight-bearing dorsiflexion range of motion was calculated (Appendix I).
Both of these measurements were taken on all patients during the first, fourth and sixth visits.

3.5.1.2) The Secondary Data

The relevant secondary data was collected from various journal articles, textbooks and the Internet.

3.5.2) Measurement Methods

3.5.2.1) The Subjective Measurements

a) The Numerical Pain Rating Scale – 101 (NRS – 101)

The NRS – 101 (Appendix G) was chosen as it is easy to use, and it has been found to be a reliable and valid method to record subjective information relating to the patients' level of pain (Jensen, et al. 1986:125). The patients had to rate their pain as a percentage on two separate lines drawn from 0 (equivalent to no pain at all) to 100 (equivalent to pain as bad as it could be). The first number had to be their pain when it was at its worst, and the second number had to be their pain when it was at its least.

b) The Foot Function Index Pain Subscale (FFI)

The FFI (Appendix H) was used to obtain information on the impact of the patients' foot pain on their daily activities. It was found to be a validated and reliable scale for measuring foot pain, disability and activity restriction in orthopedic interventional trials (Saag, et al. 1996:506). It consists of 9 questions that are scored from 0 (equivalent to no pain at all) to 10 (equivalent to the worst pain imaginable).

3.5.2.2) The Objective Measurements

a) The Algometer

The algometer was used to measure the point of maximal tenderness, usually located over the antero-medial calcaneal tubercle. Fischer (1986:213) found the algometer to be adequate for measuring pressure threshold on ligaments, joint capsules, tendons and periosteum. The area of maximal tenderness was located by palpation and the algometer was set to zero. The rounded end of the rod was placed on the tender spot while passively dorsiflexing the great toe, and pressure was slowly increased until the patient informed the researcher when they first started to perceive pain. This represented the patients' pressure pain threshold.

b) Weight-bearing dorsiflexion measurement

The method used to measure maximal weight-bearing ankle dorsiflexion was as follows:

> Participants stood on the involved leg and dorsiflexed the ankle while flexing the knee, up to a point where no further dorsiflexion would take place without lifting

the heel from the ground. A large set square was used to measure the vertical distance (*x*) from the front of the knee to the ground, and the horizontal distance (y) from this point to the back of the heel was measured similarly. The degree of dorsiflexion was calculated using simple trigonometry (Appendix I).

<u>3.6) STATISTICAL ANALYSIS</u>

<u>3.6.1) Procedure One: Comparison between two unpaired (independent) samples</u>

<u>3.6.1.1) The Mann-Whitney U-test</u>

The Mann-Whitney U-test was used to compare two independent samples.

In each test, the null hypothesis states that there is no difference between groups one (manipulation only) and two (manipulation combined with stretches) with respect to the variable in charge, at the $\propto = 0{,}05$ level of significance. The alternative hypothesis states that there is a difference.

<u>3.6.1.2) The Decision Rule</u>

The null hypothesis was rejected at the $\propto$ level of significance if $p < \propto$ where p was the observed significance level or p-value. Otherwise, the null hypothesis was not rejected at the same level.

<u>3.6.2 Procedure Two: Comparison between two related samples within Group One</u>

<u>3.6.2.1) Friedman's Test</u>

Friedman's test was used to compare results from related samples.

The Dunn Procedure was then used in cases where the null hypothesis was rejected to determine at which consultation an improvement was observed.

In each test, the null hypothesis states that there is no improvement between the consultations being compared, at the $\propto$ level of significance. The alternative hypothesis states that there is an improvement.

3.6.2.2) The Decision Rule

The null hypothesis was rejected at the $\propto$ level of significance if $p < \propto$ where p was the observed significance level or p-value. Otherwise, the null hypothesis was not rejected at the same level.

3.6.3) Procedure Three: Comparison between related samples within Group Two

Procedure Two was repeated within Group Two with the same decision rule.

3.6.4) Procedure Four: Summary Statistics

Visual summaries of analytical findings were given by the use of bar charts to compare Groups One and Two. Average (mean) readings were used to construct the bar charts.

3.6.5) The Statistical Package

The statistical package used was the SPSS Inc. 1999 Version 9 for Windows®. All data was entered and analysed via this package.

CHAPTER FOUR

THE RESULTS

4.1) INTRODUCTION

All the results following the statistical analysis are presented in this chapter:

a. The subjective data includes data from the NRS-101 and the FFI.

b. The objective data includes data from the algometer readings and the dorsiflexion measurements.

c. Both the subjective and objective data were collected prior to the first treatment, prior to the fourth treatment, and at the follow-up sixth visit.

d. Intra- and inter-group comparisons were carried out for Group One and Group Two.

e. A brief summary of the demographic data (age, gender, duration of symptoms, presence of heel spur, body mass index, foot affected) are also included.

4.2) SOLVING THE SUBPROBLEMS

4.2.1) The First Subproblem

The first subproblem was to evaluate the relative effectiveness of manipulation of the subtalar joint alone in the treatment of PF in terms of subjective and objective clinical findings.

4.2.2) The Second Subproblem

The second subproblem was to evaluate the relative effectiveness of manipulation of the subtalar joint combined with static stretch of the Triceps Surae muscles in the treatment of PF in terms of subjective and objective clinical findings.

4.2.3) The Third Subproblem

The third subproblem was to evaluate the relative effectiveness of manipulation of the subtalar joint alone compared to manipulation of the subtalar joint combined with static stretch of the Triceps Surae muscles in the treatment of PF.

4.3) THE DEMOGRAPHIC DATA

Table 1: Demographic data

	Group One		**Group Two**		**Total**	
Age Distribution	Oldest: 53 Youngest: 20 Average: 36,8		Oldest: 60 Youngest: 22 Average: 44,7		Oldest: 60 Youngest: 20 Average: 40,75	
Gender Distribution						
Males	8		11		19	
Females	12		9		21	
Duration Of Symptoms						
3 weeks – 3 months	5		5		10	
3 months – 6 months	7		3		10	
6 months – 1 year	1		7		8	
> 1 year	7		5		12	
Heel Spur Present	2		2		4	
Body Mass Index	**Men:**	**Women:**	**Men:**	**Women:**	**Men:**	**Women:**
Highest:	38	38,3	33	36,5	38	38,3
Lowest:	23,9	22	24,1	22,5	23,9	22
Average:	30,3	28,9	27,1	28,8	28,4	28,8
Foot Affected						
Right Foot	7		8		15	
Left Foot	8		12		20	
Both Feet	5				5	

4.4) RESULTS OF STATISTICAL ANALYSIS

4.4.1) The Mann-Whitney U-test

This statistical method was used to compare results from two independent samples.

4.4.1.1) Subjective Data

Table 2:

Statistical results comparing the response to treatment of Group One and Group Two after each consultation in terms of subjective measurements using the NRS-101.

Ranks

	GROUPS	N	Mean Rank	Sum of Ranks
VISIT 1	1	20	21.67	433.50
	2	20	19.33	386.50
	Total	40		
VISIT 4	1	20	20.67	413.50
	2	20	20.33	406.50
	Total	40		
VISIT 6	1	20	19.55	391.00
	2	20	21.45	429.00
	Total	40		

Test Statistics[b]

	VISIT 1	VISIT 4	VISIT 6
Mann-Whitney U	176.500	196.500	181.000
Wilcoxon W	386.500	406.500	391.000
Z	-.639	-.095	-.515
Asymp. Sig. (2-tailed)	.523	.924	.607
Exact Sig. [2*(1-tailed Sig.)]	.529[a]	.925[a]	.620[a]

a. Not corrected for ties.

b. Grouping Variable: GROUPS

There was no difference between the subjective data of Group One and Group Two. The null hypothesis was thus not rejected, and this indicates that the two groups were similar in terms of pain perception.

Table 3:

Statistical results comparing the response to treatment of Group One and Group Two after each consultation in terms of subjective measurements using the FFI Question one.

Ranks

	GROUPS	N	Mean Rank	Sum of Ranks
VISIT 1	1	20	21.15	423.00
	2	20	19.85	397.00
	Total	40		
VISIT 4	1	20	18.75	375.00
	2	20	22.25	445.00
	Total	40		
VISIT 6	1	20	18.35	367.00
	2	20	22.65	453.00
	Total	40		

Test Statistics[b]

	VISIT 1	VISIT 4	VISIT 6
Mann-Whitney U	187.000	165.000	157.000
Wilcoxon W	397.000	375.000	367.000
Z	-.357	-.959	-1.170
Asymp. Sig. (2-tailed)	.721	.338	.242
Exact Sig. [2*(1-tailed Sig.)]	.738[a]	.355[a]	.253[a]

a. Not corrected for ties.

b. Grouping Variable: GROUPS

There was no difference between the subjective data of Group One and Group Two. The null hypothesis was thus not rejected, and this indicates that the two groups were similar in terms of the worst pain that was experienced.

Table 4:

Statistical results comparing the response to treatment of Group One and Group Two after each consultation in terms of subjective measurements using the FFI Question 2.

Ranks

	GROUPS	N	Mean Rank	Sum of Ranks
VISIT 1	1	20	22.17	443.50
	2	20	18.83	376.50
	Total	40		
VISIT 4	1	20	19.42	388.50
	2	20	21.58	431.50
	Total	40		
VISIT 6	1	20	18.08	361.50
	2	20	22.92	458.50
	Total	40		

Test Statistics[b]

	VISIT 1	VISIT 4	VISIT 6
Mann-Whitney U	166.500	178.500	151.500
Wilcoxon W	376.500	388.500	361.500
Z	-.921	-.587	-1.325
Asymp. Sig. (2-tailed)	.357	.557	.185
Exact Sig. [2*(1-tailed Sig.)]	.369[a]	.565[a]	.192[a]

a. Not corrected for ties.

b. Grouping Variable: GROUPS

There was no difference between the subjective data of Group One and Group Two. The null hypothesis was thus not rejected, and this indicates that the two groups were similar in terms of the pain experienced in the mornings.

<u>Table 5</u>:

Statistical results comparing the response to treatment of Group One and Group Two after each consultation in terms of subjective measurements using the FFI Question Three.

Ranks

	GROUPS	N	Mean Rank	Sum of Ranks
VISIT 1	1	20	18.90	378.00
	2	20	22.10	442.00
	Total	40		
VISIT 4	1	20	19.48	389.50
	2	20	21.52	430.50
	Total	40		
VISIT 6	1	20	18.45	369.00
	2	20	22.55	451.00
	Total	40		

Test Statistics[b]

	VISIT 1	VISIT 4	VISIT 6
Mann-Whitney U	168.000	179.500	159.000
Wilcoxon W	378.000	389.500	369.000
Z	-.873	-.561	-1.124
Asymp. Sig. (2-tailed)	.383	.574	.261
Exact Sig. [2*(1-tailed Sig.)]	.398[a]	.583[a]	.277[a]

a. Not corrected for ties.

b. Grouping Variable: GROUPS

There was no difference between the subjective data of Group One and Group Two. The null hypothesis was thus not rejected, and this indicates that the two groups were similar in terms of <u>pain experienced when walking barefoot</u>.

Table 6:

Statistical results comparing the response to treatment of Group One and Group Two after each consultation in terms of subjective measurements using the FFI Question Four.

Ranks

	GROUPS	N	Mean Rank	Sum of Ranks
VISIT 1	1	20	19.95	399.00
	2	20	21.05	421.00
	Total	40		
VISIT 4	1	20	20.00	400.00
	2	20	21.00	420.00
	Total	40		
VISIT 6	1	20	18.63	372.50
	2	20	22.38	447.50
	Total	40		

Test Statistics[b]

	VISIT 1	VISIT 4	VISIT 6
Mann-Whitney U	189.000	190.000	162.500
Wilcoxon W	399.000	400.000	372.500
Z	-.301	-.273	-1.033
Asymp. Sig. (2-tailed)	.764	.785	.302
Exact Sig. [2*(1-tailed Sig.)]	.779[a]	.799[a]	.314[a]

a. Not corrected for ties.

b. Grouping Variable: GROUPS

There was no difference between the subjective data of Group One and Group Two. The null hypothesis was thus not rejected, and this indicates that the two groups were similar in terms of pain experienced when standing barefoot.

Table 7:

Statistical results comparing the response to treatment of Group One and Group Two after each consultation in terms of subjective measurements using the FFI Question Five.

Ranks

	GROUPS	N	Mean Rank	Sum of Ranks
VISIT 1	1	20	19.63	392.50
	2	19	20.39	387.50
	Total	39		
VISIT 4	1	20	19.58	391.50
	2	19	20.45	388.50
	Total	39		
VISIT 6	1	20	17.70	354.00
	2	19	22.42	426.00
	Total	39		

Test Statistics[b]

	VISIT 1	VISIT 4	VISIT 6
Mann-Whitney U	182.500	181.500	144.000
Wilcoxon W	392.500	391.500	354.000
Z	-.213	-.241	-1.316
Asymp. Sig. (2-tailed)	.831	.809	.188
Exact Sig. [2*(1-tailed Sig.)]	.835[a]	.813[a]	.204[a]

a. Not corrected for ties.

b. Grouping Variable: GROUPS

There was no difference between the subjective data of Group One and Group Two. The null hypothesis was thus not rejected, and this indicates that the two groups were similar in terms of pain experienced when walking with shoes on.

Table 8:

Statistical results comparing the response to treatment of Group One and Group Two after each consultation in terms of subjective measurements using the FFI Question Six.

Ranks

	GROUPS	N	Mean Rank	Sum of Ranks
VISIT 1	1	20	19.63	392.50
	2	19	20.39	387.50
	Total	39		
VISIT 4	1	20	20.02	400.50
	2	19	19.97	379.50
	Total	39		
VISIT 6	1	20	18.20	364.00
	2	19	21.89	416.00
	Total	39		

Test Statistics[b]

	VISIT 1	VISIT 4	VISIT 6
Mann-Whitney U	182.500	189.500	154.000
Wilcoxon W	392.500	379.500	364.000
Z	-.213	-.014	-1.032
Asymp. Sig. (2-tailed)	.831	.989	.302
Exact Sig. [2*(1-tailed Sig.)]	.835[a]	.989[a]	.322[a]

a. Not corrected for ties.

b. Grouping Variable: GROUPS

There was no difference between the subjective data of Group One and Group Two. The null hypothesis was thus not rejected, and this indicates that the two groups were similar in terms of pain experienced when standing with shoes on.

Table 9:

Statistical results comparing the response to treatment of Group One and Group Two after each consultation in terms of subjective measurements using the FFI Question Seven.

Ranks

	GROUPS	N	Mean Rank	Sum of Ranks
VISIT 1	1	2	2.75	5.50
	2	4	3.88	15.50
	Total	6		
VISIT 4	1	2	2.25	4.50
	2	4	4.13	16.50
	Total	6		
VISIT 6	1	2	3.25	6.50
	2	4	3.63	14.50
	Total	6		

Test Statistics[b]

	VISIT 1	VISIT 4	VISIT 6
Mann-Whitney U	2.500	1.500	3.500
Wilcoxon W	5.500	4.500	6.500
Z	-.705	-1.174	-.235
Asymp. Sig. (2-tailed)	.481	.240	.814
Exact Sig. [2*(1-tailed Sig.)]	.533[a]	.267[a]	.800[a]

a. Not corrected for ties.

b. Grouping Variable: GROUPS

There was no difference between the subjective data of Group One and Group Two. The null hypothesis was thus not rejected, and this indicates that the two groups were similar in terms of pain experienced when walking while wearing orthotics.

<u>Table 10</u>:

Statistical results comparing the response to treatment of Group One and Group Two after each consultation in terms of subjective measurements using the FFI Question Eight.

Ranks

	GROUPS	N	Mean Rank	Sum of Ranks
VISIT 1	1	2	1.75	3.50
	2	4	4.38	17.50
	Total	6		
VISIT 4	1	2	2.00	4.00
	2	4	4.25	17.00
	Total	6		
VISIT 6	1	2	3.50	7.00
	2	4	3.50	14.00
	Total	6		

Test Statistics[b]

	VISIT 1	VISIT 4	VISIT 6
Mann-Whitney U	.500	1.000	4.000
Wilcoxon W	3.500	4.000	14.000
Z	-1.644	-1.389	.000
Asymp. Sig. (2-tailed)	.100	.165	1.000
Exact Sig. [2*(1-tailed Sig.)]	.133[a]	.267[a]	1.000[a]

a. Not corrected for ties.

b. Grouping Variable: GROUPS

There was no difference between the subjective data of Group One and Group Two. The null hypothesis was thus not rejected, and this indicates that the two groups were similar in terms of <u>pain experienced when standing while wearing orthotics</u>.

Table 11:

Statistical results comparing the response to treatment of Group One and Group Two after each consultation in terms of subjective measurements using the FFI Question Nine.

Ranks

	GROUPS	N	Mean Rank	Sum of Ranks
VISIT 1	1	20	22.83	456.50
	2	20	18.17	363.50
	Total	40		
VISIT 4	1	20	20.25	405.00
	2	20	20.75	415.00
	Total	40		
VISIT 6	1	20	18.58	371.50
	2	20	22.42	448.50
	Total	40		

Test Statistics[b]

	VISIT 1	VISIT 4	VISIT 6
Mann-Whitney U	153.500	195.000	161.500
Wilcoxon W	363.500	405.000	371.500
Z	-1.275	-.136	-1.053
Asymp. Sig. (2-tailed)	.202	.891	.292
Exact Sig. [2*(1-tailed Sig.)]	.211[a]	.904[a]	.301[a]

a. Not corrected for ties.

b. Grouping Variable: GROUPS

There was no difference between the subjective data of Group One and Group Two. The null hypothesis was thus not rejected, and this indicates that the two groups were similar in terms of pain experienced at the end of the day.

4.4.1.2 Objective Data

Table 12:

Statistical results comparing the response to treatment of Group One and Group Two after each consultation in terms of the objective measurement of dorsiflexion range of motion

Ranks

	GROUPS	N	Mean Rank	Sum of Ranks
VISIT 1	1	20	20.48	409.50
	2	20	20.52	410.50
	Total	40		
VISIT 4	1	20	21.38	427.50
	2	20	19.63	392.50
	Total	40		
VISIT 6	1	20	20.77	415.50
	2	20	20.23	404.50
	Total	40		

Test Statistics[b]

	VISIT 1	VISIT 4	VISIT 6
Mann-Whitney U	199.500	182.500	194.500
Wilcoxon W	409.500	392.500	404.500
Z	-.014	-.478	-.151
Asymp. Sig. (2-tailed)	.989	.632	.880
Exact Sig. [2*(1-tailed Sig.)]	.989[a]	.640[a]	.883[a]

a. Not corrected for ties.

b. Grouping Variable: GROUPS

There was no difference between the objective data of Group One and Group Two. The null hypothesis was thus not rejected, and this indicates that the two groups were similar in terms of measured dorsiflexion range of motion.

Table 13:

Statistical results comparing the response to treatment of Group One and Group Two after each consultation in terms of the objective measurement of Algometer readings.

Ranks

	GROUPS	N	Mean Rank	Sum of Ranks
VISIT 1	1	20	17.30	346.00
	2	20	23.70	474.00
	Total	40		
VISIT 4	1	20	18.52	370.50
	2	20	22.48	449.50
	Total	40		
VISIT 6	1	20	19.58	391.50
	2	20	21.42	428.50
	Total	40		

Test Statistics[b]

	VISIT 1	VISIT 4	VISIT 6
Mann-Whitney U	136.000	160.500	181.500
Wilcoxon W	346.000	370.500	391.500
Z	-1.737	-1.072	-.502
Asymp. Sig. (2-tailed)	.082	.284	.616
Exact Sig. [2*(1-tailed Sig.)]	.086[a]	.289[a]	.620[a]

a. Not corrected for ties.

b. Grouping Variable: GROUPS

There was no difference between the objective data of Group One and Group Two. The null hypothesis was thus not rejected, and this indicates that the two groups were similar in terms of the algometer readings.

4.4.2) The Friedman's Test – Group One

This statistical method was used to compare results within each sample.

The Dunn Procedure was used in cases where the null hypothesis was rejected to determine at which consultation an improvement was observed:

If $|R_j - R_{j'}| \geq 13{,}41$, then an improvement was observed (if n =20).

Let R_1, R_2, and R_3 be the treatment rank totals for visits one, four and six respectively.

4.4.2.1) Subjective Data

Table 14:

Statistical results comparing the NRS – 101 in response to treatment of Group One after each consultation.

Ranks

	Mean Rank
VISIT 1	2.95
VISIT 4	1.90
VISIT 6	1.15

Test Statistics[a]

N	20
Chi-Square	33.538
df	2
Asymp. Sig.	.000[b]

a. Friedman Test

b. <0.001

Dunn Procedure:

$R_1 - R_2 = 31$

$R_1 - R_3 = 36$

$R_2 - R_3 = 15$

Rejection of the null hypothesis, i.e. improvement in the patient's pain perception, occurred between the first and fourth visits (i.e. 31 > 13,41), between the first and sixth visits (i.e. 36 > 13,41) and between the fourth and sixth visits (i.e. 15 > 13,41). Maximal improvement was noted between the first and sixth visits, while the least improvement was noted between the fourth and sixth visits.

Table 15:

Statistical results comparing the FFI Question One in response to treatment of Group One after each consultation.

Ranks

	Mean Rank
VISIT 1	2.88
VISIT 4	1.83
VISIT 6	1.30

Test Statistics[a]

N	20
Chi-Square	27.811
df	2
Asymp. Sig.	.000[b]

a. Friedman Test

b. < 0,001

Dunn Procedure:

$R_1 - R_2$ = 21

$R_1 - R_3$ = 31,6

$R_2 - R_3$ = 10,6

Rejection of the null hypothesis, i.e. improvement with regards to the worst pain experienced by the patients, occurred between the first and fourth visits (i.e. 21 > 13,41) and between the first and sixth visits (i.e. 31,6 > 13,41). There was no improvement between the fourth and sixth visits (i.e. 10.6 < 13,41), therefore the null hypothesis was not rejected. Maximal improvement was noted between the first and sixth visits, while the least improvement was noted between the first and fourth visits.

<u>Table 16</u>:

Statistical results comparing the FFI Question Two in response to treatment of Group One after each consultation.

Ranks

	Mean Rank
VISIT 1	2.95
VISIT 4	1.80
VISIT 6	1.25

Test Statistics[a]

N	20
Chi-Square	32.986
df	2
Asymp. Sig.	.000[b]

a. Friedman Test

b. < 0,001

Dunn Procedure:

$R_1 - R_2 = 23$

$R_1 - R_3 = 11$

$R_2 - R_3 = 34$

Rejection of the null hypothesis, i.e. improvement in the morning pain experienced by the patients, occurred between the first and fourth visits (i.e. 23 > 13,07) and between the first and sixth visits (i.e. 34 > 13,07). There was no improvement between the fourth and sixth visits (i.e. 11 < 13,07), therefore the null hypothesis was not rejected. Maximal improvement was noted between the first and sixth visits, while the least improvement was noted between the first and fourth visits.

<u>Table 17</u>:

Statistical results comparing the FFI Question Three in response to treatment of Group One after each consultation.

Ranks

	Mean Rank
VISIT 1	2.67
VISIT 4	1.90
VISIT 6	1.42

Test Statistics[a]

N	20
Chi-Square	21.233
df	2
Asymp. Sig.	.000[b]

a. Friedman Test

b. < 0,001

Dunn Procedure:

$R_1 - R_2$ = 15,4

$R_1 - R_3$ = 25

$R_2 - R_3$ = 9,6

Rejection of the null hypothesis, i.e. improvement in the pain while walking barefoot, occurred between the first and fourth visits (i.e. 15,4 > 13,41) and between the first and sixth visits (i.e. 25 > 13,41. There was no improvement between the fourth and sixth visits (i.e. 9,6 < 13,41) and thus the null hypothesis was not rejected. Maximal improvement was noted between the first and sixth visits, while the least improvement was noted between the first and fourth visits.

Table 18:

Statistical results comparing the FFI Question Four in response to treatment of Group One after each consultation.

Ranks

	Mean Rank
VISIT 1	2.70
VISIT 4	1.95
VISIT 6	1.35

Test Statistics[a]

N	20
Chi-Square	24.000
df	2
Asymp. Sig.	.000[b]

a. Friedman Test

b. < 0,001

Dunn Procedure:

$R_1 - R_2$ = 15

$R_1 - R_3$ = 12

$R_2 - R_3$ = 27

Rejection of the null hypothesis, i.e. improvement in the pain when standing barefoot, occurred between the first and fourth visits (i.e. 15 > 13,41) and between the first and sixth visits (i.e. 27 > 13,41). There was no improvement between the fourth and sixth visits (i.e. 12 < 13,41), thus the null hypothesis was not rejected. Maximal improvement was noted between the first and sixth visits, while the least improvement was noted between the first and fourth visits.

Table 19:

Statistical results comparing the FFI Question Five in response to treatment of Group One after each consultation.

Ranks

	Mean Rank
VISIT 1	2.70
VISIT 4	1.95
VISIT 6	1.35

Test Statistics[a]

N	20
Chi-Square	22.875
df	2
Asymp. Sig.	.000[b]

a. Friedman Test

b. < 0,001

Dunn Procedure:

$R_1 - R_2$ = 15

$R_1 - R_3$ = 12

$R_2 - R_3$ = 27

Rejection of the null hypothesis, i.e. improvement in the pain when walking with shoes on, occurred between the first and fourth visits (i.e. 15 > 13,41) and between the first and sixth visits (i.e. 27 > 13,41). There was no improvement between the fourth and sixth visits (i.e. 12 < 13,41), thus the null hypothesis was not rejected. Maximal improvement was noted between the first and sixth visits, while the least improvement was noted between the first and fourth visits.

Table 20:

Statistical results comparing the FFI Question Six in response to treatment of Group One after each consultation.

Ranks

	Mean Rank
VISIT 1	2.75
VISIT 4	1.95
VISIT 6	1.30

Test Statistics[a]

N	20
Chi-Square	26.375
df	2
Asymp. Sig.	.000[b]

a. Friedman Test

b. < 0,001

Dunn Procedure:

$R_1 - R_2$ = 16

$R_1 - R_3$ = 13

$R_2 - R_3$ = 29

Rejection of the null hypothesis, i.e. improvement in the pain while standing with shoes on, occurred between the first and fourth visits (i.e. 16 > 13,41) and between the first and sixth visits (i.e. 29 > 13,41). There was no improvement between the fourth and sixth visits (i.e. 13 < 13,41), thus the null hypothesis was not rejected.. Maximal improvement was noted between the first and sixth visits, while the least improvement was noted between the first and fourth visits.

Table 21:

Statistical results comparing the FFI Question Seven in response to treatment of Group One after each consultation.

Ranks

	Mean Rank
VISIT 1	2.50
VISIT 4	1.75
VISIT 6	1.75

Test Statistics[a]

N	2
Chi-Square	2.000
df	2
Asymp. Sig.	.368

a. Friedman Test

There was no difference between any of the consultations with regard to the pain felt when walking and wearing orthotics, and thus the null hypothesis was not rejected.

Table 22:

Statistical results comparing the FFI Question Eight in response to treatment of Group One after each consultation.

Ranks

	Mean Rank
VISIT 1	1.25
VISIT 4	1.75
VISIT 6	3.00

Test Statistics[a]

N	2
Chi-Square	3.714
df	2
Asymp. Sig.	.156

a. Friedman Test

There was no difference between any of the consultations with regard to the pain felt when standing and wearing orthotics, and thus the null hypothesis was not rejected.

Table 23:

Statistical results comparing the FFI Question Nine in response to treatment of Group One after each consultation.

Ranks

	Mean Rank
VISIT 1	2.75
VISIT 4	1.92
VISIT 6	1.33

Test Statistics[a]

N	20
Chi-Square	25.200
df	2
Asymp. Sig.	.000[b]

a. Friedman Test

b. < 0,001

Dunn Procedure:

$R_1 - R_2$ = 16,6

$R_1 - R_3$ = 11,8

$R_2 - R_3$ = 28,04

Rejection of the null hypothesis, i.e. improvement in the pain at the end of the day, occurred between the first and fourth visits (i.e. 16,6 > 13,41) and between the first and sixth visits (i.e. 28,04 > 13,41). There was no improvement between the fourth and sixth visits (i.e. 11,8 < 13,41), thus the null hypothesis was not rejected. Maximal improvement was noted between the first and sixth visits, while the least improvement was noted between the first and fourth visits.

4.4.2.2) Objective Data

Table 24:

Statistical results comparing the Algometer readings in response to treatment of Group One after each consultation.

Ranks

	Mean Rank
VISIT 1	1.33
VISIT 4	2.08
VISIT 6	2.60

Test Statistics[a]

N	20
Chi-Square	19.043
df	2
Asymp. Sig.	.000[b]

a. Friedman Test

b. < 0,001

Dunn Procedure:

$R_1 - R_2$ = 15

$R_1 - R_3$ = 10,4

$R_2 - R_3$ = 25,4

Rejection of the null hypothesis, i.e. improvement in the Algometer readings, occurred between the first and fourth visits (i.e. 15 > 13,41) and between the first and sixth visits (i.e. 25,4 > 13,41). There was no improvement between the fourth and sixth visits (i.e. 10,4 < 13,41), thus the null hypothesis was not rejected. Maximal improvement was noted between the first and sixth visits, while the least improvement was noted between the first and fourth visits.

Table 24:

Statistical results comparing the Dorsiflexion measurements in response to treatment of Group One after each consultation.

Ranks

	Mean Rank
VISIT 1	2.72
VISIT 4	1.88
VISIT 6	1.40

Test Statistics[a]

N	20
Chi-Square	24.441
df	2
Asymp. Sig.	.000[b]

a. Friedman Test

b. < 0,001

Dunn Procedure:

$R_1 - R_2$ = 16,8

$R_1 - R_3$ = 9,6

$R_2 - R_3$ = 26,4

Rejection of the null hypothesis, i.e. improvement in the dorsiflexion range of motion, occurred between the first and fourth visits (i.e. 16,8 > 13,41) and between the first and sixth visits (i.e. 26,4 > 13,41). There was no improvement between the fourth and sixth visits (i.e. 9,6 < 13,41), thus the null hypothesis was not rejected. Maximal improvement was noted between the first and sixth visits, while the least improvement was noted between the first and fourth visits.

4.4.3) The Friedman's Test – Group Two

This statistical method was used to compare results within each sample.

The Dunn Procedure was used in cases where the null hypothesis was rejected to determine at which consultation an improvement was observed:

If $|R_j - R_{j'}| \geq 13{,}41$, then an improvement was observed (if n =20).

If $|R_j - R_{j'}| \geq 13{,}07$ then an improvement was observed (if n =19).

Let R_1, R_2, and R_3 be the treatment rank totals for visits one, four and six respectively.

4.4.3.1) Subjective Data

Table 25:

Statistical results comparing the NRS – 101 in response to treatment of Group Two after each consultation.

Ranks

	Mean Rank
VISIT 1	2.53
VISIT 4	1.95
VISIT 6	1.52

Test Statistics[a]

N	20
Chi-Square	11.041
df	2
Asymp. Sig.	.004

a. Friedman Test

Dunn Procedure:

$R_1 - R_2$ = 11,6

$R_1 - R_3$ = 8,6

$R_2 - R_3$ = 20,2

Rejection of the null hypothesis, i.e. improvement with regards to the pain experienced by the patients, occurred between the first and sixth visits (i.e. 20,2 > 13,41). There was no improvement between the fourth and sixth visits (i.e. 8,6 < 13,41) or between the first and fourth visits (i.e. 11,6 < 13,41), thus the null hypothesis was not rejected.

Table 26:

Statistical results comparing the FFI Question One in response to treatment of Group Two after each consultation.

Ranks

	Mean Rank
VISIT 1	2.55
VISIT 4	1.83
VISIT 6	1.63

Test Statistics[a]

N	20
Chi-Square	12.032
df	2
Asymp. Sig.	.002

a. Friedman Test

Dunn Procedure:

$R_1 - R_2$ = 14,4

$R_1 - R_3$ = 4

$R_2 - R_3$ = 18,4

Rejection of the null hypothesis, i.e. improvement with regards to the worst pain experienced was noted between the first and fourth visits (i.e. 14,4 > 13,41) and between the first and sixth visits (i.e. 18,4 > 13,41). There was no improvement between the fourth and sixth visits (i.e. 4 < 13,41), thus the null hypothesis was not rejected. Maximal improvement was noted between the first and sixth visits, while the least improvement was noted between the first and fourth visits.

Table 27:

Statistical results comparing the FFI Question Two in response to treatment of Group Two after each consultation.

Ranks

	Mean Rank
VISIT 1	2.60
VISIT 4	1.83
VISIT 6	1.58

Test Statistics[a]

N	20
Chi-Square	13.057
df	2
Asymp. Sig.	.001

a. Friedman Test

Dunn Procedure:

$R_1 - R_2$ = 15,4

$R_1 - R_3$ = 5

$R_2 - R_3$ = 20,4

Rejection of the null hypothesis, i.e. improvement in the morning pain, occurred between the first and fourth visits (i.e. 15,4 > 13,41) and between the first and sixth visits (i.e. 20,4 > 13,41). There was no improvement between the fourth and sixth visits (i.e. 5 < 13,41), thus the null hypothesis was not rejected. Maximal improvement was noted between the first and sixth visits, while the least improvement was noted between the first and fourth visits.

Table 28:

Statistical results comparing the FFI Question Three in response to treatment of Group Two after each consultation.

Ranks

	Mean Rank
VISIT 1	2.58
VISIT 4	1.88
VISIT 6	1.55

Test Statistics[a]

N	20
Chi-Square	13.303
df	2
Asymp. Sig.	.001

a. Friedman Test

Dunn Procedure:

$R_1 - R_2$ = 14

$R_1 - R_3$ = 6,6

$R_2 - R_3$ = 20,6

Rejection of the null hypothesis, i.e. improvement in the pain felt while walking barefoot was noted between the first and fourth visits (i.e. 14 > 13,41) and between the first and sixth visits (i.e. 20,6 > 13,41). There was no improvement between the fourth and sixth visits (i.e. 6,6 < 13,41), thus the null hypothesis was not rejected. Maximal improvement was noted between the first and sixth visits, while the least improvement was noted between the first and fourth visits.

Table 29:

Statistical results comparing the FFI Question Four in response to treatment of Group Two after each consultation.

Ranks

	Mean Rank
VISIT 1	2.25
VISIT 4	2.03
VISIT 6	1.73

Test Statistics[a]

N	20
Chi-Square	4.036
df	2
Asymp. Sig.	.133

a. Friedman Test

There was no difference between the consultations in terms of the pain felt while standing barefoot, therefore the null hypothesis was not rejected.

Table 30:

Statistical results comparing the FFI Question Five in response to treatment of Group Two after each consultation.

Ranks

	Mean Rank
VISIT 1	2.50
VISIT 4	1.87
VISIT 6	1.63

Test Statistics[a]

N	19
Chi-Square	11.878
df	2
Asymp. Sig.	.003

a. Friedman Test

Dunn Procedure:

$R_1 - R_2$ = 11,97

$R_1 - R_3$ = 4,56

$R_2 - R_3$ = 16,53

Rejection of the null hypothesis, i.e. improvement in the pain felt while walking with shoes on was noted between the first and sixth visits (i.e. 16,53 > 13,07). There was no improvement between the fourth and sixth visits (i.e. 4,56 < 13,07) or between the first and fourth visits (i.e. 11,97 < 13,07), thus the null hypothesis was not rejected.

Table 31:

Statistical results comparing the FFI Question Six in response to treatment of Group Two after each consultation.

Ranks

	Mean Rank
VISIT 1	2.39
VISIT 4	1.92
VISIT 6	1.68

Test Statistics[a]

N	19
Chi-Square	7.269
df	2
Asymp. Sig.	.026

a. Friedman Test

Dunn Procedure:

$R_1 - R_2$ = 8,93

$R_1 - R_3$ = 13,49

$R_2 - R_3$ = 4,56

Rejection of the null hypothesis, i.e. improvement in the pain felt while standing with shoes on was noted between the first and sixth visits (i.e. 13,49 > 13,07). There was no improvement between the fourth and sixth visits (i.e. 4,56 < 13,07) or between the first and fourth visits (i.e. 8,93 < 13,07), thus the null hypothesis was not rejected.

Table 32:

Statistical results comparing the FFI Question Seven in response to treatment of Group Two after each consultation.

Ranks

	Mean Rank
VISIT 1	2.50
VISIT 4	2.25
VISIT 6	1.25

Test Statistics[a]

N	4
Chi-Square	4.667
df	2
Asymp. Sig.	.097

a. Friedman Test

There was no difference between the consultations in terms of the pain felt while walking and wearing orthotics, therefore the null hypothesis was not rejected.

Table 33:

Statistical results comparing the FFI Question Eight in response to treatment of Group Two after each consultation.

Ranks

	Mean Rank
VISIT 1	1.88
VISIT 4	2.63
VISIT 6	1.50

Test Statistics[a]

N	4
Chi-Square	3.000
df	2
Asymp. Sig.	.223

a. Friedman Test

There was no difference between the consultations in terms of the pain felt while standing and wearing orthotics, therefore the null hypothesis was not rejected.

Table 34:

Statistical results comparing the FFI Question Nine in response to treatment of Group Two after each consultation.

Ranks

	Mean Rank
VISIT 1	2.22
VISIT 4	1.98
VISIT 6	1.80

Test Statistics[a]

N	20
Chi-Square	2.433
df	2
Asymp. Sig.	.296

a. Friedman Test

There was no difference between the consultations in terms of the pain felt at the end of the day, therefore the null hypothesis was not rejected.

4.4.3.2) Objective Data

Table 35:

Statistical results comparing the Algometer readings in response to treatment of Group Two after each consultation.

Ranks

	Mean Rank
VISIT 1	1.67
VISIT 4	2.05
VISIT 6	2.28

Test Statistics[a]

N	20
Chi-Square	4.141
df	2
Asymp. Sig.	.126

a. Friedman Test

There was no difference between the consultations in terms of the Algometer readings; therefore the null hypothesis was not rejected.

Table 36:

Statistical results comparing the Dorsiflexion measurements in response to treatment of Group Two after each consultation.

Ranks

	Mean Rank
VISIT 1	2.47
VISIT 4	1.85
VISIT 6	1.67

Test Statistics[a]

N	20
Chi-Square	8.576
df	2
Asymp. Sig.	.014

a. Friedman Test

Dunn Procedure:

$R_1 - R_2$ = 12,4

$R_1 - R_3$ = 16

$R_2 - R_3$ = 3,6

Rejection of the null hypothesis, i.e. improvement in the dorsiflexion range of motion was noted between the first and sixth visits (i.e. 16 > 13,07). There was no improvement between the fourth and sixth visits (i.e. 3,6 < 13,07) or between the first and fourth visits (i.e. 12,4 < 13,07), thus the null hypothesis was not rejected.

4.4.4) Data Mean Scores

Figure 1:

Graphical comparison of NRS-101 mean scores for Groups One and Two.

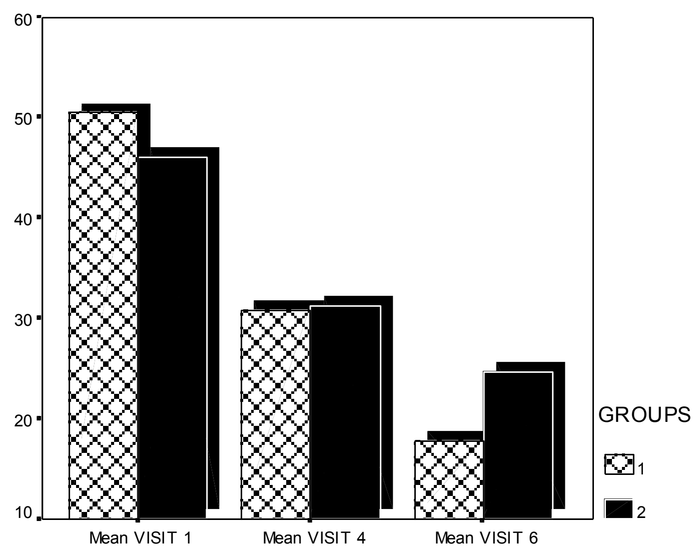


Figure 2:

Graphical comparison of the Algometer readings mean scores for Groups One and Two.

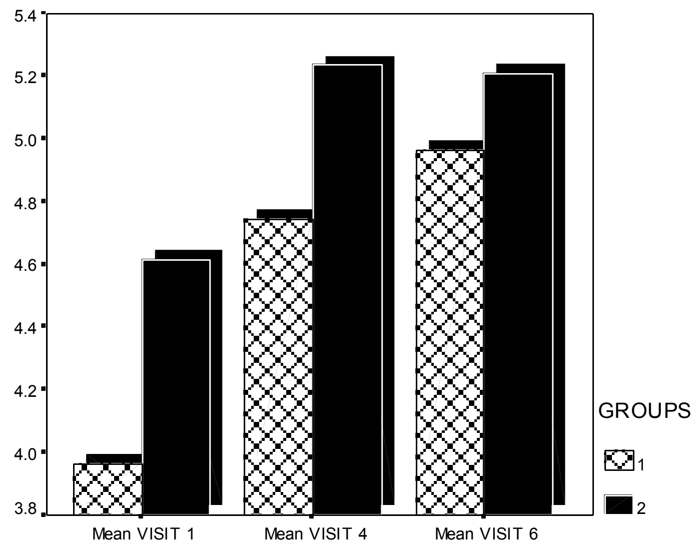
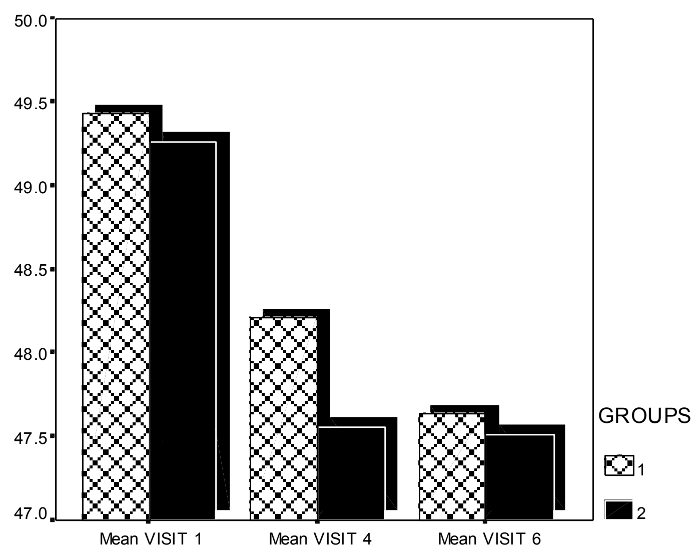


Figure 3:

Graphical comparison of the Dorsiflexion measurements mean scores for Groups One and Two.



CHAPTER FIVE

DISCUSSION OF THE RESULTS

5.1) INTRODUCTION

The results obtained from the demographic analysis, NRS – 101, FFI, Algometer readings, and Dorsiflexion range of motion as presented in Chapter Four will be discussed in this chapter.

The data obtained from the inter-group evaluation with reference to the first, fourth and sixth consultations will reflect any indication of the significant differences in the subjective and objective findings between each group.

The data obtained from the intra-group evaluation with reference to the first, fourth and sixth consultations will reflect any indication of the significant differences in the subjective and objective findings within each group.

5.2) DISCUSSION OF DEMOGRAPHIC DATA

Of the 40 patients who participated, 19 (47,5%) were males and 21 (52,5%) were females.

The average age was 40,75 years old, the oldest patient being 60 and the youngest being 20. This is in keeping with the findings of Brantingham et al. (1992:76), Brown (1996:877), Gill and Kiebzak (1996:529), who found the average age range of patients suffering from PF to be 36 years, 40-60 years, and 30-65 years respectively.

Seven (17,5%) of the patients had suffered with symptoms for greater than 6 months, and 12 (30%) had suffered for more than 1 year. This supports the findings of Gill and Kiebzak (1996:529) whose study of 396 symptomatic patients found 23% to have

suffered with symptoms greater than 6 months and 30% to have suffered for greater than 1 year.
Only four (10%) of the patients had been previously diagnosed with a heel spur on x-ray. Heel spurs, as discussed in Chapter Two, may be present (Reid, 1992:196), but their presence on radiographical examination does not guarantee that the patient suffers from PF. Williams, et al. (1987) found 75% of symptomatic subjects to have heel spurs on x-ray, while 63% of asymptomatic heels also demonstrated a heel spur. Thus, since many symptomatic individuals may not have an associated heel spur, this was interpreted as an incidental finding.

The left foot was affected in 20 (50%) patients, the right foot was affected in 15 (37,5%), and 5 (12,5%) of the patients had symptoms in both feet. Another study reported right foot involvement in 29%, left foot involvement in 45% and bilateral symptoms in 26% of cases (Davis, Severund and Baxter, 1994:531).

Fourteen (74%) of the men had a body mass index (BMI) of over 25, and 13 (62%) of the women had a BMI over 25.

The BMI is calculated by the formula: weight (kg)/height $(m)^2$.

The normal range for both men and women is 20 – 25. Obesity is defined as a BMI above 30 (Davidson's Principles and Practice of Medicine, 1995:580). This supports other studies that state that PF is often associated with obesity (Barret and O'Malley, 1999:2200; Brown, 1996:877; Ryan, 1995:891).

The primary purpose of this research was not to investigate demographics, and thus these results should not be interpreted on the same level as other studies that were structured specifically to investigate the demographics of a population suffering from PF.

5.3) INTER-GROUP COMPARISONS

5.3.1) The Subjective Data

The subjective data is comprised of the NRS – 101, and the FFI.

5.3.1.1) The NRS –101

The statistical analysis of the NRS – 101 showed that there were no significant differences between the two groups at the first, fourth or sixth consultations. This indicates that adjusting the subtalar joint in combination with static stretch of the gastro-soleus muscles appears to be no more effective than adjusting the subtalar joint alone in reducing the patient's perception of their pain intensity.

5.3.1.2) The FFI

The statistical analysis of the FFI from Question One through Question Nine showed that there were no significant differences between the two groups at the first, fourth or sixth consultations. This indicates that adjusting the subtalar joint in combination with static stretch of the gastro-soleus muscles appears to be no more effective than adjusting the subtalar joint alone in reducing:

- The patient's perception of their pain at its worst,
- The pain in the morning,
- Pain walking barefoot,
- Pain standing barefoot,
- Pain walking with shoes,
- Pain standing with shoes,
- Pain walking with orthotics,
- Pain standing with orthotics, or
- Pain at the end of the day.

5.3.2) The Objective Data

The objective data includes measurements from the algometer and dorsiflexion range of motion.

5.3.2.1) The Algometer Readings

The statistical analysis of the Algometer readings showed that there were no significant differences between the two groups at the first, fourth or sixth consultations. This indicates that adjusting the subtalar joint in combination with static stretch of the gastro-soleus muscles may be no more effective than adjusting the subtalar joint alone in reducing the pain pressure threshold as measured by the algometer.

5.3.2.2) The dorsiflexion range of motion

The statistical analysis of the dorsiflexion ranges of motion showed that there were no significant differences between the two groups at the first, fourth or sixth consultations. This indicates that adjusting the subtalar joint in combination with static stretch of the gastro-soleus muscles may be no more effective than adjusting the subtalar joint alone in increasing the patients' dorsiflexion range of motion.

5.4) INTRA-GROUP COMPARISONS

5.4.1) The Subjective Data

The subjective data is comprised of the NRS – 101, and the FFI.

5.4.1.1) The NRS –101

The statistical analysis of the NRS – 101 for Group One showed that there was a significant improvement in the patient's pain perception. This occurred between the first and fourth visits, between the first and sixth visits and between the fourth and sixth visits.

The statistical analysis of the NRS – 101 for Group Two showed that there was a significant improvement in the patient's pain perception, which occurred between the first and sixth visits.

These findings suggest that both treatments may be effective in reducing the patients' pain perception. The patients in Group Two responded to the treatment slower than Group One. Perhaps the addition of a slow stretching technique has a dampening effect on the reflex stimulation of the mechanoreceptors following manipulation, resulting in a slower but longer lasting effect. Unfortunately there was no long-term follow-up to assess whether this indeed took place.

5.4.1.2) The FFI

Question One: Worst pain?

The statistical analysis of Group One showed that a significant improvement occurred between the first and fourth visits and between the first and sixth visits. There was no significant improvement between the fourth and sixth visits.

The statistical analysis of Group Two showed that a significant improvement occurred between the first and fourth visits and between the first and sixth visits. There was no significant improvement between the fourth and sixth visits.

These findings suggest that both treatments may be effective in improving the patients' perception of the worst pain experienced.

Question Two: Morning Pain?

The statistical analysis of Group One showed that a significant improvement occurred between the first and fourth visits and between the first and sixth visits. There was no significant improvement between the fourth and sixth visits.

The statistical analysis of Group Two showed that a significant improvement occurred between the first and fourth visits and between the first and sixth visits. There was no significant improvement between the fourth and sixth visits.

These findings suggest that both treatments may be effective in improving the patients' perception of the pain experienced in the mornings. This finding is particularly useful as a number of studies on PF seem to regard pain felt on initial steps as a classic symptom of PF and the treatments given are aimed at reducing this (Pollard and So, 1999:95; Young, Rutherford and Niedfeldt, 2001:467; Porter, et al. 2002:620).

Question Three: Pain walking barefoot?

The statistical analysis of Group One showed that a significant improvement occurred between the first and fourth visits and between the first and sixth visits. There was no significant improvement between the fourth and sixth visits.

The statistical analysis of Group Two showed that a significant improvement occurred between the first and fourth visits and between the first and sixth visits. There was no significant improvement between the fourth and sixth visits.

These findings suggest that both treatments may be effective in improving the patients' perception of pain while walking barefoot.

Question Four: Pain standing barefoot?

The statistical analysis of Group One showed that a significant improvement occurred between the first and fourth visits and between the first and sixth visits. There was no significant improvement between the fourth and sixth visits.

The statistical analysis of Group Two showed that there was no significant improvement between any of the consultations.

Thus, adjusting the subtalar joint in combination with gastro-soleus stretches did not appear to be effective in reducing the pain felt while standing barefoot. Since the gastro-soleus muscle is designed for slow sustained contractions, (i.e. for postural maintenance due to the high proportion of type I fibres) perhaps its supportive function during standing (especially without the support of shoes) may be augmented when the muscle is tight. During a treatment program involving regular static stretches, this additional support may be temporarily lost as the muscle gradually becomes more flexible. Again, a long-term follow-up visit would have been helpful to assess the progress of this result.

Question Five: Pain walking with shoes?

The statistical analysis of Group One showed that a significant improvement occurred between the first and fourth visits and between the first and sixth visits. There was no significant improvement between the fourth and sixth visits.

The statistical analysis of Group Two showed that there was a significant improvement between the first and sixth visits. There was no significant improvement between the fourth and sixth visits or between the first and fourth visits.

These findings suggest that both treatments appeared to be effective in reducing the patients' pain while walking with shoes on. The patients in Group Two responded to the treatment slower than Group One. Again, perhaps the addition of a slow stretching technique after manipulation results in a slower but longer lasting effect and unfortunately there was no long-term follow-up to assess whether this indeed took place.

Question Six: Pain standing with shoes?

The statistical analysis of Group One showed that a significant improvement occurred between the first and fourth visits and between the first and sixth visits. There was no significant improvement between the fourth and sixth visits.

The statistical analysis of Group Two showed that a significant improvement occurred between the first and sixth visits. There was no significant improvement between the first and fourth visits or between the fourth and sixth visits.

These findings suggest that both treatments may be effective in reducing the patients' pain while standing with shoes on. The patients in Group Two responded to the treatment slower than Group One. A long-term follow-up visit would have been helpful to assess the progress of this result.

Question Seven: Pain walking with orthotics?

The statistical analysis of Group One showed that there was no significant improvement between any of the consultations.

The statistical analysis of Group Two showed that there was no significant improvement between any of the consultations.

These findings suggest that neither treatment appeared to be effective in reducing the pain felt while walking with orthotics. Only 2 patients in group One and 4 patients in Group Two were wearing orthotics for the duration of this study, therefore these results may not be accurate since the sample size that answered this question was too small.

Question Eight: Pain standing with orthotics?

The statistical analysis of Group One showed that there was no significant improvement between any of the consultations.

The statistical analysis of Group Two showed that there was no significant improvement between any of the consultations.

These findings suggest that neither treatment appeared to be effective in reducing the pain felt while standing with orthotics. Only 2 patients in group One and 4 patients in Group Two were wearing orthotics for the duration of this study, therefore these results may not be accurate since the sample size that answered this question was too small.

Question Nine: Pain at the end of the day?

The statistical analysis of Group One showed that a significant improvement occurred between the first and fourth visits and between the first and sixth visits. There was no significant improvement between the fourth and sixth visits.

The statistical analysis of Group Two showed that there was no significant improvement between any of the consultations.

Thus, adjusting the subtalar joint in combination with gastro-soleus stretches did not appear to be effective in reducing the pain felt at the end of the day. Perhaps during the treatment period, the effect of the reflex stimulation of mechanoreceptors that occurs after manipulation, and contributes greatly to pain relief, was dampened by the slow static stretches that were given to patients in Group Two. This result may have been different had the stretches been applied before the manipulation.

5.4.2) The Objective Data

5.4.2.1) The Algometer Readings

The statistical analysis of Group One showed that a significant improvement occurred between the first and fourth visits and between the first and sixth visits. There was no significant improvement between the fourth and sixth visits.

The statistical analysis of Group Two showed that there was no significant improvement between any of the consultations.

Thus, adjusting the subtalar joint in combination with gastro-soleus stretches did not appear to be effective in reducing the pressure pain threshold as measured by the algometer.
Similarly, perhaps the effect of the reflex stimulation of mechanoreceptors that occurs after manipulation was dampened by the slow static stretches (and thus a relative period of immobiliation) that were given to patients in Group Two. This result may have been different had the stretches been applied before the manipulation, and had there been a long-term follow-up visit to assess the algometer readings again.

5.4.2.2) The Dorsiflexion range of motion

The statistical analysis of Group One showed that a significant improvement occurred between the first and fourth visits and between the first and sixth visits. There was no significant improvement between the fourth and sixth visits.

The statistical analysis of Group Two showed that a significant improvement occurred between the first and sixth visits. There was no significant improvement between the first and fourth visits or between the fourth and sixth visits.

These findings suggest that both treatments may be effective in improving the range of dorsiflexion at the ankle. The patients in Group Two responded to the treatment slower than the patients in Group One. A long-term follow-up visit would have been useful to assess the progress of this result.

5.5) SUMMARY OF THE RESULTS

5.5.1) Summary of the Subjective Data

Although no significant results were seen between the two groups, significant results were seen for intra-group comparisons of the NRS – 101, and FFI Questions One, Two, Three, Five and Six of both groups.

These findings suggest that the patient's pain was reduced regardless of which treatment they received.

In FFI Questions Four and Nine, only Group One showed significant results. This suggests that subtalar manipulation alone may be effective, and that subtalar manipulation in combination with gastro-soleus stretches did not appear to be effective in reducing pain and disability relating to these questions.

Explanations for these results may be attributed to the possible dampening of the reflex stimulation of mechanoreceptors after manipulation (by use of slow static stretching in Group Two and thus a relative period of immobilization), and contribution to pain relief is lessened. This result may have been different had the stretches been applied before the manipulation, and had there been a long-term follow-up visit to assess the readings again. Since the gastro-soleus muscle is designed for postural maintenance perhaps its supportive function may be augmented when the muscle is tight. During a treatment program involving regular static stretches, this additional support may be temporarily lost as the muscle gradually becomes more flexible. Again, a long-term follow-up visit would have been helpful to assess the progress of this result.

Neither group showed significant results in FFI Questions Seven and Eight.

5.5.2) Summary of the Objective Data

Although no significant results were seen between the two groups, significant results were seen for intra-group comparisons of the Algometer readings and the Dorsiflexion range of motion measurements of Group One.

Group Two showed no significant results for intra-group comparisons of the Algometer readings but significant results were seen for intra-group comparisons of the Dorsiflexion range of motion measurements.

This suggests that subtalar manipulation alone may be effective in reducing the pressure pain threshold and improving dorsiflexion range of motion, whereas combining manipulation with stretches did not appear to be effective in reducing pressure pain threshold but may be effective in improving dorsiflexion range of motion.

Explanations for these results may similarly be attributed to the possible dampening of the reflex stimulation of mechanoreceptors after manipulation by the slow static stretches that were given to patients in Group Two during a period of relative immobilisation of the foot and ankle. This result may have been different had the stretches been applied before the manipulation, and had there been a long-term follow-up visit to assess the readings again. Similarly, since the gastro-soleus muscle is designed for postural maintenance perhaps its supportive function may be augmented when the muscle is tight. During a treatment program involving regular static stretches, this additional support may be temporarily lost as the muscle gradually becomes more flexible.
In the study by Morris (2000), a 1 month follow-up treatment was given during which final measurements were taken. During this time the participants in both groups

continued to wear the night splints. This study reported an improvement in dorsiflexion range of motion in both groups. The study by Pope, et al. (1998:165) stated that the subjects received stretches almost every second day over a period of 12 weeks. Thus, perhaps increasing the number of stretches and adding a long-term follow-up visit would have been helpful to assess the progress of this result.

5.6) THE LIMITATIONS OF THE STUDY

5.6.1) The Subjective Questionnaires

The data recovered from the NRS – 101 and the FFI may have been slightly biased if the patients' had tried to please the researcher by choosing a better score – Hawthorne Effect as described by Mouton (1996:152). If this bias had occurred, it would have been present equally in both groups as each group was treated exactly the same, thus one group would not have been prejudiced over the other.

The questionnaires also lend themselves to another type of bias: Since the patients' were not allowed to see their original questionnaire, it often happened that they were not able to remember what they had scored previously. For example, for some patients' that had reported an improvement, the score filled in was often identical or slightly worse than the previous score, thus incorrectly reflecting a worsening of the condition. Mouton (1996:152) refers to this as "memory decay," where patients are unable to remember for various reasons positive or investigated correlations.

5.6.2) The Objective Measurements

The algometer lends itself to potential bias due to instrument error and examiner error. The standing method to measure ankle dorsiflexion range of motion was susceptible to examiner error as the ruler was not fixed and may not always have been perfectly vertical and perpendicular to the ground.

All motion palpation and adjustments were performed by the researcher, a sixth year chiropractic student. A higher level of accuracy may have been achieved had an experienced chiropractor performed this.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1) RECOMMENDATIONS

a. The treatment protocol for this study was 5 treatments within two weeks with a 6th follow-up consultation no longer than one week later. There seemed to be a common trend observed by the researcher while giving the treatment to those in Group Two (manipulation and stretching) in that the patients mentioned that they felt a definite improvement, but this was not always reflected in the subjective or objective measurements. This was not observed as often in Group One (manipulation only).

b. The researcher recommendation would be that there should have been extra follow-up consultations at 1 month and 3 months after the final treatment to analyse the long-term benefit of adding a stretching regime to treatment.

c. A larger sample size would have strengthened the results of the statistical analysis.

d. The results of the researcher could have been strengthened had blinding been used. In future studies there should be a blinded clinician performing the treatment, and a separate blinded clinician taking the measurements.

e. As stated in Chapter Five, the adjustments were performed the researcher, a sixth year chiropractic student. An experienced chiropractor would have been able to provide more accuracy with regard to motion palpation findings and delivering the adjustment.

f. Future studies should try and focus on a specific population. For example, limit the study to long-distance runners only.

g. There should also be a study investigating the demographics of PF sufferers. Areas of interest would be to investigate the pattern of motion palpation findings, or to x-ray each patient to determine the presence of heel spurs.

6.2) CONCLUSIONS

This study consisted of 40 patients who were randomly divided into 2 equal groups. All patients underwent an extensive case history, physical and foot regional examination. It was then determined whether or not the patient did suffer from PF, and whether they fit the criteria to be a part of the research.

Both groups were treated 5 times over a two-week period, with a 6^{th} follow-up consultation one week after the fifth visit. Group One received manipulation to restrictions in the subtalar joint, while Group Two received subtalar manipulation in addition to static gastro-soleus muscle stretches.

The patients' perception of their pain, discomfort and disability was assessed using FFI and NRS 101 questionnaires. These did not show any significant differences between the two groups.

However significant results were seen for intra-group comparisons of the NRS – 101, and FFI Questions One, Two, Three and Five of both groups. These findings suggest that in these instances the patient's pain was reduced regardless of which treatment they received.

In FFI Questions Four, Six and Nine, only Group One showed significant results. This suggests that subtalar manipulation alone was effective, and that subtalar manipulation in combination with gastro-soleus stretches was not effective in reducing pain and disability relating to these questions.

Neither group showed significant results in FFI Questions Seven and Eight.

The objective measurements showed that although no significant results were seen between the two groups, significant results were seen for intra-group comparisons of the algometer readings and the dorsiflexion range of motion measurements of Group One.

Group Two showed no significant results.

This suggests that subtalar manipulation alone may be effective in reducing the pressure pain threshold and improving dorsiflexion range of motion, whereas combining manipulation with stretches did not appear to be effective.

Thus, both types of treatments may be effective in improving the subjective measurements. Group One was appeared to be effective in improving the objective measurements, whereas Group Two did not. Neither group showed significant superiority over the other when compared.

REFERENCE LIST

Ambrosius, H. and Kondracki, M.P. 1992. Plantar Fasciitis. European Journal of Chiropractic. **40**:29-40.

Arnheim, D.D., Prentice, W.E. 1993. Principles of Athletic Training. 8th ed. USA:Mosby. p. 44.

Barret, S.L. and O'Malley, R. 1999. Plantar Fasciitis and other causes of Heel Pain. American Family Physician. **59**(8)2200-2206.

Batt, M.E., and Tanji, J.L. 1995. Management Options for Plantar Fasciitis. The Physician and Sports Medicine. **23**(6)77-85.

Bergmann, T.F., Peterson, D.H. and Lawrence, D.J. 1993. Chiropractic Technique. USA:Churchill Livingstone

Berkowitz, J.F., Kier, R. and Rudicel, S. 1991. Plantar Fasciitis. MR Imaging. Radiology. **179**:665-667

Brantingham, J.W., Snyder, W.R., Dishman, R.W., Hubka, M.J., Brown, R.A., Brantingham, C.R., and Markham, D.J. 1992. Plantar Fasciitis. Chiropractic Technique. **4**(3)75-82.

Brown, C. 1996. A Review of Subcalcaneal Heel Pain and Plantar Fasciitis. Australian Family Physician. **25**(6):875-885.

Davies, M.S., Weiss, G.A. and Saxby, T.S. 1999. Plantar Fasciitis: How successful is surgical intervention? Foot and Ankle International. **20**(12)803-807

Davis, P.F., Severund, E. and Baxter, D.E. 1994. Painful Heel Syndrome: Results of Nonoperative Treatment. Foot and Ankle International. **15**(10)531-535

Donatelli, R. 1990. The Biomechanics of the Foot and Ankle. Philadelphia:FA Davis Co. p. 47

Fischer, A.A. 1987. Pressure Threshold Measurement for Diagnosis of Myofascial Pain and Evaluation of Treatment Results. The Clinical Journal of Pain. **2**(4)208-214.

Gatterman, M.I. 1990. Chiropractic Management of Spine Related Disorders. Baltimore:Williams & Wilkins.

Gill, L.H. and Kiebzak, G.M. 1996. Outcome of Non-surgical Treatment for Plantar Fasciitis. Foot and Ankle International. **17**(9)527-532

Hall, S.J., and Meissier, S.P. 1993. Biomechanics of fitness exercise. *In*: Durstine, J.L., King, A.C., Painter, P.L., Roitman, J.L. and Zwiren, L.D. (eds.) American College of Sports Medicine Resource Manual for Guidelines for Exercise Testing and Prescription. 2nd ed. USA:Williams & Wilkins. pp38-47

Hammond, S.L. 2000. The Relative Efficacy of Chiropractic Manipulative Therapy compared to Placebo in Patients with Plantar Fasciitis. A Dissertation submitted to the Faculty of Health in partial compliance with the requirements for a Master's Degree in Technology: Chiropractic at Technikon Natal.

Hunt, G.C. (ed.) 1988. Physical therapy of the Foot and Ankle. New York:Churchill Livingstone Inc.

Hyde, T.E. and Gengenbach, M.S. 1997. Conservative Management of Sports Injuries. USA: Williams & Wilkins

Jensen, M.P., Karol, P. and Barver, F. 1986. The Measurement of Clinical Pain Intensity: A Comparison of Six Methods. Pain. **27**:117-126.

Jerosch, J. 2000. Endoscopic release of plantar fasciitis – a benign procedure? Foot and Ankle International. **21**(6)511-513

Kamel, M. and Kotob, H. 2000. High Frequency Ultrasonographic Findings and Assessment of Local Steroid Injection. Journal of Rheumatology. **27**(9)2139-2141

Kane, D., Greaney, T., Duffy, G., Bresnihan, B., Gibney, R. and FitzGerald, O. 1988. Ultrasound imaging of Plantar Fasciitis correlates with bone scintography and with response to heel injection. British Journal of Rheumatology. **37**:95

Khan, K.M., Cook, J.L., Taunton, J.E. and Bonar, F. 2000. Overuse tendinosis, not tendinitis: a new paradigm for a difficult clinical problem (part 1). Physical Sports Medicine. **28**:38-48

Kibler, W.B., Goldberg, C. and Chandler, T. J. 1991. Functional biomechanics of Athletes with Plantar Fasciitis. American Journal of Sports Medicine. **19**(1)66,71.

Kitaoka, H.B., Luo, Z.P., Growney, E.S., Berglund, L.J. and An, K. 1994. Material Properties of the Plantar Aponeurosis. Foot and Ankle International. **15**(10)557-560)

Krivickas, L. 1997. Anatomical factors associated with overuse sports injuries. Sports Medicine. **24**(2)132-143

Kwong, P.K., Kay, D., Voner, R.T. and White, M.W. 1988. Plantar Fasciitis: mechanics and pathomechanics of treatment. Clinical Sports Medicine. **7**(119-126)

Leach, R., Jones, R. and Silva, T. 1978. Rupture of the plantar fascia in athletes. The Journal of Bone and Joint Surgery. **60**(4)537-539.

Leach, R.E., Seavey, M.S. and Salter, D.K. 1986. Results of Surgery in Athletes with Plantar Fasciitis. Foot and Ankle. **7**(3)156-161

Magee, D.J., 1997. Orthopeadic Physical Assessment. 3rd ed. USA:W.B. Saunders.

McCarthy, D. 1998. Non-steroidal anti-inflammatory drug-related gastrointestinal toxicity: Definitions and Epidemiology. American Journal of Medicine. **105**:3S-9S

Meyer, H.R. 1996. The Female Foot. Foot and Ankle International.**17**:120-124

Montgomery, L.C., Nelson, F.R., Norton, J.P. and Deuster, P.A. 1989. Orthopedic history and examination in the etiology of overuse injuries. Medicine and Science in Sports and Exercise. 21:237-243

Moore, K.L. and Dalley A.F. 1999. Clinically Oriented Anatomy. 4th ed. USA:Williams & Wilkins.

Morris, C.A.V. 2000. The Relative Effectiveness of Anterior Night Splints and a combination of Anterior Night Splints and Manipulation of the Foot and Ankle Joints in the Treatment of Plantar Fasciitis. A Dissertation submitted to the Faculty of Health in partial compliance with the requirements for a Master's Degree in Technology: Chiropractic at Technikon Natal

Mouton, J. 1996. Understanding Social Research. South Africa:J.L. van Schaik Publishers.

Norkin C.C. and Levangie P.K., 1992. Joint Structure and Function: A comprehensive analysis. 2nd Ed. USA:F.A. Davis Company.

Polkinghorn, B.S. 1995. Posterior Calcaneal Subluxation: An Important Consideration in Chiropractic Treatment of Plantar Fasciitis. Chiropractic Sports medicine. **9**(2)44-51

Pollard, H. and So, V. 1999. Management of Plantar Fasciitis: A Case Report. Sports Chiropractic and Rehabilitation. **13**(3)93-97

Pope, R., Herbert, R., Kirwan, J. 1998. Effects of ankle dorsiflexion range and pre-exercise calf muscle stretching on injury risk in Army recruits. Australian Physiotherapy. **44**(3)167- 169.

Porter, D., Barrill, E. Oneacre, K. and May, B.D. 2002. The Effects of Duration and Frequency of Achilles Tendon Stretching on Dorsiflexion and Outcome in Painful Heel Syndrome: A Randomised, Blinded, Control Study. Foot and Ankle International. **23**(7)619-624

Poul, J., West, J., Buchanan, N. and Grahame, R. 1993. Local action of transcutaneous Flurbiprofen in the treatment of soft tissue rheumatism. British Journal of Rheumatology. 32: 1000-1003.

Probe, R.A., Baca, M., Adams, R. and Preece, C. 1999. Night Splint Treatment for Plantar Fasciitis. Clinical Orthopedics and Related Research. 368:195

Reid, D.C. 1992. Sports Injury Assessment and Rehabilitation. Pennsylvania:Churchill Livingstone.

Riddle, D.L. and Freeman, D.B. 1988. Management of a patient with a diagnosis of bilateral plantar fasciitis and achilles tendonitis: a case report. Physical Therapy. **68**(1913-1916)

Ryan, J. 1995. Use of Posterior Night Splints in the Treatment of Plantar Fasciitis. American Family Physician, **52**(3):893-896.

Saag, K.G., Saltzman, C.L., Brown, C.K. and Budiman, E. 1996. The Foot Function Index for Measuring Rheumatoid Arthritis Pain:Evaluating Side-to-Side Reliability. Foot and Ankle International. **17**(8)506-510.

Schafer, R.C. and Faye, L.J. 1990. Motion Palpation and Chiropractic Technic. USA:The Motion Palpation Institute. P. 402-403

Sellman, J.R.1994. Plantar fascia rupture associated with corticosteroid injection. Foot and Ankle International. **15**(7)376-381.

Stanley, K.L. and Weaver, J.E. 1998. Pharmacologic management of pain and inflammation in athletes. Clinical Sports Medicine. **17**:375-392

Taunton, J.E., Clement, D.B. and McNicol, K. 1982. Plantar fasciitis in runners. Canadian Journal of Applied Sports Science. **7**(41-44)

Travell, J.G., Simons, D.G. 1983. Myofascial Pain and Dysfunction:The Trigger Point Manual. The lower extremities. Vol 2. USA:Williams & Wilkins. p. 415, 449.

Vegso, J.J. 1995. Principles of Stretching. In: Torg, J.S., Shepard, R.J. Current Therapy in Sports Medicine. 3rd ed. USA:Mosby. p. 477.

Wapner, K.L. and Sharkey, P.F. 1991. The Use of Night Splints for Treatment of Recalcitrant Plantar Fasciitis. Foot and Ankle. **12**(3)135-136

Wilk, B.R., Fisher, K.L. and Gutierrez, W. 2000. Defective running shoes as a contributing factor in Planar Fasciitis in a Triathlete. Journal of Orthopedic and Sports Physical Therapy. **30**(1)21-31

Williams, P.L., Smibert, J.G., Cox, R. 1987. Imaging study of the painful heel syndrome. Foot and Ankle. **6**:345

Wolgin, M, Cook, C., Graham, C. and Mauldin, D. 1994. Conservative Treatment of Plantar Heel Pain: Long-Term Follow-Up. Foot and Ankle International.**15**(3)97-102

Young, C.C., Rutherford, D.S. and Niedfeldt, W. 2001. Treatment of Plantar Fasciitis. American Family Physician. **63**(3)467-474