The effectiveness of combined manipulation and rehabilitation versus rehabilitation only, in the management of chronic ankle instability.

By

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I, Danella Lubbe, do declare that this dissertation is representative of my own work in both conception and execution (except where acknowledgments indicate to the contrary)

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To my parents and brother – for all the never-ending love and support you have given me over these many trying years. I am truly blessed to have the family that I do.

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Abstract

Purpose: Chronic ankle instability (CAI) is characterised by ankle pain, weakness, edema, crepitus, adhesions, restrictions and ligamentous laxity. Various treatment options target a variety of aspects of this condition. However, there is a paucity of literature with regards to combined treatment choices. The purpose of this study was to investigate the relative effectiveness of combining manipulation with rehabilitation, compared to rehabilitation only, in participants with CAI.

Methods: The study was a single blinded, randomised and comparative clinical trial at a chiropractic day clinic.

Thirty participants with grade I and II CAI were recruited and randomly allocated into one of two treatment groups. Fifteen participants received a combination of manipulation and rehabilitation (coupled peroneal muscle strengthening and proprioception) and fifteen received the rehabilitation only programme. All six treatments in each group were conducted over five weeks.

Results: A p value of <0.05 was considered statistically significant. The intra-group outcomes in the Manipulation and Rehabilitation Group indicate that statistically significant improvements were achieved for all six parameters in this study (VAS $p<0.001$; FADI $p<0.001$; Algometer $p<0.001$; motion palpation $p<0.001$; WBD $p=0.001$ and BBS $p<0.001$). This is in comparison to the three outcomes where statistical significance was achieved (VAS $p<0.001$; FADI $p<0.001$ and BBS $p<0.001$) in the Rehabilitation only Group. Inter-group analysis revealed statistically significant improvement in favour of the Manipulation and Rehabilitation Group for VAS ($p<0.001$); algometer readings ($p=0.002$) and Motion palpation findings ($p<0.001$).

Conclusions: The findings of this study show that manipulation in combination with rehabilitation is relatively more effective than rehabilitation only for most outcome measures.

Key indexing terms: *Ankle; Combination Therapy; Joint Instability; Manipulation; Rehabilitation*

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GLOSSARY OF TERMS

Chronic ankle instability:

The presence of four or more of a combination of symptoms including lateral ankle pain, joint weakness, edema joint crepitus, adhesions resulting in the formation of restrictions in the joint and ligamentous laxity (Reid, 1992; Caulfield, 2000; Pellow and Brantingham, 2001; Ajis and Maffulli, 2006; McBride and Ramamurthy, 2006).

Grade one CAI:

Evidence of minimal swelling with minimal dysfunction, point tenderness over the joint with absence of positive anterior drawers sign (Reid, 1992).

Grade two CAI:

There is a moderate amount of swelling and haemorrhage over the ankle mortise with pain more on weight bearing. Potentially positive anterior drawers sign but with no varus laxity CAI (Reid, 1992; Pellow and Brantingham, 2001; Rimando, 2008).

Grade three CAI:

Severe swelling and haemorrhage with positive anterior drawers sign and rupture of ligamentous structures (Reid, 1992).

Ankle: The ankle is composed of four bones namely the talus, calcaneus, tibia and the fibula. These four bones make up the three joints of the ankle namely the talocrural joint (also known as the mortise), the inferior tib-fib joint and the subtalar joint (Moore and Dalley, 1992)

Mortise: Is a joint that is present in the ankle and is composed of the articulations from the distal end of the fibula and tibia as well as the posterior end of the talus (Moore and Dalley, 1992).

CHAPTER ONE

1.1 INTRODUCTION

Inversion ankle sprains are noted as the most frequently encountered injury to the ankle (Ferran and Maffulli, 2006) especially in the sporting arena (Balint *et al.*, 2003; Delahunt, 2007; Bozzelle and Kishner, 2008). With up to 40% of these acutely injured participants often progressing to a state of chronic ankle instability (CAI), it is a condition frequently encountered in practice (Verhagen *et al.*, 1995; Balint, 2003; Ajis and Maffulli, 2006; Ajis *et al.*, 2006).

Ankle sprains occur as a result of trauma which invariably leads to increased strain on ligaments. All ligamentous damage is referred to as a sprain. Repeated ligamentous injury or even one severe inversion sprain may progress to CAI. (Moore and Dalley, 1992 and Reid, 1992).

CAI is characterised by the presence of four or more of the following symptoms: ankle pain, joint weakness, edema, crepitus, adhesions, restrictions and ligamentous laxity (Caulfield, 2000; Pellow and Brantingham, 2001; Ajis and Maffulli, 2006 and McBride and Ramamurthy, 2006).

Three underlying features have been identified as the components that contribute to the persistence of CAI (Richie, 2001 and Sefton *et al.,* 2009). These three components are:

1. Secondary loss or restriction of full joint function (Vicenzino *et al.,* 2006). This will be referred to as fixations: (which is defined as a restriction of motion at end range or the presence of accessory motions of the mortise, subtalar and tarsal joints),
2. As well as muscular weakness (Richie, 2001) and
3. Proprioceptive alterations (Richie, 2001 and Delahunt, 2007).

With the persistence of these three elements in CAI there is a greater likelihood that the chronic instability will remain unresolved and continue to create problems for patients (Reid, 1992; Richie, 2001and Delahunt, 2007).

Various treatment options target several aspects of this condition (Reid, 1992). However, there is paucity of literature with regards to combined treatment options (van der Wees *et al.*, 2006; de Vries *et al.*, 2006 and McKeon and Hertel, 2008). The general need for combination therapy in clinical settings has been stressed, not only in the ankle but in all regions of the body (Bekker-Smith, 2002; Francis, 2005 and Jensen *et al.*, 2009). This is demonstrated in the studies conducted at The Durban University of Technology that reflect the need and importance of such combination protocols throughout the musculoskeletal system (Bekker-Smith, 2002 and Francis, 2005) as well as in studies that have been published with reference to the ankle (Green *et al.*, 2001; Collins, 2002; Eisenhart *et al.*, 2003; Vicenzino *et al.*, 2006 Jensen *et al.*, 2009 and Joseph *et al.*, 2010). Combination therapies allow for enhanced awareness of the implication of these results, and directly have an impact on improved practice management and reduced risk as well as cost to the patient, as they may recover more rapidly over a shorter time period (Kohne *et al.*, 2007).

Studies have demonstrated that joint fixations within the ankle are commonly noted in most patients with CAI (Pellow and Brantingham, 2001, Vicenzino *et al.*, 2006, and Joseph *et al.*, 2010). Furthermore, Pellow and Brantingham (2001), Gillman (2004), Vicenzino (2006) and Joseph *et al.*, (2010) have reported that manipulation, (i.e. attempting to remove these fixations) is a successful intervention tool for the treatment of CAI. A treatment effect for the Manipulation Group was observed (p=0.005) for the McGill Pain Questionnaire and overall ankle function (p=0.001) in the inter-Group analysis at the final treatment in the study conducted by Pellow and Brantingham (2001).

Peroneal muscle weaknesses as well as proprioceptive alterations have also been universally encountered in cases of CAI (Reid, 1992; Delahunt, 2007). Studies have indicated that coupled peroneal muscle strengthening and proprioceptive training of the ankle are seen as one of the most effective means of rehabilitation for CAI (Reid, 1992; Caulfield, 2000; Ajis *et al.*, 2006; Ajis and Maffulli, 2006; McBride and Ramamurthy, 2006; van der Wees, 2006 and Lee and Lin, 2008).

However, although combination therapy research addressing the muscle weakness and proprioceptive deficits is evident (Richie, 2001), the treatment options researched, have thus far focused on using only these two individual aspects as one treatment protocol, and not on all three components that encompass CAI (i.e. muscle weakness, proprioceptive deficits and joint fixation). As a result, there is a paucity of literature, clinical research and treatment options, which address these three major components together in one treatment protocol, that have been implicated in the persistence of CAI. This is necessary to address, as it would stand to reason that a combination approach could produce increased clinically and statistically significant outcomes as opposed to standard singular intervention.

1.2 RATIONALE

1.2.1 Inversion ankle sprains are the most frequently encountered injury to the ankle (Ferran and Maffulli, 2006) especially in the sporting arena (Balint *et al.*, 2003; Delahunt, 2007 and Bozzelle and Kishner, 2010). With up to 40% of these acutely injured participants often progressing to a state of chronic ankle instability (CAI), it is a condition frequently encountered in practice (Verhagen *et al.*, 1995; Balint, 2003; Ajis and Maffulli, 2006 and Ajis *et al.*, 2006).Therefore, the ankle as well as the management of CAI requires further investigation with regard to treatment options as it is a commonly noted condition.

1.2.2 It has been identified that there are three components (Richie, 2001 and Sefton *et al.*, 2009) that contribute to the persistence of CAI namely joint fixations (in the mortise and subtalar joint) as well as muscular weakness (Richie, 2001) and proprioceptive alterations (Richie, 2001; Kohne *et al.*, 2007; Delahunt, 2007; Lopez-Rodriguez *et al.,* 2007 and Joseph *et al.,* 2010). Two of these components, peroneal muscle weakness as well as proprioceptive alterations, have both been universally encountered in cases of CAI and research on treatment options targeting these two components in combination have been performed (Reid, 1992; Delahunt, 2007; Lopez-Rodriguez *et al.,* 2007 and Joseph *et al.,* 2010). These studies have indicated that coupled peroneal muscle strengthening and proprioceptive training of the ankle are seen as the most efficient means of rehabilitation for CAI (Reid, 1992; Caulfield, 2000; Ajis *et al*, 2006; Ajis and Maffulli, 2006; McBride and Ramamurthy, 2006 and Lee and Lin, 2008). The third component of CAI (joint fixations) has also been addressed, but separately. Pellow and Brantingham, (2001) and Gillman, (2004) have reported that manipulation (that functions to attempt to remove fixations) is also a successful intervention tool for the treatment of CAI. In the study conducted by Pellow and Brantingham, (2001), a treatment effect for the

Manipulation Group was observed (*p*=0.005) for the McGill Pain Questionnaire and overall ankle function (*p*=0.001) in the inter-Group analysis at the final treatment. Statistically significant improvements in the Manipulation only Group, for the intra-Group analysis, were noted specifically with respect to reduced pain on the NRS101 (*p*=0.001) and McGill Pain Questionnaire (*p*=0.001), improved range of motion (*p* =0.002), algometry readings (*p*=0.013) and improved ankle function (*p*=0.001). This is in comparison to the sham Ultrasound Group where NRS101 readings were *p*=0.007; McGill Pain Questionnaire (*p*=0.038); goniometry readings (*p*=0.199) Algometer (*p*=0.017) and overall ankle function (*p*=0.004). However, there is no clinical research on the combination of all three treatment protocols that address all three components contributing to the persistence of CAI in a single protocol (Van der Wees *et al.*, 2006; Whitman *et al.*, 2009).

1.2.3 It is hypothesised that a combination approach would produce increased clinically and statistically significant outcomes as opposed to standard single intervention, inclusive of comparatively greater reduction in pain, improvement in range of motion, proprioception and function with an associated quicker recovery time (Green *et al.*, 2001; Collins *et al.*, 2002; Eisenhart *et al.*, 2003; Vicenzino *et al.*, 2006 and Joseph *et al.*, 2010). However, there are insufficient studies, particularly high quality studies, with the required methodology, to make a definitive decision regarding whether a combination approach would yield better results (Van der Wees *et al.*, 2006 and Whitman *et al.*, 2009). Treatment benefits for patients may not only include an improvement of symptomatology but also a time (reduced number of days lost at work and/or faster return to sport) and cost saving benefit (as fewer treatments are required). If research suggests that better results are yielded from this combination approach, the manipulative therapists (such as chiropractors or osteopaths) will benefit from attaining this knowledge and be encouraged to use this combination approach as the treatment of choice for CAI.

1.3 AIMS, OBJECTIVES AND THE STATEMENT OF THE NULL AND ALTERNATIVE HYPOTHESES

The aim of the study was to investigate the subjective and objective responses of participants who received a combination of a manipulation and a rehabilitation program, as compared to those participants that received a rehabilitation programme only program as a treatment for CAI; and in doing so, to determine whether a combination of treatments addressing all three major components comprising CAI indeed yield better results.

The objectives of the study were:

1.3.1 The first objective, null and alternative hypothesis.

1.3.1.1 The first objective:

To determine the relative effectiveness of manipulation and rehabilitation (coupled peroneal muscle strengthening and proprioception) versus stand alone rehabilitation (coupled peroneal muscle strengthening and proprioception) to the ankle in terms of objective measurements in participants experiencing CAI following an ankle inversion sprain.

1.3.1.2 The first null hypothesis:

It was hypothesized that the manipulation in combination with a rehabilitation programme would be no different to the Rehabilitation only Group, in the terms of objective findings and concomitant clinical measures (i.e. weight bearing dorsiflexion range of motion, balance, pain threshold and motion palpation findings).

1.3.1.3 The first alternative hypothesis:

It was hypothesized that the manipulation in combination with a rehabilitation programme would be different to the Rehabilitation only Group in the terms of objective findings and concomitant clinical measures (i.e. weight bearing dorsiflexion range of motion, balance, pain threshold and motion palpation findings).

1.3.2 The second objective, null and alternative hypothesis

1.3.2.1 The second objective:

To determine the relative effectiveness of manipulation and rehabilitation (coupled peroneal muscle strengthening and proprioception) versus stand alone rehabilitation (coupled peroneal muscle strengthening and proprioception) in the ankle in terms of subjective measurements in participants experiencing CAI following an ankle inversion sprain.

1.3.2.2 The second null hypothesis:

It was hypothesized that the manipulation in combination with a rehabilitation programme would be no different to the Rehabilitation only Group in terms of subjective findings and concomitant clinical measures (i.e. the reduction of pain perception and other clinical outcomes observed from the foot ankle disability index (Hale and Hertel, 2005)).

1.3.2.3 The second alternative hypothesis:

It was hypothesized that the manipulation in combination with a rehabilitation programme would be different to the Rehabilitation only Group in terms of subjective findings and concomitant clinical measures (i.e. the reduction of pain perception and other clinical outcomes observed from the foot ankle disability index (Hale and Hertel, 2005)).

1.4 DELIMITATIONS

1.4.1 Proprioception has multiple meanings which include joint position sense, kinaesthesia and balance (Lephart and Fu, 1995; Deshpande *et al.*, 2003). According to Deshpande *et al.*, (2003), joint position sense is described as the awareness of the position of the limb in space whereas kinaesthesia is referred to as the position of the joint. It is evident that these terms may or may not be related to one another and thus requires them to be measured separately. Deshpande *et al.*, (2003) noted that there is increased reliability and sensitivity with respect to joint position sense as opposed to kinaesthesia in terms of movement measured with respect to kinaesthetic measures. For purposes of this study therefore, proprioception refers to joint position sense.

1.4.2 Subjective parameters are based on the honesty and/or integrity of the recordings made, with or by the participant and/or examiners which reflects the outcome measures used, the understanding of the participant, and the parameters of the participant at the time in which the recording was made.

1.5 CONCLUSION

Both treatment modalities i.e. a) manipulation and b) rehabilitation have been investigated separately, and have been found to be effective for the treatment of CAI. However, combination therapy including both manipulation and rehabilitation in the same treatment protocol has yet to be explored. Thus the addition of a manipulation programme, to a rehabilitation programme including strengthening and proprioception that has already been researched and (was at the time considered to be the most effective when compared to other treatment protocols), was examined in order to determine the efficacy of this combination approach in the treatment of CAI. This study, for the first time addresses all three individual components that are implicated in CAI as one unit (fixations, muscular weakness and proprioception alterations). It is essential that the three are addressed and removed, to avoid recurrence or the development of chronic problems in these patients. With the patient's best interest in mind, it is the responsibility of every therapist to investigate and attain the treatment protocol that would assist individual patients the most in terms of reduction of pain, improved function and range of motion with CAI. This study has been designed with this factor in mind, and if the research hypothesis (alternative hypothesis) is supported, it may result in patients being able to receive fewer treatments (reducing the cost involved) with greater clinical outcomes achieved over a shorter time period. Therefore, the aim of this study was to explore the relative effectiveness of a combination of manipulation and rehabilitation as compared to rehabilitation only in the treatment of CAI.

The Literature Review that follows in Chapter Two will explore all information surrounding the ankle as well as CAI, and how the condition is diagnosed and treated in practice. Chapter Three explores the methodology that was adopted for this study in a step by step manner. Chapter Four includes the statistical analysis of the data and Chapter Five includes the interpretation of the data obtained from Chapter Four. Chapter Six explores aspects such as future recommendations and final conclusions about the study.

CHAPTER TWO

2.1 INTRODUCTION

The following chapter investigates the literature surrounding CAI. The anatomy of the ankle as well as biomechanics associated with this condition will be discussed in detail. Other aspects that will be addressed include the definition of the condition (CAI) as well as the mechanism of injury. Incidence and prevalence will be discussed as pertaining to CAI. Differential diagnoses and the orthopaedic tests that allow one to diagnose these conditions will also be looked at in depth. Different treatment methods employed and their efficacy based on previous studies conducted on CAI will be explored. This will function to illustrate existing treatment options that are available and will disclose the deficiency in the literature with respect to management protocols of CAI.

2.2 ANATOMY

2.2.1 Bones and ligaments

Bones:

The osseous structures of the foot and ankle constitute a total of twenty six bones held together by ligaments and thus forming articulating joints between surfaces (Jahss *et al.*, 1982; Moore and Dalley, 1992 and Sinnastamby, 2006). There are three Groups of bones in the foot and ankle region:

1. Hindfoot - the talus, and calcaneus;
2. Midfoot - cuboid, navicular and the three cuneiforms and
3. Forefoot - the five metatarsals, and the phalanges (Jahss *et al.*, 1982 and Moore and Dalley, 1992).

1. Hindfoot

The talus is a bone that consists of three parts, namely the head, neck and body (Moore and Dalley, 1992). The majority of the surface of the bone is covered in cartilage due to its multiple articulating surfaces (Agur and Lee, 1991). Tendinous attachments do not exist on the talus but rather a multitude of ligaments which allow the talus to form articulations between itself and surrounding osseous structures such as the calcaneus (Calliet, 1997). The full weight of the human body is dissipated through the talus which is situated on the superior aspect of the calcaneus (Sinnastamby, 2006).

The largest bone of the foot is known as the calcaneus, situated posterior and inferior to the talus. It forms the insertion site of the Achilles tendon of the posterior compartment of the leg (Moore and Dalley, 1992 and Meiring *et al.,* 2000). It has three dorsal surfaces and communicates with the talus above and the cuboid anteriorly (Calliet, 1997).

2. Midfoot

The cuboid bone is said to be wedge shaped and articulates with the calcaneus proximally and the fourth and fifth digits distally (Agur and Lee, 1991). Articulation with the lateral cuneiform occurs medially. The cuboid along with the calcaneus and fourth and fifth digits assist in the formation of the lateral longitudinal arch of the foot. The presence of a groove on the short lateral border allows for the passage of the peroneus longus tendon to pass under the foot to attach to the medial cuneiform and first metatarsal (Moore and Dalley, 1992).

The navicular is situated anterior to the talus and medially to the cuboid bone (Agur and Lee, 1991). This boat shaped structure sets up the main part of the longitudinal arch of the foot (Calliet, 1997).

The cuneiforms are the last of the tarsal bones and these three bones each have their apexes pointing inferiorly (Meiring *et al.,* 2000). These aptly named wedge shaped structures provide the stability that is required to keep the foot in its position (Grey, 1901). The cuneiforms collectively articulate with the first three metatarsals distally and the navicular proximally (Moore and Dalley, 1992).

3. Forefoot

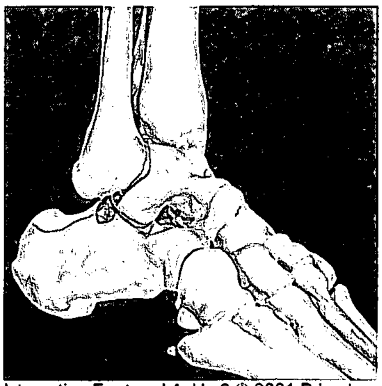
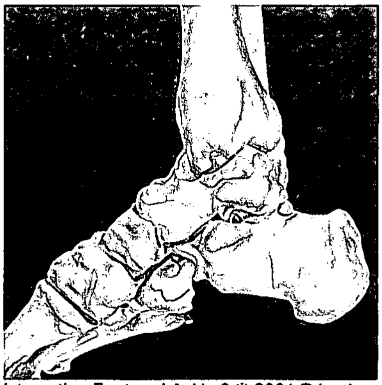
The forefoot consists of the five metatarsals and phalanges (Moore and Dalley, 1992). The metatarsals are classified as long bones with a shaft and two heads (Grey, 1901). The first row of the phalanges articulates with the metatarsal bones behind and the second row of phalanges in the front (Moore and Dalley, 1992).

Joints:

The mortise joint is a synovial joint of the hinge variety (Agur and Lee, 1991). It permits the movements of dorsiflexion and plantar flexion (Reid, 1992). The articulating structures that form the ankle joint include the distal aspects of the tibia and fibula (this creates a socket like structure) to which the trochlear of the talus fits (Moore and Dalley, 1992). The primary motion of the subtalar joint is that of inversion and eversion (Reid, 1992).

The subtalar joint is a plane type of synovial joint (Moore and Dalley, 1992 and Meiring *et al.,* 2000). It is located distally to the ankle joint and is responsible for the motion of inversion and eversion (Reid, 1992).The articulating surfaces of this joint are formed by the head and body of the talus and the body of the calcaneus (Meiring *et al.,* 2000 and Sinnastamby, 2006).

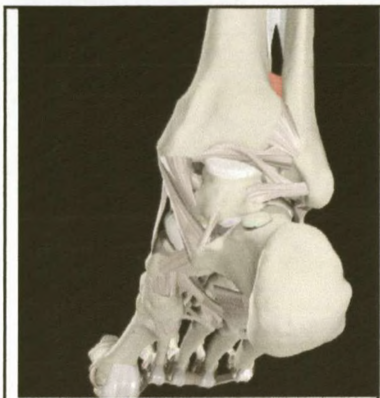
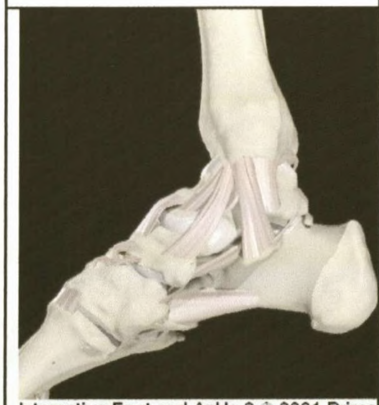
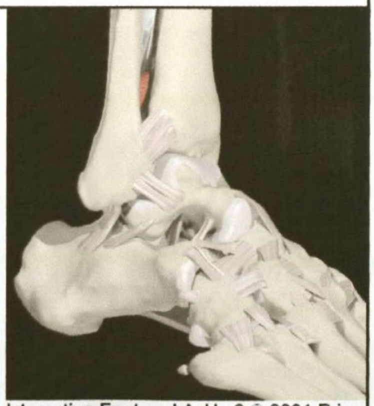
Table 2.1 Bones of the ankle region

 Interactive Foot and Ankle 2 © 2001 Primal Pictures Ltd **Figure 2.1: Foot and Ankle bones(Printed with permission from Primal Pictures).**	 Interactive Foot and Ankle 2 © 2001 Primal Pictures Ltd **Figure 2.2: Foot and Ankle bones(Printed with permission from Primal Pictures).**

Ligaments:

In general, ligaments are the structures that are present to reduce the amount of side to side and /or rotatory motions in the joint (Reid, 1992). They function to connect bone to bone and in doing so reduce the likelihood of joint separation and incongruency (Moore and Dalley, 1992).This section will deal only with the intrinsic ligaments of the foot and ankle. The intrinsic ligaments consist of:

Table 2.2 Ligaments of the ankle region

 Interactive Foot and Ankle 2 © 2001 Prima Pictures Ltd **Figure 2.3: Crural interosseous ligaments (Printed with permission from Primal Pictures)**	 Interactive Foot and Ankle 2 © 2001 Prima Pictures Ltd **Figure 2.4: Anterior tibiofibular ligaments (Printed with permission from Primal Pictures)**	 Interactive Foot and Ankle 2 © 2001 Prima Pictures Ltd **Figure 2.5: Posterior tibiofibular ligaments (Printed with permission from Primal Pictures)**
 Interactive Foot and Ankle 2 © 2001 Prima Pictures Ltd **Figure 2.6: Medial deltoid ligament (Printed with permission from Primal Pictures)**	 Interactive Foot and Ankle 2 © 2001 Prima Pictures Ltd **Figure 2.7: Interosseous membrane (Printed with permission from Primal Pictures)**	 Interactive Foot and Ankle 2 © 2001 Prima Pictures Ltd **Figure 2.8: The lateral collateral ligaments (Printed with permission from Primal Pictures)**

For the purposes of the study, only the lateral collateral ligaments are elaborated on below as CAI has the most impact in pathomechanics in this area (Reid, 1992 and Moore and Dalley, 1992). They function to prevent varus stress at the lateral ankle complex (Meiring *et al.,* 2000). The lateral collateral ligaments are weaker and are thus prone to more injuries than any other ligaments of the foot and ankle joint (Souza, 1998 and Meiring *et al.,* 2000). The lateral collateral ligaments are composed of three main bands namely the anterior talofibular ligament, the posterior talofibular ligament and the calcaneofibular ligament (Agur and Lee, 1991; Moore and Dalley, 1992 and Mering *et al.,* 2000):

- The anterior talofibular ligaments (ATFL)
  - Attaches from the neck of the talus to the fibula (Grey, 1901 and Moore and Dalley, 1992).
  - Quadrilateral in shape (Taser *et al.*, 2006).
  - Described as a flat and weak band.

- The posterior talofibular ligaments (PTFL)
  - Attaches from the tip of the talus to the fibula.
  - It is noted to be trapezoid in shape and follows a horizontal plane (Taser *et al.*, 2006).
  - Described as the strongest of all three of the lateral collaterals and is rarely injured (Grey, 1901 and Moore and Dalley, 1992).

Interactive Foot and Ankle 2 © 2001 P Pictures Ltd

Figure 2.9 : Foot and Ankle ligaments (Printed with permission from Primal Pictures)

- The calcaneofibular ligaments (CFL)
  - Attaches from the calcaneus to the tip of the fibula (Souza, 1998).
  - Oval shaped ligament located below insertion of the ATFL (Taser *et al.*, 2006).
  - This is the second weakest of the three ligaments (Moore and Dalley, 1992).

Retinaculum:

Interactive Foot and Ankle 2 © 2001 Primal Pictures Ltd

Figure 2.10 : The retinaculum (Printed with permission from Primal Pictures)

The retinaculum serves to guide important structures such as the neurovascular bundle and tendons to their relevant sites in a specified area (Calliet, 1983).

The superior extensor retinaculum of the foot is a continuation of the deep fascia of the leg and foot. It is located on the dorsal aspect of the foot and is a fibrous band through which tendons (tibialis anterior, extensor hallicus longus, extensor digitorum longus, and peroneus tertius) will pass (Moore and Dalley, 1992). The superior extensor retinaculum is attached across the expanse of the anterior tibia and lateral malleolus of the leg (Calliet, 1982 and Sinnastamby, 2006).

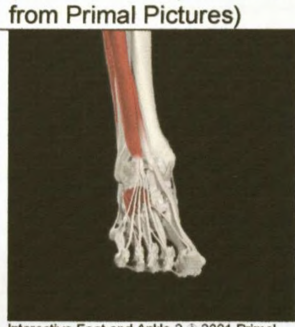
The inferior extensor retinaculum may be Y or X shaped and is attached from the calcaneus (Jahss *et al.*, 1982; Calliet, 1982) to the medial malleolus and plantar aponeurosis of the foot near the ankle joint (Sinnastamby, 2006).

The flexor retinaculum is triangular in shape and is present over the space between the medial malleolus and the calcaneus (Jahss *et al.*, 1982).

The peroneal retinaculum is a fibrous band that crosses from the lateral malleolus to the lateral aspect of the calcaneus to allow the peroneii to be held in place. (Jahss *et al.,* 1982).

2.2.2 Muscles

Table 2.3: Muscles of the anterior compartment of the leg – Table adapted from Agur and Lee, (1991); Moore and Dalley, (1992); Bergmann *et al.,* (1993); Meiring *et al.,* (2000); Sinnastamby,

Muscle	Origin	Insertion	Action	Innervation	Diagram
Tibialis anterior	Lateral condyle and the superior half of the lateral surface of the tibia and the interosseous membrane.	Medial and inferior surfaces of the medial cuneiform bone and the base of the first metatarsal.	Dorsiflexion and inversion of the ankle	Deep fibular nerve (L4/5)	 Interactive Foot and Ankle 2 © 2001 Primal Pictures Ltd Figure 2.11 : Tibialis anterior muscle (Printed with permission from Primal Pictures)
Extensor digitorum longus	Lateral condyle of the tibia and superior aspect of the medial surface of the fibula and the adjacent interosseous membrane	The lateral four digits on the middle and distal phalanges	Extension of the lateral four digits and the dorsiflexion of the ankle	Deep fibular nerve (L5/S1)	 Interactive Foot and Ankle 2 © 2001 Primal Pictures Ltd Figure 2.12 : Extensor digitorum longus (Printed with permission from Primal Pictures)
Extensor hallicus	Middle aspect of the anterior surface of the fibula and the adjacent interosseous membrane	Dorsal aspect of the base of the distal phalanx of the hallux	Extends the hallux and dorsiflexion at the ankle	Deep fibular nerve	 Interactive Foot and Ankle 2 © 2001 Primal Pictures Ltd Figure 2.13 : Extensor hallicus (Printed with permission from Primal Pictures)

(2006) and Pictures taken with permission from Primal Pictures Ltd, (2003).

Table 2.4: Muscles of the lateral compartment of the leg - Table adapted from Agur and Lee, (1991); Moore and Dalley, (1992); Bergmann *et al.,* (1993); Meiring *et al.,* (2000); Sinnastamby, (2006) and Pictures taken with permission from Primal Pictures Ltd, (2003).

Muscle	Origin	Insertion	Action	Innervation	Diagram
Peroneus longus	the fibula head and the upper 2/3 of the lateral aspect of the body of the bone	Base of the first metatarsal and the medial cuneiform	Eversion of the foot and plantarflexion at the ankle	Superficial fibular nerve	 Interactive Foot and Ankle 2 © 2001 Primal Pictures Ltd Figure 2.14 : Fibularis longus (Printed with permission from Primal Pictures)
Peroneus brevis	The fibula body on the 2/3 inferior aspect of the lateral surface	Lateral aspect of the base of the fifth metatarsal	Eversion of the foot and plantarflexion at the ankle	Superficial peroneal nerve	 Interactive Foot and Ankle 2 © 2001 Primal Pictures Ltd Figure 2.15 : Fibularis brevis (Printed with permission from Primal Pictures)

Table 2.5: Muscles of the posterior compartment of the leg - Table adapted from Agur and Lee, (1991); Moore and Dalley, (1992); Bergmann *et al.,* (1993); Meiring *et al.,* (2000); Sinnastamby, (2006) and Pictures taken with permission from Primal Pictures Ltd, (2003).

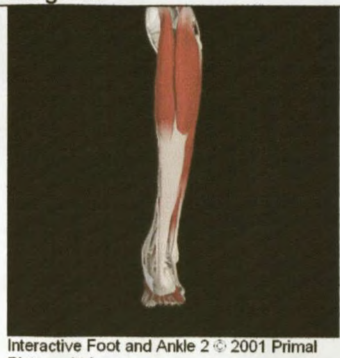
Muscle	Origin	Insertion	Action	Innervation	Diagram
Gastrocnemius	The lateral portion of the muscle attaches form the lateral aspect of the lateral femoral condyle and the medial aspect from the popliteal surface of the femur and medial condyle	On the posterior aspect of the calcaneus by the insertion of the calcaneus tendon	Serves to plantarflex the ankle whilst the knee is in extension, raise the heel when walking and functions to flex the leg at the knee joint	Tibial nerve	 Interactive Foot and Ankle 2 © 2001 Primal Pictures Ltd Figure 2.16 : Gastrocnemius (Printed with permission from Primal Pictures)
Soleus	Posterior aspect of the head of the upper part of the fibula, the superior ¼ of the posterior surface of the fibula body soleal line	Posterior surface of the calcaneus via the tendon	Plantarflexion at the ankle	Tibial nerve	 Interactive Foot and Ankle 2 © 2001 Primal Pictures Ltd Figure 2.17 : Soleus (Printed with permission from Primal Pictures)
Plantaris	Inferior end of the lateral supracondylar line of the femur and oblique popliteal ligament	Posterior aspect of the surface of the calcaneus via its tendon	Weakly assists the Gastrocnemius muscle to plantaflex the ankle	Tibial nerve	 Interactive Foot and Ankle 2 © 2001 Primal Pictures Ltd Figure 2.18 : Plantaris (Printed with permission from Primal Pictures)

Table 2.5: Muscles of the posterior compartment of the leg continued

Muscle	Origin	Insertion	Action	Innervation	Diagram
Tibialis posterior	Surface of the tibia and fibula and adjacent interosseous membrane	Navicular tuberosity, cuneiforms, cuboid and the base of the second, third and fourth metatarsals	Plantarflexes and inverts the foot	Tibial nerve	 Interactive Foot and Ankle 2 © 2001 Primal Pictures Ltd Figure 2.19 : Tibialis posterior (Printed with permission from Primal Pictures)

2.2.3 Nerve and blood supply

Articular and motor supply to the functional unit of the ankle is derived from the common fibular nerve (Moore and Dalley, 1992). This nerve bifurcates into two branches namely the tibial nerve (L4/5 and S1/2/3) and the deep fibular nerve (L4/5 and S1) (Sinnastamby, 2006).

The role of proprioception at the ankle is to allow for joint stability and skilled movements in speed, while there is activity related motion (Lephart and Fu, 1995 and Deshpande *et al.,* 2003). Damage to these proprioception receptors lead to reflex instability, biomechanical alterations and deformed postural control (Lephart and Fu, 1995). The innervations associated with proprioception (i.e. joint position sense and balance) are sensory in nature (Adragna *et al.,* 1990). Three organ receptors of proprioception that are noted are the Golgi tendon organ, the muscle spindle, the Ruffini end organ and the Pacinian corpuscle (Miller and Narson, 1995). These mechanoreceptors form part of the medial lemniscal division of the somatosensory nervous system – which respond to changes due to stretch (Sinnastamby, 2006). These receptors are located in the capsule of joints, tendons, skin and ligaments (Deshpande *et al.,* 2003). These receptors are present in order to detect changes in joint positions and balance, once this takes place information from the mechanoreceptors in the tendon are sent to the brain in order to be processed to provide a conscious awareness of the joint in relation to its environment to allow one to maintain balance (Adragna *et al.,* 1990).

Blood supply to the ankle is derived from the posterior tibial artery which gives rise to the peroneal artery to supply the foot and ankle on the lateral aspect. The significance of this is directly related to the damage ensued and the amount of haemorrhage and edema in the area (Moore and Dalley, 1992).

2.2.4 Biomechanics

The feet are responsible for the function of locomotion of the human body (Jahss *et al.*, 1982). They are required to provide the relevant shock absorption and support to the body whilst stationary and in locomotion (Grey, 1901). The ankle region is structurally suited to allow for stability and mobility (Grey, 1901 and Magee, 2002). Stability allows the foot to pass forces from the body to the ground; mobility is required in order for locomotion to take place and for the feet to adapt to differing types of terrain (Souza, 1998).

Anatomically, the foot and ankle are either in a closed or open pack position (Reid, 1992). When the foot is placed in the plantar flexed and inverted position it is said to be in the open pack position. The foot and ankle are predominantly in this position when the foot is in a non-weight bearing position (Magee, 2002). The closed pack position occurs with weight bearing dorsiflexion and eversion of the foot (Reid, 1992; Meiring *et al.,* 2000 and Magee, 2002). What begins as a malleable appendage, whilst in the open pack position, will become a rigid pedal from which the body will be propelled in a specific direction in the closed pack position (Jahss *et al.*, 1982). During the motion of dorsiflexion, the mortise joint is at its most stable position due to surrounding support of tendons and ligaments. However, during plantar flexion the ankle is unstable due to the aberrant movement of the talus anteriorly on the mortise which can allow for some degree of lateral movement in this position (Moore and Dalley, 1992). The foot and ankle are responsible for carrying the full weight of the body over a small surface area, resulting in it being a high pressure zone (Cutnell and Johnson, 2007). As a result of this, the feet carry up the compounded forces that equate to ten times the weight of the body with forces distributed along the arches (transverse and longitudinal) and axes of motion which is 25° from the frontal plane and 10° from the transverse plane (Reid, 1992; Michaud, 1997). With this in mind there is a greater likelihood for injury to take place when all these factors are taken into consideration. As discussed by Bonnel *et al.,* (2010), morphological and anatomical factors need to be addressed when considering the biomechanics and pathomechanics of CAI. These factors are inclusive of bone, ligaments and joint kinematics.

The mortise joints' primary axes of motion are that of dorsiflexion and plantar flexion and its motion is directly related to that of the subtalar joint, which is inversion and eversion (Moore and Dalley, 1992 and Reid, 1992). Greater range of motion is noted in plantar flexion (allowing a range of between 45-55 degrees in active motion) than in dorsiflexion (a range of between 0 degrees of 15-20 degrees of active motion (Reid, 1992; Bozkurt and Doral, 2006, Vicenzino, 2006). The ankle joint provides no degree of transverse motion. The axis of motion of the ankle joint is from the inferior tip of the medial malleolus to the lateral malleolus (Jahss *et al.*, 1982). It must also be noted that the axis of rotation is orientated in an oblique fashion to all three anatomical planes (Bozkurt and Doral, 2006).

The subtalar joint has a primary motion of inversion, (approximately an average of less than or equal to 20-25 degrees) and eversion (approximately and average of about 5 – 10 degrees), although there is currently much controversy regarding these figures (Moore and Dalley, 1992). In a normal foot, there is an allowance of 6 degrees eversion motion in the normal walking gait cycle (Reid, 1992).

The transversotarsal joints primary function is that of adduction and abduction (Sinnastamby, 2006). Some degree of dorsiflexion and plantar flexion with pronation and supination may be noted in these joints (Moore and Dalley, 1992). At these joints there is limited motion. However, there will be a compensatory increase in motion at this level if the involved subtalar or mortise joint proves to have a decreased range of motion (Jahss *et al.*, 1982).

The midtarsal joints provide the function of dorsiflexion and plantar flexion. Although this direction of motion is permitted at this joint, it is very limited in terms of the degree of range of motion (Jahss *et al.*, 1982).

2.3 CHRONIC ANKLE INSTABILITY

2.3.1 Definition

The meaning of functionally unstable ankles refers to the constant tendency of the ankle to sprain (Caulfield, 2000).

According to Bonnel *et al.,* (2010) there are two types of ankle instabilities that exist:

1. Mechanical instability - (relates to anatomical variants of bone or ligaments that are present at birth or acquired) and cannot be corrected through conservative management, or
2. Functional instability - related to aberrant proprioception and musculature that is defective which is able to be corrected through rehabilitation of the ankle. This is the case in CAI.

It has been identified that there are three anatomical components (Richie, 2001; Sefton *et al.*, 2009) that contribute to the persistence of CAI:

1. Joint fixations or hypomobility (Reid, 1992; Whitman *et al.*, 2009 and Joseph *et al.,* 2010) with associated articular sensory nerve interruption (in the ankle, subtalar joint and tarsals).
2. Muscular weakness and reduced peroneal reaction time (Richie, 2001).
3. Proprioceptive alterations all contribute to the development of CAI (Richie, 2001; Delahunt, 2007).

Other factors that are considered as causative factors to the development of CAI have been hypothesised to include (Caulfield, 2000)

- Aberrant mechanical output of the muscles and ligaments, in and around the ankle joint. This includes the primary ankle evertors which may be weak as well as the increased strength of the invertors (Vizniak and Carnes, 2004).
- Aberrant postural control at the level of the ankle (Reid, 1992; Caulfield, 2000; Richie, 2001 and Delahunt, 2007).
- Local nerve damage due to trauma (Reid, 1992 and Moore and Dalley, 1992).

These aforementioned factors are directly linked to the clinical signs and symptoms in the following manner:

Joint fixations – will give rise to the development of restrictions and adhesion formation at the joint. Crepitus and reduced range of motion will be noted on the part of the patient and practitioner (Kessler and Hertling, 1983; Reid, 1992; Caulfield, 2000 and Richie, 2001).

Muscular weakness and reduced peroneal muscle reaction time – will give rise to the development of the repeated ankle sprains and sensation of unsteadiness in the ankle because of the delayed peroneal activation time. The constant sense of "giving way" in the ankle will persist if the problem is not corrected and may be one of the first clinical features noted on the part of the patient. Increased strength of the invertors (as a compensatory mechanism to the weakened evertors) pulls the ankle into further inversion and increases likelihood of damage to the ankle. Orthopaedic testing in the form of a positive anterior drawers sign may confirm this finding in a clinical setting (Caulfield, 2000 and Richie, 2001).

Aberrant postural control and proprioceptive alterations – are responsible for the sensation of giving way at the level of the ankle as well as generalised laxity noted on orthopaedic tests as a result of delayed peroneal reaction (Reid, 1992; Caulfield, 2000; Richie, 2001 and Delahunt, 2007).

Local nerve damage related to repetitive trauma can generate pain as a result of tissue inflammation and local impingement of nerves or tearing and shearing of nerves in the area, minor swelling may also ensue as a result of the development of inflammation at the site which my compress nerves causing pain to be elicited (Reid, 1992).

For the purpose of this study, CAI is defined by the presence of four or more clinical features (Reid, 1992; Caulfield, 2000), inclusive of lateral ankle pain, weakness, edema, crepitus, adhesions resulting in the formation of restrictions in the joint and ligamentous laxity (Pellow and Brantingham, 2001; Ajis and Maffulli, 2006; McBride and Ramamurthy, 2006; Caulfield, 2000). Where there is evidence of improper protection and preventative measures in place at the level of the ankle and inappropriate rehabilitation is administered, there is a greater probability of re-injury taking place and perpetuating the cycle of instability (Reid, 1992).

2.3.2 Grading

There is a three tier grading system on which to classify ankle sprains and determine their severity (Reid, 1992). This grading system is based on the clinical signs and symptoms with which the patient presents.

Table 2.6 Grading of CAI (Reid, 1992).

Grade one	**Grade two**	**Grade three**
Mild	Moderate	Severe
Evidence of minimal swelling with minimal dysfunction, point tenderness over lateral joint, absence of positive anterior drawers sign with no evidence of varus laxity. This implies that in the clinical setting the patient will experience minor or no limping and/or minimal loss of function of the ankle.	Moderate amount of swelling and haemorrhage over the ankle with pain more so on weight bearing. Potentially positive anterior drawers sign but with no varus laxity at such point, contours of the Achilles tendon are not as visible. This implies in a clinical setting that patients will experience inability to run and rise up onto the toes and will walk with a limp.	Severe swelling and haemorrhage with positive anterior drawers sign and rupture of ligamentous structures which results in varus laxity at the ankle within a clinical setting. This implies that patient will experience swelling around the Achilles tendon and severe laxity at the level of the ankle

2.3.3 MECHANISM OF INJURY

History of repeated inversion ankle sprains leads to disruption of ligaments of the lateral aspect of the ankle. This predisposes the ankle to weakness in eversion (as a result of muscle and ligamentous strain) and as a result the likelihood of developing recurrent inversion sprains is higher (Moore and Dalley, 1992). Without the correction of proprioceptive deficits, muscular abnormalities and joint fixations that occur as a result of the inversion ankle sprain, there is an inherent deficit at the ankle which predisposes it to the development of CAI.

Factors that have been noted in the development of this injury have been identified as intrinsic and extrinsic factors. Intrinsic factors pertain to aspects of the patient inclusive of generalised ligamentous laxity, the range of motion the patient has in the foot and ankle, proprioceptive deficits, and variations in the bony or other anatomy in the region (Bozkurt and Doral, 2006). Whereas extrinsic factors include those that may be controlled by the individual, such as the extent to which the player trains; the type of terrain and condition of the grounds; equipment quality, the level of exertion as well as the amount of exercise over a given period of time (Reid, 1992; Bozkurt and Doral, 2006 and Sekir, 2008).

Some of these predisposing factors include:

1. Biomechanical factors:

A tight Achilles tendon may be a contributing factor where the tight pull of the gastrocnemius and soleus will pull the calcaneus into a greater amount of inversion than in the neutral position. As a result of this, landing from a height or deceleration activity may predispose to the development of "turning the ankle inward" leading to the inversion ankle sprain (Reid, 1992).

2. Sporting activities

Sports such as ballet and soccer have a significant role to play in the development of inversion ankle sprains and subsequently CAI (Reid, 1992). Both sports place a significant amount of stretch on the lateral ligaments of the ankle causing weakness of the musculature with bone and joint changes due to stress, resulting in an increase likelihood of inversion at the level of the ankle (Thaker *et al.*, 1999; Oztekin *et al.*, 2008 and Walls *et al.*, 2010).

3. Anatomical factors

Generalised ligamentous laxity due to a predisposed condition such as Marfan's Syndrome or other connective tissue disorders (e.g. Ehler Danlos) may lead to a predisposition for the development of inversion ankle sprains (Reid, 1992 and Bozkurt and Doral, 2006).

Variations in osseous anatomy of the bones (Bozkurt and Doral, 2006) and other disorders that affect anatomy, such as tarsal coalition and varus deformities of the calcaneus are predisposing factors that may promote the development of inversion ankle sprains (Reid, 1992).

Muscular imbalances with the presence of weak evertor muscles or strong invertor muscles will lead to a greater likelihood of a neutral position of the foot being placed in the inverted position which increases likelihood of inversion ankle sprains (Vizniak and Carnes, 2004).

4. Miscellaneous

Other factors that contribute to the development of this condition include uneven terrain and ill fitting footwear (Reid, 1992). In contrast, factors such as bracing and correctly fitted orthotics may in fact prevent future inversion sprains (Reid, 1992).

With all the above mentioned factors in mind, the pathomechanics of this condition can be better understood. When the foot is placed in the open pack position (the foot is placed in excessive inversion with rotation or plantar flexion) the greatest chance exists of developing ankle inversion sprains (Reid, 1992 and Wright *et al.,* 2000). This action affects primarily the anterior talofibular ligament followed by the calcaneofibular and the posterior talofibular ligament (Puffer, 2001). Damage in the form of a tear or stretch that is placed on these lateral muscles, tendons and ligaments (Moore and Dalley, 1992) causes them to have an inherent chronic rotational instability at the level of the ankle. As a result CAI may ensue without any rehabilitation (Reid, 1992).

2.3.4 INCIDENCE AND PREVALENCE OF CAI

Foot pain as a syndrome is regarded as a widespread condition (Souza, 1998; Balint *et al.,* 2003). It may be linked to either biomechanical abnormalities, or to an organic condition which may be vascular or neurological in nature (Souza, 1998). In general, ankle conditions are repeatedly encountered during sports (Balint *et al.*, 2003; Ferran and Maffulli, 2006; Delahunt, 2007; Bozzelle and Kishner, 2010).

Ankle sprains are often noted in a clinical setting with up to one in ten thousand people suffering with an ankle sprain on a daily basis (Reid, 1992; Souza, 1998). More specifically, ankle sprains of the plantar flexed / inverted origin (i.e. inversion ankle sprain), are the most frequently noted injuries of this particular region, contributing to 85% of all complaints (Caulfield, 2000; Balint *et al.*, 2003; Ferran and Maffulli, 2006; Bozzelle and Kishner, 2010). Epidemiological studies have discussed that in injuries of the lateral ligamentous complex; approximately 40% are likely to progress to a state of CAI (Souza, 1998) within the ankle and the hind foot (Ajis *et al.*, 2006; Rimando, 2008). It is evident that CAI is a recurrent problem that is often encountered in the setting of clinical practice (Ajis and Maffulli, 2006; Ferran and Maffulli, 2006).

In a study conducted by Oztekin *et al.,* (2008) that looked into foot and ankle injuries in football players, it was noted that inversion ankle sprains were the most common (30.3%)

injuries. The study also noted that the mean time lost due to the injury accounted for up to 61 days. Ballet dancers are also highly likely to suffer with this type of condition as the result of the nature of their sport and high stress impact it places on the foot and ankle (Walls *et al.*, 2010).

2.3.5 DIAGNOSTIC AND ORTHOPAEDIC TESTS

Diagnostic and orthopaedic examinations are of clinical importance to enable the practitioner to differentiate what the potential cause of the condition is or in fact to make the final diagnosis. The use of the following named orthopaedic tests assists the practitioner in making that final decision (Souza, 1998: Magee, 2002; Tourne *et al.*, 2010).

The orthopaedic tests that are pertinent to CAI are as follows:

1. The anterior drawer's test: (Souza, 1998; Magee, 2002)

The participant lies in supine position on the examining table. The doctor stabilises the tibia and fibula of the leg with one hand. The participant's foot is placed in approximately 20 degrees of plantar flexion by the pressure of the doctor's alternate hand. The tibia is drawn forward against the ankle joint to check the presence of laxity at the talocrural joint. A positive for this test will reveal a 'clunking' sound or there may be between three to five millimeters laxity as well as a softened end feel. A true positive is indicative of damage to the anterior talofibular ligament, anterior capsule and the anterior fibular ligament.

2. Talar tilt test: (Souza, 1998; Magee, 2002)

The participant lies on their side with the limb that is being examined located superiorly. The doctor is situated with their back to the participant. The foot is held at 90 degrees to ensure the calcaneofibular ligament is perpendicular to the talus. The doctor then places their thumbs at the calcaneofibular ligament. The talus is then tilted in adduction and abduction to increase the stress on the calcaneofibular ligament. A true positive will be noted with increased movement at the joint of between three to five mm in either direction. This test is examining both medial and lateral motion.

3. Kleiger's test: (Magee, 2002)

The following test is utilised to determine if there has been a rupture of the deltoid ligament. The participant is seated with the leg and foot in a non weight bearing position with the knee flexed at 90 degrees. The doctor must then stabilise the participant's leg and hold the foot firmly and allow lateral rotation. A positive for this test will be pain located medially and laterally to the talocrural joint and the doctor may feel the talus displace medially as well.

4. The swing test: (Magee, 2002)

The participant is seated on a chair such that their legs and feet are dangling in a non weight bearing position. The doctor holds the dorsal aspect of both feet and palpates the anterior aspect of the talus with their thumbs. The doctor then passively plantar- and dorsiflexes the participant's foot to compare the quality and degree of movement of each test. This test assesses for posterior tibiotalar sublaxation and a true positive is one where the participant resists normal dorsiflexion in pain.

Certain cases of CAI may warrant the use of further imaging techniques such that they utilise aspects of imaging in order to provide a clearer idea of this soft tissue condition. This includes the use of diagnostic ultrasonography (Morvan *et al.*, 2001), Magnetic Resonance Imaging and other special tests to provide a clearer picture of the area (Birrer *et al.*, 1999).

2.3.6 DIFFERENTIAL DIAGNOSIS

CAI is a condition of the foot and ankle (Ferran and Maffuli, 2006). It is with this in mind that there are a magnitude of conditions that may mimic CAI and thus need to be explored before such a diagnosis can be confirmed. All these relevant differential diagnosis serve to rule out certain pathology in the best interest of the patient.

2.3.6.1 Lateral malleolar bursitis

This is a form of bursal inflammation that can result from prolonged periods of plantar flexion and inversion at the level of the ankle. Its key feature is that of pain over the lateral malleolar complex and may be diagnosed with the use of transillumination or ultrasound to the affected site. The pain is located at the site of the lateral malleolus (Balint *et al.*, 2003).

2.3.6.2 Osteochondritis dessicans

This condition is classically noted where there is fragmentation of the cartilage that may or may not separate from the bone. It is most frequently seen in the subtalar and mortise joint as well as on the dome of the talus after trauma (Bhojani and Kalke, 2010). The ideal mechanism in order to visualise such pathology is to view it on radiographs or Magnetic Resonance Imaging and CT scans for clear definition (Balint *et al.*, 2003). The condition is characterised by mild to moderate pain with locking of joints in certain motions (Bhojani and Kalke, 2010)

2.3.6.3 Ankle impingement syndromes

Impingement syndromes of the ankle may be related either to soft tissue, bone or peripheral nerve impingement (Masciocchi *et al.*, 1998 and Milner, 2010). For example a very common impingement syndrome is an exostosis on the anterior tibia that impinges the talus on dorsiflexion causing pain (Masciocchi *et al.*, 1998). Impingement syndromes are classically mistaken by the both practitioner and patient as a form of chronic arthritis. The anterior impingement injury is more commonly noted in an ankle that has undergone severe supination or repeated dorsiflexion or a combination of the two (Balint *et al.*, 2003. The more noted of the signs and symptoms include anterior foot pain with reduced dorsiflexion at the ankle joint (Birrer *et al.*, 1999). The anteromedial form of the injury occurs in conjunction with inversion sprains or a fracture of the talus (Balint *et al.*, 2003 and Vann and Manoli, 2010). The anterolateral impingement is the most commonly noted of all the impingement syndromes (Billi *et al.*, 1998 and Vann and Manoli, 2010). The mechanism that is utilised to determine and differentiate this condition is the impingement sign. The patient is in supine position for this testing procedure. The practitioner's hands are placed around the calcaneus with the thumb located over the anterolateral aspect of the ankle to allow motion in dorsi- and plantar flexion. Dorsiflexion with thumb pressure producing pain will elicit pain at the ankle and is regarded as a true positive for impingement (Molloy *et al.*, 2003). Impingement syndromes are not isolated to sportsmen and women and are sometimes (although uncommonly) linked to the pathology of CAI (Billi *et al.*, 1998).

2.3.6.4 Posterior Tibial Tendon Dysfunction

This condition is noted as the most common adult flatfoot condition related to morphological abnormalities and most often noted in patients that suffer with diseases of lifestyle such as obesity, hypertension and diabetes mellitus (Squires and Jeng, 2006). Dysfunction of this tendon may be a precursor to the rupture which in itself can lead to greater problems. The single limb heel raise is the key test that is specific and sensitive enough to be able to detect this condition (Balint *et al.*, 2003).

2.3.6.5 Sinus tarsi syndrome

Inversion ankle injuries as well as degenerative joint disease have been indicated as the causative factors of this condition (Balint *et al.*, 2003). Traumatic supination of the hindfoot caused by sport related or traumatic injuries have been noted to cause ligamentous rupture (of the lateral ligaments of the ankle) associated with this condition (Zwipp *et al.*, 1996). The syndrome itself is characterised by the presence of lateral foot and ankle pain, weakness in the ankle as well as that of tenderness over the superolateral aspect of the foot. Anterior drawers test and excessive talar tilt on inversion will rule out sinus tarsi syndrome in the face of suspected CAI (Balint *et al.*, 2003).

2.3.6.6 Tarsal coalition

Tarsal coalition is a condition where there may be total or partial union of the tarsals (Fopma and Macnicol, 2002 and Balint *et al.*, 2003). The union that takes place may be cartilaginous, fibrous or bony in nature (Sakellariou, 1998). This congenital abnormality may only present symptomatic in the later stages of life, where restricted range of motion is noted (Fopma and Macnicol, 2002 and Balint *et al.*, 2003) and where sporting and physical activity begins to increase in comparison to previous amount of activity (Chambers and Haggerty, 2006). Asymptomatic patients with this condition require no form of intervention. However, those that present with pain in the foot and ankle may opt for the surgical and non surgical treatment options (Sakellariou, 1998). The patient will usually present with focal pain located over the sinus tarsi region with altered biomechanics noted throughout the foot (Chambers and Haggerty, 2006).

2.3.6.7 Peroneal tendonitis

The peroneal tendon is located in the region posterior to the lateral malleolus (Moore and Dalley, 1992). The condition may be due to congenital anatomical changes such as a unilateral flatfoot and forefoot abduction. The condition is characterised by that of pain and swelling in the region of the lateral malleolus (Balint *et al.*, 2003). It is a common condition that will follow an ankle sprain but is poorly understood and less frequently diagnosed as a result. Surgical decompression is recommended for immediate relief of pain (Gray and Alpar, 2001) among a list of other conservative therapies (Pferer *et al.*, 2009).

2.3.6.8 Achilles tendon rupture

Most Achilles tendon ruptures occur within the realms of the sporting arena (Audenaert *et al.*, 2004). The Achilles tendon rupture may be preceded by a singular traumatic event to the tendon or as a result of an already existing condition (Birrer *et al.*, 1999 and Lesic and Bumbasirevic, 2004). The diagnosis of such a condition may be difficult to mask with the condition characterised with large amounts of swelling, bleeding into the tendon and pain (Lesic and Bumbasirevic, 2004 and Garneti *et al.*, 2005). Evidence surrounding the treatment of this condition is that of a surgical way to restore function as soon as possible (Lynch, 2004).

2.3.6.9 Osteoarthritis

Osteoarthritis is the loss of integrity of the cartilage on bones as a result of wear and tear over numerous years (Boon *et al.*, 2006) and specifically due to a history of CAI, fractures or inflammatory arthritis in the ankle (Milner, 2010). It is prevalent in the lower limb joints of the body (Henden and Beeson, 2009) but is ten times less commonly noted in the foot and ankle joints than in the larger joints such as the knee and hip (Henden and Beeson, 2009 and Milner, 2010). Signs and symptoms include swelling, loss of motion in the joint and crepitus (Laing, 2004). Arthroscopic surgery to remove osteophytes is often considered in severe cases but conservative treatment includes restricted activity and analgesia (Milner, 2010).

2.3.6.10 Fractures

Three classifications of fractures include; 1. Fragility fractures due to osteoporosis, 2. Pathological fractures due to Pagets disease as an example and 3. Stress fractures due to overuse (*Boon et al.*, 2006). There are many classification types of fractures such as the Danis-Weber and Launge-Houston methods (Lesic and Bumbasirevic, 2004). Ankle fractures are commonly noted and the most frequent location is in the malleolus and calcaneus (Peris, 2003 and Lesic and Bumbasirevic, 2004). Computed tomography and magnetic resonance imaging scans are used to visualise such fractures clearly where radiographs will indicate sclerosis (Peris, 2003).

2.3.6.11 Other differential diagnoses

A host of conditions need to be addressed and eliminated in the case of CAI. The following conditions may be associated with the differentials list for CAI but are less commonly noted. These include (in no particular order):

a) Cuboid syndrome (Souza, 1998).
b) Joint dysfunction of any joint in the foot and ankle (Souza, 1998).
c) Benign and malignant tumours (Lines and Hepple, 2005).
d) Sublaxation of tendons (Souza, 1998).
e) Diastasis (Magee, 2002).
f) Muscle wasting, atrophy or hypertrophy (Boon *et al.*, 2006).
g) General ankle swelling due to systemic disorders e.g. heart disease (Boon *et al.*, 2006).

2.3.7 TREATMENTS

The following section discusses the treatment protocols that are associated with the treatment of CAI. These interventions have been widely explored within the area of manual therapy as well as surgery. Clinical and statistical significance are the factors to consider within treatment and aspects such as pain reduction, reduced swelling, improved general ankle functioning and reduced time for healing are all considered in the review of literature (Kessler and Hertling, 1983; Reid, 1992; Caulfield, 2000 and Richie, 2001).

2.3.7.1 Non steroidal anti-inflammatory drugs (NSAID's)

The analgesic properties of this medicinal form of treatment far surpass that of its anti-inflammatory nature and needs to be taken for between two to three weeks for optimal results to be noted (Green, 2001). Literature indicates that the widespread use of NSAIDS has been noted in the majority of all musculoskeletal conditions (Green, 2001) and even more so in the sporting environment (Ziltener *et al.*, 2010). Although its widespread use has seen its benefits in aspects of reduction in pain and swelling, it may encourage sportsmen to return to the field prior to the full recovery of the injury (Green, 2001). Ziltener *et al.*, (2010) remain steadfast in the fact that NSAID use be restricted to short term and used mainly in the case of acute ankle injuries due to the negative side effects associated with the continuous use of this substance. A practical management guidelines paper was produced by Ziltner *et al.,* (2010) and was developed to assist practitioners in treating patients adequately for muscle tears, ligament damage (as with acute ankle sprains) and tendinopathy. The papers that were assessed were Randomised clinical trials, meta-analyses or peer reviewed literature reviews. To generate the update of this information on NSAIDs treatment protocols, all the relevant articles were read and assessed and the articles that dealt with NSAIDs and motor system pathology were selected for review. There was no classification system for the methodological quality of the papers. With reference to ligament damage (which is pertinent to this study) the initial usage of NSAIDs will lead to quicker recovery and return to sport but with potentially detrimental effects in the long term due to poor quality of the time of healing. Reductions in pain and short term return to sport were all favourable outcomes for the review however; long term residual laxity poses a problem for athletes. In general NSAIDs are advocated for acute and chronic traumatic injuries where there is evidence of an inflammatory component but there are limitations on this statement as there are few high quality studies, with regard to methodology. Additionally NSAIDS have also been criticized for their negative gastrointestinal side effects of mucosal lining irritation and gastric ulcers and bleeding; however, new developments in the pharmaceutical industry have allowed this to be avoided (Neal, 2003 and Boon *et al.,* 2006).

A recent study was conducted that may provide an alternative to NSAIDS and which may be helpful in reducing the side effects. A prospective, comparative, non randomised trial that as conducted by Coetzer *et al.*, (2001) assessed the efficacy of manipulation in comparison to Piroxicam for the treatment of acute inversion ankle sprains. Thirty participants were recruited where half received manipulation to the ankle joint and the other half received a course of Piroxicam for a period of six weeks. The inter-group analysis revealed that there were no statistically significant differences for any of the outcomes measures between the two groups i.e. for algometer readings (p=0.460), goniometer readings (p= 0.011), NRS 101 (p=0.093), McGill Pain Questionnaire (p=0.386) and athletic limitation (p=0.181). Intra-group analysis however revealed statistically significant values for all outcomes measures in both groups i.e. algometer readings for manipulation group (p=0.001) and Piroxicam group (p=0.000), for goniometer readings in the manipulation group (p=0.000) and the Piroxicam group (p=0.001), NRS101 for the manipulation group and Piroxicam groups were both p=0.000, McGill Pain Questionnaire for the manipulation group was p=0.001 and the Piroxicam group was p=0.000 and for athletic training the manipulation and rehabilitation group both had p=0.000. In both the inter – and intra-group analysis the manipulation Group had a greater number of fixations removed from the ankle than the Piroxicam Group. The study's findings concluded that both treatment protocols are effective for the treatment of ankle inversion sprains but the manipulation group was more effective in reducing the number of fixations found.

2.3.7.2 Bracing and taping agents

In an in vivo study conducted by Eils *et al.*, (2002), twenty-four participants were required to wear ten brace supports for the ankle and were tested actively and passively for effectiveness of the braces. In conclusion, it was noted that all the braces provided restricted range of motion in and around the ankle itself in comparison to no bracing for both active and passive testing. The most distinct change (reduced) in range of motion was for inversion for all bracing types. For eversion and plantar flexion both the rigid and semi-rigid braces showed improved stability and only slight stability improvement was noted for dorsiflexion and internal rotation for all braces. A statistically significant correlation was observed between passively and rapidly induced inversion for all brace types (p=0.0031) But, practitioners would need to be cautious when recommending the use of such devices as they are protective against passive changes in direction as opposed to rapid dynamic changes.

With regard to treatment options, bracing of the ankle has been advocated as a prophylactic method rather than immediate or long term treatment for CAI. Noteworthy commentary by Papadopoulos *et al.*, (2005) and Mickel *et al.*, (2006), discuss in their review that bracing will not assist in the correction of weakened or loss of muscle power and balance.

2.3.7.3 Ultrasound

In a study conducted by Zammit and Herrington (2005), thirty-four patients were randomly spilt into one of three treatment groups (the first being a treatment with active ultrasound therapy, the second being a placebo ultrasound Group and the third being a no treatment group). Ultrasound therapy for CAI was not advocated, in this study for the inter-group analysis, as it did not show any statistically significant reduction in any of the outcome measures (pain (VAS), swelling (tape measure method), range of motion for dorsiflexion and plantar flexion and postural stability) at visit one, eight, fifteen and twenty-two. However, statistically significant results were noted with respect to reduced pain, swelling, postural stability and improved range of motion within the treatment groups (p=0.005) indicating that all groups were effective but not different.

Ultrasound is not deemed as an effective tool to reduce disability and improve general ankle functioning (Roebroeck *et al.*, 1998).

Ultrasound therapy has been advocated as an option of treatment of general musculoskeletal conditions throughout the body for many years (Gam and Johannsen, 1995). In a meta-analysis of information surrounding ultrasound and its use as a treatment modality, 293 papers were evaluated for inclusion into the review. Of these papers twenty-two papers compared ultrasound with either sham ultrasound, non-ultrasound treatment or no treatment controls. Sixteen of these twenty-two papers addressed therapeutic ultrasound with sham ultrasound. Out of the sixteen papers, thirteen cases of the data were presented in a manner to allow for pooling into the study. According to Gam and Johannsen, (1995) due to the poor quality of design of many of the thirteen studies (examples include minimal detail on randomisation processes, the apparatus of the ultrasound used, control of use of the apparatus, follow up time and dropout rates) little statistical evidence was found to support these claims in favour of the use of ultrasound in musculoskeletal conditions.

2.3.7.4 Laser

In a randomised clinical trial conducted by de Bie (1998), 217 patients were randomly allocated into one of three treatment groups [viz. high level laser, lower level laser and a placebo group and all patients received a standardised elastic bracing device]. Over the four week period, 12 treatments were conducted. All dosages of laser therapy were ineffective between groups and within groups with no difference noted on the primary outcome measure of pain (p=0.41). This form of therapy is therefore not advocated in the use of treatment for pain and should be revised as such.

2.3.7.5 Surgery

Many varieties of surgical procedures are present in order to treat CAI. However, surgery is only advocated for severe CAI of grade three nature where mechanical instability is marked (Reid, 1992). In these cases the Bromston-Guld procedure is the ideal form of surgery to correct these conditions. Postoperative care is of a high-quality and return to activity is achieved in a shorter time period (Keller *et al.*, 1996). Another procedure known as the transferring of the extensor digitorum muscle is useful in the treatment of functional ankle instability and is advocated in participants who have not yet reached the stage of physical maturation (Westlin *et al.*, 2003).

2.3.7.6 Manipulation

Manipulation helps to restore normal neuromuscular firing (Leach, 2004) of the joint. Also manipulation can help ensure better alignment and correction of the biomechanics to restore the ankle to its near normal state (Gatterman, 1990; and Haldeman, 1992; Bergmann, 1993; Redwood and Cleveland, 2003 and Leach, 2004).

Manipulation, as a form of therapy for CAI has been advocated through a multitude of studies(Pellow and Brantingham, 2001; Green *et al.,* 2001; Collins *et al.,* 2002; Gillman 2004; Jennings and Davies, 2005; Brantingham *et al.*, 2009; Joseph *et al.,* 2010).

A single blinded controlled pilot study conducted by Pellow and Brantingham (2001) investigated the effects of manipulation in comparison to detuned ultrasound in 30 patients that were split into two equal treatment groups suffering with CAI. Group A received amanipulation (specifically axial elongation / ankle joint separation/ mortise long axis distraction) and Group B received five minutes of detuned ultrasound. The study was conducted over a four week period with all eight treatments conducted in that time frame. The outcome for the study suggested that manipulation is effective as a treatment for CAI. A treatment effect for the Manipulation Group was observed (p=0.005) for the McGill Pain Questionnaire and overall ankle function (p=0.001) in the inter-Group analysis at the final treatment. Statistically significant improvements in the Manipulation only Group, for the intra-Group analysis, were noted specifically with respect to reduced pain on the NRS101 (p=0.001) and McGill Pain Questionnaire (p=0.001), improved range of motion (p =0.002), algometry readings (p=0.013) and improved general ankle functioning (p=0.001). This is in comparison to the sham ultrasound Group where NRS101 readings were p=0.007; McGill Pain Questionnaire (p=0.038); goniometry readings (p=0.199) Algometer p=0.017 and overall ankle function (p=0.004). Thus it was concluded that manipulation to the ankle complex (at the site of fixations in the ankle) would be effective in the treatment of CAI. Improvements were noted specifically in terms of enhanced range of motion, reduced pain intensity and quality and generalised improved ankle function (Pellow and Brantingham, 2001).

Collins *et al.*, (2002), conducted a study on 16 participants with Grade II sub acute ankle instability to assess the effectiveness that Mulligan mobilisation with motion has on weight bearing dorsiflexion, there were other parameters analysed but weight bearing ankle dorsiflexion was included due to the linkage in this study. Each of the participants was randomly allocated into one of the three research Groups: Group one was a mobilisation with movement treatment, Group two was a placebo and Group three was a no treatment control Group. Intra-group results of this study showed statistical significant improvement in the mobilisation with movement Group for improved range of motion, specifically for weight bearing dorsiflexion (p=0.013). This was in comparison to the placebo Group (p=0.202) and the no treatment control Group (p=0.208), where no statistically significant improvements were noted for this outcome. Inter group analysis revealed a treatment effect for the mobilisation with movement group treatment group (p=0.002) for weight bearing dorsiflexion. For statistical analysis on pain, there were no inter-Group differences noted but time effects for the mobilisation with movement Group (p=0.010) which was not noted in the placebo or control Groups (p=0.017).

Eisenhart *et al.,* (2003) conducted a single blinded randomised clinical trial (n=55) between two groups of patients for ankle sprains. Group One received an intervention of RICE (acronym for: rest, ice compression, elevation) and NSAID's and Group Two received the same protocol as the control group as well as manipulation to fixated lesions. The statistical analysis post treatment one for the Manipulation Group showed statistically significant improvements for oedema (p<0.001) and pain (p<0.001) and clinically significant improvements for pain (a decrease in 4.1 points on ten point scale). However in terms of range of motion (p=0.08) results, an improvement of eleven degrees was noted, but this was not a statistically significant improvement. The inter group analysis at the one week follow up for the group receiving OMT with RICE's protocol revealed a statistically significant improvement in terms of range of motion in comparison to the control group.

With respect to joint restrictions, a case report on two young athletes conducted by Gillman (2004), discusses the success of manipulation as a primary tool for the treatment in CAI. The manipulation was administered to the fixated segments that were noted in the spine, pelvis, extremities and specifically the ankle. It was documented that the participants of this study noted a decrease in the number of episodes of the ankle "giving way" as well as a generalised reduction in the clinical features seen in CAI.

Studies that have looked at specific manipulations of specified fixations were conducted by Jennings and Davies (2005) and Vincenzio *et al.*, (2006). These are discussed below.

The Jennings and Davies (2005) study looked at patients with ankle sprains and the presence of cuboid fixations as a result of this injury and if found, whether manipulations to this fixated cuboid would reduce clinical symptomatology. In the study (n=7) two treatments were conducted on patients who had endured an ankle sprain between one to eight weeks prior. All seven of the participants in the study had cuboid fixations recorded following their inversion sprain Statistical analysis indicated that there was no recurrence of injury (CAI) following these visits for the study time or for the next two to eight months after.

Vincenzino *et al.*, (2006) conducted a double blinded RCT (n=16) with a total of three treatment groups [viz. Group One – mobilisation with movement in the weight bearing position, Group Two – mobilisation with movement in the non weight bearing position and Group Three – no treatment in the control Group]. Results from the study indicated that in the mobilisation with movement weight bearing Group, a statistically significant increase in the degree of posterior talar glide and centimetres dorsiflexion was observed when compared to the control Group. In both the weight and non weight bearing Groups, improved talar glide was noted up to 50%, which was greater than the value for the control (p<0.001). Weight bearing and non weight bearing Groups noted an improved dorsiflexion by 26 % (p<0.017) as compared to the 9% noted in the control Group.

A single blinded randomised clinical trial investigated the effects of manipulation on proprioception (kinaesthetic sense where the joint of the foot is in space) and ankle dorsiflexion in CAI patients by Kohne *et al.*, (2007). Thirty participants were placed into two groups. Both groups received manipulation as the form of intervention. However, Group one received six treatments over a four week period whereas the control Group received a single manipulation to the ankle. The study revealed statistically significant treatment effect for the six treatment Group on two (five degrees plantar flexion and inversion) out of the four tested measures of proprioception (p=0.029 and p=0.047) and dorsiflexion range of motion (p=0.028).

In a review article by Brantingham *et al.*, (2009), manipulation to the lower extremity was advocated as a method of treatment for mechanical conditions and in addition to this, manipulation to the foot and ankle appeared to be a treatment intervention of choice in participants with CAI (Pellow and Brantingham, 2001; Gillman, 2004). All literature that was revised in the systematic review was deemed in the review as an overall B grade (fair evidence from relevant studies) standard of quality (Brantingham *et al.*, 2009).

In a study conducted by Joseph *et al.,* (2010), on the comparative effect of muscle energy technique as compared to manipulation for the treatment of CAI, forty participants were split into two equal groups. The primary outcome measures for this study were that of one leg standing test and numerical pain rating scale 101. For both parameters, statistical and clinically significant changes were noted in the intra-group analysis, for the one leg standing test for eyes open and closed (p=0.003), NRS 101 (p<0.000) and plantar- and dorsiflexion range of motion (p<0.05) for both groups. There was no apparent intergroup difference for any of the parameters (p>0.05).

It is evident from all the literature (Pellow and Brantingham, 2001; Collins *et al.,* 2002; Eisenhart *et al.,* 2003; Jennings and Davies, 2005; Vincenzino, 2006 and Brantingham *et al.,* 2009) that manipulation as a form of treatment for the ankle in the case of CAI, has shown either a clinically or statistically significant improvement or both with respect to the reduction of pain, improved range of motion and improved dorsiflexion with reduced swelling, as opposed to the control groups or other intervention groups to which it was compared. Literature (Gatterman, 1990; Bergmann, 1993; Redwood and Cleveland, 2003; Leach, 2004 and Haldeman, 1992) seems to indicate that manipulation is a useful form of treatment to include, in order to correctly rehabilitate the ankle.

2.3.7.7 Rehabilitation

A study conducted by Yildaz *et al.*, (2003) assessed strength ratios in patients with CAI in comparison to patients that had unaffected ankles. Eight patients with CAI and nine unaffected ankles were accepted into the study. Invertor and evertor muscles of the ankle were measured in both groups. A deficit in evertor weakness was revealed in both concentric and eccentric evaluation for the affected group. As a result of these findings, strength training of the weakened evertors of the ankle (peroneus) is advocated in the treatment protocol for rehabilitation of CAI.

In a study conducted by Lee and Lin (2008), it was found, during a twelve week programme on postural stability and ankle proprioception in patients that suffered with CAI. The study consisted of twelve students with unilateral CAI. An isokinetic dynamometer was used to record and asses the active and passive joint position sense and the twelve week training programme was given to the students. Statistical results of the study indicated, after the twelve week exercise programme, that postural stability improved and improved neuromuscular capability was evident. All p values for the study were $p<0.05$ (the level of statistical significance).

Review of literature on the neuromuscular contributions to functional instability of the ankle joint by Delahunt, (2007) revealed the relevance that balance, strength and proprioceptive deficits have on the persistence of CAI. Delahunt (2007) supported Desphande's (2003) statements about proprioception and neuromuscular deficits as contributing factors for the development of CAI and that treatment of this deficit is required in order to restore the ankle to normality. The way in which this is corrected is in the manner of treatment with postural control exercises and strengthening of the musculature that control postural elements (Desphande, 2003).

A systematic review of the literature of exercise therapy and mobilisation of the ankle by van der Wees (2006), there were 198 papers that were considered for the initial screening process and only seventeen papers on randomised clinical trials were used for review. Of these seventeen papers that evaluated exercise therapy (for purposes of this study that he defined it as strengthening and/or proprioception and/or stretching) in comparison to mobilisation with at least one clinically relevant outcome measure was accepted into the review. Of these that were most relevant to this study eight randomised clinical trials contained exercise therapy and some form of proprioceptive exercise (e.g. wobble board or ankle disc exercises) of these eight studies there were three that looked specifically at exercise therapy (strengthening) and proprioception in a multi faceted approach. These three articles supported each other that combination treatment was effective. According to van der Wees (2006) the literature surrounding CAI and its treatment seem to suggest that exercise and proprioceptive activity is effective in treatment and prevention of CAI (classified as a level 2 in the systematic review). .

CAI has been noted to show proprioceptive defaults, as well as peroneal muscle weakness which contribute to the persistence of this condition (Reid, 1992; Richie, 2001; Kynsberg *et al.,* 2006). Proprioceptive rehabilitation is therefore a valuable means of restoring normal neuromuscular firing within the problematic ankle (Kynsberg *et al.*, 2006; Sefton *et al.*, 2009). An improvement in local muscle strengthening in the region affected has been researched and found to be a primary aspect in the treatment of the ankle for it to regain full functionality (Ajis and Maffulli, 2006). CAI management should therefore ideally include a combination of strength training of weakened peroneal musculature and proprioception to prevent future problems setting in (Reid, 1992; Lee and Lin, 2008; Karlsson and Sancone, 2006; Ajis *et al.*, 2006; McBride and Ramamurthy, 2006; Ajis and Maffulli, 2006).

Bonnel *et al.,* (2010) strongly advocates the use of postural corrective habits and muscle strengthening as a form of intervention for the conservative management of CAI. At present, evidence exists that promotes the use of a combination of proprioception and strength training as ankle rehabilitation because of the reduced peroneal reaction time and proprioceptive deficits that occur as a result of the injury (Reid, 1992; Richie, 2001; Ajis *et al.*, 2006; Delahunt, 2007).

2.4 CONCLUSION

The extensive review of the literature in this Chapter pertaining to CAI includes many aspects such as anatomy, biomechanics and differential diagnoses, and reveals that there is a vast amount of literature that provides greater insight into the explanation of the mechanism of CAI, as well as treatment options available thus far.

Treatments that are available for this condition range from conservative to highly invasive surgical correction. Most conservative treatment options thus far have targeted only one, or at most two of the three components that have been implicated in the persistence of CAI(namely joint fixations (in the mortise and subtalar joint) as well as muscular weakness (Richie, 2001) and proprioceptive alterations (Richie, 2001; Kohne 2007: Delahunt, 2007; Lopez-Rodriguez 2007; Joseph *et al.*, 2010)). No clinical research thus far, combining the three treatments that address all three components contributing to the persistence of CAI into one single protocol (Van der Wees *et al.*, 2006; Whitman *et al.*, 2009).

The general need for combination therapy in clinical settings has been stressed not only in the ankle but in all regions of the body (Bekker-Smith, 2002; Francis, 2005 and Jensen *et al.*, 2009). This need has been further stressed in many studies that have been published with specific reference to the ankle (Green *et al.*, 2001; Collins, 2002; Eisenhart *et al.*, 2003; Vicenzino *et al.*, 2006 Jensen *et al.*, 2009 and Joseph *et al.*, 2010). According to Kohne *et al.*, (2007) combination therapies may allow for enhanced awareness of the implication of these results may directly have an impact on improved practice management, and reduced risk as well as reduced cost to the patient, as they may recover more rapidly over a shorter period (Kohne *et al.*, 2007).

With this condition being prevalent, especially among sportsmen and women (Thaker *et al.*, 1999), it stands to reason that a need exists with respect to investigation into this combination approach; and that the practitioners involved in the treatment of CAI would endeavour to find the treatment protocol that would best benefit the patient (i.e. allowing return to activity as fast as possible with minimal chance of recurrence of the condition, and causing elimination of the entire condition and not only parts thereof). Benefits of this nature would not only assist the patient with relief of pain, improved range of motion, function and proprioception, but may also place less financial burden on the patient (with fewer visits being required as a result of improved clinical outcomes over a shorter time period).

If research suggests that better results are yielded from this combination approach, manipulative therapists (such as chiropractors or osteopaths) will benefit from attaining this knowledge, and be encouraged to use this combination approach as the treatment of choice for CAI.

CHAPTER THREE

3.1 INTRODUCTION

The following chapter outlines the methodology of the study. This includes study design, advertising, participant recruitment and sampling i.e. method, size, inclusion criteria, exclusion criteria, participant intervention, data collection, instruments and the data analysis.

3.2 STUDY DESIGN

This research study was designed in the form of a quantitative single-blinded randomised, controlled clinical trial to compare two treatment interventions.

3.3 ADVERTISING

Participants were recruited by the convenience sampling method (Mouton, 1996). Advertisements and posters (Appendix A), were placed on the notice boards of the Chiropractic Day Clinic (CDC), around the Durban University of Technology (DUT) Berea and City campuses, local universities, gyms, athletics clubs, libraries and the local shopping complexes as well as in the local newspapers and direct contact with prospective participants through personal communication. Permission was sought for distribution of pamphlets, flyers or posters at sites outside of the DUT. No restrictions were placed on the participants with respect to their ethnic group, gender, occupation or residential area.

3.4 PARTICIPANT RECRUITMENT AND INITIAL SCREENING

3.4.1 Participant recruitment

Prospective participants that responded personally or telephonically to the advertisements were provided with more information regarding the nature of the study by the researcher. Thereafter, those who wished to participate in the study and complied with all the criteria in the telephonic interview were invited for an initial consultation at the CDC.

3.4.2 Telephonic interview

Questions posed to the prospective participants tried to ascertain whether or not they were eligible for participation into the study. Prospective participants, who the researcher contacted telephonically, were asked the following questions as an initial screening:

- How old are you?
- How long ago was your last ankle sprain?
- Do you have any pain, swelling, clicking and/or weakness in your ankle?
- Are you currently taking any pain medication and if so when last was it taken?

If, for question one, the prospective participant answered between 18 and 45 years (Chowdry *et al.*, 2006), for question two, longer than 6 weeks ago and yes to question 3 (Caulfield, 2000; Pellow and Brantingham, 2001; Ajis and Maffulli, 2006 and McBride and Ramamurthy, 2006) they were eligible to be considered for a consultation to determine if they would be able to participate in the study. If the participant had answered yes to question 4 (i.e. if they were taking muscle relaxants or any anti inflammatory medication), the participant was required to have a wash out period of three days before participating in the study (Poul *et al.*, 1993 and Seth, 1999).

3.5 Sample

3.5.1 Sample size

The study included 30 participants with CAI (Brantingham, 1993; Pellow and Brantingham, 2001; Parker, 2005 and Brantingham, 2009).

3.5.2 Sample allocation and Method

A computer generated randomisation table (Appendix O) determined the allocation of the participants to each of the treatment Groups (Esterhuizen, 2010). The one group received manipulation and rehabilitation to the ankle and the other received rehabilitation only.

3.5.3 Sample characteristics

3.5.3.1 Inclusion criteria

- Participants that were between the ages of 18 - 45 years (Pellow and Brantingham, 2001; Parker, 2005 and Chowdry *et al.*, 2006), were included. This ensured greater homogeneity within the population sample (Mouton, 1996). This was achieved by eliminating participants that had not yet completed full skeletal growth as well as participants that may have degenerative changes to the bones or joints. (Yochum and Rowe, 2002 and Chowdry *et al.*, 2006).

- Participants had to have Grade One or Two CAI (Reid, 1992; Pellow and Brantingham, 2001 and Rimando, 2008).

- Participants required a clinical diagnosis of having CAI (Reid, 1992; Caulfield, 2000; Pellow and Brantingham, 2001; Ajis and Maffulli, 2006 and McBride and Ramamurthy, 2006).

- Participants required a visual analogue scale (VAS) (Liggins, 1982; Jensen and Karoly, 1993; Yeomans, 2000 and Salaffi *et al.*, 2003) reading of between 20 and 70 millimetres to ensure homogeneity was maintained within the sample (Mouton, 1996).

- Participants required a foot and ankle disability index reading (FADI) (Hale and Hertel, 2005) of between 50 and 90 points to ensure homogeneity was maintained within the sample (Mouton, 1996).

- Participants required a Berg Balance Scale (BBS) reading (Kornetti *et al.*, 2004) of less than 45/56 to maintain homogeneity within the sample (Mouton, 1996).

- Participants were required to have the presence of at least one fixation in either the mortise joint, the subtalar joint or the tarsal joints (Dannanberg *et al.*, 2000; Green *et al.*, 2001; Collins *et al.*, 2002; Dannanberg, 2004; Jenning and Davies, 2005; Vicenzino *et al.*, 2006; Brantingham *et al.*, 2009 and Whitman *et al.*, 2009).

- Participants were required to give informed consent (Appendix B) in order to participate in the research.

- Participants that were on muscle relaxants or any anti-inflammatory medication were required to have a wash out period of three days before participating in the study (Poul *et al.*, 1993 and Seth, 1999).

3.5.3.2 Exclusion criteria

- Participants who had experienced an acute injury or acute re-injury (six weeks prior to or during the study) were excluded from the study because they did not comply with the six-week interval (i.e. chronic injuries) (Pellow and Brantingham, 2001).

- Participants who presented with balance disorders of a neurological and/or otological and/or vascular origin, that could have mimicked instability and defective proprioception at the ankle level (Clark and Burden, 2005; Kynsberg *et al.*, 2006); were excluded.

- Participants who presented with secondary manifestations of any conditions, which may have compromised balance and / or proprioception, that were contraindicated to Rehabilitation were excluded. These conditions included but were not limited to (Frontera, 1999)
  - Causes of dizziness present during the treatment.
  - Causes of peripheral vascular disease.

- Participants, who presented with connective tissue disorders that created excessive generalised ligamentous laxity, were excluded. They were excluded as it was hypothesised that these participants would not have benefited from the treatment protocols. Additionally the exclusion of these participants assisted with increasing the homogeneity of the sample in the study (Mouton, 1996).

- Participants that had Grade Three CAI or gross mechanical instability of the lateral ankle were excluded, as the severity of this grade of injury usually requires surgical intervention and is unresponsive to conservative therapy (Reid, 1992; Pellow and Brantingham, 2001 and Rimando, 2008).

- Participants that presented with contraindications to manipulation were excluded. These contraindications included but were not limited to (Kirkaldy-Willis and Burton, 1992):
    - Absolute contraindications: Destructive injury of the skeletal structures of the body; fractures and dislocations of all varieties; neurological damage as in cauda equina syndrome, abdominal aortic aneurysm, referred pain of a visceral nature.
    - Relative contraindications: bone demineralization, psychosomatic conditions, anticoagulant therapy and/or conditions where hemorrhaging may be present.

3.6 FURTHER PARTICIPANT SCREENING

Once the participant was deemed eligible to participate in the study they were given a participant Letter of Information and Informed Consent form to read and sign (Appendix B), and were given the opportunity to ask the researcher any questions with regard to the research process. The participants were then required to give the researcher a verbal and written response as to whether or not they wished to participate, and were excluded if he/she chose not to participate in the study.

The researcher then completed a full case history (Appendix C) and a senior physical examination (Appendix D) was conducted, which also included a foot and ankle regional examination (Appendix E) and a SOAPE note (Appendix F). If the participant met any of the exclusion criteria, he/she was excluded from the study. If not he/she proceeded to the next stage.

The participant was then randomly allocated into one of the two treatment Groups by a computer generated randomisation table produced by Esterhuizen, (2010) (Appendix 0).

3.7 THE BLINDING IN THE STUDY

3.7.1 Research assistants

Two independent assistants were utilised for blinding purposes throughout the duration of the study.

- One assistant performed all motion palpation to the entire hind foot and ankle. This included: the mortise joint (long axis distraction, dorsiflexion and plantar flexion, anterior to posterior and posterior to anterior), the subtalar joint (long axis distraction, inversion and eversion) and the tarsals (shearing, adduction and abduction).
- The second independent assistant conducted all pre and post treatment readings, except for motion palpation, in each Group. This independent assistant was required to perform the tests and capture these readings at the necessary treatment intervals in an impartial manner in the documentation provided.
- The researcher was required to conduct the case history (Appendix C), physical examination (Appendix D), foot and ankle regional examination (Appendix E) as well as all the treatments in each group, which included teaching and supervising all rehabilitation of peroneal muscle strengthening and proprioception (Reid, 1992 and Frontera, 1999) as well as performing all manipulation. This allowed the researcher to obtain enough information at the outset of the study to ensure that participants were able to fit into the inclusion criteria from a diagnostic evaluation point. The remainder of the baseline readings were taken by the two independant assistants (and from here informed the researcher if participants were to be included or excluded from the study based on their findings). At no point did the independant observers divulge any of the baseline or other readings to the researcher until the completion of the study. The researcher was blinded to all subjective and objective clinical findings that were taken at visit one, five and seven. Therefore the researcher may have in fact known about the patient and condition but was blinded to baseline readings and changes (or lack thereof) in the outcome measure (VAS, FADI, BBS, WBD and motion palpation). Therefore there was no means of affecting the results or the statistics of the study.

3.7.2 Mechanism to ensure blinding

The following steps ensured blinding was evident:

- No communication between the researcher and two assistants was permitted.
- Not more than one of the two assistants or researcher was allowed near the treatment rooms when the other assistant or researcher was performing their duties.
  - a) The assistant performing motion palpation was blinded to the treatment group that the participant was in as well as all pre-post treatment readings throughout the study's duration.
  - b) The assistant performing the pre–post treatment readings was blinded to the motion palpation findings as well as the treatment group to which the participant belonged throughout the study's duration.
  - c) The researcher was blinded to the motion palpation findings as well as the pre-post treatment readings throughout the study's duration.
  - d) The researcher was only handed all paperwork at the end of the study.

3.7.3 Mechanism to ensure that all assistants were proficient in their relative tasks

- The assistant performing the motion palpation began with assessing one ankle per day for the first month prior to the commencement of the study. This value increased on a weekly basis to a point where a month before the research commenced this assistant was assessing five ankles daily.
- The assistant performing the pre-post treatment readings was taught all the relevant tests by the researcher, and was required to practice on at least ten willing volunteers within the month prior to the commencement of the research.
- The researcher was required to practice adjusting techniques at the same time intervals as the assistant performing motion palpation.
- All assistants and the researcher needed to be available to perform three trial runs of the entire procedure (as discussed in the methodology) involved for the study prior to the commencing of the study. All this was done to ensure that everyone involved in the execution of the study was adequately trained in their various roles.

3.8 TREATMENT TO EACH OF THE GROUPS

The treatment that was received by the participants was either a combination of manipulation and rehabilitation or rehabilitation only programme.

3.8.1 Rehabilitation

Both groups received a rehabilitation protocol inclusive of peroneal muscle strengthening and proprioceptive training. Peroneal muscle strengthening was performed with the use of a Theraband (Hale and Hertel, 2005). This was conducted with the participant seated on the floor with their lower extremity outstretched in front of the participant. The Theraband was attached to a sturdy object, parallel to the participant's position and on the medial aspect of the leg performing the exercise. The Theraband was wrapped around the foot and the participant was taught to evert the foot so as to strengthen the peroneal muscle (the primary function of this muscle) (Moore and Dalley, 1992 and Vizniak and Carnes, 2004). The exercise was performed daily with 3 sets of 12-repetitions with the onset of mild fatigue present on the last set (Unknown, 2006).

Table 3.1 Rehabilitation with Theraband

 **Figure 3.1 Picture of person standing next to Theraband.**	 **Figure 3.2 Person on ground leg outstretched.**	 **Figure 3.3 Person with all parts of Theraband attached.**	 **Figure 3.4 Person performing the action of ankle eversion.**

Proprioception was conducted on a Bosu Ball (also known as a Hedgehog) of the 32cm variety. The participant was required to stand on the Bosu Ball (Hedgehog) for a time of 10 minutes per time in the treatment room at the CDC. The participant stood with both feet on the top surface of the Bosu Ball (Hedgehog) and was required to balance. The balancing exercise was conducted under the watchful supervision of the researcher on the scheduled days of appointments at the CDC however; home exercises were conducted alone with the guidance of the instructions given to the participants.

Table 3.2 Rehabilitation with Bosu Ball (Hedgehog)

 **Figure 3.5** **Person standing next to Bosu Ball (Hedgehog)**	 **Figure 3.6** **Person on the Bosu Ball (Hedgehog)**

The full rehabilitative programme was conducted under the supervision of the researcher that applied the treatment at the first visit at the CDC. Subsequent to this, the rehabilitation programme was carried out at home, by the participant, with the instructions on the diary. To promote compliance, the researcher wrote out instructions in the diary that was handed to the participants on their first visit (Appendix M).

The Bosu Ball (Hedgehog) and the Therabands were given to the participants on completion of the study. They were unaware of this incentive until the completion of their seven visits.

3.8.2 Manipulation

The group that received the manipulation in addition to the rehabilitation programme, received a low amplitude high velocity thrust, to a minimum of one and a maximum of three of the most restricted segments that were found within the mortise joint, subtalar joint and tarsals. The number of restricted segments that required manipulation were determined and documented by the independent assistant performing the motion palpation.

The researcher conducted the manipulation portion of the study at each visit to the CDC.

Participants (in both Groups) received six treatments (visit seven being a readings only visit) over a period of a minimum of three weeks and a maximum of five weeks (Pellow and Brantingham, 2001 and Clark and Burden, 2005). There was a minimum of one-day rest period between the treatments with a maximum of three treatments per week (Pellow and Brantingham, 2001 and Clark and Burden. 2005; Hale and Hertel, 2005 and Hughes and Rochester, 2008).

Table 3.3 The mortise joint

Figure 3.7
Mortise long axis distraction

Figure 3.8
Mortise dorsiflexion

Figure 3.9
Mortise plantarflexion

Figure 3.10
Mortise posterior to anterior

Figure 3.11
Mortise anterior to posterior

Table 3.4 The subtalar joint

 **Figure 3.12** **Subtalar long axis distraction**	 **Figure 3.13** **Subtalar eversion**	 **Figure 3.14** **Subtalar inversion**

Table 3.5 The tarsals

 **Figure 3.15** **Tarsal shearing**	 **Figure 3.16** **Tarsal adduction**	 **Figure 3.17** **Tarsal abduction**

 **Figure 3.18** **Tarsal plantar to dorsal**	 **Figure 3.19** **Tarsal dorsal to plantar**

3.9 INTERVENTION AND DATA COLLECTION

3.9.1 Frequency of treatments and intervention

All participants were required to attend the CDC on the date of their scheduled appointment when the pre and/or post treatment readings were taken on visit one, five and seven. On visits three, four and six, the participants in the Rehabilitation only Group were given the option of attending the CDC to answer any questions about the research, and to re-check that they were performing the home exercises correctly (the daily home exercises had to be completed either at the CDC or at home on these days). The participants in the Manipulation and Rehabilitation Group were required to attend the CDC for the manipulation portion of the research and the rehabilitation was then conducted at home (with the option to perform this at the CDC). These participants also had the opportunity to re-check that they were performing these home exercises in the correct manner and were able to ask any questions that they had in relation to the rehabilitation portion of the study.

Table 3.6 Frequency of treatments

Visit	Manipulation and Rehabilitation	Rehabilitation
1	Pre treatment readings Manipulation and Rehabilitation both at CDC	Pre-treatment readings Rehabilitation at CDC
2	Manipulation and Rehabilitation at CDC	Rehabilitation at CDC
3	Manipulation at CDC (Rehabilitation at CDC or home)	Rehabilitation at CDC or home
4	Manipulation at CDC (Rehabilitation at CDC or home)	Rehabilitation at CDC or home
5	Pre treatment readings Manipulation and Rehabilitation at CDC	Pre treatment readings Rehabilitation at CDC
6	Manipulation at CDC (Rehabilitation at CDC or home)	Rehabilitation at CDC or home
7	Post treatment readings – no treatment	Post treatment readings – no treatment

3.9.2 Instruments

All the Groups received similar base line readings.
The pre treatment analysis included:

3.9.2.1 Subjective measures

- VAS (Appendix G) was used to assess the level of pain that the participant experienced initially, and to track changes in this level of pain during treatment intervals. This subjective pain scale is dubbed as the gold standard with respect to its validity and reliability (Liggins, 1982; Jensen and Karoly, 1993; Yeomans, 2000 and Salaffi *et al.*, 2003). A straight line of 100 mm was marked on the page. One end of the scale no pain and the opposite end displayed maximal pain experienced (these were denoted in text on the document at either end of the scale). The participant was then required to make a selection between these two reference points as to the severity of their pain at that time.

- FADI (Appendix H) was utilised to assess the general ankle function in these participants before the commencing of certain treatments (Hale and Hertel, 2005) to be able to compare to post treatment readings. Participants were required to fill out this index under the supervision and guidance of the independent assistant performing this task.

3.9.2.2 Objective measures

- Vicenzino *et al.*, (2001) Collins *et al.*, (2002); Jones *et al.*, (2005) and Vicenzino, (2006) advocate the use of the weight bearing ankle dorsiflexion test (Appendix I) as a measurement to assess improvement in ankle dorsiflexion, post treatment, for CAI. The weight bearing ankle dorsiflexion test was performed as follows:

    - The participant was requested to stand, facing a wall or vertical structure. The participants were requested to stand in a position so as to ensure that the second toe; centre of the heel and the knees were all perpendicular to the wall that the participant was facing. The heel was required to, at all times, be in full contact with ground. This had to be maintained throughout the test.

- The participant was then required to lunge forward (to affect talocrural dorsiflexion) such that the knee bent, allowing the anterior aspect of the knee to contact the wall in front of the participant. This lunge was performed at a slow and steady rate until maximum dorsiflexion was obtained - either at the onset of pain or at maximum range of motion. Once the participant's knee was in contact with the wall they were required to move their foot back, slowly, until such point where the anterior aspect of the knee was just touching the wall and maximal dorsiflexion was obtained.
- A measurement was then made between the big toe and the wall.
- These measurements were repeated a total of three times after which an average was recorded on Appendix I.
- The greater the distance between the wall and the big toe the greater the amount of dorsiflexion that was obtained.

Figure 3.20 Weight bearing dorsiflexion procedure

- Pressure algometer readings (Appendix J) were taken at the necessary intervals (with the participant seated on the examination bed), at the lateral ankle, to assess the pain threshold of the participant (Vaughan *et al.*, 2007). This reading was conducted on the first, fifth and seventh visits where averages of three readings were noted as the final score for that visit. The algometer that was utilised was the Wagner FDK20 Force Dial (Wagner Instruments, P.O.Box 1217, Greenwich, CT, 06836, USA). The algometer was used as follows:
    - The independent assistant located the point of maximal tenderness over the lateral ankle.
    - The algometer was set at 0kg in order for use.
    - The algometer was then placed at a 90° angle perpendicularly to the skin at this site of maximal tenderness, and the independent assistant applied a slow, consistent pressure until the participant indicated pain.
    - The reading was repeated three times and an average was calculated.
    - It must be noted that the higher the reading the greater the pressure was applied to the site and thus the greater the participant's pain threshold.

- Motion palpation was utilised to determine the presence of joint fixations (Bergmann *et al.,* 1993; Pellow and Brantingham, 2001 and Brantingham *et al.*, 2009) and adjustable articular lesions that may have been present in the joints being assessed (Schafer and Faye, 1990). It functioned, for the purposes of this study, to detect the end feel within a specific joint along all axes of motion and therefore determined the quality of movement, and whether it had improved or had remained the same (Haas *et al.*, 1995 and Lakhani *et al.*, 2009). Although its validity has been debated in the past it remains a frequently used and reliable tool in combination with a variety of pre/post treatment readings from other objective and subjective measures (Haas *et al.*, 1995; Liebenson and Lewit, 2003 and Lakhani *et al.*, 2009). The participant was required to be seated on the bed with their foot off the edge. Motion palpation of the mortise joint (long axis distraction, dorsiflexion and plantar flexion, anterior to posterior and posterior to anterior) the subtalar joint (long axis distraction, inversion and eversion) and the tarsals (shearing, adduction and abduction) were conducted as per the protocol set out in Schafer and Faye (1990). There was one blinded independent assistant that was required to record all fixated segments in descending order, as far as possible (Appendix K).

- BBS (Appendix L) was utilised to evaluate the proprioceptive function of the ankle and subsequent stability that was present at the ankle joint. The BBS is noted as the clinically acceptable method in which balance should be measured over a period of time (Kornetti *et al.*, 2004 and Halsaa *et al.,* 2007). The BBS was conducted with the instruction and under supervision of the other independent assistant. The test consisted of fourteen individual activities, which needed to be performed by all the participants. Each of these activities was independently scored on a five point system (minimum zero and maximum four points). For homogeneity a cut-off score (and an exclusion criteria) of 45/56 was the established value to be utilised (Kornetti *et al.*, 2004 and Mouton, 1996).

The post treatment analysis included all of the above-mentioned measurements.

3.10 DATA ANALYSIS

3.10.1 Statistical analysis:

Data that was obtained was captured in EXCEL. Information that had been computed into EXCEL was imported into the SPSS 15.0 programme (SPSS Inc., Chicago, Illinois, USA). It must be noted that a p value of <0.05 was considered to be statistically significant. T-tests were used to compare quantitative variables between treatment groups and Mann-Whitney tests were used to compare ordinal variables. Pearson's chi square tests were used to compare categorical variables between the treatment groups. Repeated measures ANOVA tests were used to assess the time effect in intra-group analysis and the time*Group or treatment effect in inter-group analysis. Profile plots were generated in order to assess the direction and trend of the treatment effect. Pearson's correlation analysis was used to examine the relationship between changes in subjective and objective intra-group outcomes.

3.10.2 Analysis of clinical significance:

Clinical significance is a term that is used to describe the change (whether positive, negative or insignificant) that is evaluated as a result of the effect of the clinical implication of an intervention both within and between groups (Ogles *et al.*, 2001 and Atkins *et al.*, 2005). It allows the results that are determined and interpreted from the study, to be extrapolated to a population beyond the group that has been studied, which cannot be done without statistical significance (Fetheney, 2010).

The importance of clinically significant results is conveyed in the meaning of the results whereby practical implications are given to statistics (even in the case where statistical significance is not evident) to indicate relevance in practice (Ogles *et al.*, 2001 and Fetheny, 2010). Cook (nd) describes that clinically significant results will determine the quality of the intervention and the impact it has on patients in terms of their recovery.

Two terms that are associated with clinical significance are MCID (Minimally Clinically Important Difference) and MDC (Minimal Detectable Change). The MCID reflects that the changes in results due to the intervention are in fact meaningful to the patient (Cook, nd) whereas MDC is the minimum amount of change that can be detected on an outcome measure.

The clinically significant values for the parameters in this study are tabulated below:

Table 3.7 Clinically significant values for each parameter used

Parameter	Value for MCID	Value for MDC
VAS	The MCID for this scale is 30 % improvement must be noted on the 100mm scale (Farrar *et al.*, 2001).	Not available
FADI	Eight points improvement must be made on the 104 point scale for MCID to be achieved (Eechaute *et al.*, 2007).	Eechaute *et al.*, (2007) describe the MDC that a participant is able to perceive in the FADI is approximately 4.48 points.
Algometer	MCID of an improvement of 1.77kg.cm^2 is required (Chesterton *et al.*, 2007).	Not available
Motion palpation	Not applicable.	Not applicable
WBD	Generally a 0.4-0.5cm improvement is regarded as significant change however; a 1cm change must be made in order for MCID to be met (Green *et al.*, 2001 and Vicenzino *et al.*, 2006).	Not available
BBS	At present there is no MCID that is available (Donohugue and Stokes, 2009).	The accepted MDC for this scale is 3.3 points for participants that fall into the 45-56 category and 4.9 in the 35-44 point category (Donohugue and Stokes, 2009).

3.11 Conclusion

The methodology described in this chapter was applied to all participants that were part of this study. Great care was taken to ensure that blinding was evident throughout the study and that a sound methodological approach was adopted in all aspects of the data collection phase.

CHAPTER FOUR

4.1 INTRODUCTION

The following chapter in this dissertation is a presentation of all statistical data that was encountered throughout the duration of the study. Statistical data was obtained through the subjective and objective readings during the seven visit period.

4.2 DATA THAT WILL BE ADDRESSED

4.2.1 The primary data:

The primary data consisted of the following:

The Case History (Appendix C).
The Relevant Physical Examination (Appendix D).
The Foot and Ankle Regional Examination (Appendix E).
The SOAPE note (Appendix F).
The VAS readings (Appendix G).
The FADI score readings (Appendix H).
WBD readings (Appendix I).
Algometer readings (Appendix J).
Motion palpation findings in the foot and ankle (Appendix K).
BBS readings (Appendix L).

4.2.2 The secondary data

The secondary data was collected from a variety of different sources and all the available literature was screened and the relevant data selected for this particular study. These sources included journal articles and textbooks.

4.3 KEY TERMS AND ABBREVIATIONS

MDC	:	Minimally detectable change.
MCID	:	Minimally clinically important difference.
N	:	Full sample size/ total number of participants in study.
n	:	Sample size per Group.
p	:	The value that deems if information is of statistical significance.
r	:	Pearson's correlation coefficient.

4.4 REVIEW OF THE OBJECTIVES OF THIS STUDY

The aim of the study was to investigate the relative effectiveness of a combination of manipulation and rehabilitation as compared to rehabilitation only in the treatment for CAI, in terms of subjective and objective clinical assessments.

The specific objectives of the study were:

1. To determine the relative effectiveness of manipulation and rehabilitation (coupled peroneal muscle strengthening and proprioception) versus rehabilitation only, to the ankle in terms of objective assessments (algometer, Berg Balance Scale, weight bearing ankle dorsiflexion test and Foot and Ankle Disability Index) in participants experiencing CAI.
2. To determine the relative effectiveness of manipulation and rehabilitation (coupled peroneal muscle strengthening and proprioception) versus rehabilitation only, to the ankle in terms of subjective assessments (visual analogue scale and motion palpation) in participants experiencing CAI.

The following results and statistical analysis are presented in this chapter:

1. Demographic data that was collected in the statistical analysis.
2. Subjective data from the VAS and FADI.
3. Objective data collected via the BBS, algometer, WBD and motion palpation findings.
4. Statistical analysis conducted intra and inter-group for both treatment groups.
5. All readings that were conducted pre treatment at visit one, and five and post treatment at visit seven.

Notes:

X axis = time: 1 – visit one baseline reading; 2 – Visit five; 3 – Visit seven

*****Wilk's lambda results are inversely proportional to the outcome i.e. the lower the Wilk's lambda scores the higher/ greater improvement made in terms of readings.***

4.5 RESULTS

4.5.1 Demographic data

4.5.1.1 The sample characteristics.

The sample in this study consisted of 30 participants with CAI. Participants were placed into one of two treatment groups according to a computer generated randomization table (Appendix O) produced by Esterhuizen (2010). There was no statistical difference (p>0.005) noted between the treatment groups in terms of any of the demographic variables.

4.5.1.2 The comparison of demographic information between the two treatment Groups.

Table 4.1: Comparison of categorical demographic data between the two Groups

		Group				*p* value
		Manipulation and Rehabilitation		Rehabilitation only		
		Count	Column %	Count	Column %	
Gender	Male	8	53.3%	8	53.3%	1.000
	Female	7	46.7%	7	46.7%	
Ethnicity	White	8	53.3%	10	66.7%	0.247
	Black	2	13.3%	3	20.0%	
	Indian	4	26.7%	0	.0%	
	Coloured	1	6.7%	1	6.7%	
	Other	0	.0%	1	6.7%	
MOI*	Sport	13	86.7%	9	60.0%	0.183
	Trauma	1	6.7%	5	33.3%	
	Unknown	1	6.7%	1	6.7%	
Ankle	L	6	40.0%	10	66.7%	0.143
	R	9	60.0%	5	33.3%	

**MOI = mechanism of injury*

Table 4.2: Comparison of quantitative demographic data between the two Groups

	Group		*p* value
	Manipulation and Rehabilitation	Rehabilitation only	
Age in years (mean)	25.5	25.7	0.914
BMI (mean)	24.7	24.4	0.837
Number of sprains (median)	4	6	0.187
Chronicity in weeks (median)	192	336	0.838

4.5.2 Baseline data analysis

Table 4.3: Baseline outcomes analysis

	Group	N	Mean	Standard Deviation	Standard Error Mean	*p* value
VAS1	Manipulation and Rehabilitation	15	47.33	15.169	3.917	0.229
	Rehabilitation only	15	40.00	17.395	4.491	
Algometer1	Manipulation and Rehabilitation	15	1.747	1.2100	.3124	0.860
	Rehabilitation only	15	1.680	.7975	.2059	
WBD1	Manipulation and Rehabilitation	15	6.235	3.6640	.9460	0.696
	Rehabilitation only	15	6.713	2.9374	.7584	
BBS1	Manipulation and Rehabilitation	15	40.05	10.418	2.690	0.224
	Rehabilitation only	15	43.47	2.134	.551	
FADI1	Manipulation and Rehabilitation	15	80.40	10.494	2.709	0.289
	Rehabilitation only	15	75.87	12.397	3.201	
Total number of fixations	Manipulation and Rehabilitation	15	3.13	.352	.091	0.426
	Rehabilitation only	15	3.00	.535	.138	

As has been demonstrated in the Table 4.3, there were no baseline differences between the groups in terms of any of the outcome measures at the outset of the study (all *p>0.05)*. Baseline outcomes were not significantly different between the two treatment groups due to the randomisation process and stringent inclusion and exclusion criteria that allowed for greater homogeneity within the population sample (Mouton, 1996). As a result of this, all results post visit one, five and seven were related to the treatment itself and not due to the varying symptomatology and the randomisation process was deemed as successful. The significance of this data is that it indicates that both groups were similar and that results are based purely on the treatment effect and no statistical data had to be manipulated.

4.5.3 The intra-Group analysis

The subjective data that was collected was from the readings obtained from VAS (Liggins, 1982; Jensen and Karoly, 1993; Yeomans, 2000 and Salaffi *et al.*, 2003), and FADI (Hale and Hertel, 2005).

The objective data was analysed from readings obtained from the algometer (Vaughan *et al*, 2007), motion palpation (Bergmann *et al.,* 1993; Pellow and Brantingham, 2001 and Brantingham *et al.*, 2009), WBD (Collins *et al.*, 2002 and Vicenzino, 2006) and BBS (Kornetti *et al.*, 2004 and Halsaa *et al.,* 2007).

4.5.3.1 To assess the intra-group changes over time with regard to the subjective clinical findings

4.5.3.1.1 Manipulation and Rehabilitation Group

This group received a combination of manipulation and rehabilitation to the foot and ankle as a form of intervention.

4.5.3.1.1.1 VAS

There was a highly statistically significant decrease in VAS over time in this group. It must be noted that an average change in score between initial and final visit in this group was 41.13mm.The highest change in score was 71mm and the lowest was 19mm. The MCID for this 100 point scale is a 30% improvement and participants within this group have improved up to 40% as an average (Farrar *et al.,* 2001). This change in value from the initial to the final visit is well above the MCID for VAS and is thus a highly clinically significant change noted in these participants. By visit seven, 66% (ten out of fifteen participants) made a clinically significant improvement. Of these 66% (ten out of fifteen participants), five participants reported no pain by visit seven (i.e. a score of 0mm on the scale). The breakdown is noted in the table below:

Table 4.4: Breakdown of clinically significant improvements made by participants

% Improvement	Number of participants
19-29	5
*30-39	3
*40-49	2
*50-59	2
*60 and above	3

**indicates clinically significant improvement was made*

Table 4.5: Repeated measures ANOVA for VAS in the Manipulation and Rehabilitation Group

Effect	Statistic	*p* value
Time	Wilk's lambda=0.139	<0.001

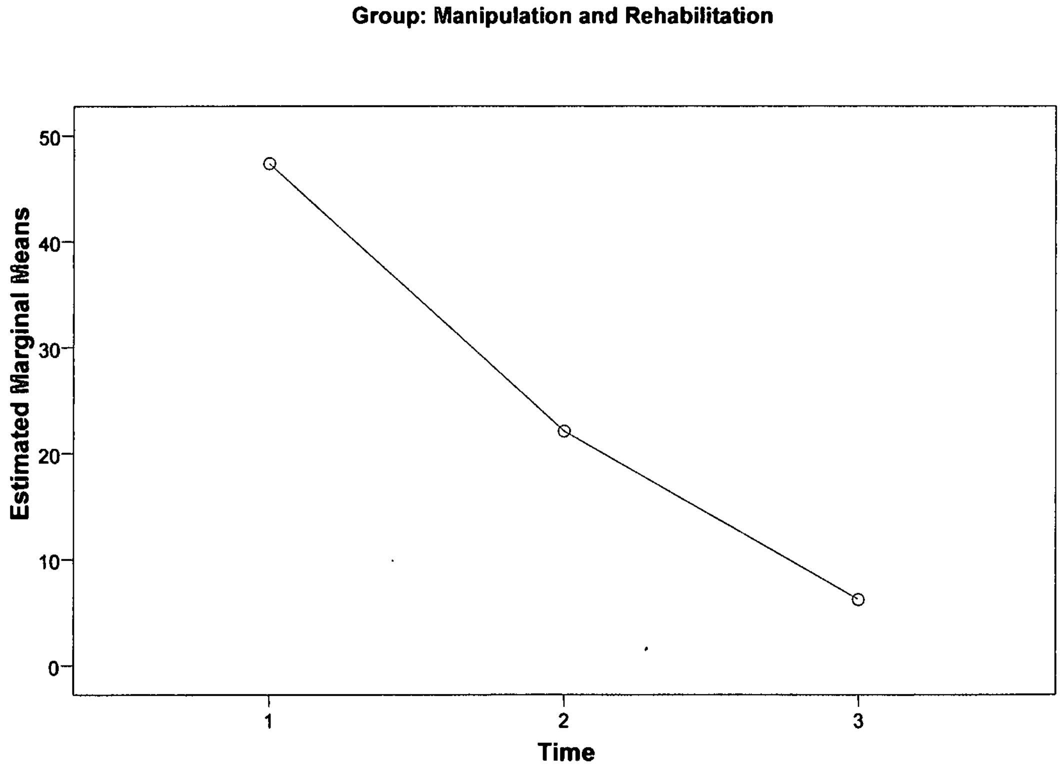


Figure 4.1: Profile plot for VAS over time in the Manipulation and Rehabilitation Group

4.5.3.1.1.2 FADI

Table 4.6: Breakdown of each participant's progress in the study

Patient	Visit 1	Visit 5	Visit 7	Number of points improved	MDC achieved
1	64	86	88	24	Yes
2	90	102	104(*√)	14	Yes
3	90	95	101(√)	11	Yes
4	80	94	103(√)	23	Yes
5	86	104	104(*√)	18	Yes
6	90	95	103(√)	13	Yes
7	90	92	102(√)	12	Yes
8	67	104	104(*√)	37	Yes
9	89	92	104(*√)	15	Yes
10	90	98	100(√)	10	Yes
11	88	90	92	4	No
12	69	71	75	6	Yes
13	64	104	104(*√)	40	Yes
14	74	83	104(*√)	30	Yes
15	75	52	96	21	Yes

(*) Highest total score for this scale is 104/104 – which was achieved by six participants by visit seven.
(√)Score of >100 was achieved by eleven participants by visit seven.

There was a highly statistically significant increase in FADI readings over time in this Group. For this study the Manipulation and Rehabilitation Group participants noted, on average, a change of 18.5 points between their initial and final visits. The greatest change made in the group was 40 points and the smallest change was 6 points between visit one and seven. According to Eechaute *et al.*, (2007), the MCID of the FADI is an eight point change on the scale. The average of 18.5 points improvement was noted in this group, illustrated between visits one and seven, and therefore the average increase in FADI was clinically significant. From this group there were 86.6% (thirteen out of fifteen participants) that made a clinically significant change individually, and 40% (six out of fifteen participants) achieved full score of 104/104 on this function scale by the end of visit seven. Eechaute *et al.*, (2007) proceed to describe the MDC that a participant is able to perceive in the FADI is approximately 4.48 points. The change is noted below in the following table:

Table 4.7: Breakdown of clinically significant improvements made by participants

Points improvement	Number of participants
0-8	2
*9-19	7
*20-25	3
*26-39	3

**indicates clinically significant improvement was made*

Table 4.8: Repeated measures ANOVA for FADI in the Manipulation and Rehabilitation Group

Effect	Statistic	p value
Time	Wilk's lambda=0.216	<0.001

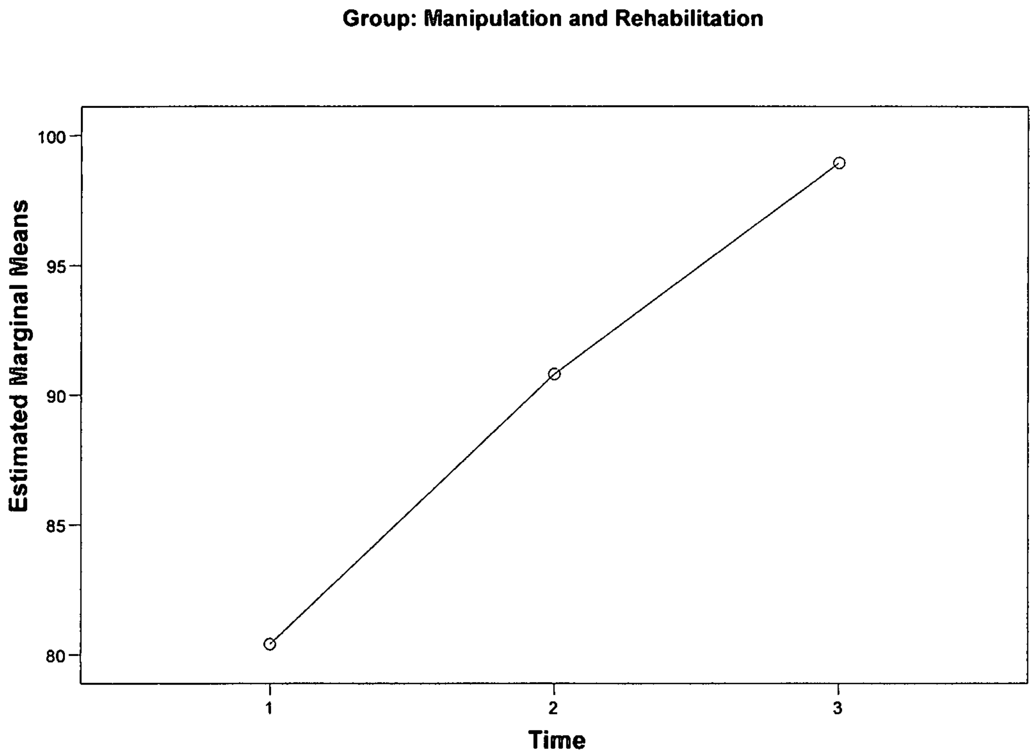


Figure 4.2: Profile plot for FADI over time in the Manipulation and Rehabilitation Group

Rehabilitation only:

This Group received Rehabilitation only to the foot and ankle as a form of intervention.

4.5.3.1.2.1 VAS:

There was a highly statistically significant decrease in VAS over time in this group. There was an average change in score of 17.86mm with the highest change being 59mm and the smallest difference of 1mm. The value of 30% improvement is the MCID for this value and is regarded as both statistically and clinically significant (Farrar *et al.,* 2001). The average percentage change in VAS score noted in this group was 17.846% and this is below the MCID. Therefore the percentage improvement was not regarded as clinically significant for the group as a unit. Of the 15 participants in this group, 13.3% (two out of fifteen participants) made a clinically significant change in their VAS score, and 0% (zero out of fifteen participants) reported no pain (i.e. 0mm on the scale) by visit seven. The breakdown of this percentage improvement is indicated below:

Table 4.9: Breakdown of clinically significant improvements made by participants

% Improvement	Number of participants
1-9%	4
10-19%	5
20-29%	4
*30-39%	1
*40-49%	0
*50-59%	1

**indicates clinically significant improvement was made*

Table 4.10: Repeated measures ANOVA for VAS in the Rehabilitation Group

Effect	Statistic	*p* value
Time	Wilk's lambda=0.260	<0.001

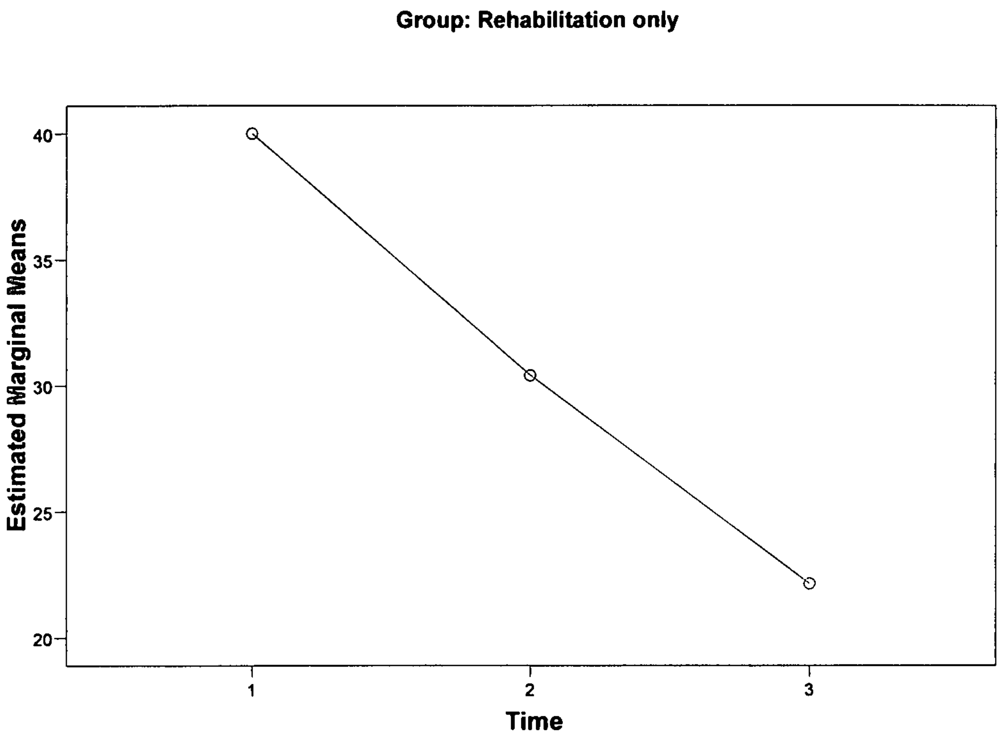


Figure 4.3: Profile plot for VAS over time in the Rehabilitation Group

4.5.3.1.2.2 FADI:

Table 4.11: Breakdown of each participant's progress in the study

Patient	Visit 1	Visit 5	Visit 7	Number of points improved	MDC achieved
1	90	100	102(*)	12	Yes
2	57	60	81	24	Yes
3	73	76	79	6	Yes
4	87	87	96	9	Yes
5	57	90	94	37	Yes
6	81	84	94	13	Yes
7	74	68	90	16	Yes
8	87	94	99	12	Yes
9	86	98	98	12	Yes
10	73	89	100(*)	27	Yes
11	64	72	75	11	Yes
12	88	98	101(*)	13	Yes
13	86	81	86	0	No
14	80	92	98	18	Yes
15	55	71	77	22	Yes

(*) Highest total score for this scale is 104/104 – which was not achieved by any participants however a score of over 100 was achieved by three.

There was a highly significant increase in FADI scores over time in this group. The average change in score for the FADI in this group was 15.46 points. The greatest change in the group was 37 points and the smallest change was 0 points. It must be noted that for FADI to be deemed clinically significant in this group, an improvement of eight points must be made (Eechaute *et al.,* 2007). The average change of 15.46 points is therefore deemed as clinically significant for this group as a unit. From this group, 86.6% (thirteen out of fifteen participants) made a clinically significant improvement individually. None of the participants (zero out of fifteen) made a full recovery (i.e.104/104 for this scale) in terms of foot function. The data is shown in the table below:

Table 4.12: Breakdown of clinically significant improvements made by participants

Points improvement	Number of participants
0-8%	2
*9-19%	9
*20-25%	2
*26-39%	2

**indicates clinically significant improvement was made*

Table 4.13: Repeated measures ANOVA for FADI in the Rehabilitation Group

Effect	Statistic	*p* value
Time	Wilk's lambda=0.217	<0.001

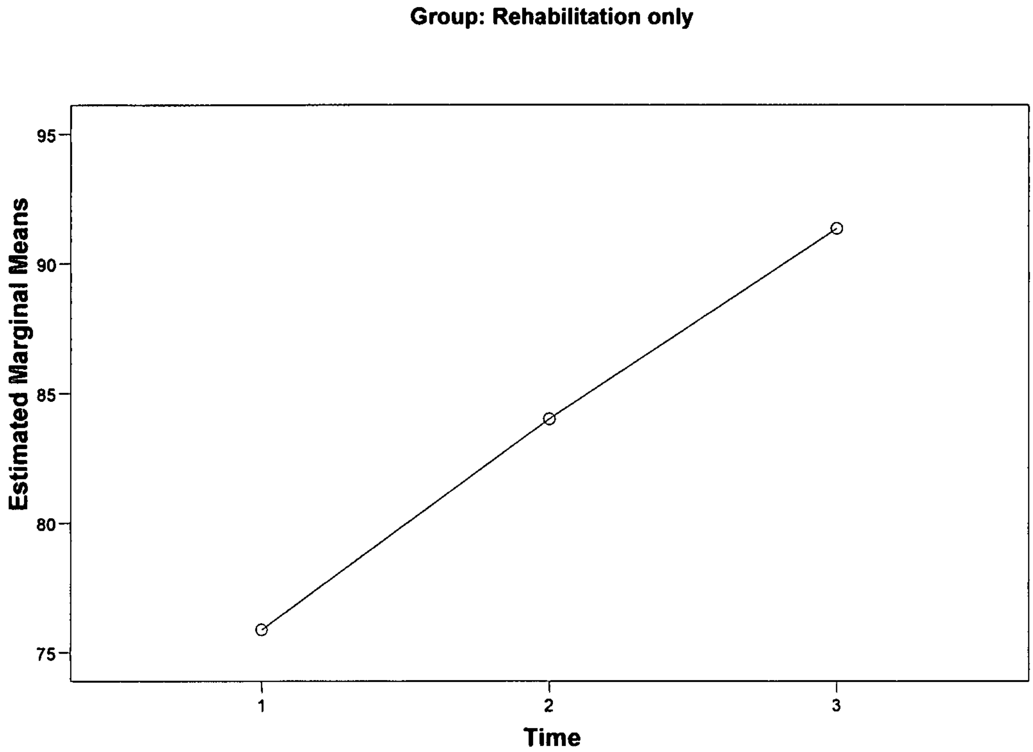


Figure 4.4: Profile plot for FADI over time in the Rehabilitation Group

4.5.3.2 To assess the intra-Group changes over time with regard to the objective clinical findings

4.5.3.2.1 Manipulation and Rehabilitation:

4.5.3.2.1.1 Algometer

There was a highly significant increase in algometer readings over time in this group. The average improvement made by this group was 1.23kg.cm^{2}. The highest average change noted in this group between visit one and seven was 3.1kg.cm^{2} and the lowest was 0kg.cm^{2}. According to Chesterton *et al.*, (2007) a MCID of an improvement of 1.77kg.cm^{2} is required in order for algometry readings to be deemed clinically significant. The average improvement of 1.23kg.cm^{2} was not sufficient to deem this reading as clinically significant for this whole group. However, clinically significant improvement was noted in 26.6% (four out of fifteen of the participants) who made a greater than 1.77kg.cm^{2} improvement.

Table 4.14: Repeated measures ANOVA for Algometer in the Manipulation and Rehabilitation Group

Effect	Statistic	*p* value
Time	Wilk's lambda=0.300	<0.001

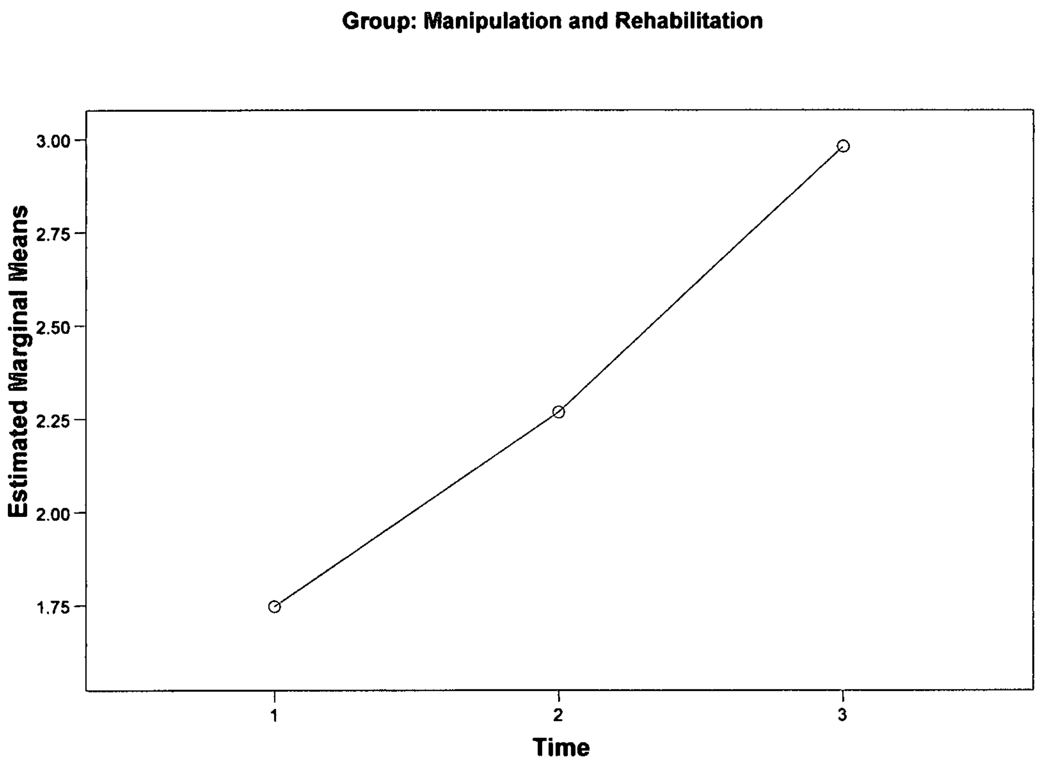


Figure 4.5: Profile plot for Algometer reading over time in the Manipulation and Rehabilitation Group

4.5.3.2.1.2 Motion palpation

Table 4.15 Breakdown of fixations remaining between visits one, five and seven for the Manipulation and Rehabilitation Group.

Participant	Number of fixations at visit one	Number of fixations at visit five	Number of fixations at visit seven
1	4	5	2
2	4	4	2
3	3	3	2
4	3	2	1
5	3	2	1
6	3	3	1
7	3	2	1
8	4	2	1
9	3	2	1
10	3	3	2
11	3	4	1
12	3	4	1
13	3	2	1
14	3	2	0
15	3	2	1

There was a highly statistically significant decrease in number of fixations over time in this group. In this group the participants had an average number of three fixations on visit one. The highest number being four fixations and the lowest being three. Visit one motion palpation findings revealed that 80% (twelve out of fifteen participants) began the study with three fixations and 20% (three out of fifteen) began with four fixations. A more in depth breakdown revealed that between visit one and five there was an increase of one fixation in 20% (three out of fifteen participants), with 26.7% (four out of fifteen participants) the number of fixations remained the same, a decrease of one fixation occurred in 46.7% (seven out of fifteen participants) and, a decrease of two fixations occurred in 6.7% (one out of fifteen participants). However, by visit seven 100% (fifteen out of fifteen participants) had a decrease in the number of fixations, compared to visit one. Here, a more in depth breakdown revealed that, by visit seven an increase in the number of fixations occurred in 0% (zero out of fifteen participants) while 0% (zero out of fifteen participants) remained the same and a decrease of one fixation occurred in 13.3% (two out of fifteen participants), a decrease in two fixations was noted in 73.3% (eleven out of fifteen participants), and a decrease of three fixations occurred in 13.3% (two out of fifteen participants).

Table 4.16: Repeated measures ANOVA for motion palpation in the Manipulation and Rehabilitation Group

Effect	Statistic	*p* value
Time	Wilk's lambda=0.065	<0.001

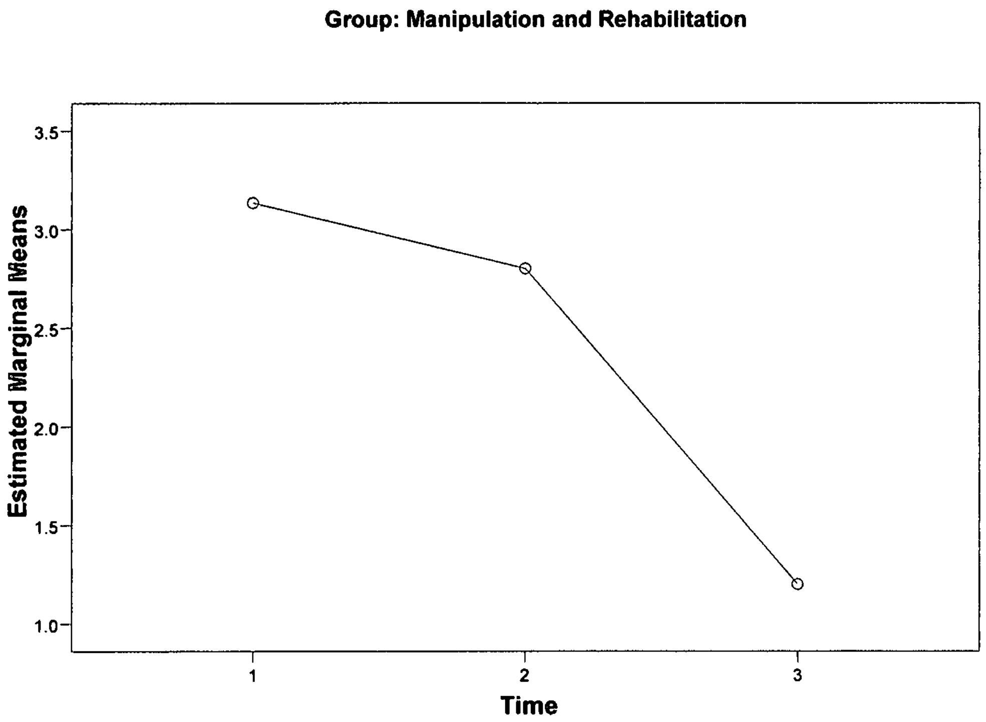


Figure 4.6: Profile plot for motion palpation over time in the Manipulation and Rehabilitation Group

4.5.3.2.1.3 WBD

Table 4.17: Breakdown of each participant's progress in the study in the Manipulation and Rehabilitation Group

Patient	Visit 1	Visit 5	Visit 7	Improvement in reading (cm)	MCID achieved
1	4.6	8.6	11.5	6.9	Yes
2	8.5	9.4	9.1	0.6	No
3	6.5	10.7	10.7	4.2	Yes
4	15.5	16.4	16.7	1.2	Yes
5	5.8	6.5	6.7	0.9	No
6	5.5	9.4	9.7	4.2	Yes
7	11.1	13.6	16.2	5.1	Yes
8	9.6	11	11.5	1.9	Yes
9	2.7	9.8	12.5	9.8	Yes
10	5.1	10.1	9.9	4.8	Yes
11	5	5.5	5.5	0.5	No
12	2.2	2.7	8.3	6.1	Yes
13	5.1	3.8	6.4	1.3	Yes
14	5	7.1	10.8	5.8	Yes
15	1.3	3.5	4.3	3.0	Yes

There was a highly statistically significant increase in WBD readings over time in the Manipulation and Rehabilitation Group. It must be noted that this group made an average of 3.75cm improvement between visits one and seven. The largest improvement that was made was 9.8cm and the smallest was 0.5cm. An increase of about 0.4-0.5cm ankle dorsiflexion appears significant, while a 1cm increase is generally considered clinically important (Green *et al.*, 2001 and Vicenzino *et al.*, 2006). Clinically significant improvement was therefore noted in this group (improvement of 3.75cm as an average as mentioned above). Within this group, 80% (twelve out of fifteen participants) made clinically significant improvements by visit seven and all participants showed some improvement in the WBD parameter.

Table 4.18: Repeated measures ANOVA for WBD in the Manipulation and Rehabilitation Group

Effect	Statistic	*p* value
Time	Wilk's lambda=0.331	0.001

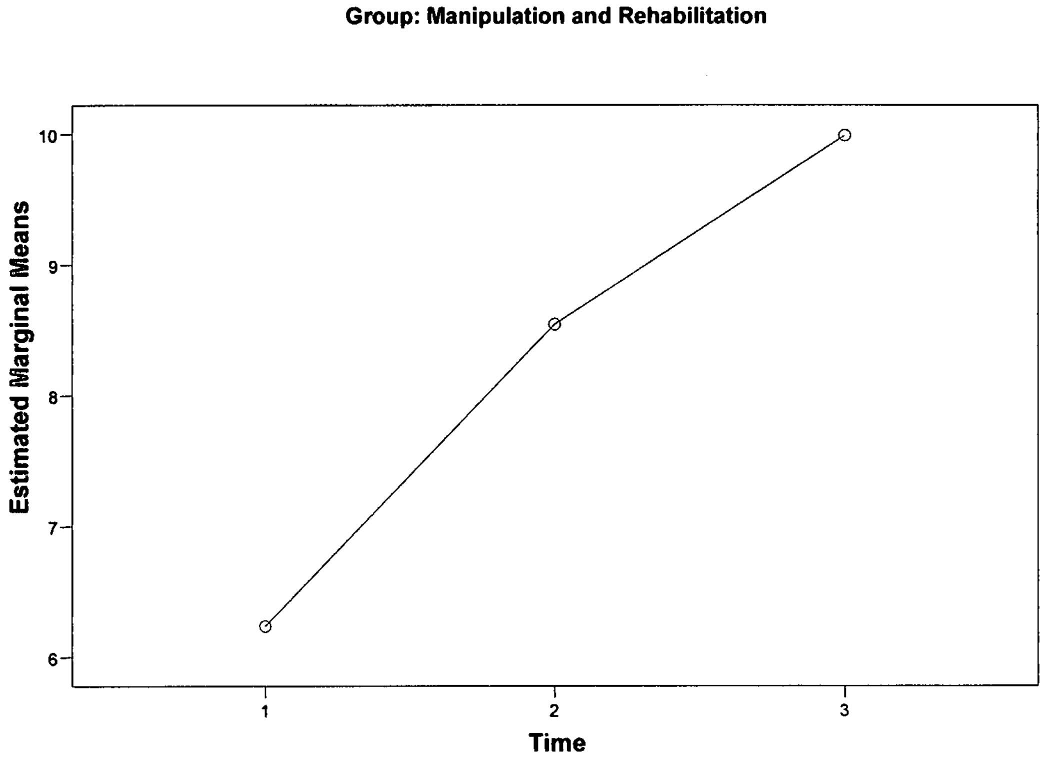


Figure 4.7: Profile plot for WBD over time in the Manipulation and Rehabilitation Group

4.5.3.2.1.4 BBS

Table 4.19: Breakdown of each participant's progress in the study

Patient	Visit 1	Visit 5	Visit 7	Change in score	MDC achieved
1	37	48	54	17	YES
2	43	53	56(*)	13	YES
3	45	51	56(*)	11	YES
4	44	54	56(*)	12	YES
5	44	47	56(*)	12	YES
6	43	55	56(*)	13	YES
7	44	54	55	11	YES
8	43	65	56(*)	13	YES
9	44	52	56(*)	12	YES
10	45	55	56(*)	11	YES
11	35	35	50	15	YES
12	38	52	56(*)	18	YES
13	43	53	56(*)	13	YES
14	43	55	56(*)	13	YES
15	44	52	54	10	YES

(*) Highest total score for this scale is 56/56 – which was achieved by eleven participants by visit seven.

There was a highly statistically significant increase in BBS readings over time in this group. All the participants made some degree of improvement, and an average of 12.9 points between visits one and seven was noted in this group. The highest amount of change noted, was an improvement by 18 points and the lowest was by 10 points. The accepted MDC for this scale is 3.3 points for participants that fall into the 45-56 category and 4.9 points in the 35-44 point categories (Donoghue and Stokes, 2009) and the average score for this group meet the required MDC in all categories between visit one and seven (but not between visit one and five or visit five and seven). The MCID is yet to be established at this point for this outcome measure (Donoghue and Stokes, 2009). It is important to note that if the amount of improvement in points of individual participants are analysed in this group, it can be observed that all participants started at a value between 35 and 45 and all reached between 50 and 56 by visit seven. A score of 56 points was reached by 73.3% (eleven out of fifteen participants) of the participants, 55 points by 6.6% (one out of fifteen participants), 54 points by 13.5.% (two out of fifteen participants) and 50 points by 6.6% (one out of fifteen participants).

Table 4.20: Repeated measures ANOVA for BBS in the Manipulation and Rehabilitation Group

Effect	Statistic	*p* value
Time	Wilk's lambda=0.226	<0.001

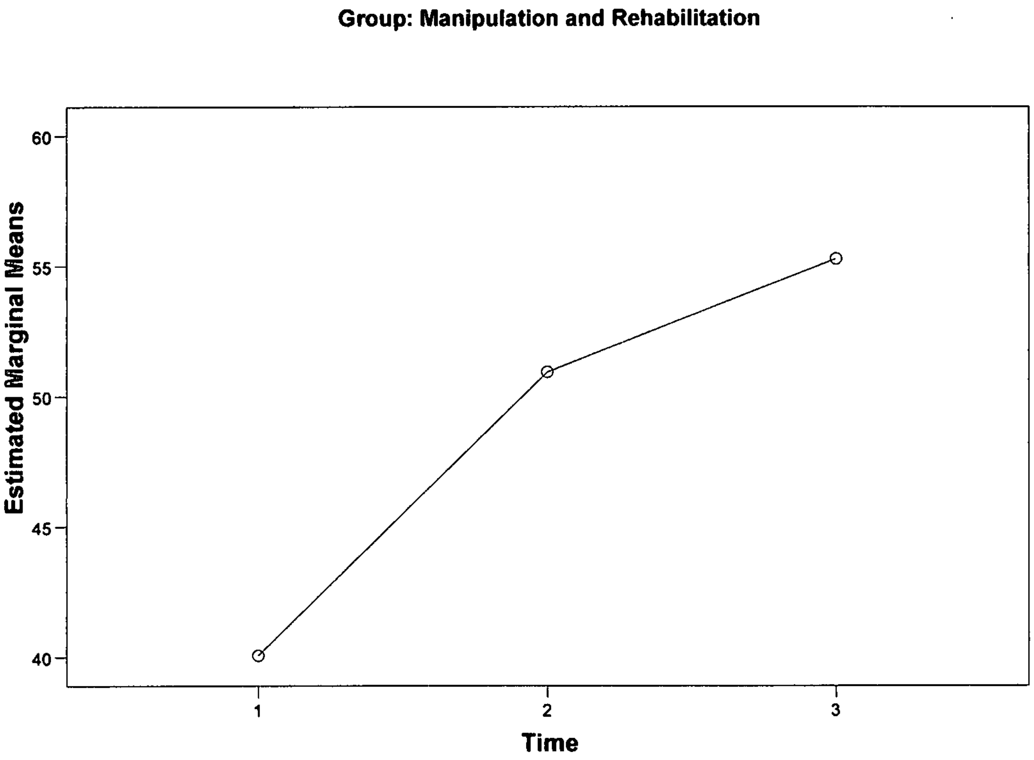


Figure 4.8: Profile plot for BBS over time in the Manipulation and Rehabilitation Group

4.5.3.2.2 Rehabilitation only

4.5.3.2.2.1 Algometer

There was no significant statistical change in algometer readings over time in this group. The average change in algometer score was noted as 0.16kg.cm^2. The highest average change between visit one and seven was an increased value of 0.9kg.cm^2. The lowest change that was made was a value of 1.2kg.cm^2 lower than the initial reading on visits one, and thus describes a worsening of symptoms in that time. A MCID of 1.77kg.cm^2 is deemed as clinically significant. The group average was far below the MCID. Therefore, a clinically significant improvement was not noted in this group. No participants (zero out of fifteen participants) in this study made an improvement of more than 1.77kg.cm^2, indicating that none of the participants made a clinically significant improvement.

Table 4.21: Repeated measures ANOVA for Algometer in the Rehabilitation Group

Effect	Statistic	*p* value
Time	Wilk's lambda=0.904	0.519

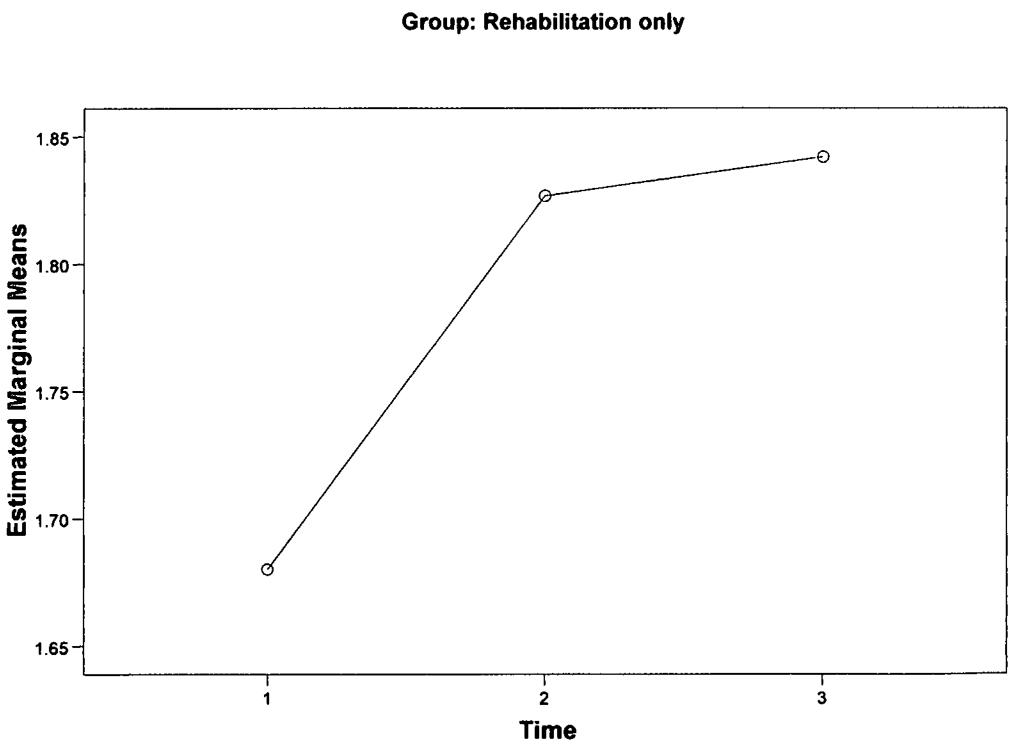


Figure 4.9: Profile plot for Algometer readings over time in the Rehabilitation Group

4.5.3.2.2.2 Motion palpation

Table 4.22 Breakdown of fixations remaining between visits one, five and seven for the Rehabilitation only Group.

Participant	Number of fixations remaining at visit one	Number of fixations remaining at visit five	Number of fixations remaining at visit seven
1	3	5	5
2	3	6	5
3	4	4	4
4	2	3	3
5	2	3	3
6	3	4	4
7	3	4	4
8	3	3	3
9	4	5	4
10	3	3	3
11	3	4	4
12	3	4	4
13	3	3	3
14	3	3	3
15	3	3	3

There was a significant increase in the number of fixations over time in this group. In this group the average number of fixations noted on visit one was three. The highest number of fixations that was noted was four and the lowest two. Visit one motion palpation findings revealed that that 13.3% (two out of fifteen participants) had two fixations at the outset of the study, 73.4% (eleven out of fifteen participants) had three fixations at the outset and 13.3% (two out of fifteen participants) had four fixations. A more in depth breakdown revealed that between visit one and five that an increase in one fixation occurred in 46.7% (seven out of fifteen participants), an increase of two fixations occurred in 6.7% (one out of fifteen participants) and an increase of three fixations occurred in 6.7% (one out of fifteen participants) and 40% (six out of fifteen participants) had no change in fixations by visit five. A decrease in fixations by visit five was not evident in any participant's in this Group. A more in depth breakdown of this data demonstrated that in comparison to visit five, by visit seven an increase of two fixations had occurred in 13.3% (two out of fifteen participants), an increase of one fixation had occurred in 40% (six out of fifteen participants), 47% (seven out of fifteen participants) had no change in the number of fixations and 0% (zero out of fifteen participants) had a decrease in fixations compared to visit one.

Table 4.23: Repeated measures ANOVA for motion palpation in the Rehabilitation Group

Effect	Statistic	*p* value
Time	Wilk's lambda=0.511	0.013

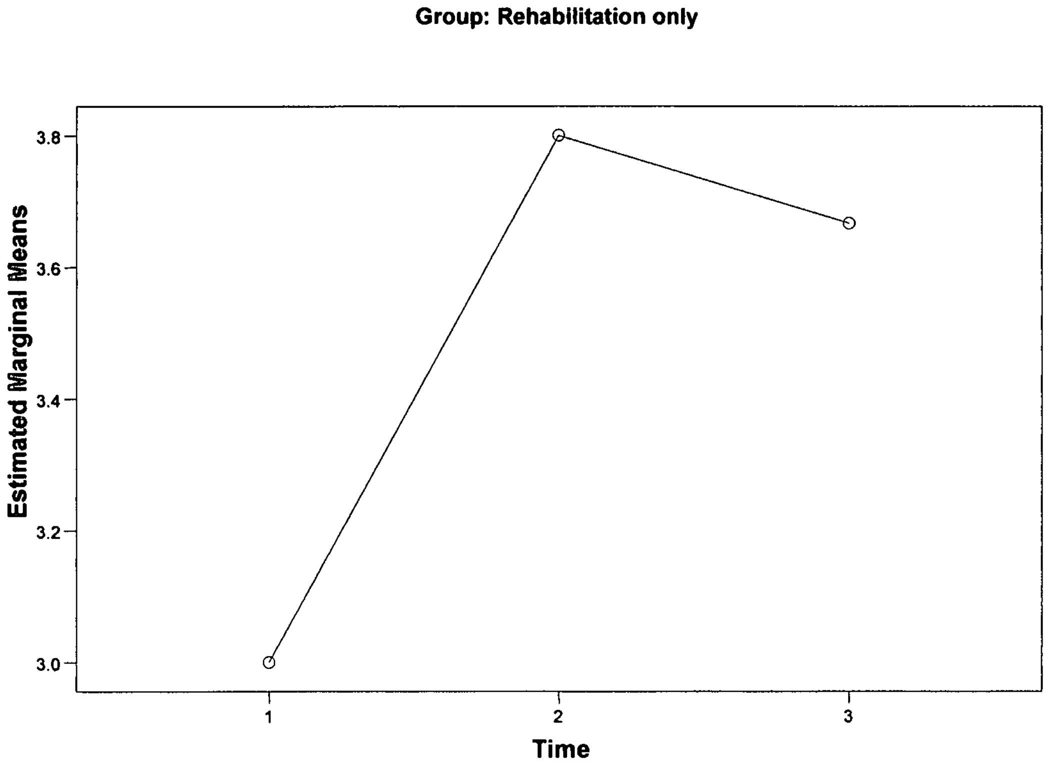


Figure 4.10: Profile plot for motion palpation over time in the Rehabilitation Group

4.5.3.2.2.3 WBD

Table 4.24: Breakdown of each participant's progress in the study

Patient	Visit 1	Visit 5	Visit 7	Improvement in reading (cm)	MDC achieved
1	12.4	16.8	12.2	-0.2	NA
2	1	3.6	3.6	2.6	NA
3	9.6	10.8	12.2	2.6	NA
4	6.2	8	10.2	4	NA
5	5.9	16.7	16.6	10.7	NA
6	11.3	10.8	11.3	0	NA
7	5.6	6.5	7.3	1.7	NA
8	6.4	5.7	6.5	0.1	NA
9	7.6	8.7	8.8	1.2	NA
10	3.5	3.7	9.6	6.1	NA
11	4.8	4.9	5.9	1.1	NA
12	8.4	13	13.1	4.7	NA
13	4.8	7.4	6.1	1.3	NA
14	1.8	9.2	10.7	8.9	NA
15	5.4	6.3	5.3	-0.1	NA

There was a significant increase in WBD readings over time in this group. The average change in score for this parameter within this group was 2.98cm. The highest increase was 10.7cm within this group and the smallest change was 0cm. It must be noted that in this group a negative change (not noted in any participant in the Manipulation and Rehabilitation Group) of 0.2cm (in one participant) and 0.1cm (in another participant) was observed. This indicated a worsening of WBD range of motion results in comparison to visit one in 13% (two out of fifteen participants). It was observed that one participant made no change in readings from visit one to seven, and all other participants (twelve out of fifteen participants) improved by at least 0.1cm. An increase of 0.4-0.5cm ankle dorsiflexion appears significant while a 1cm increase is generally considered clinically important (Green *et al.,* 2001 and Vicenzino *et al.,* 2006). The Group average improvement of 2.98cm is considered as clinically significant and 73% (eleven out of fifteen participants) individually made clinically significant improvements. In summary, 73% (eleven out of fifteen participants) made clinically significant improvements, 6.7% (one out of fifteen participants) made no change in readings and 13% (two out of fifteen participants) had a worsening of weight bearing ankle dorsiflexion.

Table 4.25: Repeated measures ANOVA for WBD in the Rehabilitation Group

Effect	Statistic	p value
Time	Wilk's lambda=0.538	0.018

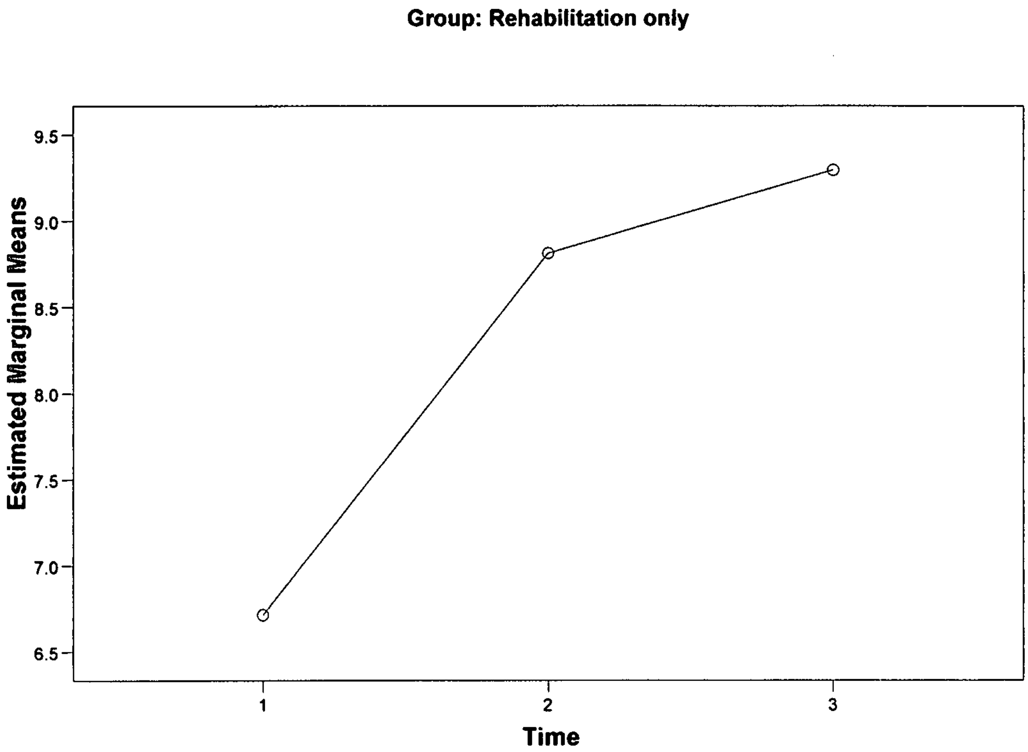


Figure 4.11: Profile plot for WBD over time in the Rehabilitation Group

4.5.3.2.2.4 BBS:

Table 4.26: Breakdown of each participant's progress in the study

Patient	Visit 1	Visit 5	Visit 7	change in score	MDC achieved
1	45	54	54	10	Yes
2	40	42	49	9	Yes
3	43	54	55	12	Yes
4	45	55	55	10	Yes
5	45	55	56(*)	11	Yes
6	43	51	55	12	Yes
7	45	54	55	10	Yes
8	45	53	54	9	Yes
9	43	51	54	11	Yes
10	45	48	55	10	Yes
11	39	50	55	16	Yes
12	45	53	55	10	Yes
13	44	44	55	11	Yes
14	45	45	55	10	Yes
15	40	40	51	11	Yes

(*) Highest total score for this scale is 56/56 – which was achieved by one participant by visit seven.

There was a highly statistically significant increase in BBS over time in this group. The participants within this group all made improvements in terms of this scale with an average of 10.73 points between visit one and visit seven. The highest point score increase was 16 points and the lowest was 9 points. At present, no MCID exists so clinical importance cannot be measured (Donohugue and Stokes, 2009). MDC is 3.3 points for participants in the 45-56 point category and 4.9 points in the 35-44 categories. All participants in this group began with scores in the range between 39 and 45 points and all reached between 49 and 56 points by visit seven. Of the fifteen participants, only 6.6% (one out of fifteen participants) reached the full score of 56 points, 60% (nine out of fifteen participants) of the participants reached 55 points, 20% (three out fifteen participants) reached 54 points, 6.6% (one out of fifteen participants) reached 51 points and 6.6% reached the 49 point score.

Table 4.27: Repeated measures ANOVA for BBS in the Rehabilitation Group

Effect	Statistic	*p* value
Time	Wilk's lambda=0.024	<0.001

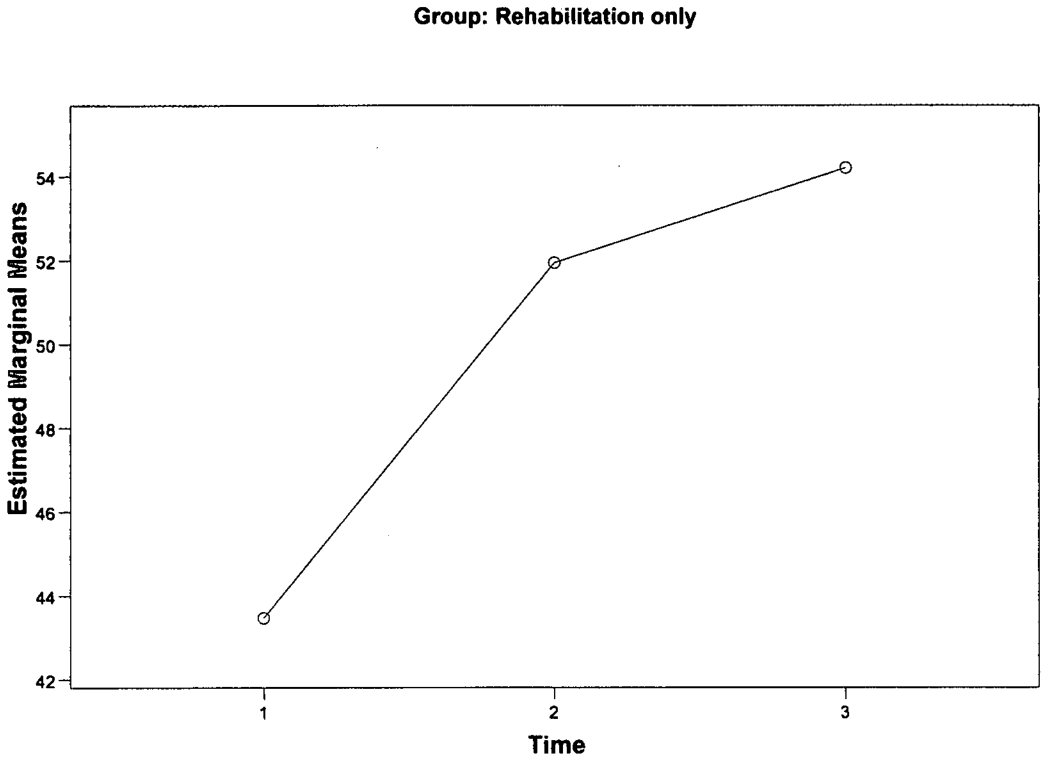


Figure 4.12: Profile plot for BBS over time in the Rehabilitation Group

Table 4.28: Summary table to compare intra-Group analysis differences between both Groups (as discussed above)

Intra-Group analysis of Manipulation and Rehabilitation Group			**Intra-Group analysis of Rehabilitation only Group**		
Variable	**Statistical**	***p* value**	**Variable**	**Statistical**	***p* value**
VAS	Wilk's lambda=0.139	<0.001(*)	**VAS**	Wilk's lambda=0.260	<0.001(*)
FADI	Wilk's lambda=0.216	<0.001(*)	**FADI**	Wilk's lambda=0.217	<0.001(*)
Algometer	Wilk's lambda=0.300	<0.001(*)	**Algometer**	Wilk's lambda=0.904	0.519
Motion Palpation	Wilk's lambda=0.065	<0.001(*)	**Motion Palpation**	Wilk's lambda=0.511	0.013
WBD	Wilk's lambda=0.331	0.001(*)	**WBD**	Wilk's lambda=0.538	0.018
BBS	Wilk's lambda=0.226	<0.001(*)	**BBS**	Wilk's lambda=0.024	<0.001(*)

( )Indicates statistically significant improvements.*

The summary table above compares all the intra-Group analysis for the Manipulation and Rehabilitation Group and the Rehabilitation only Group. As can be seen from Table 4.25 and the results discussed above, the Manipulation and Rehabilitation Group made statistically significant changes in all six parameters for this study. This is in comparison to the Rehabilitation only Group, where statistical significance was achieved in only half (i.e. three) of the parameters.

4.5.4 Inter-Group analysis

4.5.4.1 To assess the inter-Group treatment (for the Manipulation and Rehabilitation Group and the Rehabilitation only Group) effect over time with regard to the subjective clinical findings

4.5.4.1.1 VAS:

There was a statistically significant treatment effect for VAS (p=0.002). Figure 4.13 shows that the slope of the profile is steeper in the Manipulation and Rehabilitation Group over time compared with the Rehabilitation only Group, thus indicating that the Manipulation combined with Rehabilitation was significantly more effective. Therefore, although the intra-group analysis reveals that both treatment groups made statistically significant improvements (p<0.001), the Manipulation and Rehabilitation Group were able to make greater improvements (reduction in pain score on the scale) in a shorter time period in comparison to the Rehabilitation only Group, which suggested a faster rate of change over time. When clinical significance was compared between the two Groups, it was observed that clinically significant improvements were achieved by 66% (ten out of fifteen participants) of the participants in the Manipulation and Rehabilitation Group, in comparison to 13.3% (two out of fifteen participants) in the Rehabilitation only Group.

Table 4.29: Repeated measures ANOVA of between and within participant's effects for VAS

Effect	Statistic	*p* value
Time	Wilk's lambda=0.198	<0.001
Time*Group	Wilk's lambda=0.626	0.002
Group	F=1.401	0.207

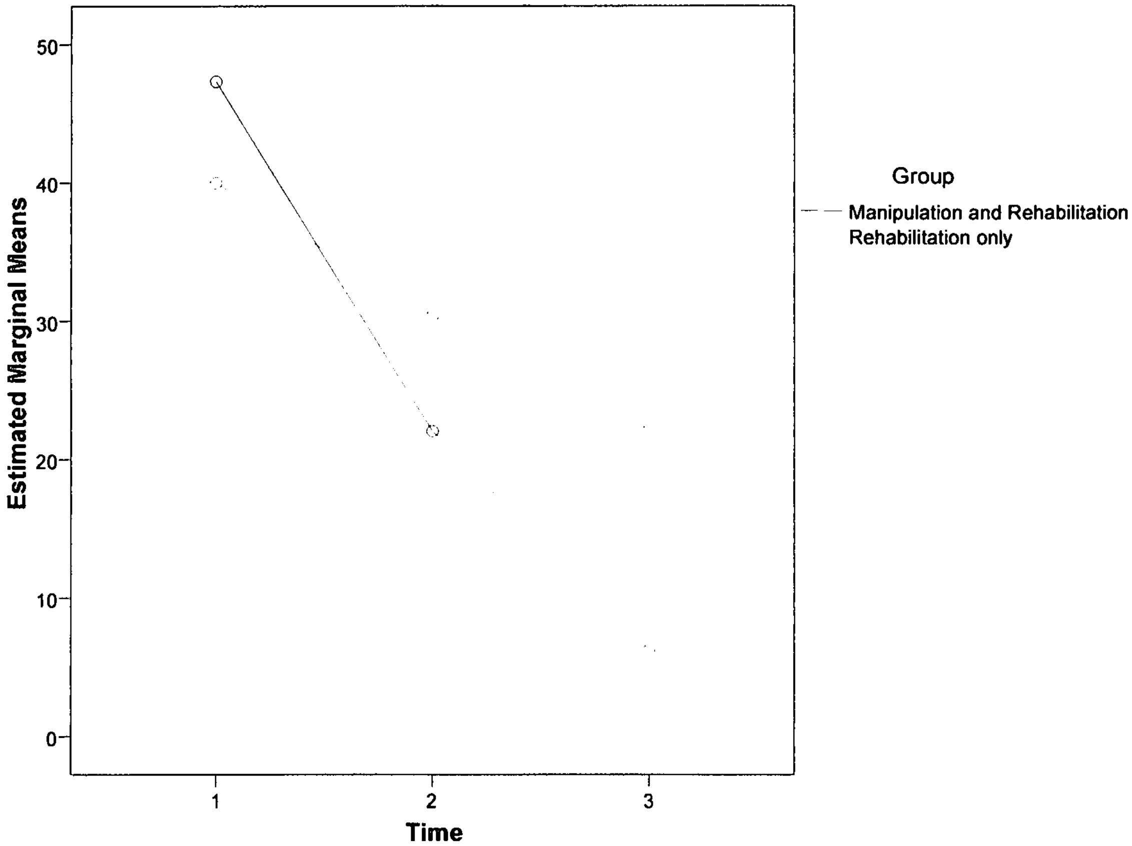


Figure 4.13: Profile plot of VAS by time and Group

4.5.4.1.2 FADI

There was no difference in effect between the two treatment groups for this outcome (p=0.705). The profile plots shows that the rate of increase over time was the same in both groups; therefore, the manipulation and rehabilitation had no effect on this outcome. This is evident from the intra-group analysis where both Manipulation and Rehabilitation and the Rehabilitation only Group made statistically significant changes (p<0.001) and clinical significance was achieved by 86.6% (thirteen out of fifteen participants) in both groups. There were no statistically or clinically significant differences between the two Groups.

Table 4.30: Repeated measures ANOVA of between and within participant's effects for FADI

Effect	Statistic	*p* value
Time	Wilk's lambda=0.219	<0.001
Time*Group	Wilk's lambda=0.974	0.705
Group	F=3.363	0.077

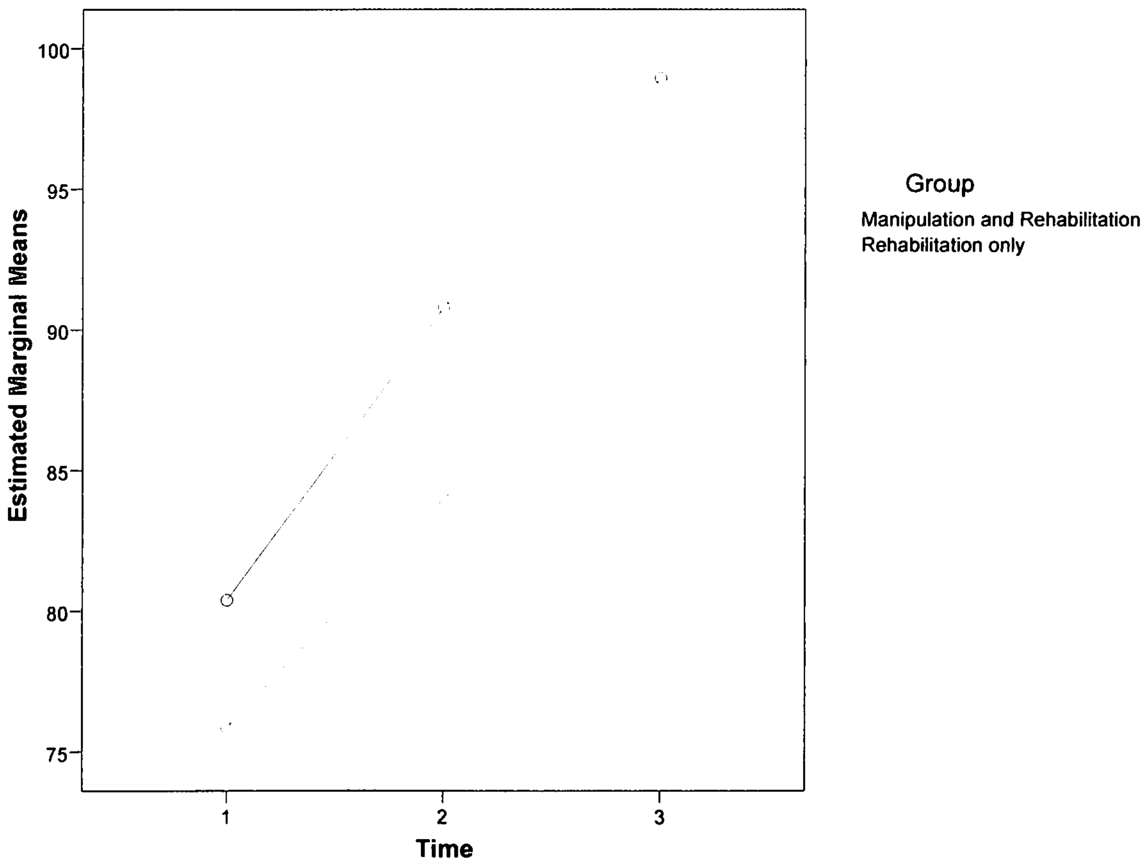


Figure 4.14: Profile plot of FADI by time and Group

4.5.4.2 To assess the inter-Group treatment effect over time with regard to the objective clinical findings

4.5.4.2.1 Algometer

There was a statistically significant treatment effect for algometer readings (p=0.002). Figure 4.15 shows that the slope of the increase is steeper in the Manipulation and Rehabilitation Group over time compared with the Rehabilitation Group, thus the Manipulation and Rehabilitation was significantly effective and suggested a faster rate of change over time. Intra-group analysis results revealed that although statistical significance was met in the Manipulation and Rehabilitation Group (p<0.001) this was not the case in the Rehabilitation only Group (p=0.519). When clinical significance was compared between the two groups, it was observed that clinically significant improvements were achieved by 26.6%(four out of fifteen participants) in the Manipulation and Rehabilitation Group as compared to 0% in the Rehabilitation only Group.

Table 4.31: Repeated measures ANOVA of between and within participant's effects for Algometer

Effect	Statistic	p value
Time	Wilk's lambda=0.539	<0.001
Time*Group	Wilk's lambda=0.639	0.002
Group	F=2.113	0.157

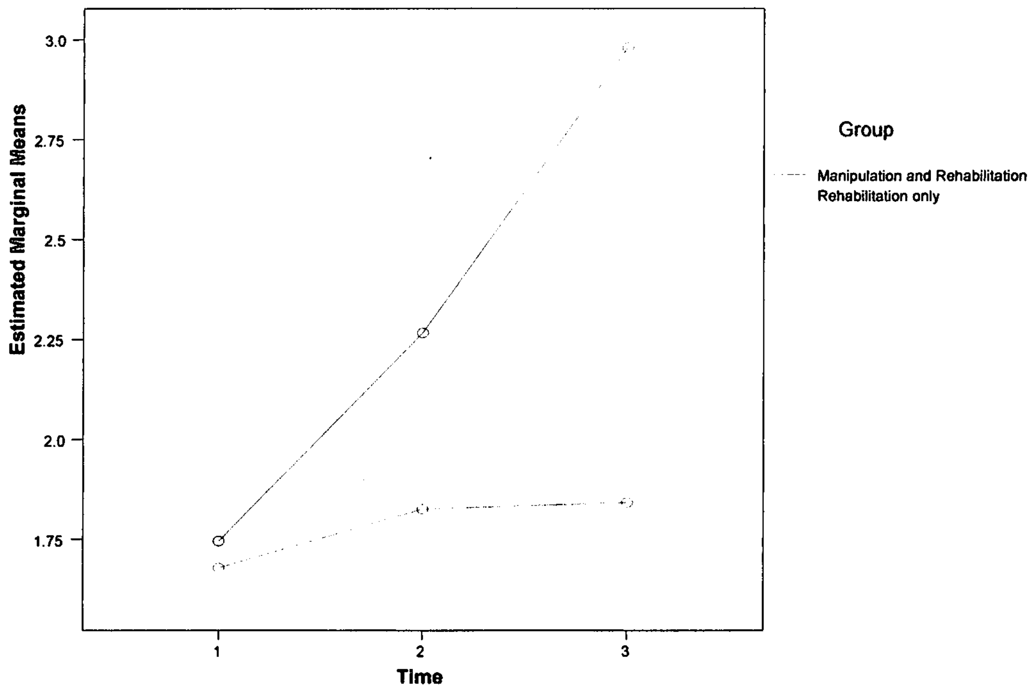


Figure 4.15: Profile plot of algometer readings by time and Group

4.5.4.2.2 Motion palpation:

There was a highly statistically significant treatment effect for number of fixations (p<0.001). The plot shows that there was a decrease in the Manipulation and Rehabilitation Group and a contrasting increase in the Rehabilitation only Group. In summary, for the Manipulation and Rehabilitation Group, there was a decrease in the number of fixations in 100% (fifteen out of fifteen participants) and an increase in the number of fixations in 0% (zero out of fifteen participants) between visit one and seven. For the Rehabilitation only Group a decrease in the number of fixations occurred in 0% (zero out of fifteen participants), an increase in the number of fixations occurred in 53.3% (eight out of fifteen participants) and 47% (seven out of fifteen participants) remained the same by visit seven. Therefore the Manipulation and Rehabilitation was significantly more effective compared with the Rehabilitation only Group. This is also evident in the intra-group analysis whereby the Manipulation and Rehabilitation Group made a statistically significant improvement (p<0.001) with a decrease in the number of fixations, in comparison to Rehabilitation only Group (p=0.013) where the number of fixations actually increased by visit seven.

Table 4.32: Repeated measures ANOVA of between and within participant's effects for motion palpation

Effect	Statistic	*p* value
Time	Wilk's lambda=0.251	<0.001
Time*Group	Wilk's lambda=0.152	<0.001
Group	F=27.301	<0.001

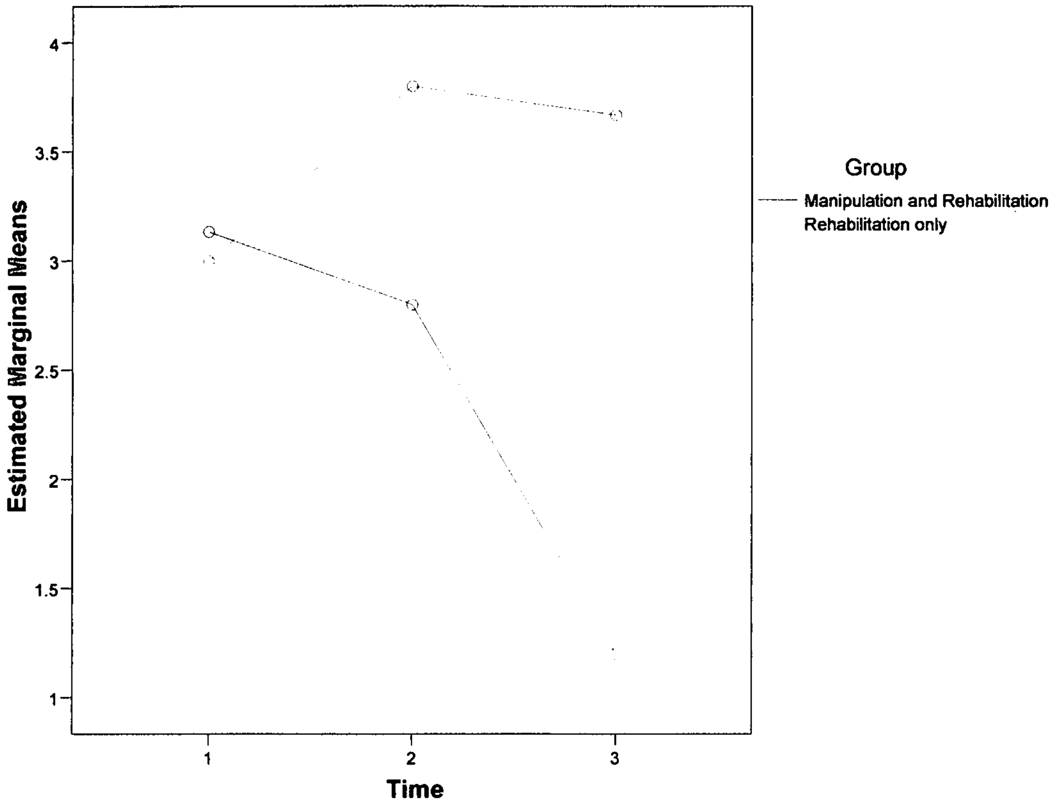


Figure 4.16: Profile plot of motion palpation by time and Group

4.5.4.2.3 WBD

There was no statistical evidence of a Manipulation and Rehabilitation effect for this outcome (p=0.381). However, the profile plot does suggest a trend of a higher rate of increase in the Manipulation and Rehabilitation Group after time two (visit five). Furthermore, Intra-group analysis revealed a highly statistically significant improvement in the Manipulation and Rehabilitation Group (p=0.001), which was not evident in the Rehabilitation only Group (p=0.018). Clinically significant improvement was achieved by 80% (twelve out of fifteen participants) in the Manipulation and Rehabilitation Group and 73% (eleven out of fifteen participants) in the Rehabilitation only Group.

Table 4.33: Repeated measures ANOVA of between and within participant's effects for WBD

Effect	Statistic	p value
Time	Wilk's lambda=0.426	<0.001
Time*Group	Wilk's lambda=0.931	0.381
Group	F=0.00	0.989

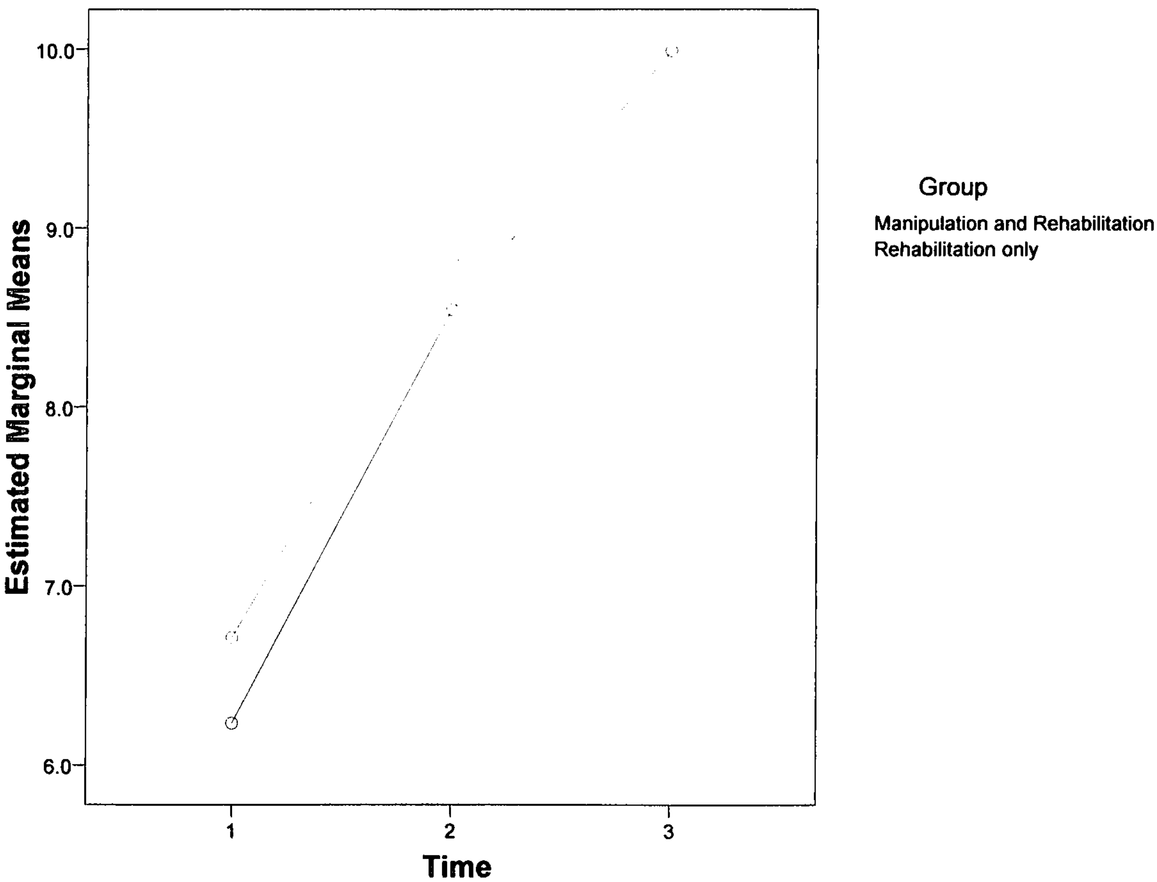


Figure 4.17: Profile plot of WBD by time and Group

4.5.4.2.4 BBS

There was no statistical evidence of a Manipulation and Rehabilitation effect for this outcome (p=0.095) although the profile plot suggests a trend of a higher rate of increase in the Manipulation and Rehabilitation Group after time two (visit five) which suggested a faster rate of change over time for this parameter. From the intra-Group analysis both the Groups made a statistically significant improvement (p<0.001) in this parameter. The MCID is yet to be established and assumptions about clinical significance cannot be addressed. From Table 4.24 it can be observed, that the total score of 56 points was achieved by 73.3% (eleven out of fifteen participants) in the Manipulation and Rehabilitation Group in comparison with the Rehabilitation only Group where only 6.6% (one out of fifteen participants) reached the full score. The score of 55 points was reached by 6.6% (one out of fifteen participants) in the Manipulation and Rehabilitation Group and 60% (nine out of fifteen participants) for the Rehabilitation only Group. If the number of participants who achieved these scores are added up (to allow for clearer interpretation) it can be observed that, the Manipulation and Rehabilitation Group achieved scores of 55 and 56 in 79.9% (twelve out of fifteen participants) of the participants, in comparison to the Rehabilitation only Group where 67% (ten out of fifteen participants) achieved either 55 or 56 points.

Table 4.34: Repeated measures ANOVA of between and within participant's effects for BBS

Effect	Statistic	*p* value
Time	Wilk's lambda=0.194	<0.001
Time*Group	Wilk's lambda=0.840	0.095
Group	F=0.776	0.389

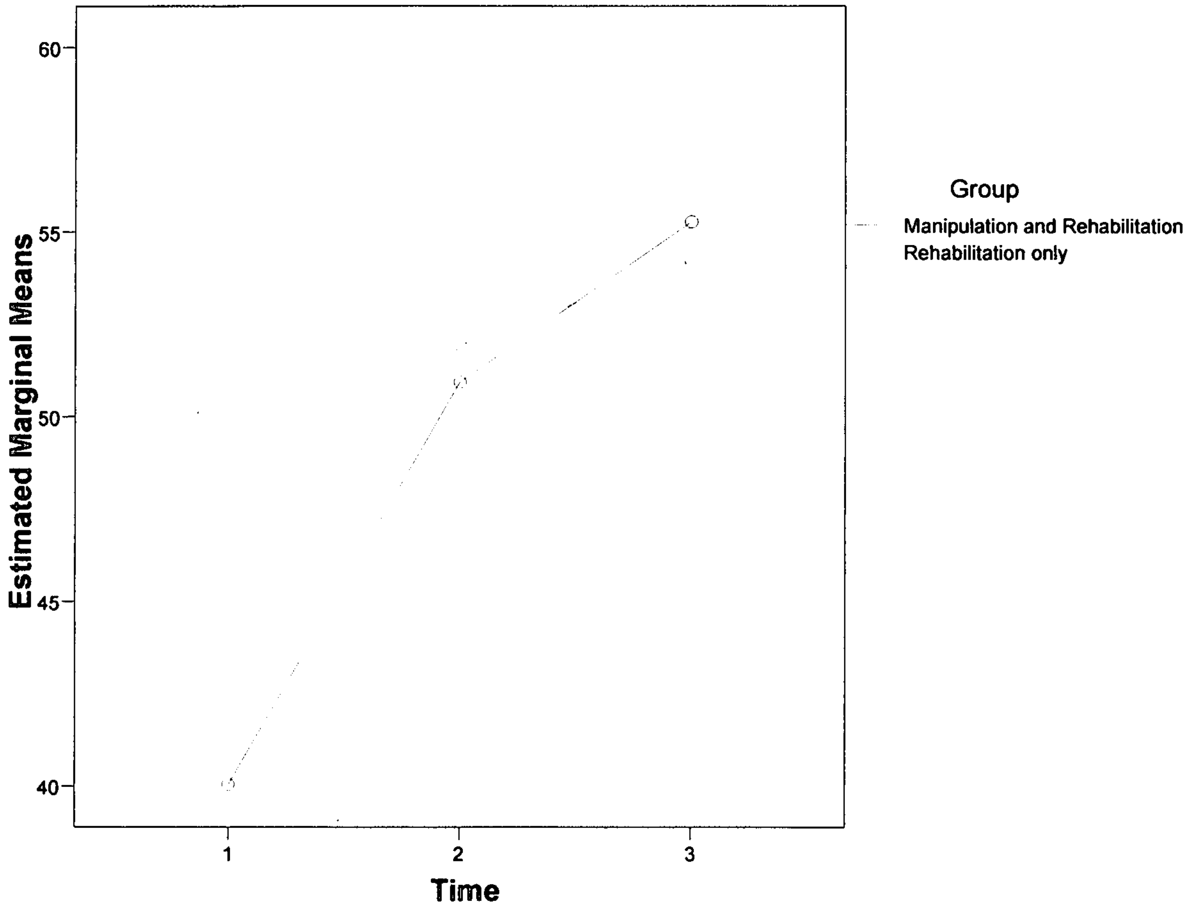


Figure 4.18: Profile plot of BBS by time and Group

Table 4.35: Summary of all inter-Group analysis (as discussed above)

Variable	Effect	Statistic	P value
VAS			
	Time	Wilk's lambda=0.198	<0.001
	Time*Group	Wilk's lambda=0.626	0.002(*)
	Group	F=1.401	0.207
FADI			
	Time	Wilk's lambda=0.219	<0.001
	Time*Group	Wilk's lambda=0.974	0.705(**)
	Group	F=3.363	0.077
Algometer			
	Time	Wilk's lambda=0.539	<0.001
	Time*Group	Wilk's lambda=0.639	0.002(*)
	Group	F=2.113	0.157
Motion palpation			
	Time	Wilk's lambda=0.251	<0.001
	Time*Group	Wilk's lambda=0.152	<0.001(*)
	Group	F=27.301	<0.001
WBD			
	Time	Wilk's lambda=0.426	<0.001
	Time*Group	Wilk's lambda=0.931	0.381(**)
	Group	F=0.00	0.989
BBS			
	Time	Wilk's lambda=0.194	<0.001
	Time*Group	Wilk's lambda=0.840	0.095(**)
	Group	F=0.776	0.389

(*) VAS, Algometer and Motion palpation findings all reveal statistically significant differences in favour of the Manipulation and Rehabilitation Group.
(**) FADI, WBD and BBS show no statistically significant differences between Groups suggesting both Groups fared similarly in terms of these parameters.

The summary of the inter-group analysis (Table 4.33) illustrated that the Manipulation and Rehabilitation Group had a statistically significant treatment effect for VAS, Algometer and Motion palpation findings. However, it is important to note in the case of WBD and BBS, where statistically significant differences were not noted between the two treatment groups, the profile plots suggests a faster rate of change over time in the Manipulation and Rehabilitation Group. FADI readings were neither statistically significant for a treatment effect nor was there a rate of change over time noted in either group.

4.6 TO ASSESS INTRA-GROUP CORRELATIONS BETWEEN CHANGES IN SUBJECTIVE AND OBJECTIVE VARIABLES OVER TIME.

4.6.1 Manipulation and Rehabilitation Group

Table 4.36: Pearson's correlation analysis of changes in outcomes over time in the Manipulation and Rehabilitation Group

		Change in VAS	Change in Algometer	Change in WBD	Change in BBS	Change in FADI	Change in number of fixations
Change in VAS	Pearson Correlation	1	.012	.549(*)	-.198	-.410	.106
	Sig. (2-tailed)		.966	.034	.479	.130	.707
	N	15	15	15	15	15	15
Change in Algometer	Pearson Correlation	.012	1	-.141	-.193	-.135	-.303
	Sig. (2-tailed)	.966		.617	.490	.632	.273
	N	15	15	15	15	15	15
Change in WBD	Pearson Correlation	.549(*)	-.141	1	-.190	-.172	-.082
	Sig. (2-tailed)	.034	.617		.498	.540	.773
	N	15	15	15	15	15	15
Change in BBS	Pearson Correlation	-.198	-.193	-.190	1	.598(*)	-.072
	Sig. (2-tailed)	.479	.490	.498		.019	.799
	N	15	15	15	15	15	15
Change in FADI	Pearson Correlation	-.410	-.135	-.172	.598(*)	1	-.570(*)
	Sig. (2-tailed)	.130	.632	.540	.019		.027
	N	15	15	15	15	15	15
Change in number of fixations	Pearson Correlation	.106	-.303	-.082	-.072	-.570(*)	1
	Sig. (2-tailed)	.707	.273	.773	.799	.027	
	N	15	15	15	15	15	15

* Correlation is significant at the 0.05 level (2-tailed).

As can be seen from Table 4.36 with respect to the Manipulation and Rehabilitation Group, there was a significant positive correlation between change in VAS and change in WBD (r=0.549) as well as change in FADI and change in BBS (r=0.598). This implied that an increase in one score was accompanied by an increase in the other and vice versa. There was a significant negative correlation between change in number of fixations and change in FADI (r= - 0.570). This meant that as the number of fixations decreased, FADI score increased. These statistically significant correlations have been highlighted in red in the Table above.

4.6.2 Rehabilitation only Group

Table 4.37: Pearson's correlation analysis of changes in outcomes over time in the Rehabilitation Group

		Change in VAS	Change in Algometer	Change in WBD	Change in BBS	Change in FADI	Change in number of fixations
Change in VAS	Pearson Correlation	1	-.256	-.306	.105	-.374	.060
	Sig. (2-tailed)		.358	.267	.710	.170	.831
	N	15	15	15	15	15	15
Change in Algometer	Pearson Correlation	-.256	1	.164	.078	.050	.439
	Sig. (2-tailed)	.358		.559	.783	.858	.102
	N	15	15	15	15	15	15
Change in WBD	Pearson Correlation	-.306	.164	1	-.084	.645(**)	.041
	Sig. (2-tailed)	.267	.559		.767	.009	.886
	N	15	15	15	15	15	15
Change in BBS	Pearson Correlation	.105	.078	-.084	1	-.193	-.132
	Sig. (2-tailed)	.710	.783	.767		.490	.640
	N	15	15	15	15	15	15
Change in FADI	Pearson Correlation	-.374	.050	.645(**)	-.193	1	.177
	Sig. (2-tailed)	.170	.858	.009	.490		.527
	N	15	15	15	15	15	15
Change in number of fixations	Pearson Correlation	.060	.439	.041	-.132	.177	1
	Sig. (2-tailed)	.831	.102	.886	.640	.527	
	N	15	15	15	15	15	15

** Correlation is significant at the 0.01 level (2-tailed).

As can be seen from Table 4.37 with respect to the Rehabilitation only Group, a change in FADI and change in WBD were positively correlated (r=0.645), therefore as one score increased so did the other. These statistically significant correlations are highlighted in the Table above.

4.7 CONCLUSION

As it can be seen by the results displayed in Chapter Four subjective and objective changes were illustrated in both of the treatment groups. Baseline readings and demographics were presented to provide a clearer indication of the sample population characteristics. Overall positive readings were noted in most subjective and objective parameters and negative readings (a worsening parameter results) was noted in certain subjective and/or objective parameter results. Both statistically and clinically significant parameters were presented.

CHAPTER FIVE

5.1 Introduction

All results that were presented in Chapter Four will be discussed in greater detail within this Chapter. The main focus of this Chapter is to present the findings of the study and compare to present literature and to note any similarities and differences that are in line with present literature thus categorical and quantitative demographic data will also be discussed.

Baseline data measurements are discussed to indicate the level of homogeneity between the two Groups at the outset of the study.

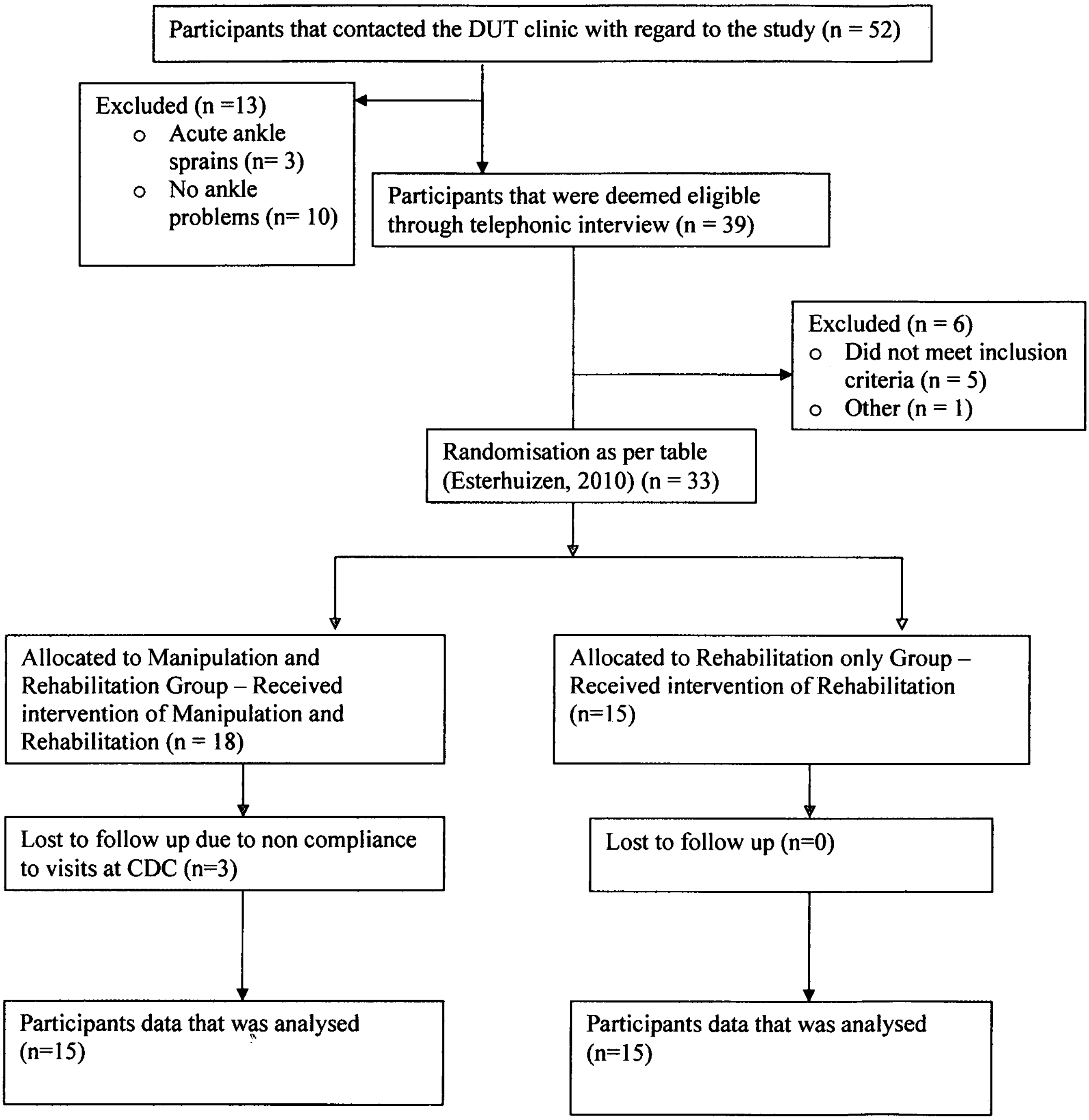
The data from intra-group analysis with respect to both subjective and objective measurements at the first, fifth and seventh consultations will be discussed and indications will be made to statistical and clinically significant findings and the proposed theories of these findings.

The data from inter-group analysis with respect to both subjective and objective measurements at the first, fifth and seventh consultations will be discussed and indications will be made to statistical and clinically significant findings and the proposed theories of these findings.

Assessment of intra-group correlations between changes in subjective and objective variables over time will also be analysed in this Chapter and indications will be made to statistical and clinically significant findings.

5.2 Consort diagram

Flow diagram adapted from Moher, Schulz and Altman, (2001).



From the above flow diagram it must be noted that of the three participants that dropped out of the Manipulation and Rehabilitation Group, one of the participants indicated that he kept forgetting about appointments, another had a sudden overseas commitment which he needed to attend to and the third was due to a lack of transportation to and from the CDC. This data is of value because it indicated that the dropout rate was due to external factors and not related to the treatment (Mouton, 1996).

5.3 Demographic data discussion

The mean age of the Manipulation and Rehabilitation Group was 25.5 and 25.7 years of age in the Rehabilitation only Group. The range of ages in the total study population was between 20 and 37 years, with the Manipulation and Rehabilitation Group ranging between 20 – 35 years and the Rehabilitation only Group ranging between 20 and 37 years of age. This range is in keeping or similar with the proposed affected ages in other studies on CAI (Brantingham *et al.,* 2009, Pellow and Brantingham, 2001, and Vicenzino *et al.,* 2006). This indicates that the age range of the condition is within the age limits described in previous studies.

The ethnic breakdown of the study Group was White (n=18), Black (n=5), Indian (n =4), Coloured (n=2) and other (n=1). The larger amount of White subjects could potentially be due to the general demographics of the area, where there is a larger white community. Of the 30 participants, the gender boundaries were as follows females 46.7 % (n = 14) and males 53.3 % (n=16). This distribution of gender across the study is consistent with Coetzer *et al.,* (2001) and Pellow and Brantingham (2001) as well as other studies conducted at Durban University of Technology (Bellingham *et al.,* 2001; Lindsey-Renton, 2005).

Participants with CAI presenting in the left ankle was 53.3 %; with 46.6% presenting in the right ankle. None of the participants presented with pain in bilateral ankles. This supports studies by Menz (2004) and Kohne *et al.,* (2007) where Oztekin (2008) suggested that this is related to ankle dominance, where dominant ankles (whether left or right for that subject) appear to be the most frequently injured (Oztekin *et al.,* 2008).

Frequency of ankle sprains is another contributing factor to the development of CAI. Participants that presented with between 2-4 ankle sprains totalled 50% whereas 43% presented with 5-7 ankle sprains and 7% presented with 8 or more ankle sprains in their lifetime.

The inversion ankle sprain is singularly the most common injury that is sports related (Reid, 1992). In this study, 73% showed sports related injury whilst 26.6% were non sport related (either due to direct trauma such as a fall or causes that the participant could not recall). Of the sport related injuries, in this study, ten were related to soccer; five related to rugby; four as a result of ballet induced injuries; two due to netball and one related to hockey. This statistical data is in keeping with the articles produced about soccer, ballet and other sports codes (Mack, 1982; Thaker *et al.,* 1999; Kohne *et al.,* 2007; Oztekin, 2008 and Walls *et al.,* 2010).

All statistical data analysed with respect to demographic data inclusive of categorical and quantitative data, showed no statistically significant differences between the two Groups with respect to CAI, with p values ranging between 0.143 and 1.000.

5.4 Discussion of subjective and objective data

5.4.1 Subjective data

5.4.1.1 VAS

There was a highly statistically significant decrease ($p<0.001$) in VAS over time in the Manipulation and Rehabilitation Group. This suggests that this group showed significant statistical and clinical improvement in pain perception between the first and fifth, the first and seventh and the fifth and seventh visit at the CDC.

There was a highly statistically significant decrease ($p<0.001$) in VAS over time in the Rehabilitation only Group. This suggest that this group showed significant improvement in pain perception between the first and fifth, first and seventh and fifth and seventh visit at the CDC.

Although both treatment groups showed a statistically significant improvement for VAS readings ($p < 0.001$), there was however a significant treatment effect (p=0.002) for the Manipulation and Rehabilitation Group as compared to the Rehabilitation only Group. This suggests that the addition of manipulation to the Manipulation and Rehabilitation Group is effective for the treatment of CAI, and suggests a faster rate of change over time as compared to the Rehabilitation only Group. The Manipulation and Rehabilitation Group made an average improvement of 24.8 mm by visit five and 41.13 mm in total by visit seven. The Rehabilitation only Group produced results that were considerably less than the Manipulation and Rehabilitation Group with average improvements of 10.8 mm by visit five and 17.8 mm by visit seven. Far more participants in the Manipulation and Rehabilitation Group (66% or ten out of fifteen participants) made clinically significant improvements as compared to the Rehabilitation only Group (13.3% or two out of fifteen participants). Furthermore 33.3% (five out of fifteen participants) of the participants in the Manipulation and Rehabilitation Group reported no pain (i.e. 0mm reading on this scale) by the end of visit seven, whereas no such changes were reported in the Rehabilitation only Group.

The proposed theories that are related to the reduced pain for each of the Groups are described as follows.

a) In the case of a manipulation: initially the affected tissue is presented with restricted end feel due to a subluxation complex, positional fault (or joint dysfunction) and reflex muscle spasm and pain which is the primary source of mechanical dysfunction and pain (Bergmann, 1993 and Vicenzino *et al.,* 2006). The primary aim of the manipulation is to restore mechanical function, remove pain and the fixation as well as relieve spasm and painful muscular guarding, especially in the initial stages of treatment. The manipulation may also alter motor and sensory function (Gatterman, 1990 and Lopez-Rodriguez *et al.,* 2007). When the manipulation is applied to the fixated area it stimulates superficial and deep somatic mechanoreceptors, proprioceptors and nociceptors. This then leads to afferent stimulation of the sensory neurons of the spinal cord. This reflex inhibits pain and restores the joint to normality as a result of which, patients that are adjusted will experience reduction of pain and normalized function as a result of this action (Bergmann, 1993 and Joseph *et al.,* 2010).

b) With respect to rehabilitation, the proposed theory of pain reduction in this group is as follows: when proprioceptive work (exercise therapy) is done on a joint there is stimulation of the Type IV mechanoreceptors. These receptors are responsible for detecting painful stimulus and nociception. They are activated by stimuli such as mechanical or chemical changes (Wyke, 1981). With respect to both proprioceptive and strength training there is an inherent mechanical stimulation of these receptors when the activity is performed which directly inhibits the Type IV fibres, this in turn leads to a reduction of pain as perceived by the participant (Wyke, 1981 and Joseph *et al.*, 2010).

The theories discussed above have been added to support the results observed regarding VAS, by demonstrating the possible differing mechanisms by which pain reduction was achieved in both groups (i.e. how manipulation could have achieved pain reduction and how rehabilitation could have achieved pain reduction). In the case of VAS the manipulation mechanism is more efficient; therefore a statistically significant improvement was noted in this group in comparison to the Rehabilitation Group.

The results observed in the Manipulation and Rehabilitation Group of this study are in keeping with the research conducted by Green, (2001); Pellow and Brantingham, (2001); Kohne *et al.*, (2007) and Joseph *et al.*, (2010). All of these studies noted a statistically significant improvement in pain intensity and quality as well as a significant treatment and time effect in the manipulation or mobilisation groups.

The results that are observed in the Rehabilitation only Group of this study appear to support the results found in studies previously conducted by van der Wees *et al.*, (2006), Kohne *et al.*, (2007) and Joseph *et al.*, (2010). Similar reduction in VAS was seen in our Rehabilitation only Group as was observed in other randomised clinical trials for ankle inversion sprain (van der Wees *et al.*, 2006; Kohne *et al.*, 2007 and Joseph *et al.*, 2010).

The study performed by Eisenhart *et al.*, (2003) and Kohne *et al.*, (2007) suggested evidence of a faster rate of change made within the Manipulation Group with respect to pain intensity. The findings in this study are similar to those results observed in Eisenhart *et al.*, (2003) and Kohne *et al.*, (2007). However, the findings in this study, and those of Eisenhart *et al.*, (2003) and Kohne *et al.*, (2007) were dissimilar to those in Joseph *et al*, (2010) study, where these time effects for the intervention were not evident

5.4.1.2 FADI

There was a highly significant increase ($p<0.001$) in FADI readings over time in the Manipulation and Rehabilitation Group. This suggests that the Manipulation and Rehabilitation Group showed significant improvement in general ankle functioning within the foot and ankle between the first and fifth, first and seventh (with greatest change is noted) and the fifth and seventh visits.

There was a highly significant increase ($p<0.001$) in FADI readings over time in the Rehabilitation only Group. This suggests that the Rehabilitation only Group showed significant improvement in general ankle functioning within the foot and ankle between the first and fifth, first and seventh (greatest change is noted) and the fifth and seventh visits.

There was no statistical evidence of an intervention effect for this outcome ($p=0.705$). The profile plots shows that the rate of increase over time was the same in both groups; therefore one intervention had no more effect than another on this outcome. Although both treatments are efficacious and no statistically significant difference was observed, the Manipulation and Rehabilitation Group descriptively improved on a greater scale, according to the inter-group analysis referred (i.e. reaching a higher value overall than the Rehabilitation only Group although the rate of change was the same in both groups) than the Rehabilitation only Group. The Manipulation and Rehabilitation Group improved by 13.46 points on average by visit five and by a total score of 18.5 by visit seven. This is in comparison to the Rehabilitation only Group where average improvements of 8.23 points was made by visit five and 15.46 points by visit seven. Two participants (13.6%) within the Manipulation and Rehabilitation Group made a full recovery in terms of the FADI (i.e. 104/104 for this scale) by visit five with a total of six out of fifteen participants (40%) making a full recovery (i.e. a score of 104/104 for this scale) by visit seven. From the Manipulation and Rehabilitation Group there were 86.6% (thirteen out of fifteen participants) of the participant's that made a clinically significant improvement individually. This clinically significant improvement was also noted in 86.6% (thirteen out of fifteen participants) for the Rehabilitation only Group. However, in the Rehabilitation only Group, not one participant made a full recovery with respect to function (i.e. a score of 104/104 on this scale) by visit seven.

The following proposed hypothesis for a) manipulation effect is based on the circulatory theory by Bergmann, (1993), and b) the resistance and proprioceptive effect that is rehabilitation effect is proposed by Reid (1992):

a) When a fixated segment is manipulated by manual therapy there is a direct effect on the autonomic nervous system. This effect leads to a reflex vasoconstriction of vessels at the level of the where the manipulation was performed. Inadvertently this increases the pump action of the muscle causing improved circulation at the joint and restores normal joint function by having removed the cause. This hereby improves the general function of the joint by purposes of manipulation with the removal of aberrant joint alignment and function (Bergmann, 1993).

b) Reid, (1992) proposes that resistance training to the joint will improve muscle strength and improve circulation to the area. Retraining the muscles of the ankle, reduced the chance of re-injury and allowed the muscle to produce smooth co-ordinated motion. The reason for this is when strength activity increases the overall function; the ankle improves due to the improved tone and neuronal pool firing. Proprioceptive rehabilitation is beneficial in the fact that it assists in stimulating the Wyke receptors and thus causing an improvement in balance and co-ordination and as a result leads to the restoring of the joint to its full function (Lopez-Rodriguez *et al.*, 2007, Kohne *et al.*, 2007 and Joseph *et al.*, 2010). Active contraction of muscle increases the rate of firing due to elongation of the tendon and deformation of the Golgi organ, thus improving stability of the muscles that surround the ankle (Calliet, 1997)

The theories that have been put forward have been added to support the findings that were observed for FADI by demonstrating the possible differing mechanisms by which function was restored in both groups (i.e. how the manipulation could have restored function and how the rehabilitation could have restored function independently). Since no statistically significant treatment effect was noted between the groups for the inter-group analysis, both mechanisms appear to be equally effective as both groups showed statistically and clinically significant improvements.

The readings observed in the FADI of this study (for the Manipulation and Rehabilitation Group) are similar to those noted in foot function scores used in studies by Pellow and Brantingham, (2001) and Joseph *et al.*, (2010). However contrasting results were found in Green *et al.* (2001), whereby the differing readings in foot function scores was noted in that study and the time effect for differing treatment groups was not noted in this study.

The statistics relating to the Rehabilitation only Group, for function indices, are in keeping with the studies that have been performed by Clarke and Burden, (2005) and Jospeh *et al.*, (2010).

Similarities in the rate of speed of improvements in the Manipulation and Rehabilitation Group that were noted within this study are in keeping with Joseph *et al.*, (2010).

5.4.2 Objective data

5.4.2.1 Algometer

There was a highly significant increase ($p<0.001$) in algometer readings over time in Manipulation and Rehabilitation Group. This suggests that the Manipulation and Rehabilitation Group showed significant improvement in pain threshold within the ankle between the first and fifth, first and seventh and the fifth and seventh visits where the largest difference is noted.

A statistically significant increase was not observed ($p=0.519$) in algometer readings over time in Rehabilitation only Group. Small changes in pain threshold were noted between visit one and five and between visits five and seven, but no statistically significant values were noted within the Rehabilitation only Group.

Algometer readings indicated a statistically significant treatment effect ($p=0.002$) for the Manipulation and Rehabilitation Group. This suggests that manipulating a participant's foot and ankle, in combination with a Rehabilitation programme appears to be significantly more effective (statistically) than a Rehabilitation only programme in terms of reducing point tenderness. The above intra and inter-group findings suggest that the Manipulation and Rehabilitation Group is effective in the treatment of CAI in terms of pain threshold but this does not hold true for the Rehabilitation only Group. The profile plots also suggested a faster rate of change in the Manipulation and Rehabilitation Group as compared to the Rehabilitation only Group with respect to clinical significance, 26.6% (four out of fifteen participants) made a greater than $1.77kg.cm^2$ improvement in the Manipulation and Rehabilitation Group indicating a clinically significant improvement in these participants, in comparison to the Rehabilitation only Group where no participants (zero out of fifteen participants) in this study made clinically significant improvements.

The proposed theories with regard to these findings in this study for the mechanism by which a) manipulation and b) rehabilitation each reduce point tenderness are described in detail below.

a) Pain threshold reduced significantly in the Manipulation Group possibly due to the effect that the manipulation has on the Type IV Wyke receptors (Wyke, 1981). These types of receptors are stimulated whenever there is mechanical stimulation at the level of the joint. In the Manipulation Group, the joint is taken into the paraphysiologial space to generate the cavitations; which stimulate the Type IV receptors. When the joint is taken to its end feel in order to administer the thrust, stretching of ligaments and tendons will inadvertently take place. As a result of this, the Type IV receptors are stimulated even further. This stimulation of these receptors causes a response in the central nervous system to dampen the effects of the pain and reduce pain threshold (Wyke, 1981). It must also be noted that manipulation to the affected segment has an inherent neurological effect and alters motor and sensory function and as a result affects pain threshold accordingly (Gatterman, 1990).

b) In theory, proprioception and strength training will restore normality to the muscle length and correct any aberrant neuromuscular feedback and thus reduce pain (Calliet, 1997). However, Reid, (1992) stresses the fact that in some cases there may be a need for 20 weeks of therapy, and in order for the continued protection that is offered by proprioception and strength training to be effective and for change to be detected using an outcome measure, even if the participant is in their final stage of rehabilitation at two or three weeks. As a result the Rehabilitation only Group may have required more time for reductions in pain threshold to be detected using an outcome measure.

Thus it can be seen from the theories proposed above that both a) manipulation and b) rehabilitation can increase pain threshold. The results of the study seem to indicate that the manipulation mechanism is more effective. However, it is important to take into consideration the time related matter described by Reid, (1992), for rehabilitation, could account for the poor results obtained in this study (at least in part) due to the shorter time period of treatment as was the case for this study (i.e. every day for a five week treatment programme).

In manipulation studies that have been conducted by Pellow and Brantingham, (2001) and Kohne *et al.,* (2007), increases in algometric readings were noted as statistically significant for manipulation or mobilisation. The findings of this study are therefore in line with these studies performed previously.

The minimal reductions in algometry readings for this study are in accordance with other randomised clinical trials for ankle inversion sprains where rehabilitation was the form of intervention i.e. statistical significance was not achieved in previous studies (van der Wees *et al.*, 2006; Pellow and Brantingham, 2001 and Kohne *et al.*, 2007).

5.4.2.2 Motion palpation

There was a highly significant decrease ($p<0.001$) in the number of fixations over time in the Manipulation and Rehabilitation Group. This suggests that the addition of the manipulation combined with the rehabilitation programme resulted in a significant improvement in the quality of end feel within the joints of the foot and ankle between the first and fifth (minimal change noted), and first and seventh (the most improvement noted). A more in depth breakdown revealed that between visit one and five there was an increase of one fixation that occurred in 20% (three out of fifteen participants), with 26.7% (four out of fifteen participants) the number of fixations remained the same, a decrease of one fixation occurred in 46.7% (seven out of fifteen participants) and, a decrease of two fixations occurred in 6.7% (one out of fifteen participants). However, by visit seven 100% (fifteen out of fifteen participants) had a decrease in the number of fixations, compared to visit one. Here, a more in depth breakdown revealed that, by visit seven an increase in the number of fixations occurred in 0% (zero out of fifteen participants) while 0% (zero out of fifteen participants) remained the same and a decrease of one fixation occurred in 13.3% (two out of fifteen participants), a decrease in two fixations was noted in 73.3% (eleven out of fifteen participants), and a decrease of three fixations occurred in 13.3% (two out of fifteen participants).

In contrast to this, there was a significant increase ($p=0.013$) in the number of fixations over time in the Rehabilitation only Group. This indicates that not only was there no improvements noted in the end feel of the fixations in this group, but the opposite in fact was observed, where an increase in the number of fixations occurred. A more in depth breakdown revealed that between visit one and five there was an increase of one fixation that occurred in 46.7% (seven out of fifteen participants), an increase of two fixations occurred in 6.7% (one out of fifteen participants) and an increase of three fixations occurred in 6.7% (one out of fifteen participants), 40% (six out of fifteen participants) had no change in fixations by visit five. A decrease in fixations by visit five was not evident in any participant's in this group. A more in depth breakdown of this data demonstrated that in comparison to visit five, by visit seven an increase of two fixations had occurred in 13.3% (two out of fifteen participants), an increase of one fixation had occurred in 40% (six out of fifteen participants), 47% (seven out of fifteen participants) had no change in the number of fixations and 0% (zero out of fifteen participants) had a decrease in fixations compared to visit one.

Motion palpation readings indicated a significant treatment effect in Manipulation and Rehabilitation Group ($p<0.001$) for the number of fixations noted during the inter-group analysis. The motion palpation of the Manipulation and Rehabilitation Group noted a statistically significant reduction in the number of fixations present within the Manipulation and Rehabilitation Group ($p<0.001$), whereas a contrasting effect was seen in the Rehabilitation only Group where a significant increase (a worsening, $p=0.013$) in the number of fixations noted between the first, fifth and seventh visits to the CDC. In summary, for the Manipulation and Rehabilitation Group, there was an increase in the number of fixations in 0% (zero out of fifteen participants) and a decrease in the number of fixations in 100%(fifteen out of fifteen participants) between visit one and seven. For the Rehabilitation only Group there was an increase in the number of fixations in 53.3% (eight out of fifteen participants) and 47% (seven out of fifteen participants) remained the same. A decrease in the number of fixations occurred in 0% (zero out of fifteen participants) by visit seven.

The significant decrease in the number of fixations in the Manipulation and Rehabilitation Group is easily represented by the proposed theories of Gatterman (1990) and Bergmann (1993). Adjusting an articular lesion improves joint alignment and any dysfunction of motion that the joint previously had. When the manipulation is applied, the joint is taken to its end feel (Redwood and Cleveland, 2003) and the cavitation is heard. It thus serves to improve the motion/end feel in that joint that has been manipulated (Lakhani *et al.,* 2009) and maximise normal motion (Haldeman, 1992). The Rehabilitation only Group (60%) did not have fixations removed after visit five and only a slight increase was observed in 13% after visit seven. It is as a result of these fixations not being cleared that minimal change was detected in the quality of the end feel.

Reid's (1992) proposed theory suggests that the persistence of symptoms related to CAI occurs as a result of subtalar joint motion that is reduced as well as incomplete rehabilitation programmes. Fixations are removed from an articular surface through manual manipulation or mobilisation of the joint causing a change in the joint (Haldeman, 1992). Manipulation was not included in the Rehabilitation Group, and this is a possible reason why the fixations were not removed and the joint mechanics remained in its state of dysfunction.

Thus manipulating the foot and ankle in combination with a Rehabilitation programme appeared to be highly statistically and clinically significant in the reduction of the number of fixations as compared to many participants in the Rehabilitation only Group who fared worse than when they began or remained the same (this could potentially be caused by the fact that there was no removal of the fixation in the rehabilitation only group and a resultant worsening of fixations of the ankle).

With such a significant statistical improvement in the number of fixations in the rehabilitation only Group, potential long term effects of these findings require investigation. According to Schafer and Faye, (1990) the long term effects of a persistent and chronic fixation will include signs of hypoactivity with the inclusion of clinical features such as weakness, reduced function and general musculoskeletal degeneration. These changes may be related either to neural facilitation (spasm and hypertonicity) or with inhibition (weakness and trophic changes). Redwood and Cleveland, (2003) suggests that nerve irritation or compression at the site of the fixation can adversely affect the axoplasmic flow which will inadvertently lead to trophic changes and damage to end organs affecting proprioception.

It must be noted that in the case where a site of articulation between joints is hindered at end feel it dictates that another joint nearby will take on a compensatory role leading to aberrant motion, inflammation and subsequently pain (Schafer and Faye, 1990).

With the long term adverse effects of fixations being similar to the clinical features presenting in CAI, it is suggested that fixations present on a long term basis possibly increase the chance of this negative effect (in weakness, decreased function, pain tolerance and proprioception) in patients with CAI even if they are receiving other forms of therapy that exclude manipulation; this however requires further investigation in the way of studies including longer follow up periods to determine the long term effects.

5.4.2.3 WBD

There was a highly statistically significant increase (p=0.001) in WBD readings over time in the Manipulation and Rehabilitation Group. This suggests that the Manipulation and Rehabilitation Group showed significant improvement in range of motion in ankle dorsiflexion within the foot and ankle between the first and fifth, first and seventh and the fifth and seventh visits. The largest differences were noted between the first and the fifth visit.

There was a significant increase (p=0.018) in WBD readings over time in the Rehabilitation only Group. This suggests that although the Rehabilitation only Group showed significant improvement in range of motion in ankle dorsiflexion between the first and fifth and first and seventh with the largest difference being noted between the fifth and seventh visit. It was not observed as a statistically significant change.

With respect to WBD no statistical significant differences were noted between the two groups (p=0.381). However, the Manipulation and Rehabilitation Group indicated the rate of change was faster after the fifth and seventh visit as compared to the Rehabilitation Group. This indicates that although the Manipulation and Rehabilitation Group and the Rehabilitation only Group appear to both be effacious in improving ankle dorsiflexion, the former group appears to have seen this improved dorsiflexion at an earlier point in time. Both treatment groups have been documented to show improvement in range of motion at the ankle (specifically dorsiflexion). It is, however, noted that the Manipulation and Rehabilitation Group fared marginally better descriptively with improvements made with 3.7cm by visit seven, as compared to 2.98cm improvement in the Rehabilitation only by visit seven. Within the Manipulation and Rehabilitation Group 80% (twelve out of fifteen participants) made clinically significant improvements by visit seven and all participants improved in the WBD parameter whereas 73% (eleven out of fifteen participants) of the Rehabilitation only Group made clinically significant improvements and only 86.6% (thirteen out of fifteen participants) improved in the WBD parameter .

The proposed theory as to how this mechanism works in the a) Manipulation and b) Rehabilitation Group is described as follows.

a) There are four types of mechanoreceptors that are present in the joints, namely Type I to IV (Wyke, 1981). Type I receptors detect amplitude of joint motion and Type III receptors are affected by external ROM when considerable stress is placed on the joint. A manipulation to a joint or fixated segment stimulates the Type I and II mechanoreceptors when placed at end feel and into accelerated joint motion, leading to changes in articular pressure. The Type III receptors will be stimulated when stretched at the elastic barrier. As a result, it is evident that the manipulation and rehabilitation in combination will have an effect on weight bearing ankle dorsiflexion especially at the end of range of motion by affecting Type I, II and III receptors.

b) Type III Wyke receptors which are stimulated by stretch and motion are activated during rehabilitation exercises of strengthening and proprioception as a result of the motion involved in the action. As a result rehabilitation has a positive effect on WBD by affecting Type III receptors (Wyke, 1981).

The proposed theories discussed above show that the change in readings for the a) manipulation and b) rehabilitation will improve WBD, but perhaps more effectively within the Manipulation Group to its effect on more Wyke receptors. It is observed that the theories provide reasoning as to why there is no statistically significant changes noted between the treatment groups.

According to studies by Dannenberg (2000), Collins *et al.*, (2002); Vincenzo *et al.*, (2006); Kohne *et al.*, (2007); and Joseph *et al.*, (2010*),* it was noted that the manipulation groups noted a statistically significant increase in WBD. Green *et al.*, (2001) noted a statistically significant effect for WBD in a rehabilitation group that improved WBD over a period. The findings of this study are in keeping with all the above-mentioned studies that have previously been conducted on range of motion and specifically weight bearing in ankle dorsiflexion.

5.4.2.4 BBS

There was a highly significant increase ($p<0.001$) in BBS readings over time in the Manipulation and Rehabilitation Group. This suggests that the Manipulation and Rehabilitation Group showed significant improvement in balance and proprioception in the foot and ankle between the first and fifth, first and seventh and the fifth and seventh visits. The largest differences were noted between the first and the fifth visit.

There was also a highly significant increase ($p<0.001$) in BBS over time in the Rehabilitation only Group. This suggests that Rehabilitation Group showed significant improvement in balance and proprioception within the foot and ankle between the first and fifth, first and seventh and the fifth and seventh visits. The largest differences were noted between the first and the fifth visit.

There was no statistical evidence of an intervention effect for this outcome ($p=0.095$), although the profile plot suggests a trend of a higher rate of increase in the Manipulation and Rehabilitation Group after time 2 (visit five).

The profile plots for the inter-group analysis suggested that the Manipulation and Rehabilitation Group made a faster rate of change over time. By visit five the Manipulation and Rehabilitation Group increased their score by 9.2 points and by 12.9 points by visit seven. The Rehabilitation Group only increased by 8.2 points by visit five and 10.73 points by visit seven. The total score of 56 points was achieved by 73.3% (eleven out of fifteen participants) in the Manipulation and Rehabilitation Group, in comparison with the Rehabilitation only Group where only 6.6% (one out of fifteen participants) reached the full score. The score of 55 points was reached by 6.6% (one out of fifteen participants) in the Manipulation and Rehabilitation Group and 60% (nine out of fifteen participants) for the Rehabilitation only Group. Overall, 13.3% of the participants in the Manipulation and Rehabilitation Group made improvements, where they reached scores of 55 and 56 points.

The proposed theories of the effect of the treatment on balance are as follows for a) Manipulation and b) Rehabilitation.

a) The basis of the proposed effect of manipulation is that aberrant joint mechanics in the ankle will subsequently lead to aberrant firing of Wyke receptors. In turn, abnormal neural firing will lead to aberrant proprioception and balance at the ankle. Manipulation corrects this aberrant pattern by stimulating an afferent input and in doing so corrects the proprioception problem (Bergmann, 1993). Manipulation provokes change in all afferent output and restores normality to the Golgi tendon and proprioceptive organ and at the same time functions to remove the neural scar.

b) Proprioceptive activity functions to re-educate the Golgi tendon organs as they refine the joint position sense. With this being corrected there is stabilisation of the joint and the chance of re- injury to the ankle is reduced

The theories discussed above have been added to support the results observed regarding BBS, by demonstrating the possible differing mechanisms by which balance was restored in both groups (i.e. how manipulation could have restored balance and how rehabilitation could have restored balance). Both mechanisms by which balance is restored to the ankle appear to be effective in both groups with respect to statistically significant improvements, due to the fact that no statistically significant difference noted for a treatment effect between the two groups.

5.4.2.5 Compliance Diaries

The use of the compliance diaries was effective in both groups. There was a 100% (fifteen out of fifteen participants) return rate on the diaries in the Manipulation and Rehabilitation Group with a 93.3% (fourteen out of fifteen participants) return rate in the Rehabilitation only Group. On average the Manipulation and Rehabilitation Group completed the rehabilitation programme for 28.93 days out of 35 and the Rehabilitation only Group in 26.86 days out of 35 days. This suggests that non-compliance to the Rehabilitation programme had limited influence on the entire study population with respect to the outcome of results.

5.4.2.6 Discussion regarding correlation between changes in subjective and objective variables.

Correlation analysis of changes in outcomes over time in both groups was noted regarding the outcome measures.

Within the Manipulation and Rehabilitation Group:

1. There were significant positive correlations between change in VAS and change in WBD (r=0.549) as well as change in FADI and change in BBS (r=0.598). This implies that an increase (or improvement) in one score was accompanied by an increase in the other and a decrease (or worsening) in one score was accompanied by a decrease in the other.
2. There was a significant negative correlation between change in number of fixations and change in FADI (r= - 0.570). This meant that as the number of fixations decreased, function in the ankle or the FADI score increased.

Table 5.1 Statistically significant correlations between the Manipulation and Rehabilitation Group:

Primary outcome	Relationship:	Dependant outcome:	Description of proposed mechanisms for correlations occurring between parameters
WBD	Positive	VAS	Manipulation functions to increase joint motion as well as end feel (Bergmann *et al.*, 1993) and produce an associated reflex decrease in pain as perceived by the patients (Wyke, 1981).
BBS	Positive	FADI	Manipulations that are given to sublaxations, function to correct abnormal neurological firing and correct proprioceptive abnormalities (Bergmann *et al*, 1993) and cause a resultant improved end feel and joint function (Reid, 1992).
FADI	Negative	Number of fixations	Manipulation functions to remove fixations and to correct the neurological feedback and as a result lead to improved general function of the ankle (Bergmann *et al.*, 1993).

Within the Rehabilitation only Group

1. Change in FADI and change in WBD were positively correlated (r=0.645), therefore as one score increased so did the other.

Table 5.2 Statistically significant correlations between the Rehabilitation only Group

Primary outcome	Relationship:	Dependant outcome:	Description of proposed mechanisms for correlations occurring between parameters
WBD	Positive	FADI	Proprioceptive and strength training function to improve the joint range of motion specifically in dorsiflexion. The resultant improvement in range of motion assists in the correction of abnormal neurological firing at the joint (Bergmann *et al.*, 1993) a well as function.

5.5 Summary and additional information noted in the duration of the study

Within the time frame of the study, an important fact related to full recovery was observed. Full recovery is described as a total score in three parameters where maximum scores could be achieved (i.e. 0mm on the VAS, 104/104 for FADI and 56/56 for BBS) and in the remainder of the parameters where full scores are not achievable statistical significance was used (i.e. Motion palpation findings, Algometer readings and WBD). It was noted that by the fifth visit, the Manipulation and Rehabilitation Group had one participant that made a full recovery in terms of both subjective and objective data by the fifth visit i.e. VAS score of 0mm; FADI score of 104/104; BBS score of 56/56 (all finite parameters) as well as improvements in algometer findings, WBD and reduction in fixations (infinite parameters). This, however, was not noted in any of the participants in the Rehabilitation only Group by visit five.

By visit seven, the Manipulation and Rehabilitation Group had five participants who had made a full recovery in terms of subjective and objective findings i.e. VAS score of 0mm; FADI score of 104/104; BBS score of 56/56 (all finite parameters) as well as improvements in algometer findings, WBD and reduction in fixations (infinite parameters). However, with respect to the Rehabilitation only Group there was only one participant that made a full recovery in terms of the BBS scale (56/56) but in no other parameter by visit seven. This information may be of particular importance to sports professionals where the need arises for them to return to safe, full function activity at the quickest possible rate in order for them to reduce number of training days lost and reduce the chance of re injury at a later stage.

The intra-Group outcomes in the Manipulation and the Rehabilitation Group indicate that statistically significant improvements were achieved for all six parameters in this study (VAS $p<0.001$; FADI $p<0.001$; Algometer $p<0.001$; motion palpation $p<0.001$; WBD $p=0.001$ and BBS $p<0.001$). This is in comparison to the three outcomes where statistical significant improvement was achieved (VAS $p<0.001$; FADI $p<0.001$ and BBS $p<0.001$) in the Rehabilitation only Group. In all outcomes measures for the intra-Group analysis there was a trend that was in favour of the Manipulation and Rehabilitation Group with respect to larger improvements in the outcomes that were made in a shorter time period.

In the inter-group analyses statistically significant differences were found between the two groups in favour of the Manipulation and Rehabilitation Group for the following parameters: VAS ($p<0.002$; algometer readings ($p=0.002$) and motion palpation findings ($p<0.001$). In two out of the three remaining parameters i.e. BBS and WBD, although statistically significant differences were not found between the two groups, in all outcomes measures for the intra-group analysis there was a trend that was in favour of the Manipulation and Rehabilitation Group with respect to faster rate of change over time. However, in the last parameter, FADI, there was neither a statistically significant difference noted between the two groups nor was there a trend that suggested a faster rate of change in any of the groups. There are no readings, objective or subjective, that indicate that the Rehabilitation only Group improved more when compared to the Manipulation and Rehabilitation Group.

5.6 Revision of hypotheses

5.6.1 The first null hypothesis

It was hypothesized that manipulation in combination with a rehabilitation programme, and stand alone rehabilitation, would be no different in terms of subjective findings and concomitant clinical measures (i.e. the reduction of pain and other clinical outcomes observed from the foot and ankle disability index (Hale and Hertel, 2005)).

5.6.2 The first alternative hypothesis

It was hypothesized that manipulation in combination with a rehabilitation programme, and stand alone rehabilitation, would be different in terms of subjective findings and concomitant clinical measures (i.e. the reduction of pain and other clinical outcomes observed from the foot ankle disability index (Hale and Hertel, 2005)).

- There was a statistically significant treatment effect between the groups for the parameter of VAS thus the null hypothesis was rejected, and the alternative hypothesis was accepted for this parameter
- There was no statistical evidence of a treatment effect for the parameter of FADI thus the null hypothesis was accepted and the alternative hypothesis was rejected for this parameter.

5.6.2 The second null hypothesis

It was hypothesized that manipulation in combination with a rehabilitation programme, and stand alone rehabilitation, would be no different in the terms of objective findings and concomitant clinical measures (i.e. dorsiflexion range of motion, balance and pain threshold).

5.6.4 The second alternative hypothesis

It was hypothesized that manipulation in combination with a rehabilitation programme, and stand alone rehabilitation, would be different in the terms of objective findings and concomitant clinical measures (i.e. dorsiflexion range of motion, balance and pain threshold (Hale and Hertel, 2005)).

- There was a significant treatment effect for algometer and motion palpation readings between the two groups thus the null hypothesis was rejected and, the alternative hypothesis was accepted for these parameters.
- There was no statistically significant difference for a treatment effect for WBD and BBS between the two groups thus the null hypothesis was accepted for these parameters. There was no statistically significant difference for a treatment effect for WBD and BBS between the two groups thus the alternative hypothesis was rejected for these parameters.

5.7 Limitations

5.7.1 Subjective

Human error as well as the Hawthorne effect (Mouton, 1996) should be taken into consideration with respect to subjective outcomes with the need for the participant to produce results that they feel is pleasing to the researcher.

The nature of this particular study requires all participants to record their daily compliance with the rehabilitation protocol in the form of a diary. This will be collected at the end of the participant's treatments at the CDC.

The nature of the blinding of the study would place limitations on the study design and affect the internal validity of the study. There is difficulty in the concept where the researcher was both blinded (to subjective and objective outcomes) and involved in the intake and treatment of the study.

5.7.2 Objective

Although an independent assistant was performing all testing (Mouton, 1996), it is possible that Objective data may have been subject to human error and observer bias.

Reliability of one of the measures employed in this study (example motion palpation) is challenged in literature and as a result remains an area of concern with respect to the validity of its findings.

5.8 Conclusion

This chapter addressed all the theories based on the subjective and objective findings within this study. All results were described in detail and proposed methods of these results were discussed. The subsequent chapter will assess the final conclusions and future recommendations for studies to be done on CAI.

CHAPTER 6

6.1 INTRODUCTION

This chapter will discuss the outcomes of this study, as well as discuss the recommendations for future studies on CAI.

6.2 CONCLUSION

The aim of the study was to investigate the subjective and objective responses of participants who received a combination of manipulation and a rehabilitation programme, as compared to those participants that received a rehabilitation programme only as a treatment for CAI; and in doing so, to determine whether a combination of treatments addressing all three major components comprising CAI indeed yield better results.

The following was observed from the data analysis

In terms of statistical analysis:
The intra-group outcomes in the Manipulation and Rehabilitation Group indicate that statistically significant improvements were achieved for all six parameters in this study (VAS $p<0.001$; FADI $p<0.001$; algometer $p<0.001$; motion palpation $p<0.001$; WBD $p=0.001$ and BBS $p<0.001$). This is in comparison to the Rehabilitation only Group where statistically significant improvements were achieved for three out of six parameters in this study(VAS $p<0.001$; FADI $p<0.001$ and BBS $p<0.001$).

With respect to the inter-group analyses, statistically significant differences were found between the two groups in favour of the Manipulation and Rehabilitation Group for the following parameters: VAS ($p<0.002$; algometer readings ($p=0.002$) and motion palpation findings ($p<0.001$). In two out of the three remaining parameters i.e. BBS and WBD, although statistically significant differences were not found between the two groups, in all outcomes measures for the intra-group analysis there was a trend that was in favour of the Manipulation and Rehabilitation Group with respect to faster rate of change over time. However, in the last parameter, FADI, there was neither a statistically significant difference noted between the two groups nor was there a trend that suggested a faster rate of change in any of the groups.

In terms of Clinical Significance:

Table 6.1 Clinically significant results were illustrated in the subjective and objective scores as follows:

Outcome	Significant	Manipulation and Rehabilitation Group	Rehabilitation only Group
VAS	Clinically significant results achieved	66% (ten out of fifteen participants)	13.3% (two out of fifteen participants)
	100% improvement achieved	and 33% (5five out of fifteen participants)	and 0% (zero out of fifteen participants)
FADI	Clinically significant results achieved	86.6% (thirteen out of fifteen participants)	86.6% (thirteen out of fifteen participants)
	100% improvement achieved	40% (six out of fifteen participants)	0% (zero out of fifteen participants)
Algometer	Clinically significant results achieved	26.6% (four out of fifteen participants)	0% (zero out of fifteen participants)
	100% improvement achieved	NA	NA
WBD	Clinically significant results achieved	80% (twelve out of fifteen)	73% (eleven out of fifteen)
	100% improvement achieved	NA	NA

As can be seen from the table above, clinically significant results were achieved by the Manipulation and Rehabilitation Group in four out of six parameters (the remaining two parameters do not have measures of clinical significance and therefore will be discussed below). There was 100% improvement in scores by visit seven in VAS (33%) and FADI (40%), which were finite values. This was not the case for the Rehabilitation only Group (where 0% of the participants made 100% improvement in scores).

Even in the parameters, namely BBS and motion palpation, where there was no value defining clinical significance available in the literature, the results revealed some significant findings:

For the parameter of BBS in the Manipulation and Rehabilitation group, 73.3% (eleven out of fifteen participants) reached full score by visit seven. This is in comparison to the Rehabilitation group only where 6.6% (one out of fifteen participants) reached full score by visit seven.

With respect to motion palpation results in the Manipulation and Rehabilitation Group, a decrease in the number of fixations was evident in 100% (fifteen out of fifteen participants) and an increase in the number of fixations was evident in 0% (zero out of fifteen participants) between visit one and seven. For the Rehabilitation only Group there was a decrease in the number of fixations in 0% (zero out of fifteen participants) and an increase in the number of fixations in 53.3% (eight out of fifteen participants) and 47% (seven out of fifteen participants) remained the same.

Literature (discussed in detail in Chapter Two) indicates that addressing all the components that contribute to the persistence of CAI might be essential in targeting and treating the condition effectively (that is, removal of fixations, restoration of proprioceptive deficits and correcting weakened musculature).

It was hypothesised that a combination approach [aiming to target all 3 components mentioned above] would produce increased clinical and statistically significant outcomes as opposed to standard single intervention, leading to greater improvements of the subjective and objective clinical results

The findings/observations in this study, do allow this hypothesis to be accepted [although not completely but to a great extent]. This is indicated by:

1. The overall intra group statistical analysis, where statistically significant improvements were achieved by the Manipulation and Rehabilitation Group, for all six parameters in this study, in comparison to the Rehabilitation only Group where statistically significant improvements were achieved for three out of six parameters in this study.

2. The Overall results pertaining to inter group analyses, where statistically significant differences in favour of the Manipulation and Rehabilitation Group were noted in three (VAS, Algometer readings and Motion palpation findings) out of six parameters. Even in two (WBD and BBS) of the other three parameters where statistically significant difference were not found, a trend suggesting that the Manipulation and Rehabilitation Group fared better was evident in these cases. However, in the last parameter (FADI) no inter-group effect and no trend suggesting a faster rate of change over time was observed.

3. The overall results pertaining to clinical significance, with clinically significant improvements in the Manipulation and Rehabilitation Group being greater in three

(VAS, algometer readings and WBD) of the four measurable parameters, and equal in the fourth parameter (FADI). Of the remaining two parameters, motion palpation showed great improvements in the Manipulation and Rehabilitation Group with all fixations decreasing by the seventh visit compared with the Rehabilitation Group, where no participants showed a decrease in fixations by visit seven. For BBS findings, 73.3% (eleven out of fifteen participants) managed to score full points by visit seven and only 6.6% (one out of fifteen participants) in the Rehabilitation only Group achieving full scores.

As a result of the data analysis in this study suggesting a strong trend in favour of the group where manipulation was included as an adjunct to rehabilitative techniques [strengthening and proprioception], (i.e. a larger scale of improvement noted in the case where manipulation is added to a rehabilitation protocol), a suggestion may be made that it might be beneficial to include manipulation with the rehabilitation program used in all patients suffering with CAI that have fixations present. Furthermore, manipulative therapists may now confidently perform such rehabilitative treatment with manipulation on these patients with CAI, expecting greater results in fewer treatments. This may be of benefit to patients in practice, where fewer treatments may achieve not only greater clinical outcomes but also a) saving costs (whether on medical aids or personal costs), b) saving time away from work and c) saving time lost before being able to get back to sport, as a result of the outcomes of this study.

6.3 RECOMMENDATIONS

Further strengthening of the studies validity may be noted with the use of a specific population Group e.g. sportsmen and women only and will thus allow for a more accurate outcome. The reasoning behind this is the high incidence of CAI in sports related incidents (Thaker,*et al.,* 1999 and Walls *et al.,* 2010). This could be achieved by targeting, as an example, male soccer players (that have the highest incidence of inversion ankle sprains and CAI)

Within this study the shortest period of chronicity was eight weeks and the longest 1152 weeks. Although the ranges in chronicity of CAI seen in participants in this study appear to be quite wide, the groups were relatively homogenous [as can be seen in Table 4.2 and from the statistical analysis between the groups that was performed]. However, future studies might prefer to cap this value i.e. a maximum period of chronicity could be set to prevent statistical differences being found between the groups. Alternatively a stratification process could be adopted in order to separate the varying periods of chronicity.

Both grade one and two ankle sprains were accepted into the study. To further improve homogeneity of the study it can be limited to only one grade of ankle sprain. Alternatively a stratification process should be adopted in order to separate the varying grades.

Participant's progress was recorded at visit five and seven for each outcome measure as per the methodology of the study. However, Overall Therapy Effectiveness (Brantingham *et al.*, 2010), which is an objective clinical outcomes measure, was not assessed. It may be advisable in future studies, to add the Overall Therapy Effectiveness to the outcomes measure included in this study so that in parameters where statistical significance is not met they may be an indication of general improvement and contentment with the therapy the participant is receiving.

It is recommended in future studies that there be a medium (one month) and long (three month) term follow up after the full treatment programme is completed to assess if there are any long term improvements or setbacks in these participants (Pellow and Brantingham, 2001). An example seen in this study, which may be relevant to this longer term follow up, is seen in the motion palpation parameter where a decrease in the number of fixations was noted in the Manipulation and Rehabilitation Group in comparison to the Rehabilitation only Group, where an increase in fixations was noted. Although all participants may respond to both forms of intervention within the five week period, an investigation into the effect of the increase in fixations in the Rehabilitation only Group over a longer term may show a change i.e. improvement or worsening in results seen at the three month follow up.

References:

Adragna, P.J., Schmidt, R. and Solomon, E. 1990. *Human Anatomy and Physiology.* 2nd ed. USA: Saunders College Publishing.

Agur, A.M.R. and Lee, M.J. 1991. *Grant's atlas of anatomy.* 9th ed. USA: Williams and Wilkins.

Ajis, A. and Maffulli, N. 2006. Conservative management of Chronic Ankle Instability. *Foot and Ankle Clinic North America*, 11: 531-537.

Ajis, A., Younger, A., Maffulli, N. 2006. Anatomical Repair for Chronic Lateral ankle Instability. *Foot and Ankle Clinic North America*, 11: 539-545.

Atkins, D.C., Bedics, J.D., Mcglinchey, J.B. and Beauchaine, T.P. 2005. Assessing clinical significance: does it matter which method we use? *Journal of Consulting and Clinical Psychology*, 73(5): 982-989.

Audenaert, E.A., Van Nuffel, J. Deroo, K.F., Vuylsteke, M. and Verdonk, R. 2004. Bilateral simultaneous traumatic Achilles tendon rupture. *Foot and Ankle Surgery*, 10: 49-50.

Balint, G.P., Korda, J., Hangody, L., and Balint, P. 2003. Foot and ankle disorders. *Best Practice and Research Clinical Rheumatology*, 17: 87-111.

Bekker-Smith, C. 2003. *The effectiveness of spinal Manipulation and interferential current therapy versus oral melixicam and interferential current therapy in the treatment of acute mechanical low back pain.* M.Tech thesis: Chiropractic. Durban University of Technology.

Bellingham, S.G. 2001. *The relative effectiveness of Piroxicam versus Protease administration in the treatment of acute Grade 1 and Grade 2 ankle inversion sprains.* M.Tech thesis: Chiropractic. Durban University of Technology.

Bergmann, T., Petersen, D. and Lawrence, D. 1993. *Chiropractic Technique Principles and Procedure.* USA: Churchill Livingstone.

Bhojani, K.S. and Kalke, S. 2010. Approach to foot pain. *Indian Journal of Rheumatology*, 5 (3): 124-130.

Billi, A., Catalucci, A., Barile, A. and Maschiocchi, C. 1998. Joint impingement syndrome: clinical features. *European Journal of radiology*, 27: 539-541.

Birrer, R.B., Fani-Salek, M.H., Totten, Y., Herman, L. and Politi, V. 1999. Managing ankle injuries in the emergency department. *The Journal of Emergency Medicine.*

Bonnel, F., Toullec, E., Mabit, C., Tourne, Y. and Sofcot et la. 2010. Chronic ankle instability: Biomechanics and pathomechanics of ligamentous injury and associated lesions. *Orthopaedics and Traumatology: Surgery and Research*, 96: 424-432.

Boon, N.A., Colledge, N.R., Walker, B.R. and Hunter, J.A.A (editors). 2006. Davidson's Principles and Practice of Medicine. 20th ed. USA: Churchill Livingstone.

Bozkurt, M., and Doral, M.N. 2006. Anatomic factors and biomechanics in ankle instability. *Foot and Ankle Clinics North America*, 11: 451-465.

Bozzelle, J.R. and Kishner, S. 2010. *Recurrent ankle sprains.* [Online] Available: http://www.emedicine.medscape.com/article/1233624-diagnosis, [Accessed January 2010].

Brantingham , J.W. , Globe, G., Cassa, T., Globe, D., DeLuca, K., Pollard, H., Lee, F., Bates, C., Jensen, M., Mayer, S. and Korporaal, C. A single-Group pre-test post-test design using full kinetic chain manipulative therapy with Rehabilitation in the treatment of 18 patients with hip osteoarthritis. *Journal of Manipulative and Physiological Therapeutics.* 2010 *In Press.*

Brantingham, J., Snyder, R., Wong, J., Brantingham, C. and Haggart, B. 1993. Chronic ankle pain (unresolved ankle sprain). *Dynamic Chiropractic,* 11(2).

Brantingham, J.W., Pollard, H., Hicks. M., Korporaal, C. and Hoskins, W. 2009. Manipulative therapy for lower extremity conditions: expansion of literature review. *Journal of Manipulative and Physiological Therapeutics*, 32:53-71.

Calliet, R. 1997. Foot and Ankle pain. 3rd ed. Philadelphia: F.A. Davis Company.

Caulfield, B. 2000. Functional instability of the ankle joint, features and underlying causes. *Physiotherapy,* 86:8.

Chambers, H.G. and Haggerty, C. 2006. The Foot and Ankle in Children and Adolescents. *Operative Techniques in Sports Medicine,* 14:173-187.

Chesterton, L.S., Sim, J., Wright, C.C. and Foster, N.E. 2007. Interrater reliability of algometery in measuring pressure pain thresholds in healthy humans, using multiple raters. *Clinical Journal of Pain*, 23(9):760-6.

Chowdry, F.U., Robinson, P., Grainger, A.J. and Harris, N. 2006. Transient regional osteoporosis: a rare cause of foot and ankle pain. *Foot and Ankle Surgery,* 12:79-83.

Clark, V.M. and Burden, A.M. 2005. A 4-week wobble board exercise programme improved muscle onset latency and perceived stability in individuals with a functionally unstable ankle. *Physical Therapy in Sport,* 6:181-187.

Coetzer, D., Brantingham, J. and Nook, B. 2001. The relative effectiveness of piroxicam compared to Manipulation in the treatment of acute grades 1 and 2 inversion ankle sprains. Journal of the Neuromusculoskeletal system, 9(1):1-12.

Collins, N., Teys, P. and Vicenzino, B. 2002. The Initial Effects of a Mulligan's Mobilisation with Movement Technique on Dorsiflexion and Pain in Sub acute ankle Sprains. *Manual Therapy,* 9:77-82.

Cook, C.E. nd. Clinimetrics Corner: The Minimal Clinically Important Change Score (MCID): A Necessary Pretense. *The Journal of Manual & Manipulative Therapy,* 16(4).

Cutnell, J.D. and Johnson., C. 2007. Cutnell and Johnson physics. USA: Wiley.

Dannenberg, H.J. 2004. Manipulation of the ankle as a method of treatment for ankle and foot pain. *Journal of the American Podiatric Medical Association,* 94: 395-399.

Dannenberg, H.J., Shearstone, J. and Guiliano, M. 2000. Manipulation methods for treatment of ankle equines. *Journal of the American Podiatric Medical Association,* 190: 385-389.

De Bie, R.A., de Vet, H.C.W., Lenssen, T.F., van den Wildenberg, F.A.J.M., Kootstra, G. and Knipschild, P.G. 1998. Low level laser therapy in ankle sprains: a randomised clinical trial. *Archives of Physical and Medical Rehabilitation,* 79:1415-1420.

de Vries, J.S., Krips, R., Sierevelt, I.N. and Blankevoort, L. 2006. Interventions for treating chronic ankle instability. *Cochrane Database Systematic Review,*.4:CD004124.

Delahunt, E. 2007. Neuromuscular contributions to functional instability of the ankle joint. *Journal of Bodywork and Movement Therapies,* 11:203-213.

Deshpande, N., Connely, D.M., Culham, E.G. and Costigan, P.A., 2003. Reliability and Validity of Ankle Proprioceptive Measures. *Archives of Physical and Medical Rehabilitation,* 84(6): 883-9.

Donoghue, D. and Stokes, E. 2009. How much change is true change? The minimal detectable change of berg balance scale (full) in elderly people. *Journal of Rehabilitation Medicine*, 41:343-346.

Eechaute, C., Vaes, P., Van Aerscof, L., Asman, S. and Duquet, W. 2007. The clinimetric qualities of patient assessed instruments for measuring chronic ankle instability: a systematic review. *BMC Musculoskeletal Disorders*, 8(6):1-11.

Eils, E., Demming, C., Kollmeier, G., Thorwestan, L., Volker, L. and Rosenbaum, D. 2002. Comprehensive testing of ten different ankle braces evaluation of passive and rapidly induced stability in participants with chronic ankle instability. *Clinical Biomechanics*, 17:526-535.

Eisenhart, A.W., Gaeta, T.J. and Yens, D.P. 2003. Osteopathic Manipulative Treatment in the Emergency Department for Participants with Acute Mortise Injuries. *Journal of American Osteopathic Association*, 103(9); 417-421.

Esterhuizen. T. 2010. Personal communication with D. Lubbe. 13 January 2010.

Farrar, J.T., Young, J.P., LaMoreaux, L., Werth, J.L. and Poole, R.M. 2001. Clinical importance of changes in chronic pain intensity measured on an 11-point numerical pain rating scale. *Pain,* 94(2):149-158.

Ferran, N.A., and Maffulli, N. 2006. Epidemiology of sprains of the lateral mortise complex. *Foot and Ankle Clinic North America*, 11:659-662.

Fetheney, J. 2010. Statistical and clinical significance, and how to use confidence intervals to help interpret both. Australian Critical Care 23, 93—97.

Fopma, E. And Macnicol, M.F. 2002. Tarsal Coalition. *Current Orthopaedics,* 16:65-73.

Francis, R. 2005. *To investigate the effectiveness of proprioceptive neuromuscular facilitation with cryotherapy in the treatment of mechanical neck pain caused by hypertonic posterior cervical muscles.* M.Tech thesis: Chiropractic. Durban University of Technology.

Frontera, W.R., Dawson, D.M., and Slovik, D.M. 1999. *Exercise in Rehabilitation Medicine.* USA: Human Kinetics.

Gam, A.N. and Johannsen, F. 1995. Ultrasound therapy in musculoskeletal disorders: meta-analysis. *Pain*, 63:85-91.

Garneti, N., Holton, C. and Shenolikar, A. 2005. Bilateral simultaneous traumatic Achilles tendon rupture: a case report. *Accident and Emergency Nursing*, 13:220-223.

Gatterman, M.I. 1990. *Chiropractic Management of Spine Related Disorders*. Baltimore, Maryland: Williams and Wilkens.

Gillman, S.F. 2004. The impact of chiropractic manipulative therapy on chronic recurrent lateral mortise sprains in two young athletes. *Journal of Chiropractic Medicine* 4 (3).

Gray, J.M. and Alpar, E.K. 2001. Peroneal tenosynovitis following ankle sprains. *Injury, International Journal of the Care of the Injured*, 32:487-489.

Green, G.A. 2001. Understanding NSAIDs: from aspirin to COX-2. *Sports medicine*, 3:50-59.

Green, T., Refshauge, K., Crosbie, J. and Adams, R.A. 2001. A randomised controlled trial of a passive accessory joint mobilisation on acute mortise inversion sprains. *Physical Therapy*, 81 (4): 984-994.

Grey, H. 1901. *Grays's anatomy*. Philadelphia: Kaimon and Polon.

Haas, M., Panzer, D., Peterson, D., and Raphael, R. 1995. Short term responsiveness of manual thoracic end play assessment to spinal Manipulation: a randomized controlled trial of construct validity. *Journal of Manipulative and Physiological Therapeutics*, 18:582-589.

Haldeman, S. 1992. *Principles and Practice of Chiropractic*. Conneticut: Appleton and Lange.

Hale, S.A. and Hertel, J. 2005. Reliability and sensitivity of the foot and ankle disability index in subjects with chronic ankle instability. *Journal of Athletic Training*, 40:35-40.

Halsaa, K., Brovold, T., Graver, V. and Sandvik, L. 2007. Assessments of Interrater Reliability and Internal Consistency of the Norwegian Version of the Berg Balance Scale. *Archives of Physical and Medical Rehabilitation*, 88:94-8.

Henden, L. and Beeson, P. 2009. A review of differences between normal and osteoarthritis articluar cartilage in human knee and ankle joints. *The Foot*, 19:171-176.

Hughes, T. and Rochester, P. 2008. The effects of proprioceptive exercise and taping on proprioception in participants with functional mortise instability: A review of the literature. *Physical Therapy in Sport* 9; 136-147.

Jahss, M.D. 1982. 2nd ed. *Disorders of the foot and ankle: medical and surgical management.* Volume 1. USA: W.B. Saunders company.

Jennings, J. and Davies, G. 2005. Treatment of cuboid syndrome secondary to lateral ankle sprains: a case series. *Journal of Orthopaedic and Sports Physical Therapy,* 35:409-415.

Jensen, I.B., Busch, H., Bodin, L., Hagberg, J., Nygren, A., and Bergstrom, G. 2009. Cost effectiveness of two Rehabilitation programmes for neck and back pain patients: seven year follow up. *Pain,* 142:202-208.

Jensen, M.P. and Karoly, P. 1993. Self-*report scales and procedures for assessing pain in adults.* New York: Guilford Press.

Jones, R., Carter, J. Moore, P. and Willis, A. 2005. A study to determine the reliability of an ankle dorsiflexion weight – bearing device. *Physiotherapy,* 91: 242-249.

Joseph, L.C., de Busser, N., Brantingham, J.W. 2010. The comparative effect of muscle energy technique vs. Manipulation for the treatment of chronic recurrent ankle sprain. *Journal of American Chiropractic Association,* 47(7):8-22.

Karlsson, J. and Sancone, M. 2006. Management of acute ligament injuries of the mortise. *Foot and Ankle Clinic North America,* 11: 521 – 530.

Keller, M., Grossman, J., Caron, M., Mendicino, R.W. 1996. Lateral ankle instability and Brostrom-Gould procedure. *The Journal of Foot and Ankle Surgery,* 35:513-520.

Kessler, R.M., Hertling, D. 1983. *Management of Common Musculoskeletal Disorders.* Philadelphia: Harper and Row.

Kirkaldy-Willis., W.H. and Burton, C.V. 1992. *Managing low back pain.* 3rd edition. United States of America: Churchill Livingstone.

Köhne E, Jones A, Korporaal C, Price J, Brantingham J, Globe G. 2007. A prospective, single-blinded, randomized, controlled clinical trial of the effects of Manipulation on proprioception and ankle dorsiflexion in chronic recurrent ankle sprain. *Journal of the American Chiropractic Association,* 44(5):7-17.

Kornetti, D.L., Fritz, S.L., Chiu, Y., Light, K.E. and Velozo, V.A. 2004. Rating scale analysis of the Berg Balance Scale. *Archives of Physical Medical Rehabilitation*, 85; 1128-35.

Kynsberg, A., Halasi, T. Tallay, A. and Beker, I. 2006. Changes in joint position sense after conservatively treated chronic lateral mortise instability. *Foot and Ankle Clinic North America*, 14 2399 – 1306.

Laing, P. 2004. Common disorders of the adult foot and ankle. *Orthopaedic Surgery* 45-48.

Lakhani. E, Nook. B, Haas, M and Docrat. A. 2009. Motion palpation used as a post Manipulation assessment tool for monitoring end feel improvement: a randomized controlled trial of test responsiveness. *Journal of Manipulative and Physiological Therapeutics*, 32:549-555.

Leach, R.A. 2004. 3rd Ed. *The Chiropractic Theories: Principles and Clinical Applications*.Baltimore: Lippincott, Williams and Wilkins.

Lee, A and Lin, W.H. 2008. Twelve week biomechanical mortise platform system training on postural stability and mortise proprioception in participants with unilateral functional mortise Instability. *Clinical Biomechanics*, 23: 1065 – 1072.

Lephart, S.M. and Fu, F.H. 1995. The role of proprioception in the treatment of sports injuries. *Sports Exercise and Injury*, 1: 96-102.

Lesic, A and Bumbasirevic, M. 2004. Ankles Fractures. *Current Orthopaedics*, 18:232-244.

Lesic, A. And Bumbasirevic, M. 2004. Disorders of the Achilles tendon. *Current Orthopaedics*, 18: 63-75.

Liebenson, C. and Lewit. K. 2003. Palpations reliabity: a question of art vs. science. *Journal of Bodywork and Movement Therapy*, 7(1): 46-48.

Liggins, C.A. 1982. The measurement of pain – a brief review. *Physiotherapy*. 38(2): 34-37.

Lindsey-Renton, C. 2005. The immediate effect of Manipulation in chronic ankle instability in terms of objective clinical findings. M.Tech thesis: Chiropractic. Durban University of Technology.

Lines, S.P. and Hepple, S. 2005. Glomagioma on the dorsum of the foot: A case report of a large Glomagioma. *The Foot,* 15:54-46.

Lopez-Rodriguez S, Fernandez de-Las-Penas C, Alburquerque-Sendin F, Rodriguez-Blanco C, Palomeque-del-Cerro L. 2007. Immediate effects of Manipulation of the talocrural joint on stabilometry and baropodometry in patients with ankle sprain. *Journal of Manipulative and Physioogical Therapeutics*; 30(3): 186-192.

Lynch, R.M. 2004. Achilles tendon rupture: surgical versus nonsurgical treatment. *Accident and Emergency Nursing,* 12:149-158.

Mack, R.P. 1982. Ankle injuries in Athletics. Clinics in Sports Medicine, 1(1):71-84.

Magee, D.J. 2002. 4th ed. *Orthopedic Physical Assessment.* U.S.A: Saunders.

Masciocchi, C., Catalucci, A. and Barile, A. 1998. Ankle impingement syndrome. *European Journal of Radiology,* 27: 570-573.

McBride, D. and Ramamurthy, C. 2006. Chronic ankle instability: management of chronic lateral ligamentous dysfunction and the varus tibiotalar joint. *Foot and Ankle Clinic North America,* 11: 607 – 62.

McKeon, P.O. and Hertel, J. 2008. Systematic review of postural control and lateral ankle instability, part II: is balance training clinically effective? *Journal of Athletic Training,* 43(3):305-315.

Meiring, J.H., Liebenberg, S.W., van Heerden, L., Jacobs, C.J., Vorster, W., Scheepers, M.D. and Greyling, L.M. 2000. *Human anatomy.* Pretoria: Van Shaik Publishers.

Menz, H.B. 2004. Two feet , or one person? Problems associated with statistical analysis of paired data in foot and ankle medicine. *The Foot*, 14:2-5.

Michaud, T.C. 1997. *Foot orthoses and other forms of conservative foot care.* 2nd ed. Baltimore: Williams and Wilkins.

Mickel, T.J., Bottoni, C.R., Tsuji, G., Chang, K., Baum, L. And Tskushige, K.A.S. 2006. Prophylactic bracing versus taping for prevention of ankle sprains in high school athletes: a prospective, randomised clinical trial. *The Journal of Foot and Ankle surgery,* 45:360-365.

Miller, A.S., Narson, T.M. 1995. Protocols for Proprioceptive Active Retraining Boards. *Chiropractic Sports Medicine* 52-55 .

Milner, S. 2010. Common disorders of the foot and ankle. *Orthopaedic Surgery: Lower Limb,* 28:514-517.

Molloy, S., Solan, M.C., Bendall, S.P. 2003. Synovial impingemnt in the ankle: A new physical sign. *The Journal of Bone and Joint Surgery.*

Moore, K.L. and Dalley, S. 1992. *Clinically Orientated Anatomy.* 3rd edition. United States of America: Williams and Wilkins.

Morvan, G., Busson, J., Wybier, P. and Mathieu, P. 2001. Ultrasound of the ankle. *European Journal of Ultrasound,* 14: 73-82.

Mouton, J. 1996. *Fundamentals of Research Methodology.* 2nd edition. USA: Churchill Livingstone.

Mouton, J. 1996. Understanding Social Research. 1st Edition. Pretoria: Van Schaik Publishers.

Neal M.J. *Medical pharmacology at a glance.* 4th ed. Oxford: Blackwood science.

Ogles, B.M., Lunnen, K.M., and Bonesteel, K. 2001.Clinical Significance: History, Application and current practice, *Clinical Psychology Review,* 21(3); 421–446.

Oztekin, H.H., Boya, H., Ozcan, O., Zeren, B. and Pinar, P. 2008. Foot and ankle injuries and time lost from play in professional soccer players. *The Foot,* 19:22-28.

Papadopoulos, E.S., Nicolpoulos, C., Anderson, E.C., Curran, M. and Athanapoulos, S. 2005. The role of ankle bracing in injury prevention, athletic performance and neuromuscular control: a review of the literature. *The Foot,* 15:1-6.

Parker, A., Docrat, A., Korporaal, C., and Carey-Loghmani. 2005. *The efficacy of the graston technique instrument assisted soft tissue mobilisation in the reduction of scar tissue in the management of chronic lateral mortise instability syndrome following an ankle inversion sprain.* M.Tech thesis: Chiropractic. Durban University of Technology.

Pellow, J.E. and Brantingham, J.W. 2001. The efficacy of adjusting the mortise in the treatment of subacute and chronic Grade I and Grade II ankle inversion sprains. *Journal of Manipulative and Physiological Therapeutics*, 24:17-24.

Peris, P. 2003. Stress Fractures. *Best Practice and Research Clinical Rheumatology,* 17 (6): 1043 – 1061.

Pferfer, M.T., Cooper, S.R. and Lihl, N.L. 2009. Chiropractic management of Tendinopathy: a Literature synthesis. *Journal of Manipulative and Physiological Therapeutics.* 31:41-52.

Poul, J., Buchannan, N. and Graham, R. 1993. Local action transcutaneous flubiprofen in the treatment of soft tissue rheumatism. *British Journal of Rheumatology.*32: 1000-1003.

Primal Pictures Ltd, 2003. Sports Injuries Series. Primal Pictures Ltd, London, United Kingdom.

Puffer, C. 2001. The Sprained Ankle. *Sports Medicine*, 3:38-49.

Redwood, D. and Cleveland. 2003. Fundamentals of chiropractic. USA: Mosby.

Reid, C.D. 1992. *Sports Injury Assessment and Rehabilitation.* U.S.A.: Churchill Livingston Inc.

Richie, D.H. 2001. Functional instability of the mortise and the role of neuromuscular control: A comprehensive review. *The Journal of Foot and Ankle Surgery*, 40: 240 – 251.

Rimando, M.P. 2008. *Anklesprain.* [online] Available : http://.emedicine.com , [accessed August 2009].

Roebroeck, M., Dekker, J., Oostendorp, R.A.B., Bosveld, W. 1998. Physiotherapy for patients with lateral ankle sprains, a prospective surgery of practice patterns in dutch primary healthcare. *Physiotherapy*, 84(9):421-432.

Sakellariou, A. and Claridge, R.J. 1998. Tarsal coalition: ailogy, diagnosis and treatment. *Current Orthopaedics*, 12:135-142.

Sallafi, F., Stancati, A., Silvestri, C.A. Ciapetti, A. And Grassi, W. 2003. Minimally clinicaloly important changes in chronic musculoskeletal pain intensity measured on a numerical rating scale. European journal of pain, 8:283-291.

Sandoz, R.W. Some Reflex Phenomena associated with Spinal derangements and adjustments. Read in part at the Australian Chiropractic Association Conference held at Hobart. p. 45-65 .

Schafer, R. and Faye, L. 1990. *Motion Palpation and Chiropractic Technique – Principles of dynamic Chiropractic.* 2nd edition. USA: The Motion Palpation Institute.

Sefton, J.M., Hicks-Little, C.A., Hubbard, T.J., Clemens. M.G., Yengo, C.M., Koceja, D.M. and Cordova, M.L. 2009. Sensorimotor function as a predictor of chronic mortise instability. *Clinical Biomechanics.* 24:451-458.

Sekir, U., Yildiz, Y., Hazneci, B., Ors. F., Saka, T., and Ayadin, T. 2008. Reliability of a functional test battery evaluating functionality, proprioception and ankle strength in recreational athletes with functional ankle instability. *European Journal of Physical and Rehabilitation Medicine,* 44:407-415.

Seth, S. D. 1999. *Textbook of Pharmacology.* 2nd edition. USA: Churchill Livingstone.

Sinnastamby, C.S. Lasts Anatomy. 2006. 11th ed. United Kingdom: Churchill Livingstone.

Souza, T.A. 1998. *Differential diagnosis for the chiropractor: protocols and algorithms.* Maryland: Aspen Publishers.

Squires, N. A. and Jeng, C.C. 2006. Posterior tibial tendon dysfunction. *Operative Techniques in Orthopaedics,* 16:44-52.

Taser, F., Shafiq, Q. And Ebraheim, N.A. 2006. Anatomy of lateral ankle ligaments and their relationship to bony landmarks. *Surgical Radiological Anatomy,* 28:391-397.

Thaker, S.B., Stroup, D.F., Branche, C.M., Gilchrist, J., Goodman, R.A. and Weitman, E.A. 1999. The Prevention of Ankle Sprains in Sports. *The American Journal of Sports Medicine..* 27,(6).

Tourne, Y., Besse, J.L., Mabit, C. and Sofcot. 2010. Chronic ankle instability. Which test to assess the lesions? Which therapeutic options? *Orthopaedics and Traumatology: Surgery and Research,* 96:433-446.

Unknown. 2006. Therabands [online]. Available: http://therabandacademy.com [accessed 09 August 2009].

van der Wees, P., Lenssen, A.F., Hendriks, E.J., Stomp, D.J., Dekker, J. and de Bie, R.A. 2006. Effectiveness of Exercise Therapy and Manual Mobilisation in the Mortise Sprain and Functional Instability: A systematic Review. *Australian Journal of Physiotherapy,* 52(1):27-37.

Vann, M.A. and Manoli, A. 2010. Medial impingement syndrome in Female Gymnasts. *Operative Techniques in Sports Medicine,* 18:50-52.

Vaughan, B., Mclaughlin, P. and Gosling, C. 2007. Validity of electronic pressure algometer. *International Journal of Osteopathic Medicine,* 10:24-28.

Verhagen, R.A.W., De Keizer, G. and Van Dijk, C.N. 1995. Long term follow up of inversion trauma of the mortise. *Arch Ortho trauma surg,* 114:92-96.

Vicenzino B, Prangley I, Martin D. The initial effect of two Mulligan mobilisation with movement treatment techniques on ankle dorsiflexion. Australian Conference of Science and Medicine in Sport. A Sports Medicine Odyssey. Challenges, Controversies and Change [CD ROM]. Sports Medicine Australia; 2001.

Vicenzino, B., Branjerdporn, M., Teys, P. and Jordan, K. 2006. Initial Changes in Posterior Talar Glide and Dorsiflexion of the Mortise after Mobilisation with Movement in Individuals with Recurrent Mortise Sprains. *Journal of Orthopaedic and Sports Physical Therapy,* 36:464-471.

Vizniak, N.A. and Carnes M.A. 2004. *Quick Reference Clinical Chiropractic Manual.* Canada: DC Publishing International.

Walls, R.J., Brennan, S.A., Hodnett, P., O'Byrne, J.M., Eustace, S.J. and Stephens, M.M. 2010. Overuse ankle injuries in professional Irish dancers. *Foot and Ankle Surgery,* 16:45-49.

Westlin, N.E., Vogler, H.W., Albertson, M.P., Arvidson, T. and Montgomery, F. 2003. Treatment of lateral ankle instability with transfer of extensor digitorum brevis muscle. *Journal of Foot and Ankle Surgery,* 42:163-192.

Whitman, J.M., Cleland, J.A. Mintken, P.E.Kierans, M. Bieniek, M.L. Albin, A.R., Magel, J. and Mcpoil, T.G. 2009. Predicting Short-term Response to Thrust and Non-thrust Manipulation and Exercise in participants post Inversion Ankle Sprain. *Journal of Orthopaedic and Sports Physical Therapy,* 39(3); 188-200.

Wright, I.C., Neptune, R.R., Van den Bogert, A.J. and Nigg, B.M. 2000. The influence of foot positioning on ankle sprains. *Journal of Biomechanics*, 33:53-515.

Wyke, B.D. The neurology of joints: a review of general principles. *Clinics in Rheumatic Diseases*. 1981;7:223-239 .

Yeomans, S. 2000. *The Clinical Application of Outcomes Assessment*. USA: Appleton and Lange.

Yildaz, Y., Aydin, T., Sekir, U., Hazneci, B., Komurcu, M. and Kaylon, T.A. 2003. Peak and end range eccentric evertors/concentric invertor muscle strength ratios in chronically unstable ankles: Comparision with healthy individuals.

Yochum, T.R. and Rowe, L.J. 1996. *Essentials of Skeletal Radiology*. USA: Lippincott Williams and Wilkins.

Zammit, E. and Herrington, L. 2005. Ultrasound therapy in management of acute lateral ligament sprained of the ankle joint. *Physical Therapy in Sport*, 6:116-121.

Ziltener, J.L., Leal, S. and Fournier, P.E. 2010. Nonsteroidal anti inflammatory drugs for athletes: an update. *Annals of Physical and Rehabilitation Medicine*, 53:278-288.

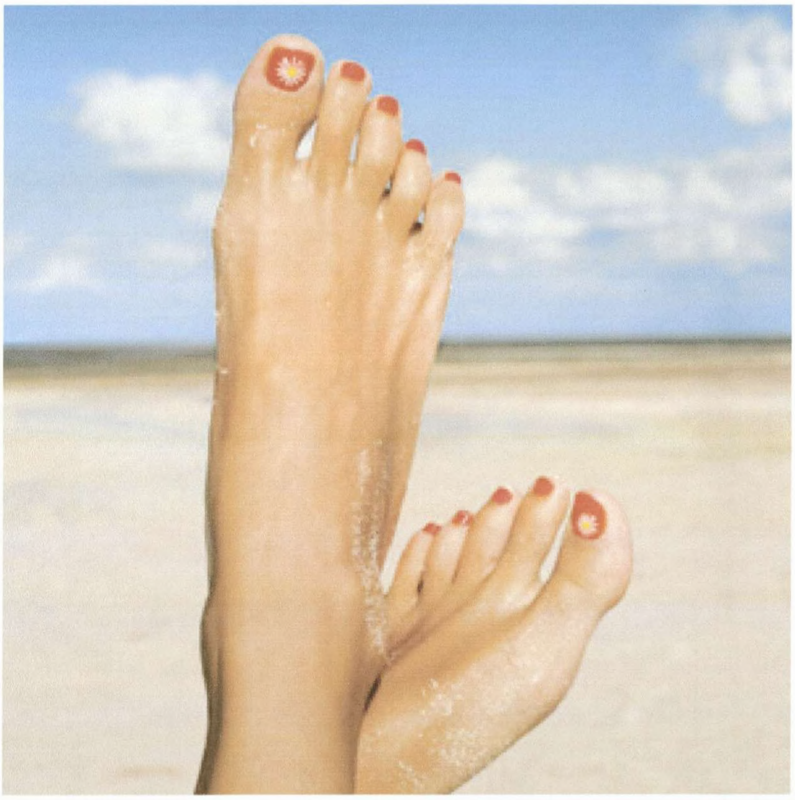
Zwipp, H., Bemmerl, J.G., Holch, M., Themann, H. and Mascheck, H.J. 1996. Sinus tarsi and canalis tarsi syndromes. A post traumatic entity. Foot ans Ankle Surgery, 2:181-188

APPENDIX A - ADVERTISMENT

Do you suffer with chronic ankle sprains /Sprain your ankle repeatedly?

DO YOU SUFFER WITH

1. Pain in and around your ankle?
2. A feeling of "giving way"?
3. Swelling in and around your ankle?
4. Recurrent ankle sprains?
5. Joint clicking in your ankle?



Then you may have unstable ankles!!!

If you are between the ages of 18 – 45 then come receive free treatment at the DUT Chiropractic Clinic

Contact: 031-3052205 (Clinic)

APPENDIX B - LETTER OF INFORMATION AND CONSENT

Dear participant, thank you for your interest in this research study,

Title of the Research Study: The effectiveness of combined Manipulation and Rehabilitation versus Rehabilitation only, in the management of chronic ankle instability.

Principle Investigator/s: Danella Lubbe
Co-Investigator/s: Dr. E. Lakhani and Dr. J. Brantingham

Brief Introduction and Purpose of the Study: You have been selected to take part in a study investigating the effect of Manipulation and Rehabilitation versus stand-alone Rehabilitation, in participants with chronic ankle instability.

Thirty people will be required to complete this study at the Durban University of Technology.

Outline of the Procedures:
To be part of this study you must

1. Be between the ages of 18-45 years.
2. Give informed consent to participate in the research.
3. Have the presence of at least 4 of these clinical features lateral ankle pain, joint weakness, edema, joint crepitus, adhesions resulting in the formation of restrictions in the joint and ligamentous laxity.

You will not be eligible to take part in this study if you

1. Have any contraindications to adjustments.
2. Have any contraindications to Rehabilitation.
3. Have any balance disorders.
4. Are taking any medications for treatment for their mortise.

Risks or Discomforts to the Participant: The participant may experience transient muscle pain – post treatment as a result of the nature of the treatment. The participation in this study is safe with minimal likelihood to cause adverse side effects.

Benefits: The participant (you) will benefit from the study with the treatment of their condition (CAI) over the five week period and the researcher will benefit from the study by obtaining their Master degree in technology, as well as publications in one or two accredited journals.

Reason/s why the Participant May Be Withdrawn from the Study: The participant may be withdrawn from the study if compliance to treatment is not met (i.e. attending all appointments at the CDC at relative intervals).

Remuneration: The participant will receive a Theraband and Bosu Ball (Hedgehog) on completion of the full study.

Costs of the Study: The participant in the study will not be required to pay for anything during this study.

Confidentiality: Only the researcher and supervisors will have access to the data and all participant information will remain confidential. The names of the participants of the study will not be divulged to any party. Data sheets will be stored in the participant files in the CDC for a period of 5 years before being shredded. The results in the form of a mini dissertation will be available at the DUT library; however no confidential documentation will be included.

Persons to Contact in the Event of Any Problems or Queries:

If any queries arise as a matter of the research study the supervisor of this research, Dr. E.Lakhani, can be reached on 0313732094 (w) or alternatively at ektal@dut.ac.za. Mr Vikesh Singh of the faculty of health sciences research and ethics committee can be contacted on 031 3732701

Statement of Agreement to Participate in the Research Study:

(I,………………………………………………………….. (participant's full name), ID number ………………………………………………………., have read this document in its entirety and understand its contents. Where I have had any questions or queries, these have been explained to me by …………………………………………………to my satisfaction. Furthermore, I fully understand that I may withdraw from this study at any stage without any adverse consequences and my future health care will not be compromised. I, therefore, voluntarily agree to participate in this study.

Participant's name (print) ………………………………

Participant's
signature:………………………………………………………Date:…………………

Researcher's name (print):……………………….

Researcher's
signature:………………………………………………………Date:........................

Witness name (print): ………………….. ……….

Witness signature:
…………………………………………………………........Date:…………………..

APPENDIX C – CASE HISTORY

DURBAN UNIVERSITY OF TECHNOLOGY
CHIROPRACTIC DAY CLINIC
CASE HISTORY

Participant: ______________________________ Date: ________

File # : __________ Age: ________

Intern : ______________________ Signature ______________

FOR CLINICIANS USE ONLY:
Initial visit
Clinician: Signature :

Case History:

Examination:
Previous: Current:

X-Ray Studies:
Previous: Current:

Clinical Path. lab:
Previous: Current:

CASE STATUS:

PTT:	Signature:	Date:

CONDITIONAL:
Reason for Conditional:

Signature: Date:

Conditions met in Visit No:	Signed into PTT:	Date:
Case Summary signed off:		Date:

<u>Intern's Case History:</u>

1. **Source of History:**

2. **Chief Complaint: (participant's own words):**

3. **Present Illness:**

	Complaint 1	**Complaint 2**
< Location		
< Onset : Initial:		
Recent:		
• Cause:		
< Duration		
< Frequency		
< Pain (Character)		
< Progression		
< Aggravating Factors		
< Relieving Factors		
< Associated S & S		
< Previous Occurrences		
< Past Treatment		
(a) **Outcome:**		

4. **Other Complaints:**

5. **Past Medical History:**

< General Health Status

< Childhood Illnesses

< Adult Illnesses

< Psychiatric Illnesses

< Accidents/Injuries

< Surgery

< Hospitalizations

6. Current health status and life-style:

< Allergies

< Immunizations

< Screening Tests incl. xrays

< Environmental Hazards (Home, School, Work)

< Exercise and Leisure

< Sleep Patterns

< Diet

< Current Medication
Analgesics/week:

< Tobacco

< Alcohol

< Social Drugs

7. Immediate Family Medical History:

< Age

< Health

< Cause of Death

< DM

< Heart Disease

< TB

< Stroke

< Kidney Disease

< CA

< Arthritis

< Anaemia

< Headaches

< Thyroid Disease

< Epilepsy

< Mental Illness

< Alcoholism

< Drug Addiction

< Other

8. Psychosocial history:

< Home Situation and daily life

< Important experiences

< Religious Beliefs

9. Review of Systems:

< General

< Skin

< Head

< Eyes

< Ears

< Nose/Sinuses

< Mouth/Throat

< Neck

< Breasts

< Respiratory

< Cardiac

< Gastro-intestinal

< Urinary

< Genital

< Vascular

< Musculoskeletal

< Neurologic

< Haematologic

< Endocrine

< Psychiatric

APPENDIX D – PHYSICAL EXAMINATION

Durban University of Technology

PHYSICAL EXAMINATION: SENIOR

Participant Name : ______________________ **File no :** ________ **Date :**

Student : **Signature :**

VITALS:					
Pulse rate:			Respiratory rate:		
Blood pressure:	R	L	Medication if hypertensive:		
Temperature :			Height:		
Weight:	Any recent change? Y / N		If Yes: How much gain/loss	Over what period	

GENERAL EXAMINATION:		
General Impression		
Skin		
Jaundice		
Pallor		
Clubbing		
Cyanosis (Central/Peripheral)		
Edema		
Lymph nodes	Head and neck	
	Axillary	
	Epitrochlear	
	Inguinal	
Pulses		
Urinalysis		

SYSTEM SPECIFIC EXAMINATION:
CARDIOVASCULAR EXAMINATION
RESPIRATORY EXAMINATION
ABDOMINAL EXAMINATION
NEUROLOGICAL EXAMINATION
1.1.1 COMMENTS

Clinician: **Signature :**

APPENDIX E – FOOT AND ANKE REGIONAL

DURBAN INSTITUTE of TECHNOLOGY

Foot and ankle regional examination

Participant:______________________________File no:____

Intern / Resident ________________Signature:__________

Clinician:___________________Signature:__________

Observation
Gait analysis (antalgic limp,toe off, arch, foot alignment, tibial alignment).

____

____

Swelling____
Heloma dura / molle____
Skin____
Nails____
Shoes____
Contours (achilles tendon, bony prominences)___________________

Active movements

Weight bearing:	Ⓡ	Ⓛ	***Non weight bearing:***	Ⓡ	Ⓛ
Plantarflexion			50°		
Dorsiflexion			20°		
Supination					
Pronation					
Toe dorsiflexion			40°(mtp)		
Toe plantarflexion			40° (mtp)		
		Big toe dorsiflexion (mtp) (65-70°)			
		Big toe plantarflexion (mtp) 45°			
		Toe abduction + adduction			
		5° first ray dorsiflexion			
		5° first ray plantarflexion			

Passive movement motion palpation (Passive ROM quality, ROM overpressure, joint play)

	Ⓡ	Ⓛ		Ⓡ	Ⓛ
Mortise joint: *Plantarflexion*			Subtalar joint: *Varus*		
Dorsiflexion			*Valgus*		
Talocrural: *Long axis distraction*			Midtarsal:*A-P glide*		
First ray: *Dorsiflexion*			*P-A glide*		
Plantarflexion			*Rotation*		
Circumduction of forefoot on fixed rearfoot			Intermetatarsal glide		
			Tarso metatarsal joints: *A-P*		
Interphalangeal joints: *L /A dist*			Metatarsophalangeal dorsiflexion (with associated plantarflexion of each toe		
A-P glide					
lat and med glide					
rotation					

Resisted Isometric movements

	Ⓡ	Ⓛ		Ⓡ	Ⓛ
Knee flexion			Pronation (eversion)		
Plantarflexion			Toe extension (dorsiflexion)		
Dorsiflexion			Toe flexion (plantarflexion)		
Supination (inversion)					

Neurological

	Ⓡ	Ⓛ
Dermatomes		
Myotomes		
Reflexes		
Balance/proprioception		

Special tests

	Ⓡ	Ⓛ
Anterior drawer test		
Talar tilt		
Thompson test		
Homan sign		
Tinel's sign		
Test for rigid/flexible flatfoot		
Kleiger test (med. deltoid)		

Alignment

	Ⓡ	Ⓛ
Heel to ground		
Feiss line		
Tibial torsion		
Heel to leg (subtalar neutral)		
Subtalar neutral position:		
Forefoot to heel (subtalar & Midtarsal neutral)		
First ray alignment		
Digital deformities		
Digital deformity flexible		

Palpation

Anteriorly

	Ⓡ	Ⓛ
Medial maleoli		
Med tarsal bones, tibial (post) artery		
Lat.malleolous, calcaneus, sinus tarsi, and cuboid bones		
Inferior tib/fib joint, tibia, mm of leg		
Anterior tibia, neck of talus, dorsalis pedis artery		

Posteriorly

Calcaneus, Achilles tendon, Musculotendinous junction		

Plantarily

Plantar muscles and fascia		
Sesamoids		

APPENDIX F – SOAPE NOTE

S: *Numerical Pain Rating Scale (Participant)* *Intern Rating* *A:*

Least *0 1 2 3 4 5 6 7 8 9 10* *Worst*

0: *P:*

E:

Special attention to: *Next appointment:*

Date: *Visit:* *Intern:*

Attending Clinician: *Signature:*

S: *Numerical Pain Rating Scale (Participant)* *Intern Rating* *A:*

Least *0 1 2 3 4 5 6 7 8 9 10* *Worst*

O: *P:*

E:

Special attention to: *Next appointment:*

Date: *Visit:* *Intern:*

Attending Clinician: *Signature*

S: *Numerical Pain Rating Scale (Participant)* *Intern Rating* *A:*

Least *0 1 2 3 4 5 6 7 8 9 10* *Worst*

O: *P:*

E:

Special attention to: *Next appointment:*

APPENDIX G – VISUAL ANALOGUE SCALE

Below is a ten-centimeter line that begins with 0 and ends with 10. On this scale 0 stands for "no pain". 10 stands for pain "as bad as it can be."

No pain ______________________________ Maximal pain

APPENDIX H – FOOT/ANKLE DISABILITY INDEX

Foot and Ankle Disability Index Item						
◦ Standing	4	3	2	1	0	n/a
◦ Walking on even ground	4	3	2	1	0	n/a
◦ Walking on even ground without shoes	4	3	2	1	0	n/a
◦ Walking up hills	4	3	2	1	0	n/a
◦ Walking down hills	4	3	2	1	0	n/a
◦ Going up stairs	4	3	2	1	0	n/a
◦ Going down stairs	4	3	2	1	0	n/a
◦ Walking on uneven ground	4	3	2	1	0	n/a
◦ Stepping up and down curves	4	3	2	1	0	n/a
◦ Squatting	4	3	2	1	0	n/a
◦ Sleeping	4	3	2	1	0	n/a
◦ Coming up on your toes	4	3	2	1	0	n/a
◦ Walking initially	4	3	2	1	0	n/a
◦ Waling 5 minutes or less	4	3	2	1	0	n/a
◦ Walking approximately 10 minutes	4	3	2	1	0	n/a
◦ Walking 15 minutes or greater	4	3	2	1	0	n/a
◦ Home responsibilities	4	3	2	1	0	n/a
◦ Activities of daily living	4	3	2	1	0	n/a
◦ Personal Care	4	3	2	1	0	n/a
◦ Light to moderate work (standing, walking)	4	3	2	1	0	n/a
◦ Heavy work (push/pulling, climbing, carrying)	4	3	2	1	0	n/a
◦ Recreational activities	4	3	2	1	0	n/a
◦ General level of pain	4	3	2	1	0	n/a
◦ Pain at rest	4	3	2	1	0	n/a
◦ Pain during your normal activity	4	3	2	1	0	n/a
◦ Pain first thing in the morning	4	3	2	1	0	n/a

APPENDIX I - WEIGHT BEARING ANKLE DORSIFLEXION TEST

	Pre-treatment one			Pre-treatment five			Post-treatment seven		
DATE									
READING									

APPENDIX J - ALGOMETER MEASUREMENTS

	Pre-treatment one			Pre-treatment five			Post-treatment seven		
DATE									
READING									

APPENDIX K - MOTION PALPATION FINDINGS

Please indicate on the table (in order of most to least fixated)

joint	Fixation noted	Non cavitations	cavitations
1. mortise	A B C		
2. subtalar	A B C		
3. tarsals	A B C		

APPENDIX L - BERG BALANCE SCALE

1. SITTING TO STANDING		**8. REACHING FORWARD WITH OUTSTRETCHED ARM**	
Able to stand without using hand and stabilise indep	4	Can reach forward confidently > 25 cm	4
Able to stand independently using hands	3	Can reach forward >12 cm safely	3
Able to stand using hands after several tries	2	Can reach forward >5cm safely	2
Needs minimal aid to stand or stabilise	1	Reaches forward but needs supervision	1
Needs moderate or maximal assist to stand	0	Loses balance while trying; requires external support	0
2. STANDING UNSUPPORTED		**9. PICK UP OBJECT FROM FLOOR**	
Able to stand safely for two mins	4	Able to pick up slipper safely and easily	4
Able to stand two minutes with supervision	3	Able to pick up slipper but needs supervision	3
Able to stand 30 seconds unsupported	2	Unable to pick up but reaches to 2-5cm from slipper and keeps balance indep	2
Needs several tries to stand 30 seconds unsupported	1	Unable to pick up and needs supervision while trying	1
Unable to stand 30 seconds unassisted	0	Unable to try /needs assist to keep from losing balance or falling	0
3. SIITING UNSUPPORRTED		**10.TURN TO LOOK BEHIND**	
Able to sit safely and securely 2 minutes	4	Looks behind from both sides and weight shifted well	4
Able to sit two minutes under supervision	3	Looks behind one side only other side shows left weight shift	3
Able to sit 30 seconds	2	Turns sideways only but maintains balance	2
Able to sit 10 seconds	1	Needs supervision when turning	1
Unable to sit without support 10 seconds	0	Needs assist to keep from losing balance or falling	0
4.STANDING TO SITTING		**11. TURN 360 °**	
Sits safely with minimal use of hands	4	Able to turn 360 degrees safely in 4 seconds or less	4
Controls descent by using hands	3	Able to turn 360degrees safely one side only in 4 seconds or less	3
Uses back of legs against chair to control descent	2	Able to turn 360 degrees safely but slowly	2
Sits independently but has uncontrolled descent	1	Needs close supervision or verbal cueing	1
Needs assistance to sit	0	Needs assistance while turning	0
5.TRANSFERS		**12. PLACE ALTERNATRE FOOT ON STEP OF STOOL**	
Able to transfer safely with minor use of hands	4	Abel to stand independently and safely and complete 8 steps in 20 seconds	4
Able to transfer safely minor use of hands	3	Able to stand independently and compete 8 steps > 20 seconds	3
Able to transfer with verbal cueing and/or supervision	2	Able to complete 4 steps without aid with supervision	2
Needs one person to assist	1	Able to complete > 2 steps needs minimal assist	1
Needs two people to assist	0	Needs assistance to keep from falling / unable to try	0
6. STANDING UNSUPPORTE DWITH EYES CLOSED		**13.TANDEM STANCE**	
Able to stand 10 seconds safely	4	Able to place foot tandem independently and hold 30 seconds	4
Able to stand 10 seconds with supervision	3	Able to place foot ahead of other independently and hold 30 seconds	3
Able to stand 3 seconds	2	Able to take small step independently and hold 30 seconds	2
Unable to keep eyes closed 3 seconds but stays steady	1	Needs help to step but can hold 15 seconds	1
Needs help to keep from falling	0	Loses balancer whilst stepping or standing	0
7.STANDING UNSUPPORTED WITH FEET TOGHETRE		**14. STANDING ON ONE LEG**	
Able to place feet together independently and stand one minute safely	4	Able to lift le independently and hold > 10 seconds	4
Able to pace feet together independently and stand one minute with supervision	3	Able to lift leg independently and hold 5-10 seconds	3
Able to place feet together independently but unable to hold for 30 seconds	2	Able to lift leg independently and hold = or > 3 seconds	2
Needs help to attain position but unable to stand 15 seconds feet together	1	Tries to lift leg unable to hold 3 seconds but remains standing independently	1
Needs help to attain position and unable to hold for 15 seconds	0	Unable to try or needs assist to prevent fall	0

APPENDIX M - PARTICIPANT DIARY

Title of research project: The effectiveness of combined Manipulation and Rehabilitation versus Rehabilitation only, in the management of chronic ankle instability.
Name of research student: Danella Lubbe
Tel: (031) 373 2205 / 0834537765

The following diary will assist the participant to perform their daily exercises. The pictures below will assist you as to how to perform the exercises.
Please place a √ in the block if you have completed your exercises for the day.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Week one							
Week two							
Week three							
Week four							
Week five							

Figure 1.1

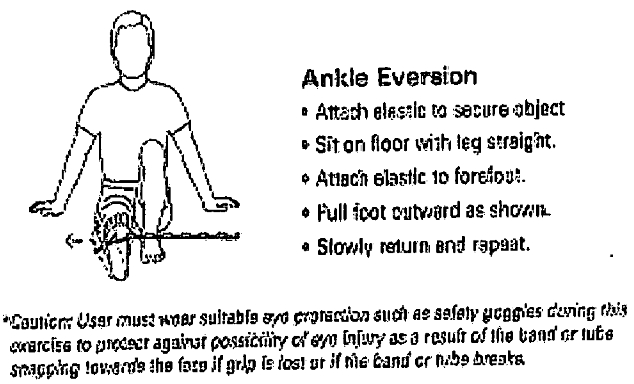
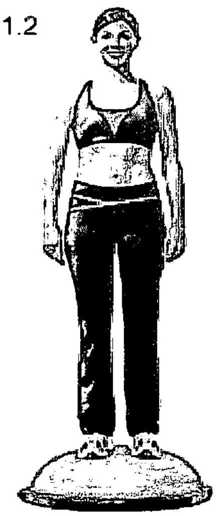


Figure 1.2



How to perform the exercises

Theraband – perform as per instructions above. Must complete three sets of twelve repetitions.	Hedgehogs– you will be required to stand on the hedgehog for a continuous total of ten minutes per day. Ensure there is a wall nearby to hold onto in case of loss of balance.

APPENDIX N - RANDOMISATION TABLE

0001: A	0005: A
0002: B	0006: B
0003: B	0007: A
0004: B	0008: A

========================

0009: B	0012: A
0010: A	0013: A
0011: B	0014: B

========================

0015: A	0017: A
0016: B	0018: B

========================

0019: B	0022: B
0020: A	0023: B
0021: A	0024: A

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0025: B	0028: B
0026: B	0029: A
0027: A	0030: A

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DURBAN UNIVERSITY of TECHNOLOGY

ETHICS CLEARANCE CERTIFICATE

Student Name	Danella Lubbe	**Student No**	20430598
Ethics Reference Number	010/10	**Date of FRC Approval**	19/05/2010
Qualification	M.Tech (Chiropractic)		
Research Title:	The effectiveness of combined manipulation and rehabilitation versus rehabilitation only, in the management of chronic ankle instability.		

In terms of the ethical considerations for the conduct of research in the Faculty of Health Sciences, Durban University of Technology, this proposal meets with Institutional requirements and confirms the following ethical obligations:

1. The researcher has read and understood the research ethics policy and procedures as endorsed by the Durban University of Technology, has sufficiently answered all questions pertaining to ethics in the DUT 186 and agrees to comply with them.
2. The researcher will report any serious adverse events pertaining to the research to the Faculty of Health Sciences Research Ethics Committee.
3. The researcher will submit any major additions or changes to the research proposal after approval has been granted to the Faculty of Health Sciences Research Committee for consideration.
4. The researcher, with the supervisor and co-researchers will take full responsibility in ensuring that the protocol is adhered to.
5. ***The following section must be completed if the research involves human participants:***

	YES	NO	N/A
❖ Provision has been made to obtain informed consent of the participants	X		
❖ Potential psychological and physical risks have been considered and minimised	X		
❖ Provision has been made to avoid undue intrusion with regard to participants and community	X		
❖ Rights of participants will be safe-guarded in relation to: - Measures for the protection of anonymity and the maintenance of confidentiality.	X		
- Access to research information and findings.	X		
- Termination of involvement without compromise	X		
- Misleading promises regarding benefits of the research	X		

12-05-10

SIGNATURE OF STUDENT/RESEARCHER DATE

17/5/2010

SIGNATURE OF SUPERVISOR/S DATE

17/5/10

SIGNATURE OF HEAD OF DEPARTMENT DATE

17/05/2010

SIGNATURE CHAIRPERSON OF RESEARCH ETHICS COMMITTEE DATE