

The Relative Effectiveness of the Activator Adjustment Instrument versus Diversified Manipulation Technique in Chronic Ankle Instability Syndrome (CAIS) in terms of Objective and Subjective Findings.

By

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A dissertation presented to the faculty of Health at Durban University of Technology in partial compliance with the requirements for the Master's Degree in Technology: Chiropractic.

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DEDICATION

I dedicate this work in the loving memory of my mother,
Maria Magdalena Petronella Grobler.

(03/01/1948 – 11/06/2005)

Psalm 131

“a rich child often sits in a poor mother’s lap”
- Danish Proverb (unknown author) -

ACKNOWLEDGEMENTS

I would like to thank the following people for their contribution to this work:

Dr Charmaine Korporaal, who never ceases to amaze me with how well she functions with so little sleep. Your passion for the profession is a blessing and an inspiration. A meticulous miracle-worker with patience, advice, guidance, understanding, encouragement, support, motivation and assistance. You have played a pivotal role during our entire period of study. Without your expertise as my supervisor, this dissertation would not have been possible.

Dr Horace White, thank you for taking the time to co-supervise this research; for your practical knowledge and your ever willingness to help. I really appreciate it.

The administrative staff at DUT (Kershnee, Linda, Pat and Wendy). Kersh, you smoothed out the road for us coming into and throughout the Chiropractic programme. Linda, Pat and Wendy, you became good friends of mine during my time at clinic and during the research process.

Mrs Tonya Esterhuizen, thank you for all the help and advice with the statistical analysis.

All the patients who participated in this study. Thank you for your time and co-operation.

The academic staff at DUT who contributed their knowledge during my studies. Without your dedication, this institute would not be as recognised as it is, and this course would not be as highly regarded.

My fellow classmates, I wish you success for the future in where ever you go and whatever you do. A special thanks to my friend, Dr Kanwal Deep Sood, for his

friendship over the years, and to Timothy William Ford, it has been a privilege and a pleasure to struggle this road with you. Timmy, my mate, we started together – we finished together 😊.

My friend in Christ, Sÿa Marringje Slingerland, for the role you played in my walk to salvation. All of this would mean nothing, if it was not done to the glory of God (1Corinthians10v31).

My family, for all the encouragement, continual prayers and belief in me. I am truly blessed and very proud to have a wonderful family like you. Thank you for the foundation you lay for me, and the support you give while I build on that foundation. A special word of thanks to my granddad, Oupa Koos, and to my sister, 'Net'. I love you all.

My partner, Farzana Naiker. Appie, thank you for your prayers and never-ending patience. You have been a source of wisdom and support through a trying year. Thank you for all the help and fun in between. You are my best friend, you have given me direction and have opened many doors for me. Thank you for your unending selfless love and self-sacrifice. I love you and can't wait to celebrate with you. The A-Team.

My Lord and Saviour, Jesus Christ. For the Glory of God, we are Elected by the Father, Redeemed by the Son, and Sealed by the Spirit. We are saved from God, by God, for God.

ABSTRACT

Background: Lateral ankle sprains and the sequelae of Chronic Ankle Instability Syndrome (CAIS) are common, reaching a peak prevalence of 85%. Manual joint manipulation is an intervention utilised for CAIS. Manipulations are applied either manually or via a mechanical device. The Activator Adjustment Instrument (AAI) is commonly applied to extremities; however, a paucity of research exists, in respect of extremity conditions. Thus this study compared an AAI manipulation with a manual long-axis distraction manipulation (diversified technique) in the treatment of CAIS.

Method: This ethics approved, quantitative, randomised controlled clinical trial, of 40 participants allocated between two groups. After receipt of informed consent participants were evaluated against the inclusion criteria and baseline measures were taken. One treatment of either manual or activator manipulation was followed by a measurements-only consultation within 48 hours. A p -value <0.05 was considered statistically significant. Intra- and inter-group analyses were done utilising repeated measures ANOVA tests.

Results: Both groups showed a statistically significant improvement on all outcome measures over time, but neither group showed a significant improvement over the other. A trend in the inter-group comparisons reflected parallel improvements in the Algometer, Berg Balance Scale and the dorsiflexion range of motion (objective measures) and non-parallel improvements in the Numerical Pain Rating Scale and Foot and Ankle Disability Index.

Conclusion: The results suggested a trend towards subjective improvement in the AAI group, which may have been influenced by the novelty of the AAI. Further research with larger sample sizes and more homogenous participant groups are needed to verify this outcome.

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LIST OF ABBREVIATIONS

“A”	treatment group who received a manual long-axis distraction manipulation by diversified technique / defined as the blue line on the figures.
“B”	treatment group who received an AAI manipulation with the AAI set at full tension / defined as the green line on the figures.
“df”	differential.
“F”	frequency (Bland, 1996; Swinscow, 1996; Wright, 1997; Campbell and Machin, 1999 and Hinton, 2001).
“N”	sample size. Sample in this case is defined as <i>“A subset of a population”</i> (Tropper, 1998).
“p”	<i>p</i> -value which indicates the data statistical significance (Bland, 1996; Swinscow, 1996; Wright, 1997; Campbell and Machin, 1999 and Hinton, 2001).
“Sig”	significance (Bland, 1996; Swinscow, 1996; Wright, 1997; Campbell and Machin, 1999 and Hinton, 2001).
“Tx”	treatment.
“%”	percentage.
“<”	a figure “less than” the figure reported.
“=”	equals to.

LIST OF DEFINITIONS

AAI: The Activator Adjustment Instrument (AAI) is a mechanical instrument that is used to produce a High Velocity, Low-Amplitude (HVLA) thrust to a joint, whilst reducing physical stress on the clinician. In addition it precisely controls the speed, force, and direction of the manipulative thrusts (Fuhr, 2002).

AMCT Protocol: The Activator Methods Chiropractic Technique (AMCT) is a subtle low force programme that makes use of specific procedures to detect spinal joint dysfunctions, mechanical body problems and analyses leg length inequality (Fuhr, 1997). Leg length inequality is determined by the prone leg check. Pressure testing by the doctor combined with certain specific hand/arm movements of the patient, points to the fixated joints. The AAI is then applied to that specific area and a few High-Velocity, Low-Amplitude (HVLA) thrusts are delivered to the involved joint in quick succession (Fuhr, 1997).

CAIS: Chronic Ankle Instability Syndrome (CAIS) is diagnosed when there is repetitive lateral ankle instability leading to recurrent ankle sprains (Hertel, 2002) and is characterised by the following clinical symptoms and signs:

1. Joint fixations or hypomobility (Reid, 1992; Whitman *et al.*, 2009 and Joseph *et al.*, 2010) with associated articular deafferentation (in the ankle, subtalar joint and tarsals), adhesion formation, reduced motion and when motion is present is associated with crepitus (Kessler and Hertling, 1983; Reid, 1992; Caulfield, 2000 and Richie, 2001) as well as
2. Ligamentous laxity (Caulfield, 2000 and Richie, 2001) and proprioceptive alterations (Richie, 2001; Delahunt, 2007).

Diversified Technique: Is the manual assessment of the biomechanics of the spine and extremities to detect abnormal motion at these joints and to apply a manual thrust technique to restore normal biomechanics, function and motion. This technique is simple and the most widely used technique in the chiropractic profession (Bergmann *et al.*, 1993).

Incidence: Is the proportion of a clearly defined group or population that is initially free of a condition but develops the condition over a given period (Redwood and Cleveland, 2003).

Manipulation or Adjustment: A High-Velocity Low-Amplitude (HVLA) thrust that is specifically directed at correcting the biomechanical functioning of a joint and the related local or remote symptoms (Haldeman, 2005).

Prevalence: Is the number of people in a defined population who have a specified disease or condition at a point in time. Prevalence is usually measured by surveying a particular population containing individuals with and without the condition of interest. Thus, prevalence equals the number of people with a health problem at a point in time divided by the total defined population alive at that point in time (Waddell, 2004).

Proprioception: Proprioception and the innervation associated with joint position sense and balance are sensory in nature (Solomon *et al.* 1990). Three organs of proprioception that are noted are the Golgi tendon organ, the muscle spindle and the Pacinian corpuscle (Miller and Narson, 1995). 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 (Solomon *et al.*, 1990).

Syndesmosis: Is a joint consisting of two bones connected by a ligament (Cramer and Darby, 1995).

Vector: Is the term used to describe the direction of the manipulative thrust. Errors in the orientation of the manipulative vectors may have dramatic effects on manipulative specificity and effectiveness. Possible unwanted effects include joint compression instead of distraction or cavitation at undesired levels (Bergmann *et al.*, 2003).

CHAPTER ONE

INTRODUCTION

1.1 Introduction

This chapter presents and discusses the background to the research problem and its associated objectives and hypothesis. In addition the purpose or rationale and limitations of the study are presented followed by a short conclusion.

1.2 Background to the Problem

Classically, Chronic Ankle Instability Syndrome (CAIS) is diagnosed when there is untreated lateral ankle instability leading to recurrent ankle sprains (Hertel, 2002 and Hubbard and Wikstrom, 2010) and is characterised by the following clinical symptoms and signs:

1. Joint fixations or hypomobility (Reid, 1992; Whitman *et al.*, 2009 and Joseph *et al.*, 2010) with associated articular de-afferentation (in the ankle, subtalar joint and tarsals), adhesion formation, reduced motion and when motion is present is associated with crepitus (Kessler and Hertling, 1983; Reid, 1992; Caulfield, 2000 and Richie, 2001) as well as
2. Ligamentous laxity (Caulfield, 2000 and Richie, 2001), which can be measured subjectively (ankle giving way or feeling of instability) or objectively by means of manual stress tests or radiographs (Hubbard and Wikstrom, 2010) and
3. Proprioceptive alterations (Richie, 2001 and Delahunt, 2007).

According to Hubbard and Wikstrom (2010), instability and joint laxity can still be present six months after injury. Untreated, CAIS leaves a patient with an inverted ankle, reduced muscle co-contraction, and a lower dynamic stiffness in the joint (Lin *et al.*, 2011), which in turn leads to articular degeneration of the talus and resultant osteoarthritis of the ankle joint in the long term (Hubbard and Wikstrom, 2010). Loss

of talus movement plays a crucial role in the adaptation of the foot to the surface when walking (Lopez-Rodriguez *et al.*, 2007). It was found that a single joint mobilisation treatment, specifically anteroposterior talocrural mobilization (de Souza *et al.*, 2008), could significantly increase the dorsiflexion range of motion (Hoch and McKeon, 2011) and immediately reduce self-reported pain (Pellow and Brantingham, 2001). Additionally, the mortise separation manipulation has very little chance of further compromising the integrity of the lateral ligament complex of the ankle (Pellow and Brantingham, 2001 and Brantingham *et al.*, 2008).

Moreover, manipulations can be useful in the treatment of conditions in which clinical joint instability is present (Pellow and Brantingham, 2001), particularly as the instability is usually related to hypomobility of the same segment or related segments (Brantingham *et al.*, 1992 and Brantingham *et al.*, 2008). These manipulations are applied either manually or in cases where clinicians are unable to utilise their hands, via a mechanical device. The AAI (a mechanical device) is used to produce a thrust imparted into a joint. It has a combined benefit of reducing physical stress on the clinician (Schafer and Faye, 1990 and Bergmann *et al.*, 1993) as well as precisely controlling the speed, force and direction of the manipulative thrusts (Fuhr and Menke, 2002). Another advantage is that this modality helps clinicians who may have degenerative joint disease and who may find manual manipulation difficult as they continue with their career (Schafer and Faye, 1990 and Bergmann *et al.*, 1993).

These instruments represent the second most common approach (the first being manual application) for applying manipulative forces (Kawchuk *et al.*, 2006) and are used by 72% of Chiropractors on 21% of their patients (Colloca *et al.*, 2005). It was determined that the AAI could maximally produce a force of 0.3J of kinetic energy, which is enough to cause some movement at the joint level, but this force is also a lot lower than the energy value needed to cause injury (with only a 3-millisecond excursion) (Fuhr and Menke, 2005). This force is also sufficient to stimulate the type III high threshold mechanoreceptors (Polkinghorn and Colloca, 1999 and Leach, 2004), which could be beneficial since ligamentous injury often causes changes in mechanoreceptors, joint capsules, golgi tendon organs and muscle spindles (Hertel, 2000 and Hubbard *et al.*, 2005).

With this brief introduction, a four-to-two consensus was reached supporting the statement that AAI procedures are as effective as manual High-Velocity, Low-Amplitude (HVLA) procedures in having clinical benefit and causing biological change (Taylor *et al.*, 2004). This is, however, clinically untested and based mainly on anecdotal evidence (Fuhr, 2011).

Chronic Ankle Instability Syndrome (CAIS) is a common condition that presents to practitioners utilising both manual and AAI manipulative interventions, thus it is of importance to determine whether AAI interventions are of clinical benefit to the patients receiving such care (Fuhr and Menke, 2002 and Brantingham *et al.*, 2008).

1.3 Objectives and Hypothesis

The aim of the study was to compare an AAI manipulation with a manual long-axis distraction manipulation by diversified technique, in the treatment of CAIS.

Objective One: The First Objective was to determine the effectiveness of a manual long-axis distraction manipulation by diversified technique (treatment Group A) to the ankle, on CAIS in terms of subjective and objective findings.

Objective Two: The Second Objective was to determine the effectiveness of an AAI manipulation, set at full tension (treatment Group B), to the ankle, on CAIS in terms of subjective and objective findings.

Objective Three: The Third Objective was to determine whether there are any differences between the manual long-axis distraction manipulation by diversified technique and the AAI manipulation to the ankle, on CAIS in terms of the noted subjective and objective findings.

Based on Objective Three, the Null Hypothesis read as:

There would be no differences between the manual long-axis distraction manipulation by diversified technique and the AAI manipulation treatment groups in terms of the noted subjective and objective findings (viz. Numerical Pain Rating

Scale-101 (NRS), Algometer, Berg Balance Scale (BBS), Foot and Ankle Disability Index (FADI), Weight Bearing Dorsiflexion Test).

1.4 Purpose or Rationale

Lateral ankle sprains are common in physically active populations (Ferran and Maffulli, 2006), reaching a peak prevalence of 85% in various sports (Delahunt, 2007). Re-injury occurs when the ankle is plantarflexed and inverted repeatedly (Gillman, 2004), injuring the lateral ankle ligament and resulting in peroneal tendon strain or rupture, capsular compromise, joint impaction and / or joint distraction along with the cellular sequelae of oedema and the healing cascade (Reid, 1992; Souza, 2001 and Leach, 2004). This leads to CAIS which produces anterior-posterior, posterior-anterior, and long-axis motion abnormalities of the talocrural and subtalar joints (Pollard *et al.*, 2002).

One of the interventions for CAIS is manual joint mobilization or manipulation, which reduces a fixation and improves range of motion (Brantingham *et al.*, 2008). It was found that HVLA manipulative therapy showed improved clinical outcomes when applied to the talocrural and subtalar articulations (Gillman, 2004). These manipulations may be applied either manually or via a mechanical device (Mykietiuk *et al.*, 2009).

The advantages of AAI (in contrast to manual manipulation) include the ability to produce a thrust imparted into a joint, whilst reducing physical stress on the clinician (Schafer and Faye, 1990 and Bergmann *et al.*, 1993). In addition, it precisely controls the speed, force, and direction of the manipulative thrusts (Fuhr and Menke, 2002). However, with the paucity of research on the AAI (Fuhr and Menke, 2002) in respect of extremity conditions, little is known of the AAI in terms of its clinical efficacy and relative effectiveness. To the researchers knowledge, no study has been done to test the effectiveness of AAI on CAIS (Fuhr, 2011), even though this modality is often utilised in practice both within and outside of its protocol in the treatment of extremity conditions (Triano, 2000; Fuhr and Menke, 2002 and Mykietiuk *et al.*, 2009).

Therefore, this research aimed to investigate the relative effectiveness of the AAI manipulation versus a manual long-axis distraction manipulation by diversified technique in CAIS in terms of subjective and objective findings.

1.5 Limitations of the Study

It is never entirely possible for a researcher to be able to assume that participants will respond to subjective data collection tools honestly (Dyer, 1997). This is because the participant may be responding to the effects of the clinical interaction known as the “Hawthorne Effect” or the “Observer Effect” (Brink, 1996 and Mouton, 1996). Additionally patients have also been found to want to “please” the doctor and sometimes report improvements that are not the reality of their clinical context (Dugmore, 2005 and Richardson, 2007).

1.6 Outline of Chapters

This chapter has presented the context of the study, with emphasis on developing a rationale for the study and providing the reader with the stated objectives and the limitations of the study. Chapter Two follows with a review of the literature, with Chapter Three presenting the material and methods of the study. The results obtained and the contextualisation of these results in the literature occurs in Chapter Four. This is followed by Chapter Five which highlights the conclusions and presents recommendations for future studies to consider.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The ankle complex consists of the tibiotalar, subtalar and distal tibiofibular syndesmosis. This combined osseous and soft tissue support complex provides the ankle with proprioception, stabilization and movement control of the talus and calcaneus around their movement axes (Espinosa *et al.*, 2006). The talus is the only tarsal bone that has no tendinous or muscular attachments. It attaches to four other bones via seven articulations (Bozkurt and Doral, 2006).

2.2 Bony Anatomy and Articular Surfaces of the Ankle Joint

2.2.1 Talocrural Joint

The ankle joint (talocrural articulation or mortise joint) is a uniaxial, saddle shaped, hinge or ginglymoarthrodial type of synovial joint (Moore and Dalley, 1992 and Fuhr, 2009). The joint is formed by the articulation of the distal ends of the tibia and fibula (joined by the inferior transverse part of the posterior tibiofibular ligament to form a deep socket or mortise) and the tibial plafond or superior part of the talus (Moore and Dalley, 1995; Magee, 1997; Douglas *et al.*, 2005 and Bozkurt and Doral, 2006). The pulley-shaped trochlea of the talus is a rounded superior articular surface, and it fits into this socket (Moore and Dalley, 1999). The body of the talus can be felt just distally to the anterior margin of the most inferior part of the tibia, when the tendons are relaxed (Bozkurt and Doral, 2006). The joint can be felt anteriorly as a slight depression between the tendons, about one centimetre (cm) proximal to the tip of the medial malleolus (Moore and Dalley, 1999).

The malleoli extend along the sides of the talus allowing the medial surface of the lateral malleolus (fibula) to articulate with the lateral surface of the tibia and the smooth lateral surface of the medial malleolus with its crescentic facet to articulate with the medial talar surface (Standring, 2008). When the ankle is in the neutral position, the talus fits tightly between the two malleoli and the joint is stable. During weight-bearing, the compressive forces also add to the stability (Ajis *et al.*, 2006). The inferior surface of the tibia rests on the talus to form the roof of the mortise (Moore and Dalley, 1999 and Bozkurt and Doral, 2006). This provides stability and limits ankle rotation (Moore and Dalley, 1995 and Waldman, 2006).

The talus rests on the calcaneus and the lateral malleolus extends further inferiorly than the medial malleolus because of the weak interosseus tibiofibular ligament and the fibula which does not rest on the talus (Moore and Dalley, 1999). The medial malleoli of the tibia is externally rotated when compared to the proximal end of the tibia and the distal border of it, points anteriorly and is depressed posteriorly (Standring, 2008). It also ends more proximal than the lateral malleoli and lies in a more anterior plane (Bozkurt and Doral, 2006). This relative shortness of the medial malleoli leads to a natural tendency for the ankle to go into inversion rather than eversion and results in lateral ankle sprains (Ferran and Maffulli, 2006). The malleoli provide a designated path for the talus to rock anteriorly and especially posteriorly (Moore and Dalley, 1999).

The talar dome has a larger circumference laterally (Russel *et al.*, 2008). The anterior part of the talus (trochlea) is about 4.2 millimeter (mm) wider than the posterior, and during dorsiflexion the trochlea slides posteriorly, filling the mortise and forcing the malleoli apart (Moore and Dalley, 1992; Douglas *et al.*, 2005 and Bozkurt and Doral, 2006) and leading to the position of highest stability of the ankle (Espinosa *et al.*, 2006). The fibula externally rotates through the tibiofibular syndesmosis to allow for the widened anterior part of the talus. The foot also rotates in the same manner (Reid, 1992). This widening is limited by strong interosseus and tibiofibular ligaments (Moore and Dalley, 1995).

During plantarflexion the ankle is unstable because the trochlea of the talus moves anteriorly, so that its narrower posterior portion fits loosely within the mortise (Calliet,

1997), the osseous structures are not so tightly bound and the soft tissue structures are predisposed to strain (Ajis and Maffulli, 2006). Most injuries occur when the ankle is in this unstable position (Moore and Dalley, 1999).

2.2.2 Subtalar Joint

The functioning of the ankle is highly reliant on the subtalar joint. It is here that most of the inversion and eversion occurs (Reid, 1992). The subtalar or talocalcaneal joint is a plain synovial joint and is found slightly distal to the ankle joint (Standring, 2008). The joint is formed by the articulation of the superior surface of the calcaneus with the inferior surface of the talar body (Standring, 2008). A fibrous articular capsule surrounds this joint, and it attaches to the margins of the articular facets (Standring, 2008). This is a weak capsule that is reinforced by the medial, lateral and posterior interosseous talocalcaneal ligaments (Moore and Dalley, 1999).

2.2.3 Distal Tibiofibular Joint

The inferior medial surface of the fibula articulates with a facet on the inferior end of the tibia to form this syndesmosis or fibrous joint. Strong interosseous ligaments connect the tibia and fibula. The stability of the ankle largely depends on this joint. It keeps the lateral malleolus secured against the lateral surface of the talus and the tibia. The strong anterior and posterior inferior tibiofibular ligaments reinforce the joint anteriorly and posteriorly. (Moore and Dalley, 1999 and Standring, 2008).

2.3 Articular Capsule of the Ankle Joint

The fibrous capsule attaches proximally to the borders of the tibia and malleolar articular surfaces and distally to the talus, and is lined on the inside by a loose synovial membrane that often extends superiorly between the malleoli up to the interosseus ligament of the inferior tibiofibular joint. It is connected to an anterior groove close to the articular surface (Bozkurt and Doral, 2006). The capsule is thin anteriorly and posteriorly but is reinforced externally on either side by strong collateral ligaments (Moore and Dalley, 1999). The capsule is rather thin and weak

and thus the stability of the ankle joint greatly relies on the ligaments being intact (Norkin and Levangie, 1992).

2.4 Ligaments of the Ankle Joint

The major contributor of passive stability in the ankle joint is the bony mortise, where the trochlea is in contact with the tibial plafond and the two malleoli contact the medial and lateral concave cartilaginous surfaces. This bony structure is well supported by the different ligaments that connect the tibia, fibula, talus and calcaneus (Bozkurt and Doral, 2006). These are the medial (deltoid), lateral (calcaneofibular), inferior tibiofibular, anterior and posterior talofibular ligaments and they endure strain and sprain and even minor trauma which can lead to pain and dysfunction in the ankle (Waldman, 2006). Peroneus longus and brevis tendons also run across these ligaments for added stability (Moore and Dalley, 1992).

The ankle joints stability comes from the passive stability provided by the ligaments and on the active stability of the muscular support. There are no muscular attachments to the talus and therefore its stability relies on the bony contours, ligamentous integrity and musculotendinous complexes that run across the talus to attach distally (Bozkurt and Doral, 2006). Each of the ligaments in the lateral complex stabilises the ankle or subtalar joint depending on the position of the foot (Pagenstert *et al.*, 2006).

2.4.1 Lateral Collateral Ligament Complex

The lateral collateral ligament complex consists of the anterior talofibular ligament (ATFL), the calcaneofibular ligament (CFL), and the posterior talofibular ligaments (PTFL) (Moore and Dalley, 1995; Aji and Maffulli, 2006 and Ferran and Maffulli, 2006). The lateral talocalcaneal ligament (LTCL) is most often not present, but when it is, it limits subtalar movement (Caprio *et al.*, 2006).

2.4.1.1 Anterior Talofibular Ligament

The ATFL is the thin, flat and weakest of all three ligaments and runs anteromedially from the lateral malleolus to the neck of the talus and blends with the anterior capsule of the ankle (Moore and Dalley, 1995), which is commonly labelled a thickening of the lateral joint capsule (Ajis and Maffulli, 2006) about 18mm above the subtalar joint line. It is 20mm long, 8mm wide and 2mm thick. It is the only ligament in this complex that crosses both tibiotalar and talocalcaneal joint lines (Espinosa *et al.*, 2006).

The ATFL runs horizontally in the neutral anatomic position, but when plantarflexed, it runs parallel to the long-axis of the leg and it is in this position (coupled with slight inversion) that the ligament is at its weakest and under the most tensile strain. The ATFL has a tensile strength of 140 +/- 24 Newton (N) after which the competence of the ligament is jeopardised and the talus is allowed to rotate internally and sublunate anteriorly on the tibia (Bozkurt and Doral, 2006). The ATFL is the first ligament to restrict supination of the foot (Pagenstert *et al.*, 2006) and is the most easily injured ligament (Ajis and Maffulli, 2006) being involved in 80% of all lateral ankle sprains. In 20% more forceful inversions, the CFL becomes involved (Malliaropoulos *et al.*, 2006).

2.4.1.2 Calcaneofibular Ligament

The CFL is a round, cord-like, extra-capsular ligament which runs posteroinferiorly from the tip of the lateral malleolus, deep to the peroneal tendons, and attaches to the tubercle on the posterior aspect of the lateral surface of the calcaneus (Moore and Dalley, 1995 and Ajis and Maffulli, 2006), 13mm distal and posterior to the subtalar joint line (Standring, 2008). It averages at 25mm long, 5mm wide and 4mm thick and about 3 times stronger than the ATFL (Espinosa *et al.*, 2006). It is the only ligament in this compartment that crosses and stabilises both tibiotalar and talocalcaneal joint lines (Caprio *et al.*, 2006 and Espinosa *et al.*, 2006) and hence this muscle must be attached in such a way that it does not restrict the motion of either the ankle or subtalar joint (Pagenstert *et al.*, 2006). It limits supination of the

ankle and subtalar joints and inversion and internal rotation of the subtalar joint (Pagenstert *et al.*, 2006).

During dorsiflexion, as the CFL and the subtalar joint becomes more vertically orientated (Pagenstert *et al.*, 2006), the CFL is the main stabiliser of the ankle and an accessory stabiliser of the subtalar joint. The ankle is stable in this position, so sole injuries to this ligament are not common (Ajis and Maffulli, 2006). As the ankle moves into plantarflexion, the CFL stops resisting talar tilt and the ATFL takes over the role as collateral ligament and limits talar tilt (Pagenstert *et al.*, 2006). Injuries do however occur when the ankle is dorsiflexed and inverted (Caprio *et al.*, 2006).

The angle between the ATFL and the CFL is important and necessary in the stability of the ankle (Bozkurt and Doral, 2006). They form an angle of 105° in the sagittal plane and 95° in the frontal plane (Espinosa *et al.*, 2006). In neutral, the ATFL mainly resists anterior translation of the talus and the CFL resists inversion (Griffith and Brockwell, 2006). But in full plantarflexion, both ligaments oppose inversion stress (Ajis and Maffulli, 2006 and Griffith and Brockwell, 2006).

2.4.1.3 Posterior Talofibular Ligament

The PTFL is a thick, strong and horizontal ligament which runs medially from the lateral malleolar fossa to the posterolateral tubercle of the talus and to the os trigonum when it is present (Moore and Dalley, 1995 and Ajis and Maffulli, 2006). This ligament is in the shape of a trapezoid (Ajis and Maffulli, 2006) and often hides under the lateral malleolus forming a hammock (Bozkurt and Doral, 2006). Injury to this ligament seldom presents and only when complete dislocation has occurred (Caprio *et al.*, 2006). When the ankle is dorsiflexed, this ligament is stressed maximally, the CFL is taut and the ATFL is loose. In plantarflexion, the PTFL and CFL are loose as the ATFL tightens (Espinosa *et al.*, 2006 and Pagenstert *et al.*, 2006).

2.4.1.4 Talocalcaneal Ligament

The talocalcaneal ligament is the strongest bond between the talus and calcaneus, originating at the most medial part of the sinus tarsi and running inferolaterally to the sulcus calcanei to blend with the medial part of the cervical ligament. This ligament is found inside the sinus tarsi and runs obliquely from the talar neck to the superior part of the calcaneus (Espinosa *et al.*, 2006).

2.4.2 Medial Ligament Complex

The large, strong medial or deltoid ligament attaches proximally to the medial malleolus and distally to the talus, calcaneus and navicula. From anterior to posterior, it is formed by the anterior tibiotalar ligament, the tibionavicular ligament, the calcaneotibial ligament (CTL) and the posterior talotibial ligaments (PTTL) (Moore and Dalley, 1995). At times, a fifth ligament (calcaneonavicular) can form part of this medial ligament complex. The CTL and PTTL stretch between the sustentaculum tali and the tibia and lie superficially to the other ligaments of this complex (Bozkurt and Doral, 2006). This ligament complex is normally injured with repetitive or excessive eversion and pronation (Hintermann *et al.*, 2006).

2.4.3 Syndesmosis

The syndesmotic ligaments are important in maintaining ankle stability and their integrity is necessary for this reason. They consist of the anterior inferior tibiofibular ligament (AITFL), the interosseus ligament and membrane (IOL and IOM), the posterior inferior tibiofibular ligament (PITFL) and the transverse tibiofibular ligament (TTFL). The AITFL provides 35%, TTFL 33%, IOL 22% and SPITFL (superficial) 9% of total ankle stability and if even two of these ligaments failed, significant mechanical laxity of the syndesmosis would result and could lead to diastasis.

Syndesmotic injuries were first mentioned by Quenu in 1912 (Espinosa *et al.*, 2006), and have since been found to occur in 1 to 18% of ankle sprains. They are normally

misdiagnosed or undiagnosed and can lead to chronic ankle pain, disability and arthritic changes. Isolated syndesmotic injuries are difficult to diagnose and longer recovery periods are needed as compared to normal ankle sprains. Injury occurs when the ankle is hyperdorsiflexed and externally rotated as often seen in players during an American football game and skiing. With dorsiflexion, the talus is forced between the malleoli and during external rotation the talus pushes the fibula further away and in extreme cases can even fracture the fibula. Isolated syndesmotic injuries, has however, not been reproducible (Espinosa *et al.*, 2006).

2.5 Stability Tests

Ligament injuries are graded from I to III depending on the damage and morbidity (see Tables 3.2 and 3.2).

The lateral ankle ligaments are responsible for restricting varus (mostly inversion) movements and the medial ankle ligaments for restricting valgus (mostly eversion) movements (Calliet, 1997). They prevent subluxation or partial dislocation (Moore, 1999).

The stability of these ligaments can be tested in the event of an ankle sprain. Stress tests like the anterior drawer test, inversion test and the talar tilt test all test the ATFL but for anterior and lateral instability respectively (Mack, 1982 and Griffith and Brockwell, 2006). Ankle laxity is tested with the patient sitting on the edge of the examiner bed with their legs hanging over the edge of the bed. This prevents involuntary peroneal muscle contraction and reactive muscle stabilisation (Pagenstert *et al.*, 2006).

2.5.1 Anterior Drawer Test

Injured ATFL and CFL ligaments will offer no resistance to anterior translation, internal rotation and adduction (Espinosa *et al.*, 2006). For the Anterior Drawer Test, the ankle must be in 20 degrees of plantarflexion (Ajis and Maffulli, 2006) and the hindfoot is drawn anteriorly with respect to the tibia or the tibia can be pushed

posteriorly against the fixed foot. It is thought that axial loading might decrease the amount of translation and reduce sensitivity of the test, so it is still disputed as to how much loading should be applied (Griffith and Brockwell, 2006). The most prominent indication of instability is the “suction sign” which appears as the synovium and skin are sucked into the joint. If no sign presents, the clinician must gauge the end feel and the amount of anterior movement of the talus as compared to the normal side (Ajis and Maffulli, 2006).

2.5.2 Inversion Test

The inversion test for ATFL insufficiency is done by inverting the hindfoot relative to the tibia (Griffith and Brockwell, 2006) and will result in localised pain over the lateral malleolus, that is if the test shows a positive score after repetitive micro trauma (overuse or misuse) or sudden acute inversion overload (Waldman, 2006). The talar tilt also produces a suction sign and abnormal movement when the hindfoot is tilted whilst the ankle is plantarflexed (Ajis and Maffulli, 2006). Talar tilt is more specific to CFL injury and anterior drawer test to ATFL damage (Pagenstert *et al.*, 2006).

These tests are accurate at diagnosing ligament injury, but not specific as to how much damage was done, and could thus be subject to false negatives (Ajis and Maffulli, 2006 and Pagenstert *et al.*, 2006). Some authors suggest doing these tests under anaesthetic as to exclude stiffness from muscle spasm in response to pain (Griffith and Brockwell, 2006). Ankles that resist anterior and varus stress tests are classified as stable and can be treated conservatively (Baker and Todd, 1995). Structural ligament insufficiency will give a positive talar tilt and anterior drawer sign. Functional ankle instability is most probably caused by mechanoreceptor injury in the lateral ligaments and is therefore best diagnosed using gait analysis or electromyographic (EMG) studies of the peroneal muscle (Pagenstert *et al.*, 2006).

2.5.3 Syndesmosis Stress Tests

The syndesmosis can be tested by rotating the talus in the mortise, by the squeeze test (squeezing the tibia and fibula together at mid-calf level) and by trying to weight-

bear in plantarflexion. These abnormal movements will result in pain and a feeling of weakness if the syndesmosis is injured (Espinosa *et al.*, 2006 and Griffith and Brockwell, 2006). These tests, are however, not as reliable as the external rotation test of the foot (Espinosa *et al.*, 2006). When the ankle is dorsiflexed, the medial malleolus becomes a central pivot, the fibula moves posteriorly, the talus glides anteriorly and the syndesmotic ligaments are taut (Pagenstert *et al.*, 2006).

2.6 Blood Supply of the Ankle Joint

The fibular and anterior and posterior tibial arteries send malleolar branches to the ankle joint (Moore and Dalley, 1999). The fibular artery is the largest branch of the posterior tibial artery and supplies the lateral malleolus via the lateral malleolar branch. The medial malleolar branch comes off the posterior tibial artery and supplies this area (Moore and Dalley, 1999). Normally, there is a history of one or more ankle injuries, but in patients with a varus or cavovarus foot, instability might develop spontaneously (Ajis and Maffulli, 2006). Therefore, the blood supply needs to be assessed thoroughly, as these conditions might predispose to instability of the ankle (Griffith and Brockwell, 2006).

2.7 Innervation of the Ankle Joint

The tibial nerve, which lies between the tendons of the flexor hallucis longus and the flexor digitorum longus, and deep fibular nerve, which originates from the common fibular nerve, innervates the ankle joint (Moore and Dalley, 1999). The sural nerve courses about 13mm posteroinferiorly to the lateral malleolus (Espinosa *et al.*, 2006). Ankle instability often occurs when there are neurological impediments (Griffith and Brockwell, 2006). Therefore, a thorough neurological examination must be done (Ajis and Maffulli, 2006).

2.8 Musculature Related to the Ankle Joint

The muscles, nerve supply and the movements which they produce at the ankle joint are represented in Table 2.1, Table 2.2 and Table 2.3.

Table 2.1: Muscles in the Anterior Compartment of the Leg (Adapted from Köhne, 2005)

Muscle:	Innervation:	Main action:
Tibialis anterior	Deep fibular (peroneal) nerve (L4 and L5)	Dorsiflexes ankle and inverts the foot
Extensor digitorum longus	Deep fibular (peroneal) nerve (L5 and S1)	Dorsiflexes the ankle and extends the lateral four digits
Extensor hallucis longus	Deep fibular (peroneal) nerve (L5 and S1)	Dorsiflexes the ankle and extends the great toe
Fibularis (peroneus) tertius	Deep fibular (peroneal) nerve (L5 and S1)	Dorsiflexes the ankle and aids in eversion of the foot

Bold indicates primary innervation

Table 2.2: Muscles in the Lateral Compartment of the Leg (Adapted from Köhne, 2005)

Muscle:	Innervation:	Main action:
Fibularis (peroneus) longus	Superficial fibular (peroneal) nerve (L5, S1 and S2)	Everts the foot and weakly plantarflexes the ankle
Fibularis (peroneus) brevis	Superficial fibular (peroneal) nerve (L5, S1 and S2)	Everts the foot and weakly plantarflexes the ankle

Bold indicates primary innervation

Table 2.3: Muscles in the Posterior Compartment of the Leg (Adapted from Köhne, 2005)

Muscle:	Innervation:	Main action:
Gastrocnemius	Tibial nerve (S1 and S2)	Plantarflexes the ankle when the knee is extended
Soleus	Tibial nerve (S1 and S2)	Plantarflexes the ankle independent of the knee position
Plantaris	Tibial nerve (S1 and S2)	Weakly assists the gastrocnemius in plantarflexing the ankle
Flexor hallucis longus	Tibial nerve (S2 and S3)	Weakly plantarflexes the ankle
Flexor digitorum longus	Tibial nerve (S2 and S3)	Plantarflexes the ankle
Tibialis posterior	Tibial nerve (L4 and L5)	Plantarflexes the ankle and inverts the foot

Bold indicates primary innervation

2.9 Biomechanics of the Ankle Joint

The ankle joint is normally thought of as a uniaxial joint, allowing dorsiflexion and plantarflexion for ambulation (Waldman, 2006), but it has a dynamic axis of rotation that shifts during dorsiflexion and plantarflexion (Bozkurt and Doral, 2006) and allows for different positions in dorsiflexion and plantarflexion (Moore and Dalley, 1992).

Movement at the ankle joint is multiplanar and linked to the tibia. Movement at the subtalar joint is triplanar, with inversion and eversion as the calcaneus turns inwards and outwards respectively (Espinosa *et al.*, 2006). In full plantarflexion of the ankle, some side movement (Moore and Dalley, 1992) and axial rotation (Douglas *et al.*, 2005) and slight abduction and adduction can be seen (Moore and Dalley, 1995).

The talus rotates internally and slightly supinates when the ankle is plantarflexed because of its conical and wedge shape. This also makes the fibula appear to be posteriorly positioned and when this happens the lateral malleolus does not contribute to the structural stability of the ankle and the joint is predisposed to sprain (Bozkurt and Doral, 2006). It was found that in patients with unilateral chronic ankle instability (CAI), the fibula was positioned more anteriorly (Bozkurt and Doral, 2006) and it was also found that in patients with CAI, the tibial plafond had a varus tilt, more than in patients with acute ligament sprains (Bozkurt and Doral, 2006). Also varus tilt of the tibiotalar joint has been indicated in chronic lateral ligament dysfunction (McBride and Ramamurthy, 2006).

Hindfoot varus is an important predisposing factor in ankle instability (Ajis and Maffulli, 2006 and Bozkurt and Doral, 2006) and even cavovarus hindfoot with or without neurologic dysfunction and deformity in the forefoot and midfoot are being considered (McBride and Ramamurthy, 2006). The talocrural or talotibial joint has a resting position of 10° plantarflexion and can dorsiflex to about 20° and plantarflex to about 40°. Its capsular pattern thus allows more plantarflexion than dorsiflexion and has a firm ligamentous normal joint end feel (Vizniak, 2010).

Dorsiflexion is produced by muscles in the anterior compartment of the leg, namely tibialis anterior and extensor digitorum longus (Vizniak, 2010), and is limited by the passive resistance to stretching of the triceps surae muscle and by tension in the medial and lateral ligaments (Moore and Dalley, 1999). Plantarflexion is produced by muscles in the posterior compartment of the leg, namely soleus, gastrocnemius, tibialis posterior, flexor digitorum longus, flexor hallucis longus (Moore and Dalley, 1999 and Vizniak, 2010). The subtalar or talocalcaneal joint allows for 30° of foot inversion and 15°-20° of hindfoot eversion (Waldman, 2006 and Vizniak, 2010).

Healthy and well-functioning ankle and subtalar joints are necessary to allow ankles to adapt when walking on uneven surfaces (Espinosa *et al.*, 2006).

2.10 Introduction to Chronic Ankle Instability Syndrome

When referring to ankle sprains, terms like ankle ligament laxity (Lubbe, 2011), lateral ankle instability and chronic ankle instability, are used at random. A clear definition is needed to avoid confusion. Laxity is a physical sign and can be determined on objective examinations such as stress tests (Magee, 1997). Lateral ankle instability (unstable ankle) is the result of lateral ligamentous injury and experienced as the ankle giving way. Chronic ankle instability is the repetitive occurrences of instability that in turn leads to recurrent ankle sprains (Ferran and Maffulli, 2006).

2.11 Incidence and Prevalence of CAIS

One of the most commonly injured major joints in the body is the ankle joint (Fallat *et al.*, 1998). Between 15 to 25% of all musculoskeletal injuries are lateral ankle ligament sprains (Caprio *et al.*, 2006). Sprains occur in recreational and competitive sport (Boyer and Younger, 2006) and leisure activities (Bozkurt and Doral, 2006) especially during adolescent years and in young adult males and athletes (Espinosa *et al.*, 2006). Professional athletes lose playtime (up to one sixth of all time lost from sport due to injury) and incur high costs of rehabilitation for their clubs (Wright *et al.*, 2000 and Ferran and Maffulli, 2006).

Thousands of ankle sprains are reported daily by the general population, estimated at 1 in 10 000 (Reid, 1992) and 7 per 1 000 person-years (Ajis *et al.*, 2006). But, with the recent increase in participation in all sports on all levels, it was found that this estimated incidence rate has increased to between 60 (Griffith and Brockwell, 2006) and 70 in 10 000 people of diverse age and gender differences who report to an accident or emergency department (Karlsson and Sancone, 2006 and Malliaropoulos *et al.*, 2006).

There is a 16% incidence and 6 to 25% prevalence for inversion sprains (Mack, 1982; Prentice, 1994; Yeung *et al.*, 1994; Jerosh and Bischof, 1996; Lofvenberg *et al.*, 1996 and Garrick and Schelkun, 1997). That is an incidence of 5 000 inversion sprains every day in the United Kingdom (Karlsson and Sancone, 2006) or between 52.7% (Caprio *et al.*, 2006) and 60.9% (Ferran and Maffulli, 2006) per 10 000 of accident and emergency attendances, which puts a great burden on these departments (Ferran and Maffulli, 2006). A “twisted” ankle is usually related to stepping off a curb awkwardly, landing on an irregular surface, or to a sporting injury where forced inversion results in a large supination torque which overloads and sprains the lateral ligaments (Wright *et al.*, 2000 and Douglas *et al.*, 2005).

Medial ligament involvement is usually only found in fractures of the ankle (McBride and Ramamurthy, 2006). Lateral, inversion or supination ankle sprains (Caulfield, 2000; Balint *et al.*, 2003 and Ferran and Maffulli, 2006), account for 25% of all musculoskeletal injuries (Ajis and Maffulli, 2006) and are very common in physically active populations, reaching a peak prevalence of 85% in various sports (Pollard *et al.*, 2002; Balint *et al.*, 2003; Ferran and Maffulli, 2006 and Delahunt, 2007).

In 85% of ankle injuries, the ligaments will be sprained to some degree (Garrick and Schelkun, 1997). A large proportion (85%) of these sprains are classified as inversion sprains (Malliaropoulos *et al.*, 2006) involving the lateral structures (Espinosa *et al.*, 2006), 20% of inversion sprains lead to functional instability (Ajis and Maffulli, 2006) and 30 to 40% of sprains become a chronic condition (Garrick and Schelkun, 1997 and Bozkurt and Doral, 2006), making it the most common sports-related injury (Wright *et al.*, 2000 and Karlsson and Sancone, 2006) constituting 11% of all soccer injuries (Griffith and Brockwell, 2006) [also referred to as “footballers ankle” (McBride and Ramamurthy, 2006)] and 40% of all athletic injuries (Ajis *et al.*, 2006).

Most sprains resolve with little medical intervention (Boyer and Younger, 2006) and 70 to 85% of all grades of ankle sprains can improve remarkably with functional rehabilitation (Caprio *et al.*, 2006 and Lubbe, 2011). But, 20 to 40% of severe sprains will have chronic pain and instability (Caprio *et al.*, 2006) and between 15 to 48% will lead to recurrent instability (Boyer and Younger, 2006). Ankle sprains are

associated with increased susceptibility to subsequent or chronic ankle instability (20 to 50% of all sprain sufferers) and it has been found that 47% of ankle sprains occur in ankles that had been previously sprained (Wright *et al.*, 2000).

2.12 Mechanism of Injury

Anatomic variations and biomechanical abnormalities are the main risk factors for ankle sprains, as the bone structure and supporting ligaments interact in a complex mechanical fashion (Bozkurt and Doral, 2006). Chronic ankle pain resulting from ankle inversion sprains is common (Brantingham *et al.*, 1993). The injury is termed a sprain when some fibres are torn, but the ligament as a whole is structurally intact (Douglas *et al.*, 2005). Laterally, the bony stability is greater than medially (Mack, 1982), and therefore the ankle tends towards inversion and causes injury to the lateral ligamentous structures (Baker *et al.*, 1995).

The typical mechanism of injury occurs when the ankle is plantarflexed at the tibiotalar joint, inverted and internally rotated (Bennet, 1994; Garrick and Schelkun, 1997; Ajis and Maffulli, 2006; Ajis *et al.*, 2006; Caprio *et al.*, 2006 and Ferran and Maffulli, 2006) past the point of where the peroneal muscles can limit these movements (Shapiro *et al.*, 1994). The secondary protectors of the ankle are the lateral ligaments, of which the ATFL is the most prominent (Veenema, 2000) but also the most vulnerable (Ferran and Maffulli, 2006 and Karlsson and Sancone, 2006). When these structures fail, the last barrier to stop this inversion movement is the bone on bone impaction of the calcaneus and the medial malleoli (Shapiro *et al.*, 1994).

In severe sprains, the lateral malleolus can even be fractured (Moore and Dalley, 1995). Surgical intervention is very successful, but functional or mechanical instability, persistent talar tilt, decreased range of motion, and pain may continue long after surgery (Bozkurt and Doral, 2006). After an ankle sprain, ankle instability normally sets in and is one of the major causes of symptoms (Griffith and Brockwell, 2006).

2.13 Types of Instability

There are two types of instability and they can occur together or independently from one another. Mechanical insufficiencies include pathologic laxity, impaired arthrokinematics, and synovial and degenerative changes. Functional insufficiencies include impaired proprioception, altered neuromuscular control, strength deficits, and diminished postural control (Hubbard *et al.*, 2007). The mechanical instability presents itself as a sign and is due to severe laxity of the ligaments. Up to 20% of patients will develop symptomatic functional instability (Ajis *et al.*, 2006) which is diagnosed by recurrent bouts of the ankle “giving” way (especially on sloped or uneven ground). There does not necessarily have to be laxity for there to be instability and similarly there can be vast laxity and no instability and so conservative management is a safe option (Ajis and Maffulli, 2006).

However, it was found that mechanical instability was less likely to benefit from structural rehabilitation than functional instability (Ajis and Maffulli, 2006). Classically, CAIS occurs when there is untreated mechanical lateral ankle instability of the talocrural joint, due to inversion sprains (Pellow and Brantingham 2001) and damage to the ATFL and CFL (Hertling and Kessler, 1996). The CFL is not commonly involved, but there is an association with a posteromedial talar dome injury (Griffith and Brockwell, 2006). Most of the acute injuries (58%) involve the ATFL and CFL combined, whereas the ATFL in isolation is involved in 40% of acute injuries. The PTFL alone is barely affected in acute injuries, as findings indicate only a 2% involvement (McBride and Ramamurthy, 2006).

2.14 Diagnosis

The diagnosis is based on a comprehensive medical history and certain specific clinical findings since it is asymptomatic in 30% of cases (Pagenstert *et al.*, 2006). To distinguish between subtalar instability and lateral ankle instability is difficult according to Griffith and Brockwell (2006), but CAIS is generally characterised by the following clinical symptoms and signs:

1. Joint fixations or hypomobility (Reid, 1992; Whitman *et al.*, 2009 and Joseph *et al.*, 2010) with associated articular de-afferentation (in the ankle, subtalar joint and tarsals), stiffness or restriction due to adhesions formed by a healing ligament (Hertling and Kessler, 1996), reduced motion and when motion is present is associated with joint crepitus (Kessler and Hertling, 1983; Reid, 1992; Caulfield, 2000 and Richie, 2001) as well as
2. Ligamentous weakness or laxity (Caulfield, 2000 and Richie, 2001), which can be functional and measured subjectively (ankle giving way or feeling of instability) or mechanical and measured objectively by means of manual stress tests or radiographs (Ajis and Maffulli, 2006; Hubbard and Wikstrom, 2010).
3. Proprioceptive alterations (Richie, 2001 and Delahunt, 2007).
4. Muscle spasm, point tenderness, localised lateral ankle pain and swelling or oedema (Reid, 1992) and sometimes bruising (Pagenstert *et al.*, 2006), although pain does not normally accompany instability, it might be felt as a deep pain due to osteochondral defects or superficial due to peroneal tendon tears (Espinosa *et al.*, 2006).
5. Repetitive episodes of instability and recurrent sprains, making it synonymous with functional instability (Espinosa *et al.*, 2006).

These symptoms are related to the untreated ligament damage (Reid, 1992 and Pellow and Brantingham, 2001) and any of these signs and symptoms make the patient more prone to repeated injuries (Hockenbury and Sammarco, 2001) and recurrent ankle sprains (Hertel, 2002 and Hubbard and Wikstrom, 2010), especially if they are classified under functional instability (Ajis *et al.*, 2006). If the symptoms are still present six weeks after the acute sprain, the injury becomes a chronic ankle instability syndrome. This refers to the fact that it presents due to a prior ankle sprain which distinguishes it from a chronic ankle sprain (Hertel, 2002 and Hertling and Kessler, 1996).

A correct diagnosis is necessary in order to start a successful treatment plan (Espinosa *et al.*, 2006). Inaccurate assessments, inadequate management of the injury and over/underestimations of time needed before returning to sports is common (Malliaropoulos *et al.*, 2006) and could result in a chronic disability

(Espinosa *et al*, 2006). Patients who have chronic ankle instability, and suffer recurrent ankle sprains despite a rehabilitation programme, are candidates for surgery (Ajis *et al*, 2006).

2.15 Consequences of CAIS

Associated with lateral ankle sprains are three classes of impingement syndrome: bone impingement, peripheral nerve entrapment and soft tissue impingement (Reid, 1992). Lateral ankle sprains contribute to soft tissue entrapment, where premature mobilisation leads to chronic inflammation of scar tissue and hypertrophy of the synovium (Reid, 1992 and Subotnick, 1999). Especially dorsiflexion will impinge these structures between the talus and fibular malleolus to cause pain and a snapping joint sensation (Billi *et al*, 1998 and Masciocchi *et al*, 1998).

According to Hubbard and Wikstrom (2010), instability and joint laxity can still be present over six months after injury. Untreated, CAIS leaves a patient with an inverted ankle, reduced muscle co-contraction, and a lower dynamic stiffness in the joint (Lin *et al*, 2011), which in turn leads to articular degeneration of the talus and resultant osteoarthritis of the ankle joint (Hubbard and Wikstrom, 2010).

This is further enhanced by re-injury which occurs when the ankle is plantarflexed and inverted (Gillman, 2004), repeatedly injuring the lateral ankle ligament, which is weaker than the medial ligament (Norkin and Levangie, 1992), and resulting in peroneal tendon strain or rupture. Chronic ankle sprains are the result of: inappropriate or late immobilisations; scar tissue formations; inappropriate mobility and strengthening rehabilitation; and/or development of hypermobility (Brantingham *et al*, 1993).

Notably, anterior-posterior, posterior-anterior, and long axis restrictions of the talocrural and subtalar joint are presented most commonly in this type of joint impaction (Pollard *et al*, 2002). Loss of talus movement plays a crucial role in the adaptation of the foot to the surface when walking (Lopez-Rodriguez *et al*, 2007). When the joints of the foot and ankle are hypomobile, they do not adequately absorb

the weight-bearing stresses of impaction during walking (Brantingham *et al.*, 1992). It seems that lateral ankle sprains result in decreased talocrural arthrokinematics and therefore limited dorsiflexion (Baker *et al.*, 1995; Baumhauer *et al.*, 1995; Green *et al.*, 2001 and Denegar and Miller, 2002). Other causes of this restricted range of motion could be pain at end range of motion, capsular contraction and/or intra-articular adhesions (Bassewitz and Shapiro, 1997).

2.16 Intervention

The prevalence rate of chronic instability setting in after lateral ankle sprains is between 10 to 30% (Espinosa *et al.*, 2006). The high rate of incidence alone makes this an important clinical problem (Griffith and Brockwell, 2006), but regardless of this high incidence, there is still some contention about the optimal method of management (Ajis and Maffulli, 2006). Management of ligament injuries appear to be simple, but residual problems are common (Karlsson and Sancone, 2006).

2.16.1 Manual Mobilisation and Manipulation

One of the noted interventions for CAIS is manual joint mobilization and / or manipulation, which improves the range of motion (reduces a restriction) (Brantingham *et al.*, 2008), improves function (proprioception and muscle function) and reduces pain (Hubbard and Wikstrom, 2010), specifically when done in the subacute and chronic Grade I and II ankle inversion sprains (Pellow and Brantingham, 2001).

Manipulation is also thought to breakdown scar tissue and formed adhesions in the injured ligaments (Kesson and Atkins, 1998). Good results were found when chronic ankle pain was treated with midtarsal mobilisation and subtalar manipulation (Brantingham *et al.*, 1993), but the High-Velocity, Low-Amplitude Chiropractic Manipulative Therapy (HVLA-CMT) had best clinical outcomes when applied to the talocrural and subtalar articulations (Gillman, 2004 and Brantingham *et al.*, 2008).

Passive mobilisation of the talus has demonstrated to restore the range of dorsiflexion (Green *et al.*, 2001) and a single joint mobilisation treatment, specifically anteroposterior talocrural mobilization (de Souza *et al.*, 2008), could significantly increase the dorsiflexion range of motion (Hoch and McKeon, 2011) and immediately reduce self-reported pain (Pellow and Brantingham, 2001). The mortise separation manipulation has very little chance of compromising the integrity of the lateral ligament complex of the ankle (Pellow and Brantingham, 2001 and Brantingham *et al.*, 2008). Moreover, manipulations can be useful in the treatment of conditions in which clinical joint instability is present, as the instability is usually relative to hypomobility within the same or an adjacent joint (Pellow and Brantingham, 2001).

These manipulations are applied either manually or in cases where clinicians are unable, via a mechanical device. These mechanical devices can include patient positioning devices, mechanical assistance from a table, or handheld instruments (Triano, 2000 and Triano, 2001). Of the latter, the spring-based Activator Adjustment Instrument (AAI) is most commonly applied to extremities, both within and outside of the Activator Methods Chiropractic Technique (AMCT) protocol (Fuhr and Menke, 2002; Kawchuk *et al.*, 2006 and Mykietiuik *et al.*, 2009). Different techniques appeal to individual Chiropractors and are preferred by individual patients and therein lies the necessity behind research into the AAI (Haldeman, 2005).

2.16.2 AAI Manipulation

The AAI has been described as a hand-held device that delivers a controlled and reproducible force. It forms the platform of the AMCT, but has also been used by Chiropractors when manual manipulation is not recommended as in osteoarthritic joints or osteoporotic patients (Read, 2006). Instrumented adjusting is thought to convey multiple benefits to both patients and practitioners (Huggins *et al.*, 2012). AMCT (Fuhr, 2009) is a commonly used technique system in Chiropractic that has been extensively studied in relation to the spine and the results suggest that this method may be similar to hands-only manipulation procedures. It is a subtle low force programme that makes use of specific procedures to detect spinal joint dysfunctions, mechanical body problems and analyses leg length inequality (Fuhr *et*

al., 1997). Leg length inequality is determined by the prone leg check. Pressure testing by the doctor combined with certain specific hand/arm movements of the patient, points to the fixated joints. The AAI is then applied to that specific area and a few HVLA thrusts are delivered to the involved joint in quick succession (Fuhr *et al.*, 1997). AAI manipulation showed a low peak force and the lowest thrust duration. Force-delivery characteristics and lines-of-drive are along planes of joint without segment rotation, may also reduce risk of unintended and iatrogenic effects of spinal manipulative therapy for high-risk patients (Fuhr and Menke, 2002). AMCT has been reported to be useful in the treatment of plantar fasciitis associated with calcaneal spurs among other conditions (Symons, 2000).

Additionally, AAI is used to produce a thrust or percussion when it is triggered (Bergmann *et al.*, 1993). A known variable force of up to 10 pounds (lb) (Leach, 2004) is imparted into a joint, whilst reducing physical stress on the clinician. In addition, it precisely controls the speed, force, and direction of the manipulative thrusts (Bergmann *et al.*, 1993, Gatterman, 1995 and Fuhr and Menke, 2002). The idea behind the AAI was to use low-force contacts to produce changes in body dynamics (Bergmann *et al.*, 1993) and correct a manipulable lesion (Haldeman, 2005). These instruments now represent the second most common approach for applying manipulative forces (Haldeman, 2005 and Kawchuk *et al.*, 2006), its usage increased significantly over the last few years (Christensen *et al.*, 2005) and is now used by 72% of Chiropractors on 21% of their patients (Leach, 2004; Colloca *et al.*, 2005 and Haldeman, 2005). Fuhr and Menke (2005) determined that the AAI could maximally produce a force of 0.3 Joules (J) of kinetic energy, which is enough to cause some movement at the joint level, but this force is also lower than the energy value needed to cause injury and with only a 3 millisecond excursion, Fuhr and Menke (2005) state it is completely safe (Cooperstein and Gleberzon, 2004).

This force is also sufficient to stimulate even the type III high threshold mechanoreceptors (Polkinghorn and Colloca, 1999), which could be beneficial since ligamentous injury often causes changes in mechanoreceptors, joint capsules, golgi tendon organs and muscle spindles (Hertel, 2000 and Hubbard *et al.*, 2005). Along with lateral ligamentous damage, proprioceptive organs are also injured in ankle joint inversion sprains. Proprioceptive organs are afferent pathways in reflexes and play

a most important role in posture and muscle tone (Miller and Narson, 1995 and Jerosch and Bischof, 1996). Inappropriate proprioceptive retraining leads to high rates of recurring injuries (Hoffman and Payne, 1995 and Anderson, 2002).

The phases after injury are termed acute if 48 hours after, and subacute if five days after injury (Reid, 1992). If proprioceptive retraining is not started after the acute phase, re-injury is more likely to occur in the chronic phase, as the organs cannot operate in their normal range (Kessler and Hertling, 1983). The rate of recurrent ankle sprains in athletes was drastically decreased by proprioceptive retraining to a similar level as people without any ankle sprain history (Verhagen *et al.*, 2000). Multiple manipulations applied to sprained ankles, lead to rapid recoveries (Pellow and Brantingham, 2001) and it was proposed that the manipulations restored normal proprioceptive input (Wyke, 1981 and Slosberg, 1988).

Köhne (2005) and Lindsey-Renton (2005) established the clinical outcome effect on proprioception between a single and multiple manipulations. It is recommended that Chiropractors test proprioception and neuromuscular co-ordination during examinations, especially after trauma (Brynin and Farrar, 1995). It may also be more likely that the AAI has more of a direct effect on soft tissue receptors and cutaneous nerve endings and through these pathways, indirectly influence the joint dysfunction (Polkinghorn and Colloca, 1999). After reviewing the literature and debating the issue, a four-to-two consensus was reached supporting the statement that AAI procedures are as effective as manual HVLA procedures in having clinical benefit and causing biological change (Taylor *et al.*, 2004). However several manipulations are normally necessary to bring about an asymptomatic state (Polkinghorn and Colloca, 1999).

With the paucity of research on the AAI (Fuhr and Menke, 2002), in respect of extremity conditions, little is known of the AAI (within and outside of its protocol) in terms of its clinical efficacy and effectiveness. This method of manipulating remains controversial, but its popularity warrants that it receives adequate attention (Haldeman, 2005), in order to allow practitioners to be able to provide evidence based care. Therefore, this research aims to investigate the relative effectiveness of

the AAI manipulation versus a manual long-axis distraction manipulation by diversified technique in CAIS in terms of objective and subjective findings.

According to Fuhr (2011) no studies have been compiled to test the effectiveness of AAI on CAIS, even though this modality is often utilised in practice both within and outside of its protocol in the treatment of extremity conditions (Triano, 2000; Fuhr and Menke, 2002 and Mykietiuk *et al.*, 2009). CAIS is a common condition that presents to practitioners utilising both manual and AAI manipulative interventions, thus it is of importance to determine whether AAI interventions are of clinical benefit to the patients receiving such care (Fuhr and Menke, 2002 and Brantingham *et al.*, 2008).

2.17 Conclusion

Chronic ankle instability is a significant cause of morbidity (Ajis and Maffulli, 2006). In the general clinic population, ankle sprains have many long-term restrictions to functionality. It is therefore necessary to further investigate appropriate and effective treatment options to reduce these functional limitations (Braun, 1999).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Introduction:

This chapter includes an outline and detailed description of the design of the study and a description of the criteria for inclusion or exclusion of patients. It also describes the interventions used for the study, including a description of each treatment group; along with the methods employed in data collection. Finally the statistical methods used for the analysis and interpretation of the data are also discussed.

3.2 Design

This research was a randomised, controlled, single blinded, clinical assessment, to compare an Activator Adjustment Instrument (AAI) manipulation with a manual long-axis distraction manipulation by diversified technique, in the treatment of Chronic Ankle Instability Syndrome (CAIS). The study was quantitative in nature and the results of the trial were stipulated and calculated in a statistical numerical format to determine the outcome of each individual treatment group.

The above research design was approved (Appendix A) by the Institutional Research and Ethics Committee (IREC) of the Durban University of Technology (DUT), indicating that the proposal and hence the research that was undertaken was compliant with the Declarations of Helsinki, Belmont and Nuremberg (Johnson, 2005).

3.3 Sample

3.3.1 Size

In total 40 participants (as determined by the power analysis supplied by Esterhuizen, 2012) were recruited from the greater Durban area. This was greater than the 15 per group recommended by Köhne et al., (2007). According to the institute's regulations, only 10% of the total numbers of participants were allowed to be Chiropractic students.

3.3.2 Recruitment:

Once appropriate permission was sought, advertisement flyers (Appendix B) were posted on the DUT campus notice boards and at the DUT Chiropractic Day Clinic, to inform potential participants that research, in the treatment of chronic ankle instability syndrome was being conducted at the DUT Chiropractic Day Clinic. Advertisement flyers were also posted at various sport clubs, sport shops and gymnasiums after appropriate permissions were sought. Participants were also recruited via word-of-mouth advertising and participants who were treated previously at the clinic for similar conditions were contacted to ascertain if they were interested in participating in this study if a three month washout period had elapsed since their last treatment.

Most of those participants who responded to the advertisements contacted the researcher or the DUT Chiropractic Day Clinic directly. The participant evaluation and selection process began with all possible participants undergoing a cursory telephonic discussion with the researcher, to exclude participants that did not fit the criteria for the study.

Therefore, participants were recruited through convenience sampling by means of their responses (self-selection) to the advertisement flyers (Howell, 1999; Mouton, 2006 and Mouton, 2008).

3.3.3 Sample Selection

In the telephonic discussion, the participants were asked the following questions to determine if the participant could be eligible for the study. These questions were:

Table 3.1: Telephonic Interview Questions and Required Answers

	Question	Required Answer
1	Would you be willing to answer a few questions with regards to your ankles in order for me to be able to determine your eligibility for the study?	Yes
2	How old are you?	20-40 years of age
3	Have you injured the outside of your ankle during the last year?	Yes
4	Is there any pain, swelling, crepitus and subjective weakness and / or limited movement at the affected ankle?	Yes to any of these symptoms / signs
5	Have you had recurrent injuries on the same ankle since?	Yes
6	Have you injured your ankle in the last 6 weeks?	No
7	Do you have any form of arthritis that affects your feet and / or ankle?	No
8	Have you had any surgery to your feet and / or ankles?	No
9	Do you have any problems with feeling in your feet and / or ankles?	No

In the event that the potential participants did not meet the requirements, they were thanked for their interest and time and then they were advised in terms of treatment options for their specific conditions. They were informed of possibly attending the DUT Chiropractic Day Clinic as an out-patient, where treatments were available to the general public at reasonable costs. If this was not possible then referral to the next most appropriate health care provider outside of the DUT was suggested as an alternative.

For the potential participants who met the criteria, an appointment was scheduled at the DUT Chiropractic Day Clinic to potentially enter the research study for CAIS. At the initial consultation, each potential participant received a Letter of Information and Informed Consent Form (Appendix C) that gave a detailed explanation of what the research programme entailed and what would be expected from them as participants. The letter also informed them that they were free to withdraw from the study at any time without any repercussions for future care at the clinic. After reading the Letter of Information and Informed Consent Form (Appendix C), the participants were allowed to ask any questions to clarify the process and procedures of the study. Special care was taken to make sure the participants had full and clear understanding of the process going forward, before they were required to sign the Letter of Information and Informed Consent Form (Appendix C).

3.3.4 Sample Characteristics

If the potential participants stated they understood the details of the letter, they were asked to sign the Letter of Information and Informed Consent Form (Appendix C). The participants then had a case history (Appendix D), physical (which included a dermatome, myotome and reflex assessment) examination (Appendix E) and foot-and-ankle regional examination (Appendix F) done in order to diagnose and to screen them for inclusion into the study. All the data was noted on a SOAPE note (Appendix G) and discussed with the clinician that was on duty in order to ensure that the potential participants met all research requirements. A SOAPE note was a basic summary of the doctor-patient interaction, which in short recorded the subjective statements by the patient, the objective findings pertaining to the patient's complaint, the assessment and analysis (diagnosis) of the findings, the implemented plan of action or treatment, and the education or further advice given to the patient.

It should be noted that no restrictions were enforced in terms of ethnicity, gender, occupation or level of income. Participants were in no way compensated for taking part in the research.

3.3.4.1 Inclusion Criteria

- Participants had to be between 20 and 40 years of age which was well within the recommended (Pellow and Brantingham, 2001) age group of 15 to 50 years (Pellow and Brantingham, 2001). The adaptation of age group in this study was to improve homogeneity and decrease variance in terms of participant response to the intervention (Mouton, 1996; Mouton, 2006 and Mouton, 2008).
- Participants were required to have CAIS defined by the presence of four or more of the following clinical features (Kessler and Hertling, 1983; Reid, 1992; Pellow and Brantingham, 2001; Ajis and Maffulli, 2006; McBride and Ramamurthy, 2006 and Caulfield, 2007) inclusive of :
 - Lateral ankle pain,
 - Joint weakness,

- Ankle instability,
 - Oedema,
 - Joint crepitus and / or
 - Stiffness or adhesions.
- Participants had to have presented with two or more unilateral ankle sprains in the last two years (Goldie *et al.*, 1994 and Read, 1996).
 - The participants had to have had an ankle sprain no more than two years prior to the consultation (Goldie *et al.*, 1994).
 - Participants were required to have previously sprained or injured their ankle in a way that did not cause severe trauma to the ankle structures, and did not need surgery or other significant intervention as per Table 3.2. Thus, the criteria according to Reid (1992) were applied, which indicated that participants required no more than a Grade I or Grade II previous ankle sprain.

Table 3.2: Grading for Ankle Sprains Grade I and II (Adapted from Reid, 1992)

Grade I (mild): Stable	No haemorrhage
	Minimal swelling
	Point tenderness
	Negative anterior drawer sign
	No varus laxity
Grade II (moderate): Stable	Some haemorrhage
	Localized swelling
	Less defined margins of Achilles tendon
	Anterior drawer sign may be positive
	No varus laxity

- The mechanism of ankle injury had to involve weight-bearing and inversion of the ankle (Goldie *et al.*, 1994), with subsequent damage to the lateral collateral ligaments of the ankle (viz. anterior and posterior talofibular and the calcaneofibular ligaments).
- Participants were required to have restricted motion in the talocrural / subtalar joints as defined by Bergmann and Peterson (2011) and Byfield (2012).
- Participants were required to sign the Letter of Information and Informed Consent Form (Appendix C).

3.3.4.2 Exclusion Criteria

- Participants with any relative or absolute contra-indications to manipulation, determined through the preliminary history taking, physical and regional examination (Gatterman, 1990; Bergmann *et al.*, 1993; Pellow and Brantingham, 2001; Haldeman, 2005 and Morris, 2006).
- Participants taking anti-inflammatory drugs or pain killers for their condition. Alternatively participants were required to endure a three day wash-out period before being accepted for the study (Poul *et al.*, 1993 and Seth and Seth, 2008), as these may influence certain measurements (Pellow and Brantingham, 2001).
- Participants having been part of another research trial were not permitted to take part in this study until a three month wash-out period had taken place. Similarly, a participant who had attended / had been attending the DUT Chiropractic Day Clinic for treatment were not permitted into this study until a two week wash out period had taken place (this is according to the DUT Chiropractic Day Clinic protocol). Participants were asked not to initiate any other form of treatment while taking part in this study (Pellow and Brantingham, 2001).
- Participants who experienced re-injury during the study were excluded to rule out acute ankle injuries (Pellow and Brantingham, 2001).
- Participants who showed signs of gross mechanical ankle instability (Pellow and Brantingham, 2001) explained by Reid (1992) as a Grade III ankle sprain (according to Table 3.3) and syndesmosis injury (Alonso *et al.*, 1998).

Table 3.3: Grading for Ankle Sprains Grade III (Adapted from Reid, 1992)

Grade III (severe):	Diffuse swelling on both sides of Achilles tendon
2-ligament, unstable	Early haemorrhage
	Tenderness may occur medially and laterally
	Positive anterior drawer sign
	Positive varus laxity

- Participants who have had reconstructive or any other major surgery done to the affected ankle.

- Participants that did not wish to participate or did not sign the Letter of Information and Informed Consent Form (Appendix C).

The potential participants, who opted not to sign the Letter of Information and Informed Consent Form (Appendix C), were thanked for their interest and time and reminded about the DUT Chiropractic Day Clinic out-patient service that was available to the general public at a minimal charge.

Those participants who did not meet the inclusion criteria were referred to other interns in the DUT Chiropractic Day Clinic for treatment for their presenting condition.

3.4 Research Procedure

Once the suitability of the participants was determined, they were randomly allocated according to the randomisation table (Appendix H) supplied by Esterhuizen (2012), by concealed allocation (Howell, 1999; Mouton, 2006 and Mouton, 2008) to one of two equal groups of 20 participants each. The accepted participants were randomly assigned numbers 1 – 40 on the randomisation table (Appendix H), as they came into the clinic for their treatment. Then, according to the number they came in as, they fell in either treatment Group A (manual long-axis distraction manipulation by diversified technique) or Group B (AAI technique) according to the randomisation table (Appendix H) (Cottrell and McKenzie, 2005) as supplied by Esterhuizen (2012).

As per agreement, the clinic administrators of the DUT Chiropractic Day Clinic (Appendix I and Appendix J), were in charge of the concealed allocation. Under no circumstances was the researcher allowed any access to the randomisation table (Appendix H).

3.5 Interventions

The accepted (40) participants underwent two consultations - one treatment and one follow-up consultation. It was known that multiple treatments are effective for treating chronic conditions, but since we were testing the immediate effects of such treatments on chronicity, only one treatment was given. Group A received a manual long-axis distraction manipulation by diversified technique to the ankle talocrural joint (Schafer and Faye, 1990 and Bergmann *et al.*, 1993).

Table 3.4: Method of Manual Manipulation (Adapted from Schafer And Faye, 1990 and Bergmann *et al.*, 1993)

Group A:	Manual manipulation (mortise separation):
Patient's position:	Supine, gripping table, resisting caudal movement.
Doctor's position:	Kneeling at the foot of the table.
Doctor's Indifferent hand:	Either hand, grasps either the medial or lateral border of the foot with the thumb on the sole of the foot and the fingers on the dorsum (dome of talus).
Doctor's Contact hand:	Either hand, grasps the opposite border of the foot from the indifferent hand but holds the foot in the same manner (reinforcing contact hand).
Vector:	Dorsiflex (to point of joint lock) the ankle, internally rotate the entire leg, then evert the foot. Apply slight traction to lock up the joint, remove tissue and joint slack and thrust directly toward the doctor with the line of drive parallel to the floor (anterior to posterior with respect to talar dome and thus in a caudad direction in respect of the patient).

Group B received an anterior-lateral talus (Line of Drive being posterior-medial) AAI manipulation with full tension (Fuhr *et al.*, 1997).

Table 3.5: Method of AAI Manipulation (Adapted from Fuhr *et al.*, 1997)

Group B:	Activator:
Patient's position:	Prone.
Doctor's position:	Stands by the foot end.
Contact point:	Tip of the AAI.
Segmental Contact point:	Contact the neck of the talus by positioning the tip of the instrument into the sinus tarsi.
Doctor's Indifferent hand:	Flexing the patient's knee to 90° to ensure a precise contact and line of drive as well as prevent unnecessary wrist flexion or extension during the manipulation.
Vector:	Line of drive is posterior and medial toward the Achilles tendon

As treatment with an AAI does not normally cause a cavitation, it was pre-decided that only a single application with a double impact (thrust) was to be used. In the same instance, 2 thrusts were applied with the manual manipulation, unless cavitation was heard or movement was felt after the first.

Post-treatment home care advice included that participants were not to change their normal routine. Also as they were not on any form of analgesics (topical or oral – as part of exclusion criteria) they were asked to not start any such treatment now even if discomfort was caused from the treatment.

3.6 Intervention Frequency

Both groups attended a follow-up consultation within 48 hours to re-assess the condition of the ankle post-treatment (Coetzer, 1999; Eisenhart *et al.*, 2003; Collins *et al.*, 2004; Vicenzino *et al.*, 2006 and Lopez-Rodriguez *et al.*, 2007).

3.7 Measurement Tools

Data collection took place on both the first and the second consultation. All measurements were done by the blinded assessor as per agreement (Appendix R). Participants were monitored and assessed in the form of subjective and objective data that was collected pre- and post-treatment. The following subjective measurement tools were used to assess the ankle joint.

3.7.1 Subjective Measurement Tools

3.7.1.1 Numerical Pain Rating Scale-101 (NRS)

The Numeric pain Rating Scale (Appendix K) was used to assess the participants' pain (Bolton and Wilkinson, 1998). Participants were asked to give a pain rating score to the blinded assessor, prior to treatment and again at the follow-up consultation, as to ascertain if the treatment had an effect on reducing the participants' symptomatic pain. The patient was asked to indicate how they perceived their pain, on a scale of 0 to 100. Zero (0) indicated no pain and one hundred (100) indicated the most extreme pain they had ever experienced. The minimal clinically important difference (MCID) was noted at 20 to 25mm (Lee *et al.*, 2003 and Ostelo and de Vet, 2005).

3.7.1.2 Experience of Treatment

Participants were asked to indicate their experience of the treatment (Appendix L) directly after the treatment, and again at the follow-up consultation, under the blinded assessor's guidance.

3.7.1.3 Foot and Ankle Disability Index (FADI)

A Foot and Ankle Disability Index (Appendix M) or FADI, was utilised to assess the general ankle function in these participants, noting any improvements that were made before the commencement of certain treatments (Hale and Hertel, 2005). The FADI was a prequel to the Foot and Ankle Ability Measure (FAAM). The two instruments were identical apart from five items found on the FADI, four to assess pain, and the fifth to evaluate sleeping ability. The FADI was composed of 26 activities of daily living and 8 sports items (Martin and Irrgang, 2007). Hale and Hertel (2005) found that the FADI was reliable in detecting functional limitations in subjects with CAI, sensitive to differences between healthy subjects and subjects with CAI and sensitive to improvements in function after rehabilitation in subjects with CAI (Hale and Hertel, 2005). Subjects were required to fill out this index before the treatment and again at the second consultation under the guidance and supervision of the blinded assessor.

3.7.2 Objective Measurement Tools

The following objective measurement tools were used to assess the ankle joint:

3.7.2.1 Algometer

The algometer (Appendix N) was a calibrated force pressure gauge that was used to assess an individual's pain-pressure threshold or PPT (Hutchinson, 2007). Pressure pain detection threshold (PPdt) was the point in which a steadily increasing non-painful pressure stimulus turned into a painful pressure sensation. Pressure pain

tolerance threshold (PPtt) was the highest level of pain, which a subject was prepared to tolerate (Egloff *et al.*, 2011). Tissue sensitivity was quantifiably measured by algometers (Fryer and Hodgson, 2005) and many studies indicated the reliability of these instruments in determining PPT on bony and muscular landmarks (Ohrbach and Gale, 1989). Pressure algometry had good validity when assessed by pain and disability questionnaires and since it assessed a different aspect of pain, it was warranted in addition to other measures. No normative values were established outside of which pathology could have been identified reliably, thus the patient's healthy side may have been used as a normal reference in unilateral painful conditions. It was useful to note that many classified pressure algometry as an objective measure (Ylinen, 2007). However, even though it was a quantitative measure, it was nevertheless a subjective measure, as it was based on the patient's report of pain. Since PPT may have been influenced subconsciously by the tester while compressing the pressure algometer (AP), blinding was recommended in studies (Ylinen, 2007).

The algometer was used to assess the minimum pressure inducing pain or discomfort (PPdt) over the point of maximum tenderness (Blake, 2003). The algometer was set to zero and positioned over the sinus tarsi and pressure was slowly increased until the participant informed the blind assessor of the point at which the pressure became painful. This area was chosen in order to rule out any periosteal tenderness (which may have occurred in places overlying a bone), as the algometer was originally designed to measure soft tissue injuries and as such the device was utilized according to the guidelines as prescribed by Fischer (1987). This value was recorded into the data sheet. The second reading was taken by the blinded assessor at the follow-up consultation to identify an increase or decrease in the participant's symptoms. A higher reading on the follow-up consultation would have indicated improvement and a lower reading would have indicated worsening of the condition. The Wagner KDK20 Force Dial (Wagner Instruments, PO Box 1217, Greenwich, CT, 06836, USA) was used. The Minimal Clinically Important Difference MCID) was noted at 15% (Paungmali *et al.*, 2003; Potter *et al.*, 2006 and O'Leary *et al.*, 2007), or with regards to MCID, 1.77kg/cm² (Chesterton *et al.*, 2007).

3.7.2.2 Weight-Bearing Ankle Dorsiflexion Test

The weight-bearing ankle dorsiflexion test was designed to assess improvement in ankle dorsiflexion post treatment for CAI (Blake, 2003; Maartens, 2005; Collins *et al.*, 2004; Dunn, 2005 and Vicenzino, 2006). This method had a high intra and inter-examiner reliability (Jones *et al.*, 2005). The method for measurement (Appendix P) was as follows; Participants stood on the involved leg and dorsiflexed the ankle while keeping the heel in full contact with the floor. A large set square was used to measure the distance from the heel to the anterior aspect of the knee (x) and from the ground to the anterior aspect of the knee (y). The degree of dorsiflexion was determined by $\tan\theta = y/x$. Measurements were taken by the blind assessor before and after the treatment. Since this was a study with chronic ankle injuries, the researcher expected that the limiting factor in movement would have been restriction and not pain. If, however, pain was experienced, it was noted down as such.

3.7.2.3 Berg Balance Scale (BBS)

Proprioception of the ankle and stability of the joint was determined by the Berg Balance Scale. This scale was a clinically acceptable method of measuring balance over time. A cut-off score of 45/56 was suggested for the sake of homogeneity (Kornetti *et al.*, 2004), but we did not adhere to this due to the BBS not forming part of the exclusion criteria. Future research might want to keep this in mind. This was completed before and after treatment by the blind assessor.

3.7.2.4 Motion Palpation

Joint restrictions were assessed with motion palpation and formed part of the foot-and-ankle regional examination (see Appendix F). This assessment detected the range of motion within a specific joint along all axes of motion, and determines if after the treatment, the range of motion increased, decreased or remained the same. This was a reliable intra-examiner assessment tool, however, the validity might have been questioned in terms of inter-examiner reliability (Liebenson and Lewit, 2003). Thus, the results were considered in light of the results obtained from the other

measurement tools such as NRS, BBS, algometer, FADI and weight-bearing ankle dorsiflexion test. The whole foot-and-ankle regional examination was done, but specific attention was given to the Range of Motion (ROM) of the mortise and subtalar joints.

3.8 Assessor

A blinded assessor (Appendix R) was utilised to take recordings of the clinical measures. All pre- and post-treatment measurements were taken by the blinded assessor and all assessments were done under her supervision and guidance. This was done in order to ensure that the researcher (who was treating the patients) had no input and thus no potential bias in terms of the noted improvements or lack thereof in terms of the study intervention (Mouton, 2006 and Mouton, 2008). Prior to starting the research, both the researcher and the blinded assessor were instructed by White (2012) in the use of the AAI and all measurement tools, after which White (2012) and Korporaal (2012) assessed the researcher and the blinded assessor's competency. The blinded assessor's time was rewarded with an hourly cash remuneration rate.

3.9 Measurement Frequency

All data was taken from the corresponding data collection sheets (Appendices K, L, M, N, O and P) and entered onto a Microsoft (MS) Office Excel spreadsheet. From the MS Excel spreadsheet, the data was imported into SPSS version 20.

3.10 Statistical Analysis

Following consultation with a research statistician (Esterhuizen, 2012), statistical analysis was conducted on the data using the latest version of SPSS (manufactured by SPSS Inc., 444N. Michigan Ave, Chicago, Illinois, 60611, USA). A *p*-value of <0.05 was considered as statistically significant.

Descriptive data was presented with frequency tables, bar graphs, and summary statistics including mean, standard deviation and range. Demographics were compared between treatment groups using Pearson's chi square tests and t-tests.

Intra- and inter-group analyses were done utilising repeated measures ANOVA tests. Inter-group analyses reported the effect of the time on group interaction as the effect of the intervention.

This was also interpreted using profile plots to show mean change in the outcome measure over time and by treatment group in order to assess trends and direction of the effect (Esterhuizen, 2012).

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This study consisted of 40 participants, with ages ranging from 20 to 40 years of age, and these participants were divided into two treatment groups of 20 participants each. No consideration was made for gender, ethnicity or occupation.

One treatment group (treatment Group A) was treated with a manual long-axis distraction manipulation by diversified technique, and the other treatment group (treatment group B) was treated with an AAI set at full tension. Statistical analyses of the participants' pain and discomfort levels were carried out to assess the extent of the non-specific effects that occurred between the two treatment groups. Both intra- and inter-group comparisons were drawn. The results of the statistical analyses together with the discussion of the results are presented in this chapter in order to maintain a pragmatic flow.

4.2 Data

4.2.1 Primary Data

The primary data used to collect information from the participants were subjective measurements:

- Numerical Pain Rating Scale-101 (NRS):
- Experience of Treatment:
- The Foot and Ankle Disability Index (FADI):

The objective measurements were:

- Algometer (Pain-Pressure Threshold):
- Weight-Bearing Ankle Dorsiflexion Test:
- Berg Balance Scale (BBS):
- Motion palpation:

Other primary data was collected in the form of the case history (Appendix D), physical examination (Appendix E), foot-and-ankle regional examination (Appendix F) and a SOAPE note (Appendix G), in order to ensure participants' compliance with the respective inclusion criteria (see Section 3.3.3.1).

4.2.2 Secondary Data

Secondary data sources that were employed, included communications with the statistician (Esterhuizen, 2013); various literature on statistical analysis (Bland, 1996; Swinscow, 1996; Wright, 1997; Campbell and Machin, 1999 and Hinton, 2001) and communication and discussion with the supervisors of the research project (Korporaal, 2013 and White, 2013). The discussions in Chapters Two and Five were formulated from various journal articles and books as mentioned in the reference list.

4.3 Abbreviations

- “A”** treatment group who received a manual long-axis distraction manipulation by diversified technique / defined as the blue line on the figures.
- “B”** treatment group who received an AAI manipulation with the AAI set at full tension / defined as the green line on the figures.
- “df”** differential.
- “F”** frequency (Bland, 1996; Swinscow, 1996; Wright, 1997; Campbell and Machin, 1999 and Hinton, 2001).
- “N”** sample size. Sample in this case is defined as *“A subset of a population”* (Tropper, 1998).
- “p”** *p*-value which indicates the data statistical significance (Bland, 1996; Swinscow, 1996; Wright, 1997; Campbell and Machin, 1999 and Hinton, 2001).

“Sig” significance (Bland, 1996; Swinscow, 1996; Wright, 1997; Campbell and Machin, 1999 and Hinton, 2001).

“Tx” treatment.

“%” percentage.

“<” a figure “less than” the figure reported.

“=” equals to.

4.4 Participant Flow as Per the Consort Diagram¹

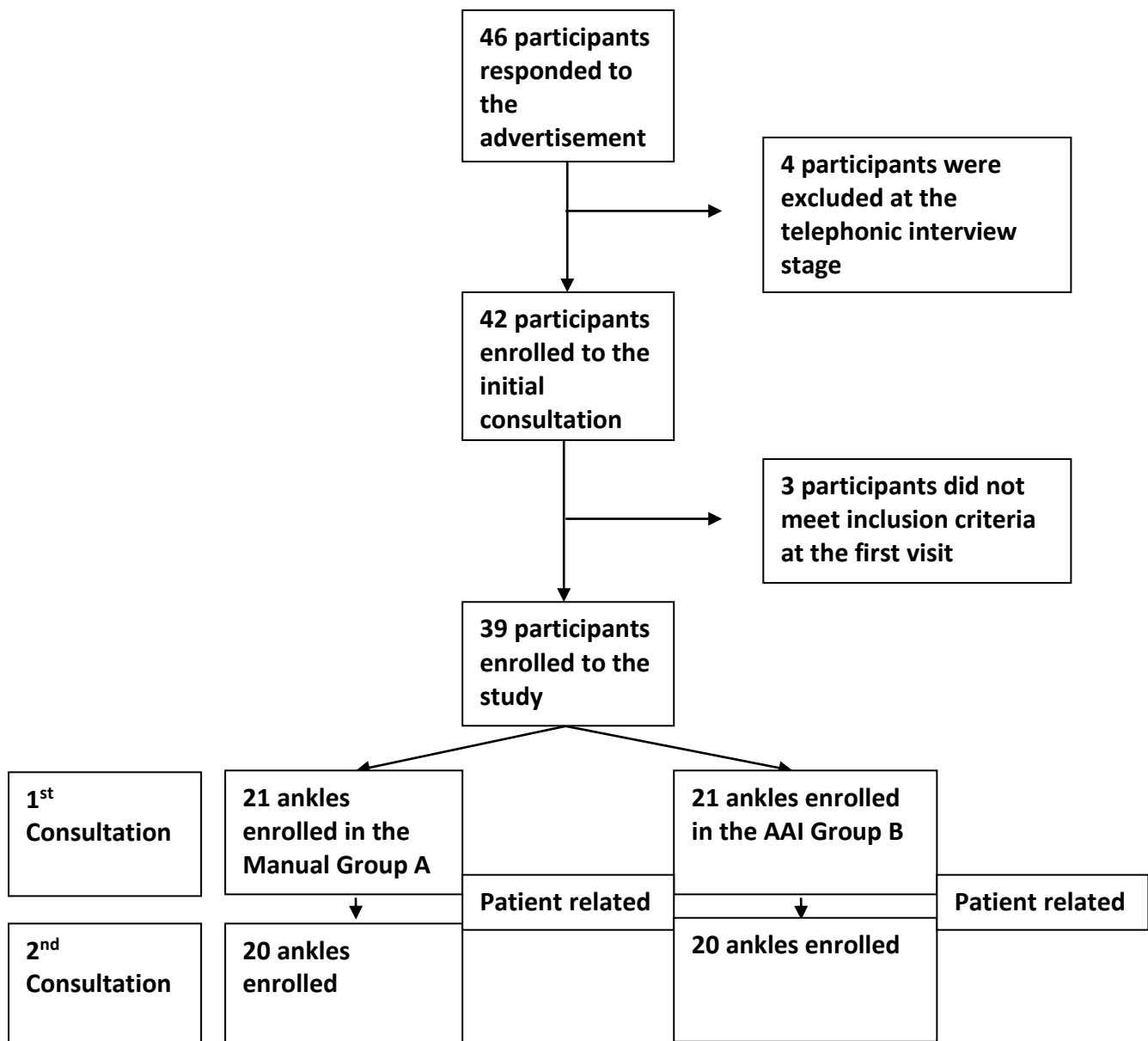


Figure 4.1 Consort Diagram Outlining Patient Flow in this Study

¹ Please note that three of the participants enrolled into both treatment groups as they had bilateral CAIS. This is the reason why the Consort refers first to “participants” and then to “ankles”. Thus 37 participants = 40 ankles.

4.4.1 Discussion of the Consort

The Consort diagram reflects the need for a consort statement within the body of any research text and as such, functions as a “checklist and a flow diagram for reporting a randomized controlled trial (RCT)”. The purpose of this checklist is to accurately report the progress of participants through the research study and to reflect on the probability of selection bias or withdrawal bias from the study (Moher *et al.*, 2001).

As per the Consort diagram (Figure 4.1) 46 individuals responded to the advertisements for this study, four people were eliminated from the onset of the study for not meeting the inclusion criteria (either through the telephonic or clinical screening process). This indicates that the inclusion criteria were stringently applied in the study, allowing for the participants to achieve homogeneity so as to enable direct comparison between the treatment groups without skewing of this comparison by the demographic data. Therefore, the strength of the results is more likely to display the effects of the intervention than those of demographic data differences between the treatment groups (Esterhuizen, 2013). This is significant in that the randomisation process utilised in this study (to allocate participants to their respective treatment groups), achieved its goal of obtaining two treatment groups of a similar nature without bias or interference from the researcher or by means of participant withdrawal from the study (Mouton, 2006).

During the research process, it was noted that two participants dropped out of the study (one from each treatment group respectively). Both of these participants were no longer able to fulfil their commitment to this study due to personal reasons. It could, therefore be seen that the impact of the treatment was not the principle reason for participants withdrawing from the study and that there were no instances in which participants withdrew or were withdrawn due to adverse effects of the intervention. This implies that bias did not play a role through the exclusion of these participants from the study. Additionally, as one participant from each treatment group dropped out, it could be stated that the effect of the drop outs was not detrimental to the outcomes of either treatment group and it therefore did not have a negative impact on the outcome measurements of this study.

4.5 Baseline Results

There was no difference between the treatment groups in terms of demographics.

4.5.1 Age

There was no difference between the treatment groups in terms of age of the participants ($p=0.802$), as there was only a two year difference between the means of the two treatment groups.

Table 4.1: Age

	Tx A		Tx B		<i>p</i> -value
	Mean	Standard Deviation	Mean	Standard Deviation	
AGE	29	6	27	4	0.802

4.5.2 Body Mass Index (BMI)

There was no difference between the treatment groups in terms of BMI, with an average BMI of 25 in treatment Group A and 26 in treatment Group B ($p=0.331$).

Table 4.2: BMI

	Tx A		Tx B		<i>p</i> -value
	Mean	Standard Deviation	Mean	Standard Deviation	
BMI = Kg/m ²	25	4	26	4	0.331

4.5.3 Ethnicity

There was no difference between the treatment groups in terms of the ethnic make-up. The results do however show that there were proportionally more Caucasians and Indians in the treatment groups than any other ethnic groups.

Table 4.3: Ethnicity

		Tx A		Tx B		<i>p</i> -value
		Count	Column N %	Count	Column N %	
ETHNICITY	African	2	10.0	3	15.0	0.700
	Caucasian	10	50.0	7	35.0	
	Coloured	1	5.0	2	10.0	
	Indian	7	35.0	8	40.0	

4.5.4 Occupation

In terms of occupation, there was very little difference between the treatment groups greater than that which is equal to chance alone, with the $p=0.472$.

Table 4.4: Occupation

Table 4.4: Occupation					
	Tx A		Tx B		
OCCUPATION	Count	Column N %	Count	Column N %	p-value
Account Broker	0	0.0	1	5.0	0.472
Administrative / Housewife	1	5.0	0	0.0	
Agency Director	1	5.0	0	0.0	
Agent	1	5.0	0	0.0	
Attorney	0	0.0	2	10.0	
Banker	1	5.0	0	0.0	
Broker	2	10.0	1	5.0	
Build Contractor	1	5.0	0	0.0	
Casting Agent	1	5.0	0	0.0	
Clerk	0	0.0	1	5.0	
Contractor	1	5.0	0	0.0	
Dietician	0	0.0	1	5.0	
Event Caterer	1	5.0	0	0.0	
Financial Advisor	0	0.0	2	10.0	
Financial Manager	1	5.0	0	0.0	
Laboratory Technician	0	0.0	1	5.0	
Personal Trainer	0	0.0	1	5.0	
Political Economist	0	0.0	1	5.0	
PR Consultant	1	5.0	0	0.0	
Project Manager	0	0.0	1	5.0	
Research Analyst	1	5.0	1	5.0	
Signage	1	5.0	1	5.0	
Social Worker	0	0.0	1	5.0	
Student	4	20.0	5	25.0	
Treasury Dealer	1	5.0	0	0.0	
Unemployed	1	5.0	0	0.0	

4.5.5 Gender

There was no difference between the treatment groups in terms of the genders, even though there were a slightly higher proportion of males in both treatment groups.

Table 4.5: Gender

		Tx A		Tx B		p-value
GENDER		Count	Column N %	Count	Column N %	
	Female	5	25.0	9	45.0	0.185
	Male	15	75.0	11	55.0	

4.5.6 Side Involved

The side involved refers to the side (left or right) with respect to the injured or involved ankle that was treated in this study. There was no difference between the treatment groups in terms of the genders, even though there were a slightly higher proportion of right sided ankles that were injured. It is of interest to note that randomisation equally allocated left and right ankles to each of the respective study treatment groups.

Table 4.6: Side Involved

		Tx A		Tx B		<i>p</i> -value
		Count	Column N %	Count	Column N %	
SIDE	Left	8	40.0	8	40.0	1.000
	Right	12	60.0	12	60.0	

4.5.7 Discussion of Baseline Results

There was no difference between the treatment groups in terms of demographics.

Age: The $p=0.802$, indicates that with regards to gender there was no difference between the two treatment groups and therefore the influence of age was statistically insignificant. This compares favourably with the literature where ankle injuries appear to affect people of a diverse age group (Karlsson and Sancone, 2006; Malliaropoulos *et al.*, 2006). However, it must be noted that treatment Group A was slightly older, ranging from 23 to 35 with 29 being the average, as opposed to treatment Group B's age range of 23 to 31 with 27 years of age as an average. This was not anticipated to have affected the results of this study (Mouton, 2006).

Apart from the fact that ankle injuries mostly occur in the younger, more active individuals, it must also be noted that the study was performed on an academic campus, which would in effect have drawn younger people into the study.

BMI: The $p=0.331$ revealed a statistically insignificant difference between the treatment groups, with no effect on the outcomes obtained in this study. The BMI between the two treatment groups was very similar, with treatment Group A having

an average of 25 with a standard deviation of 4, and treatment Group B having an average of 26 and a standard deviation of 4 as well. The BMI is an estimated, but more accurate measure of body fat than weight alone. The value was calculated by taking the participants' weight in kilograms (kg) and dividing it by the participants' height in meters squared (m^2). This value is compared to a BMI chart (Bickley, 2007). When referring to a BMI Chart (Appendix S), most candidates fell in the overweight range. It is recommended that if the BMI is more than 35, the waist circumference should be measured. If this measurement (taken just above the hip bones) is more than 35 inches (87.5cm) in females and 40 inches (100cm) in males, the patients may have excess body fat. The BMI criteria however, are merely guidelines for increasing risks for health and wellbeing (Bickley, 2007).

Ethnicity: Ethnicity was not statistically significant between the two groups of this study, since the findings indicated a $p=0.700$. It is however interesting to note that the majority of participants were of either Caucasian or Indian decent. This could be attributed to the location of where the study was conducted, as the Indian populations in the greater Durban area are high. Even though the African population makes up the majority of the student population of the DUT Campus, it was found that the African population was not that well represented in this study. A possible reason for few African participants could be the fact that in general, the African community have had less exposure to the science of Chiropractic than other population groups in South Africa (Myburgh and Mouton, 2007).

Occupation: There was no remarkable statistical significance of occupation between the treatment group, as $p=0.472$ indicates. It would be of interest to note that just under a quarter of the total participants (9/40) were in fact students (concurring with the younger age of the participants and the location of the study), but also that with taking this into consideration, the mean age was still 27 and 29 for each treatment group respectively. Apart from the limitation of only allowing 10% of the total allocated number of research participants, to be Chiropractic students from the institution, several more were recruited from other faculties. This also is largely a consequence of the location of the clinic where the study took place. It must also be remembered that it is not necessarily during working hours that the participants

would injure themselves, but during their recreational activities (Boyer and Younger, 2006). Occupation did thus not contribute to the study.

Gender: The $p=0.185$ means that gender was statistically insignificant. In total, more males (26) participated in this study, which equates to 65%. Also it should be noted that in both treatment groups, there were more males than females. Treatment Group A had three times more males than females, whereas treatment Group B had only a slightly higher number of males to females (11 males to 9 females). The ratio of male to female in treatment Group A is 3:1 which is larger than that of treatment Group B which had a ratio of 1:0.8. This seems to be in line with literature (Espinosa *et al.*, 2006).

Affected Side Involved: The treatment groups were identical as indicated by the $p=1.0$. It also shows that there was statistically no significance. Out of the 40 participants, 16 were affected on the left hand side, and the remaining 24 were affected on the right. It should also be noted that three of the participants were treated for bilateral ankle involvement and fell into both treatment groups (see Consort Diagram (Figure 4.1)). The comparative weakness of the non-dominant side in relation to the probability of being injured should also be considered. Similarly the increased chance of injury to the dominant side as it is used more often (Norkin and Levangie, 1992).

From an overview of the baseline demographics, it can be seen that there are no p -values that are statistically significant, and therefore, there is a congruency between the two treatment groups. As a result, the treatment groups can be viewed as homogenous and therefore comparable, allowing for discussion and conclusions to be drawn more specifically to the intervention rather than extraneous variables (Mouton, 2006). It also implies that none of the statistical analyses were required to be controlled by any variable related to the baseline data.

4.6 Results and Discussion of Intra-Group Analyses

4.6.1 Objective One

The First Objective was to determine the effectiveness of a manual long-axis distraction manipulation by diversified technique (Treatment Group A) to the ankle, on CAIS in terms of subjective and objective findings.

4.6.1.1 Subjective Findings in Group A

4.6.1.1.1 Group A – NRS

Repeated measures ANOVA testing for the treatment Group A showed that there was a significant effect of the intervention over time on NRS ($p=0.000$), indicating that the significance falls into the 99% confidence interval ($p<0.01$).

Table 4.7: NRS change over time within Group A ($p<0.001$)

Multivariate Tests^{a,b}						
Effect		Value	F	Hypothesis df	Error df	Sig
Time	Pillai's Trace	0.643	34.200 ^c	1.000	19.000	0.000
	Wilks' Lambda	0.357	34.200 ^c	1.000	19.000	0.000
	Hotelling's Trace	1.800	34.200 ^c	1.000	19.000	0.000
	Roy's Largest Root	1.800	34.200 ^c	1.000	19.000	0.000

a. Tx = A

b. Design: Intercept / Within Subjects Design: time

c. Exact statistic

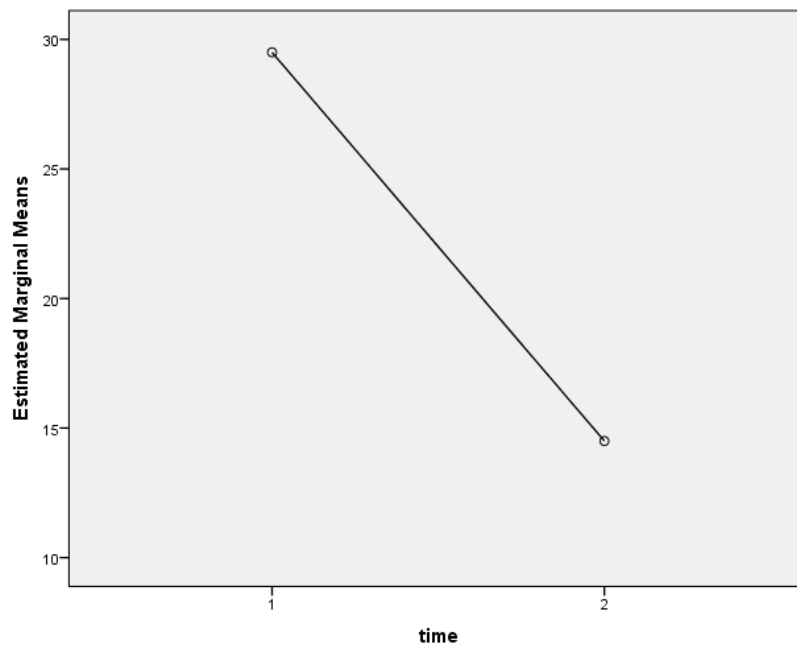


Figure 4.2: NRS readings over two reading points for Group A

From Table 4.7 and Figure 4.1, it can be observed that there is a statistically significant effect of the treatment over time ($p=0.000$).

The findings in this study are congruent to Pellow and Brantingham (2001) and Köhne's (2005), findings. This could be expected as manual manipulation has been reported to affect:

- the neurological system (Leach, 2004), allowing for immediate relief of pain and discomfort. This is proposed to work through the Gate Control Theory (Melzack and Wall, 1965 and Melzack and Wall, 1988) and in the new integrated pain theories (Chaitow and DeLany, 2000).
- the biomechanical system (Bergmann *et al.*, 1993; Bergmann and Peterson, 2011), which has a less immediate effect but assists in increasing range of movement. This system works by stimulation of the Wyke receptors (Leach, 2004), thus invoking a stronger action of the Gate Control theory (decreased pain) over a longer, sustained period (24 hours) and its underlying clinical benefits. Therefore, participants were expected to have increasing benefit over time, which resulted in the improved results seen at time point two.

It is noted in the literature that an MCID for NRS is 20 to 25mm on a 100mm NRS scale (Lee *et al.*, 2003 and Ostelo and de Vet, 2005). Therefore, in terms of the NRS, the improvement, which was noted as a 15mm point improvement, indicates that there is no clinically significant improvement for NRS. It is important to note here that the MCID may have been affected by the sample size in this study and therefore future studies should consider increasing the sample size within each of the treatment groups, particularly if the outcomes of this study are to be verified.

Comments on the long term effect of a single manual manipulation is also beyond this study and future studies are encouraged to consider this, as the long term effects of a single manipulation between manual manipulation and AAI are not known – particularly as it relates to pain control. The outcomes of the value of the manual manipulation versus the AAI should thus perhaps also be considered in the context of the effect of multiple manipulations (either to the ankle joint or the full kinematic chain ipsilateral to the involved ankle).

4.6.1.1.2 Group A - Experience of Treatment

Table 4.8: Experience of Treatment of Group A

^a		Count	Column N %
SETUP	Comfortable	16	80.0
	Uncomfortable	4	20.0
THRUST	Pleasant	14	70.0
	Unpleasant	6	30.0
FEEDBACK	Helpful	15	75.0
	Unhelpful	5	25.0

a. Treatment = Manual Long-Axis Manipulation

From Table 4.8, it can be seen that 75% of the participants in treatment Group A, considered that manual long-axis distraction manipulation by diversified technique was helpful. One possible reason for only three quarters of the sample indicating that manual manipulation assisted them, may be related to the fact that the NRS scores at the outset were not utilised as part of the inclusion criteria, which implies that there may have been participants that had lesser degrees of possible improvement open to them when compared to other participants in the same treatment group (and with a higher NRS). Therefore, it is possible that these latter participants were less likely to report a substantive improvement as they would not

have had the possibility to experience this. It is therefore suggested that future studies include the NRS as an inclusion tool as well as a measurement tool.

4.6.1.1.3 Group A – FADI

The analysis of the FADI, indicated that this outcome measure changed over time to a statistically significant degree ($p=0.001$), irrespective of the analysis type that was used.

Table 4.9: FADI change over time within Group A ($p=0.001$)

Multivariate Tests ^{a,b}						
Effect		Value	F	Hypothesis df	Error df	Sig
Time	Pillai's Trace	0.436	14.710 ^c	1.000	19.000	0.001
	Wilks' Lambda	0.564	14.710 ^c	1.000	19.000	0.001
	Hotelling's Trace	0.774	14.710 ^c	1.000	19.000	0.001
	Roy's Largest Root	0.774	14.710 ^c	1.000	19.000	0.001

a. Tx = A

b. Design: Intercept / Within Subjects Design: time

c. Exact statistic

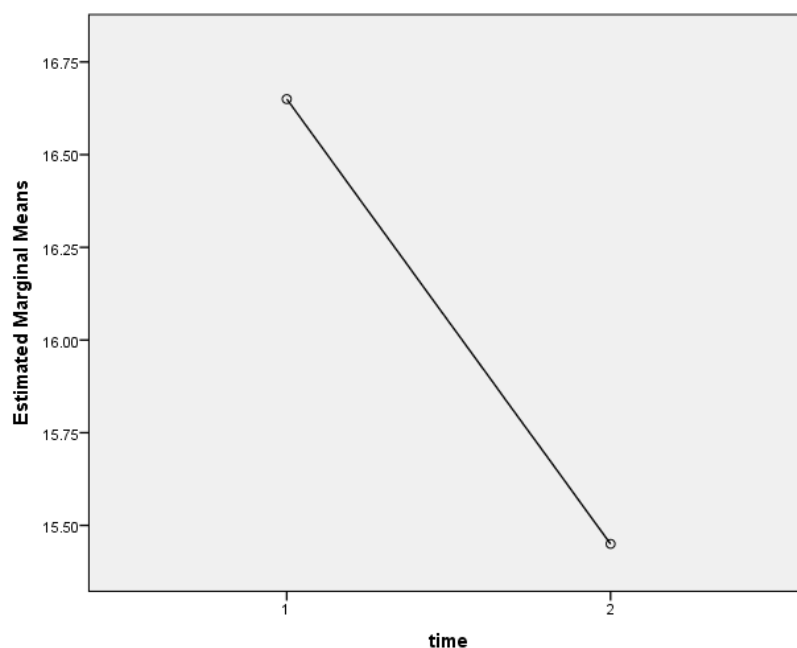


Figure 4.3: FADI readings over two reading points for Group A

It was noted that with regards to the FADI, in Table 4.9 and Figure 4.3, that the participants in the treatment Group A, improved to a statistically significant level ($p=0.000$).

Clinically, the effect could not be determined as no literature benchmark (MCID) could be found in terms of its clinical significance. It is however noted to be unlikely to have achieved significance, as the overall value dropped by about one of sixty possible points.

Nevertheless, the improvement obtained is in line with the functional ability of the participant improving, as reflected in the NRS, thus as participants perceive less pain, they become more functionally active with their activities of daily living (Yeomans, 2000).

4.6.1.2 Objective Findings in Group A

4.6.1.2.1. Group A – Algometer

There was a significant effect of the intervention from the algometer outcome ($p=0.001$).

Table 4.10: Algometer change over time within Group A ($p=0.001$)

Multivariate Tests^{a,b}						
Effect		Value	F	Hypothesis df	Error df	Sig
Time	Pillai's Trace	0.426	14.119 ^c	1.000	19.000	0.001
	Wilks' Lambda	0.574	14.119 ^c	1.000	19.000	0.001
	Hotelling's Trace	0.743	14.119 ^c	1.000	19.000	0.001
	Roy's Largest Root	0.743	14.119 ^c	1.000	19.000	0.001

a. Tx = A

b. Design: Intercept / Within Subjects Design: time

c. Exact statistic

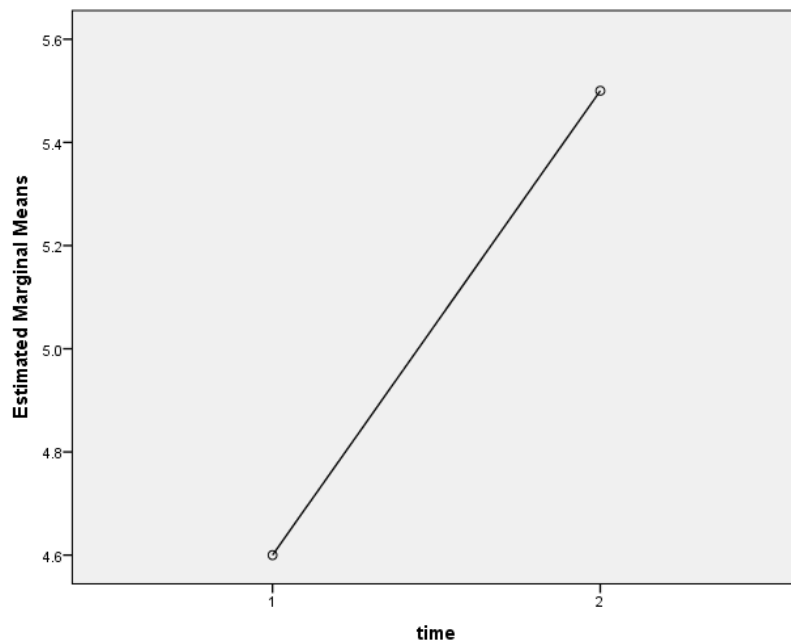


Figure 4.4: Algometer readings over two reading points for Group A

From the above Table 4.10 and Figure 4.4 it becomes evident that in terms of the algometer, it was noted that there was a statistical significance ($p=0.001$). This was coupled with a MCID, which showed a clinical improvement of 0.9. This does not compare favourably with the MCID which Paungmali *et al.*, (2003), Potter *et al.*, (2006) and O'Leary *et al.*, (2007) noted as having to be greater than a 15% change from the baseline reading or as noted by Chesterton *et al.*, (2007) to be greater than 1.77kg/cm².

For this outcome, the algometer was placed in the region of the sinus tarsi, which is an area where oedema accumulates (Reid, 1992 and Subotnick, 1999). Manipulation has been noted by Bergmann *et al.*, (1993) and Bergmann and Peterson (2011) to reduce tissue congestion and increase blood flow, as the mechanics of the joint are restored. The algometer results (reported tenderness) obtained in this study, seem to support these assertions in the literature. Additionally however, it needs to be noted that this reduction in oedema / congestion, is not likely to occur instantaneously (Solomon and Davis, 1987 and Clancy and McVicar, 2002), but rather over time. Therefore, the anticipated improvement of the patient with regards to the effects of the oedema may be slower when compared to the NRS, but consistent with the FADI. This latter possibility is confirmed by the pattern of results discussed up to this point in this study.

4.6.1.2.2 Group A – Dorsiflexion

It was noted that the range of motion – particularly dorsiflexion, recorded a significant change over time within treatment Group A ($p=0.001$).

Table 4.11: Dorsiflexion change over time within Group A ($p=0.001$)

Multivariate Tests ^{a,b}						
Effect		Value	F	Hypothesis df	Error df	Sig
Time	Pillai's Trace	0.448	15.430 ^c	1.000	19.000	0.001
	Wilks' Lambda	0.552	15.430 ^c	1.000	19.000	0.001
	Hotelling's Trace	0.812	15.430 ^c	1.000	19.000	0.001
	Roy's Largest Root	0.812	15.430 ^c	1.000	19.000	0.001

a. Tx = A

b. Design: Intercept / Within Subjects Design: time

c. Exact statistic

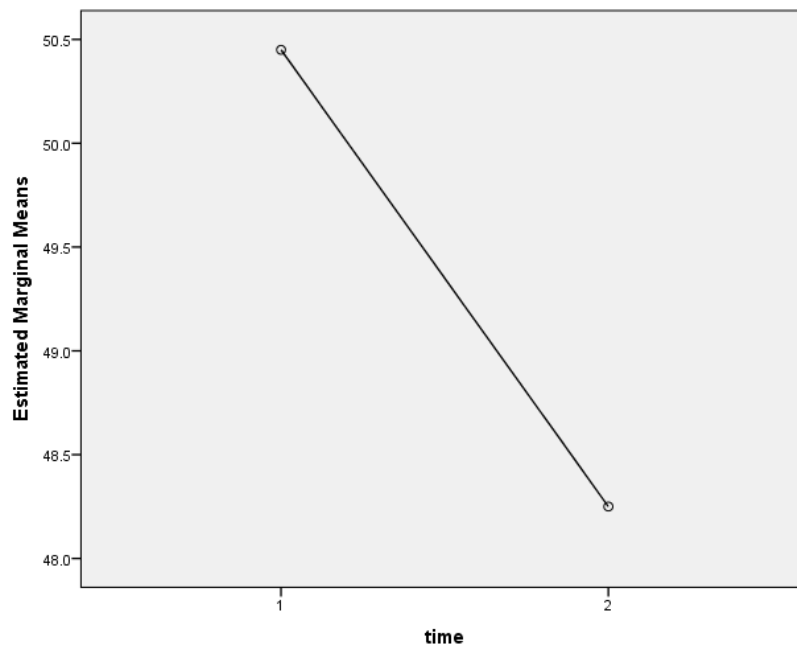


Figure 4.5: Dorsiflexion readings over two reading points for Group A

The above results as indicated in Table 4.11 and Figure 4.5, shows that there was a significant decrease, in the angle measured for dorsiflexion (Appendix P). The decrease in the angle would reflect an increase in the range of motion available after the manual manipulation, which would be a significant reading change over time. No benchmark for comparison could be found for the MCID in terms of improved range of motion.

This concurs with the literature (Schafer and Faye, 1990; Bergmann *et al.*, 1993; Bergmann and Peterson, 2011 and Byfield, 2012), which indicates that manual manipulation has a primary role for improving the range of motion of the manipulated joint (Pellow and Brantingham, 2001; de Souza, 2008 and Hoch and McKeon, 2011). This finding would also assist with the understanding the improved FADI, the decreased NRS readings and the mildly improved algometer scores.

4.6.1.2.3 Group A – BBS

The principle role of the BBS in this study was to measure the effects of the manual manipulation on the proprioception. In this regard it is noted that the BBS improved to a statistically significant extent for the manual manipulation treatment group ($p=0.000$), indicating that the significance falls into the 99% confidence interval ($p<0.01$).

Table 4.12: BBS change over time within Group A ($p<0.001$)

Multivariate Tests^{a,b}						
Effect		Value	F	Hypothesis df	Error df	Sig
Time	Pillai's Trace	0.595	27.874 ^c	1.000	19.000	0.000
	Wilks' Lambda	0.405	27.874 ^c	1.000	19.000	0.000
	Hotelling's Trace	1.467	27.874 ^c	1.000	19.000	0.000
	Roy's Largest Root	1.467	27.874 ^c	1.000	19.000	0.000

a. Tx = A

b. Design: Intercept / Within Subjects Design: time

c. Exact statistic

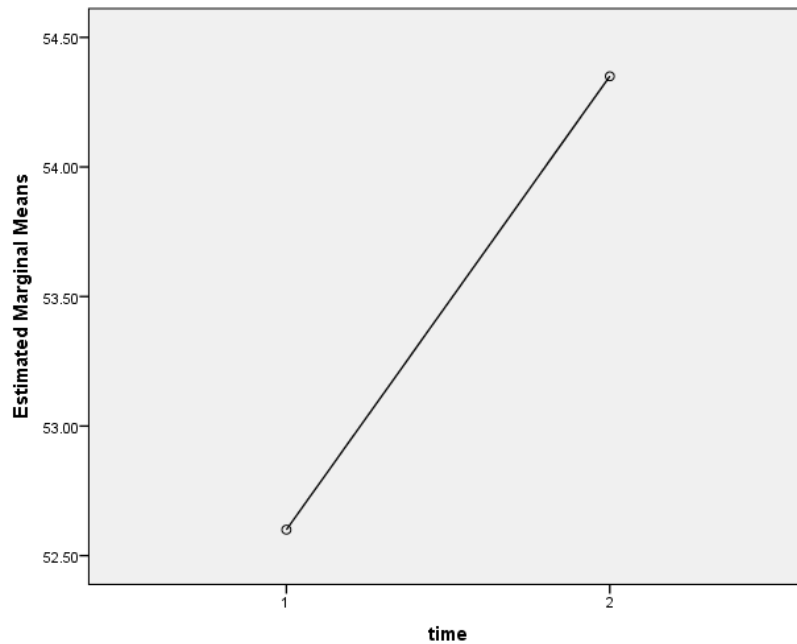


Figure 4.6: BBS readings over two reading points for Group A

Table 4.12 and Figure 4.6, show that there was a significant improvement when read together. This improvement is not mirrored clinically as it could not be determined what the MCID was for the BBS.

Nevertheless, the improvement in this outcome is consistent with the literature (Wyke, 1981 and Leach, 2004), where it is indicated that manual long-axis distraction manipulation by diversified technique has an effect on the mechanoreceptors (Sakamoto *et al.*, 2001 and Hillermann *et al.*, 2006), in particular the proprioceptors (Köhne, 2005). Thus, this change is consistent with the literature outcomes and its suggestions.

Additionally, although noted in this study as a measurement tool, the BBS was not included in the inclusion criteria. Therefore, after having utilised the BBS as a repeated measure of improvement, it has become self evident that a baseline should have been incorporated into the inclusion criteria (viz. 45/56 is accepted in literature), with regards to the BBS.

4.6.2 Objective Two

The Second Objective was to determine the effectiveness of an AAI manipulation, set at full tension (Treatment Group B), to the ankle, on CAIS in terms of subjective and objective findings.

4.6.2.1 Subjective Findings in Group B

4.6.2.1.1 Group B – NRS

Repeated measures ANOVA testing for the treatment Group B showed that there was a significant effect of the intervention over time on NRS ($p=0.000$), indicating that the significance falls into the 99% confidence interval ($p<0.01$).

Table 4.13: NRS change over time within Group B ($p<0.001$)

Multivariate Tests^{a,b}						
Effect		Value	F	Hypothesis df	Error df	Sig
Time	Pillai's Trace	0.681	40.586 ^c	1.000	19.000	0.000
	Wilks' Lambda	0.319	40.586 ^c	1.000	19.000	0.000
	Hotelling's Trace	2.136	40.586 ^c	1.000	19.000	0.000
	Roy's Largest Root	2.136	40.586 ^c	1.000	19.000	0.000

a. Tx = B

b. Design: Intercept / Within Subjects Design: time

c. Exact statistic

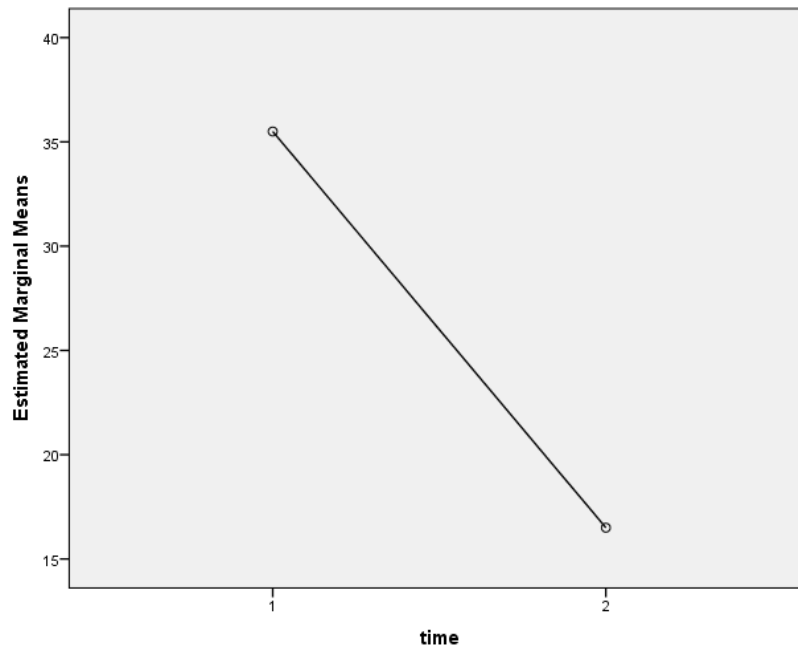


Figure 4.7: NRS readings over two reading points for Group B

The results from Table 4.13 and Figure 4.7, show that there is a statistically significant effect of the treatment over time ($p=0.000$).

These results are not unexpected when reviewing the work of Polkinghorn and Colloca (1999), where they suggest that the AAI is thought to stimulate soft tissue receptors more so than joint receptors (as would be found in manual manipulation (Leach, 2004)). This stimulation is thought to have increased the effects on the affector sensors and facilitate a decrease in perceived pain (Melzack and Wall, 1988). Additionally the stimulation of these soft tissue receptors is thought to be associated with modification of the effector neurons, thereby decreasing muscle spasm. These latter two assertions are supported by the work of Song (2009). From these findings it would thus be possible to expect a concomitant increases in the BBS and algometer readings with a decrease in the FADI and angle of dorsiflexion readings. These will be discussed below.

4.6.2.1.2 Group B - Experience of Treatment

Table 4.14: Experience of Treatment of Group B

^a		Count	Column N %
SETUP	Comfortable	18	90.0
	Uncomfortable	2	10.0
THRUST	Pleasant	15	75.0
	Unpleasant	5	25.0
FEEDBACK	Helpful	19	95.0
	Unhelpful	1	5.0

a. Treatment = Activator Adjustment Instrument Manipulation

From the findings stated in Table 4.14, it can be seen that 95% of the participants in treatment Group B, considered that AAI manipulation was helpful. This is of interest as a larger proportion of the participants in the AAI treatment group improved when questioned about the experience of the AAI treatment. This is not inconsistent with the significant reduction of the pain (as per Section 4.6.2.1.1). It is, however, at odds with the level of improvement in the manual manipulation treatment group. These results therefore need to be interpreted with the following in mind:

- The participants may have responded differently to the application of a novel treatment (Brink, 1996; Hrobjartsson, 1996; Kirsch, 1998 and Mouton, 2006), thereby giving responses on subjective data sheets that did not reflect their clinical reality.
- The participants may have been open to a greater placebo effect in the AAI treatment group, particularly if they were expecting manual manipulation (this would have been similar to results achieved by Dugmore (2006), where she found that the response to the AAI versus placebo were similar for patients with low back pain); and
- Participants in the AAI treatment group were also younger (although not significantly so), but this may have resulted in a different physiological response in terms of healing (viz. quicker), meaning that this treatment group would have portrayed different results (even if they had received manual manipulation). This may be linked to the decreased numbers / likelihood of repeated ankle sprains in the younger treatment group.

4.6.2.1.3 Group B – FADI

The analysis of the FADI, indicated that this outcome measure changed over time to a statistically significant degree ($p=0.000$), irrespective of the analysis type that was used. This indicates that the significance level falls into the 99% confidence interval ($p<0.01$).

Table 4.15: FADI change over time within Group B ($p<0.001$)

Multivariate Tests ^{a,b}						
Effect		Value	F	Hypothesis df	Error df	Sig
Time	Pillai's Trace	0.515	20.148 ^c	1.000	19.000	0.000
	Wilks' Lambda	0.485	20.148 ^c	1.000	19.000	0.000
	Hotelling's Trace	1.060	20.148 ^c	1.000	19.000	0.000
	Roy's Largest Root	1.060	20.148 ^c	1.000	19.000	0.000

a. Tx = B

b. Design: Intercept / Within Subjects Design: time

c. Exact statistic

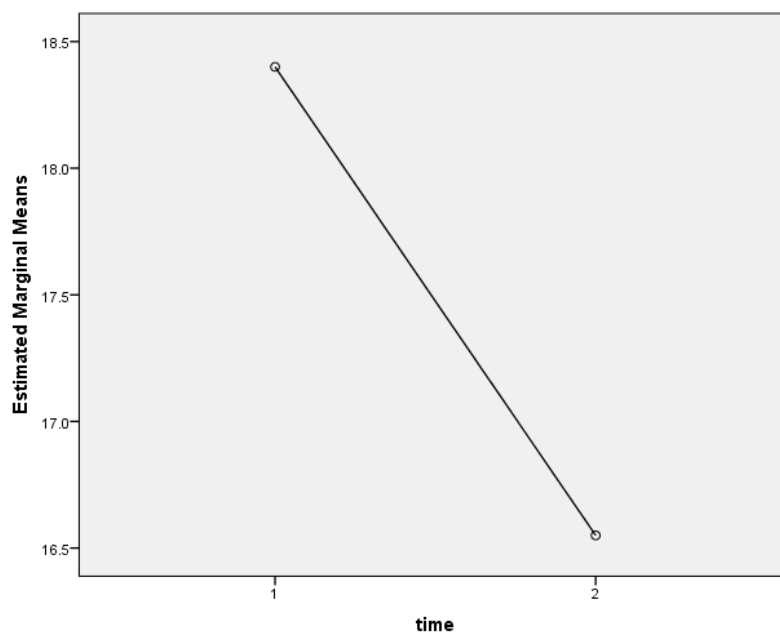


Figure 4.8: FADI readings over two reading points for Group B

It was noted that in congruence with the decrease in the NRS scores (Table 4.13) and the experience of the participants (Table 4.14), that their general foot and ankle disability scores decreased significantly over the intervention time period. This decrease in the FADI may be linked to the perceived decrease in pain through actual or perceived benefit from the AAI (Dugmore, 2006 and Richardson, 2007). It would

be of interest to compare the FADI and NRS outcomes to that of the actual increases in dorsiflexion range of motion as this finding would relate more specifically to the improved joint function as opposed to simply neurological changes that are associated with the use of the AAI (Polkinghorn and Colloca, 1999 and Song, 1999).

4.6.2.2 Objective Findings in Group B

4.6.2.2.1. Group B – Algometer

There was a significant effect of the intervention for algometer outcome ($p=0.001$).

Table 4.16: Algometer change over time within Group B ($p=0.001$)

Multivariate Tests ^{a,b}						
Effect		Value	F	Hypothesis df	Error df	Sig
Time	Pillai's Trace	0.426	14.119 ^c	1.000	19.000	0.001
	Wilks' Lambda	0.574	14.119 ^c	1.000	19.000	0.001
	Hotelling's Trace	0.743	14.119 ^c	1.000	19.000	0.001
	Roy's Largest Root	0.743	14.119 ^c	1.000	19.000	0.001

a. Tx = B

b. Design: Intercept / Within Subjects Design: time

c. Exact statistic

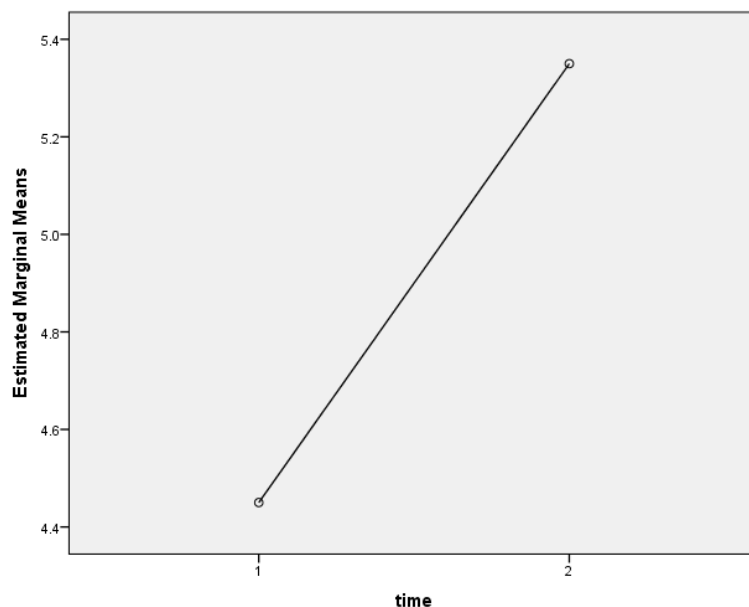


Figure 4.9: Algometer readings over two reading points for Group B

The algometer was placed in the region of the sinus tarsi, which is an area where oedema accumulates (Reid, 1992 and Subotnick, 1999). The significant changes over time would concur with the suggestion by Polkinghorn and Colloca (1999) where they indicated that the effect of the AAI was principally on the soft tissues at the point of application. This effect is likely to result in decreased tenderness and therefore increased algometer measures. This is also true in the context of the Gate Control (Melzack and Wall, 1965 and Melzack and Wall, 1988) and the integrated pain theories as discussed by Leach (2004) and Chaitow and DeLany (2000).

4.6.2.2.2 Group B – Dorsiflexion

It was noted that the range of motion – particularly dorsiflexion, recorded a significant change over time within treatment Group A ($p=0.000$), indicating that the significance falls into the 99% confidence interval ($p<0.01$).

Table 4.17: Dorsiflexion change over time within Group B ($p<0.001$)

Multivariate Tests^{a,b}						
Effect		Value	F	Hypothesis df	Error df	Sig
Time	Pillai's Trace	0.489	18.191 ^c	1.000	19.000	0.000
	Wilks' Lambda	0.511	18.191 ^c	1.000	19.000	0.000
	Hotelling's Trace	0.957	18.191 ^c	1.000	19.000	0.000
	Roy's Largest Root	0.957	18.191 ^c	1.000	19.000	0.000

a. Tx = B

b. Design: Intercept / Within Subjects Design: time

c. Exact statistic

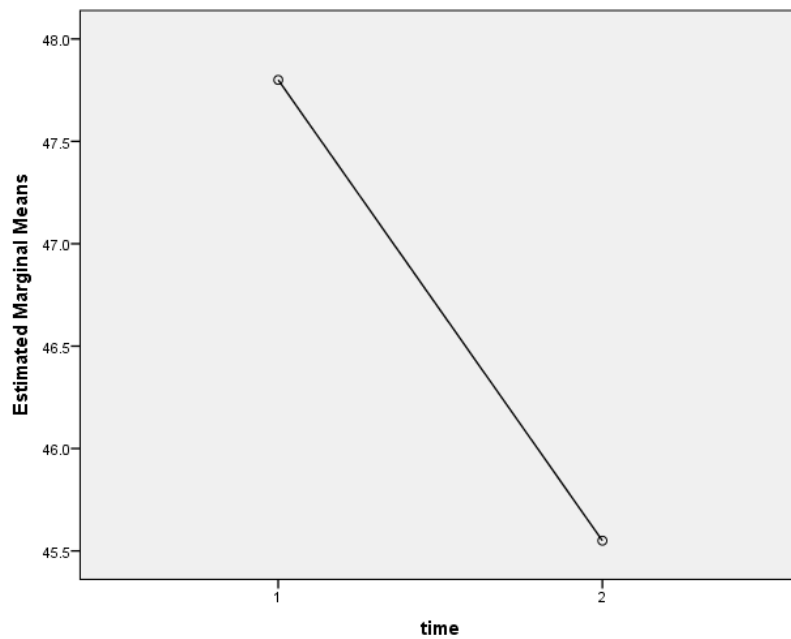


Figure 4.10: Dorsiflexion readings over two reading points for Group B

It is noted that there is a significant decrease in the angle representing the degree of approximation of the shin (tibia) to the dorsum of the foot. This indicates that the participants increased their dorsiflexion range significantly over time. This may be a secondary result of the neurological changes that have been linked to the application of the AAI (Polkinghorn and Colloca, 1999; Fuhr, 2009 and Song, 2009). However, the actual effect of imparting a force into the talocrural joint through the mechanics of the AAI cannot be excluded and this would need to be compared to the manual manipulation to see the relative effect size.

4.6.2.2.3 Group B – BBS

The principle role of the BBS in this study was to measure the effects of the manual manipulation on the proprioception ability of the participant. In this regard, it is noted that the BBS improved to a statistically significant extent for the manual manipulation treatment group ($p=0.000$), indicating that the significance falls into the 99% confidence interval ($p<0.01$).

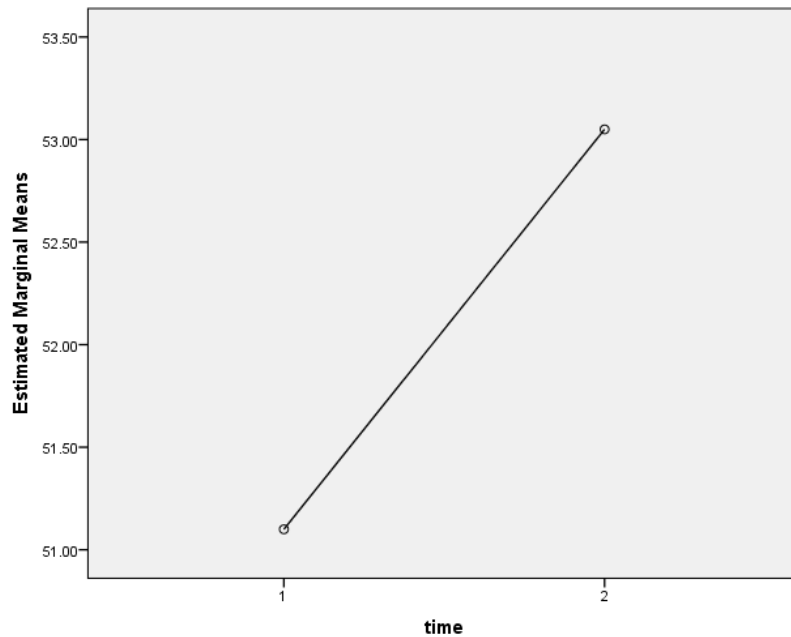
Table 4.18: BBS change over time within Group B ($p < 0.001$)

Multivariate Tests ^{a,b}						
Effect		Value	F	Hypothesis df	Error df	Sig
Time	Pillai's Trace	0.608	29.519 ^c	1.000	19.000	0.000
	Wilks' Lambda	0.392	29.519 ^c	1.000	19.000	0.000
	Hotelling's Trace	1.554	29.519 ^c	1.000	19.000	0.000
	Roy's Largest Root	1.554	29.519 ^c	1.000	19.000	0.000

a. Tx = B

b. Design: Intercept / Within Subjects Design: time

c. Exact statistic

**Figure 4.11: BBS readings over two reading points for Group B**

When considering the emphasis on the neurological stimulation that the AAI is thought to provide, it is not difficult to draw a link with the effect on changes within the proprioception that is intricately linked to the neurological feedback loops (Cramer and Darby, 1995; Clancy and McVicar, 2002 and Leach, 2004). It is however not possible to categorically state that the effect is of a neurological origin and joint separation may also be affected by the AAI and therefore the changes in the biomechanical function of the joint may also have a contribution to the development of both movement and neurological changes with its clinical sequelae (viz. proprioception).

Collectively, the above results attained for the AAI treatment group, may also be linked to the approximation of the “natural resonance of the body” and the dynamic

mechanical stimulus (AAI), which when imparted into the body is able to achieve greater and more clinically effective results at a lesser force magnitude than the use of manual manipulation (Fuhr and Menke, 2005). Based on this latter assertion, Maigne and Guillon (2000), Herzog *et al.*, (2001) and Cramer *et al.*, (2002) found in their respective spinal studies (comparing manual manipulation to the AAI), that similar levels of movement and clinical change were possible when comparing these techniques.

4.7 Results and Discussion of Inter-Group Analyses

4.7.3 Objective Three

The Third Objective was to determine whether there were any differences between the manual long-axis distraction manipulation by diversified technique and the AAI interventions to the ankle, on CAIS in terms of the noted subjective and objective findings.

4.7.3.1 Subjective Findings in Comparison

4.7.3.1.1 Comparison – NRS

There were no significant differences between the treatment effects of the two treatment groups ($p=0.316$).

Table 4.19: NRS comparison between the two treatment groups ($p=0.316$)

Multivariate Tests^a						
Effect		Value	F	Hypothesis df	Error df	Sig
Time * Tx	Pillai's Trace	0.026	1.034 ^b	1.000	38.000	0.316
	Wilks' Lambda	0.974	1.034 ^b	1.000	38.000	0.316
	Hotelling's Trace	0.027	1.034 ^b	1.000	38.000	0.316
	Roy's Largest Root	0.027	1.034 ^b	1.000	38.000	0.316

a. Design: Intercept + Tx / Within Subjects Design: time

b. Exact statistic

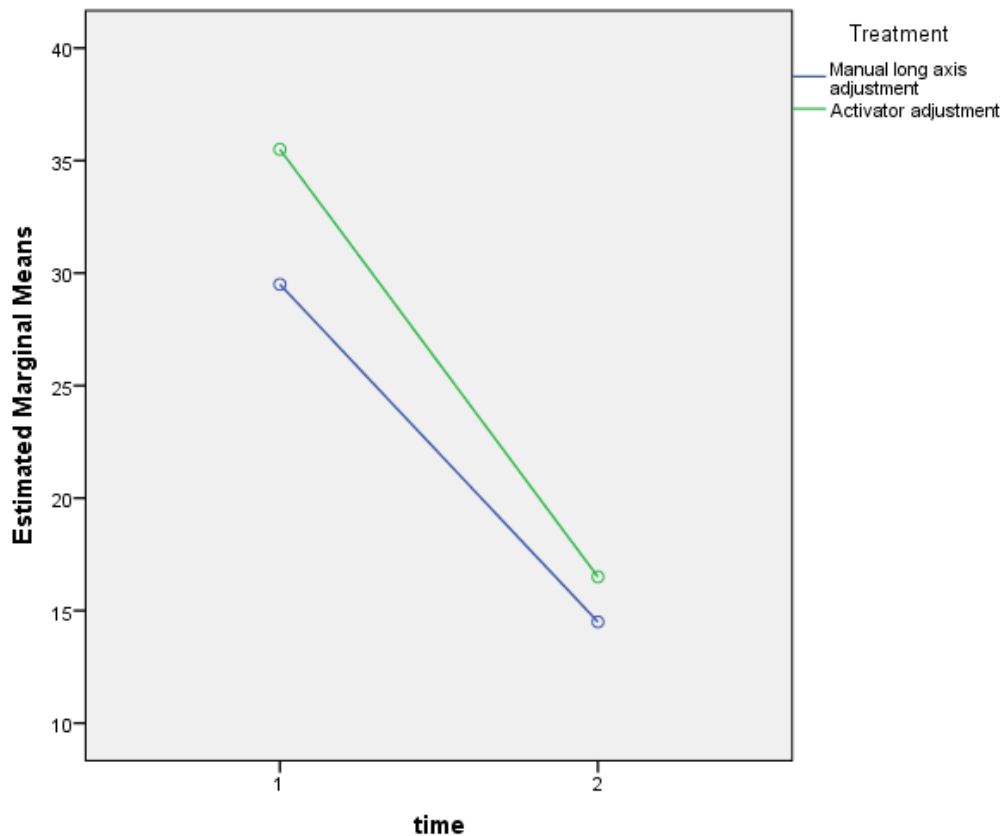


Figure 4.12: NRS comparison between the two groups

Although the p -value for both treatment groups were found to be 0.000, on examination of Figure 4.12, it becomes apparent that treatment Group B had a slightly steeper curve of improvement with regards to NRS readings. There are several possible reasons for this small but apparent finding. The manual long-axis distraction manipulation by diversified technique being a distraction force with soft pliable contact would have a greater effect on bone movement and possible joint separation. Thus there is an increased stimulation of more mechanoreceptors than in the AAI treatment group (Sakamoto *et al.*, 2001) along with a mechanical joint effect with the restoration of movement (Bergmann *et al.*, 1993 and Bergmann and Peterson, 2011). In treatment Group B, where the AAI was applied, there was more of a momentary compressive effect followed by pulsed resonance. This vibratory effect will stimulate the neurological receptors resulting in a decrease in pain prior to a secondary increase in ROM as the tissues relax and spasms cease. However, this latter effect is not coupled with a significant change in the joint motion, and therefore, the synergistic effect as found in the manual manipulation treatment group is decreased.

Another aspect that should be considered is the effect of the two treatment methods on the actual oedema. Theoretically, a compressive force should have a more preferred effect on swelling and tenderness, (the process of applying ischemic compression, usually results in a decrease in perceived pain and tenderness (Travell and Simons, 1983 and Chaitow and DeLany, 2000), particularly in soft tissue structures such as muscle or fascia (Travell and Simons, 1983; Chaitow and DeLany, 2000 and Sahrmann, 2002) which is the precise effect of the AAI (Fuhr, 2009). This is in contrast to the manual long-axis distraction manipulation by diversified technique which does not promote compression. However, the results would suggest that the opposite is true in that oedema decreases (along with reported pain) to a “steeper” extent on Figure 4.12 for the manual manipulation treatment group, indicating that the compressive force from holding the ankle is more effective than the momentary compressive impulse from the AAI in its effect on edema. It should, therefore, be considered that future studies assess the effect of compressive / distractive forces on the presence / reduction of oedema. Additionally, the effect of increased range of motion and biomechanical normalcy and its relationship to oedema should be investigated.

However, due consideration of the physiological effect of the manual manipulation may also render a reason for their decreased improvement on the FADI (less steep line on Figure 4.12). Manual manipulation by virtue of its distractive force, may result in the breaking of adhesions (Leach, 2004), which makes it likely that the intervention (unlike the AAI) may result in increased oedema in the short term. This would facilitate a slower improvement over time for this treatment group when compared to the AAI treatment group. Longer term follow-ups would however be necessary to confirm this possibility.

Further to the above, the chronicity of the CAIS should be taken into account. This was discussed with the age of the participants (see Section 4.6.2.1.2). Following the principle of taking less time to treat an “younger” / subacute condition as opposed to an “older” chronic condition, it logically follows that the longer the person has had the condition, the more recalcitrant the condition to improvement with care.

In terms of the MCID for each of the intervention groups, neither of the treatment groups was able to achieve a significant change in their clinical presentations after only one intervention.

4.7.3.1.2 Comparison - Experience of Treatment

No significant difference between the treatment effects of the two treatment groups was recorded.

Table 4.20: Experience of Treatment comparison between the two groups

		Manual Manipulation (A)		AAI Manipulation (B)		p -value
		Count	Column N %	Count	Column N %	
SETUP	Comfortable	16	80.0	18	90.0	0.376
	Uncomfortable	4	20.0	2	10.0	
THRUST	Pleasant	14	70.0	15	75.0	0.723
	Unpleasant	6	30.0	5	25.0	
FEEDBACK	Helpful	15	75.0	19	95.0	0.182
	Unhelpful	5	25.0	1	5.0	

Although there were no significant changes noted between the treatment groups, it is seen that there is a trend for greater satisfaction with the intervention as indicated by the AAI treatment group. This has some important implications when reading the results:

- The participants may have responded differently to the application of a novel treatment (Brink, 1996; Hrobjartsson, 1996; Kirsch, 1998 and Mouton, 2006) and therefore may have been open to a greater placebo effect in the AAI treatment group (Dugmore, 2006). Therefore, it is suggested that future research test the AAI against a placebo AAI (set to zero tension).
- Participants in the AAI treatment group were also younger (although not significantly so), but this may have resulted in a different physiological response in terms of healing (viz. quicker), meaning that this treatment group would have portrayed different results (even if they had received manual manipulation). This may be linked to the decreased numbers / likelihood of repeated ankle sprains in the younger treatment group.

In future research it would be interesting to note how many participants (especially those who fell in the AAI treatment group) had previous experience with AAI and to consider the possible effect this could have had on their experience of the treatment.

4.7.3.1.2 Comparison – FADI

No significant difference between the treatment effects of the two treatment groups ($p=0.217$).

Table 4.21: FADI comparison between the two groups ($p=0.217$)

Multivariate Tests ^a						
Effect		Value	F	Hypothesis df	Error df	Sig
Time * Tx	Pillai's Trace	0.040	1.578 ^b	1.000	38.000	0.217
	Wilks' Lambda	0.960	1.578 ^b	1.000	38.000	0.217
	Hotelling's Trace	0.042	1.578 ^b	1.000	38.000	0.217
	Roy's Largest Root	0.042	1.578 ^b	1.000	38.000	0.217

a. Design: Intercept + Tx / Within Subjects Design: time

b. Exact statistic

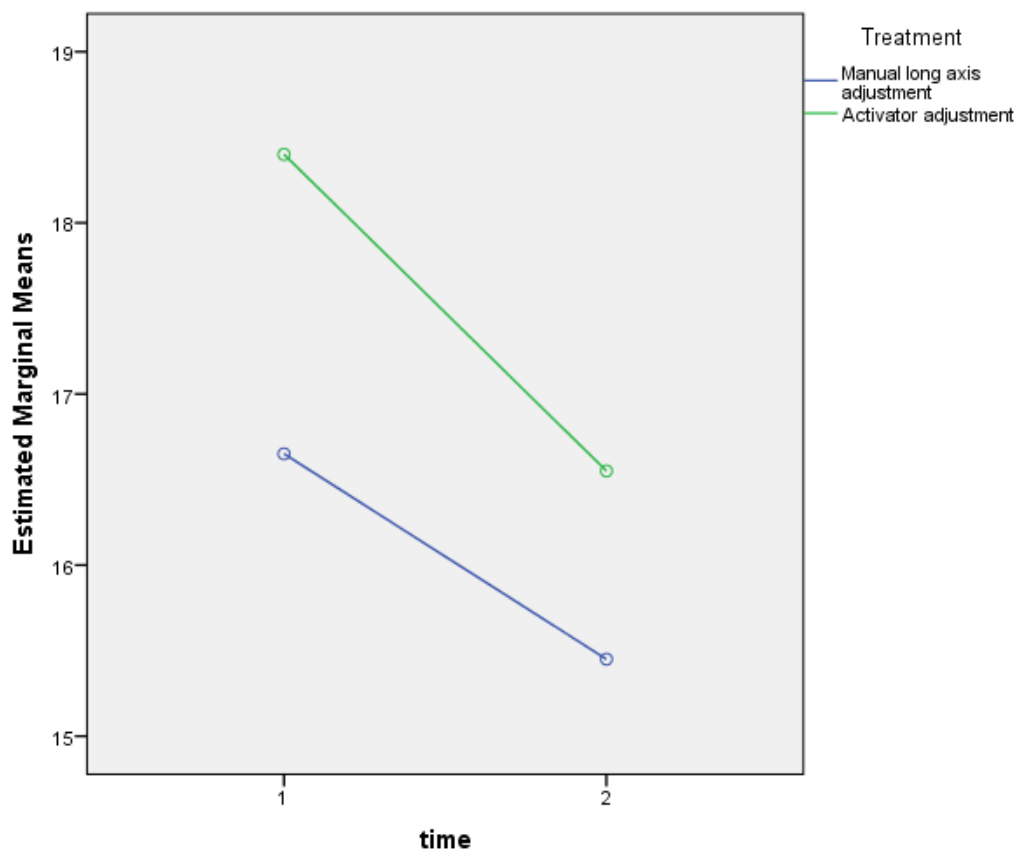


Figure 4.13: FADI comparison between the two groups

Once again, as with the NRS, the findings in Figure 4.13 in terms of FADI in the two treatment groups were similar, with treatment Group B showing a slightly steeper curve. It is difficult to determine whether the improvement in the FADI readings was as a result of increased ROM (Fuhr, 2009) or because of decreased experience of pain (Melzack and Wall, 1988) or as a result of perceptual improvement related to Hawthorne or related effects (Brink, 1996; Hrobjartsson, 1996; Kirsch, 1998 and Mouton, 2006). However, in the context of the statement that “principally disability is precipitated by the perception of pain, in that pain limits a participant’s ability to complete tasks of daily living” (Yeomans, 2000), it is possible that the latter suggestions are most likely reflected in the results of the FADI.

However, due consideration of the physiological effect of the manual manipulation may also render a reason for their decreased improvement on the FADI (less of a steep line on Figure 4.13). Manual manipulation by virtue of its distractive force, may result in the breaking of adhesions (Leach, 2004), which makes it likely that the intervention (unlike the AAI) may result in increased oedema in the short term. This would facilitate a slower improvement over time for this treatment group when compared to the AAI treatment group. Longer terms follow-ups would however be necessary to confirm this possibility.

In terms of clinical significance, it was noted that there were no clinical significances obtained in either treatment group.

4.7.3.2 Objective Findings in Comparison

4.7.3.2.1. Comparison – Algometer

No significant difference between the treatment effects of the two treatment groups ($p=1.000$).

Table 4.22: Algometer comparison between the two groups ($p=1.000$)

Multivariate Tests ^a						
Effect		Value	F	Hypothesis df	Error df	Sig
Time * Tx	Pillai's Trace	0.000	0.000 ^b	1.000	38.000	1.000
	Wilks' Lambda	1.000	0.000 ^b	1.000	38.000	1.000
	Hotelling's Trace	0.000	0.000 ^b	1.000	38.000	1.000
	Roy's Largest Root	0.000	0.000 ^b	1.000	38.000	1.000

a. Design: Intercept + Tx / Within Subjects Design: time

b. Exact statistic

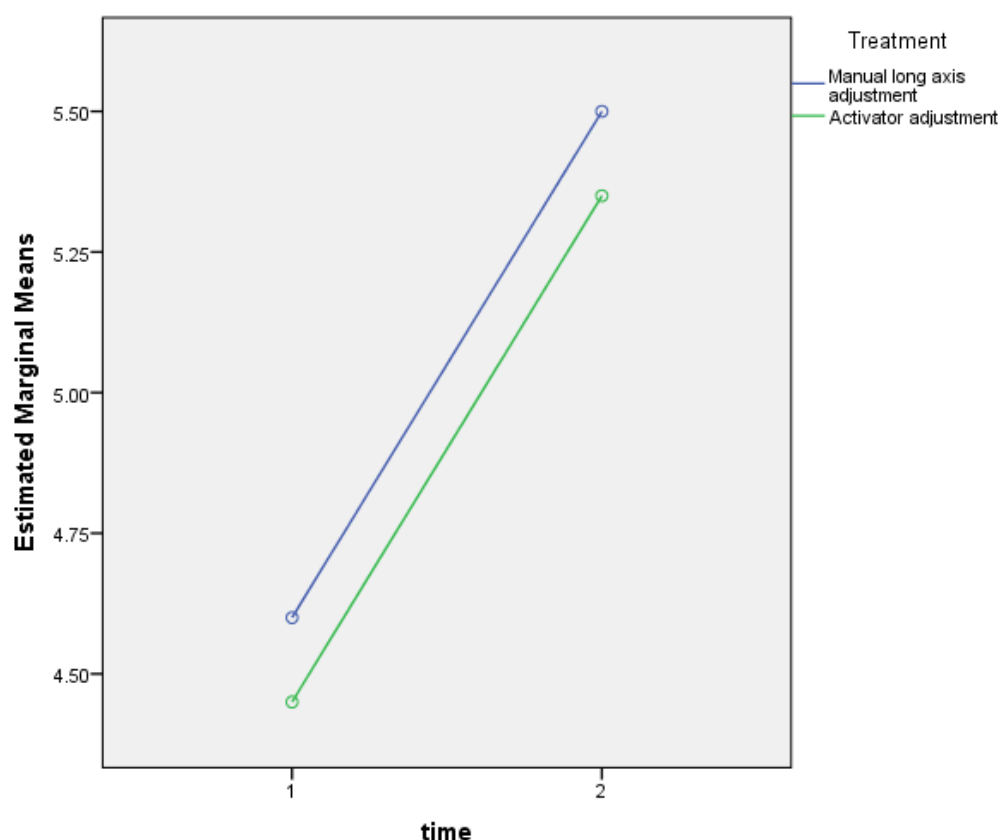


Figure 4.14: Algometer comparison between the two groups

Figure 4.14 clearly shows a more proportional improvement in terms of the algometer readings. This contrasts with the discussions related to the NRS (see

Section 4.6.1.1.1 for the manual manipulation and Section 4.6.2.1.1 for the AAI treatment group) and the FADI (see Section 4.6.1.1.3 for the manual manipulation and Section 4.6.2.1.3 for the AAI treatment group); in that both treatment interventions are of benefit, without one gradient being steeper than another. The difference may be accounted for by the fact that the placement of the algometer was on the sinus tarsi over the region of the ATFL or slightly anterior to this. Although the ATFL may be involved in many of the injuries in the progression to the development of CAIS, it may not have been the most appropriate placement for the algometer in terms of measuring oedema resolution (which were recorded in the NRS gradient changes and the FADI gradient changes).

In terms of clinical significance, no clinical significance was attained by either treatment group after one intervention when applying the criteria as set out by Paungmali *et al.*, (2003), Potter *et al.*, (2006), Chesterton *et al.*, (2007) and O'Leary *et al.*, (2007) (see Section 3.7.2.1).

4.7.3.2.2 Comparison – Dorsiflexion

There were also no significant difference between the treatment effects of the two treatment groups ($p=0.949$).

Table 4.23: Dorsiflexion comparison between the two groups ($p=0.949$)

Multivariate Tests^a						
Effect		Value	F	Hypothesis df	Error df	Sig
Time * Tx	Pillai's Trace	0.000	0.004 ^b	1.000	38.000	0.949
	Wilks' Lambda	1.000	0.004 ^b	1.000	38.000	0.949
	Hotelling's Trace	0.000	0.004 ^b	1.000	38.000	0.949
	Roy's Largest Root	0.000	0.004 ^b	1.000	38.000	0.949

a. Design: Intercept + Tx / Within Subjects Design: time

b. Exact statistic

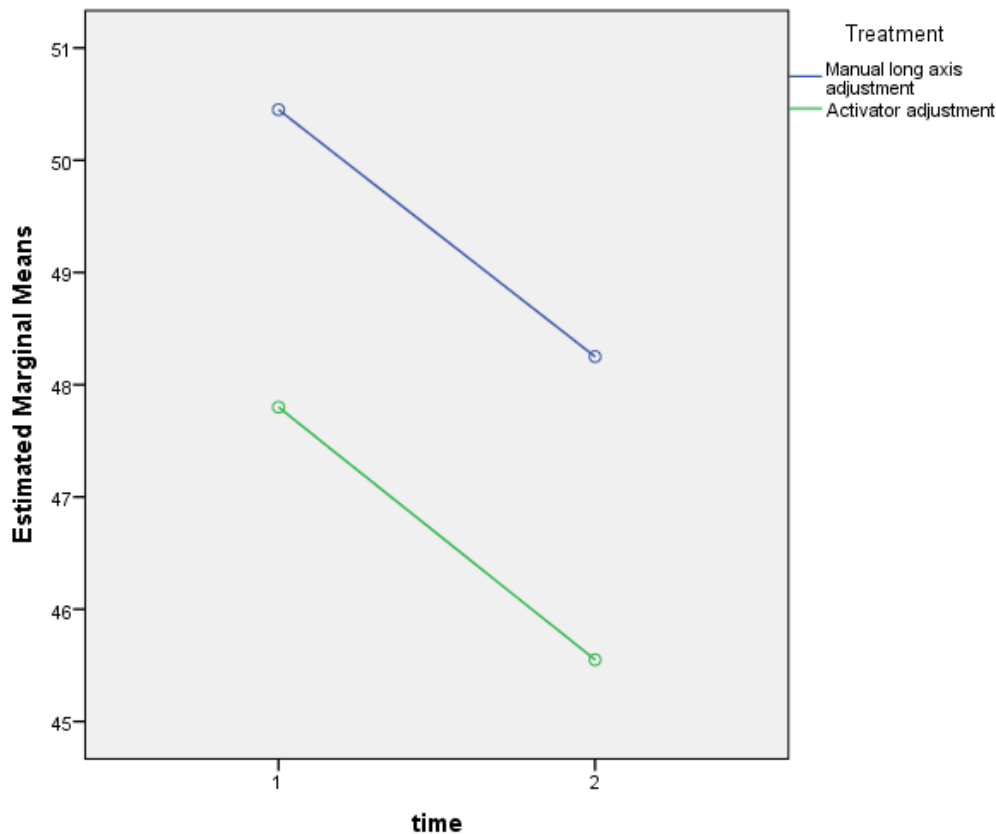


Figure 4.15: Dorsiflexion comparison between the two groups

In terms of the dorsiflexion range of motion it can be seen that it follows the same principles as discussed in Section 4.7.3.2.1. Also, in terms of the clinical significance, neither treatment group attained clinical significance after one intervention.

4.7.3.2.3 Comparison – BBS

No significant difference between the treatment effects of the two treatment groups were found ($p=0.685$).

Table 4.24: BBS comparison between the two groups ($p=0.685$)

Multivariate Tests ^a						
Effect		Value	F	Hypothesis df	Error df	Sig
Time * Tx	Pillai's Trace	0.004	0.168 ^b	1.000	38.000	0.685
	Wilks' Lambda	0.996	0.168 ^b	1.000	38.000	0.685
	Hotelling's Trace	0.004	0.168 ^b	1.000	38.000	0.685
	Roy's Largest Root	0.004	0.168 ^b	1.000	38.000	0.685

a. Design: Intercept + Tx / Within Subjects Design: time

b. Exact statistic

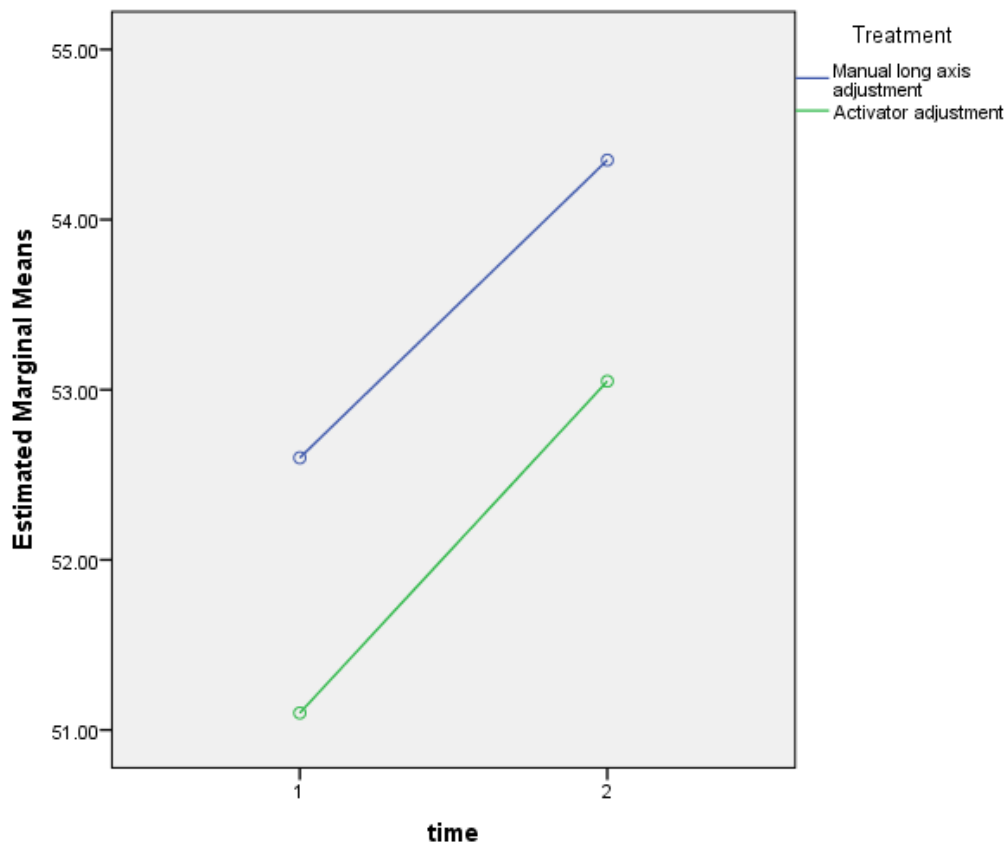


Figure 4.16: BBS comparison between the two groups

In terms of the BBS it can be seen that it follows the same principles as discussed in Section 4.7.3.2.1 and Section 4.7.3.2.2. In terms of the clinical significance, this could not be calculated as no literature / published norm exists in order to determine the improvement of the participants in this study to the published norm.

4.8 Discussion of Inter-Group Analyses

Baseline evaluation of all outcome measures revealed that there was no statistically significant difference between the two groups at baseline, therefore any difference between the groups would either be related to natural history (time) or the intervention. Table 4.25 outlines the overall findings of the study.

Table 4.25: Overall Outcomes

	Manual Manipulation		AAI Manipulation		Gradient comparison in related figures
	Outcome	MCID	Outcome	MCID	
NRS	Significant	Not attained	Significant	Not attained	Favourable and thus steeper gradient (AAI)
FADI	Significant	-	Significant	-	Favourable and thus steeper gradient (AAI)
Algometer	Significant	Not attained	Significant	Not attained	Parallel
Dorsiflexion	Significant	Not attained	Significant	Not attained	Parallel
BBS	Significant	-	Significant	-	Parallel

From the Overall Outcomes Table 4.25, it can be seen that both the treatment groups improved equitably from pre- to post- applied manipulation in terms of the objective findings in this study (algometer, dorsiflexion range of motion and Berg Balance Scale). By contrast, the subjective findings (FADI and NRS) reflected similar trends. These summarised outcomes seem to suggest that from a neurological and biomechanical vantage point, that the two interventions are equally effective after one intervention session, but not to the point of attaining clinical significance (at least for those measures where such parameters exist).

There does however seem to be an “Observer”, Hawthorne or other such effect (Brink, 1996; Hrobjartsson, 1996 and Mouton, 2006) that presents itself within the outcomes of the subjective findings as it is consistently seen that there is a tendency for the perception of improved outcomes for the AAI treatment group. It cannot however be discarded that the effects of manual manipulation result in the distraction and damage of adhesions or other soft tissue structures which resulted in decreased subjective improvement in patients. The objective outcomes in this study did not measure oedema so the effects of reactive oedema cannot be commented on. Thus it is suggested that future research consider measuring this outcome with the “figure of 8” measure for ankle swelling (Tatro-Adams *et al.*, 1995 and Parker, 2005), in order to test this suggested effect.

4.9 Correlation Tables per Intervention Group:

Correlation tables (Tables 4.26 and 4.27) as outlined below indicate whether there is any significant relationship between any of the outcome measures within any of the treatment groups in the study.

Table 4.26: Correlations^a Manual Manipulation Group A

		Change in NRS	Change in FADI	Change in algometer	Change in dorsiflexion	Change in BBS
Change in NRS	Pearson Correlation	1	0.230	-.214	-.165	-.077
	Sig (2-tailed)		0.330	0.365	0.487	0.746
	N	20	20	20	20	20
Change in FADI	Pearson Correlation	0.230	1	0.162	-.057	-.558*
	Sig (2-tailed)	0.330		0.496	0.811	0.011
	N	20	20	20	20	20
Change in algometer	Pearson Correlation	-.214	0.162	1	0.031	-.149
	Sig (2-tailed)	0.365	0.496		0.895	0.530
	N	20	20	20	20	20
Change in dorsiflexion	Pearson Correlation	-.165	-.057	0.031	1	-.383
	Sig (2-tailed)	0.487	.811	0.895		0.096
	N	20	20	20	20	20
Change in BBS	Pearson Correlation	-.077	-.558*	-.149	-.383	1
	Sig (2-tailed)	0.746	0.011	0.530	0.096	
	N	20	20	20	20	20

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

a. Treatment = Manual Long-Axis Manipulation

Bold indicates significant and strong correlations

From Table 4.26, it can be seen that in the manual manipulation treatment group, that a significant and strong relationship exists between the changes in the BBS (Kornetti *et al.*, 2004) and the FADI (Hale and Hertel, 2005 and Martin and Irrgang, 2007). This is an expected correlation in that these measures, although one subjective and the other objective reflect changes in functional ability (Yeomans, 2000).

The lack of a relationship between the improvement in the range of motion and the NRS, FADI and BBS may attest to the suggested hypothesis of reactive oedema in

participants that underwent the manual manipulation, in that it would have obscured the relationship between these factors and thus rendered them insignificant.

Table 4.27: Correlations^a AAI Manipulation Group B

		Change in NRS	Change in FADI	Change in algometer	Change in dorsiflexion	Change in BBS
Change in NRS	Pearson Correlation	1	0.208	-.472*	0.008	-.293
	Sig (2-tailed)		0.380	0.036	0.972	0.211
	N	20	20	20	20	20
Change in FADI	Pearson Correlation	0.208	1	-.419	-.088	-.104
	Sig (2-tailed)	0.380		0.066	0.713	0.662
	N	20	20	20	20	20
Change in algometer	Pearson Correlation	-.472*	-.419	1	-.031	0.089
	Sig (2-tailed)	0.036	0.066		0.896	0.710
	N	20	20	20	20	20
Change in dorsiflexion	Pearson Correlation	0.008	-.088	-.031	1	-.059
	Sig (2-tailed)	0.972	0.713	0.896		0.805
	N	20	20	20	20	20
Change in BBS	Pearson Correlation	-.293	-.104	0.089	-.059	1
	Sig (2-tailed)	0.211	0.662	0.710	0.805	
	N	20	20	20	20	20

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

a. Treatment = Activator Manipulation

Bold indicates significant and strong correlations

From Table 4.26, it can be seen that in the AAI treatment group, that a significant and strong relationship exists between the changes in the algometer and the NRS (Bolton and Wilkinson, 1998; Lee *et al.*, 2003 and Ostelo and de Vet, 2005).

The outcomes of the correlation Tables 4.26 and 4.27, when compared seem to suggest that the manual manipulation has a greater effect on the outcomes of functional ability, whereas the AAI treatment group has a greater effect on pain reduction. Therefore, it would be necessary for future studies to consider different assessment methods for clinical improvement to find a common ground for the evaluation of these two techniques, such that they could be compared more equitably in terms of their physiological and thus clinical effects. A study such as this may have drawn the inference of a placebo effect, if it were not for the strength of the correlations presented at the end of this chapter / in Chapter Five.

4.10 Review of the Objectives and Hypotheses

The objectives as noted in Chapter One were as follows:

- Objective One:** The First Objective is to determine the effectiveness of a manual long-axis distraction manipulation by diversified technique (treatment Group A) to the ankle, on CAIS in terms of subjective and objective findings.
- Objective Two:** The Second Objective is to determine the effectiveness of an AAI manipulation, set at full tension (treatment Group B), to the ankle, on CAIS in terms of subjective and objective findings.
- Objective Three:** The Third Objective is to determine whether there are any differences between the manual long-axis distraction manipulation by diversified technique and the AAI interventions to the ankle, on CAIS in terms of the noted subjective and objective findings.

Based on these three objectives, the Null Hypothesis indicated there would be no significant difference between the manual long-axis distraction manipulation by diversified technique and the AAI manipulation treatment groups in terms of the subjective and objective findings in this study.

4.11 Summary and Conclusion

This chapter presented the findings of the study that was structured on the methodology presented in Chapter Three. Additionally, the chapter also presented the discussion of these findings and their contextualisation in the literature. The outcome of this chapter revealed that the Null Hypothesis, as stated and based on the results reviewed in this chapter, was accepted indicating that there was no significant difference between the single AAI and manual manipulation interventions in participants that met the inclusion criteria for CAIS.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The primary goal of any clinical trial is to evaluate the potential beneficial effect of a therapy. Statistically significant results are necessary but not sufficient to show a difference in effect between the two study groups. The clinical importance of the effect must also be demonstrated to make the results of the trial relevant to patient care (Farrar *et al.*, 2001). This chapter will summarise the outcome of this study.

5.2 Conclusion

With the high prevalence of ankle sprains and the resultant high rate of non-resolution of the signs and symptoms related to ankle sprains (known as CAIS), this study aimed to determine the effect of a single intervention by two different manipulative techniques to determine the effect of these techniques on the clinical resolution of CAIS. It was anticipated through the Null Hypothesis that the treatment groups would fare equally well with no significant difference. The Null Hypothesis was tested utilising two treatment groups of 20 participants that underwent a clinical assessment for inclusion into the study before being randomly allocated to one of either the AAI treatment group or the manual manipulation treatment group. The treatment groups each received one intervention with measurements taken prior to and at 24 hours after the intervention. The outcome measures included the NRS, FADI, Algometer, BBS and the dorsiflexion range of motion of the ankle (talocrural joint).

Both groups improved significantly, statistically, on all outcome measures taken, with neither surpassing the other. It was noted that there was a trend reflected in the inter-group comparisons with parallel improvements in the Algometer, BBS and the dorsiflexion range of motion (objective measures) and non-parallel improvements in

the NRS and FADI. This suggested a trend towards a subjective improvement in the AAI treatment group, which may have been influenced by the novelty of the AAI.

When assessing the correlation tables for each of the treatment groups, the significant and strong correlations seemed to suggest that the clinical outcomes within the manual manipulation treatment group was related to a strong relationship between the functional activity measures, whereas the AAI treatment group reflected a strong relationship between the pain outcomes. It is therefore suggested that there may be differences in the physiological effects of these interventions and that common clinical outcomes should be utilised to more equitably compare the treatment groups.

5.3 Recommendations

The recommendations stem from the presentation and discussion of the results in the previous chapter and reflect, in part, the limitations of this study, but also make recommendations based on the outcomes obtained in this study.

5.3.1 Methodological (Based on Study Limitations)

Based on the discussions above, it is therefore suggested that future studies need to consider the following:

- Ensure that the treatment groups are more equitable / homogenous (see 5.3.2) and that the study sample is closer to the baseline characteristics of the general population.
- Consider the comparison of the AAI instrument against placebo.
- Detail the possible effect of age on the resolution of joint dysfunction as associated with CAIS.
- Use as an inclusion criteria (point or period prevalence), the number of prior ankle sprains that the patients reported within a specific time period prior to the study.
- Increasing the sample size of the respective intervention groups in order to verify the results of this study.

- Increasing the homogeneity of the sample with regards to the BBS scores (using cut-off scores as an exclusion criterion) and the NRS scores.
- Consider using orthopaedic tests for post-treatment outcomes.
- Consider doing immediate post-treatment assessments for a more clear indication of immediate effects of treatments on the condition.
- Consider how many participants wore orthotics.
- Homogeneity in terms of the length of time since the participant's first ankle sprain to the date of participation in the trial, as it may impact on the outcome of the study. Alternatively, a point or a period prevalence may need to be considered in order to ensure greater sample homogeneity.
- Increase the number of measurement points (viz. baseline, immediately post intervention, 24, 48 and 72 hours post intervention). This would assist in tracking the changes that relate to oedema (Clancy and McVicar, 2002) more effectively and may provide for a baseline comparison between the treatment groups.
- Increased time could potentially have resulted in a cross-over effect for this outcome (NRS) and potentially lead to a significant difference between the interventions.
- It is therefore suggested that future studies include the NRS as an inclusion tool as well as a measurement tool.

5.3.2 Future Research

- Compare the AAI (zero setting) to the AAI (full tension) for CAIS, to determine the efficacy of the AAI in extremity care and rule out improvements due to novelty of treatment.
- Compare the effects of single to multiple manipulations with AAI (the combination has already been tested for manual manipulation (Köhne, 2005)).
- Compare the effects of single to multiple manipulations with AAI to multiple manual manipulations.

- Compare the AAI and manual manipulation for CAIS with improved outcomes that are reflective of both manipulative techniques effects so that they can be compared more equitably.
- Consider using orthopaedic tests for post-treatment outcomes.
- Consider doing immediate post-treatment assessments for a more clear indication of immediate effects of treatments on the condition.
- Consider how many participants wore orthotics.
- Consider using the BBS cut-off score as an exclusion criterion for homogeneity.
- Consider the effects of full kinetic chain manipulations and the effect of this on the clinical presentation of CAIS.
- Repeat the same / similar study for other joints within the extremities as the results achieved in this study may not be applicable to other joints.

5.3.3 Practical Considerations

- From the results, it would seem that AAI is as effective as the manual manipulation utilised in practice, therefore it is suggested that for single application use, the AAI performs well and may assist in a patient's health or patient care.
- Practitioners may wish to consider the use of the AAI in the short term, when they are for any reason unable to apply manual manipulation. However, caution is needed when applying the AAI over the long term as this study is not able to comment on the effectiveness of the AAI in longer term.

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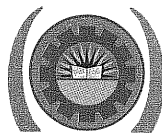
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D U R B A N
UNIVERSITY of
TECHNOLOGY

INSTITUTIONAL RESEARCH ETHICS COMMITTEE (IREC)

24 August 2012

IREC Reference Number: **REC 30/12**

Mr A Botha
36A Stofbergstreet
Warmbaths
Bela-Bela
0480

Dear Mr Botha

The relative effectiveness of the activator adjustment instrument versus diversified manipulation technique in Chronic Ankle Instability Syndrome (CAIS) in terms of objective and subjective findings

I am pleased to inform you that Full Approval has been granted to your proposal REC 30/12.

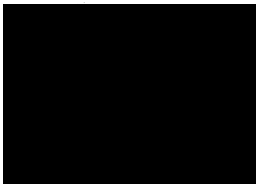
The Proposal has been allocated the following Ethical Clearance number **IREC 030/12**. Please use this number in all communication with this office.

Approval has been granted for a period of one year, before the expiry of which you are required to apply for safety monitoring and annual recertification. Please use the Safety Monitoring and Annual Recertification Report form which can be found in the Standard Operating Procedures [SOP's] of the IREC. This form must be submitted to the IREC at least 3 months before the ethics approval for the study expires.

Any adverse events [serious or minor] which occur in connection with this study and/or which may alter its ethical consideration must be reported to the IREC according to the IREC SOP's. In addition, you will be responsible to ensure gatekeeper permission.

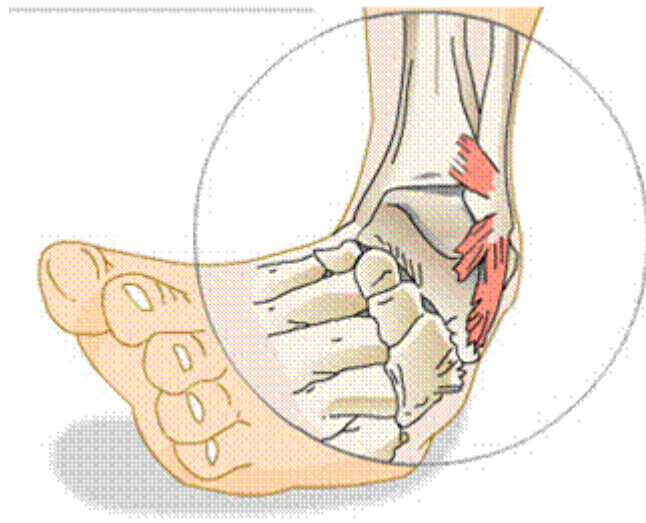
Please note that any deviations from the approved proposal require the approval of the IREC as outlined in the IREC SOP's.

Yours Sincerely,



Dr D F Naude
Chairperson: IREC

Do you suffer from chronic recurrent ankle sprains?



Research is currently being conducted at the Durban
University of Technology - Chiropractic Day Clinic.

If you are between the ages of 20 and 40 and suffer from
recurrent ankle sprains, treatment is being offered to those
who qualify to take part in this study.

For more information call André Botha:

031 373 2205 / 084 841 4066

Appendix C: Letter of Information and Informed Consent Form

DEAR PARTICIPANT

Welcome to my research project. Thank you for taking the time to consider taking part in my study.

TITLE OF RESEARCH STUDY:

The relative effectiveness of the activator adjustment instrument versus diversified manipulation technique in chronic ankle instability syndrome (CAIS) in terms of objective and subjective findings.

Principal investigator: André Botha (Contact number : 0848414066)

Co-Investigators: Dr. C. Korporaal (M.Tech: Chiropractic) (Contact number : 031 3732611)

Dr H White (BSc, BEd, M.Tech:Chiropractic) (Contact number :031 4642490)

Introduction and Purpose of the study: Lateral ankle sprains are common in physically active people and often lead to Chronic Ankle Instability Syndrome (CAIS). One of the treatments for CAIS is manual joint mobilization / manipulation, which improves movement. Manipulations are applied either manually or via a mechanical device. The Activator Adjustment Instrument (AAI) is commonly applied to joints of the limbs. This research aims to determine the effectiveness of these two methods of treatment in comparison with one another.

Forty participants will be needed in this study. Should you agree to take part in this study you will now be asked to sign this letter of information and informed consent. You will then have a case history, physical and foot and ankle regional examination done in order to confirm your ability to take part. Once accepted onto the study you will be expected to attend a 1st visit, where you will receive either a manual manipulation or an activator adjustment. A follow-up visit within 48hours will also have to be attended to do the post-treatment measurements. The initial visit will take about 2 hours, and the follow-up will be no longer than 30min.

Risks / discomforts and Benefits: You may feel short-term stiffness or discomfort after the treatment as is common with any manual therapy, and should resolve without further complication to you. If not, please report this to me so that I can take the appropriate action on your behalf. In terms of the treatment, it is hypothesized to render benefit to you and your recurrent ankle pain.

Remuneration: Other than the treatment, you will not receive any benefit for taking part in my study.

Cost: Your taking part in this research is free of charge.

Confidentiality: Your personal information will remain private by the use of a coding system for data analysis and reporting. Your taking part in this study is by free will and refusal to take part will not result in any negative consequences. You are free to withdraw from the study at any time.

Should there be a research related injury: The DUT Clinic Protocol will be followed and the injury would also need to be reported to the Health Research and Ethics Committee, so please make sure that you inform me of any such problems.

Withdrawal from study: There will be no penalty against people who withdraw from or fall out of the study. Reason for withdrawal will be noted down and further advice with regards to their condition and situation will be given and also noted down.

Persons to contact in the event of any Problems or Queries:

Supervisors: Dr Korporaal (M. Tech: Chiropractic, CCFC, CCSP, ICSSD)
Dr White (BSc, BEd, M.Tech:Chiropractic)

IREC Research Administrator (IREC)

Tel: 0832463562

Tel: 0314642490

Tel: 0313732900

Appendix C: Letter of Information and Informed Consent Form

Statement of Agreement to Participate in the Research Study:

I, (participant's full name)
..... (ID number) have read this document in it is entirely and understand its contents. Where I have had any questions or queries, these have been explained to me by André Botha 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 name (print)

Participant signature

Date

Researcher name (print)

Researcher signature

Date

Witness name (print)

Witness signature

Date



Patient: _____

Date: _____

File # : _____

Age: _____

Sex : _____

Occupation: _____

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:

Intern's Case History:

1. Source of History:

2. Chief Complaint : (patient'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		
< 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. x-rays
- < 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



PHYSICAL EXAMINATION: SENIOR

Patient 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)		
Oedema		
Lymph nodes	Head and neck	
	Axillary	
	Epitrochlear	
	Inguinal	
Pulses		
Urinalysis		

SYSTEM SPECIFIC EXAMINATION:

CARDIOVASCULAR EXAMINATION
RESPIRATORY EXAMINATION
ABDOMINAL EXAMINATION
NEUROLOGICAL EXAMINATION
COMMENTS

Clinician: _____

Signature : _____

Appendix F: Foot and Ankle Regional Examination

Patient: _____ File no: _____ Date: _____

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

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

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

Resisted Isometric movements

	R	L		R	L
Knee flexion			Pronation (eversion)		
Plantar flexion			Toe extension (dorsiflexion)		
Dorsiflexion			Toe flexion (plantar flexion)		
Supination (inversion)					

Neurological

	R	L
Dermatomes		
Myotomes		
Reflexes		
Balance/proprioception		

Special tests

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

Alignment

	R	L
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

	R	L
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		

Patient Name:		File #:	Page:
Date:	Visit:	Intern:	Signature:
Attending Clinician:		Signature:	
S: Numerical Pain Rating Scale (Patient) Least 0 1 2 3 4 5 6 7 8 9 10 Worst		Intern Rating <input style="width: 40px; height: 20px;" type="text"/>	A:
O:		P:	
		E:	
Special attention to:		Next appointment:	
Date:	Visit:	Intern:	Signature:
Attending Clinician:		Signature:	
S: Numerical Pain Rating Scale (Patient) Least 0 1 2 3 4 5 6 7 8 9 10 Worst		Intern Rating <input style="width: 40px; height: 20px;" type="text"/>	A:
O:		P:	
		E:	
Special attention to:		Next appointment:	
Date:	Visit:	Intern:	Signature:
Attending Clinician:		Signature:	
S: Numerical Pain Rating Scale (Patient) Least 0 1 2 3 4 5 6 7 8 9 10 Worst		Intern Rating <input style="width: 40px; height: 20px;" type="text"/>	A:
O:		P:	
		E:	
Special attention to:		Next appointment:	

Appendix H: Randomisation Table

Subject	Treatment Group
1	B
2	A
3	A
4	A
5	B
6	A
7	B
8	A
9	B
10	B
11	A
12	A
13	B
14	B
15	B
16	B
17	A
18	A
19	A
20	A
21	A
22	A
23	B
24	B
25	A
26	B
27	B
28	B
29	B
30	A
31	B
32	A
33	A
34	B
35	B
36	A
37	B
38	A
39	B
40	A

Appendix I: Letter of Agreement from Clinic Administrator

To: André Botha

From: Linda Twiggs

Re: Agreement to participate as “sample allocators”.

Date: 1 June 2012

As per our verbal discussion, I hereby agree in writing that I willingly wish to participate in your research as your “sample allocator”. I am in agreement to the proposal as set out in the PG4a document, and I am aware of what is required of me in my role as a “sample allocator”.

I trust you find the above in order.

Kind regards

Linda Twiggs

Appendix J: Letter of Agreement from Clinic Administrator

To: André Botha

From: Pat van den Berg

Re: Agreement to participate as “sample allocators”.

Date: 1 June 2012

As per our verbal discussion, I hereby agree in writing that I willingly wish to participate in your research as your “sample allocator”. I am in agreement to the proposal as set out in the PG4a document, and I am aware of what is required of me in my role as a “sample allocator”.

I trust you find the above in order.

Kind regards

Pat van den Berg

Appendix K: NRS

Patient Name:

File number:

Date:

0		100
---	--	-----

0 = least pain

100 = worst pain

Appendix L: Experience of Treatment

Patient name:

File number:

Date:

Treatment received:

Please circle the word/s that best describes your experience of the treatment.

Uncomfortable	Comfortable	Unpleasant	Pleasant	Unhelpful	Helpful
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Appendix N: Algometer (Pain-Pressure Threshold) Readings

Patient name			File number	
	Date	Reading 1	Reading 2	Average
Measurement				

Appendix O: Weight Bearing Ankle Dorsiflexion Test

Patient name:

File number:

1) 2) 3)

Date: _____

1 = distance from floor to knee (anterior most tip)

2 = the distance from the heel to the wall / right angle of the set square

3 = the ankle dorsiflexion angle

Appendix M: The Foot and Ankle Disability Index

FOOT/ANKLE DISABILITY INDEX

Name: _____

Date: _____

Please read: This questionnaire has been designed to give the Physical Therapist information as to how your foot/ankle pain has affected your ability to manage everyday life. Please answer by marking the one box which most closely applies to you.

SECTION 1 – PAIN INTENSITY

- ☐ I have no pain in my foot/pain
- ☐ The pain in my foot/ankle is intermittent or mild and does not limit my activity
- ☐ The pain in my foot/ankle is intermittent but limits my activity
- ☐ The pain in my foot/ankle is constant and moderately limits my activity
- ☐ The pain in my foot/ankle is constant and severely limits my activity
- ☐ The pain in my foot/ankle is constant and I am unable to do anything

SECTION 2 – STANDING

- ☐ I can stand as long as I want to
- ☐ I am able to stand for over 60 minutes before symptoms increase
- ☐ I am able to stand 31-60 minutes before symptoms increase
- ☐ I am able to stand 11-30 minutes before symptoms increase
- ☐ I am only able to stand for very short periods: 10 minutes or less
- ☐ I am unable to stand for any length of time

SECTION 3- WALKING/WEIGHT BEARING TOLERANCE

- ☐ I can walk normally without assistive devices
- ☐ I can walk without assistive devices, but only for 31-60 minutes
- ☐ I can walk without assistive devices, but only for 30 minutes or less
- ☐ I can walk as far as I need but I must use assistive devices
- ☐ I must use assistive devices and can bear only partial weight on my injured foot
- ☐ I must use assistive devices and can bear minimal to no weight on my injured foot

SECTION 4 – CLIMBING STAIRS

- ☐ I am able to go up & down stairs normally
- ☐ I am able to go up & down stairs step over step if I go slowly
- ☐ I am able to go up & down stairs step over step but only a limited number at a time
- ☐ I am able to go up & down stairs but only one at a time
- ☐ I am able to go up & down a limited number of stairs and only one at a time
- ☐ I am unable to use stairs

SECTION 5 – SWELLING

- ☐ I have no swelling with my highest level of activity
- ☐ I have minimal swelling only after my highest level of activity
- ☐ I have no swelling with normal daily activity
- ☐ I have minimal swelling after simple activity
- ☐ I have almost constant swelling but it can be controlled by medication/rest/ice/compression/elevation
- ☐ I have constant swelling without relief foot/ankle

SECTION 6 – WORK

- ☐ I can do as much work as I want to.
- ☐ I can do my usual work, but it increases my foot/ankle pain.
- ☐ I can do most, but not all, of my usual work because of my foot/ankle pain.
- ☐ I can do about half of my usual work because of foot/ankle pain.
- ☐ I can only do minimal work because of my foot/ankle pain.
- ☐ I can't do any work at all because of my foot/ankle pain.

SECTION 7 – DRIVING

- ☐ I can drive my car as long as I want without any foot/ankle pain.
- ☐ I can drive my car as long as I want, but it increases pain in my foot/ankle
- ☐ I can drive my car 31-60 minutes before my foot/ankle pain gets worse
- ☐ I can drive my car 11-30 minutes before my foot/ankle pain gets worse
- ☐ I can drive my car for only 10 minutes or less before my foot/ankle pain gets worse.
- ☐ I am unable to drive my car because of my foot/ankle pain.

SECTION 8 – SLEEPING

- ☐ I have no trouble sleeping
- ☐ My sleep is slightly disturbed by foot/ankle pain. (It wakes me up 1 time/night)
- ☐ My sleep is mildly disturbed by foot/ankle pain. (It wakes me up 2 times/night)
- ☐ My sleep is moderately disturbed by foot/ankle pain (It wakes me 3-4 times/night)
- ☐ My sleep is greatly disturbed by foot/ankle pain (It wakes me 5-6 times/night)
- ☐ My sleep is completely disturbed by foot/ankle pain (It wakes me 7-8 times/night or more)

SECTION 9 – HOUSE & YARD WORK

- ☐ I have no foot/ankle limitations with house or yard work
- ☐ I am able to do all house & yard work necessary if I take a few breaks.
- ☐ I am able to do all house & yard work necessary, but it increases my foot/ankle pain
- ☐ I am able to do some, but not all, house & yard work; it increases my foot/ankle pain
- ☐ I am able to do only the minimum of house & yard work because of my foot/ankle pain
- ☐ I am unable to do any house or yard work because of my foot/ankle pain

SECTION 10 – RECREATION/SPORTS

- ☐ I am able to engage in all my recreation/sports activities with no foot/ankle symptoms
- ☐ I am able to engage in all my recreation/sports activities with some symptoms in my foot/ankle
- ☐ I am able to engage in most, but not all, of my usual recreation/sports activities because of symptoms in my foot/ankle
- ☐ I am able to engage in a few of my usual recreation/sports activities because of symptoms in my foot/ankle
- ☐ I can hardly do any recreation/sports activities because of symptoms in my foot/ankle
- ☐ I am unable to do any recreation/sports activities because of my symptoms

Please mark an "x" on the line below indicating the level of pain you have had in the past 24 hours.

no pain at all _____ worst possible pain _____ /50 = _____ %

Appendix P: Method for Measurement of Weight-Bearing Ankle Dorsiflexion Test

(Adapted from Blake, 2003)

Appendix Q: Berg Balance Scale

File number:

Patient Name:

Date:

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. SITING UNSUPPORTTED		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 UNSUPPORTED WITH 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 TOGETHER		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 R: Letter of Agreement from Blind Assessor

To: André Botha

From: Linn Matsebula

Re: Agreement to participate as “blinded assessor”.

Date: 13 March 2012

As per our verbal discussion, I hereby agree in writing that I willingly wish to participate in your research as your “blinded assessor”. I am in agreement to the proposal as set out in the PG4a document, and I am aware that it is required of me to take the subjective and objective readings for all 40 patients, regardless of the time period that might be required to complete this study.

I trust you find the above in order.

Kind regards

Linn Matsebula

Body Mass Index Table

Normal							Overweight					Obese										Extreme Obesity																	
BMI	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54			
Height (inches)	Body Weight (pounds)																																						
58	91	96	100	105	110	115	119	124	129	134	138	143	148	153	158	162	167	172	177	181	186	191	196	201	205	210	215	220	224	229	234	239	244	248	253	258			
59	94	99	104	109	114	119	124	128	133	138	143	148	153	158	163	168	173	178	183	188	193	198	203	208	212	217	222	227	232	237	242	247	252	257	262	267			
60	97	102	107	112	118	123	128	133	138	143	148	153	158	163	168	174	179	184	189	194	199	204	209	215	220	225	230	235	240	245	250	255	261	266	271	276			
61	100	106	111	116	122	127	132	137	143	148	153	158	164	169	174	180	185	190	195	201	206	211	217	222	227	232	238	243	248	254	259	264	269	275	280	285			
62	104	109	115	120	126	131	136	142	147	153	158	164	169	175	180	186	191	196	202	207	213	218	224	229	235	240	246	251	256	262	267	273	278	284	289	295			
63	107	113	118	124	130	135	141	146	152	158	163	169	175	180	186	191	197	203	208	214	220	225	231	237	242	248	254	259	265	270	278	282	287	293	299	304			
64	110	116	122	128	134	140	145	151	157	163	169	174	180	186	192	197	204	209	215	221	227	232	238	244	250	256	262	267	273	279	285	291	296	302	308	314			
65	114	120	126	132	138	144	150	156	162	168	174	180	186	192	198	204	210	216	222	228	234	240	246	252	258	264	270	276	282	288	294	300	306	312	318	324			
66	118	124	130	136	142	148	155	161	167	173	179	186	192	198	204	210	216	223	229	235	241	247	253	260	266	272	278	284	291	297	303	309	315	322	328	334			
67	121	127	134	140	146	153	159	166	172	178	185	191	198	204	211	217	223	230	236	242	249	255	261	268	274	280	287	293	299	306	312	319	325	331	338	344			
68	125	131	138	144	151	158	164	171	177	184	190	197	203	210	216	223	230	236	243	249	256	262	269	276	282	289	295	302	308	315	322	328	335	341	348	354			
69	128	135	142	149	155	162	169	176	182	189	196	203	209	216	223	230	236	243	250	257	263	270	277	284	291	297	304	311	318	324	331	338	345	351	358	365			
70	132	139	146	153	160	167	174	181	188	195	202	209	216	222	229	236	243	250	257	264	271	278	285	292	299	306	313	320	327	334	341	348	355	362	369	376			
71	136	143	150	157	165	172	179	186	193	200	208	215	222	229	236	243	250	257	265	272	279	286	293	301	308	315	322	329	338	343	351	358	365	372	379	386			
72	140	147	154	162	169	177	184	191	199	206	213	221	228	235	242	250	258	265	272	279	287	294	302	309	316	324	331	338	346	353	361	368	375	383	390	397			
73	144	151	159	166	174	182	189	197	204	212	219	227	235	242	250	257	265	272	280	288	295	302	310	318	325	333	340	348	355	363	371	378	386	393	401	408			
74	148	155	163	171	179	186	194	202	210	218	225	233	241	249	256	264	272	280	287	295	303	311	319	326	334	342	350	358	365	373	381	389	396	404	412	420			
75	152	160	168	176	184	192	200	208	216	224	232	240	248	256	264	272	279	287	295	303	311	319	327	335	343	351	359	367	375	383	391	399	407	415	423	431			
76	156	164	172	180	189	197	205	213	221	230	238	246	254	263	271	279	287	295	304	312	320	328	336	344	353	361	369	377	385	394	402	410	418	426	435	443			

Source: Adapted from *Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults: The Evidence Report*.

The Relative Effectiveness of the Activator Adjustment Instrument versus Diversified Manipulation Technique in Chronic Ankle Instability Syndrome (CAIS) in terms of Objective and Subjective Findings.

Dr. A. Botha

M. Tech: Chiropractic (DUT)

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ABSTRACT:

Background and Introduction: Lateral ankle sprains and the sequelae of Chronic Ankle Instability Syndrome (CAIS) are common, reaching a peak prevalence of 85%. Manual joint manipulation is an intervention utilised for CAIS. Manipulations are applied either manually or via a mechanical device. The Activator Adjustment Instrument (AAI) is commonly applied to extremities; however, a paucity of research exists, in respect of extremity conditions. Thus this study compared an AAI manipulation with a manual long-axis distraction manipulation (diversified technique) in the treatment of CAIS.

Methods: This was an ethics approved, quantitative, randomised controlled clinical trial of 40 participants who were allocated between two groups. After receipt of informed consent participants were evaluated against the inclusion criteria and baseline measures were taken. One treatment of either manual or activator manipulation was followed by a measurements-only consultation within 48 hours. A p-value <0.05 was considered statistically significant. Intra- and inter-group analyses were done utilising repeated measures ANOVA tests.

Results: Both groups showed a statistically significant improvement on all outcome measures over time, but neither group showed a significant improvement over the other. A trend in the inter-group comparisons reflected parallel improvements in the Algometer, Berg Balance Scale and the dorsiflexion range of motion (objective measures) and non-parallel improvements in the Numerical Pain Rating Scale and Foot and Ankle Disability Index (subjective measures).

Conclusions: The results suggested a trend towards subjective improvement in the AAI group, which may have been influenced by the novelty of the AAI. Further research with larger sample sizes and more homogenous participant groups are needed to verify this outcome.

Key indexing terms: Chronic Ankle Instability Syndrome, Diversified Manipulation, Activator Adjustment Instrument.

INTRODUCTION:

Lateral ankle sprains are common in physically active populations¹, reaching a peak prevalence of 85% in various sports². Re-injury occurs when the ankle is plantarflexed and inverted repeatedly³, injuring the lateral ankle ligament and resulting in peroneal tendon strain or rupture, capsular compromise, joint impaction and / or joint distraction along with the cellular sequelae of oedema and the healing cascade^{4, 5, 6}. This leads to CAIS which produces anterior-posterior, posterior-anterior, and long-axis motion abnormalities of the talocrural and subtalar joints⁷.

Classically, Chronic Ankle Instability Syndrome (CAIS) is diagnosed when there is untreated lateral ankle instability leading to recurrent ankle sprains^{8, 9} and is characterised by the following clinical symptoms and signs:

1. Joint fixations or hypomobility^{4, 10, 11} with associated articular deafferentation (in the ankle, subtalar joint and tarsals), adhesion formation, reduced motion and when motion is present is associated with crepitus^{4, 12, 13, 14} as well as
2. Ligamentous laxity^{13, 14}, which can be measured subjectively (ankle giving way or feeling of instability) or objectively by means of manual stress tests or radiographs⁹ and
3. Proprioceptive alterations^{2, 14}.

According to Hubbard and Wikstrom⁹, instability and joint laxity can still be present six months after injury. Untreated, CAIS leaves a patient with an inverted ankle, reduced muscle co-contraction, and a lower dynamic stiffness in the joint¹⁵, which in turn leads to articular degeneration of the talus and resultant osteoarthritis of the ankle joint in the long term⁹. Loss of talus movement plays a crucial role in the adaptation of the foot to the surface when walking¹⁶.

One of the interventions for CAIS is manual joint mobilization or manipulation, which reduces a fixation and improves range of motion¹⁷. It was found that HVLA manipulative therapy showed improved clinical outcomes when applied to the talocrural and subtalar articulations³. These manipulations may be applied either manually or via a mechanical device¹⁸.

It was found that a single joint mobilisation treatment, specifically anteroposterior talocrural mobilization¹⁹, could significantly increase the dorsiflexion range of motion²⁰ and immediately reduce self-reported pain²¹. Additionally, the mortise separation manipulation has very little chance of further compromising the integrity of the lateral ligament complex of the ankle^{17, 21}.

Moreover, manipulations can be useful in the treatment of conditions in which clinical joint instability is present²¹, particularly as the instability is usually related to

hypomobility of the same segment or related segments^{17, 22}. These manipulations are applied either manually or in cases where clinicians are unable to utilise their hands, via a mechanical device. The AAI (a mechanical device) is used to produce a thrust imparted into a joint. It has a combined benefit of reducing physical stress on the clinician^{23, 24} as well as precisely controlling the speed, force and direction of the manipulative thrusts²⁵. Another advantage is that this modality helps clinicians who may have degenerative joint disease and who may find manual manipulation difficult as they continue with their career^{23, 24}.

These instruments represent the second most common approach (the first being manual application) for applying manipulative forces²⁶ and are used by 72% of Chiropractors on 21% of their patients²⁷. It was determined that the AAI could maximally produce a force of 0.3J of kinetic energy, which is enough to cause some movement at the joint level, but this force is also a lot lower than the energy value needed to cause injury (with only a 3-millisecond excursion)²⁸. This force is also sufficient to stimulate the type III high threshold mechanoreceptors^{6, 29}, which could be beneficial since ligamentous injury often causes changes in mechanoreceptors, joint capsules, golgi tendon organs and muscle spindles^{30, 31}.

The advantages of AAI (in contrast to manual manipulation) include the ability to produce a thrust imparted into a joint, whilst reducing physical stress on the clinician^{23, 24}. In addition, it precisely controls the speed, force, and direction of the manipulative thrusts²⁵. However, with the paucity of research on the AAI²⁵ in respect of extremity conditions, little is known of the AAI in terms of its clinical efficacy and relative effectiveness. To the researchers' knowledge, no study has been done to test the effectiveness of AAI on CAIS³², even though this modality is often utilised in practice both within and outside of its protocol in the treatment of extremity conditions^{18, 25, 33}.

Therefore, this research aimed to investigate the relative effectiveness of the AAI manipulation versus a manual long-axis distraction manipulation by diversified technique in CAIS in terms of subjective and objective findings.

With this brief introduction, a four-to-two consensus was reached supporting the statement that AAI procedures are as effective as manual High-Velocity, Low-Amplitude (HVLA) procedures in having clinical benefit and causing biological change³⁴. This is, however, clinically untested and based mainly on anecdotal evidence³².

Chronic Ankle Instability Syndrome (CAIS) is a common condition that presents to practitioners utilising both manual and AAI manipulative interventions, thus it is of importance to determine whether AAI interventions are of clinical benefit to the patients receiving such care^{17, 25}.

METHOD:

Design: This research was a randomised, controlled, single blinded, clinical assessment. The study was quantitative in nature and the results of the trial were stipulated and calculated in a statistical numerical format to determine the outcome of each individual treatment group. The research design was approved by the Institutional Research and Ethics Committee (IREC) of the Durban University of Technology (DUT), indicating that the proposal and hence the research that was undertaken was compliant with the Declarations of Helsinki, Belmont and Nuremberg³⁵.

Sample size, recruitment and selection: In total 40 participants (as determined by the power analysis supplied by Esterhuizen³⁶ were recruited from the greater Durban area. Participants were recruited through convenience sampling by means of their responses (self-selection) to the advertisements^{37, 38, 39}. The participant evaluation and selection process began with a cursory telephonic discussion, to exclude participants that did not fit the criteria for the study. Once the suitability of the participants was determined, they were randomly allocated according to the randomisation table supplied by Esterhuizen³⁶, by concealed allocation^{37, 38, 39} to one of two equal groups of 20 participants each.

At the initial consultation, each potential participant received a Letter of Information and Informed Consent Form that gave a detailed explanation of what the research programme entailed and what would be expected from them as participants. If the potential participants stated they understood the details of the letter, they were asked to sign the Letter of Information and Informed Consent Form. The participants then had a case history, physical examination and foot-and-ankle regional examination done in order to diagnose and to screen them for inclusion into the study. All the data was noted on a SOAPE note and discussed with the clinician that was on duty in order to ensure that the potential participants met all research requirements. It should be noted that no restrictions were enforced in terms of ethnicity, gender, occupation or level of income.

Inclusion criteria: Both male and female participants were allowed to participate in this study. They would have had to be between 20 and 40 years of age²¹ for homogeneity^{38, 39, 40}. Participants were required to have CAIS defined by the presence of four or more of the following clinical features^{4, 13, 21, 41, 42, 43} inclusive of: lateral ankle pain, joint weakness, ankle instability, oedema, joint crepitus and / or stiffness or adhesions.

They had to have a history of at least two unilateral ankle sprains in the last two years^{44, 45} and sprains could not have been worse than a Grade I or Grade II ankle sprain as defined by Reid⁴. The mechanism of ankle injury had to involve weight-

bearing and inversion of the ankle⁴⁴, with subsequent damage to the lateral collateral ligaments of the ankle (viz. anterior and posterior talofibular and the calcaneofibular ligaments). Participants were required to have restricted motion in the talocrural / subtalar joints as defined by Bergmann and Peterson⁴⁶ and Byfield⁴⁷.

Exclusion criteria: Participants with any relative or absolute contra-indications to manipulation^{21, 24, 48, 49, 50} were excluded. Those on anti-inflammatory drugs or pain killers were excluded unless they underwent a three day wash-out period^{51, 51}, as these may influence certain measurements²¹. Participants having been part of another research trial were not permitted to take part in this study until a three month wash-out period had taken place. Similarly, a participant who had been receiving treatment for any other condition, were not permitted into this study until a two week wash out period had taken place (this is according to the DUT Chiropractic Day Clinic protocol). Participants were asked not to initiate any other form of treatment while taking part in this study²¹. Participants who experienced re-injury during the study were excluded to rule out acute ankle injuries²¹. Participants who showed signs of gross mechanical ankle instability²¹ explained by Reid⁴ as a Grade III ankle sprain and syndesmosis injury⁵³, or who have had reconstructive or any other major surgery done to the affected ankle, were excluded.

Treatment and measurement frequencies: The accepted (40) participants underwent two consultations - one treatment and one follow-up consultation. It was known that multiple treatments are effective for treating chronic conditions, but since we were testing the immediate effects of such treatments on chronicity, only one treatment was given. Group A received a manual long-axis distraction manipulation by diversified technique to the ankle talocrural joint^{23, 24}. Group B received an anterior-lateral talus (Line of Drive being posterior-medial) AAI manipulation with full tension⁵⁴.

Both groups attended a follow-up consultation within 48 hours to re-assess the condition of the ankle post-treatment^{16, 55, 56, 57, 58}. Data collection took place on both the first and the second consultation. All measurements were done by the blinded assessor as per agreement. Participants were monitored and assessed in the form of subjective and objective data that was collected pre- and post-treatment (NRS, Experience of Treatment, FADI, Algometer, Weight Bearing Ankle Dorsiflexion Test, BBS and Motion Palpation).

Statistical methods: All data was taken from the corresponding data collection sheets and entered onto a Microsoft (MS) Office Excel spread-sheet. From the MS Excel spread-sheet, the data was imported into SPSS version 20.

Following consultation with a research statistician³⁶, statistical analysis was conducted on the data using the latest version of SPSS (manufactured by SPSS

Inc., 444N. Michigan Ave, Chicago, Illinois, 60611, USA). A p-value of <0.05 was considered as statistically significant.

Descriptive data was presented with frequency tables, bar graphs, and summary statistics including mean, standard deviation and range. Demographics were compared between treatment groups using Pearson's chi square tests and t-tests.

Intra- and inter-group analyses were done utilising repeated measures ANOVA tests. Inter-group analyses reported the effect of the time on group interaction as the effect of the intervention.

This was also interpreted using profile plots to show mean change in the outcome measure over time and by treatment group in order to assess trends and direction of the effect³⁶.

RESULTS:

NRS: There were no significant differences between the treatment effects of the two treatment groups ($p=0.316$).

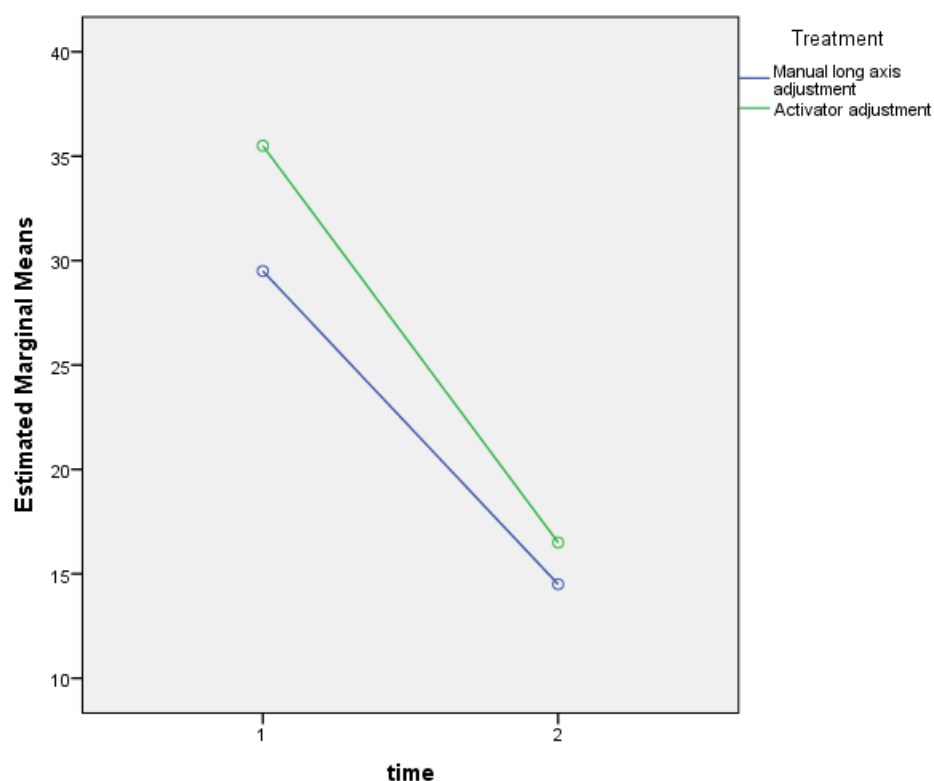


Figure 1: NRS comparison between the two groups

In terms of the MCID for each of the intervention groups, neither of the treatment groups was able to achieve a significant change in their clinical presentations after only one intervention.

Experience of Treatment: Although the p -value for both treatment groups was found to be 0.000, on examination of Figure 1, it becomes apparent that treatment Group B had a slightly steeper curve of improvement with regards to NRS readings.

Table 1: Experience of treatment comparison between the two groups

		Manual Manipulation (A)		AAI Manipulation (B)		p -value
		Count	Column N %	Count	Column N %	
SETUP	Comfortable	16	80.0	18	90.0	0.376
	Uncomfortable	4	20.0	2	10.0	
THRUST	Pleasant	14	70.0	15	75.0	0.723
	Unpleasant	6	30.0	5	25.0	
FEEDBACK	Helpful	15	75.0	19	95.0	0.182
	Unhelpful	5	25.0	1	5.0	

Although there were no significant changes noted between the treatment groups, it is seen that there is a trend for greater satisfaction with the intervention as indicated by the AAI treatment group.

FADI: No significant difference between the treatment effects of the two treatment groups ($p=0.217$).

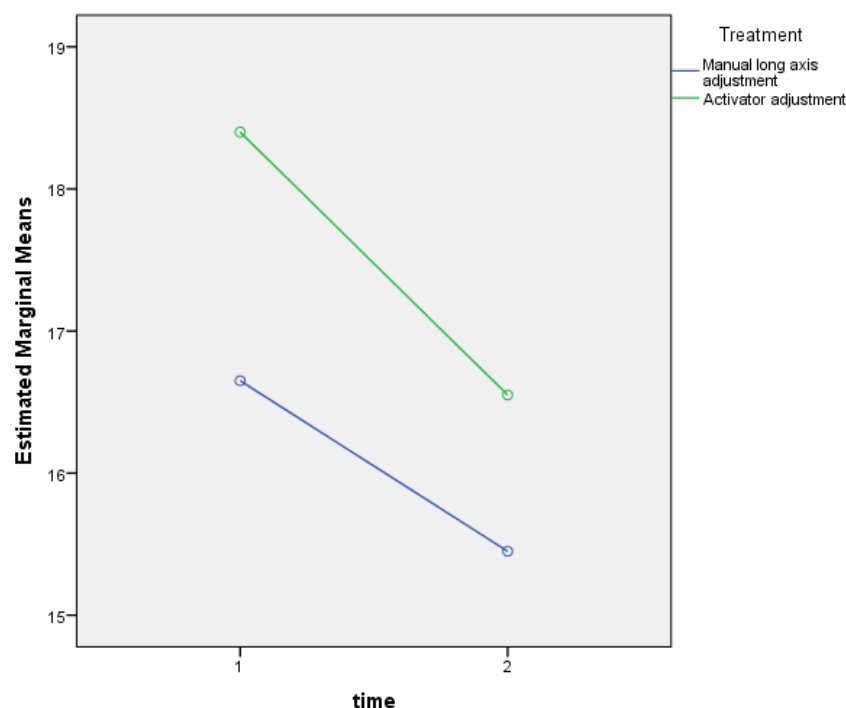


Figure 2: FADI comparison between the two groups

Once again, as with the NRS, the findings in Figure 2 in terms of FADI in the two treatment groups were similar, with treatment Group B showing a slightly steeper

curve. In terms of clinical significance, it was noted that there were no clinical significances obtained in either treatment group.

Algometer: No significant difference between the treatment effects of the two treatment groups ($p=1.000$).

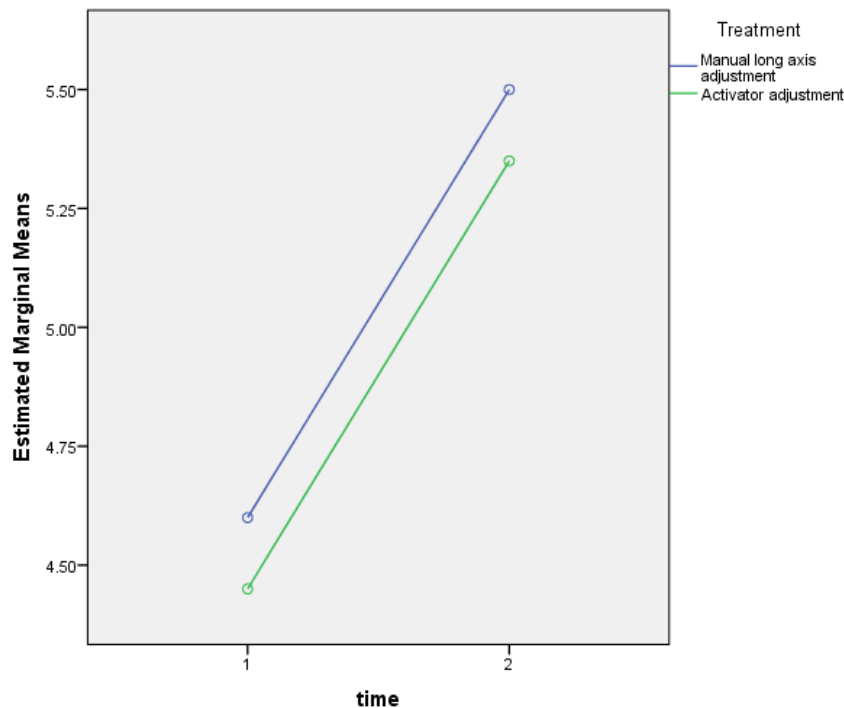


Figure 3: Algometer comparison between the two groups

Figure 3 clearly shows a more proportional improvement in terms of the algometer readings. In terms of clinical significance, no clinical significance was attained by either treatment group after one intervention when applying the criteria as set out by Paungmali *et al.*,⁵⁹ Potter *et al.*,⁶⁰ Chesterton *et al.*,⁶¹ and O'Leary *et al.*,⁶².

Weight-Bearing Ankle Dorsiflexion: There were also no significant difference between the treatment effects of the two treatment groups ($p=0.949$).

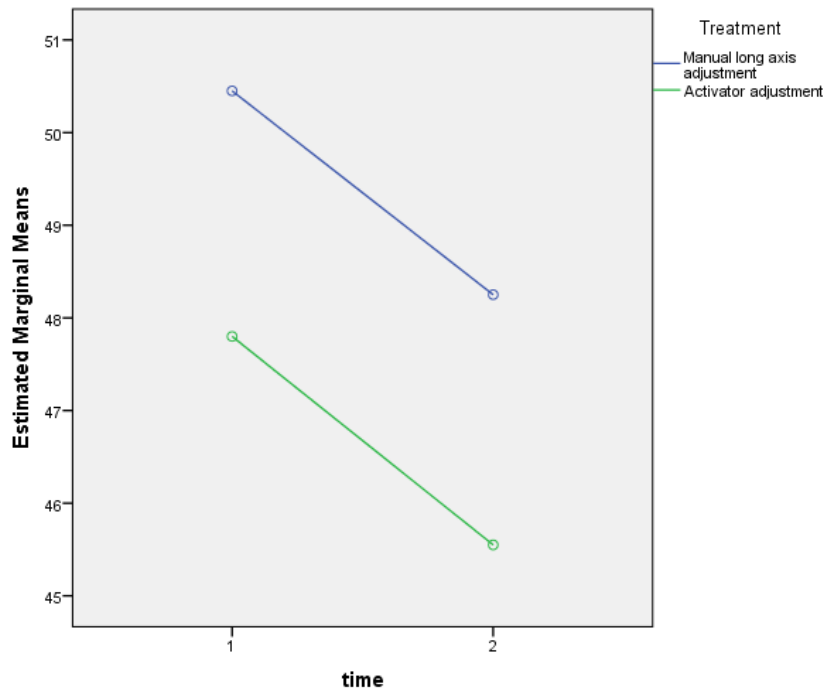


Figure 4: Dorsiflexion comparison between the two groups

In terms of the dorsiflexion range of motion it can be seen that it follows the same principles as discussed in the section of Algometer Comparison. Also, in terms of the clinical significance, neither treatment group attained clinical significance after one intervention.

BBS: No significant difference between the treatment effects of the two treatment groups were found ($p=0.685$).

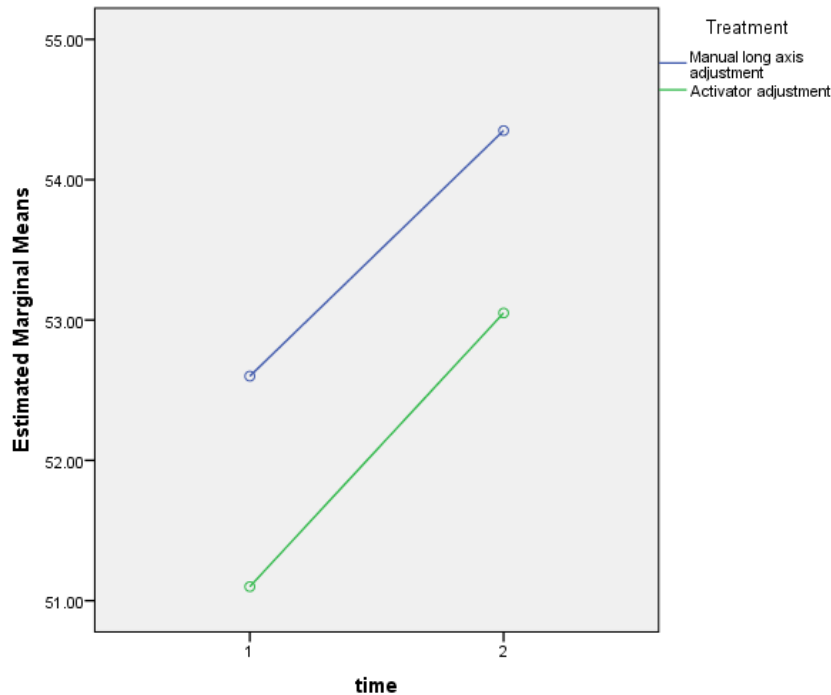


Figure 5: BBS comparison between the two groups

In terms of the BBS it can be seen that it follows the same principles as discussed in the sections on Algometer Comparison and Dorsiflexion Comparison. In terms of the clinical significance, this could not be calculated as no literature / published norm exists in order to determine the improvement of the participants in this study to the published norm.

DISCUSSION:

Baseline evaluation of all outcome measures revealed that there was no statistically significant difference between the two groups at baseline, therefore any difference between the groups would either be related to natural history (time) or the intervention. In terms of the overall findings of the study, Table 2 outlines the overall effects that were found.

Table 4.2: Overall Outcomes

	Manual Manipulation		AAI Manipulation		Gradient comparison in related figures
	Outcome	MCID	Outcome	MCID	
NRS	Significant	Not attained	Significant	Not attained	Favourable and thus steeper gradient (AAI)
FADI	Significant	-	Significant	-	Favourable and thus steeper gradient (AAI)
Algometer	Significant	Not attained	Significant	Not attained	Parallel
Dorsiflexion	Significant	Not attained	Significant	Not attained	Parallel
BBS	Significant	-	Significant	-	Parallel

From the Overall Outcomes Table 2, it can be seen that both the treatment groups improved equitably from pre- to post- applied manipulation in terms of the objective findings in this study (algometer, dorsiflexion range of motion and Berg Balance Scale). By contrast, the subjective findings (FADI and NRS) reflected similar trends. These summarised outcomes seem to suggest that from a neurological and biomechanical vantage point, that the two interventions are equally effective after one intervention session, but not to the point of attaining clinical significance (at least for those measures where such parameters exist).

There does however seem to be an “Observer”, Hawthorne or other such effect^{38, 63, 64} that presents itself within the outcomes of the subjective findings as it is consistently seen that there is a tendency for the perception of improved outcomes for the AAI treatment group. It cannot however be discarded that the effects of manual manipulation result in the distraction and damage of adhesions or other soft tissue structures which resulted in decreased subjective improvement in patients. The objective outcomes in this study did not measure oedema so the effects of reactive oedema cannot be commented on. Thus it is suggested that future research

consider measuring this outcome with the “figure of 8” measure for ankle swelling^{65, 66}, in order to test this suggested effect.

Correlation tables (Tables 3 and 4) as outlined below indicate whether there is any significant relationship between any of the outcome measures within any of the treatment groups in the study.

Table 3: Correlations^a Manual Manipulation Group A

		Change in NRS	Change in FADI	Change in algometer	Change in dorsiflexion	Change in BBS
Change in NRS	Pearson Correlation	1	0.230	-.214	-.165	-.077
	Sig (2-tailed)		0.330	0.365	0.487	0.746
	N	20	20	20	20	20
Change in FADI	Pearson Correlation	0.230	1	0.162	-.057	-.558*
	Sig (2-tailed)	0.330		0.496	0.811	0.011
	N	20	20	20	20	20
Change in algometer	Pearson Correlation	-.214	0.162	1	0.031	-.149
	Sig (2-tailed)	0.365	0.496		0.895	0.530
	N	20	20	20	20	20
Change in dorsiflexion	Pearson Correlation	-.165	-.057	0.031	1	-.383
	Sig (2-tailed)	0.487	.811	0.895		0.096
	N	20	20	20	20	20
Change in BBS	Pearson Correlation	-.077	-.558*	-.149	-.383	1
	Sig (2-tailed)	0.746	0.011	0.530	0.096	
	N	20	20	20	20	20

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

a. Treatment = Manual Long-Axis Manipulation

Bold indicates significant and strong correlations

From Table 3, it can be seen that in the manual manipulation treatment group, that a significant and strong relationship exists between the changes in the BBS⁶⁷ and the FADI^{68, 69}. This is an expected correlation in that these measures, although one subjective and the other objective reflect changes in functional ability⁷⁰.

The lack of a relationship between the improvement in the range of motion and the NRS, FADI and BBS may attest to the suggested hypothesis of reactive oedema in participants that underwent the manual manipulation, in that it would have obscured the relationship between these factors and thus rendered them insignificant.

Table 4: Correlations^a AAI Manipulation Group B

		Change in NRS	Change in FADI	Change in algometer	Change in dorsiflexion	Change in BBS
Change in NRS	Pearson Correlation	1	0.208	-.472*	0.008	-.293
	Sig (2-tailed)		0.380	0.036	0.972	0.211
	N	20	20	20	20	20
Change in FADI	Pearson Correlation	0.208	1	-.419	-.088	-.104
	Sig (2-tailed)	0.380		0.066	0.713	0.662
	N	20	20	20	20	20
Change in algometer	Pearson Correlation	-.472*	-.419	1	-.031	0.089
	Sig (2-tailed)	0.036	0.066		0.896	0.710
	N	20	20	20	20	20
Change in dorsiflexion	Pearson Correlation	0.008	-.088	-.031	1	-.059
	Sig (2-tailed)	0.972	0.713	0.896		0.805
	N	20	20	20	20	20
Change in BBS	Pearson Correlation	-.293	-.104	0.089	-.059	1
	Sig (2-tailed)	0.211	0.662	0.710	0.805	
	N	20	20	20	20	20

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

a. Treatment = Activator Manipulation

Bold indicates significant and strong correlations

From Table 4, it can be seen that in the AAI treatment group, that a significant and strong relationship exists between the changes in the algometer and the NRS^{71, 72, 73}.

The outcomes of the correlation Tables 3 and 4, when compared seem to suggest that the manual manipulation has a greater effect on the outcomes of functional ability, whereas the AAI treatment group has a greater effect on pain reduction. Therefore, it would be necessary for future studies to consider different assessment methods for clinical improvement to find a common ground for the evaluation of these two techniques, such that they could be compared more equitably in terms of their physiological and thus clinical effects. A study such as this may have drawn the inference of a placebo effect, if it were not for the strength of the correlations presented in Tables 3 and 4.

CONCLUSION:

With the high prevalence of ankle sprains and the resultant high rate of non-resolution of the signs and symptoms related to ankle sprains (known as CAIS), this study aimed to determine the effect of a single intervention by two different manipulative techniques to determine the effect of these techniques on the clinical

resolution of CAIS. It was anticipated through the Null Hypothesis that the treatment groups would fare equally well with no significant difference. The Null Hypothesis was tested utilising two treatment groups of 20 participants that underwent a clinical assessment for inclusion into the study before being randomly allocated to one of either the AAI treatment group or the manual manipulation treatment group. The treatment groups each received one intervention with measurements taken prior to and at 24 hours after the intervention. The outcome measures included the NRS, FADI, Algometer, BBS and the dorsiflexion range of motion of the ankle (talocrural joint).

Both groups improved significantly, statistically, on all outcome measures taken, with neither surpassing the other. It was noted that there was a trend reflected in the inter-group comparisons with parallel improvements in the Algometer, BBS and the dorsiflexion range of motion (objective measures) and non-parallel improvements in the NRS and FADI. This suggested a trend towards a subjective improvement in the AAI treatment group, which may have been influenced by the novelty of the AAI.

When assessing the correlation tables for each of the treatment groups, the significant and strong correlations seemed to suggest that the clinical outcomes within the manual manipulation treatment group was related to a strong relationship between the functional activity measures, whereas the AAI treatment group reflected a strong relationship between the pain outcomes. It is therefore suggested that there may be differences in the physiological effects of these interventions and that common clinical outcomes should be utilised to more equitably compare the treatment groups.

From the results, it would seem that AAI is as effective as the manual manipulation utilised in practice, therefore it is suggested that for single application use, the AAI performs well and may assist in a patient's health or patient care.

Practitioners may wish to consider the use of the AAI in the short term, when they are for any reason unable to apply manual manipulation. However, caution is needed when applying the AAI over the long term as this study is not able to comment on the effectiveness of the AAI in longer term.

ACKNOWLEDGEMENTS:

None noted.

CONFLICTING INTEREST:

None of the authors have any known conflict of interest to declare.

Participants were in no way compensated for taking part in the research.

CONTRIBUTIONS BY THE AUTHORS:

AB - Principle researcher (masters study)
CMK - Supervisor of masters study
HW - Co-Supervisor of masters study

FUNDING:

The study was funded through a grant from the Durban University of Technology.

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