

**The short and intermediate effect of manipulation on  
chronic ankle instability syndrome.**

**By**

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Institute of Technology in partial compliance with the  
requirements for the Master's Degree in Technology:  
Chiropractic**

I, Eckard Köhne do declare that this dissertation is representative of  
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## DEDICATION:

This is dedicated to my loving family, for all the encouragement and support they have given me, not only to complete this dissertation, but my academic career as well. Your never-ending motivation, prayers and sacrifices did not go unnoticed! I am truly grateful for all that you have done for me. May the Lord bless you all.

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## ABSTRACT:

Following an inversion ankle joint sprain, damage to the proprioceptive organs can occur, which is made worse by lack of proprioceptive retraining and will increase the chances of re-injury (Hoffman and Payne 1995:144 and Anderson, 2002).

Pellow and Brantingham (2001) indicated that patients who received multiple manipulations improved more rapidly than patients in the placebo group.

Therefore it is proposed that manipulation provokes changes in afferent input that may restore normal proprioceptive input (Slosberg, 1988). However, Pellow and Brantingham (2001) were not able to establish what effect multiple manipulations had, as opposed to a single manipulation, on the proprioception on the foot and ankle complex and how this may influence the clinical outcome of the patient's treatment.

Therefore, it was hypothesized that multiple manipulations of the foot and ankle complex would have a greater effect on chronic ankle instability syndrome than a single treatment in terms of overall improvement subjectively and objectively.

In addition to this the following was also hypothesized:

- That multiple manipulations of the foot and ankle complex would increase the ROM to a greater extent than single manipulations.
- That multiple manipulations would decrease point tenderness more effectively than a single manipulation.

This study was a prospective, controlled clinical assessment, which consisted of 30 participants, a convenience sample, between the ages of 25-45 years of age. Once selected, these patients were screened according to inclusion and exclusion criteria and randomly divided into two groups consisting of 15

participants in each group. Group 1 (control group) received a single manipulation at the initial consultation. Group 2 (adjustment group) received 6 manipulations at specified intervals over a 5 week period. Readings were taken prior to the first, fourth, sixth and at the follow-up consultation.

Data was captured in MS Excel and imported into SPSS version 11.5 (as supplied by SPSS Inc., Marketing Department, 444 North Michigan Avenue, Chicago, Illinois, 606611) for analysis.

Descriptive statistics were performed using frequency distribution tables, various graphs and charts such as the bar and pie charts and appropriate measures of central location and dispersion such as the arithmetic mean and standard deviation. Inferential statistics were parametric statistics because of the relatively normal distribution of the dependant variables. Continuous variables were analysed using appropriate paired and un-paired T-tests. The level of significance for all tests were  $P= 0,05$  or a confidence interval of 95 percent.

After analyzing all the results, it was found that the adjustment group (group 2) improved significantly better than the control group for the outcomes of plantarflexion 5° error, inversion error, and ROM dorsiflexion. For other outcomes of Algometer, plantarflexion 10° error and ROM plantarflexion, non-significant positive trends were displayed which suggested a positive treatment effect.

It would therefore seem based on this study, that multiple manipulation of the talocrural joint, as against a single manipulation, is effective for the treatment of chronic ankle instability syndrome.

Furthermore it is also suggested that patients receiving multiple manipulations in order to restore proprioception would need to receive further proprioceptive retraining and / or muscle strengthening (especially with respect to the peroneii muscles). This however would need to be tested with further research.

On the other hand it could also be argued that the single manipulation group would improve further both proprioceptively and with respect to range of motion, if they were given an initial manipulation followed by proprioceptive retraining and / or muscular strengthening in order to retain the benefits of the single manipulation.

Arguably each approach could have the same clinical outcome; however this remains untested and requires further investigation.

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## CHAPTER ONE:

### 1.1 INTRODUCTION:

This chapter will present and discuss the following:

- Background to the problem.
- The objectives and hypothesis.
- Limitations of the study.

### 1.2 BACKGROUND TO THE PROBLEM:

Chronic ankle instability syndrome can be defined as that syndrome which presents as a combination of the following continuing symptoms (Hertling and Kessler 1996: 424-425, Pellow and Brantingham, 2001):

- Mechanical instability of the talocrural joint as a result of damaged anterior talofibular ligament (ATFL) and calcaneofibular ligament (CFL)(Hertling and Kessler 1996: 424-425), which has also been identified as lateral instability by Bassewitz and Shapiro (1997)
- Stiffness or restriction as a result of adhesions formed by a healing ligament (plantar flexion-inversion of the hind foot, and anterior glide of the talus) (Hertling and Kessler 1996: 424-425)
- Lateral ankle pain
- Joint crepitus
- Weakness / giving way
- Oedema / swelling

These may result from inversion sprains (Hertling and Kessler 1996:424-425, Pellow and Brantingham 2001) in which there is muscle spasm, tenderness, stiffness, swelling and possible instability due to injury to the talofibular or calcaneofibular ligaments (Reid, 1992:219-220), which can resultantly increase the risk of repeat injuries (Hockenbury and Sammarco, 2001). Furthermore

lateral instability can present with swelling, lateral pain, tenderness and recurrent feelings of giving way. This can result from an incompetent anterior talofibular ligament (ATFL) or calcaneofibular ligament (CFL) or defects in other lateral structures (Bassewitz and Shapiro 1997).

According to Garrick (1977), Mack (1982), Prentice (1994), Yeung et al. (1994), Jerosh and Bischof (1996) and Lofvenberg et al. (1996), the incidence of ankle sprains has been estimated at around 16% with a prevalence range of 6% to 25% specifically for ankle inversion sprains. It has further been indicated that 20% - 30% of all acute ankle inversion sprains lead to the development of chronic instability and that there is a 30 % – 40 % increase in the recurrence of the ankle sprains.

Following an inversion ankle joint sprain, damage to the proprioceptive organs can occur, which is made worse by lack of proprioceptive retraining and will increase the chances of re-injury (Hoffman and Payne 1995:144 and Anderson, 2002). Thus proprioceptive organs are important for the adjustment of posture and muscle tone (Miller and Narson, 1995 and Jerosch and Bischof, 1996).

Pellow and Brantingham (2001) indicated that patients who received multiple manipulations improved more rapidly than patients in the placebo group. Therefore it is proposed that manipulation provokes changes in afferent input that may restore normal proprioceptive input (Slosberg, 1988). However, Pellow and Brantingham (2001) were not able to establish what effect multiple manipulations had, as opposed to a single manipulation, on the proprioception on the foot and ankle complex and how this may influence the clinical outcome of the patient's treatment.

Therefore, based on the above literature it leads the researcher to hypothesize that manipulation of the foot and ankle complex may have an effect on the

proprioception, as measured by joint position sense, range of motion and point tenderness.

### 1.3 THE OBJECTIVES AND HYPOTHESIS:

The aim of the study was to determine the short and intermediate term effect of manipulation on chronic ankle instability syndrome in terms of objective clinical findings.

1.3.1 The first objective was to determine the effect of a single manipulation versus multiple manipulations on chronic ankle instability syndrome in terms of proprioception (joint position sense).

It was hypothesized that multiple manipulations of the foot and ankle complex would have a greater effect on proprioception (joint position sense), than a single manipulation.

1.3.2 The second objective was to determine the effect of a single manipulation versus multiple manipulations on chronic ankle instability syndrome in terms of range of motion.

It was hypothesized that multiple manipulations of the foot and ankle complex would increase the ROM to a greater extent than single manipulations.

1.3.3 The third objective was to determine the effect a single manipulation versus multiple manipulations on chronic ankle instability syndrome in terms of point tenderness.

It was hypothesized that multiple manipulations would decrease point tenderness more effectively than a single manipulation.

1.3.4 The fourth objective was to determine the effectiveness of a single treatment versus multiple treatments on chronic ankle instability syndrome.

It was hypothesized that multiple treatments would have a greater effect on chronic ankle instability syndrome than a single treatment in terms of overall improvement.

#### 1.4 LIMITATIONS OF THE STUDY:

The latest methods of proprioception quantification included measurements of kinesthesia (ability to detect movement) and joint position sense (JPS) (Lephart and Fu, 1995). JPS was measured by determining the error associated with active or passive reproduction of a joint angle (Deshpande et al., 2003). This study only looked at joint position sense because measures of joint position sense had been found to not correlate with measures of kinesthesia and Deshpande et al., (2003) proposed they measure different aspects of proprioception. In addition to this the measures of movement had been found to be less reliable due to interference with cutaneous receptors that were activated by the instruments that were are utilised to measure kinesthesia.

This study aimed to assess the objective clinical outcomes as a direct measure of proprioception, but did not propose to define, determine or describe the mechanism by which such improvement, or lack thereof, would occur.

## CHAPTER TWO:

### REVIEW OF THE RELATED LITERATURE:

#### 2.1 INTRODUCTION:

This chapter will present and discuss the following:

- Anatomy of the ankle and sub-talar joint.
- Biomechanics of the ankle and sub-talar joint.
- Incidence and prevalence of chronic ankle instability syndrome.
- Proprioception
- Pain
- Range of motion
- Conclusion

#### 2.2.1 ANATOMY OF THE ANKLE JOINT:

The ankle, talocrural or mortice joint is a uniaxial, modified hinge synovial joint which is located between the distal ends of the tibia and fibula and superior part of the talus (Magee; 1992:448 Moore, 1999:632). These distal ends form a deep socket or mortise into which a pulley shaped trochlea (superior articular aspect) of the talus fits. The trochlea, which is approximately 2,4mm wider anteriorly and slightly concave from anterior to posterior, is wedged between the malleoli during dorsiflexion, allowing little or no inversion or eversion of the ankle joint (Magee, 1992:448; Moore, 1999:632). During plantarflexion, however, the narrower posterior trochlea lies relatively loosely within the mortice, making the ankle joint relatively unstable as a result of the increased movement.



The articular capsule of the ankle joint is a fibrous capsule, which is thin anteriorly and posteriorly and is supported on either side by strong collateral ligaments. It attaches superiorly to the borders of the tibial and malleoli articular surfaces and inferiorly to the talus (Moore, 1999:632).

The fibrous capsule is reinforced laterally by the lateral ligament (which is weaker than the medial ligament) and consists of three parts:

- The anterior talofibular ligament (ATFL)
- The posterior talofibular ligament (PTFL)
- The calcaneofibular ligament (CFL)

The stronger medial or deltoid ligament reinforces the fibrous capsule medially. It has fibres that fan out from the malleolus and attach distally to the navicular, talus and calcaneus thus forming the:

- Tibionavicular ligament
- Anterior and posterior tibiotalar ligaments
- Tibiocalcaneal ligament. (Moore, 1999:633-634)

## 2.2.2 THE SUBTALAR JOINT:

The functional unit of the ankle must include the subtalar joint, as it is here that the key motions of inversion and eversion occur (Reid, 1992:215). The subtalar joint (talocalcaneal) is found distal to the ankle joint. It is a plain synovial joint, which is formed by the articulation of the inferior surface of the body of the talus and the superior surface of the calcaneus. It is surrounded by a fibrous articular capsule, which attaches to the margins of the articular facets. Medial, lateral and posterior interosseous talocalcaneal ligaments support the weak capsule (Moore, 1999:638).

### 2.2.3 THE DISTAL TIBIOFIBULAR JOINT:

This is a fibrous (syndesmosis) joint, the integrity of which is essential for the stability of the ankle joint, as it keeps the lateral malleolus firmly against the lateral surface of the talus and the tibia. The joint is formed by the articulation of the inferior medial surface of the fibula with a facet on the inferior end of the tibia. The strong interosseous ligament forms the main connection between the tibia and fibula. The strong anterior and posterior inferior tibiofibular ligaments reinforce the joint anteriorly and posteriorly (Moore, 1999:632).

### 2.2.4 NERVE SUPPLY OF THE ANKLE JOINT:

The articular nerves of the ankle joint are derived from the tibial nerve and the deep fibular (peroneal) nerve, a division of the common fibular (peroneal) nerve (Moore, 1999:638). The distal tibiofibular joint receives additional nerve supply from the saphenous nerves (Moore, 1999:632).

### 2.2.5 MUSCLES RELATED TO THE ANKLE JOINT:

The muscles, nerve supply and the movements which they produce at the ankle joint are represented in the following table:

Muscles in the anterior compartment of the leg (Moore, 1999:577 and Bergmann et al., 1993: 635+695):

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	Dorsiflexes the ankle and

	(L5 and S1)	extends the great toe
Fibularis (peroneus) tertius	Deep fibular (peroneal) nerve (L5 and S1)	Dorsiflexes the ankle and aids in eversion of the foot

Muscles in the lateral compartment of the leg (Moore, 1999:577 and Bergmann et al., 1993:695):

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

Muscles in the posterior compartment of the leg (Moore, 1999:588-589 and Bergmann et al., 1993:695):

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

### 2.3.1 BIOMECHANICS OF THE ANKLE:

### 2.3.2 THE ANKLE JOINT:

The ankle joint is a uniaxial, modified hinge joint, with talus movement occurring primarily in the sagittal plane about the transverse axis (Bergmann et al., 1993:695). The primary movement at the ankle joint is dorsiflexion (20° to 30°) and plantar flexion (30° to 50°), although only 10° of dorsiflexion and 20° of plantar flexion are required during the normal gait pattern (Bergmann et al., 1993:695). This is in contrast to Baker and Todd (1965:61) who noted that normal dorsiflexion of the ankle joint was 15° to 20° past neutral and in agreement with Magee (1992:471), who states that for minimal normal locomotion to occur, the ankle should be able to dorsiflex 10° and plantar flex between 20° and 25°.

Thus, stability of the talocrural joint depends on the bony architecture, ligaments and musculotendinous structures (Anderson, 2002). In this respect the lateral malleolus extends more distally than the medial malleolus, thereby providing a greater barrier to lateral displacement (eversion) of the talus (Anderson, 2002). Because the trochlea of the talus is wider anteriorly than posteriorly, dorsiflexion causes the malleoli to tightly grip the trochlea as it moves posteriorly into the socket like mortise (Moore, 1999:489) Therefore stability of the ankle joint is greatest during dorsiflexion because it is in this position that the joint has a high bony stability. Further dorsiflexion or rotation in this position may result in a malleoli fracture or disruption of the mortise by tearing the interosseous membrane (Anderson, 2002).

In contrast when the ankle is plantar flexed and inverted, it is said to be in a position of low bony stability (Anderson, 2002). During this movement the trochlea of the talus moves anteriorly in the mortise, resulting in a loosened grip of the malleoli on the trochlea (Moore, 1999:489). The ligaments now have a

more significant role in providing joint stability and are more likely to be injured (Anderson, 2002). In plantar flexion, the anterior talofibular ligament assumes a vertical orientation and is the first ligament to be injured following inversion stress. If the anterior talofibular ligament fails, the calcaneofibular ligament can be sprained. The posterior talofibular ligament, which is rarely injured in isolation, can be injured in conjunction with the anterior talofibular ligament and the calcaneofibular ligament when severe injury occurs (Anderson, 2002).

The lateral ankle ligaments, namely the anterior talofibular ligament (ATFL), the calcaneofibular ligament (CFL) and the posterior talofibular ligament (PTFL) are responsible for resistance against inversion and internal rotation stresses. The ATFL resists ankle inversion in plantar flexion, and the CFL resists ankle inversion during dorsiflexion (Hockenbury and Samarco, 2001). Additional functions of the ATFL are to resist anterior talar displacement from the mortise (anterior drawer test) as well as internal rotation of the talus within the mortise. The CFL contributes to both ankle and subtalar joint stability by spanning both the lateral ankle joint and lateral subtalar joint (Hockenbury and Samarco, 2001). The PTFL whose function is to limit posterior talar displacement within the mortise, as well as external rotation, experiences greatest strain during dorsiflexion, thus it is rarely injured as the talocrural joint finds itself in the closed packed position.

The stronger, medial supporting ligaments are the superficial and deep deltoid ligaments. These are responsible for resistance to eversion and external rotation stress and are less commonly injured (Hockenbury and Samarco, 2001). The incidence of ligamentous injury tends to match both the mechanism of injury as well as ligamentous strength. The strength of ankle ligaments from weakest to strongest is ATFL, PTFL, CFL, and deltoid ligaments (Hockenbury and Samarco, 2001). Thus the most commonly sprained ligament, clinically, is the ATFL, followed by the CFL and the PTFL, which is rarely injured (Hockenbury and Samarco, 2001).

### 2.3.3 THE SUBTALAR JOINT:

The subtalar joint formed between the talus and calcaneus is also a hinge-like joint. Because the axis of movement passes through all three planes of movement, it allows for complex movements of supination (combined inversion, adduction and plantar flexion) and pronation (combined eversion, abduction and dorsiflexion) of the calcaneus on the talus (Cailliet, 1997; McDonald and Tavener, 1999; Hunt et al., 2001; Abboud, 2002). Inversion (5°) and eversion (5°) are the two main movements that occur at this joint (Bergmann et al., 1993:695). Slight gliding and rotation of the joint are responsible for this. These joint movements are also closely associated with those at the talocalcaneonavicular and calcaneocuboid joints (Moore, 1999:637). The subtalar joint works together with the ankle joint to translate rotations occurring in the tibia about the vertical axis into rotations about the sagittal axis in the foot. These coupled actions are necessary so that the rapid rotations that occur in the leg can be absorbed by a relatively fixed foot (Reid, 1992:215). During plantarflexion, the calcaneofibular ligament assumes an almost complete horizontal position, stabilizing the subtalar joint (Reid, 1992:218).

### 2.4.1 INTRODUCTION TO CHRONIC ANKLE INSTABILITY SYNDROME:

### 2.4.2 DEFINITION:

An acute (defined as that presentation within the first 48 hours (Reid, 1992:239) ankle sprain in this context is referred to as an increased degree of inversion at the subtalar joint, resulting in approximation of the medial tibial malleolus to the calcaneus as well as separation and stretching of the lateral ankle structures i.e. lateral ankle ligaments and peroneal muscles (Shapiro et al., 1994). This injury to the peroneal/fibular muscles and tendons will result in decreased effectiveness in

controlling the inversion / eversion movement at the subtalar joint (Shapiro et al., 1994). The instability and symptoms resulting from this acute injury can present later in a subacute phase (48-72 hours to 5 days later) or in the chronic phase, which presents at more than 5 days after the injury (Reid, 1992:239).

Thus the effect that the ankle sprain has on the patient experiencing further signs and symptoms is directly related to the grade of the ankle sprain initially experienced. These grades are described by Reid (1992:226) in the following manner:

SEVERITY:	PATHOLOGY:	DISABILITY:
Grade 1 – Mild	Mild stretch, no instability, single ligament involved.	No or little limp, minimal functional loss, difficulty hopping
Grade 2 – Moderate	Mild to moderate instability, complete tear of ATFL or partial tear of ATFL & CFL.	Limp with walk, inability to toe raise, inability to hop, unable to run.
Grade 3 - Severe	Significant instability Complete tear of anterior capsule and talofibular ligament and associated tear of ATFL and CFL.	Diffuse swelling both sides of Achilles tendon, Early hemorrhage May be tenderness medially and laterally Positive anterior drawer Positive varus laxity

However only the first 2 categories are pertinent to this study.

With the persistence of effects of chronic inversion ankle sprains being defined as signs and symptoms present or the inability to walk or run on uneven surfaces due to these signs and symptoms, play sports that require jumping or sudden changes of direction, loss of confidence and an increase risk of repeat injury (Hockenbury and Sammarco, 2001). In addition Reid (1992:251) is of the opinion

that the main causes for chronic symptoms following these sprains are directly related to:

- Ligament damage resulting in functional instability,
- Loss of fibular and subtalar motion (decrease range of motion),
- Restricted sensitive scar formation and
- Incomplete rehabilitation (usually lack of proprioceptive rehabilitation).

Thus in essence there is agreement between the above authors and Hertling and Kessler (1996:424-425), who go further and attribute chronic and recurrent ankle sprains to three causes:

1. Healing of the ligament with adherence to adjacent tissue (where abnormal proprioception results),
2. Loss of protective reflex muscle stabilization (due to and as a result of proprioception changes), and
3. Gross mechanical instability due to compensations for hypomobility.

Therefore for purposes of this research chronic ankle instability syndrome was defined as that syndrome which presented as a combination of the following continuing symptoms (Hertling and Kessler 1996: 424-425, Pellow and Brantingham 2001):

- Instability in one area
- Stiffness or restriction in another area
- Pain
- Crepitus
- Weakness
- Oedema



#### 2.4.3 INCIDENCE AND PREVELANCE OF CHRONIC ANKLE INSTABILITY SYNDROME:

Ankle injuries constitute 25% of all sport related injuries, including 21% to 53% of basketball injuries and 17% to 29% of all soccer injuries (Hockenbury and Samarco, 2001). According to Garrick (1977), Mack (1982), Prentice (1994), Yeung et al., (1994), Jerosh and Bischof (1996) and Lofvenberg et al., (1996), the incidence of ankle sprains has been estimated at around 16% with a prevalence range of 6% to 25% specifically for ankle inversion sprains. It has further been indicated that 20% - 30% of all acute ankle inversion sprains lead to the development of chronic instability and that there is a 30 % – 40 % increase in the recurrence of the ankle sprains. Therefore it can be seen that the incidence of chronic ankle instability syndrome is congruent with the incidence and prevalence of acute ankle injuries, which are regarded as a predisposing factor for the chronic ankle instability syndrome (Hertling and Kessler 1996: 424-425).

#### 2.5.1 PROPRIOCEPTION:

#### 2.5.2 DEFINITION:

There is considerable discrepancy in the definitions of both kinesthesia and joint position sense (JPS), as related to their physiological functions. Mountcastle and Willis (1980) (as cited in Lephart and Fu, 1995), define kinesthesia as the awareness of joint motion. Bastian (1888) (as cited in Lephart and Fu, 1995), however, defined kinesthesia as a complex of sensations including those in which movement is not featured. Sherrington (1918) (as cited in Lephart and Fu, 1995), and Deshpande et al., (2003), on the other hand, describes proprioception, as including vestibular sensations and inputs from muscles and joints that are not necessarily perceived (Lephart and Fu, 1995; Lephart, Pincivero, Rozzi, 1998). Thus for the purposes of this study proprioception was defined as:

- 1) The conscious awareness of joint position sense (JPS), limb position (Lephart and Fu, 1995 and Deshpande et al., 2003), and
- 2) Kinesthesia as the awareness of joint motion (Lephart and Fu, 1995 and Deshpande et al., 2003).

In this respect, proprioception is seen as the “perception of awareness of joint position and motion”, where proprioception forms part of the somatosensory system, which is responsible for the manifestation of proprioception. Together with the visual and vestibular systems, they are able to convey information about limb and body movement, force, pressure, tension and the movement in space that is needed for motor control (Deshpande et al., 2003). The receptors for these sensations are mechanoreceptors located in the joint capsule, ligaments, menisci, musculotendinous unit, and in the skin (Deshpande et al., 2003). These mechanoreceptors or proprioceptive organs are sensory organs that are stimulated by movement of the body. The three proprioceptive organs with which we are concerned are:

- 1) Golgi tendon organs.
- 2) Muscle spindles.
- 3) Pacinian corpuscles.

They are neurological connectors that allow your brain to know the location of each part of your body in space (Miller and Narson, 1995). They relay information to the central nervous system whenever:

- 1) There is joint movement (active or passive),
- 2) The muscles around the joint contract (concentric, eccentric, isometric, isokinetic) and
- 3) The intra-articular pressure changes (compression, distraction) (Miller and Narson, 1995).

### 2.5.3 CAUSES OF DECREASED PROPRIOCEPTION:

Impairment of proprioception has been linked to an increased age

- 1) Ligament damage
- 2) Peripheral neuropathy
- 3) Multiple sclerosis
- 4) Osteoarthritis
- 5) Chronic ankle instability as a result of repeated ankle sprains.

(Lephart and Fu, 1995 and Deshpande et al., 2003)

Being a complex system that requires integration of sensory input from many receptors, proprioception is more affected early in the disease process or through trauma (Deshpande et al., 2003).

Ligaments thus play an important role in normal joint kinematics, providing mechanical restraint to abnormal joint movement when a stress is placed on a joint. Therefore following ligamentous injury, there is an inherent loss of mechanical stability, resulting in aberrations to normal kinematics. Kennedy et al., (1982) state that in addition to their mechanical restraining function, articular ligaments also provide an important neurological feedback that directly regulates muscular reflex stabilisation about the joint. The neurological feedback for the control of muscle actions serves to protect against excessive strain on passive joint restraints and provides a prophylactic mechanism to recurrent injury. After an injury, the articular mechanoreceptors are disrupted, which inhibits neuromuscular reflex joint stabilisation and contributes to repetitive injuries on progressive decline of the joint (Lephart and Fu, 1995).

This is congruent with research aimed at determining the effects of articular musculoskeletal injury, on joint proprioception, neuromuscular control and balance, which focused on the ankle joint and demonstrated alterations in

proprioception subsequent to capsuloligamentous injury, partial restoration of proprioceptive acuity following ligamentous reconstruction, and suggested beneficial proprioceptive changes resulting from comprehensive rehabilitation programmes (Lephart, Pincivero, Rozzi, 1998). Thus proprioception and accompanying neuromuscular feedback mechanisms have been found to provide an important component for the establishment and maintenance of functional joint stability (Lephart and Fu, 1995; Lephart, Pincivero & Rozzi, 1998).

#### 2.5.4 MEASUREMENT OF PROPRIOCEPTION:

Current methods to quantify proprioception predominantly involve measurement of kinesthesia (ability to detect movement) and joint position sense (JPS); as a result a common measure of kinesthesia is the threshold for perception of slow passive movement. Whereas, JPS is assessed by determining the error associated with active or passive reproduction of a joint angle (Lephart and Fu, 1995 and Deshpande *et al.*, 2003). When kinesthesia is tested at a slow angular velocity (0.5-2.5°/s), it is thought to selectively stimulate Ruffini or Golgi-type mechanoreceptors, and because the test is performed passively, it is believed to maximally stimulate joint receptors, while minimally stimulating muscle receptors. By shutting down muscle activity, this method of measuring kinesthesia is often chosen to assess afferent activity following ligament pathology. However it has also been noted that with passively performed tests additional stimulation from cutaneous receptors, has led to interference with the degree of accuracy when try to measure kinaesthesia specifically. On the other hand JPS, which can be assessed by both active and passive positioning, is usually assessed by slow active positioning as it stimulates both joint and muscle receptors and provides a more functional assessment of the afferent pathways (Lephart and Fu, 1995).

### 2.5.5 EFFECTS OF MANIPULATION ON PROPRIOCEPTION:

Thus, with respect to chronic ankle instability syndrome and in the context of proprioception being defined as the conscious awareness of limb position and kinesthesia as the awareness of joint motion (Lephart and Fu, 1995); Kennedy et al., (1982), found that articular ligaments provide important neurological feedback that directly regulates muscular reflex stabilization about the joint, and that the neuromuscular controlling mechanism is mediated by the articular mechanoreceptors (Wyke receptors (Wyke, 1981)). These receptors thus provide the individual with the proprioceptive sensations of kinesthesia and joint position sense. The importance of proprioception in ankle sprains is explained by Miller and Narson (1995) where they state that: “When a single injury occurs, the kinetic chain is affected and proprioception is inhibited. Injury primarily occurs to the tendons and ligament structures, and therefore, impairment in proprioception is cumulative in several areas of the body after injury.”

Patterson and Steinmetz (1986) and Sandoz (1978) support Miller and Narson (1995), stating that the presence of abnormal joint mechanics will result in abnormal firing of the Wyke receptors, resulting in abnormal neuronal pool patterns and potentially resulting in altered kinesthetic / proprioceptive input into the nervous system. This abnormal neurological pattern related to the joint function, has been proposed to become the preferred pathway of neurological activity, thereby re-enforcing the abnormalcy that has been initiated. This is referred to as a “neural scar” by Patterson and Steinmetz (1986). This theory is supported in a study done by Pellow and Brantingham (2001) that was conducted on patients with subacute and chronic ankle sprains that received manipulation. The patients who received multiple manipulations improved more rapidly than the patients in the placebo group. However, it was not established in Pellow and Brantingham (2001) what the effect was with respect to multiple manipulations had as opposed to a single manipulation on the proprioception on

the foot and ankle complex and how this influences or is related to the clinical outcome of the patient's treatment.

Therefore it was proposed in this research that manipulation might provoke changes in afferent input that may restore normal proprioceptive input (Slosberg, 1988) and aid in the resolution of the patient's signs and symptoms. In addition to this, it is hypothesised that the application of multiple manipulative procedures would result in greater clinical improvement.

However in order to assess whether there is concomitant clinical improvement in the clinical parameters one would need to assess that, in addition to changes in the proprioception, there are changes in the levels of pain and range of motion.

Therefore the following sections deal with a short discussion on the how pain and range of motion are related to a chronic ankle instability syndrome and how these are affected by manipulation in order to clarify the possible relationship between these two factors and proprioception.

#### 2.5.6 EFFECTS OF MANIPULATION ON PAIN AND RANGE OF MOTION:

Wyke (1981) described four types of mechanoreceptors and pain receptors namely:

- Type I receptors: These are thinly encapsulated corpuscles, which are located in the articular capsule and fat pads. They are slowly adapting, low threshold static and dynamic mechanoreceptors, whose pattern of discharge signal intra articular pressure changes, joint position sense and the velocity, direction and amplitude of joint movement.
- Type II receptors: These are thickly encapsulated corpuscles, which are also located in the articular capsule. Although being low threshold, they

- are however rapidly adapting, dynamic receptors, which are totally inactive at rest and function to signal joint acceleration and deceleration.
- Type III receptors: These being the largest corpuscles are confined to the joint ligaments. They are very slow adapting, high threshold mechanoreceptors, which only become active when considerable stresses are generated on the joint ligaments, towards extreme ranges of motion.
  - Type IV receptors: These are pain receptors and nociceptors which comprise the plexuses and free nerve endings which are present in the articular capsule, fat pads, ligaments and walls of blood vessels. They have a higher threshold but do not adapt, remaining entirely inactive in normal circumstances, but become very active when the articular tissues are subject to marked mechanical deformation and direct or chemical irritation (Leach, 1994: 90).

During an adjustment, according to Sandoz (1978), the rapid acceleration of the joint movement and the phenomenon of cavitation accompanied by a sudden change in the intra-articular pressure is thought to intensely stimulate the Type I and Type II mechanoreceptors. Additional stimulation of the Type III receptors, which are located in the ligaments, occurs when there is sudden stretching of the ligaments at the barrier of anatomical resistance (Sandoz, 1978 and Wyke, 1981).

Type IV receptors, which convey pain, tend to be inhibited by the volley of impulses from the mechanoreceptors. Therefore, a decrease in pain should occur (Sandoz, 1978 and Wyke, 1981), as the volley of mechanoreceptor impulses tends to inhibit the input coming through the Type IV receptors, which convey pain (Melzack and Wall, 1965 and Bennett, 2005). In addition, stimulation of the type III mechanoreceptors by sudden stretching of the ligaments is probably more efficient for pains of a moderate intensity and of a chronic character than for acute pains (Sandoz, 1978).

In addition to this the mechanoreceptors around the joint (talocrural joint) demonstrate different adaptive properties based on their response to a continuous stimulus. Quick adapting (QA) mechanoreceptors, such as the Pacinian corpuscle, decrease their discharge rate to extinction within milliseconds of the onset of a continuous stimulus. Slow-m adapting (SA) mechanoreceptors, such as the Ruffini ending, Ruffini corpuscles and the Golgi tendon-like organ, continue their discharge in response to a continuous stimulus. QA mechanoreceptors are very sensitive to changes in stimulation and are therefore, thought to mediate the sensation of joint motion. Different populations of SA mechanoreceptors are maximally stimulated at specific joint angles, and thus a continuum of SA receptors is thought to mediate sensation of joint position and change in joint position (Lephart and Fu, 1995).

Thus the effect of manipulation, as proposed by Sandoz (1978) and Patterson and Steinmetz (1986) is that the presence of abnormal joint mechanics will result in abnormal firing of the Wyke receptors, resulting in abnormal neuronal pool patterns. These abnormal neurological patterns become ingrained within the neurological system with increased time of abnormalcy. This is referred to as a “neural scar” (Patterson and Steinmetz, 1986). Lephart and Fu (1995) concur that a decrease in sensory input from joint receptors can lead to abnormal body positioning and decreased postural reflex responses leading to an increased probability of re-injury (Hertling and Kessler, 1996:423).

Therefore, it is proposed that manipulation provokes changes in afferent input that may restore normal proprioceptive input (Slosberg, 1988). This is supported by Pellow and Brantingham (2001) and Needham (2001), who found that manipulation of the ankle, is beneficial in terms of range of motion when treating inversion ankle sprain patients. As a result of the above studies (Pellow and Brantingham 2001 and Needham, 2001), it stands to reason that inferences were made based on the effect on the same (ipsilateral) side as the intervention. This is supported by Pellow and Brantingham (2001) who concluded



that patients with subacute and chronic ankle sprains that received manipulation improved more rapidly, in terms of pain and range of motion, than the patients in the placebo group.

## 2.6 CONCLUSION:

Thus, in conclusion, it could be stated that in patients with chronic ankle instability syndrome which is characterised by a combination of the following:

- Instability
- Pain
- Crepitus
- Weakness
- Stiffness
- Oedema

Thus, it is hypothesised that manipulation would have a beneficial effect in respect of proprioception, pain and range of motion (ROM) thereby restoring the normalcy of the joint and decreasing the likelihood of re-injury.

In terms of proprioception, literature shows that input from increased ROM, would assist with proprioception increase sensitivity (as a result of the manipulation). In addition it could be stated that multiple manipulations have a greater neurological effect as a result of the cumulative effect of multiple manipulations on neurological scar development (Patterson and Steinmetz, 1986) in chronic ankle instability syndrome.

Therefore, this research was aimed at determining the short and intermediate effect of manipulation on chronic ankle instability syndrome and whether a single treatment was as effective as multiple treatments in chronic ankle instability syndrome patients in terms of objective clinical findings.

## CHAPTER THREE:

### MATERIALS AND METHODS:

#### 3.1 INTRODUCTION:

This chapter includes:

- a. A detailed description of the design of the study.
  - 1) Including a description of the criteria for inclusion or exclusion of patients.
- b. The interventions used for the study.
  - 1) Including a description of each treatment group
- c. The methods employed in data collection.
- d. The statistical methods used for the analysis and interpretation of the data will also be discussed.

#### 3.2 DESIGN:

This study was a prospective, controlled clinical assessment of the short and intermediate effect of single and multiple manipulations on chronic ankle instability syndrome.

#### 3.3 ADVERTISING:

Advertisements informing the public about the study were placed in newspapers, at the Durban Institute of Technology campus and at various sporting clubs and sporting events (Appendix A). Word of mouth was also used to inform the general public. The participants all had to reside in the Kwa-Zulu Natal Province.

#### 3.4.1 SAMPLING METHOD:

Participants were obtained by means of a convenience sampling method.

#### 3.4.2 SAMPLING ALLOCATION:

All participants accepted into the study were randomly divided into two equal groups. The participants accepted were randomly assigned numbers 1 – 30, by drawing numbers out of an envelope. The odd numbers fell into group 1 (control group) and the even numbers into group 2 (ankle manipulation group).

#### 3.4.3 SAMPLING SIZE:

In studies done by Pellow and Brantingham (2001) and Bellingham (2001) only thirty participants were required, therefore this study included a minimum of two groups, with fifteen participants in each group.

#### 3.5 PATIENT SCREENING:

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. In this telephonic discussion the participants were asked four questions to determine if the patient could be eligible for the study. These questions were:

- 1) How old are you?
- 2) How long ago did you sprain your ankle?
- 3) How many times in the past two years have you sprained your ankle?
- 4) Have you ever seriously injured or broken a bone in the foot or ankle that has been sprained?

Participants successfully complying with this interview were evaluated at an initial consultation, at which the patient received a letter of information (Appendix B) and was then asked to sign an informed consent form (Appendix C) explaining the study and allowing them to withdraw at any time from the study. At this consultation a diagnosis was also made based on a case history (Appendix D), relevant physical examination (Appendix E) and foot and ankle regional examination (Appendix F) for the following inclusion and exclusion criteria:

#### INCLUSION CRITERIA:

- 1) Participants had to be between the ages of 25 and 45 years of age, which fell within the recommended age group of 15 to 50 years, by Pellow and Brantingham (2001). The limitation or decrease in age group in this study facilitated increased population group homogeneity (Mouton, 1996:137), by excluding persons that were not skeletally mature (Kuhns *et al.*, 2003) and those that had early onset degeneration in the foot and ankle complex (Yochum and Rowe, 1996:827-828).
- 2) The diagnosis for this study was based on the history of the most recent sprain and any continuing symptoms of:
  - Instability
  - Pain
  - Crepitus
  - Weakness
  - Stiffness
  - OedemaIf 4 out of 6 of the above symptoms were experienced, then it was taken that the participant had chronic ankle instability syndrome (Hertling and Kessler, 1983:424-425 and Pellow and Brantingham, 2001).
- 3) Participants presenting with two or more ankle sprains in the last 2 years (Goldie *et al.*, 1994 and Reid, 1996:226).

- 4) The participants had to have had an ankle sprain at least five days prior to the consultation (Pellow and Brantingham, 2001), having had the acute signs and symptoms abate.
- 5) The participants had to have had an ankle sprain no more than two years prior to the consultation (Goldie et al., 1994), and these ankle sprains had to conform to Reid's (1996:226) grade I and II sprains as indicated below:

Grade 1 – Mild	No hemorrhage, minimal swelling, point tenderness, no anterior drawer, no varus laxity
Grade 2 – Moderate	Some hemorrhage, localized swelling, margins of Achilles tendon less defined, may be anterior drawer, no varus laxity.

- 6) The mechanism of injury had to involve weight-bearing on an inverted foot (Goldie et al., 1994).

#### EXCLUSION CRITERIA:

1. Any participants who had previously sustained major soft tissue injuries or ankle or foot fractures in the affected ankle (Slatyer et al., 1997).
2. Participants who were taking any medications or undergoing any other modes of treatment for their ankle injury (Pellow and Brantingham, 2001).
3. Participants who were showing signs of gross mechanical ankle instability (grade III ankle sprain) and syndesmosis injury were excluded (Reid 1992:226; Pellow and Brantingham, 2001).

Grade 3 – Severe	Diffuse swelling both sides of Achilles tendon, early hemorrhage, may be tenderness medially and laterally, positive anterior drawer, positive varus laxity.
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Reid (1992:226)

4. The participants who had an ankle sprain at least five days prior to the consultation but still presented with acute signs and symptoms were excluded (Pellow and Brantingham, 2001).
5. Participants who demonstrated any relative or absolute contraindications to manipulative therapy on the basis of case history, physical examination and foot and ankle examination (Pellow and Brantingham, 2001; Bergmann et al., 1993:132-133).

Those participants who were rejected from the study i.e. those who did not meet the inclusion criteria were referred to other interns in the Chiropractic Day Clinic for treatment of their presenting condition.

### 3.6.1 INTERVENTION FREQUENCY:

Those accepted (30) underwent six consultations - five treatments and one follow up.

In previous research involving the foot and ankle joints, treatment regimes had varied from 8 treatments in 4 weeks i.e. 2 per week (Pellow and Brantingham, 2001), to four treatments in 3 weeks (2:1:1 ratio) (Blake, 2003) each with a follow up one week later.

Thus in order to standardise the treatment protocol, yet be able to attain maximum clinical outcome, the treatment frequency for this study was:

Week 1 – 2 treatments

Week 2 – 2 treatments

Week 3 – one treatment

Week 4 – one treatment

Week 5 – follow up without treatment.

### 3.6.2 INTERVENTION METHOD:

Having received a single manipulation, the first group (the control group) did not receive anymore treatment -instead only the previously mentioned measurements were taken at selected intervals to compare a single manipulation of the talocrural joint to multiple manipulation protocols.

The second group received treatments by a mortice separation adjustment. This Chiropractic technique involved setting the ankle up in dorsiflexion and eversion before a long axis thrust was applied (Kirk, Lawrence and Valvo, 1991:155 and Bergmann et al., 1993:704-706). This was to minimise trauma to the already compromised integrity of the lateral ligament complex of the already injured ankle as indicated in the treatment of subacute inversion ankle sprains (Kirk, Lawrence and Valvo, 1991:155 and Bergmann et al., 1993:704-706).

### 3.7.1 DATA COLLECTION FREQUENCY:

Data collection took place:

Prior to the first, fourth, sixth and at the follow-up consultation.

### 3.7.2 DATA COLLECTION INSTRUMENTS:

The instruments to be used for measurement in the study:

a) Objective Data:

1) Proprioception:

Inability in repositioning the ankle (subtalar joint) between the set readings and the repositioning by the participant was detected by using the Saunders digital Inclinator (The Saunders Group Inc., available from <http://www.thesaundersgroup.com/index.asp?PageAction=VIEWPROD&ProdID=13>). Using this method the Inclinator was able to detect the degree of inclination of the foot (subtalar joint). This reading was then be subtracted from the set point (preset by the researcher) to determine the error in repositioning – thus this was utilised as a means of measuring the participant's ability to actively reproduce ankle joint position in each of the following positions Gross (1987), Burke et al., (1988), Thelen et al., (1998) and Deshpande et al., (2003):

- a) 5 degrees of plantarflexion
- b) 10 degrees of plantarflexion
- c) 5 degrees of dorsiflexion
- d) 5 degrees of inversion

Procedure that was utilised:

- ❖ Inclinator was set to a neutral position (90 degrees).
- ❖ The participant was asked to actively move their ankle through their available ROM.
- ❖ The participant was then asked to position the foot so as to reach the preset positions (indicated above).



- ❖ At this point the participant was stopped.
- ❖ The participant then had to concentrate on this position for 5 seconds.
- ❖ The foot was then actively moved through its full range of motion.
- ❖ Thereafter the patient was requested to return to the learned position.
- ❖ This position was attained through active movement by the patient according to Deshpande et al., (2003), which was supported by Konradsen, Raven and Sorenson (1993).
- ❖ Data was collected when the participant indicated they had reproduced the position.

The absolute difference between the preset position and learned position was calculated in order to gauge improvement Gross, (1987) and Thelen et al., (1998).

## 2) Range of motion:

The point of reference was 90 degrees of dorsiflexion, which was set as a zero point on the inclinometer, the participant was then asked to move through full plantarflexion followed by dorsiflexion and inversion. The examiner recorded the readings at the end of the above mentioned (3) ranges of motion.

## 3) Point tenderness:

The Algometer (a force dial manufactured by Wagner Instruments: P.O.Box 1217, Greenwich, CT06836, USA) was used to compare measurements of point tenderness over the antero-lateral ligament (talofibular ligament), which was most commonly injured and would thus be most tender (Hertling and Kessler, 1996:421). This area had been chosen to rule out any periosteal tenderness (which may have occurred in places overlying bone) as the Algometer was originally designed to

measure soft tissue injuries (Fischer, 1986) and as such the device was utilized according to the guidelines as prescribed by Fischer (1986).

The NRS pain rating scale was also used to assess the participants' pain (Bolton and Wilkinson, 1998).

### 3.8 DATA ANALYSIS:

Data was captured in MS Excel and imported into SPSS version 11.5 (as supplied by SPSS Inc., Marketing Department, 444 North Michigan Avenue, Chicago, Illinois, 606611) for analysis.

Descriptive statistics were performed using frequency distribution tables, various graphs and charts such as the bar and pie charts and appropriate measures of central location and dispersion such as the arithmetic mean and standard deviation. Inferential statistics were parametric statistics because of the relatively normal distribution of the dependant variables. Continuous variables were analysed using appropriate paired and un-paired T-tests. The level of significance for all tests were  $P= 0,05$  or a confidence interval of 95 percent.

Cross-sectional analysis: Pearson's chi square tests or Fisher's exact tests were used as appropriate to compare categorical variables between groups. Students' t-tests were used to compare quantitative variables between two independent groups. ANOVA, with Bonferroni post hoc tests, was used to compare quantitative variables between more than two independent groups, and Pearson's correlation was used to assess relationships between quantitative variables. Inclinator measurements were expressed as degrees of error.

Longitudinal analysis: Repeated measures ANOVA were used to assess changes over the 4 time points in measurements and to assess whether these

changes were related to the treatment group. Statistically significant group time interactions indicated a treatment effect. A significance level of 0.05 was used.

## CHAPTER FOUR:

### STATISTICAL METHODS, RESULTS AND DISCUSSION:

4.1 This chapter will present and discuss the following:

- Introduction.
- Demographic analysis by group.
- Cross-sectional analysis associated between demographics and baseline measurements.
- Longitudinal analysis: inter-group analysis.
- Intra-group correlations.
- Summary of results.

4.2 INTRODUCTION:

Thirty participants were selected for this study.

The participants were randomised into two equal groups: a control group and an adjustment group. There were no statistically significant differences between the two groups in terms of demographic characteristics (Table 1).

4.3 DEMOGRAPHICS BY GROUP:

According to Garrick (1977), Mack (1982), Prentice (1994), Yeung et al., (1994), Jerosh and Bischof (1996) and Lofvenberg et al., (1996), the incidence of ankle sprains has been estimated at around 16% with a prevalence range of 6% to 25% specifically for ankle inversion sprains. It has further been indicated that 20% - 30% of all acute ankle inversion sprains lead to the development of chronic instability and that there is a 30 % – 40 % increase in the recurrence of the ankle sprains. Therefore it can be seen that the incidence of chronic ankle instability syndrome is congruent with the incidence and prevalence of acute

ankle injuries, which are regarded as a predisposing factor for the chronic ankle instability syndrome (Hertling and Kessler 1996: 424-425).

The study consisted of 9 (30%) females and 21 (70%) males. This is consistent with the gender distribution of 63% males and 37% females seen by Pellow and Brantingham (2001), no further literature reviewed indicated the male: female ratio of presentation in the South African context. The mean age the sample was recorded as 31.73 years (SD 5.5), with the total ages range from 25 to 43 years. Yeung et al., (1994), had an average age of 24.57 (range 13-47) with Pellow and Brantingham (2001) indicating the majority of participants in their study being less than 24 years of age even though the mean attained was mean 24.9 years. In congruence with these statistics Needham (2001) showed a mean age of 29.63 with a range from 15 years to 50 years of age. A further study by Deshpande et al., (2003) indicated that ankle sprains were commonly present in their three allocated age groups, which ranged from 25 years of age to 75 years of age. Therefore it would be fair to state that the statistics presented for the 2 groups in this study are reflective of the norm as indicated in the statistics described above.

Furthermore, the majority (n=18, 60%) were Caucasian (see Figure 1). The demographics as represented by the study are not congruent with current demographic profile as defined by <http://www.statssa.gov.za/census2001/digiAtlas/index.html> (2005).

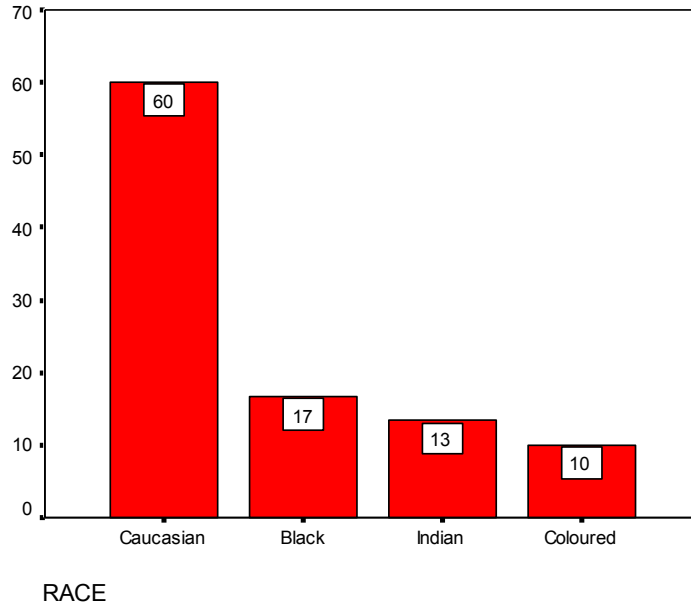


Figure 1: Racial distribution of study participants (n=30)

It would seem that the majority had injured their ankles in sports-related injuries like soccer and rugby (see Figure 2), which is in congruence with Hockenbury and Samarco (2001) who noted that ankle injuries constitute 25% of all sport related injuries. Of these 21% to 53% were related to basketball injuries and 17% to 29% of all soccer injuries (Hockenbury and Samarco, 2001).

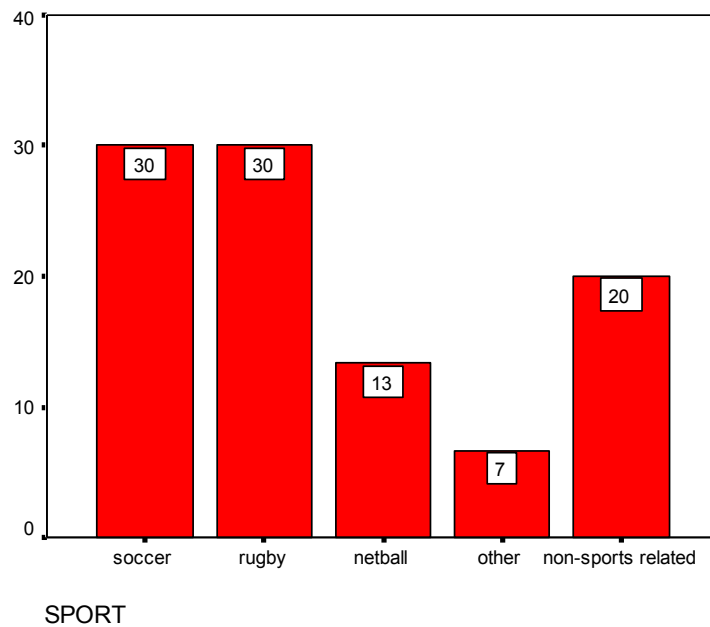


Figure 2: Sports played by study participants (n=30)

It would seem that the right ankle was the most commonly affected side in study participants, as shown in Figure 3. Yeung et al., (1994), in their epidemiological survey of ankle sprains indicated that of 139 unilateral injuries 36.6% of participants reported that the injured leg was the dominant limb, as opposed to the 15.3% that reported the non-dominant limb being affected. Thus the results obtained in this study are congruent with the norms as indicated by Yeung et al., (1994).

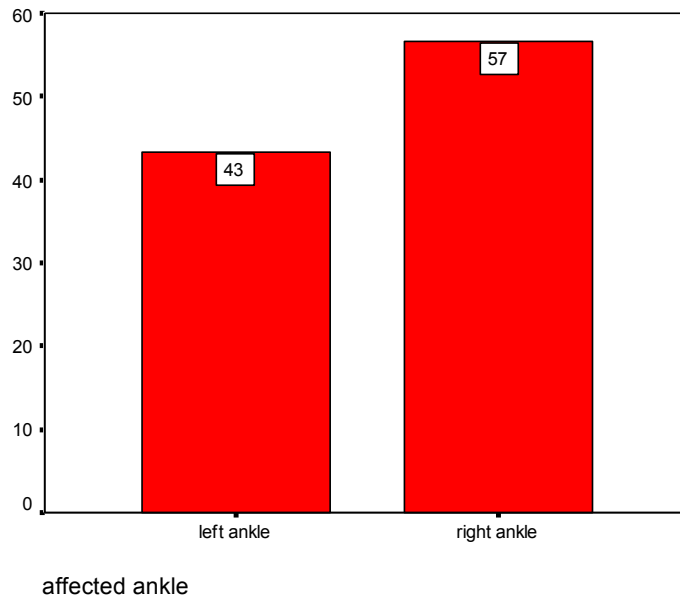


Figure 3: Side of affected ankle in study participants (n=30)

Table 1: Demographic characteristics by treatment group

		GROUP						p value
		control			adjustment			
		Count	Row %	Mean (SD)	Count	Row %	Mean (SD)	
GENDER	Male	12	57.1%		9	42.9%	0.427	
	Female	3	33.3%		6	66.7%		
ETHNICITY	Caucasian	8	44.4%		10	55.6%	0.502	
	Indigenous Africans	4	80.0%		1	20.0%		
	Indian	2	50.0%		2	50.0%		
	Coloured	1	33.3%		2	66.7%		
SPORT	Soccer	6	66.7%		3	33.3%	0.276	
	Rugby	5	55.6%		4	44.4%		
	Netball	0	.0%		4	100.0%		
	Other	1	50.0%		1	50.0%		
	Non-sports related	3	50.0%	3	50.0%			
Affected ankle	Left ankle	8	61.5%	5	38.5%	0.462		
	Right ankle	7	41.2%	10	58.8%			
AGE				31 (5.7)		32 (5.5)	0.605	

In summary, it can be seen that the 2 groups are homogenous with respect to:

- Ethnicity with the exception of the indigenous Africans,
- Sport with the exception of soccer and netball and
- Age

In respect of the affected ankle and gender, there is less of a homogeneity, which could result in outcomes bias. Therefore, these differences were controlled for in the analysis of the groups.

As a result of the randomisation of participants into each of the groups, the participant spread in terms of gender, ethnicity, sport and affected ankle could



not be controlled, but in these circumstances it can be stated that the homogeneity attained was acceptable.

#### 4.4.0 CROSS-SECTIONAL ANALYSIS ASSOCIATION BETWEEN DEMOGRAPHICS AND BASELINE MEASUREMENTS:

##### 4.4.1 GENDER:

Independent t-tests were used to compare the measurements at baseline between males and females. Only Algometer and NRS measurements differed between the genders significantly (See Table 2). For Algometer readings, the baseline mean was higher in males than females ( $p = 0.040$ ), while for NRS the mean was higher in females ( $p = 0.010$ ).

Table 2: Baseline comparison of measurement means between males and females

	SEX	N	Mean	Std. Deviation	Std. Error Mean	p value
Algometer	male	21	8.086	2.5670	.5602	0.040*
	female	9	5.633	3.4728	1.1576	
NRS	male	21	7.42	1.951	.426	0.010*
	female	9	9.31	.848	.283	
Plantarflexion 5° error	male	21	2.81	1.569	.342	0.194
	female	9	3.56	.882	.294	
Plantarflexion 10° error	male	21	3.29	1.901	.415	0.505
	female	9	2.78	1.856	.619	
Dorsiflexion error	male	21	1.71	1.309	.286	0.120
	female	9	2.56	1.333	.444	
Inversion error	male	21	5.52	5.202	1.135	0.880
	female	9	5.22	4.353	1.451	
ROM plantarflexion	male	21	46.95	9.749	2.127	0.238
	female	9	42.00	11.608	3.869	

ROM dorsiflexion	male	21	14.62	5.723	1.249	0.903
	female	9	14.33	6.042	2.014	
ROM inversion	male	21	20.95	4.213	.919	0.093
	female	9	15.44	8.443	2.814	

- statistically significant at 0.05 level

#### 4.4.2 ALGOMETER:

The Algometer was applied in the manner as described by Fischer (1986) over the region of the ATFL. This area had been chosen to rule out any periosteal tenderness (which may have occurred in places overlying bone) as the Algometer was originally designed to measure soft tissue injuries (Fischer, 1986).

In the results as indicated above (table 2), it would seem that the trend indicated as significant was that of the differences between the male and female readings, with the females showing a decreased ability to absorb pressure as resulted from applying the Algometer.

This could indicate that the females either had (Chesterton *et al.*, 2003):

- Increased sensitivity in the area tested (over the ATFL)
- Decreased pain threshold
- Increased percentage of acute injury within the group of females as compared to the males in the study, thereby skewing the results in favour of a decreased Algometer reading for the females. This is also referred to as the outlier effect (Mouton, 1996:143)

It is further noted that the readings as found in this study could be the norm, as found in a study by Fischer (1986), where the readings attained by Fischer (1986) also indicated a slightly lower average reading for females as compared to males whilst he assessed the reliability of the pressure threshold Algometer.

#### 4.4.3 NRS:

The NRS is a subjective tool for the capturing of pain, whereby the participant scored their pain out of 10, with 10 being the worst pain that they experienced at the time of reading.

It could be assumed that the readings as reported for the Algometer would correlate with the readings the NRS as both in effect measure pain rating (Fischer, 1986 and Bolton and Wilkinson, 1998). This is apparent from the readings in table 2 where the difference between male and female average readings are indicated as  $p = 0.010$ .

None of the other readings were significant which implies that the 2 groups showed a homogenous baseline in terms of Plantarflexion 5° error, Plantarflexion 10° error, Dorsiflexion error, Inversion error, ROM plantarflexion, ROM dorsiflexion and ROM inversion.

#### 4.4.4 ETHNICITY:

Table 3 shows that there was a significant difference overall between the ethnicity groups for dorsiflexion error ( $p = 0.041$ ), with the only specific significant comparison between caucasians and coloureds ( $p = 0.030$ ). Inversion error was also significantly different between the racial groups at baseline ( $p < 0.001$ ) with coloureds being significantly different to all other ethnicity groups.

Table 3: ANOVA table for comparison of baseline measurements between ethnicity groups

	F	p value	Post hoc comparisons
Algometer	.621	.608	N/A
NRS	.290	.832	N/A
Plantarflexion 5° error	.281	.839	N/A
Plantarflexion 10° error	2.010	.137	N/A
Dorsiflexion error	3.180	.041*	Caucasian vs. coloured p =0.030
Inversion error	11.568	<0.001*	Caucasian vs. coloured p<0.001 Indigenous African vs. coloured p = 0.035 Indian vs. coloured p =0.011
ROM plantarflexion	.317	.813	N/A
ROM dorsiflexion	.653	.588	N/A
ROM inversion	.288	.834	N/A

From the above table it can be seen that the Algometer, NRS, range of motion (plantarflexion, dorsiflexion and inversion) and inclinometer readings for 5° and 10° plantarflexion, were not identified as significant when pitted against ethnicity.

It must be noted that the primary movement at the ankle joint is dorsiflexion (20° to 30°) and plantar flexion (30° to 50°), although only 10° of dorsiflexion and 20° of plantar flexion are required during the normal gait pattern (Bergmann et al., 1993:695). This is in contrast to Baker and Todd (1965:61) who noted that normal dorsiflexion of the ankle joint was 15° to 20° past neutral and in agreement with Magee (1992:471), who states that for minimal normal locomotion to occur, the ankle should be able to dorsiflex 10° and plantar flex between 20° and 25°. This would be applicable to all ethnic groups and therefore no difference would be expected.

It is however evident that there is a difference in terms the error (dorsiflexion and plantarflexion) at baseline between the ethnic groups. This could be due to:

- The relative sample size – whereby there are 18 Caucasian, 5 Indigenous African, 4 Indian and 3 Coloured participants, indicates that the averages obtained for each group is relative to the number of participants in that group. Thus the outlier effect becomes more predominant in groups where the numbers are smaller and the regression to the mean is not the mean for the group as a whole (as obtained by a larger more representative sample) (Mouton 1996:143).
- Number of injuries and their grades (as per Reid, 1992) and the respective ratios / percentages within each of the groupings that these injuries constituted. This could make a difference in the healing time or stage of healing (Lachmann and Jenner, 1994:28 and Kellett, 1986 (in Norris, 1998:37)) and affect the degree of accuracy (proprioception), thereby affecting the readings obtained in this study.

#### 4.4.5 SPORT:

Table 4: ANOVA table for comparison of baseline measurements between sports

	F	p value
Algometer	2.655	.057
NRS	1.039	.407
Plantarflexion 5° error	1.040	.406
Plantarflexion 10° error	.412	.798
Dorsiflexion error	1.297	.298
Inversion error	1.883	.145
ROM plantarflexion	2.371	.080
ROM dorsiflexion	.842	.512
ROM inversion	1.255	.314

Table 4 shows that sport played did not significantly influence any of the baseline measurements.

There was no significant association between the sport played and the baseline measures as indicated above, which indicated that this factor did not need to be taken into consideration for purposes of further statistical analysis.

It is however noted that sport, (like soccer and rugby) was almost significant in respect of the reported Algometer readings. This tends to support the hypothesis the degree of ankle sprain could be related to the sport (Hockenbury and Sammarco, 2001).

#### 4.4.6 AGE:

Table 5: Correlation between age and baseline measurements

		AGE
Algometer	Pearson Correlation	-.152
	p value	.424
NRS	Pearson Correlation	.126
	p value	.506
Plantarflexion 5° error	Pearson Correlation	.348
	p value	.060
Plantarflexion 10° error	Pearson Correlation	.161
	p value	.396
Dorsiflexion error	Pearson Correlation	.152
	p value	.424
Inversion error	Pearson Correlation	.166
	p value	.381
ROM plantarflexion	Pearson Correlation	-.066
	p value	.730
ROM dorsiflexion	Pearson Correlation	-.004
	p value	.983
ROM inversion	Pearson Correlation	.126
	p value	.509

Table 5 shows Pearson’s correlation coefficients between age and baseline measurements. There were no significant correlations, thus age did not influence the baseline measurements.

However it is noted that there are negative correlations between

- Age and Algometer

This asserts that with increasing age there is a decrease in the pressure (kg/cm<sup>2</sup>) that the participant can tolerate or alternatively an increase in pain (Duarte, et al., 1999).

- Age and plantarflexion range of motion
- Age and dorsiflexion range of motion

This relationship asserts that with increased age there is a corresponding decrease in the range of motion within the joint, thereby affecting the overall range of motion within the talocrural joint. This is supported by Anderson (2002), where he indicates that long-term complications of untreated ankle sprains will at first lead to instability and then arthritis and degeneration and disability. This mirrors the process as described by Kirkaldy – Willis and Burton (1992:105-119) with respect to the spine, whereby the joints in the spine undergo a gradual process of dysfunction, instability and stabilisation that results in decreased movement within the stabilisation phase.

#### 4.4.7 AFFECTED ANKLE:

Table 6: Baseline comparison of measurements between affected ankles

	affected ankle	N	Mean	Std. Deviation	Std. Error Mean	p value
Algometer	left ankle	13	7.708	3.1561	.8753	0.581
	right ankle	17	7.076	2.9968	.7268	
NRS	left ankle	13	7.75	2.062	.572	0.561
	right ankle	17	8.17	1.805	.438	
Plantarflexion 5° error	left ankle	13	3.08	1.605	.445	0.887
	right ankle	17	3.00	1.323	.321	

Plantarflexion 10° error	left ankle	13	3.46	1.808	.501	0.410
	right ankle	17	2.88	1.933	.469	
Dorsiflexion error	left ankle	13	2.23	1.301	.361	0.358
	right ankle	17	1.76	1.393	.338	
Inversion error	left ankle	13	4.31	4.479	1.242	0.278
	right ankle	17	6.29	5.145	1.248	
ROM plantarflexion	left ankle	13	46.31	10.696	2.966	0.706
	right ankle	17	44.82	10.442	2.532	
ROM dorsiflexion	left ankle	13	15.38	5.938	1.647	0.485
	right ankle	17	13.88	5.633	1.366	
ROM inversion	left ankle	13	19.77	5.449	1.511	0.724
	right ankle	17	18.94	6.869	1.666	

The side of the affected ankle did not influence baseline measurements significantly, as shown in Table 6. Homogeneity between sides indicates that the sides are comparable in terms of baseline readings; therefore any comparisons that will be made with respect to the ankle improvement will be comparable between sides (Mouton, 1996:138)

#### 4.5 LONGITUDINAL ANALYSIS- INTER-GROUP ANALYSIS:

##### 4.5.1 ALGOMETER:

Since baseline Algometer measurements were affected by gender, gender was controlled for in the multivariate analysis for Algometer measurements.

Table 7 shows that the effect of time was significant ( $p < 0.001$ ), but there was no significant time\*group interaction ( $p = 0.223$ ). Thus the adjusted group was not significantly better than the control group. Examination of Figure 4 shows that both groups increased over time, but the adjusted group increased at a slightly faster rate than the control group. This indicates a non-significant trend towards a treatment effect, and lack of statistical power through a small sample size could be the reason this did not achieve statistical significance.



Table 7: Repeated measures ANOVA effects for Algometer

Effect	Statistic	p value
Time	Wilk's lambda 0.281	<0.001
Group	F = 1.035	0.318
Time*group	Wilk's lambda 0.846	0.223

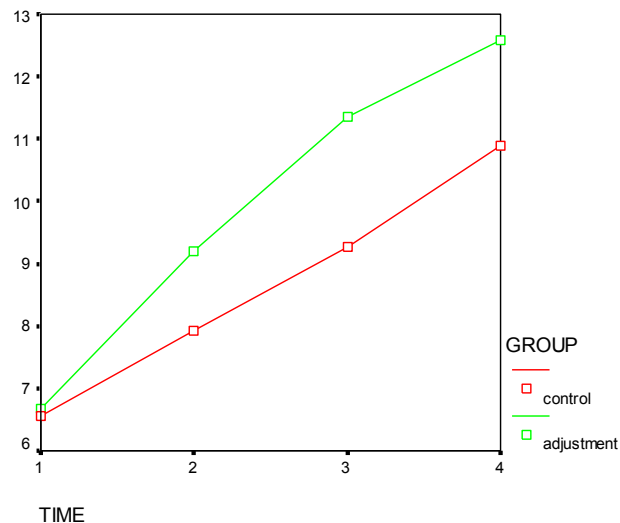


Figure 4: Profile plot of mean Algometer measurement over time by treatment group

#### 4.5.2 NRS:

Gender was also controlled for in this analysis.

Table 8 shows that there was a highly significant time effect ( $p < 0.001$ ) and a significant group effect for NRS ( $p = 0.006$ ). However, there was no time by group interaction ( $p = 0.191$ ). This means that the NRS scores changed significantly over time irrespective of group and at all time points there was a significant difference between the two groups (this does not mean a treatment effect). Figure 5 shows that both groups showed a mean decrease over time and the slopes of the lines in the two groups were approximately parallel, thus both groups improved at the same rate.

Table 8: Repeated measures ANOVA effects for NRS

Effect	Statistic	p value
Time	Wilk's lambda 0.097	<0.001
Group	F = 8.8	0.006
Time*group	Wilk's lambda 0.823	0.191

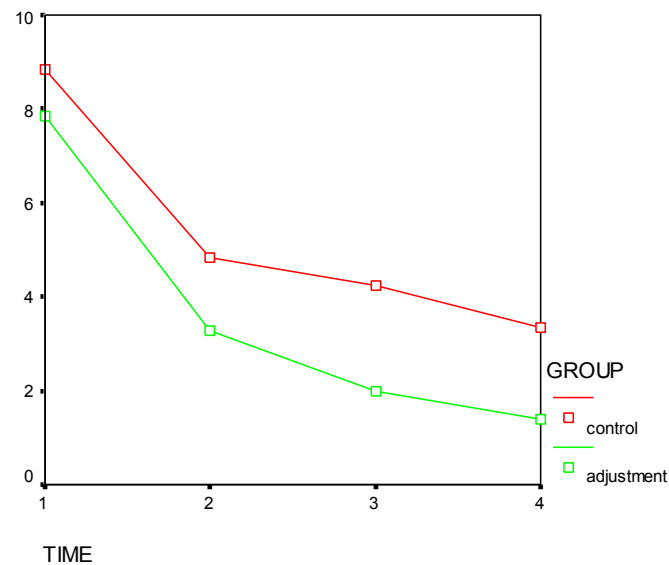


Figure 5: Profile plot of mean NRS score over time by treatment group

The figures 4 and 5 above will be discussed below.

The Algometer was used to compare measurements of point tenderness over the ATFL, which was most commonly injured and would thus be most tender (Hertling and Kessler, 1996:421). This area had been chosen to rule out any periosteal tenderness (which may have occurred in places overlying bone) as the Algometer was originally designed to measure soft tissue injuries (Fischer, 1986). The NRS pain rating scale was also used to assess the participants' pain (Bolton and Wilkinson, 1998).

With respect to figure 4 and the Algometer readings, it can be seen that there was a significant time effect, which indicates that both the groups improved significantly with time when compared with the baseline readings for each group.

It would be expected that the participants in both groups would improve, as they both received at least one treatment in the form of a long axis manipulation.

The manipulation should have resulted in one or more of the following

(Bergmann et al., 1993:123+125):

- Induction of motion (range of motion) within a restricted joint
- Improvement of alignment
- Improvement of the quality of movement
- Breaking of adhesions within a joint that is not overtly painful
- Resulting in pain relief, inhibition of muscle guarding and promotion of flexible healing, in joints with acute pain (Melzack and Wall, 1965)

However the effect of the single manipulation on the control group would have been diminished over time (Patterson and Steinmetz 1986, as cited in Leach, 1994:99-101), as the abnormal learned neurological and physiological pathways, would influence the return of the locomotor patterns (around the talocrural joint) to the patient's previously learned abnormal state (i.e. post injury).

This return to the learned abnormal state however is not the case in the multiple manipulation group where the repeated manipulations allow for increased return to the neurological and physiological normal states, by consistently -

- Inducing increased range of motion, promoting normal alignment within the talocrural joint, improving the quality of movement as well
- Breaking down of adhesions (as a result of prior injury) and
- Resulting in pain relief, inhibition of muscle guarding and promotion of flexible healing, in joints with acute pain (Bergmann et al., 1993:123+125 and Melzack and Wall, 1965)

This would allow for sustained effects of normal gait and locomotor patterns which would assist in “unlearning” the learned abnormal patterns as suggested by Patterson and Steinmetz (1986) (as cited in Leach, 1994:99-101).

These assertions are further supported by the NRS readings where it was found that there was both a significant increase with time and with group. This indicates that the patients experienced the effects of the “gate control theory” (Melzack and Wall, 1965) where the benefits of the increase Wyke receptor stimulation (Wyke, 1981) would reduce the peripheral input of pain and hence revert the cycle into a positive healing and restoration mode as opposed to a chronic negative disability mode (Anderson, 2002).

#### 4.5.3 PLANTARFLEXION 5° ERROR:

There was a significant treatment effect for plantarflexion 5° error ( $p < 0.001$ ). Figure 6 shows that the adjustment group experienced a decrease in error over time while the control group showed an increase. Thus the adjustment significantly improved this outcome.

Table 9: Repeated measures ANOVA effects for Plantarflexion 5° error

Effect	Statistic	p value
Time	Wilk's lambda 0.702	0.025
Group	F = 21.144	<0.001
Time*group	Wilk's lambda 0.710	0.029

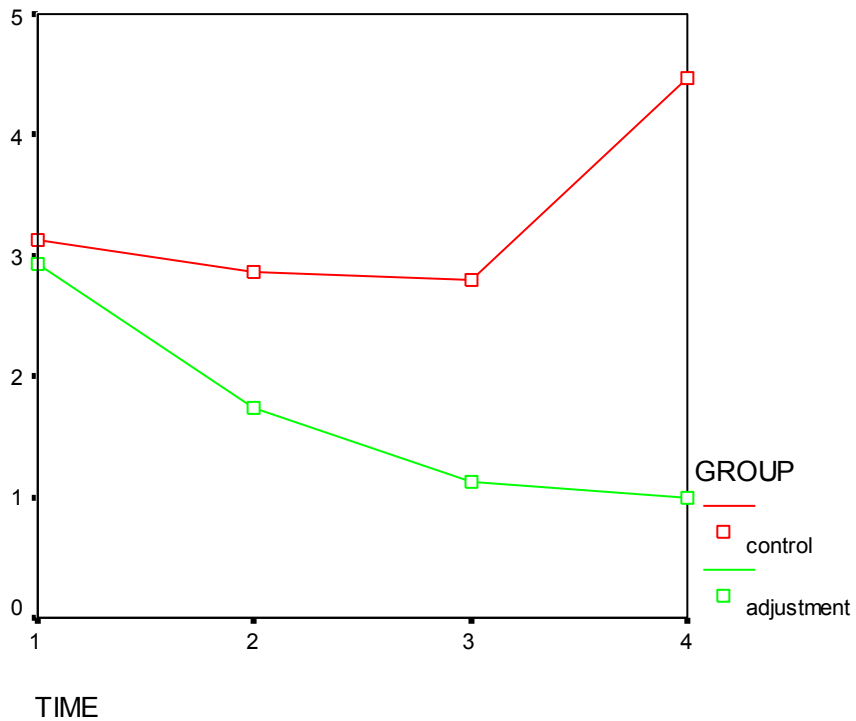


Figure 6: Profile plot of mean plantarflexion 5° error over time by treatment group

#### 4.5.4 PLANTFLEXION 10 ° ERROR:

Although there was no statistical evidence of treatment effect for this outcome, the profile plot in Figure 7 shows that the adjustment group experienced a decrease in error over time while the control group showed an increase. This may have become statistically significant if the study had more power.

Table 10: Repeated measures ANOVA effects for Plantarflexion 10° error

Effect	Statistic	p value
Time	Wilk's lambda 0.943	0.670
Group	F = 14.73	0.001
Time*group	Wilk's lambda 0.857	0.251

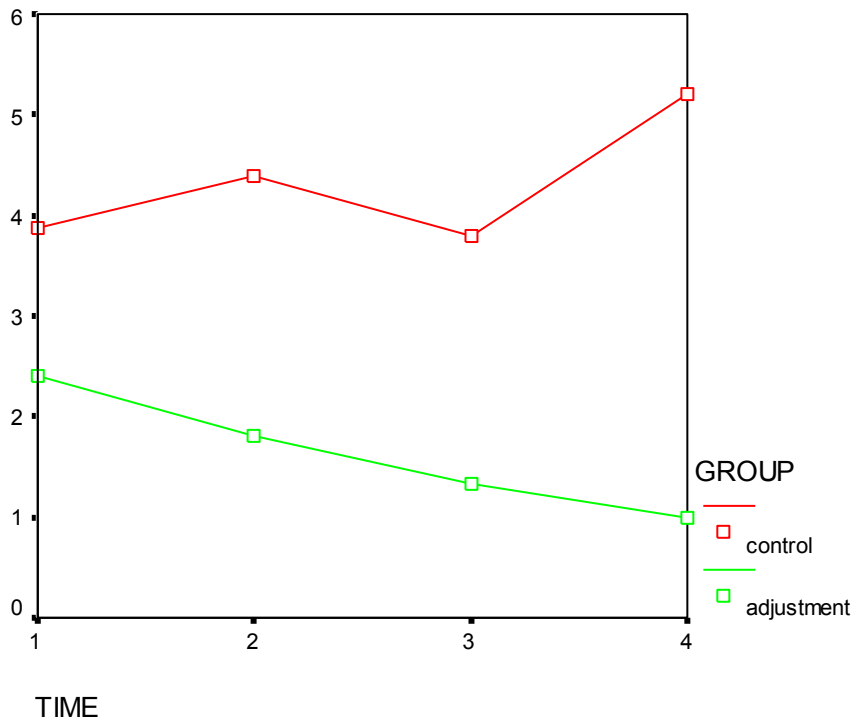


Figure 7: Profile plot of mean plantarflexion 10° error over time by treatment group

The degree of error was measured by setting the Inclinator to a neutral position (90 degrees). Then at each of these points (5° plantarflexion and 10° plantarflexion) the participant was stopped, and asked to concentrate on this point for 5 seconds. Thereafter the participant was asked to actively move their ankle through their available ROM. Thereafter the patient was requested to return to the learned position. The absolute difference between the preset position and learned position was calculated in order to gauge improvement Gross, (1987) and Thelen et al., (1998).

From the above figures (6 and 7), it can be seen that for 5° there was a significant effect in terms of the group that received multiple manipulations over the study period, whereas the group who received only one manipulation over the study period actually significantly increased their degree of error with time.

From an anatomical point of view Bergmann et al., (1993:707) notes that in an inversion sprain, the plantarflexion range of motion is the least affected range of motion when a patient has had an inversion sprain. Therefore it would stand to reason that this is the movement that would most speedily recover and show definitive signs of improvement to an intervention, whether it be a single or multiple manipulation.

However, since proprioception is a complex manoeuvre that is carried out by more than a single set of receptors (Wyke, 1981), the pure anatomical rationale cannot in itself explain the difference between the groups. It would be more plausible that repetitive stimulation of these receptors would induce a larger improvement, as the recurrent positive stimulation as well as the removal of inhibitors (scars) (Bergmann et al., 1993:123+125) would allow for improved movement facilitating and promoting normal healing (Lachmann and Jenner, 1994:28 and Kellett, 1986 (in Norris, 1998:37)). These combined efforts would in reasonably allow for the multiple manipulation group to improve over the single manipulation group.

This conforms to the theory presented by Patterson and Steinmetz (1986) (as cited in Leach, 1994:99-101), where multiple interventions would lead to an improved clinical outcome in the patient as opposed to a single intervention.

Therefore the outcome of this portion of the study would indicate that for treatment purposes in the restoration of normal plantarflexion as well as normal proprioceptive abilities in plantarflexion, that the patient undergoes a course of treatments. This may be further enhanced by additional proprioceptive retraining during the course of applied manipulative interventions in order to aid proprioceptive healing. However this remains untested and would require further research.

#### 4.5.5 DORSIFLEXION ERROR:

There was no significant treatment effect for dorsiflexion ( $p = 0.279$ ), however, Figure 8 indicates a trend towards an overall decrease in error in the adjustment group and no change in the control group. Ethnicity was controlled for in this analysis.

Table 11: Repeated measures ANOVA effects for Dorsiflexion error

Effect	Statistic	p value
Time	Wilk's lambda 0.900	0.538
Group	F = 4.6	0.043
Time*group	Wilk's lambda 0.829	0.279

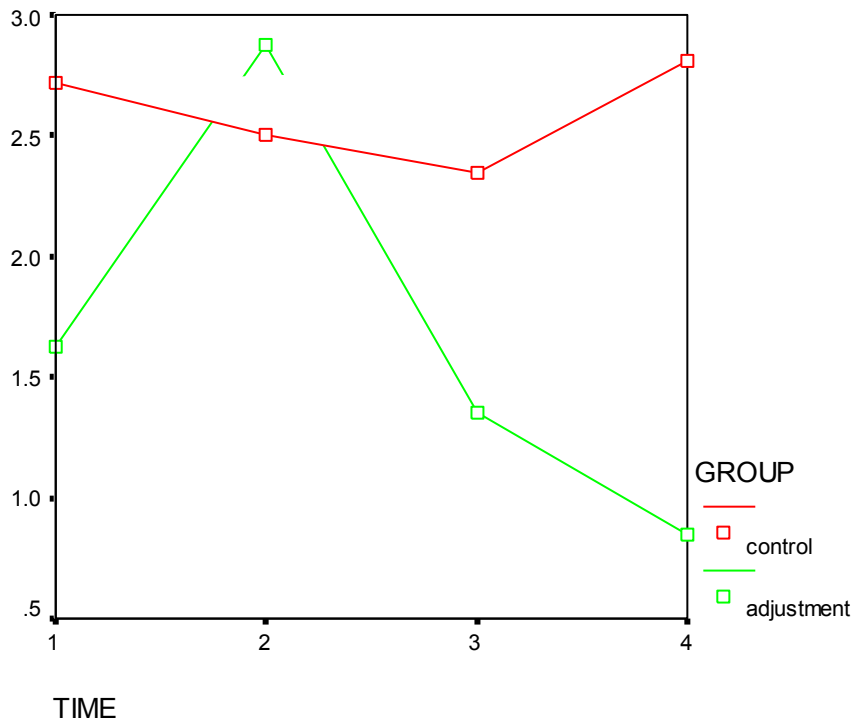


Figure 8: Profile plot of mean dorsiflexion error over time by treatment group



Following an ankle sprain, there is commonly a loss of dorsiflexion, as a result of the talar dome not being able to fully lock into the ankle mortise; thus resulting in loss of bony stabilization during movement (Bergmann et al., 1993:700, Pellow and Brantingham, 2001 and Anderson, 2002). With the decrease in dorsiflexion having been identified as the principle motion in which restriction is noted (anatomically and due to the presence of adhesions) and at which more than 6 manipulative techniques are directed (Bergmann et al., 1993:702-710), it would indicate that the degree of restriction is able to prevent the full stretch of the PTFL (posterior talofibular ligament) as well as the posterior capsule of the talocrural joint (Hockenbury and Sammarco, 2001). With these structures being one of the limiting factors in dorsiflexion, their functions are also to act as proprioceptive transducers (Wyke, 1981). This function would be obviated in the instance where decreased dorsiflexion is found (i.e. post an inversion ankle sprain).

Thus, according to Patterson and Steinmetz (1986) (as cited in Leach, 1994:99-101), several manipulations may need to address the range of motion first before the effects on the proprioceptive transducers becomes apparent, as they will only fire when placed under tension or are activated by movement. This movement (dependant on the degree of dorsiflexion restriction) would therefore indicate that the patients' improvement in the dorsiflexion error would only become apparent after several interventions.

This would be congruent with the results found in the study where patients showed an increased error at the second reading and then showed a steady improvement.

#### 4.5.6 INVERSION ERROR:

There was a significant treatment effect for inversion error ( $p = 0.047$ ). Figure 9 shows that while both groups decreased in error over time, the adjustment group showed a steeper rate of decrease. Ethnicity was controlled for in this analysis.

Table 12: Repeated measures ANOVA effects for inversion error

Effect	Statistic	p value
Time	Wilk's lambda 0.443	0.001
Group	F = 2.76	0.111
Time*group	Wilk's lambda 0.678	0.047

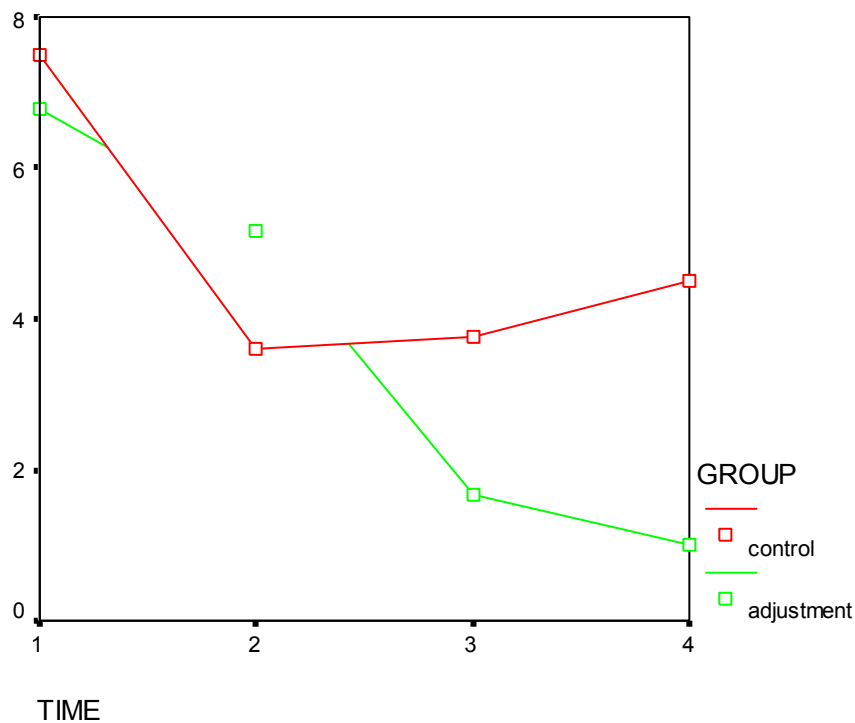


Figure 9: Profile plot of mean inversion error over time by treatment group

It is argued that the parameters for the outcome of this variable conforms to the argument as put forward for the plantarflexion improvements noted earlier with respect to the improvement in the degree of error in the multiple manipulation group versus the single manipulation group.

#### 4.5.7 ROM PLANTARFLEXION:

There was a borderline significant treatment effect for this outcome ( $p = 0.064$ ). Figure 10 shows that the adjustment group increased over time at a slightly faster rate than the control group, and the control group overall showed a decrease from their baseline level.

Table 13: Repeated measures ANOVA effects for ROM plantarflexion

Effect	Statistic	p value
Time	Wilk's lambda 0.649	0.010
Group	F = 0.333	0.568
Time*group	Wilk's lambda 0.760	0.064

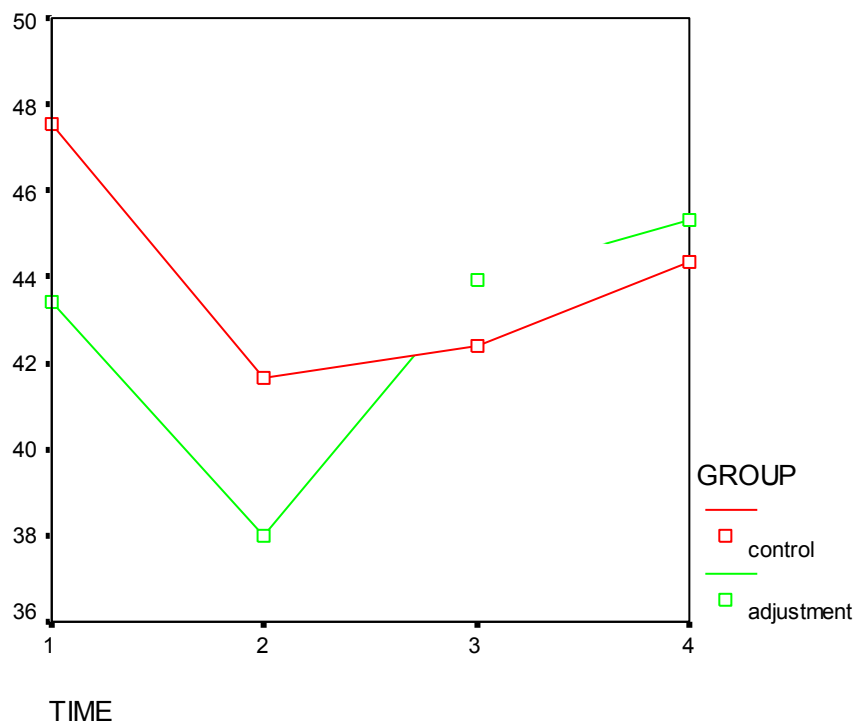


Figure 10: Profile plot of mean ROM plantarflexion over time by treatment group

#### 4.5.8 ROM DORSIFLEXION:

ROM dorsiflexion showed a significant treatment effect ( $p = 0.028$ ). Figure 11 shows that the adjustment group experienced a steep increase in values over time while the control group showed a very slight increase over time.

Table 14: Repeated measures ANOVA effects for ROM Dorsiflexion

Effect	Statistic	p value
Time	Wilk's lambda 0.602	0.004
Group	F = 6.004	0.021
Time*group	Wilk's lambda 0.709	0.028

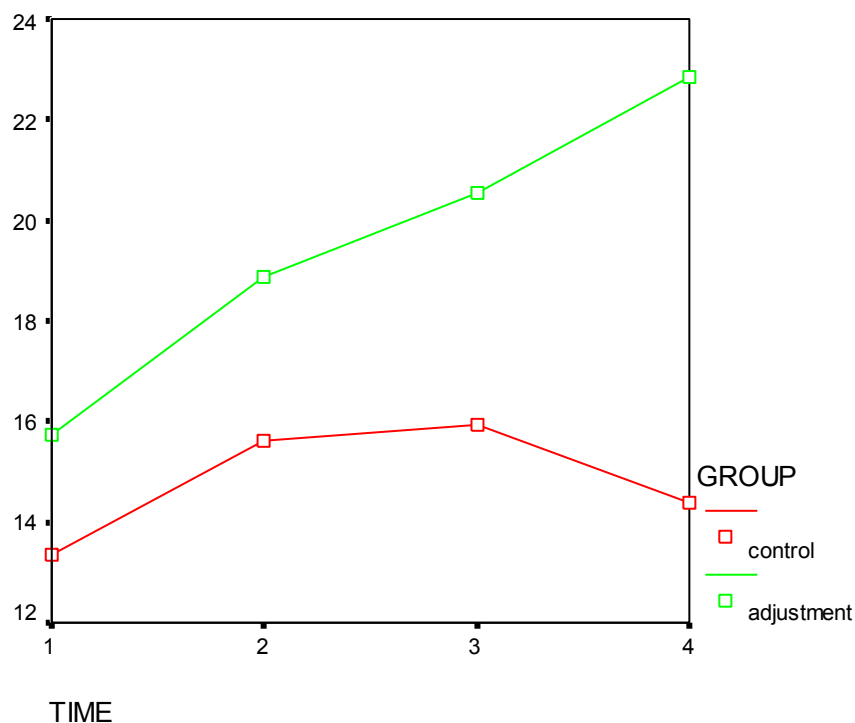


Figure 11: Profile plot of mean ROM dorsiflexion over time by treatment group

To note the functional movement of the ankle, the primary movement at the ankle joint is dorsiflexion ( $20^\circ$  to  $30^\circ$ ) and plantarflexion ( $30^\circ$  to  $50^\circ$ ), although only  $10^\circ$  of dorsiflexion and  $20^\circ$  of plantarflexion are required during the normal gait

pattern (Bergmann et al., 1993:695). This is in contrast to Baker and Todd (1965:61) who noted that normal dorsiflexion of the ankle joint was 15° to 20° past neutral and in agreement with Magee (1992:471), who states that for minimal normal locomotion to occur, the ankle should be able to dorsiflex 10° and plantar flex between 20° and 25°.

It is noted in figure 10 that in terms of the plantarflexion that:

- The treatment group decreased in plantarflexion followed by a consistent increase beyond the initial plantarflexion reading (i.e. baseline reading)
- The control group decreased in plantarflexion followed by a steady increase, which resulted in a final reading lower than the baseline reading.

These results suggest that the treatment group initially decreased in plantarflexion range of motion, which is in keeping with the increased firing of the proprioceptive transducers within and around the talocrural joint. This would account for the body's natural ability to reactively decrease the range of motion to within normal parameters, which would be closer to the 30° norm (Bergmann et al., 1993:695). However repeated manipulations seem to induce a greater instability as with follow up readings the plantarflexion progresses steadily towards and then past the baseline reading. This could be as a result of the decreased protective muscle spasm in the peroneii (Korr, 1975 as cited in Leach, 1994:98-99) as well as increased mobility within the talocrural joint as a result of the manipulation (Pellow and Brantingham, 2001 and Bergmann et al., 1993:123+125). It was also anecdotally noted that patients reported a feeling of increased "instability" in the multiple manipulation group, which concurs with the findings (figure 10) and suggestions that the patients seemed to gain increased plantarflexion range motion.

It is therefore suggested that patients receiving multiple manipulations in order to restore proprioception would need to receive further proprioceptive retraining and

/ or muscle strengthening (especially with respect to the peroneii muscles). This, however, would need to be tested with further research.

On the other hand it could also be argued that the single manipulation group would improve further, both proprioceptively and with respect to range of motion, if they were given an initial manipulation followed by proprioceptive retraining and / or muscular strengthening in order to retain the benefits of the single manipulation.

Arguably each approach could have the same clinical outcome, however this remains untested.

With respect to dorsiflexion, there has been an association between the presence of decreased range of motion in long axis and dorsiflexion (Pellow and Brantingham, 2001), which is supported by Baker and Todd (1995) who indicate that there is a decrease in the movement in the talar dome posteriorly, which does not allow for the 2 ranges of motion. When manipulating the talocrural joint it would therefore stand to reason that the restoration of normal talar dome motion within the talocrural joint would allow for increased range of motion in long axis and dorsiflexion movements. This is congruent with the findings in this study. Furthermore, this study indicated that there is a progressive improvement in the multiple manipulation group which is not seen in the single manipulation group. This could indicate that there is a need for:

- Breaking of adhesions within the affected joint (Bergmann et al., 1993: 123+125)
- Multiple manipulations in restoring joint congruency (Bergmann et al., 1993: 123+125)

or

- Multiple manipulations in order to restore normal functional properties to the muscles acting on the talocrural joint (Korr, 1975 as cited in Leach,

1994:98-99) and the ligaments (and their proprioceptive transducers) responsible for controlling movement at the talocrural joint (Wyke, 1981).

#### 4.5.9 ROM INVERSION:

For this outcome neither of the groups showed any improvement. The adjustment group decreased until time 3 and then showed a steep increase to time 4, but overall not much change from baseline. The control group showed a decrease, which levelled off until time 4 (See Figure 12). Thus there was no treatment effect for this outcome.

Table 15: Repeated measures ANOVA effects for ROM Inversion

Effect	Statistic	p value
Time	Wilk's lambda 0.907	0.458
Group	F = 0.019	0.893
Time*group	Wilk's lambda 0.942	0.666

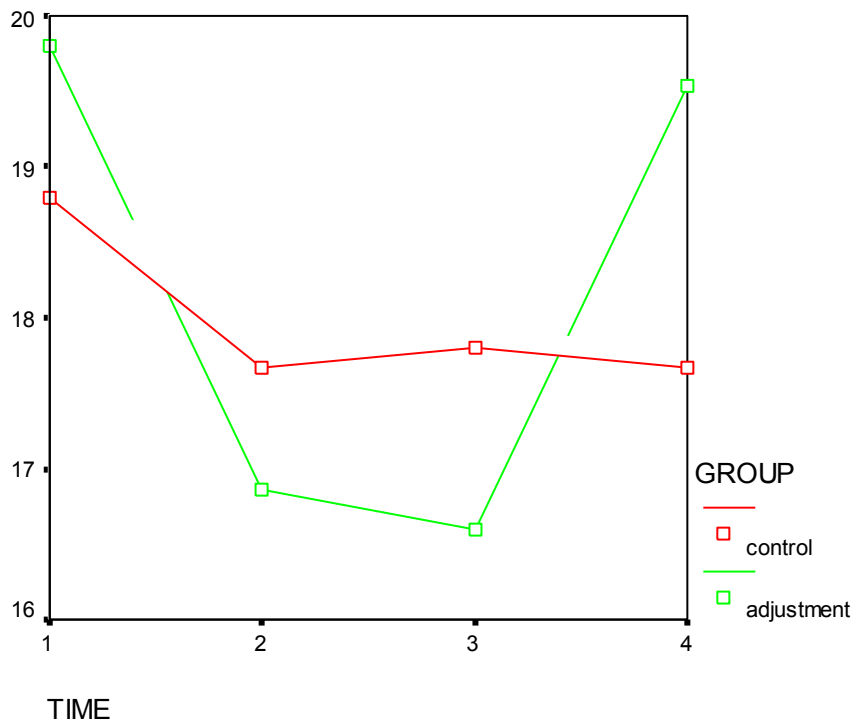


Figure 12: Profile plot of mean inversion error over time by treatment group

It would seem feasible that the argument as suggested for plantarflexion is applicable for inversion.

#### 4.6 INTRA-GROUP CORRELATIONS:

##### 4.6.1 ADJUSTMENT GROUP:

Table 16 shows the correlations between changes over the four time points in the various measurements in the adjustment group. There were a number of significant correlations. Algometer changes were positively correlated with plantarflexion 10° error ( $r=0.598$ ,  $p = 0.018$ ). NRS was significantly negatively correlated with ROM dorsiflexion ( $r = -0.548$ ,  $p = 0.035$ ). Plantarflexion 5° error was significantly correlated with plantarflexion 10° error ( $r=0.757$ ,  $p =0.001$ ) and with dorsiflexion error ( $r=0.625$ ,  $p =0.013$ ). Plantarflexion 10° error was significantly correlated with dorsiflexion error ( $r=0.583$ ,  $p =0.023$ ). ROM inversion and inversion error were significantly negatively correlated ( $r = -0.538$ ,  $p = 0.038$ ).

##### 4.6.2 CONTROL GROUP:

Table 17 shows the correlations within the control group. The only significant correlation was between plantarflexion 10 o error and ROM plantarflexion ( $r = 0.547$ ,  $p = 0.035$ )



Table 16: Pearson's correlation between changes in measurements in the adjustment group

		algometer	NRS	Plantarflexion 5° error	Plantarflexion 10° error	Dorsiflexion error	Inversion error	ROM plantarflexion	ROM dorsiflexion	ROM Inversion
Algometer	Pearson Correlation	1	.106	.388	.598(*)	.456	.158	.121	.104	-.079
	Sig. (2-tailed)	.	.708	.153	.018	.088	.574	.668	.712	.779
NRS	Pearson Correlation	.106	1	.146	.308	-.100	.249	-.180	-.548(*)	-.241
	Sig. (2-tailed)	.708	.	.603	.264	.722	.370	.520	.035	.386
Plantarflexion 5° error	Pearson Correlation	.388	.146	1	.757(*)	.625(*)	.036	-.087	.176	-.294
	Sig. (2-tailed)	.153	.603	.	.001	.013	.898	.757	.532	.288
Plantarflexion 10° error	Pearson Correlation	.598(*)	.308	.757(*)	1	.583(*)	.264	.046	-.152	-.413
	Sig. (2-tailed)	.018	.264	.001	.	.023	.341	.870	.589	.126
Dorsiflexion error	Pearson Correlation	.456	-.100	.625(*)	.583(*)	1	-.175	.213	.357	-.411
	Sig. (2-tailed)	.088	.722	.013	.023	.	.532	.446	.191	.128
Inversion Error	Pearson Correlation	.158	.249	.036	.264	-.175	1	-.277	-.296	-.538(*)
	Sig. (2-tailed)	.574	.370	.898	.341	.532	.	.318	.284	.038
ROM plantarflexion	Pearson Correlation	.121	-.180	-.087	.046	.213	-.277	1	-.034	.450
	Sig. (2-tailed)	.668	.520	.757	.870	.446	.318	.	.905	.092
ROM dorsiflexion	Pearson Correlation	.104	-.548(*)	.176	-.152	.357	-.296	-.034	1	.011
	Sig. (2-tailed)	.712	.035	.532	.589	.191	.284	.905	.	.968
ROM inversion	Pearson Correlation	-.079	-.241	-.294	-.413	-.411	-.538(*)	.450	.011	1
	Sig. (2-tailed)	.779	.386	.288	.126	.128	.038	.092	.968	.

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

Principle outcome:	Relationship:	Dependant outcome:	Description:
Plantarflexion 10° error	Positive	Algometer	With increased plantarflexion error, there is an indication that there has been serious disruption of the proprioceptive transducers and the ligaments in which they have been housed. The Algometer therefore could have measured increased sensitivity over the point of measure and then re-measure, thus resulting in a decreased Algometer reading (i.e. It was more painful). This pain could have been related to the degree of injury. This hypothesis needs further testing. There is a decrease in error (post treatment) in both the plantarflexion 5° and plantarflexion 10°, therefore indicating a positive relationship; figure 6 and 7 respectively.
	Positive	Plantarflexion 5° error	
Dorsiflexion error	Negative	NRS	With increased restriction in dorsiflexion as a result of the inversion sprain injury (Baker and Todd, 1995), the likelihood that the patient was able to estimate the dorsiflexion reading would be greater, thereby decreasing the dorsiflexion error, yet this does not mean that there would be a decrease in pain, to the contrary an increase in pain may be present. There is a decrease in both the plantarflexion 5° error and plantarflexion 10° error along with a increase in dorsiflexion, therefore indicating a positive relationship. Figure 6 and 7 and 8 as part of the chronic ankle instability syndrome in this study concur with this finding.
	Positive	Plantarflexion 5° error	
	Positive	Plantarflexion 10° error	
Inversion error	Negative	Dorsiflexion error	With increased inversion error, there is a decreased dorsiflexion error as a result of the decreased dorsiflexion with an increased degree of inversion sprain (Pellow and Brantingham, 2001); this will result in less range of motion in which the patient has the ability to estimate the initial reading (i.e. the “learned reading”).

ROM plantarflexion	Negative	Plantarflexion 5° error	With an inversion ankle sprain there could be a decrease in ROM plantarflexion, (associated with reflex muscle spasm of the peroneii muscles (Hertling and Kessler, 1996: 424-425), however there is a resultant increase in plantarflexion 5° error and inversion error, which is due to derangement in the ligaments (ATFL and CFL) and therefore proprioceptive transducers. In order to stabilise for this deranged proprioception the peroneii stabilise the talocrural joint.
	Negative	Inversion error	
ROM dorsiflexion	Negative (significant)	NRS	With decrease in dorsiflexion, the following occurred: An increased NRS, as a result of the pain being related to the restricted range of motion or the inversion sprain injury. An increased plantarflexion 10° error as this is associated with decreased proprioceptive ability as a result of ATFL disruption (Pellow and Brantingham, 2001 and Hockenbury and Sammarco, 2001). An increased inversion error (Bergmann <u>et al.</u> , 1993:700) as this is associated with decreased proprioceptive ability. An increased ROM plantarflexion (Bergmann <u>et al.</u> ), this is associated with an inversion range of motion.
	Negative	Plantarflexion 10° error	
	Negative	Inversion error	
	Negative	ROM plantarflexion	
ROM inversion	Negative	Algometer	With increased inversion the following occurred: A decreased Algometer because of increased pain as a result of the dysfunction (Fischer, 1986). A decreased NRS may have been as a result of the repeated manipulations, which stimulated the Wyke receptors (Wyke, 1981), yet resulting in the associated reported feelings of excessive
	Negative	NRS	
	Negative	Plantarflexion 5° error	
	Negative	Plantarflexion 10° error	
	Negative	Dorsiflexion error	

	<p>Negative (significant)</p>	<p>Inversion error</p>	<p>movement by the patients (Melzack and Wall, 1965), which would stimulate the gate control theory. Based on the results of this study the indication would be that for any increased inversion ROM, there would be a decreased ability to attain preset positions, thereby increasing the plantarflexion 5° and 10° error. However it could also be stated that with repeated manipulation the stimulation of the proprioceptors results in the restoration of normal proprioception even though there may be an increase in joint motion as a result of the manipulation (as expressed anecdotally by the patients). With inversion error the same argument as above holds (i.e. plantarflexion error) With respect to the dorsiflexion error changes, any increase in the inversion associated with an inversion sprain, could possibly lead to associated decreases in dorsiflexion range of motion (Baker and Todd, 1995), thereby yielding a smaller range of movement from which the patient has to choose to return to the pre-learned position. Thereby a decrease in error could be noted.</p>
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Table 17: Pearson's correlation between changes in measurements in the control group

		algometer	NRS	Plantarflexion 5° error	Plantarflexion 10° error	Dorsiflexion error	Inversion error	ROM plantarflexion	ROM dorsiflexion	ROM Inversion
Algometer	Pearson Correlation	1	.455	.209	.033	.386	.267	-.150	.421	.036
	Sig. (2-tailed)	.	.088	.455	.907	.156	.335	.594	.119	.899
NRS	Pearson Correlation	.455	1	.254	-.314	.351	.243	.029	.166	.076
	Sig. (2-tailed)	.088	.	.360	.254	.200	.383	.919	.554	.787
Plantarflexion 5° error	Pearson Correlation	.209	.254	1	.227	-.113	-.188	-.177	-.094	-.024
	Sig. (2-tailed)	.455	.360	.	.417	.688	.503	.528	.738	.931
Plantarflexion 10° error	Pearson Correlation	.033	-.314	.227	1	.245	-.106	.547(*)	.030	-.245
	Sig. (2-tailed)	.907	.254	.417	.	.380	.708	.035	.914	.380
Dorsiflexion Error	Pearson Correlation	.386	.351	-.113	.245	1	.441	.267	.294	-.061
	Sig. (2-tailed)	.156	.200	.688	.380	.	.100	.336	.288	.829
Inversion Error	Pearson Correlation	.267	.243	-.188	-.106	.441	1	-.009	-.074	.022
	Sig. (2-tailed)	.335	.383	.503	.708	.100	.	.974	.793	.938
ROM plantarflexion	Pearson Correlation	-.150	.029	-.177	.547(*)	.267	-.009	1	.176	-.113
	Sig. (2-tailed)	.594	.919	.528	.035	.336	.974	.	.530	.688
ROM dorsiflexion	Pearson Correlation	.421	.166	-.094	.030	.294	-.074	.176	1	.300
	Sig. (2-tailed)	.119	.554	.738	.914	.288	.793	.530	.	.278
ROM inversion	Pearson Correlation	.036	.076	-.024	-.245	-.061	.022	-.113	.300	1
	Sig. (2-tailed)	.899	.787	.931	.380	.829	.938	.688	.278	.

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

Principle outcome:	Relationship:	Dependant outcome:	Description:
Plantarflexion 10° error	Negative	NRS	An increased plantarflexion 10° error and a decrease in NRS due to the effects of the manipulation increasing range of motion (Bergmann <i>et al.</i> , 1993: 123) with associated decrease in pain (Wyke, 1981 and Melzack and Wall, 1965).
Dorsiflexion error	Negative	Plantarflexion 5° error	An increase in dorsiflexion error should be associated with a decrease in plantarflexion, as the normalisation post manipulation occurs with respect to the range of motion within the talocrural joint (Bergmann <i>et al.</i> , 1993:123+125).
Inversion error	Negative	Plantarflexion 5° error	As inversion error increases it would seem from this association that there is a decrease in the plantarflexion error (5° and 10°). However this is contrary to the literature where there is an association between increased ROM in both plantarflexion and inversion, which should increase the error for both movements (Bergmann <i>et al.</i> , 1993:700).
	Negative	Plantarflexion 10° error	
ROM plantarflexion	Negative	Algometer	Increased ROM plantarflexion, which is associated with a decreased Algometer reading, could be explained in the context of increased pain with increased instability and mechanical changes within the talocrural joint. Associated with an increase in plantarflexion 10° error, which is expected as the proprioceptive transducers in the ATFL and CFL are no longer able to monitor movement patterns as accurately (Hockenbury and Sammarco, 2001). Which is associated with a decreased plantarflexion error at 5° could not be explained in the context of this research, as it has been shown previously that the effects on plantarflexion should affect both plantarflexion readings. Associated with a decrease inversion error is not within the literature norm (Bergmann <i>et al.</i> , 1993:695+700), where plantarflexion and inversion are linked movements and the effects on plantarflexion should be mimicked in inversion.
	Negative	Plantarflexion 5° error	
	Positive	Plantarflexion 10° error	
	Negative	Inversion error	

ROM dorsiflexion	Negative	Plantarflexion 5° error	A decreased dorsiflexion ROM resulted in: Increased plantarflexion 5° error, due to increased movement in the talocrural joint allowing for a greater degree of freedom in both plantar and dorsiflexion, thereby making the patients task of attaining the reposition positions more difficult. Decreased inversion error due to muscle spasm in the peroneii muscles (Hertling and Kessler, 1996: 424-425).
	Negative	Inversion error	
ROM inversion	Negative	Plantarflexion 5° error	An decreased ROM inversion resulted as a result of increased peroneii spasm (Hertling and Kessler, 1996: 424-425) in order to stabilise an injured or unstable ankle, does not preclude that there would be an increase in the following degrees of error, which represent the dysfunction of the proprioceptive transducers (principally found in the injured AFTL and CFL): Increased plantarflexion 5° error increased plantarflexion 10° error increased dorsiflexion error increased plantarflexion would be associated with the above as it is an inevitable consequence of an ankle inversion sprain (Bergmann <u>et al.</u> , 1993:700) Increased ROM plantarflexion
	Negative	Plantarflexion 10° error	
	Negative	Dorsiflexion error	
	Negative	ROM plantarflexion	

#### 4.7 SUMMARY OF RESULTS:

The adjustment group (group 2) improved significantly better than the control group (group 1) for the outcomes of plantarflexion 5° error, inversion error, and ROM dorsiflexion. For other outcomes like Algometer, plantarflexion 10° error and ROM plantarflexion, non-significant trends were displayed which suggested a positive treatment effect.

Furthermore, it was noted that repeated manipulations seem to induce a greater degree of reported instability as with follow up readings the plantarflexion (ROM) progresses steadily towards and then past the baseline reading (figure 10). This could be as a result of the decreased protective muscle spasm in the peroneii (Korr, 1975 as cited in Leach, 1994:98-99) as well as increased mobility within the talocrural joint as a result of the manipulation (Pellow and Brantingham, 2001 and Bergmann *et al.*, 1993:123+125). To support this assertion, it was also anecdotally noted that patients reported a feeling of increased “instability” in the multiple manipulation group, which concurs with the findings (figure 10) and suggestions that the patients seemed to gain increased plantarflexion range motion.

It is therefore suggested that patients receiving multiple manipulations in order to restore proprioception would need to receive further proprioceptive retraining and / or muscle strengthening (especially with respect to the peroneii muscles). This, however, would need to be tested with further research.

On the other hand and based on the above findings, it could also be argued that the single manipulation group would improve further both proprioceptively and with respect to range of motion, if they were given an initial manipulation followed by proprioceptive retraining and / or muscular strengthening in order to retain the benefits of the single manipulation. Arguably each approach could have the same clinical outcome; however this remains untested and therefore requires further investigation.

*Thus in respect of the objectives and hypotheses stated in chapter 1:*

The first objective was to determine the effect of a single manipulation versus multiple manipulations on chronic ankle instability syndrome in terms of proprioception (joint position sense).



It was hypothesized that multiple manipulations of the foot and ankle complex would have a greater effect on proprioception (joint position sense), than a single manipulation.

This is accepted for plantarflexion 5° and inversion error, but rejected for plantarflexion 10° and dorsiflexion error.

The second objective was to determine the effect of a single manipulation versus multiple manipulations on chronic ankle instability syndrome in terms of range of motion.

It was hypothesized that multiple manipulations of the foot and ankle complex would increase the ROM to a greater extent than single manipulations.

This is accepted for ROM dorsiflexion, indeterminate for ROM plantarflexion and rejected for ROM inversion.

The third objective was to determine the effect a single manipulation versus multiple manipulations on chronic ankle instability syndrome in terms of point tenderness.

It was hypothesized that multiple manipulations would decrease point tenderness more effectively than a single manipulation.

This hypothesis is accepted with reservation, as there seems to be a limited time only effect, which does not isolate the treatment effect exclusively.

The fourth objective was to determine the effectiveness of a single treatment versus multiple treatments on chronic ankle instability syndrome.

It was hypothesized that multiple treatments would have a greater effect on chronic ankle instability syndrome than a single treatment in terms of overall improvement.

When addressing total clinical improvement of the patients, the above statement would be rejected in terms of the stability of the ankle for multiple treatments, whereas accepted for overall improvement in terms of point tenderness, NRS and proprioceptive function.

## CHAPTER 5:

### CONCLUSION AND RECOMMENDATIONS:

#### 5.1 INTRODUCTION:

This chapter will present and discuss the following:

1. Conclusion.
2. Recommendations.

#### 5.2 CONCLUSION:

The aim of the study was to determine the short and intermediate term effect of manipulation on chronic ankle instability syndrome in terms of subjective and objective clinical findings.

After analysing all the results, it was found that the adjustment group (group 2) improved significantly better than the control group for the outcomes of plantarflexion 5° error, inversion error, and ROM dorsiflexion. For other outcomes of Algometer, plantarflexion 10° error and ROM plantarflexion, non-significant positive trends were displayed which suggested a positive treatment effect.

It would seem, based on this study, that multiple manipulation of the talocrural joint, as against a single manipulation, is effective for the treatment of chronic ankle instability syndrome.

Furthermore, it is also suggested that patients receiving multiple manipulations in order to restore proprioception would need to receive further proprioceptive retraining and / or muscle strengthening (especially with respect to the peroneii muscles). This, however, would need to be tested with further research.

On the other hand, it could also be argued that the single manipulation group would improve further both proprioceptively and with respect to range of motion, if they

were given an initial manipulation followed by proprioceptive retraining and / or muscular strengthening in order to retain the benefits of the single manipulation.

Arguably each approach could have the same clinical outcome, however this remains untested.

### 5.3 RECOMMENDATIONS:

- Due to the fact that the sample size was relatively small, further studies should use a larger sample size, which would strengthen the conclusions made in this study. It would also ensure that subtle changes in the objective and subjective data could be more accurately ascertained without the influence of single outliers. This however was limited as a result of the available budget for this research and increased budgets should be motivated for future research.
- The effect of ethnicity, gender, sports and other factors should be further controlled in future studies so as to limit their influence on the statistical analysis of the data. This could be achieved by stratification of the sample or by stricter inclusion and exclusion criteria, which identify a particular subgroup or population.
- Researcher bias could have affected the outcome of the study and it is recommended that future research studies consider utilisation of a blinded examiner in order to limit this researcher bias.
- The use of a manual inclinometer in various settings could have influenced the results; therefore consistency with respect to application and readings would have been better achieved at a single setting with a device that would have been able to measure the parameters in more than one manner. Thereby allowing for 2 sets of independent readings that can be utilised for cross-referencing for statistical purposes.

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**Are you between the ages of  
25 and 45  
and suffering from**

**RECURRENT  
ANKLE SPRAINS**

Research is currently being carried out  
at the Durban Institute of Technology

Chiropractic Day Clinic

**FREE TREATMENT**

Is available to those who qualify to take  
part in this study

**For more information contact Eckard on 204  
2205 / 2512**

## APPENDIX B:

Date: ..... 200..

Dear Participant

Welcome to my research project.

Title of Research:

**The short and intermediate effect of manipulation on chronic ankle instability syndrome.**

NAME OF RESEARCH STUDENT

**Eckard Peter Köhne** Contact number **(031) 204-2205**

NAME OF RESEARCH SUPERVISOR

**Dr. Andrew Jones** M.Tech:Chiropractic, CCFC, CCSP  
Contact number **(031) 204-2244 or (031) 903-4467**

You have been selected to take part in a study comparing proprioception before and after manipulation in chronic ankle instability syndrome. Forty people will be required to complete this study. All participants, including you, will be randomly split into two equal groups. Each of the groups will receive a standard clinical treatment, one of which is classified as a control for the purposes of this study.

**Inclusion and exclusion:** If you are taking any medication, or undergoing any other form of treatment for your ankle sprain, or taking any medication that may have an effect on the symptoms of the ankle sprain, you may be excluded from the study. Please try not to alter your normal lifestyle or daily activities in any way as this could interfere with the results of the study.

**Research process:** At the first consultation you will be screened for suitability as a participant using a case history, physical examination and foot and ankle regional examination. You will be asked to complete questionnaires, and specific measurements of your foot pain, range of motion of your ankle and proprioception will be taken.

**Treatments:** will take place at the following times:

Week 1 – 2 treatments (first treatment administered by peer study)

Week 2 – 2 treatments

Week 3 – one treatment

Week 4 – one treatment

Week 5 – follow up without treatment.

All treatments will be performed under the supervision of a qualified Chiropractor and will be free of charge.

**Risks and discomfort:** The treatment is safe and is unlikely to cause any adverse side effects, other than transient tenderness and stiffness that is common post manipulation.

**Remuneration and costs:**

All patient information is confidential and the results of the study will be made available in the Durban Institute of Technology library in the form of a mini-dissertation.

**Implications for withdrawal from the research:**

You are free to withdraw at any stage.

Benefits of the study:

Your full co-operation will assist the Chiropractic profession in expanding its knowledge of this condition and thus making future rehabilitation of patients suffering from chronic ankle instability syndrome more successful.

**Confidentiality and Ethics:**

All patient information will be kept confidential and will be stored in the Chiropractic Day Clinic for 5 years after which it will be shredded.

Please don't hesitate to ask questions on any aspect of this study. Should you wish you can contact my research supervisor at the above details or alternatively you could contact the Faculty of Health Sciences Research and Ethics Committee as per Mr Vikesh Singh (031) 2042701.

Thank you.

Yours sincerely,

.....  
Eckard Peter Köhne  
(Research student)

.....  
Dr Andrew Jones  
(Supervisor)

APPENDIX C:

INFORMED CONSENT FORM

(To be completed by patient / subject )

**Date** : \_\_\_\_\_  
**Title of research project:** **The short and intermediate effect of manipulation on chronic ankle instability syndrome.**  
**Name of supervisor** : **Dr. Andrew Jones – M.Tech:Chiropractic, CCFC, CCSP**  
**Tel** : **(031) 2042244**  
**Name of research student** : **Eckard Peter Köhne**  
**Tel** : **(031) 2042205**

**Please circle the appropriate answer**

**YES /NO**

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

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

**Please Print in block letters:**

Patient /Subject Name: \_\_\_\_\_ Signature: \_\_\_\_\_

Parent/ Guardian: \_\_\_\_\_ Signature: \_\_\_\_\_

Witness Name: \_\_\_\_\_ Signature: \_\_\_\_\_

Research Student Name: \_\_\_\_\_ Signature: \_\_\_\_\_

**USHICILELO Cii**

**INCWADI EGUNYAZAYO**

**Usuku** :  
**Isihloko socwaningo** :  
**Igama lika Supervisor** :  
☎ :  
**Igama lomfundi ongumcwaningi** :  
☎ :

- | <u><b>Uyacelwa ukuba ukhethe impendulo</b></u>  | <b>Yebo</b> | <b>Cha</b> |
|---|-------------|------------|
| 1. Ulifundile yini iphepha elinolwazi ngocwaningo?  | Yebo        | Cha        |
| 2. Ube naso yini isikhathi sokubuza imibuzo mayelana nocwaningo?  | Yebo        | Cha        |
| 3. Wanelisekile yini izimpendulo ozitholile emibuzweni yakho?   | Yebo        | Cha        |
| 4. Ube nalo yini ithuba lokuthola kabanzi ngocwaningo?  | Yebo        | Cha        |
| 5. Uyithole yonke imininingwane eyanele ngalolucwaningo?  | Yebo        | Cha        |
| 6. Uyayiqonda imiphumela yokuzimbhandakanya kwakho kulolucwaningo?  | Yebo        | Cha        |
| 7. Uyaqonda ukuthi ukhululekile ukuyeka lolucwaningo?<br>noma inini<br>ngaphandle kokunika isizathu sokuyeka<br>ngaphandle kokubeka impilo yakho ebungozini | Yebo        | Cha        |
| 8. Uyavuma ukuvolontiya kulolucwaningo?   | Yebo        | Cha        |
| 9. Ukhulume nobani? -----   |             |            |

**Uma uphendule ngokuthi cha kokungaphezulu, sicela uthole ulwazi  
ngaphambi kokusayina.**

**BHALA NGAMAGAMA AMAKHULU:**

Igama lesiguli: \_\_\_\_\_ Sayina: \_\_\_\_\_

Umzali/Umgad: \_\_\_\_\_ Sayina: \_\_\_\_\_

Igama Witness: \_\_\_\_\_ Sayina: \_\_\_\_\_

Igama lomfundi ongumcwaningi: \_\_\_\_\_ Sayina: \_\_\_\_\_

APPENDIX D:

**DURBAN INSTITUTE OF TECHNOLOGY**  
**CHIROPRACTIC DAY CLINIC**  
**CASE HISTORY**

Patient: \_\_\_\_\_ Age: \_\_\_\_\_

File # \_\_\_\_\_

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:**

	<b>Complaint 1</b>	<b>Complaint 2</b>
<ul style="list-style-type: none"><li>▶ Location</li><li>▶ Onset : Initial: Recent:</li><li>▶ Cause:</li><li>▶ Duration</li><li>▶ Frequency</li><li>▶ Pain (Character)</li><li>▶ Progression</li><li>▶ Aggravating Factors</li><li>▶ Relieving Factors</li><li>▶ Associated S &amp; S</li><li>▶ Previous Occurrences</li><li>▶ Past Treatment</li></ul>		
<p>(a) <b>Outcome:</b></p>		

**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

APPENDIX E:

DURBAN INSTITUTE OF TECHNOLOGY

**CHIROPRACTIC DAY CLINIC**  
**PHYSICAL EXAMINATION**

Patient: \_\_\_\_\_ File#: \_\_\_\_\_ Date: \_\_\_\_\_

Clinician: \_\_\_\_\_ Signature: \_\_\_\_\_

Student: \_\_\_\_\_ Signature: \_\_\_\_\_

**1. VITALS**

Pulse rate:

Respiratory rate:

Blood pressure: R                      L                      Medication if hypertensive:

Temperature:

Height:

Weight:                                      Any change    Y/N    If Yes: how much gain/loss  
Over what period

**2. GENERAL EXAMINATION**

General Impression:

Skin:

Jaundice:

Pallor:

Clubbing:

Cyanosis (Central/Peripheral):

Oedema:

Lymph nodes - Head and neck:

- Axillary:

- Epitrochlear:

- Inguinal:

Urinalysis:

**3. CARDIOVASCULAR EXAMINATION**

1) Is this patient in **Cardiac Failure**?

2) Does this patient have signs of **Infective Endocarditis**?

3) Does this patient have **Rheumatic Heart Disease**?

**Inspection**

- Scars

- Chest deformity:

- Precordial bulge:

- Neck -JVP:

- Palpation:**
- Apex Beat (character + location):
  - Right or left ventricular heave:
  - Epigastric Pulsations:
    - Palpable P2:
    - Palpable A2:

- Pulses:**
- General Impression:
    - Dorsalis pedis:
    - Radio-femoral delay:
    - Carotid:
    - Radial:
  - Posterior tibial:
  - Popliteal:
  - Femoral:

**Percussion:** - borders of heart

- Auscultation:**
- heart valves (mitral, aortic, tricuspid, pulmonary)
  - Murmurs (timing, systolic/diastolic, site, radiation, grade).

#### 4. RESPIRATORY EXAMINATION

1) Is this patient in **Respiratory Distress**?

- Inspection**
- Barrel chest:
  - Pectus carinatum/cavinatum:
  - Left precordial bulge:
  - Symmetry of movement:
  - Scars:
- Palpation**
- Tracheal symmetry:
  - Tracheal tug:
  - Thyroid Gland:
  - Symmetry of movement (ant + post)
  - Tactile fremitus:
- Percussion**
- Percussion note:
  - Cardiac dullness:
  - Liver dullness:
- Auscultation**
- Normal breath sounds bilat.?
  - Adventitious sounds (crackles, wheezes, crepitations)
  - Pleural frictional rub:
  - Vocal resonance
    - Whispering pectoriloquy:
    - Bronchophony:
    - Egophony:

#### 5. ABDOMINAL EXAMINATION

1) Is this patient in **Liver Failure**?

- Inspection**
- Shape:
  - Scars:
  - Hernias:

- Palpation**
  - Superficial:
  - Deep = Organomegally:
  - Masses (intra- or extramural)
  - Aorta:
- Percussion**
  - Rebound tenderness:
  - Ascites:
  - Masses:
- Auscultation**
  - Bowel sounds:
  - Arteries (aortic, renal, iliac, femoral, hepatic)

- Rectal Examination**
- Perianal skin:
  - Sphincter tone & S4 Dermatome:
  - Obvious masses:
  - Prostate:
  - Appendix:

## 6. G.U.T EXAMINATION

External genitalia:  
 Hernias:  
 Masses:  
 Discharges:

## 7. NEUROLOGICAL EXAMINATION

- Gait and Posture**
- Abnormalities in gait:
  - Walking on heels (L4-L5):
  - Walking on toes (S1-S2):
  - Rombergs test (Pronator Drift):

- Higher Mental Function**
- Information and Vocabulary:
  - Calculating ability:
  - Abstract Thinking:

- G.C.S.:**
- Eyes:
  - Motor:
  - Verbal:

**Evidence of head trauma:**

- Evidence of Meningism:**
- Neck mobility and Brudzinski's sign:
  - Kernigs sign:

**Cranial Nerves:**

- I** Any loss of smell/taste:  
 Nose examination:
- II** External examination of eye:
- Visual Acuity:
  - Visual fields by confrontation:
  - Pupillary light reflexes = Direct:  
 = Consensual:  
 - Fundoscopy findings:
- III** Ocular Muscles:  
 Eye opening strength:
- IV** Inferior and Medial movement of eye:

- V** a. Sensory- Ophthalmic:  
 - Maxillary:  
 - Mandibular:  
 b. Motor - Masseter:  
 - Jaw lateral movement:  
 c. Reflexes- Corneal reflex  
 - Jaw jerk
- VI** Lateral movement of eyes
- VII** a. Motor - Raise eyebrows:  
 - Frown:  
 - Close eyes against resistance:  
 - Show teeth:  
 - Blow out cheeks:  
 b. Taste - Anterior two-thirds of tongue:
- VIII** General Hearing:  
 Rinnes = L: R:  
 Webers lateralisation:  
 Vestibular function - Nystagmus:  
 - Rombergs:  
 - Wallenbergs:  
 Otoscope examination:
- IX &** Gag reflex:  
**X** Uvula deviation:  
 Speech quality:
- XI** Shoulder lift:  
 S.C.M. strength:
- XII** Inspection of tongue (deviation):

**Motor System:**

- a. Power  
 - Shoulder = Abduction & Adduction:  
 = Flexion & Extension:  
 - Elbow = Flexion & Extension:  
 - Wrist = Flexion & Extension:  
 - Forearm = Supination & Pronation:  
 - Fingers = Extension (Interphalangeals & M.C.P's):  
 - Thumb = Opposition:  
 - Hip = Flexion & Extension:  
 = Adduction & Abduction:  
 - Knee = Flexion & Extension:  
 - Foot = Dorsiflexion & Plantar flexion:  
 = Inversion & Eversion:  
 = Toe (Plantarflexion & Dorsiflexion):
- b. Tone  
 - Shoulder:  
 - Elbow:  
 - Wrist:  
 - Lower limb - Int. & Ext. rotation:  
 - Knee clonus:

- c. Reflexes
  - ankle clonus:
  - Biceps:
  - Triceps:
  - Supinator:
  - Knee:
  - Ankle:
  - Abdominal:
  - Plantar:

**Sensory System:**

- a. Dermatomes
  - Light touch:
  - Crude touch:
  - Pain:
  - Temperature:
  - Two point discrimination:
- b. Joint position sense
  - Finger:
  - Toe:
- c. Vibration:
  - Big toe:
  - Tibial tuberosity:
  - ASIS:
  - Interphalangeal Joint:
  - Sternum:

**Cerebellar function:**

Obvious signs of cerebellar dysfunction:

- = Intention Tremor:
- = Nystagmus:
- = Truncal Ataxia:

Finger-nose test (Dysmetria):

Rapid alternating movements (Dysdiadochokinesia):

Heel-shin test:

Heel-toe gait:

Reflexes:

Signs of Parkinsons:

**8. SPINAL EXAMINATION:(See Regional examination)**

Obvious Abnormalities:

Spinous Percussion:

R.O.M:

Other:

**9. BREAST EXAMINATION:**

Summon female chaperon.

- Inspection**
- Hands rested in lap:
  - Hands pressed on hips:
  - Arms above head:
  - Leaning forward:

- Palpation**
- masses:
  - tenderness:
  - axillary tail:
  - nipple:
  - regional lymph nodes:



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:**

Ⓡ

Ⓛ

**Non weight bearing:**

Ⓡ

Ⓛ

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)

	Ⓡ	Ⓛ		Ⓡ	Ⓛ
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		
			Tarso metatarsal joints: <i>A-P</i>		
Interphalangeal joints: <i>L → A dist</i>			Metatarsophalangeal dorsiflexion (with associated plantar flexion of each toe)		
<i>A-P glide</i>					
<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

Ⓡ

Ⓛ

Dermatomes		
Myotomes		
Reflexes		
Balance/proprioception		

## Special tests

Ⓡ

Ⓛ

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

## Alignment

Ⓡ

Ⓛ

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

## Palpation

### Anteriorly

Ⓡ

Ⓛ

Medial malleoli		
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*

*Plantarily*

Plantar muscles and fascia		
----------------------------	--	--

Sesamoids		
-----------	--	--

21/10/2002

Calcaneus, Achilles tendon, Musculotendinous junction		
---	--	--

APPENDIX G:

**DURBAN INSTITUTE OF TECHNOLOGY**

<i>Patient Name:</i>	<i>File #:</i>	<i>Page:</i>
<i>Date:</i>	<i>Visit:</i>	<i>Intern:</i>
<i>Attending Clinician:</i>	<i>Signature:</i>	

*S: Numerical Pain Rating Scale (Patient) Intern Rating A:*  
*Least 0 1 2 3 4 5 6 7 8 9 10 Worst*

*O: P:*

*E:*

*Special attention to: Next appointment:*

*Date: Visit: Intern: Signature:*  
*Attending Clinician:*

*S: Numerical Pain Rating Scale (Patient) Intern Rating A:*  
*Least 0 1 2 3 4 5 6 7 8 9 10 Worst*

*O: P:*

*E:*

*Special attention to: Next appointment:*

*Date: Visit: Intern: Signature*  
*Attending Clinician:*

*S: Numerical Pain Rating Scale (Patient) Intern Rating A:*  
*Least 0 1 2 3 4 5 6 7 8 9 10 Worst*

*O: P:*

*E:*

*Special attention to: Next appointment:*

*Patient Name:* \_\_\_\_\_ *File #:* \_\_\_\_\_ *Page:* \_\_\_\_\_

*Date:* \_\_\_\_\_ *Visit:* \_\_\_\_\_ *Intern:* \_\_\_\_\_  
*Attending Clinician:* \_\_\_\_\_ *Signature:* \_\_\_\_\_

*S:* *Numerical Pain Rating Scale (Patient)* *Intern Rating* *A:*  
*Least 0 1 2 3 4 5 6 7 8 9 10 Worst*

*O:* \_\_\_\_\_ *P:* \_\_\_\_\_

*E:* \_\_\_\_\_

*Special attention to:* \_\_\_\_\_ *Next appointment:* \_\_\_\_\_

*Date:* \_\_\_\_\_ *Visit:* \_\_\_\_\_ *Intern:* \_\_\_\_\_  
*Attending Clinician:* \_\_\_\_\_ *Signature:* \_\_\_\_\_

*S:* *Numerical Pain Rating Scale (Patient)* *Intern Rating* *A:*  
*Least 0 1 2 3 4 5 6 7 8 9 10 Worst*

*O:* \_\_\_\_\_ *P:* \_\_\_\_\_

*E:* \_\_\_\_\_

*Special attention to:* \_\_\_\_\_ *Next appointment:* \_\_\_\_\_

*Date:* \_\_\_\_\_ *Visit:* \_\_\_\_\_ *Intern:* \_\_\_\_\_  
*Attending Clinician:* \_\_\_\_\_ *Signature:* \_\_\_\_\_

*S:* *Numerical Pain Rating Scale (Patient)* *Intern Rating* *A:*  
*Least 0 1 2 3 4 5 6 7 8 9 10 Worst*

*O:* \_\_\_\_\_ *P:* \_\_\_\_\_

*E:* \_\_\_\_\_

*Special attention to:* \_\_\_\_\_ *Next appointment:* \_\_\_\_\_



APPENDIX H:

**Clinical outcomes measurements:**

Patient Name: \_\_\_\_\_ File Number: \_\_\_\_\_

Patient number : \_\_\_\_\_

Group : \_\_\_\_\_ 1 \_\_\_\_\_ or \_\_\_\_\_ 2 \_\_\_\_\_

Pre Treatment

Date: \_\_\_\_\_

<u>DEGREE OF ROM</u>	<u>Inclinometer reading</u>	<u>DEG OF ERROR</u>	<u>ROM</u>
<u>5° Plantarflexion</u>	<u>90</u>		
<u>10° Plantarflexion</u>	<u>90</u>		
<u>5° Dorsiflexion</u>	<u>90</u>		
<u>5° Inversion</u>	<u>0</u>		
<u>Pain</u>			

Reading pre treatment- 4

Date: \_\_\_\_\_

<u>DEGREE OF ROM</u>	<u>Inclinometer reading</u>	<u>DEG OF ERROR</u>	<u>ROM</u>
<u>5° Plantarflexion</u>	<u>90</u>		
<u>10° Plantarflexion</u>	<u>90</u>		
<u>5° Dorsiflexion</u>	<u>90</u>		
<u>5° Inversion</u>	<u>0</u>		
<u>Pain</u>			

Reading pre treatment – 6

Date: \_\_\_\_\_

<u>DEGREE OF ROM</u>	<u>Inclinometer reading</u>	<u>DEG OF ERROR</u>	<u>ROM</u>
<u>5° Plantarflexion</u>	<u>90</u>		
<u>10° Plantarflexion</u>	<u>90</u>		
<u>5° Dorsiflexion</u>	<u>90</u>		
<u>5° Inversion</u>	<u>0</u>		
<u>Pain</u>			

Reading post treatment (follow up - 7)

Date: \_\_\_\_\_

<u>DEGREE OF ROM</u>	<u>Inclinometer reading</u>	<u>DEG OF ERROR</u>	<u>ROM</u>
<u>5° Plantarflexion</u>	<u>90</u>		
<u>10° Plantarflexion</u>	<u>90</u>		
<u>5° Dorsiflexion</u>	<u>90</u>		
<u>5° Inversion</u>	<u>0</u>		
<u>Pain</u>			

**Numerical Pain Rating Scale**

**Please circle the appropriate number:**

No pain  
pain

**Worst**

1      2      3      4      5      6      7      8      9      10