THE EFFICACY OF SOFT TISSUE THERAPY IN THE
CHIROPRACTIC MANAGEMENT OF SUBACUTE AND
CHRONIC GRADE I AND GRADE II ANKLE INVERSION
SPRAINS

A dissertation submitted to the
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CRAIG LYONS
(Student number: 9766045)

Supervisor:
Dr. Brad Beira (M.Tech Chiro-SA)(ICSSD) Date

Co-Supervisor:
Dr. Chris Yelverton (M.Tech Chiro-SA) Date
DECLARATION

I declare that this dissertation is my own, unaided work. It is being submitted for the Degree of Master of Technology at the Technikon Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other Technikon or University.

Signature of Candidate: ____________________________

On this Monday the 11th of November 2002

Signature of Supervisor: ____________________________

On this Monday the 11th of November 2002

Signature of Co-Supervisor: ____________________________

On this Monday the 11th of November 2002
ABSTRACT

The purpose of this unblinded, controlled pilot study was to compare the effectiveness of soft tissue therapy and ultrasound therapy, versus chiropractic manipulation and mobilization therapy, or a combination of the aforementioned therapeutic protocols in the treatment of sub-acute and chronic grade I and grade II inversion ankle sprains.

In executing the comparison, it was anticipated that both treatment protocols would be effective, but the combined therapy would be the most effective in treating sub-acute and chronic grade I and grade II inversion ankle sprains. This treatment protocol focused on the symptomatic pathological area of the lateral ankle and on correcting the kinetic chain’s biomechanical dysfunction, which was perhaps the contributing factor in perpetuating the pathomechanics causing the sub-acute and chronic ankle inversion sprain.

Thirty patients suffering from sub-acute and chronic inversion ankle sprains who conformed to the specified delimitations and diagnostic criteria were accepted into the investigation. These patients were recruited by means of an advertisement poster placed throughout the Technikon Witwatersrand, Doornfontein Campus and at nearby sports clubs and via an advertisement printed in a series of local newspapers through the Caxton Publishing Company.

Patients were randomly assigned to one of three groups of ten as they enrolled for participation. Group A received soft tissue therapy and ultrasound therapy and group B received chiropractic manipulation and mobilization therapy. Group C received a combination of the aforementioned therapies. Each patient received eight treatments over a four-week period followed by a one-month follow-up consultation. This follow-up period was used to determine the lasting effects of the treatment protocol.

Subjective data was collected using the Numerical Pain Rating Scale 101 and the McGill Pain Questionnaire. Objective ankle active range of motion readings in dorsiflexion, plantarflexion, inversion and eversion were recorded using a Saunders Digital Inclinometer. These measurements were taken at the initial, fourth, eighth and follow-up visits.
The results indicated that all three treatments were effective in treating the pathology. Group C showed the most positive results in terms of objective and subjective clinical findings.

In conclusion, the combination of soft tissue therapy, ultrasound therapy, and chiropractic manipulation and mobilization therapy, was the most effective treatment protocol for the management of sub-acute and chronic grade I and grade II inversion ankle sprains. This treatment protocol had a far greater benefit with regard to improving the ranges of motion of the ankle and subtalar joints, and had a similar effect in improving the patient’s perception of pain intensity, than manipulation and mobilization of joint complex dysfunction in the foot and spine, or soft tissue and ultrasound therapy alone.
DEDICATION

Thank you to my parents, Michael and Jillian Lyons for believing in me and for supporting me every step of the way. Your love, devotion and inspiration have moulded me into the person I am today.

We have been through some difficult times together and yet your courage, strength and will have guided us through unscathed. I’m so proud of you both. You are the benchmark to which every parent should aspire.
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CHAPTER ONE – INTRODUCTION

1. INTRODUCTION

Ankle sprains are one of the most prevalent acute injuries treated in emergency departments and physicians' offices. The ankle sprain is probably the single most common sports-related injury, accounting for 20% to 25% of time lost in running and jumping sports. 85% of ankle injuries are sprains. At least 95% of isolated ankle sprains involve the lateral ligaments (Pellow and Brantingham 2001:17).

Despite the frequency of this injury and the potential for significant morbidity, no accepted single method of treatment predominates (Eiff et al. 1994:83). Many ankle injuries are treated with no more than a wrap and crutch walking. This nonphysiological approach commonly results in prolonged disability, which may lead to lifelong ankle instability, recurrent sprains, and degenerative ankle disease (Smith and Stanitski 1987:61).

In an attempt to provide some answers to this problem, this unblinded and controlled pilot study investigates the effectiveness of chiropractic manipulative and mobilization therapy, as compared to soft tissue and ultrasound therapy, in the treatment of sub-acute and chronic grade I and grade II inversion ankle sprains. This research aims to compare the effects of these therapies alone, and in conjunction, to determine the most efficient means of managing sub-acute and chronic grade I and grade II inversion ankle sprains.

Three groups consisting of ten patients each were studied. Group A received soft tissue and ultrasound therapy. Group B received chiropractic manipulative and mobilization therapy of the spine, foot and ankle. Group C, received a combination of the aforementioned therapies.

Each group underwent eight treatments within a four-week period with a one-month follow-up visit. Objective data was collected using a Saunders Digital Inclinometer that measured both the examined ankle and subtalar joints' ranges of motion. Subjective data was collected using the Numerical Pain Rating Scale 101 and the McGill Pain Questionnaire. All data was collected prior to treatment one, four, eight and at the follow-up consultation.
The following literature review explains the importance of biomechanical dysfunction in the aetiology of the pathomechanics of sub-acute and chronic ankle inversion sprains. There is an in depth investigation into the myofascial dysfunction related to the pathology. The review explores the soft tissue and ultrasound therapy used, with emphasis being placed on the scope of treatment and the effectiveness thereof. The importance of chiropractic manipulative and mobilization therapy is discussed, including the usages and efficiency of such treatments. This information is vital to understand the effectiveness of the combined therapy involving these two treatment protocols.
CHAPTER TWO – LITERATURE REVIEW

2.1 ANATOMY

2.1.1 INTRODUCTION

A brief discussion of the foot and ankle joint anatomy is required to outline the functioning of the normal foot.

The foot is a complex structure including numerous joints. For the purpose of this study, joints relevant to the inversion ankle sprain pathology will be discussed.

2.1.2 JOINTS OF THE FOOT

2.1.2.1 The Ankle Joint

The ankle, or talocrural joint, is formed by the articulation between the talus and the distal tibia (tibiotalar surface) and the talus and the fibula (talofibular surface) (refer to Figure 1 a-c). The ankle is a synovial hinge joint with a thin joint capsule (Levangie and Norkin 2001:368). It normally allows only movements of dorsiflexion and plantarflexion about a horizontal axis (through the ankle) that lies in the frontal plane (Schafer and Faye 1990:406). Limited dorsiflexion at the ankle causes pathology in the lower extremity (Levangie and Norkin 2001:372). The articular arteries are derived from the malleolar branches of the fibular (peroneal) and the anterior and posterior tibial arteries. The articular nerves are derived from the tibial nerve and the deep fibular (peroneal) nerve, a division of the common fibular (peroneal) nerve (Moore 1992:490).
Figure 1. Joints of the Ankle and Foot: (a) Posterior view, with a transplant talus, showing the orientation of the tibiotalar joint and the placement of the medial and lateral malleoli. (b) Lateral view of the ankle joint showing the ligamentous and bony props that help stabilize the joint. (c) Superior view of the foot, with other joints identified (Martini 1992:291).
2.1.2.2 The Subtalar Joint

The functional unit of the ankle must include the subtalar joint, at which the motions of inversion and eversion take place (Reid 1992:215). These movements take place about an axis running in the A-P / P-A plane of the foot (Schafer and Faye 1990:406). The subtalar joint is a synovial joint surrounded by a weak fibrous capsule with articulations between the inferior surface of the body of the talus and the superior surface of the calcaneus (refer to Figure 1a). Movements of the subtalar joint are closely associated with those at the talocalcaneonavicular and calcaneocuboid joints (Moore 1992:490).

2.1.2.3 The Talocalcaneonavicular Joint

The talocalcaneonavicular articulation is a ball and socket type synovial joint (refer to Figure 1 b-c). The head of the talus articulates with the socket formed by the posterior surface of the navicular bone, the superior surface of the plantar calcaneonavicular ligament, the sustentaculum tali, and the articular surface of the calcaneus. It is part of the transverse tarsal joint (Moore 1992: 491).

2.1.2.4 The Calcaneocuboid Joint

The calcaneocuboid joint is a synovial joint located between the anterior surface of the calcaneus and the posterior surface of the cuboid (refer to Figure 1 b-c). It is part of the transverse tarsal joint (Moore 1992:491).

2.1.2.5 The Transverse Tarsal Joint

The transverse tarsal or midtarsal joint is the articular plane that extends from side-to-side across the foot (refer to Figure 1 b-c). It is composed of the talocalcaneonavicular joint medially and the calcaneocuboid joint laterally. Although anatomically separate, these joints act together during movements of the foot. Movements occurring at this joint are inversion (directing the sole of the foot toward the medial plane of the body), and eversion (directing the sole of the foot away from the median plane of the body) (Moore 1992:491).
2.1.2.6 Interrelationship Between the Joints and Injury Predilection

The ankle and subtalar joints work together to translate rotations occurring in the tibia about its vertical axis into rotations in the foot about a sagittal axis. These coupled motions are necessary to allow the rapid rotations that occur in the leg, to be absorbed by a relatively fixed foot (Reid 1992:215).

The subtalar and midtarsal joints function in concert. The position of the subtalar joint dictates the obliquity or parallely of the midtarsal joint. As the subtalar joint supinates, the midtarsal joint becomes more oblique, and less motion takes place. With the subtalar joint supinated, the medial longitudinal arch of the foot raises and the forefoot becomes more rigid. With pronation of the subtalar joint, the midtarsal joint becomes more parallel, and more mobile. The foot becomes a mobile adaptor for irregular surfaces, with various tilts and pitches. The normal locking and unlocking motion of the subtalar and midtarsal joints, dissipates contact stress. This motion allows the foot to first become a mobile adaptor on contact and then, become a rigid lever during propulsion (Levangie and Norkin 2001:375).

The most common positional abnormality of the subtalar joint is subtalar varus. This causes increased lateral heel contact with excessive compression of the lateral aspect of the shoe. This may result in a tendency toward lateral instability with sprains (Levangie and Norkin 2001:400).

2.2 INVERSION ANKLE SPRAIN

2.2.1 DEFINITION OF SUB-ACUTE AND CHRONIC INVERSION SPRAIN

An inversion ankle sprain occurs as a result of an inverting moment being applied to a foot that is plantar flexed (Self et al. 2000:138). There appear to be no standard definitions for the terms sub-acute and chronic (Pellow and Brantingham 2001:21). For the purposes of this study, definitions of these two terms are taken from Magee: sub-acute is defined as ten days to seven weeks after the initial injury, and chronic is defined as seven weeks to two years after the initial injury (Magee 1997:4).
2.2.2 PREVALENCE

The ankle complex is the most frequently injured joint, both in athletics and in daily life. The ankle sprain is the most frequent sports injury. Ten percent to 25% of injuries in athletics involve the ankle and 85% of these injuries involve sprain of the lateral ligaments (Beckman and Buchanan 1995:1138). Seventy-five percent of all ankle injuries are ankle sprains, and 85% of these sprains are caused by an inversion trauma (Baumhauer et al. 1995:564). Up to 30% of the population who sustain injury to the lateral ligaments of the ankle, complain of residual dysfunction nine months after the injury. As many as 10% to 50% of people with acute lateral ligament injuries develop chronic mechanical instability (Beckman and Buchanan 1995:1138).

2.2.3 AETIOLOGY

Injuries typically occur when the body’s weight lands on the plantar flexed and internally rotated ankle, diminishing the bony stability of the ankle joint at foot strike. There is a decrease in the talar weight-bearing surface, the articular surface is not fully loaded and the lateral ligaments absorb the added stress (Liu and Jason 1994:795).

Injuries are caused by changing direction, particularly if associated with deceleration, landing from a jump, landing on another player’s foot, running on uneven surfaces or due to a direct blow to the lateral ankle (Reid 1992:220). Forced inversion of the subtalar joint, typically due to stepping on an uneven surface or terrain, is the most common mechanism of injury for an acute lateral ankle sprain (Seto and Brewster 1994:712).

The acute inversion injury results in damage to the lateral structures, which include the lateral ligaments as well as the capsule of the talocrural and subtalar joints. These injuries may result in various degrees of mechanical ankle instability. In 15% to 60% of the cases, functional ankle instability, with recurrent sprains and giving way sensations may result. The cause of functional ankle instability is considered to be complex, with contributions from several factors: neural (proprioception, reflexes, and muscular reaction time), muscular (strength, power, and endurance), and mechanical (lateral ligamentous laxity). Researchers associate damage to the sensorimotor control system of the ankle as a primary cause of recurrent inversion injuries (Konradsen et al. 1995:712).
1998:72). Muscle weakness, particularly in the peroneal muscles, may play a significant role in the aetiology of functional instability. Residual symptoms, resulting from recurrent episodes of inversion-type ankle sprains, may be attributed to a decreased neuromuscular response of the peroneal or tibialis anterior muscles, thereby increasing the probability for reinjury. The reflex time of the peroneal muscles as opposed to the absolute strength of these muscles may be the more important indicator for providing a dynamic muscular restraint to sudden plantarflexion and inversion (Ebig et al. 1997:73).

2.2.4 RISK FACTORS

Risk factors can be classified as either extrinsic or intrinsic. Extrinsic factors include training error, type of sport, playing time, level of competition, equipment, and environmental conditions. Intrinsic factors can be physical characteristics such as malalignment, strength deficit, limited range of motion, joint instability, generalized joint laxity, age, sex and previous history of inversion ankle sprain (Baumhauer et al. 1995:564).

Individuals with a previous history of an ankle sprain, with damage to the lateral ligament complex, are two to three times more likely to sustain a subsequent ankle injury. After an inversion ankle sprain, the evertor musculature could remain weak for more than ten years (Baumhauer et al. 1995:567).

Anatomic variants of the foot, including cavovarus and pes planus deformities, have been implicated in foot and ankle injuries. Individuals with pes cavus deformities may be prone to ankle sprains. Typically, these subjects are unable to pronate their foot adequately and have decreased subtalar eversion. They are unable to adapt to changes in terrain surfaces, leaving the ankle more vulnerable to an inversion ankle sprain (Baumhauer et al. 1995:567).

2.2.5 CLASSIFICATION

Lateral ankle ligament injuries are graded from 1 to 3, based on increasing ligamentous damage and morbidity (Liu and Jason 1994:796).
A grade 1 sprain signifies an injury where the anterior talofibular ligament (ATFL) is stretched with some of the ligament fibers torn, but no frank ligamentous disruption is present (Liu and Jason 1994:796). This is a mild or minimal sprain. Mild tenderness with some swelling may be present (Berkow et al. 1992:1377).

A grade 2 sprain signifies a moderate injury to the lateral ligaments, frequently with an incomplete tear of the ATFL and an additional partial tear to the calcaneofibular ligament (CFL) (Liu and Jason 1994:796). This moderate sprain may present with obvious swelling, ecchymosis, and difficulty in walking (Berkow et al. 1992:1377).

A grade 3 sprain implies complete disruption of both the ATFL and CFL. This would entail a complete ATFL rupture with capsular tear, and a tear of the CFL. An accompanying tear of the posterior talofibular ligament (PTFL) would present as an ankle dislocation (Liu and Jason 1994:796). Swelling, haemorrhage, ankle instability, and inability to walk may be associated (Berkow et al. 1992:1377).

2.2.6 CLINICAL PRESENTATION

Chronic lateral ankle sprains may be diagnosed mainly by history (specifically the nature of the patient's complaints), physical examination, routine radiographs, and the exclusion of other causes of similar symptoms (Liu and Jason 1994:801).

2.2.6.1 History

It is often difficult to determine the amount of ligamentous damage sustained when taking the history from a patient with an inversion ankle sprain. The history, provided by the patient, is generally of no value; the injury occurs too quickly for most patients to accurately recall what transpired, and the mechanism is frequently similar for all degrees of lateral ankle ligament injuries (Liu and Jason 1994:796).

Clinically, patients usually present with a history of recurrent ankle sprain, pain, swelling, giving way, and an inability to attain pre-injury activity levels owing to their ankle's limitations (Liu and Jason 1994:800).
2.2.6.2 Patient Examination

Foot structure and function are examined to rule out predisposing influences, as described in 2.2.4 Risk Factors. Topographic examination determines the site of the ligamentous injury, by simple palpation around the lateral ankle (Berkow et al. 1992:1377). Tenderness on palpation of each portion of the lateral ligament must be recorded as tenderness of the anterior talofibular ligament (ATFL) in isolation, of both the ATFL and the calcaneofibular ligament (CFL), or of all three portions of the lateral ligament (Green et al. 2001:986). The clinical provocative tests of the anterior drawer and talar tilt have been used extensively to evaluate the integrity of these ligaments (Baumhauer et al. 1996:568).

Clinically, patients with a grade 1 sprain present with mild swelling, little or no haemorrhage on the lateral ankle, point tenderness on the ligament, and mildly restricted range of motion. Possible difficulty with full weight bearing is sometimes observed, and there is no instability on examination. Usually, after appropriate treatment, the patient suffers no significant functional loss, and return to sports can be within 7 to 10 days (Liu and Jason 1994:796).

Examination of a grade 2 sprain shows restricted range of motion with localized swelling, ecchymosis, haemorrhage, and tenderness of the anterolateral ankle. Instability on examination may be mild or may not be present. The patient experiences additional functional loss, with inability to toe rise or hop on the injured foot. A severe grade 2 injury may present with swelling and functional loss that makes it indistinguishable from a grade 3 injury in an acute setting (Liu and Jason 1994:796).

Examination of a third-degree injury (grade 3) reveals diffuse swelling, ecchymosis on the lateral side of the ankle and heel, and tenderness over the anterolateral capsule, ATFL, and CFL. Moderate to severe laxity to anterior drawer or inversion is usually present, but may not be elicited, depending on the amount of swelling and muscular spasm during examination (Liu and Jason 1994:796).
2.2.7 PATHOGENESIS

Most of the continuing symptoms following a sprained ankle, such as pain, a feeling of instability, crepitus, weakness and stiffness are believed to be directly related to untreated ligament damage. The main causes of these continuing symptoms are functional instability, joint stiffness (due to loss of joint motion), scar tissue and inadequate or absent rehabilitation (Pellow and Brantingham 2001:17).

2.2.7.1 Ligament Physiology and Biomechanics

The three major ligament groups that support the ankle joint include; the tibiofibular ligaments, the deltoid ligament complex, and the lateral ligament complex. The lateral ligament complex of the ankle consists of three separate ligaments: the anterior talofibular ligament (ATFL) courses from the anterior-inferior border of the fibula to the neck of the talus; the posterior talofibular ligament (PTFL) runs from the digital fossa on the posterior border of the lateral malleolus to the lateral tubercle of the talus; the calcaneofibular ligament (CFL) runs from the tip of the fibula to the tubercle of the calcaneus in a posterior-inferior direction under the peroneal tendons (refer to Figure 2) (Liu and Jason 1994:794). The ATFL becomes tightened in plantarflexion and orientated almost vertically, thus being almost parallel to the long axis of the tibia. This position provides maximal protection against pathologic inversion movements in the ankle joint. The PTFL is stressed during forced dorsiflexion trauma. The CFL is slightly tensed in the neutral position and only moderately resists a pathologic inversion movement of the ankle. During plantarflexion, the CFL is almost completely orientated horizontally, stabilizing only the subtalar joints (Reid 1992:218). It must be noted that the PTFL is not a significant structure in inversion-internal rotation injuries (Colville et al. 1990:199). These ligaments stabilize the ankle, serve as a guide to direct ankle motion, and aid in proprioception. Of these, the ATFL is most frequently injured (Liu and Jason 1994:795).
Figure 2. Ligaments of the Hindfoot and Midfoot (lateral view) (Magee 1997:600).

In ankle sprain, the ATFL usually is ruptured first; only then can the CFL divide. If the ATFL is intact, one can surmise that the CFL also is intact; conversely, if the ATFL is ruptured, examination for concomitant rupture of the lateral CFL must be done. In a study of 321 ligamentous injuries of the ankle, 64% of cases injured the ATFL alone, and 17% also injured the lateral CFL. The PTFL rarely ruptures (Berkow et al. 1992:1377).

Structural properties of ligaments have been shown to increase with increasing strain rates. These properties include ultimate load, energy absorbed, tensile strength, and stiffness (Self et al. 2000:142). The lateral ligament complex functions as a static stabilizer of the ankle joint preventing excessive inversion motion. The ATFL limits inversion in ankle plantarflexion, and the CFL functions to limit inversion in ankle dorsiflexion (Baumhauer et al. 1995:567-568). Strain in the ATFL increases when the ankle moves into greater degrees of plantarflexion, internal rotation, and inversion. Strain in the CFL specifically increases as the talus is dorsiflexed and inverted. These findings support the concept that the ATFL and the CFL function together at all positions of ankle
flexion to provide lateral ankle stability (Colville et al. 1990:196). It has been found that the ATFL has to cope with higher strains and rates than the CFL. This could indicate why the ATFL is more likely to fail than the CFL. The ATFL is a wide, thin ligament that often must withstand large strains and strain rates. The smaller strain rates in the CFL may show why it typically does not undergo an isolated injury (Self et al. 2000:143).

A major ankle inversion injury causes damage, not only to the lateral ligaments of the talocrural joint, but also in varying degrees to the talocrural capsule, the capsule and ligaments of the subtalar joints, the peroneal tendons, and other supportive tissue of the lateral ankle. Proprioceptive nerve endings in these structures will also be damaged by the acute trauma. As a result of the inversion injury, changes in functional properties may be expected (Konradsen et al. 1998:75).

Mechanical instability resulting in functional instability of the ankle could be due to motor incoordination, due to articular deafferentation of the mechanoreceptors as a result of injury to the ligaments and/or joint capsule. Normally, proprioceptors are stimulated when the structures of the ankle are stretched during sudden displacement. The central effect of this stimulation elicits reflex responses, which cause the muscles to fire and stabilize the joints. If an extreme amount of inversion occurs, damage to nerve fibers, ligaments, and the joint capsule can cause a disturbance of these reflexes. Damage to the nerve fibers in these structures can have central effects, including changes in the activity of neighboring muscles (Ebig et al. 1997:76).

Neuromuscular coordination may be lost when stretch receptors, in both the capsular ligaments and the muscles controlling the ankle, are stretched and damaged during ankle sprains. This may lessen proprioceptive function and slow protective reflexes, causing repeated ankle injuries (Ward 1999:57).

A chronic lateral ankle sprain requires more time for appropriate recovery than an acute grade 1 ankle sprain as a result of the compensations that have occurred with motion and strength, the constant irritation of tissues, decreased proprioception, and atrophy of the muscle (Seto and Brewster 1994:696).
2.2.8 IMPORTANT BIOMECHANICAL AND ASSOCIATED PRINCIPLES

An understanding of the normal biomechanical and kinesiologic concepts is required in order to understand the abnormal biomechanics related to inversion ankle sprains. This next section will involve a discussion of the kinetic chain (neuromusculoskeletal system) involving the ankle, foot and the spine. An analysis and linkage of the abnormal biomechanical factors involved in the causation of sub-acute and chronic grade I and grade II ankle inversion sprains will be discussed in the pathomechanical section later on in this chapter.

2.2.8.1 Kinetic Chain

An important prerequisite for normal function is that joints of the lower extremities and pelvis must move through certain minimum ranges of motion. If for any reason a joint is unable to move through its required minimum range of motion, potentially injurious compensation may occur elsewhere in the kinetic chain. While the loss of even subtle movements between the tarsal bones might be responsible for compensatory injuries, it is the larger more mobile joints that are more likely to produce pathological compensation (Levangie and Norkin 2001:79).

2.2.8.1.1 The Foot and Ankle

It should be considered an integral part of the practitioners approach to examine and treat the spine as a whole as both primary and secondary joint disorders of the lower extremities are common, and may have far-reaching biomechanical and neurological effects (Shafer and Faye 1990:373).

The foot and ankle joints are part of a complex system that provides stability and flexibility. During closed kinetic chain activities, the numerous foot and ankle joints function to

- Provide a stable base of support allowing upright posture
- Act as shock absorbers
- Act as a rigid lever during propulsion
- Act as a torque converter, allowing rotation of the pelvis and lower limbs
- Allow for adaptation to uneven terrain (Seto and Brewster 1994:695).
When there is an injury or compensation affecting the foot and ankle joints, problems may be manifested along the entire lower limb reaching as far as the spine (Seto and Brewster 1994:695).

The ankle joint is exposed to extreme mechanical conditions during single limb support. It is then subjected to the entire body weight and to the force generated by the dissipation of kinetic energy when the foot rapidly makes contact with the ground during ambulation (Kapandji 1974:148). Body weight is transmitted downward from the knee through the tibia to the ankle and foot in the upright position, and the forces generated are greatly multiplied during walking, running and jumping. Thus, the ankle and foot are affected by traumatic forces from above and below and by static deformities infrequently seen in other areas of the body (Shafer and Faye 1990:399).

The bones of the feet provide the foundation for the kinematic chain that extends from the occiput to the soles of the feet. The foot and ankle articulations play an important role in the holistic biomechanical integrity (Shafer and Faye 1990:403).

The joints of the foot and ankle must be able to meet the demands of both static and dynamic situations. The foot and ankle segments must be flexible enough (free of fixation) to accommodate to different surfaces yet be stiff enough to provide the required torque for locomotion. Pathologic function tends to occur with disruption of the mechanics of the kinematic chain (Shafer and Faye 1990:403).

2.2.8.1.2 Biomechanical Correlation between the Feet and the Spine

We need to understand the effect that the lower extremity mechanics has on the spine, through which a considerable fraction of energy expended in standing and ambulation is transmitted (Harrison 1992:105). To optimise spinal biomechanics, it is important to understand these relationships in order to evaluate and correct the juxtaposition of spinal structures (Harrison 1992:106).

The force of gravitational acceleration does not originate at the acetabulae, but at the feet from which it is transferred through the lower extremities and then via the femur heads to the pelvis (Harrison 1992:106).
Common injuries such as the ankle sprain may be perceived as uncomplicated, local events with consequential dysfunction, either at or beyond the site of injury, often not considered. The effects of ankle injury are not restricted to the ankle itself. Changes in postural sway after inversion ankle sprain suggest that the consequences of ankle injury are manifest at structures proximal to the ankle in addition to local structures (Beckman and Buchanan 1995:1138).

Sound arguments have been presented by osteopathic, podiatric, and orthopaedic researchers that positional changes in the spine and pelvis influence both movement and static loading of the feet. Conversely, changes in foot position or structure have been shown to have a mechanical influence on the spine and pelvis as a result of forces imposed by the foot upon the long bones of the lower extremity (Harrison 1992:105). The foot is a common site of single or multiple fixations that can frequently be linked to spinal fixations (Schafer and Faye 1990:409).

Chiropractors are concerned with the structure and function of the spine, including the pelvis, with the intention of maintaining optimum postural balance of the head, thorax and abdomen relative to the feet. This is intended to eliminate adverse mechanical stresses that lead to connective tissue pathology and interference with neurotransmission (Harrison 1992:105). Chiropractic treatment is primarily aimed at restoring proper spinal mechanics. Good biomechanical integration will influence the function of the nervous system. Because correct spinal mechanics and the health of the whole neuromusculoskeletal system are interdependent, chiropractic management involves the analysis of all sites of spinal joint dysfunction. Consequently, the restoration and rehabilitation of normal structure and function and not merely the relief of symptoms and/or pain drive chiropractic treatment. To concentrate on pain or other symptoms may ultimately invite long-term failure concerning the resolution or proper long-term management of a patient's condition (Troyanovich et al. 1998:37).

Abnormalities of posture (global fixations) can account for the myopathology, neuropathophysiology and kinesiopathology encountered in patients presenting to the health professional's office (Troyanovich et al. 1998:47). If spinal or pelvic mechanical dysfunction leads to deformation and altered mechanics of the foot secondary to abnormal stresses in the lower extremity, the practitioner is obligated to provide an optimal spinal corrective programme (Harrison 1992:106).
2.2.8.1.3 Pronation and Supination of the Feet

Pronation refers to a combination of dorsiflexion, eversion, and abduction movements taking place in the tarsal and metatarsal joints (Gatterman 1990:413). Supination is the result of combined plantarflexion, inversion, and adduction of the foot, causing an elevation of its medial edge (Schafer and Faye 1990:406).

Figure 3A illustrates closed-chain (weight-bearing) supination of the subtalar joint (right foot). Supination of the subtalar joint in the weight-bearing foot results in motion of both the calcaneus and the talus. The calcaneus moves in the frontal plane, and the talus moves in the transverse and sagittal planes. The calcaneus inverts, and the talus simultaneously abducts and dorsiflexes relative to the calcaneus. The leg follows the motion of the talus in the transverse plane and laterally rotates. The leg also follows the sagittal plane motion of the talus to some degree. The dorsiflexion motion of the talus on the calcaneus, therefore, tends to impart a slight extension motion to the knee (Magee 1997:605).

Figure 3B illustrates closed-chain (weight-bearing) pronation of the subtalar joint (right foot). Pronation of the subtalar joint in the weight-bearing foot results in eversion of the calcaneus; the talus adducts and plantarflexes relative to the calcaneus. The leg follows the talus in a transverse plane and medially rotates. In a sagittal plane, the leg also moves to some extent with the talus. As the talus plantarflexes, the proximal aspect of the tibia moves forward to flex the knee slightly (Magee 1997:605).
Figure 3. (A) Closed-chain (weight-bearing) Supination of the Subtalar joint (right foot). (B) Closed-chain (weight-bearing) Pronation of the Subtalar joint (right foot) (Magee 1997:605).

Figure 4A illustrates open-chain (non-weight-bearing) supination of the subtalar joint (right foot). When the non-weight-bearing foot is moved at the subtalar joint in the direction of supination, the talus is stable, and the calcaneus and foot move around the talus. The calcaneus and foot invert, plantarflex and adduct. These positional changes, associated with subtalar joint supination, are readily visible when compared with the pronated position of the subtalar joint (Magee 1997:605).

Figure 4B illustrates open-chain (non-weight-bearing) pronation of the subtalar joint (right foot). When the subtalar joint is moved into a pronated position in the non-weight-bearing foot, the foot abducts, everts, and dorsiflexes around the stable talus. The positional variances can best be appreciated by comparing this illustration with the supinated position of the subtalar joint (Magee 1997:605).
Figure 4. (A) Open-chain (non-weight-bearing) Supination of the Subtalar Joint (right foot). (B) Open-chain (non-weight-bearing) Pronation of the Subtalar Joint (right foot) (Magee 1997:605).

2.2.9 PATHOMECHANICS

Due to the complex nature of the pathomechanics related to the onset of sub-acute and chronic inversion ankle sprains, various concepts and theories will be discussed in this next section. As we have already reviewed the normal biomechanical and associated principles, it is now possible to review and discuss the abnormal phenomena.

2.2.9.1 Pathomechanical Discussion Involving Inversion Ankle Sprain

Restriction owing to soft-tissue tightness, scar tissue formation, and joint immobility all play roles in influencing normal biomechanical function (Seto and Brewster 1994:699).

In most cases, ankle sprains occur as a result of inversion injury. The follow-through momentum of the body amplifies the degree of inversion. This situation causes a moment about the ankle joint, which further inverts the ankle. The ability of the individual to effectively contract his or her peroneal muscles may counter this inversion tendency (Shapiro et al. 1994:78). The peroneal
muscles function as dynamic stabilizers of the ankle and assume an important role when the static stabilizers (the lateral ligaments) are compromised (Baumhauer et al. 1995:568). If the moment is unchecked, inversion will continue until bony apposition between the calcaneus and the medial malleolus occurs. During this process, the anterior talofibular and the calcaneofibular ligaments are loaded, and frequently tear (Shapiro et al. 1994:78). The loss of ligamentous integrity may result in a varus instability of the ankle mortise, thereby attributing to malalignment of the ankle joint (Ebig et al. 1997:75).

Perpetuation of ankle mortise varus instability may result in the talocalcaneonavicular-subtalar and transverse tarsal joints being locked in supination. This prohibits these joints from participating in shock absorption. The inability to absorb additional rotations across the supinated hindfoot puts an additional strain on the ankle joint structures, especially the lateral collateral ligaments (Levangie and Norkin 2001:400).

A common sequela of ankle sprains is the loss of ankle dorsiflexion, as a result of which the talar dome cannot lock fully into the ankle mortise; this leads to a loss of bony stability during locomotion (Pellow and Brantingham 2001:17). Restriction of dorsiflexion would normally be expected to limit gait and other functional activities. At least 10 degrees of dorsiflexion is required for normal walking, descending stairs, and kneeling, whereas running requires 20 to 30 degrees of dorsiflexion (Green et al. 2001:985). For minimal normal locomotion to occur, the ankle should also be able to actively plantarflex between 20 and 25 degrees. Restricted ankle dorsiflexion range confers an increased risk of lower limb injuries, especially ankle sprains (Pellow and Brantingham 2001:17).

People with acute ankle sprains walk slowly and take smaller steps. The available pain-free range of movement in dorsiflexion has been shown to determine walking speed, contralateral step length when the range of movement in dorsiflexion is less than 10 degrees, and single support time, with the relationships being non-linear. Subjects with less than 4 degrees of available dorsiflexion have been shown to be less symmetrical for single support time than when more than this range of movement is available (Green et al. 2001:985). Individuals with a history of a unilateral inversion sprain of the ankle have impaired single-limb balance compared to a noninjured individual. In addition, this observed instability is evident as much as two years following the injury (Cornwall and Murrell 1991:246).
Ankle position is an important functional factor showing the most pronounced change after injury. The normal stride depends on a very accurate sense of joint proprioception. In the late swing phase of gait, where the center of gravity has passed the supporting foot, the swing phase foot passes just 5 mm above the ground. Misjudging the degree of ankle inversion in this phase may cause the lateral part of the foot to collide with the ground surface, creating an ankle inversion torque (Konradsen et al. 1998:77). Ambulation may then be guarded with increased loading on the medial aspect of the forefoot, avoiding any inversion motion (Seto and Brewster 1994:712).

2.2.9.2 Clinical Effects of Abnormal Foot Motion

Most athletes never fully recover from their first injuries. Adhesions and limited range of motion about the joints secondary to injury influence biomechanical function (Baumhauer et al. 1995:568).

It is important to recognize any abnormalities occurring at the trunk, pelvis, hip, and knee that may be affected by or cause changes at the foot and ankle joints (Seto and Brewster 1994:707). Only the stance phase of gait significantly affects the biomechanical relationship between the foot and pelvis (Harrison 1992:110).

The most common types of abnormal foot motions occur as a result of excessive pronation and supination. These abnormalities are intrinsic changes that result in a form of mechanical compensation. The subtalar joint typically compensates for these changes, and it is destructive to this joint when soft-tissue damage and foot pathology occur (Seto and Brewster 1994:709).

Abnormal pronation is detrimental because of the compensatory amount of motion that occurs in addition to the normal amount of pronation during stance phase to accommodate the abnormality. Abnormal pronation leads to a flexible, mobile foot with soft tissue damages. An excessive amount of pronation places joints at the end of range and stress the noncontractile tissues supporting the joints (i.e., joint capsules and ligaments) (Seto and Brewster 1994:709).

Abnormal supination results in a different form of trauma than compensations that occur as a result of abnormal pronation. It does not demonstrate the progressive tissue breakdown as seen in the hypermobile, pronated foot. In contrast, abnormal supination exhibits a rigid, inflexible foot, leading to soft tissue inflammation and possible joint destruction. The foot is unable to dissipate the ground
reaction force on impact, thereby imposing greater loads on the joints’ articular surfaces (Seto and Brewster 1994:709).

Speed of motion also plays a role in abnormal motion at the foot. Pronation normally occurs immediately after heel strike to help dissipate the forces as the foot approaches full weight bearing. If pronation occurs too quickly, the contractile tissues attempt to slow the motion down by eccentrically contracting; over time, this may cause injury (Seto and Brewster 1994:709).

A change in the timing of events may lead to foot abnormalities. Pronation and supination must occur to ensure normal foot biomechanics. If the sequence of motion happens at the wrong time, abnormal foot mechanics may ensue. For example, if pronation occurs during propulsion when the foot should be supinated, inappropriate forefoot motion occurs and does not allow for effective pushing off of the first ray. In addition, a change in the timing of events may lead to alterations in the proper sequencing of events in the entire lower extremity and pelvis (Seto and Brewster 1994:709-710).

The type of surface the runner trains on is an important consideration. Roads are not perfectly flat and are designed with a camber. This causes a naturally occurring downward slope at the road’s edge and causes the subtalar joint closest to the center of the road to pronate and the subtalar joint furthest from the center to supinate. This is an important consideration among runners who have abnormal pronation, abnormal supination, or ankle sprains (Seto and Brewster 1994:710).

**2.2.9.3 Effects of Biomechanical Dysfunction in the Kinetic Chain and the Feet**

When a joint is not free to move, the muscles that move it cannot be free to move it. Muscles cannot be restored to normal if the joints, which they move, are not free to move. Normal muscle function is dependent on normal joint movement. Impaired muscular function perpetuates and may cause deterioration in abnormal joints (Moyal 1998:32).

Loss of function in one joint may have widespread effects on the normal functioning of much of the rest of the musculoskeletal system. This occurs as a result of the human body adapting to the biomechanical dysfunction (Moyal 1998:30). Fixations in the lowest part of the kinetic chain, the foot, can cause reflex fixations in the spine and its appendages (Broome 2000:4-5).
A higher incidence of asymmetrical pronation has been associated with an anatomical short leg on the opposite side. The effect of unilateral pronation or asymmetrical bilateral pronation has the effect of producing pelvic tilt due to unequal lowering of the tibiae and asymmetrical medial extremity rotation. Both of these situations are likely to cause internal pelvic rotation about the sacroiliac joints: The so-called As (anterior superior)/Ps (posterior superior) ileum. The pelvic rotation at the SI joints however, could have caused the foot pronation in the first place (Harrison 1992:112).

2.2.9.4 Myofascial Pain and Dysfunction Syndrome

Myofascial pain and dysfunction syndrome can be defined as pain, tenderness, and autonomic phenomena referred from active myofascial trigger points, with associated dysfunction (Travell and Simons 1999 2:4).

Myofascial pain is characterized by intense, deep muscular pain referred from hypersensitive trigger points located in the bellies of muscles and their tendinous attachments. The trigger points are extremely tender to direct pressure or squeezing and are palpable as hard, indurated nodules in the muscle and/or fascia. The pain is frequently described as a deep toothache-like pain, which refers in constant patterns. It is this pain referral that characterizes myofascial trigger points and differentiates them from tender points that are sensitive to palpation and pressure, but which lack the classical referral pain pattern (Gatterman 1990:295).

The high prevalence of pain originating from muscles is not surprising since collectively, voluntary (skeletal) muscle constitutes the largest single tissue mass in the human body, accounting for 40% or more of body weight. While the primary emphasis of chiropractic therapy is treatment by manipulation of joint dysfunction, concomitantly injured muscles, when left untreated, significantly prolong healing time and often result in unnecessary disability and can progress to multiple areas of tenderness with systemic manifestations (Gatterman 1990:285).
2.2.9.4.1 Mechanism of Myofascial Trigger Point Development

Trigger points may develop in muscles that are either acutely or chronically strained. Particularly with acute strain, there is some degree of tissue damage. This may, on the cellular level, include disruption of some of the sarcoplasmic reticulum and release of some of the stored calcium. It also impairs the ability of the sarcoplasmic reticulum to remove calcium from the injury site. The availability of extra calcium (in the presence of normal amounts of ATP) to the myofibrils results in sustained contraction of the sarcomere and eventually in fatigue. This sustained local contraction produces the palpable taught band associated with myofascial trigger points and creates a region of uncontrolled metabolism, that in turn can result in additional mast-cell liberation of histamine and the depletion of local ATP (Gatterman 1990:291).

As the energy from splitting ATP is required to “recork” the contractile mechanism, its depletion results in a progressive failure of relaxation and eventually in contracture. The sustained contractions subsequently reduce blood flow to the area, which is compounded by vasoconstriction from autonomic nerves that are activated as a result of trigger-point sensory-fiber input to the central nervous system. The resulting decrease in local blood supply results in the local accumulation of metabolites such as prostaglandins, which are also capable of sensitizing nerve endings. A self-perpetuating local muscle condition is created, which is painful, resists stretching, and results in decreased range of motion and generalized disability (refer to Figure 5) (Gatterman 1990:291).
Figure 5. Trigger Point Genesis (Gatterman 1990:292).

2.2.9.4.2 Clinical Characteristics of Myofascial Trigger Points

A myofascial trigger point is a hyperirritable spot, usually within a taught band of skeletal muscle or in the muscle’s fascia. The spot is painful on compression and can give rise to characteristic referred pain, tenderness, and autonomic phenomena (Travell and Simons 1999 2:4).
Myofascial trigger points (TrPs) are classified as either active or latent. Active trigger points produce a clinical complaint (usually pain) that the patient recognizes when the TrP is digitally compressed. It is always tender, prevents full lengthening of the muscle, weakens the muscle, and mediates a local twitch response of muscle fibers when adequately stimulated, and, when compressed within the patient’s pain tolerance, produces referred motor phenomena and often autonomic phenomena, generally in its pain reference zone. Latent TrPs are clinically quiescent with respect to spontaneous pain and are painful only when palpated. A latent TrP may have all the other clinical characteristics of an active trigger point and always has a taught band that increases muscle tension and restricts range of motion. A latent myofascial TrP may persist for years after apparent recovery from injury. It predisposes to acute attacks of pain, since minor overstretching or chilling of the muscle may be sufficient to reactivate it. Both latent and active myofascial TrPs can cause significant motor dysfunction, but only active TrPs cause pain (Travell et al. 1999 1:1,4,19).

2.2.9.4.3 Review of the Muscles Involved in the Study

2.2.9.4.3.1 Gastrocnemius Muscle

The gastrocnemius muscle is the most superficial of the muscles in the posterior leg compartment, forming most of the prominence of the calf (refer to Figure 6). The gastrocnemius is a fusiform, two-headed, two-joint muscle. The medial head of gastrocnemius attaches to the femur’s popliteal surface and superior to the medial condyle. The lateral head attaches proximally to the lateral aspect of the lateral femoral condyle. This muscles acts to plantarflex the foot at the ankle joint via its distal attachment to the posterior surface of the calcaneus by the tendocalcaneus (Moore 1992:449). A branch of the tibial nerve that contains fibres from the first and second sacral spinal nerves, supplies both heads of the gastrocnemius muscle (Martini 1992:362).
Figure 6. Attachments of the right gastrocnemius muscle (gray) seen from the rear (Travell and Simons 1999 2:400).

a) Trigger Point Location

Each head has two trigger point (TrP) regions, located towards its outer margins.

i) Medial Head

TrP 1 - It is the most common of the gastrocnemius Tps. It is located distal to the knee along the medial border of the medial head proximal to the midbelly of the muscle (Travell and Simons 1999 2:398).

TrP 3 – It is located behind the knee in the popliteal space near where the medial head attaches to the medial femoral condyle. It is the more proximal Tp (Travell and Simons 1999 2:398).
ii) Lateral Head

TrP 2 – It is the second most common location of gastrocnemius Tps. It is located distal to the knee along the lateral border of the lateral head proximal to the midbelly of the muscle. It is found slightly more distal to TrP 1 (Travell and Simons 1999:2:398).

TrP 4 – It is located behind the knee in the popliteal space near where the lateral head attaches to the lateral femoral condyle (Travell and Simons 1999:2:398).

b) Referred Pain

TrP 1 – refers pain primarily to the instep of the ipsilateral foot with a spillover zone that extends from the region of the lower posterior thigh, over the back of the knee, and down the posteromedial aspect of the leg to the ankle (refer to Figure 7) (Travell and Simons 1999:2:398).

TrP 2, TrP 3 and TrP 4 – Refer pain primarily locally around and near the TrP (refer to Figure 7) (Travell and Simons 1999:2:398).

Tenderness in the region of TrP 3 and TrP 4 can be caused by musculotendinous tension produced by taught bands accompanying a TrP 1 or TrP 2. Either or both of the two TrP regions behind the knee (TrP 3 or TrP 4), however, may harbor TrPs with their own palpable taught bands in the absence of the two more distal TrPs. They produce pain primarily in the popliteal fossa (Travell and Simons 1999:2:398).
Figure 7. Pain referred from trigger points (Xs) in the right gastrocnemius muscle. The essential pain pattern is solid gray. Gray stippling indicates the spillover extension of the essential pattern (Travell and Simons 1999: 2:399).

2.2.9.4.3.2 Soleus Muscle

The soleus muscle is a broad, flat, fleshy muscle that lies deep to the gastrocnemius and can be palpated on each side of it, inferior to the midcalf (refer to Figure 8). The soleus muscle attaches proximally to the posterior aspect of the fibula head, superior fourth of the posterior fibula surface, the soleal line and medial tibial border. This muscle acts with the gastrocnemius in plantarflexing the foot at the ankle joint via its distal attachment to the posterior surface of the calcaneus by the tendocalcaneus (Moore 1992: 449). A branch of the tibial nerve that contains fibres from the first and second sacral spinal nerves, supplies the soleus muscle (Martini 1992: 362).
Figure 8. Attachments of the soleus (dark gray) muscle of the right leg (Travelli and Simons 1999 2:431).

a) Trigger Point Location

TrP 1 – It is the most common soleus TrP, located 2 to 3 cm distal to the end of the gastrocnemius muscle belly and slightly medial to the midline (Travell and Simons 1999 2:428).

TrP 2 – It is less common and located more proximal, high on the lateral side of the calf (Travell and Simons 1999 2:428).

TrP 3 – It is very rare and is located slightly more proximal and lateral to TrP 1 (Travell and Simons 1999 2:429).

b) Referred Pain

TrP 1 – Refers pain and tenderness primarily to the posterior aspect and plantar surface of the heel and also to the distal end of the achilles tendon (refer to Figure 9). Spillover pain may be reported in
the region of the TrP and sometimes slightly forward from the heel into the instep (Travell and Simons 1999 2:428).

TrP 2 – Causes a diffuse pain in the upper half of the calf (refer to Figure 9) (Travell and Simons 1999 2:428).

TrP 3 – Refers deep pain in the ipsilateral sacroiliac joint (refer to Figure 9). Less frequently, this TrP may cause less intense spillover pain in the region of the TrP itself and over the posterior and plantar surfaces of the heel, mimicking the pattern of TrP 1 (Travell and Simons 1999 2:429).

Figure 9. Pain patterns referred from trigger points (Xs) commonly observed in the right soleus muscle. The essential pain pattern (solid gray) denotes the pain experienced by nearly everyone in whom these trigger points are active. Gray stippling indicates the occasional spillover pain pattern (Travell and Simons 1999:429).
2.2.9.4.3.3 The Peroneal Muscles

The peroneus longus and brevis muscles are located in the lateral leg compartment (refer to Figure 10). The tendons enter a common sheath above the ankle and pass posterior to the lateral malleolus and deep to the peroneal retinaculum. On the lateral surface of the foot the peroneus brevis inserts on the fifth metatarsal base. It attaches proximally to the head and superior two-thirds of the lateral fibula surface. The peroneus longus passes under the foot to insert on the medial cuneiform and first metatarsal base. Proximally, it attaches to the inferior two-thirds of the lateral fibula surface. Both muscles assist in eversion and plantarflexion of the foot (Berquist 1992:174). Peroneus tertius attaches proximally to the inferior third of the anterior surface of the fibula and interosseous membrane. It inserts distally to the dorsum of the base of the fifth metatarsal bone and functions to dorsiflex and evert the foot (Moore 1992:445). Branches of the superficial peroneal nerve supply the peroneus longus and peroneus brevis muscles via fibres from the L4, L5 and S1 spinal nerves. The deep peroneal nerve supplies the peroneus tertius with fibres from only the L5 and S1 spinal nerves (Travell and Simons 1999 2:375).

![Image of anatomical attachments and relations of the right peroneal muscles. A, lateral view. B, plantar view of right foot bones to which peroneus longus attaches (Travell and Simons 1999 2:373).](image-url)
a) Trigger Point location

The most common trigger point (TrP) location in the peroneus longus muscle is about 2-4 cm distal to the head of the fibula. TrPs in the peroneus brevis muscle are usually found on either side of, and deep to, the peroneus longus tendon near the junction of the middle and lower thirds of the leg. TrPs in the peroneus tertius muscle are palpable slightly distal and anterior to peroneus brevis TrPs, and proximal and anterior to the lateral malleolus (Travell and Simons 1999: 2:384).

b) Referred Pain

Peroneus longus and peroneus brevis TrPs project pain and tenderness primarily to the region over the lateral malleolus of the ankle, above, behind, and below it; they also extend a short distance along the lateral aspect of the foot (refer to Figure 11). A spillover pattern of the peroneus longus TrPs may cover the lateral aspect of the middle third of the leg (Travell and Simons 1999: 2:371).

Peroneus tertius TrPs refer pain and tenderness along the anterolateral aspect of the ankle with a spillover pattern projecting downward behind the lateral malleolus to the lateral aspect of the heel (refer to Figure 11) (Travell and Simons 1999: 2:371).
Figure 11. Pain patterns referred from trigger points (Xs) at commonly observed locations in the peroneal muscles. The essential patterns of referred pain and tenderness are solid gray, and the gray stippling shows the less common spillover extension of pain. These trigger points all refer pain distally. A, shows the pain pattern for the peroneus longus and peroneus brevis muscles (medium gray). The spillover pattern between the trigger points applies only to peroneus longus. B shows the pain pattern of the peroneus tertius muscle (light gray) (Travell and Simons 1999:372).

2.2.9.4.3.4 Tibialis Anterior Muscle

Tibialis anterior attaches proximally to the lateral condyle and superior half of the lateral surface of the tibia (refer to Figure 12). It inserts distally to the medial and inferior surfaces of the medial cuneiform bone and to the base of the first metatarsal bone. It functions to dorsiflex and invert the foot and is innervated by the deep peroneal nerve via fibres from the L4 and L5 spinal nerves (Moore 1992:445).
Figure 12. Attachments of the right tibialis anterior muscle (gray), anterior view (Travell and Simons 1999:357).

a) Trigger Point Location

Trigger points (TrPs) are most commonly located at approximately the junction of the proximal and middle thirds of the leg just lateral to the sharp edge of the tibia (Travell and Simons 1999 2:363).

b) Referred Pain

TrPs in the tibialis anterior muscle refer pain and tenderness primarily to the anteromedial aspect of the ankle and over the dorsal and medial surfaces of the great toe (refer to Figure 13). In addition, sometimes the pain may extend from the TrP downward over the shin to the ankle and foot anteromedially (Travell and Simons 1999 2:356).
Figure 13. Pain pattern referred from a trigger point (X) at its usual location in the right tibialis anterior muscle, as seen in the anterior view with the foot slightly abducted. The essential pain pattern is solid gray; the gray stippling indicates occasional spillover extension of the essential pattern (Travell and Simons 1999:356).

2.3 TREATMENT

2.3.1 INTRODUCTION

The main objectives when an ankle sprain is being treated are to achieve stability (both static and dynamic), gain normal ankle range of motion, and achieve optimal strength of the peroneal muscles, dorsiflexors, plantarflexors, and inverters of the ankle (Pellow and Brantingham 2001:18).

There is a lack of specific information on practice patterns of physiotherapists for patients with sprained ankles, addressing for example treatment goals, and timing of interventions in the course of treatment. Knowledge about this treatment is important for the further development of physical therapy as a professional discipline, and for designing meaningful clinical research (Roebroeck et al. 1998:421).
There appear to be few studies and, except for functional exercises and surgical intervention, few suggested treatment protocols for chronic inversion ankle sprains despite the prevalence of this injury (Pellow and Brantingham 2001:23). Treatments for an acute sprain have included surgical repair, plaster immobilization, early mobilization, strapping, elastic bandaging, anti-inflammatory medication, rest and ice (Eiff et al. 1994:83). These treatment options are combined with various rehabilitation programs that use range of motion and strengthening exercises (Giasoe et al. 1999:394).

Most ankle injuries that involve the lateral ankle ligaments can be managed favorably in the primary care setting. It has been advocated that early intervention, with conservative treatment, such as compression, mobilization, exercise, and contrast baths, is important to prevent chronic symptoms (Pellow and Brantingham 2001:18).

It would be expected that a treatment resulting in reduced pain and improved ankle dorsiflexion range of movement should also result in more rapid improvement of gait variables caused by a sprained ankle (Green et al. 2001:985).

2.3.2 THERAPEUTIC ULTRASOUND

Ultrasound is a unique physical modality using high-frequency sound to produce thermal, nonthermal, and neural effects in human tissues (Rivenburgh 1992:651).

Using ultrasound on the injured lateral ligaments of a sub-acute or a chronic inversion ankle sprain will produce the following effects:

a) Thermal Effects

Thermal effects of therapeutic ultrasound result in a reduction of pain and stiffness, alleviation of muscle spasm, increased joint range of motion and acceleration of the metabolic healing process. The extensibility of collagen is also increased by a rise in temperature, and so stretching of scars or adhesions is easier following ultrasound (Rivenburgh 1992:651).
Ultrasound may also alter muscle contractibility, reduce muscle spindle activity, or directly reduce pain, which breaks the pain-spasm-pain cycle (Rivenburgh 1992:650).

b) Nonthermal Effects

Ultrasound appears to alter diffusion of sodium and potassium ions and probably calcium as well. Ultrasonic waves produce a compression of cells, and effect the movement of tissue fluid in interstitial spaces. This plays a role in reducing edema. In conjunction with the thermal effect, the extensibility of scars and adhesions could be affected, in such a way as to make stretching them easier, and in doing so, help to reduce pain as a result of joint contracture. Ultrasound also stimulates fibroblast activity in the synthesis of reparative tissue (Rivenburgh 1992:649).

2.3.3 SOFT TISSUE THERAPY

2.3.3.1 Cross Friction / Transverse Friction Massage

Transverse friction is concerned with the mobilization of fibrotic infiltration of muscular and ligamentous tissues. Procedural therapy consists of frictional massage, perpendicular to the normal orientation of the fibrous tissue (Harrison 1992:350).

Transverse friction is a specific manipulation technique pioneered by Cyriax. The transverse friction is performed with the skin of the patient and the therapist’s finger acting as a single unit. The action demands great anatomical accuracy and must be of sufficient depth and sweep to affect the desired tissues. The aim is to produce local hyperaemia, massage analgesia and a reduction in adherent scar tissue (Norris 1993:138).

Transverse friction breaks the cross linkages in fibrous tissue, thereby creating a more extensible scar. This massage promotes the proper orientation of immature collagen and, in doing so, contributes further to the successful rehabilitation of soft tissue injuries. This type of massage will activate mechanoreceptors, which inhibit nociceptive transmission at the dorsal horn of the spinal cord, thereby reducing the sensation of pain in the affected area. Treatment is directed at fibrous adhesions in the musculotendinous areas, muscle bellies, tendon bodies and in ligamentous structures (Harrison 1992:350).
It may be used to encourage the development of a mobile scar, and as a prelude to manipulation for scar tissue rupture in a chronic injury (Norris 1993:205).

2.3.3.2 Massage Techniques

Various massage procedures are used in sports physiotherapy, and most influence the tissues by stretching or compression, resulting in both reflex and mechanical effects (Norris 1993:137).

The effects of massage are achieved through mechanical, physiological, and psychological processes. Compression and squeezing will improve venous and lymphatic drainage. Interstitial pressure is increased and fluid absorption aided. Fresh blood will enter the area. The superficial skin response to vigorous massage is an axon reflex. Redness results through the dilatation of skin arterioles and slight swelling through increased permeability of the capillary wall, allowing tissue fluid to escape into the surrounding area. Short-term pain relief may be brought about by closure of the pain gate and stimulation of endogenous opioids. Tissues are mobilized as they are moved over each other, and adhesions stretched with more forceful actions. Massage has been shown to aid recuperation from muscle fatigue (Norris 1993:138).

The classical massage techniques and their effects are outlined below.

a) Effleurage

Two types of effleurage are used: the first is a deep action, aimed at assisting lymphatic and venous drainage. The second is a superficial stroking movement, designed to produce a sensory reaction, either of relaxation (slow stroking) or of stimulation (fast stroking) (Norris 1993:137).

b) Ischaemic Compression

This involves applying a progressively stronger, painful pressure on a trigger point, with the purpose of eliminating the point's tenderness. This action blanches the compressed tissues, which usually become hyperaemic (flushed) on release of the pressure (Travell et al. 1999 1:2).
2.3.4 CHIROPRACTIC MANIPULATION AND MOBILIZATION THERAPY

Chiropractic care has been intimately associated with the manual skill referred to as the chiropractic adjustment. The care offered by chiropractors has always incorporated more than just the manual adjustment or manipulation and includes a detailed awareness of the patient’s environmental, psychological and social status. The chiropractic adjustment or manipulation however, remains the primary therapeutic modality offered by chiropractors (Haldeman 1992:413).

2.3.4.1 Spinal fixations

An important consideration in spinal biomechanical dysfunction is the spinal fixation. This is referred to as any physical, functional, or psychic mechanism that produces a loss of segmental mobility within its normal physiologic range of motion. This limitation of motion or hypomobility may set up a state of abnormal biomechanical translation and rotation leading to a biomechanical and subsequent physiologic dysfunction (Shafer and Faye 1990:2).

a) The Vertebral Subluxation Complex

The Vertebral Subluxation Complex (VSC), as presented by Lantz (1995:149) is a model of the spinal dysfunction from a chiropractic clinical perspective. Central to Lantz’s (1995) concept of subluxation, as with that of Shafer and Faye (1990:2), is some form of kinesiologic dysfunction. The primary form of kinesiopathology is hypomobility, often referred to as a fixation. As a result of this hypomobility or fixation, the joint is immobilised and may undergo immobilisation degeneration – a term referring to the consistent pattern of degeneration in all tissues associated with the hypomobile joint.

The VSC (refer to Figure 14) deals primarily with the neuromusculoskeletal components of spinal dysfunction and subsequent spinal degeneration as they relate to the chiropractic concept of subluxation (Lantz 1995:150).

The kinesiologic component is placed at the apex of the model, as restoration of motion of a fixated articulation is central to chiropractic spinal manipulative therapy. Below the kinesiologic component are the tissue-level components of the VSC. Each tissue component works in coordination with the
others to allow for and maintain correct and adequate segmental motion. Interference with any single component affects all others. Movement of the articulation (kinesiologic component) is determined by the action of muscles (myologic component). In turn, this motion is guided, controlled and stabilised by the connective tissue structures. The vascular system provides the necessary nutrition for all other tissue components. The co-ordinated function of all the above-mentioned tissue components (kinesiologic, myologic, connective tissue, vascular) is in turn, controlled by the nervous system (Lantz 1995:151).

The pathophysiologica components of the VSC encompass the following elements:

i) **Neuropathophysiology**- The subluxation causes irritation and/or compression of the neural components of motion segments and

ii) **Kinesiopathology**- The restriction in movement of motion segments is due to muscle hypertonicity, joint stabilisation, the muscle spindle spasm cycle, joint sprain and joint locking

These pathophysiologica elements may be corrected by spinal manipulation (Gatterman 1990:39).

![Organisational Model of the Vertebral Subluxation Complex](image)

**Figure 14.** Organisational Model of the Vertebral Subluxation Complex (Lantz 1995).
b) Motion Palpation of Spinal, Ankle, and Foot Fixations

Motion palpation is used by the examiner to determine the amount of movement taking place at a joint (Schafer and Faye 1990:408).

The feet are considered as the functional base of the spine. The cause of many frequently reoccurring fixations in the spine and pelvis can be traced to a mobility restriction in the feet (Schafer and Faye 1990:408).

Motion palpation examination of the feet is usually conducted immediately following the standard orthopaedic/neurological examination, including gross range of motion evaluation, muscle strength grading, reflexes, and light touch and pain perception (Schafer and Faye 1990:409).

2.3.4.2 Theory of Chiropractic Manipulative Therapy

a) Chiropractic Hypothesis

Any therapy must be based on a theory. Chiropractic therapy is based on the hypothesis that reversible joint lesions of the spine produce far-ranging effects on the human body. In reversing the subluxation complex, chiropractors rely on spinal manipulation (adjustment) as their primary therapeutic tool. Modern chiropractic adheres to the idea that biomechanical dysfunction can have a profound effect on the musculoskeletal system as well as on the other systems of the body. While the restoration and normalization of joint motion is the mechanism of chiropractic therapy, the ultimate goal is to promote body homeostasis (Gatterman 1990:52).

b) Defining the Adjustment

Kirk et al. (1985:1) defines the adjustment as “a specific form of direct articular manipulation utilizing a short lever and characterized by a dynamic, forceful, high velocity thrust of controlled amplitude.”
c) Mechanisms of the Spinal Adjustment

Manipulation consists of forcing the joint beyond its elastic barrier of resistance, which produces a cracking noise as the articular surfaces suddenly move apart. The cracking noise is the result of a sudden liberation of the dissolved synovial gases, referred to as a cavitation. Following the release of gases, there is a refractory period as the synovial gases are redissolved. During this period (approximately 20 minutes), the articular crack cannot be reproduced. Manipulation of the joint should be forceful enough to produce the articular crack but not so great as to separate the joint surfaces beyond their limit of anatomical integrity (Gatterman 1990:49). However, the presence or absence of joint cracking should not be the test for determining whether or not an adjustment has been successful (Pellow and Brantingham 2001:19).

Sandoz refers to the range of motion beyond the passive range and up to the limit of anatomical integrity as the paraphysiological space (refer to Figure 15). Carrying the joint movement beyond the limit of anatomical integrity results in sprain and, if extreme, dislocation (Gatterman 1990:50).
Figure 15. Four stages of range of movement (Rom) in diarthroidal joints: 1, Active Rom (motion produced by muscular action). 2, Passive Rom (motion produced by traction or springing the joint-joint play, up to the elastic barrier of resistance). Characterizes mobilization. 3, Paraphysiological Rom (motion beyond the elastic barrier of resistance up to the limit of anatomical integrity produced by manipulation and accompanied by an audible release). 4, Pathological movement (motion beyond the limit of normal anatomical integrity, which damages ligaments and capsule, resulting in joint hypermobility). Manipulation that is too forceful may move the joint beyond the limit of anatomical integrity, creating or perpetuating joint instability (Gatterman 1999:49).

d) Effects of Chiropractic Manipulation and Mobilization Therapy

Manipulative therapy is a procedure that may induce quick distraction and break the intraarticular adhesions (Pellow and Brantingham 2001:17). Manipulation of the injured extremity or joint can help in establishing normal biomechanical relationships, allowing for quicker healing and recovery because of normalized function of the regional anatomy (Johnson and Sautier 1998:161).

Several physiological objectives of the chiropractic adjustment have been proposed:

1) Maintenance of the postural and myotonic proficiency of the human as a biped.
Stretching exercises should be used to assist in regaining flexibility. Accessory and physiologic mobilization techniques promoting normal joint motion are important in reducing pain and restoring normal motion (Seto and Brewster 1994:699).
CHAPTER THREE – METHODOLOGY

3.1 INTRODUCTION

This chapter serves to explain the type of data collected, the way it was collected, its measurement, the treatment protocols followed, and the statistical analysis of the data, in order for them, if so desired, to be accurately replicated.

3.2 STUDY DESIGN AND PROTOCOL

The purpose of this investigation was to assess the effectiveness of chiropractic manipulative and mobilization therapy, as compared to soft tissue and ultrasound therapy, in the treatment of sub-acute and chronic grade I and grade II inversion ankle sprains. This research aimed to compare the effects of these therapies alone, and in conjunction, to determine the most efficient means of managing sub-acute and chronic grade I and grade II ankle inversion sprains.

3.2.1 THE SAMPLE AND SELECTION CRITERIA

Thirty patients were recruited by means of an advertisement poster placed throughout the Technikon Witwatersrand, Doornfontein Campus in Johannesburg, South Africa (refer to Appendix A), and at nearby sports clubs. An advertisement was also printed in a series of local newspapers through the Caxton Publishing Company. The details specified in the newspaper advertisement were consistent with those specified on the advertisement poster (refer to Appendix A). The samples of patients were screened prior to consideration for the study to ensure that they complied with the inclusion criteria.

Patients were required to:

- Be eighteen to thirty five years of age. This age group generally incorporated the physically active population.
- Sign a subject information and consent form (refer to Appendix B).
- Present with a history of a sub-acute or a chronic grade I or grade II ankle inversion sprain according to the criteria set out to determine ankle inversion sprain severity (refer to Table 1). For the purpose of this study, sub-acute was defined as ten days to seven weeks, and
chronic as seven weeks to two years after the initial injury (Magee 1997:4).

- Present with tenderness restricted to the lateral ankle ligaments to control for the presence of injury of other structures such as the deltoide ligament that may occur with severe sprains.

<table>
<thead>
<tr>
<th>GRADE/SEVERITY</th>
<th>SIGNS AND SYMPTOMS</th>
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<tbody>
<tr>
<td>Grade I (mild):</td>
<td>No haemorrhage</td>
</tr>
<tr>
<td>Stable</td>
<td>Minimal swelling</td>
</tr>
<tr>
<td></td>
<td>Point tenderness</td>
</tr>
<tr>
<td></td>
<td>Negative anterior drawer sign</td>
</tr>
<tr>
<td></td>
<td>No varus laxity</td>
</tr>
<tr>
<td>Grade II (moderate):</td>
<td>Some haemorrhage</td>
</tr>
<tr>
<td>Stable</td>
<td>Localized swelling</td>
</tr>
<tr>
<td></td>
<td>Less defined margins of Achilles tendon</td>
</tr>
<tr>
<td></td>
<td>Anterior drawer sign may be positive</td>
</tr>
<tr>
<td></td>
<td>No varus laxity</td>
</tr>
<tr>
<td>Grade III (severe):</td>
<td>Diffuse swelling on both sides of Achilles tendon</td>
</tr>
<tr>
<td>2-ligament, unstable</td>
<td>Early haemorrhage</td>
</tr>
<tr>
<td></td>
<td>Tenderness may occur medially and laterally</td>
</tr>
<tr>
<td></td>
<td>Positive anterior drawer sign</td>
</tr>
<tr>
<td></td>
<td>Positive varus laxity</td>
</tr>
</tbody>
</table>


Patients were excluded for the reasons of having:

- Had the injury for less than ten days or more than two years duration.
- Experienced an acute reinjury of the ankle whilst participating in the study.
- Taken any medications or undergoing any other modes of treatment for their ankle injury.
- Showed signs of gross mechanical instability (grade I ankle sprain).
- Demonstrated pathologies and any relative or absolute contraindication to manipulative therapy, ultrasound and/or soft tissue therapy on the basis of case history, physical examination, regional examination and radiography (if warranted) (Pellow and Brantingham 2001:18-19) (refer to Tables 2 and 3).

| Arthritis in Inflammatory Stages          | - Ankylosing Spondylitis       |
|                                        | - Rheumatoid Arthritis         |
|                                        | - Reiter’s Syndrome            |
|                                        | - Osteoarthritis               |
| Bone Infections                        | - Tuberculosis                 |
|                                        | - Osteomyelitis                |
| Congenital Malformations               | - Excessive spondylolisthesis with signs and symptoms indicating radicular compression |
| Neurological Complications             | - Cervical disc lesions and myelopathy |
|                                        | - Nerve root damage            |
| Reduced Bone Density                   | - Osteoporosis and Osteomalacia |
| Traumatic Injuries                     | - Articular trauma e.g. Dislocation & severe ligamentous strain |
|                                        | - Spinal Haematoma             |
| Tumors/Neoplasms                       | - Patients on anticoagulant therapy |
|                                        | - Primary                      |
|                                        | - Metastatic                   |

**Table 2.** Pathologies and Contraindications for Chiropractic Manipulative and Mobilization Therapy (Gatterman 1990: 55-62, 66) & (Halderman 1992: 565).

- Local or regional skin hyperaesthesia or hypoaesthesia
- Vascular conditions e.g. Thrombophlebitis, Atherosclerosis, DVT
- Neurological impairment
- Poor thermal regulation
- Over areas of suspected malignancy
- Acute inflammation
- Ultrasound over the eye, heart, pregnant uterus or testes
- Skin conditions e.g. Acute burns, wounds, ulcerations, acne
- Haematoma
- Varicose veins
- Fever

**Table 3.** Contraindications for Ultrasound Therapy and/or Soft Tissue Therapy (Rivenburgh 1992:650-651) & (Beck 1994:254-259).
A case history (Appendix E), foot and ankle regional examination (Appendix F), and a pertinent physical examination (Appendix G) were carried out to determine the patient's eligibility for the study and to give a precise diagnosis. Patients selected for group B and group C were additionally examined with a cervical spine (Appendix H) and a lumbar spine and pelvis (Appendix I) regional examination.

After a thorough clinical examination, both the researcher and the clinician on duty decided whether or not the patient would be sent for radiographs of the ankle joint. Radiographs were to be used to confirm any suspected pathology that might be a contraindication to adjustments.

Radiographs are usually unnecessary, provided that the patient does not exhibit tenderness over the posterior distal portion of either the medial or lateral malleolus, and as long as the patient is able to bear weight immediately after the injury (Pellow and Brantingham 2001:19). Stress x-rays of the ankle may help to determine the extent of ligamentous injury (Berkow et al. 1992:1378).

If after those examinations the patient fulfilled the requirements, and pathologies and contraindications for chiropractic manipulation and mobilization were excluded for patients in group B and group C, they were then accepted into the study.

3.2.2 RANDOMIZATION PROCESS

As the patients entered the study, they were asked to pick one of the letters A, B or C, with the intention of having thirty patients divided into three equal groups of ten at the end of the study. Group A received soft tissue therapy. Group B received chiropractic manipulative and mobilization therapy. Group C received a combination of soft tissue therapy and chiropractic manipulation and mobilization therapy.

3.2.3 TREATMENT PROTOCOL

In this study, three different treatment protocols were used, and compared in order to ascertain which was the most beneficial and most effective in producing lasting pain relief and improved ankle range of motion.
3.2.3.1 Group A

Patients in group A received the accepted interventions for managing grade I and grade II ankle inversion sprains. This consisted of soft tissue therapy being applied to the injured lateral ankle ligaments and lower limb muscles. The techniques were modified specifically for each patient, allowing each patient to receive maximal therapeutic benefit. The soft tissue therapy used (cross friction/transverse friction, effleurage massage and ischaemic compression) is described below under soft tissue therapy. Ultrasound therapy was applied to the injured lateral ankle ligaments following the completion of the soft tissue therapy. The ultrasound therapy was performed for 5 minutes at a dosage of 1Wcm⁻² using the 1 MHz ultrasound head on each consultation. As the injury treated was sub-acute or chronic in nature, a constant beam was selected. Patients in group A were placed in the supine position whilst receiving the soft tissue therapy and the ultrasound therapy.

3.2.3.1.1 Soft Tissue Therapy

a) Cross Friction / Transverse Friction Massage

Transverse frictions were applied perpendicular to the normal orientation of the injured lateral ankle ligament/s until the patient reported a subjective localized numbness of the treatment site. The transverse friction was performed with the skin of the patient and the therapist’s finger acting as a single unit (Norris 1993:138).

b) Effleurage Massage

In this study, effleurage massage was applied to the injured lateral ankle and the surrounding musculature.

The tissue manipulation started distally at midtarsal level, and proceeded proximally in the direction of the heart to the mid-fibula region. The researcher used his hands one at a time to create a superficial stroking movement, and then together with one supporting the other to create more force. Skin contact was maintained throughout the action, and as they moved, the hands changed shape to contour the limb (Norris 1993:137).
c) Ischaemic Compression

In this study, trigger points were detected only in the following muscles of the symptomatic lower limb. The muscle's trigger point locations and pain referral zones are described in detail in chapter two under 2.2.9.4.3 Review of the Muscles Involved in the Study:

- The gastrocnemius muscle
- The soleus muscle
- The peroneal muscles
- The tibialis anterior muscle

They were subsequently treated with ischaemic compression by applying a progressively stronger, painful pressure on the trigger point until the point's tenderness or pain referral subsided (Travell et al. 1999:12).

3.2.3.2 Group B

Patients in group B were adjusted at all fixated levels found in the cervical, thoracic, lumbar spine and pelvis, as well as at fixations found in the mortise joint and related joints in the foot. Each individual received a foot figure eight mobilization as a standard procedure prior to any foot or ankle adjustment (refer to Figure 16). Any ankle or foot fixations found on the patients were adjusted using specific techniques, which are described below. Only the injured ankle and foot was adjusted at the fixated levels. In terms of the manipulation therapy performed on the spine, specific diversified techniques were used. These are described below under 3.2.3.2.3 Spinal Manipulative Techniques.

3.2.3.2.1 Ankle Mobilization Technique

a) Foot Figure Eight

The foot figure eight is the best premanipulative technique for the foot. It loosens up tissue, breaks tarsal and metatarsal adhesions, prepares the foot for articular adjusting, improves circulation, and helps to reduce static congestion and edema (Kirk et al. 1991:151).
The contralateral hand firmly supports the lateral ankle and calcaneus of the supine patient, holding it from underneath. It prevents the heel and ankle from moving when the technique is performed. The homolateral hand firmly grasps the medial border of the foot at the midfoot level (just proximal to the bulge of the first metatarsophalangeal joint). The thumb is positioned on the sole of the foot and the fingers on the dorsum. The forefoot is moved through a figure eight motion that has a medial to lateral orientation. The motion is a combination of inversion with abduction followed by eversion with adduction (refer to Figure 16) (Kirk et al. 1991:151).

![Image of foot being mobilized](image)

**Figure 16.** Foot Figure Eight Mobilization (two views) (Kirk et al. 1991:151).

### 3.2.3.2.2 Ankle and Foot Manipulative Techniques

The below mentioned adjustments were the only techniques used to adjust the fixated segments in the ankle and foot.
a) Mortise Separation

The mortise separation is less likely to compromise the integrity of the lateral ligament complex of the already injured ankle and is indicated in the treatment of sub-acute inversion ankle sprains (Pellow and Brantingham 2001:18). It is also used to mobilize the tibiotalo joint (Kirk et al. 1991:155).

The indifferent hand grasps either the medial or the lateral border of the supine patient’s foot, with the thumb positioned on the sole of the foot and the fingers on the dorsal aspect of the foot. The contact hand grasps the opposite border of the foot from the indifferent hand, but holds the foot in the same manner. Several motions are necessary before the thrust can be delivered. Firstly, dorsiflex the ankle. Next, internally rotate the entire leg. Then evert the foot. Finally, thrust straight toward the doctor, with the line of drive parallel to the floor (refer to Figure 17) (Kirk et al. 1991:155).

![Figure 17. Mortise Separation Technique (Kirk et al. 1991:155).]

b) Plantar Snap

The plantar snap is indicated for a plantar subluxation of any tarsal bone (Kirk et al. 1991:166).
The thumb of the indifferent hand contacts the subluxated bone on the sole of the prone patient's foot, and the fingers hold the dorsal surface of the foot. The thumb of the contact hand is crossed over the indifferent hand's thumb, while the fingers also contact the dorsal surface of the foot. The ankle is then plantarflexed by axial traction on the leg so that the knee rises off the table. At that point, a quick downward snap by the wrists is given (refer to Figure 18) (Kirk et al. 1991:166).

**Figure 18. Plantar Snap Technique (Kirk et al. 1991:166).**

### 3.2.3.2.3 Spinal Manipulative Techniques

The below mentioned adjustments were the only techniques used to adjust the fixated segments in the spine.

**a) Cervical Break**

The Cervical Break technique is indicated to adjust any cervical fixation. Listings include RP-LP (Right Posterior-Left Posterior), RI-LI (Right Inferior-Left Inferior) and RL-LL (Right Lateral-Left Lateral) (Kirk et al. 1991:56).
The patient lies supine with the head resting on a level headpiece. For RP-LP and RI-Li listings, the patient's head is rotated 45 degrees to the contralateral side. For RL-LL listings, the nose is directed straight up. The doctor stands in a toggle stance on the homolateral side at right angles to the patient. An index contact of the caudad (contact) hand is taken whilst keeping the forearm parallel to the floor. For RP-LP and RI-LI listings, the posterior aspect of the articular process is contacted with skin slack removed posterior to anterior. For RL-LL listings, the anterior aspect of the transverse process is contacted with skin slack removed anterior to posterior. The cephalad (indifferent) hand cups the ear with the palm, splitting the sternocleidomastoid muscle with the chiropractic index and the index fingers. For RP-LP and RL-LL listings, the thrust is delivered straight across in line with the eyes. For RI-LI listings, the thrust is delivered across and slightly cephalad (refer to Figure 19) (Kirk et al. 1991:56).

19a. Cervical Break: RI-LI.

19b. Cervical Break: RL-LL.

19c. Cervical Break: RP-LP.

Figure 19a-c. Cervical Break Technique (Kirk et al. 1991:56).
b) Bench Thumb Movement

The Bench Thumb Movement is indicated to adjust C3-T3 fixations. Listings include RP-LP (Right Posterior-Left Posterior), RI-LI (Right Inferior-Left Inferior) and RL-LL (Right Lateral-Left Lateral) (Kirk et al. 1991:79).

The patient lies prone with the headpiece lowered and the head turned to the side homolateral to the posteriority (away from the doctor). The doctor stands in a fencer’s stance contralateral to the posteriority (homolateral to the laterality) facing cephalad. The cephalad foot is even with the patient’s shoulder. The pad of the cephalad (contact) hand’s thumb is placed on the lateral aspect of the spinous process of the listed vertebra. The forearm is parallel to the floor. The palm of the caudad (indifferent) hand cups the ear of the patient’s rotated head and then tractions cephalad and into further rotation. The contact hand then thrusts straight across (refer to Figure 20) (Kirk et al. 1991:79).

Figure 20. Bench Thumb Movement Technique (Kirk et al. 1991:79).
c) Crossed Bilateral Transverse Pisiform

The Crossed Bilateral Transverse Pisiform technique is indicated to adjust all thoracic fixations. Listings include RP-LP (Right Posterior-Left Posterior), RI-LI (Right Inferior-Left Inferior), AI (Anterior Inferior), PI (Posterior Inferior), P (Posterior) and I (Inferior). AI: T1-T4 is done from the head of the table (Kirk et al. 1991:84).

The doctor stands contralateral to the listed segment of the prone patient at the side of the table, facing cephalad in a fencer’s stance. A pisiform contact of the cephalad (contact) hand is taken on the transverse process of the listed segment contralateral to the doctor. Skin slack is removed medial to lateral. The contact hand is taken first. A pisiform contact of the caudal (indifferent) hand is taken on the transverse process of the segment below the listed segment on the side homolateral to the doctor. Skin slack is removed medial to lateral as the indifferent hand slides in second underneath the contact wrist. The thrust is delivered using a straight-arm body drop with slight torque (ulnar deviation of both hands). The line of drive and the amount of force used by the contact and indifferent hands depends on the listing. The doctor may have slight flexion of the elbows using extension of the elbows with the straight-arm body drop as well as the ulnar deviation of the hands for thrust (Kirk et al. 1991:84).

For RP-LP and RI-LI listings, the contact and indifferent hands are contacting adjacent segments. For AI, PI, I and P listings, the hands contact the same segment (refer to Figure 21) (Kirk et al. 1991:84).
Figure 21. Crossed Bilateral Transverse Pisiform Technique (Kirk et al. 1991:84).

d) Transverso-Deltoid

The Transverso-Deltoid technique is indicated to adjust low thoracics and all lumbar fixations. Listings include RP-LP (Right Posterior-Left Posterior) (Kirk et al. 1991:103).

The patient is seated straddling the edge of the table with the knees held tight to the table’s sides. The patient’s back, neck and head are erect. The patient’s arms are crossed with the hands on opposite shoulders. The homolateral arm is placed on top. The doctor stands at 90 degrees posterior to the patient. The doctor’s contralateral arm reaches around the patient whilst the elbow of the doctor’s homolateral arm is held in the doctor’s inguinal region for support. A pisiform contact of the homolateral (contact) hand is taken on the transverse or mamillary process with the fingers pointing transversely lateral. The doctor’s contralateral arm is placed around the patient’s contralateral shoulder with the contralateral (indifferent) hand placed on the anterior aspect of the patient’s homolateral shoulder. The doctor’s forearm is placed on top of the patient’s crossed arms. The patient’s torso is then rotated until slack is removed. Simultaneously, the indifferent hand
continues torso rotation and the contact hand thrusts anteriorly with body weight (refer to Figure 22) (Kirk et al. 1991:103).

**Figure 22.** Transverso-Deltoid Technique (2 views) (Kirk et al. 1991:103).

e) Thigh Ilio-Deltoid

The Thigh Ilio-Deltoid technique is indicated to adjust RPIN-LPIN (Right Posterior Ilium-Nominate-Left Posterior Ilium-Nominate) listings (Kirk et al. 1991:119).

The patient is placed side lying with the listing up. The lower shoulder is placed anterior with the hand under the head. The upper shoulder is placed posterior with the forearm resting on the lateral thoracic wall. The lower thigh and leg are kept straight and the upper thigh and leg are flexed with the dorsum of the foot in the popliteal space of the lower limb. The pelvis is brought towards the edge of the table and is positioned so that the upper ASIS (Anterior Superior Iliac Spine) is anterior to the lower ASIS or the pelvis is vertical. The doctor stands anterior to the patient in a fencer’s stance facing cephalad. Lateral thigh-to-thigh contact is made with the caudal foot off the floor. A pisiform contact of the caudal (contact) hand is placed medial and inferior to the PSIS (Posterior...
Superior Iliac Spine). The fingers point obliquely cephalad and medial across the spine. The elbow is flexed and the forearm is at right angles to the contact hand. A palmar contact of the cephalad (indifferent) hand is placed on the anterior aspect of the upper shoulder. The indifferent hand stabilizes whilst the contact hand drives the PSIS anterior with torque (ulnar deviation) and simultaneous body drop (refer to Figure 23) (Kirk et al. 1991:119).

![Image of thigh iliac-deltoid technique](image)

**Figure 23.** Thigh Iliac-Deltoid Technique (Kirk et al. 1991:119).

### 3.2.3.3 Group C

Patients in group C received a combination of the therapy performed in both of the above mentioned groups.

### 3.2.3.4 Range of Motion and Stretching Exercises

For the purpose of this research, all individuals in all three groups were asked to comply with the same home stretch exercise programme.

Gentle stretching of the triceps surae muscle group was achieved in a non-weight-bearing position. This was appropriate for those who had difficulty bearing weight fully. To stretch the gastrocnemius
muscle, the patient was positioned in a long sitting position with the foot slightly elevated to allow the heel to move freely. The subtalar joint was positioned in supination to lock the midtarsal joint. This prevented dorsiflexion across the oblique axis and allowed for talocrural joint dorsiflexion rather than forefoot motion. A towel was placed over the metatarsal heads, and the patient used the towel to pull the foot into dorsiflexion until a stretch was felt at the gastrocnemius muscle (refer to Appendix L). This stretch was maintained for 15 to 30 seconds and was performed bilaterally 3 times per set, 3 times daily, until the follow-up consultation. To isolate the soleus muscle during stretching, the leg was positioned in the same position as mentioned above, but the knee was allowed to flex 25 to 30 degrees (refer to Appendix L). This removed the influence of the gastrocnemius muscle as it crossed the knee joint (Seto and Brewster 1994:699).

Following the stretching programme, the patient was instructed to perform an ankle alphabet exercise spelling out each lower-case letter of the alphabet with the foot. This was to be performed simultaneously using both ankles three times daily.

3.2.4 TREATMENT SCHEDULE

All patients received eight treatments over a four-week period, i.e. three treatments in week one, two treatments each in weeks two and three and one treatment in week four. A final follow-up consultation was scheduled one month after the eighth treatment to assess the lasting effectiveness of the treatment protocol. The McGill Pain Questionnaire (appendix C) and the Numerical Pain Rating Scale (Appendix D) were completed and the examined ankle’s active ranges of motion measurements were recorded by means of the Saunders Digital Inclinometer (Saunders 2001:1-8). No treatment was administered.
3.3 MEASUREMENTS

3.3.1 OBJECTIVE MEASUREMENTS

3.3.1.1 The Digital Inclinometer

The *Saunders Digital Inclinometer* (Saunders 2001:1-8) was used to measure the patient’s active ankle and subtalar joint ranges of motion. These readings were taken prior to treatment at the initial (R×1), fourth (R×4) and eighth (R×8) treatment sessions, as well as at the one-month follow-up (F/U) consultation.

The digital inclinometer uses the constant vertical direction of gravity as a reference and requires only that a side rest against the body segment surface (Haldeman 1992:329). The instrument was placed along the plantar aspect of the patient’s symptomatic foot perpendicular to the tibia and fibula. The patient was asked to lie still in the supine position, whilst the examiner placed the subtalar joint in the neutral resting position. The patient was asked to actively dorsiflex, plantarflex, invert and evert the foot maximally. To ensure maximal accuracy, each of the above ankle movements were initiated from the neutral resting position in which the subtalar joint was placed.

3.3.2 SUBJECTIVE MEASUREMENTS

Each patient in the investigation was required to complete two questionnaires at the beginning of the initial (R×1), fourth (R×4), eighth (R×8) and one-month follow-up (F/U) consultations. The questionnaires were the *McGill Pain Questionnaire* (Melzack 1987:193) and the *Numerical Pain Rating Scale 101* (Vernon 1996:59) (Refer to Appendix C and Appendix D respectively).

The objectives of these questionnaires were to determine any subjective changes in the patients’ perception with regard to his/her condition or health status (Vernon 1996:58).

It was the researcher’s responsibility to ensure that the questionnaires were completed at the appropriate times before and during the course of the treatment. The questionnaires would have been invalid if completed at any other time (Vernon 1996:58). None of the patients were told his/her
scores following completion of the questionnaires, nor were they shown previously completed questionnaires or scores.

### 3.3.2.1 The McGill Pain Questionnaire

The *McGill Pain Questionnaire* provided information regarding the extent of pain. It pertained to the sensory and affective qualities of pain as well as the subjective overall intensity of the total pain experience. This questionnaire was divided into two sections. Questions 1 to 11 represented the sensory dimension of the pain experience and questions 12 to 15, represented the affective dimension as it assessed the behavioural and emotional aspect of pain. The respondent was asked to select a word that most accurately described the pain at that time. If the word did not apply, it was not chosen. A maximum of 3 for the most severe symptoms in that particular category could have been scored for each question. The sum of all the completed sections was calculated and given as a percentage of the highest possible score. If all the sections were completed, the highest possible score was 45. The higher the score, the higher the intensity of the patient's perceived symptomatic pain (McDowell and Newell 1987: 244-245).

**Example:**

\[
(30 \text{ (total scored)} \times 100 = 66.67 \%
\]

45 (total possible)

### 3.3.2.2 The Numerical Pain Rating Scale 101

The *Numerical Pain Rating Scale 101 (NPRS 101)* (Vernon 1996:59) is a refined Visual Analogue Scale (VAS) and was preferred over the VAS as it was easier to use with patients. The patients were required to measure the pain severity of their inversion ankle sprain by selecting and marking one of eleven boxes ranging from 0 (no pain) to 10 (excruciating pain). The *NPRS 101* (Vernon 1996:59) is a valid and reliable measure of pain intensity (Cassidy et al. 1992:571).
3.4 STATISTICAL ANALYSIS

3.4.1 ANALYSIS OF THE DATA

3.4.1.1 Analysis of the Subjective Data

The *McGill Pain Questionnaire* (Appendix C) was screened to ensure that the patient completed it correctly. The scores were added and converted to a percentage and recorded independently for group A, B and C. The differences between the scores prior to the first (Rx1) and fourth (Rx4) treatments, the first (Rx1) and eighth (Rx8) treatments, and the first treatment (Rx1) and the follow-up (F/U) consultation, were calculated and recorded independently for each group.

The *Numerical Pain Rating Scale 101* (Appendix D) was also screened to ensure that the patient completed it correctly. The number selected was converted to a percentage and recorded independently for group A, B and C. The differences between the number selected prior to the first (Rx1) and fourth (Rx4) treatments, the first (Rx1) and eighth (Rx8) treatments, and the first treatment (Rx1) and the follow-up (F/U) consultation, were calculated and recorded independently for each group.

3.4.1.2 Analysis of the Objective Data

The examined ankle and subtalar joint's active ranges of motion, as measured with the *Saunders Digital Inclinometer* (Saunders 2001:1-8), were recorded in degrees of dorsiflexion, plantarflexion, inversion and eversion individually from the neutral resting position of the subtalar joint of the symptomatic ankle. These measurements were recorded independently for group A, B and C. The difference between the *Digital Inclinometer* readings prior to the first (Rx1) and eighth (Rx8) treatments, and first treatment (Rx1) and follow-up (F/U) consultation for the examined ankle joint's active dorsiflexion (DF) and plantarflexion (PF), and the subtalar joint's active inversion (IN) and eversion (EV), were calculated and recorded independently for groups A, B and C.
CHAPTER FOUR – RESULTS

4.1 INTRODUCTION

The objective data for this study consisted of the injured ankle’s active ranges of motion measured in degrees, using a *Saunders Digital Inclinometer* (Saunders 2001:1-8). Active ankle dorsiflexion, plantarflexion, inversion and eversion readings were taken at the beginning of the first (Rx1), fourth (Rx4), eighth (Rx8) and one month follow-up (F/U) consultations. The statistically analysed means of the objective data were used to plot bar graphs indicating the objective changes in the ranges of motion over the course of the treatment protocol. A *Paired T-test* was used to compare the changes in the active ankle range of motion measurements from Rx1 to Rx8 and from Rx1 to the one-month F/U consultation for all three groups (GraphPad Software Inc. 1993). The *Paired T-test* indicated any statistically significant differences in the changes within the groups, as the treatments progressed, as well as providing an accurate comparison between the three groups at different times during the course of the investigation.

The subjective data for this investigation was collected from the *McGill Pain Questionnaire* (Melzack 1987:193) (refer to Appendix C) and the *Numerical Pain Rating Scale 101* (Vernon 1996:59) (refer to Appendix D). As with the objective data, the statistically analysed means of the subjective data were used to plot bar graphs. The subjective data proved to be non-normal and was subjected to the *Student-Newman-Keuls Multiple Comparisons Test* (GraphPad Software Inc. 1993). This test provided an indication of any statistical significance within each of the groups as the treatments progressed, as well as a comparison between the groups at different times during the course of the study.

The influence of the experimental protocol on all three groups was determined by the degree to which there was a significant difference between the initial measurement and the eighth treatment measurement, and the initial measurement and the follow-up measurement for each examined ankle’s active range of motion.

The efficacy of the treatment protocol was also determined by the degree to which there was a significant difference in the subjective findings, namely the way the patients perceived their pain for
the duration of the treatment period. This was measured in all three groups using the McGill Pain Questionnaire (Melzack 1987:193) and the Numerical Pain Rating Scale 101 (Vernon 1996:59). In addition, the efficacy was determined by the degree to which the subjects’ disability percentages changed as treatment progressed over the four weeks.

4.2 STATISTICAL ANALYSIS OF DATA

The statistical analysis was conducted on a 95% confidence level.

4.2.1 SUBJECTIVE DATA

a) McGill Pain Questionnaire and Numerical Pain Rating Scale 101

The subjective results for the McGill Pain Questionnaire (refer to Appendix C) and the Numerical Pain Rating Scale 101 (refer to Appendix D) were derived from statistical analysis using the Student-Newman-Keuls Multiple Comparisons Test that was run on each treatment group (Graphpad Software Inc. 1993). The units (%) compared were taken from:

i) Prior to the first (Rx1) and fourth (Rx4) treatments.

ii) Prior to the first (Rx1) and eighth (Rx8) treatments.

iii) Prior to the first (Rx1) treatment and follow-up (F/U) consultation.

The above data was collected and analysed individually for groups A, B, and C, i.e.

i) Rx4 – Rx1 (analysed separately for all three groups).

ii) Rx8 – Rx1 (analysed separately for all three groups).

iii) F/U – Rx1 (analysed separately for all three groups).

These figures were compared to determine the level of significance.
i) The Student-Newman-Keuls Multiple Comparisons Test

This test was used to see whether there was a difference in effect between the fourth treatment (Rx4) and the first treatment (Rx1), the eighth treatment (Rx8) and the first treatment (Rx1), and between the follow-up consultation (F/U) and the first treatment (Rx1). This test was also used to test whether there was any difference between the three groups. The percentages of pain and disability on the questionnaires prior to the first treatment (Rx1), fourth treatment (Rx4), eighth treatment (Rx8), and the follow-up consultation (F/U) were statistically analysed using the Student-Newman-Keuls Multiple Comparisons Test (GraphPad Software Inc. 1993).

In analysing the pain questionnaires, two values were focused on. The P-value was evaluated to determine which treatment outcome was statistically significant (P-value < 0.05 = statistically significant). The mean difference, to which the treatment outcome showed a positive (improvement) or negative (regression) response, was also evaluated. In terms of the mean difference, a positive value indicated that the fourth treatment (Rx4), the eighth treatment (Rx8), and the follow-up (F/U) consultation values were higher in score than the first treatment (Rx1) respectively. A negative mean difference indicated that the fourth treatment (Rx4), the eighth treatment (Rx8), and the follow-up (F/U) consultation values were lower than that of the first treatment (Rx1). With reference to the McGill Pain Questionnaire (refer to Appendix C) and the Numerical Pain Rating Scale 101 (refer to Appendix D), the higher the score, the more pain was felt by the patient, and was indicative of a regression or decrease in improvement or response to the treatment. A negative mean difference indicated that there was an improvement in terms of a decrease in pain.

4.2.2 OBJECTIVE DATA

a) Digital Inclinometer Readings

The examined ankle’s active ranges of motion, in terms of dorsiflexion, plantarflexion, inversion and eversion readings, were statistically analysed using the Paired T-test (GraphPad Software Inc. 1993). The units (degrees) were taken from:

i) Prior to the first treatment (Rx1) and follow-up (F/U) consultation for dorsiflexion (DF).
ii) Prior to the first treatment (Rx1) and follow-up (F/U) consultation for plantarflexion (PF).

iii) Prior to the first treatment (Rx1) and follow-up (F/U) consultation for inversion (IN).

iv) Prior to the first treatment (Rx1) and follow-up (F/U) consultation for eversion (EV).

v) Prior to the first (Rx1) and eighth (Rx8) treatments for dorsiflexion (DF).

vi) Prior to the first (Rx1) and eighth (Rx8) treatments for plantarflexion (PF).

vii) Prior to the first (Rx1) and eighth (Rx8) treatments for inversion (IN).

viii) Prior to the first (Rx1) and eighth (Rx8) treatments for eversion (EV).

The above data was collected and analysed individually for groups A, B, and C. i.e.

i) Rx1- F/U (DF, PF, IN, EV). Analysed separately for all three groups.

ii) Rx1- Rx8 (DF, PF, IN, EV). Analysed separately for all three groups.

The figures were compared to determine the level of significance, and to see whether there was any change in the digital inclinometer readings, in terms of range of motion for active dorsiflexion, plantarflexion, inversion, and eversion between groups A, B, and C as a response to the three different treatment protocols used in the research.

i) Paired T-test

The differences between the *Saunders Digital Inclinometer* readings prior to the first (Rx1) and eighth (Rx8) treatments, and the first (Rx1) and follow-up (F/U) consultations, were calculated independently for the injured foot and in all positions (dorsiflexion, plantarflexion, inversion, eversion) for each group.

These results were then statistically analysed using parametric techniques for the effective difference of the eighth treatment (Rx8) as compared to the first treatment (Rx1) (Rx8- Rx1), and the follow-up (F/U) consultation as compared to the first treatment (Rx1) (F/U- Rx1).

In analysing the *Saunders Digital Inclinometer* readings, two values were focused on. The P-value determined the significance of the statistics (P-value <0.05 = statistically significant), and the mean difference determined whether or not any change in the ankle’s active ranges of motion (ROM) were
achieved as a response to the treatment. A positive mean difference indicated that at both the eighth treatment (Rx8) and the follow-up (F/U) consultation, an increase in active range of motion was achieved as compared to the first treatment’s (Rx1) active range of motion. A negative mean difference indicated that both the eighth treatment (Rx8) and the follow-up (F/U) consultation active ROM’s had decreased and were less than the active range of motion recorded at the first treatment (Rx1). A positive mean difference value indicated that the treatment was beneficial, and a negative value indicated that the treatment was ineffective in increasing ROM.

4.3 NUMERICAL PAIN RATING SCALE 101 RESULTS

<table>
<thead>
<tr>
<th>Treatment (Rx)</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rx 1</td>
<td>60%</td>
<td>45%</td>
<td>56%</td>
</tr>
<tr>
<td>Rx 4</td>
<td>37%</td>
<td>20%</td>
<td>21%</td>
</tr>
<tr>
<td>Rx 8</td>
<td>7%</td>
<td>5%</td>
<td>3%</td>
</tr>
<tr>
<td>F/U</td>
<td>12%</td>
<td>2%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Table 4. Mean values obtained from the Numerical Pain Rating Scale 101 (%)
Figure 24. **Bar Graph Comparing the Mean Numerical Pain Rating Scale 101 Values for the Three Groups**

Group A = Soft tissue therapy  
Group B = Manipulation and mobilization therapy  
Group C = A combination of the above therapies  
Rx1 = Treatment 1  
Rx4 = Treatment 4  
Rx8 = Treatment 8  
F/U = Follow-up
<table>
<thead>
<tr>
<th>Treatment Outcome</th>
<th>Group</th>
<th>Subjects</th>
<th>Mean Difference</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>F/U - Rx 1</td>
<td>A</td>
<td>10</td>
<td>-48</td>
<td>P &lt; 0.001 ***</td>
</tr>
<tr>
<td>F/U - Rx 1</td>
<td>B</td>
<td>10</td>
<td>-43</td>
<td>P &lt; 0.001 ***</td>
</tr>
<tr>
<td>F/U - Rx 1</td>
<td>C</td>
<td>10</td>
<td>-56</td>
<td>P &lt; 0.001 ***</td>
</tr>
<tr>
<td>Rx 8 - Rx 1</td>
<td>A</td>
<td>10</td>
<td>-53</td>
<td>P &lt; 0.001 ***</td>
</tr>
<tr>
<td>Rx 8 - Rx 1</td>
<td>B</td>
<td>10</td>
<td>-41</td>
<td>P &lt; 0.001 ***</td>
</tr>
<tr>
<td>Rx 8 - Rx 1</td>
<td>C</td>
<td>10</td>
<td>-53</td>
<td>P &lt; 0.001 ***</td>
</tr>
<tr>
<td>Rx 4 - Rx 1</td>
<td>A</td>
<td>10</td>
<td>-23</td>
<td>P &lt; 0.001 ***</td>
</tr>
<tr>
<td>Rx 4 - Rx 1</td>
<td>B</td>
<td>10</td>
<td>-25</td>
<td>P &lt; 0.001 ***</td>
</tr>
<tr>
<td>Rx 4 - Rx 1</td>
<td>C</td>
<td>10</td>
<td>-35</td>
<td>P &lt; 0.001 ***</td>
</tr>
</tbody>
</table>

Effects significant at the 5% level are indicated by ***

Table 5. **Student-Newman-Keuls Multiple Comparisons Test for Numerical Pain Rating Scale**

4.3.1 EXPLANATION OF THE DATA AS RELATED TO THE NUMERICAL PAIN RATING SCALE 101 FINDINGS

Figure 24 displays a marked improvement in the *Numerical Pain Rating Scale 101* scores for all three groups.

Table 5 shows that treatment four (Rx4), treatment eight (Rx8), and the follow-up consultation (F/U) had significant effect with the P-values all being < 0.001. The *Student-Newman-Keuls Multiple Comparisons Test* showed that the differences in the median values (P) between the fourth (Rx4) and the first (Rx1) treatments, the eighth (Rx8) and the first (Rx1) treatments, and between the follow-up (F/U) and the first treatment (Rx1), were greater than would be expected by chance (refer to Table 5). This indicated a statistically significant decrease in the pain rating scores for patients in all three groups from the initial to the final visit.

A significant improvement was evident in all three groups in terms of a decrease in pain, due to the negative mean differences indicated in Table 5. A comparison between the three groups by a *Student-Newman-Keuls Multiple Comparisons Test* showed that group C had a far more significant improvement (mean difference = -35) as compared to group B (mean difference = -25), and even
more so over group A (mean difference = -23) just prior to the fourth treatment (refer to Table 5). The improvement in their response to pain experienced by group A and group C was identical (mean difference = -53), just prior to the eighth treatment (Rx8). Group B showed a lesser response (mean difference = -41) just prior to treatment eight (Rx8). At the final follow-up consultation (F/U), group C’s lower mean difference (mean difference = -56) showed that group C experienced the most significant improvement versus group A (mean difference = -48) and even more so over group B (mean difference = -43) over the entire treatment period.

4.4 McGill Pain Questionnaire Results

<table>
<thead>
<tr>
<th>Treatment (Rx)</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rx 1</td>
<td>27.55%</td>
<td>19.11%</td>
<td>28.44%</td>
</tr>
<tr>
<td>Rx 4</td>
<td>16.00%</td>
<td>8.44%</td>
<td>6.00%</td>
</tr>
<tr>
<td>Rx 8</td>
<td>4.22%</td>
<td>3.55%</td>
<td>1.11%</td>
</tr>
<tr>
<td>F/U</td>
<td>5.11%</td>
<td>0.88%</td>
<td>0.22%</td>
</tr>
</tbody>
</table>

Table 6. Mean values obtained from the short-form McGill Pain Questionnaire (%)
Figure 25. **Bar Graph Comparing the Mean McGill Pain Questionnaire Values for the Three Groups**

- **Group A** = Soft tissue therapy
- **Group B** = Manipulation and mobilization therapy
- **Group C** = A combination of the above therapies
- **Rx1** = Treatment 1
- **Rx4** = Treatment 4
- **Rx8** = Treatment 8
- **F/U** = Follow-up
<table>
<thead>
<tr>
<th>Treatment Outcome</th>
<th>Group</th>
<th>Subjects</th>
<th>Mean Difference</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>F/U - Rx 1</td>
<td>A</td>
<td>10</td>
<td>-22.44</td>
<td>P &lt; 0.001 ***</td>
</tr>
<tr>
<td>F/U - Rx 1</td>
<td>B</td>
<td>10</td>
<td>-19.33</td>
<td>P &lt; 0.001 ***</td>
</tr>
<tr>
<td>F/U - Rx 1</td>
<td>C</td>
<td>10</td>
<td>-28.44</td>
<td>P &lt; 0.001 ***</td>
</tr>
<tr>
<td>Rx 8 - Rx 1</td>
<td>A</td>
<td>10</td>
<td>-23.33</td>
<td>P &lt; 0.001 ***</td>
</tr>
<tr>
<td>Rx 8 - Rx 1</td>
<td>B</td>
<td>10</td>
<td>-16.67</td>
<td>P &lt; 0.001 ***</td>
</tr>
<tr>
<td>Rx 8 - Rx 1</td>
<td>C</td>
<td>10</td>
<td>-27.33</td>
<td>P &lt; 0.001 ***</td>
</tr>
<tr>
<td>Rx 4 - Rx 1</td>
<td>A</td>
<td>10</td>
<td>-11.66</td>
<td>P &lt; 0.001 ***</td>
</tr>
<tr>
<td>Rx 4 - Rx 1</td>
<td>B</td>
<td>10</td>
<td>-11.78</td>
<td>P &lt; 0.001 ***</td>
</tr>
<tr>
<td>Rx 4 - Rx 1</td>
<td>C</td>
<td>10</td>
<td>-21.34</td>
<td>P &lt; 0.001 ***</td>
</tr>
</tbody>
</table>

Effects significant at the 5 % level are indicated by ***

Table 7. Student-Newman-Keuls Multiple Comparisons Test for McGill Pain Questionnaire

4.4.1 EXPLANATION OF THE DATA AS RELATED TO THE Mcgill Pain Questionnaire Findings

Figure 25 displays a marked improvement in the McGill Pain Questionnaire scores for all three groups.

Table 7 shows that treatment four (Rx4), treatment eight (Rx8), and the follow-up consultation (F/U) had significant effect with the P-values all being < 0.001. The Student-Newman-Keuls Multiple Comparisons Test (refer to Table 7) showed that the differences in the median values (P) between the fourth (Rx4) and the first (Rx1) treatments, the eighth (Rx8) and the first (Rx1) treatments, and between the follow-up (F/U) and the first treatment (Rx1), were greater than would be expected by chance. This indicated a statistically significant decrease in the pain scores for patients in all three groups from the initial to the final visit.

All three groups experienced a significant improvement in terms of a decrease in pain due to the negative mean differences indicated in Table 7. These values however, were not as significant as those found in the statistical analysis of the Numerical Pain Rating Scale 101. A comparison between the three groups (refer to Table 7) by a Student-Newman-Keuls Multiple Comparisons Test showed that group C experienced the greatest improvement (mean difference = -21.34) in response
to their pain experienced, followed by group B (mean difference= -11.78), and lastly by group A (mean difference= -11.56) just prior to the fourth treatment (Rx4). Group C continued to experience the largest improvement (mean difference= -27.33) in response to their pain experienced, followed by group A (mean difference= -23.33), and lastly by group B (mean difference= -16.67) just prior to the eighth treatment (Rx8). This trend continued up to the final follow-up consultation (F/U), where group C's lower mean difference (mean difference= -28.44) showed that group C had a far more significant improvement versus group A (mean difference= -22.44) and even more so over group B (mean difference= -19.33) over the entire treatment period.

4.5 DIGITAL INCLINOMETER RESULTS

<table>
<thead>
<tr>
<th>Ankle range of motion</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dorsiflexion</td>
<td>+7.0 degrees</td>
<td>+6.8 degrees</td>
<td>+11.2 degrees</td>
</tr>
<tr>
<td>Plantarflexion</td>
<td>+5.2 degrees</td>
<td>+0.1 degrees</td>
<td>+1.9 degrees</td>
</tr>
<tr>
<td>Inversion</td>
<td>+1.9 degrees</td>
<td>+0.1 degrees</td>
<td>+1.1 degrees</td>
</tr>
<tr>
<td>Eversion</td>
<td>+2.0 degrees</td>
<td>+3.9 degrees</td>
<td>+4.3 degrees</td>
</tr>
</tbody>
</table>

Table 8. Mean differences between Rx 8 and Rx 1- Digital Inclinometer readings of ankle range of motion (degrees) (+ = increase)(- = decrease)

<table>
<thead>
<tr>
<th>Ankle range of motion</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dorsiflexion</td>
<td>+3.4 degrees</td>
<td>+4.2 degrees</td>
<td>+11.7 degrees</td>
</tr>
<tr>
<td>Plantarflexion</td>
<td>+5.3 degrees</td>
<td>-2.2 degrees</td>
<td>+2.2 degrees</td>
</tr>
<tr>
<td>Inversion</td>
<td>+2.1 degrees</td>
<td>+2.0 degrees</td>
<td>+2.6 degrees</td>
</tr>
<tr>
<td>Eversion</td>
<td>+0.9 degrees</td>
<td>+3.3 degrees</td>
<td>+4.0 degrees</td>
</tr>
</tbody>
</table>

Table 9. Mean differences between Follow-up and Rx 1- Digital Inclinometer readings of ankle range of motion (degrees) (+ = increase)(- = decrease)
Figure 26. Bar Graph Comparing the Mean Differences Between Rx8 and Rx1 for the Three Groups – Digital Inclinometer Readings

Group A = Soft tissue therapy
Group B = Manipulation and mobilization therapy
Group C = A combination of the above therapies
DF = Dorsiflexion
PF = Plantarflexion
IN = Inversion
EV = Eversion
Rx1 = Treatment 1
Rx8 = Treatment 8
Figure 27. Bar Graph Comparing the Mean Differences Between the F/U and Rx1 for the

Three Groups – Digital Inclinometer Readings

Group A = Soft tissue therapy
Group B = Manipulation and mobilization therapy
Group C = A combination of the above therapies
DF = Dorsiflexion
PF = Plantarflexion
IN = Inversion
EV = Eversion
Rx1 = Treatment 1
F/U = Follow-up
| Treatment Outcome | Group | Subjects | Mean Difference | Standard Difference | T     | Prob > |T|  |
|--------------------|-------|----------|-----------------|---------------------|-------|--------| |
| F/U – Rx1 – DF     | A     | 10       | 3.4             | 3.433               | 3.127 | 0.0122*** |
|                    | B     | 10       | 4.2             | 2.251               | 5.9   | 0.0002**** |
|                    | C     | 10       | 11.2            | 8.108               | 4.368 | 0.0018**** |
| F/U – Rx1 – PF     | A     | 10       | 5.3             | 6.183               | 2.711 | 0.0240***  |
|                    | B     | 10       | -2.2            | 4.29                | 1.622 | 0.1393   |
|                    | C     | 10       | 2.2             | 7.843               | 0.887 | 0.3981   |
| F/U – Rx1 – IN     | A     | 10       | 2.1             | 3.929               | 1.69  | 0.1252   |
|                    | B     | 10       | 2               | 4                   | 1.581 | 0.1483   |
|                    | C     | 10       | 2.6             | 2.989               | 2.751 | 0.0224*** |
| F/U – Rx1 – EV     | A     | 10       | 0.9             | 1.101               | 2.586 | 0.0294*** |
|                    | B     | 10       | 3.3             | 2.058               | 5.072 | 0.0007**** |
|                    | C     | 10       | 4               | 3.801               | 3.328 | 0.0086**** |
| Rx8 – Rx1 – DF     | A     | 10       | 7               | 8.34                | 2.654 | 0.0263*** |
|                    | B     | 10       | 6.8             | 2.781               | 7.733 | 0.0001**** |
|                    | C     | 10       | 11.7            | 8.015               | 4.616 | 0.0013*** |
| Rx8 – Rx1 – PF     | A     | 10       | 5.2             | 8.893               | 2.386 | 0.0408*** |
|                    | B     | 10       | 0.1             | 5.043               | 0.063 | 0.9514   |
|                    | C     | 10       | 1.9             | 6.935               | 0.866 | 0.4086   |
| Rx8 – Rx1 – IN     | A     | 10       | 1.9             | 5.28                | 1.138 | 0.2845   |
|                    | B     | 10       | 3.1             | 1.969               | 0.161 | 0.876    |
|                    | C     | 10       | 1.1             | 3.872               | 0.899 | 0.3923   |
| Rx8 – Rx1 – EV     | A     | 10       | 2               | 1.633               | 3.873 | 0.0038**** |
|                    | B     | 10       | 3.9             | 1.912               | 6.45  | 0.0007**** |
|                    | C     | 10       | 4.3             | 2.983               | 4.558 | 0.0014*** |

*Effects significant at the 5 % level are indicated by ***

*Effects very significant at the 5 % level are indicated by ****

Table 10. Paired T-test for Digital Inclinometer Readings – Follow-up (F/U) Consultation Vs Treatment One (Rx1) and Treatment Eight (Rx8) Vs Treatment One (Rx1)

4.5.1 EXPLANATION OF THE DATA AS RELATED TO THE SAUNDERS DIGITAL INCLINOMETER FINDINGS

In comparing the eighth treatment (Rx8) with the first treatment (Rx1), and the follow-up (F/U) consultation with the first treatment (Rx1), Table 10, shows that most of the treatment outcomes were statistically significant at the 5% level (P<0.05).

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The treatment outcomes that were not statistically significant at the 5% level (P>0.05) included group B and group C’s follow-up consultation (F/U) – first treatment (Rx1) in plantarflexion (PF) (F/U – Rx1 – PF), group A and Group B’s follow-up consultation (F/U) – first treatment (Rx1) in inversion (IN) (F/U – Rx1 – IN), group B and group C’s eighth treatment (Rx8) – first treatment (Rx1) in plantarflexion (PF) (Rx8 – Rx1 – PF), and all three groups’ eighth treatment (Rx8) – first treatment (Rx1) in inversion (IN) (Rx8 – Rx1 – IN) (refer to Table 10).

The *Paired T-test* showed that the difference in the mean values (P>0.05) between the initial (Rx1) and the eighth (Rx8) treatments, and the initial treatment (Rx1) and the follow-up (F/U) consultation respectively for the aforementioned treatment outcomes were not great enough to reject the possibility that the difference was due to random sampling variability (refer to Table 10).

In all three groups and in all ranges of motion, barring group B’s follow-up (F/U) consultation – treatment one (Rx1) in plantarflexion (PF) (F/U – Rx1 – PF) with a mean difference of -2.2, an increase in the examined ankle’s range of motion was seen throughout. This indicated that at treatment eight (Rx8) and at the follow-up (F/U) consultation, the range of motion was greater than it was at the first treatment (Rx1) for all three groups (excluding group B’s F/U – Rx1 – PF). This analysis showed that all three groups responded favourably to their specific treatment protocol.

Table 10 shows that the most significant improvement in range of motion in terms of ankle dorsiflexion (DF) was experienced by group C (mean difference= 11.7) as compared to group A (mean difference= 7), and to group B (mean difference= 6.8) just prior to the eighth treatment (Rx8). This trend continued up to the final follow-up consultation (F/U), where group C’s higher mean difference (mean difference= 11.2) showed that group C had a far more significant improvement in dorsiflexion versus group B (mean difference= 4.2) and over group A (mean difference= 3.4) throughout the entire treatment period.

The most significant improvement in range of motion in terms of ankle plantarflexion (PF) was experienced by group A (mean difference= 5.2), as compared to group C (mean difference= 1.9), and to group B (mean difference= 0.1) just prior to the eighth treatment (Rx8) (refer to Table 10). This trend continued up to the final follow-up consultation (F/U), where group A’s higher mean difference (mean difference= 5.3) showed that group A had a more significant improvement in
plantarflexion versus group C (mean difference = 2.2) and even more so over group B (mean difference = -2.2) where plantarflexion decreased over the entire treatment period.

Table 10 shows that the most significant improvement in range of motion in terms of subtalar joint inversion (IN) was experienced by group A (mean difference = 1.9) as compared to group C (mean difference = 1.1), and to group B (mean difference = 0.1) just prior to the eighth treatment (Rx8). This trend changed upon reaching the final follow-up consultation (F/U), where group C’s higher mean difference (mean difference = 2.6) showed that group C had a narrowly more significant improvement in inversion versus group A (mean difference = 2.1) and over group B (mean difference = 2.0) throughout the entire treatment period.

The most significant improvement in range of motion in terms of subtalar joint eversion (EV) was experienced by group C (mean difference = 4.3), as compared to group B (mean difference = 3.9), and to group A (mean difference = 2.0) just prior to the eighth treatment (Rx8) (refer to Table 10). This trend held firmly upon reaching the final follow-up consultation (F/U), where group C’s higher mean difference (mean difference = 4.0) showed that group C had a more significant improvement in eversion versus group B (mean difference = 3.3) and over group A (mean difference = 0.9) throughout the entire treatment period.

### 4.6 TABLES OF INTERPRETIVE DATA

<table>
<thead>
<tr>
<th>Data</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age</td>
<td>25.00</td>
<td>23.80</td>
<td>23.80</td>
</tr>
<tr>
<td>Gender distribution</td>
<td>8 Males</td>
<td>5 Males</td>
<td>5 Males</td>
</tr>
<tr>
<td></td>
<td>2 Females</td>
<td>5 Females</td>
<td>5 Females</td>
</tr>
<tr>
<td>Race distribution</td>
<td>6 Caucasians</td>
<td>9 Caucasians</td>
<td>9 Caucasians</td>
</tr>
<tr>
<td></td>
<td>2 African</td>
<td>0 African</td>
<td>1 African</td>
</tr>
<tr>
<td></td>
<td>2 Indian</td>
<td>1 Indian</td>
<td>0 Indian</td>
</tr>
</tbody>
</table>

Table 11. Demographic data within sample of 30

Table 11 refers to the mean age, gender distribution, and race distribution of all the participants in the study.
<table>
<thead>
<tr>
<th>Occurrence</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Recurrent</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 12. Single Vs. Recurrent ankle sprains encountered in sample of 30

Table 12 shows that 18 patients had experienced recurrent ankle sprains prior to entering the study, as opposed to the 12 who had injured their ankle for the first time upon entering the study.

<table>
<thead>
<tr>
<th>Chronicity</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
<th>Total %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub-acute</td>
<td>9</td>
<td>1</td>
<td>4</td>
<td>46.66%</td>
</tr>
<tr>
<td>Chronic</td>
<td>1</td>
<td>9</td>
<td>6</td>
<td>53.33%</td>
</tr>
</tbody>
</table>

Table 13. Chronicity of ankle sprain encountered within sample of 30

Table 13 shows that 46.66% of the injuries were diagnosed as being sub-acute and 53.33% were diagnosed as being chronic at the initial consultation.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
<th>Total %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade I</td>
<td>8</td>
<td>10</td>
<td>9</td>
<td>90</td>
</tr>
<tr>
<td>Grade II</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 14. Grades of ankle sprain encountered within sample of 30

Table 14 shows that 90% of the ankle sprains were diagnosed as being a grade I injury, as opposed to the 10% grade II injuries at the initial consultation.
<table>
<thead>
<tr>
<th>Region</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
<th>Total %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cervical spine</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>26.66</td>
</tr>
<tr>
<td>Lumbar spine</td>
<td>4</td>
<td>1</td>
<td>5</td>
<td>33.33</td>
</tr>
<tr>
<td>Both</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>10.00</td>
</tr>
<tr>
<td>Absent</td>
<td>5</td>
<td>4</td>
<td>0</td>
<td>30.00</td>
</tr>
</tbody>
</table>

Table 15. Cervical and lumbar spine pain associated with ankle sprain at initial consultation

Table 15 shows, that of the patients entering the study, 26.66% had associated cervical spine pain, 33.33% had associated lumbar spine pain, 10% had both cervical and lumbar spine pain, whilst 30% presented with no associated pain other than the ankle pain.

<table>
<thead>
<tr>
<th>SI Fixation</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
<th>Total %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ipsilateral to sprain</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>36.66</td>
</tr>
<tr>
<td>Contralateral to sprain</td>
<td>8</td>
<td>6</td>
<td>4</td>
<td>60</td>
</tr>
<tr>
<td>Absent</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3.33</td>
</tr>
</tbody>
</table>

Table 16. Correlation of ankle sprain with sacroiliac joint fixation at initial consultation

Table 16 shows that 36.66% of the patients had a sacroiliac joint (SIJ) fixation ipsilateral to the side of the sprained ankle at the initial consultation, whilst 60% had a SIJ fixation contralateral to the sprained ankle. One patient presented without a SIJ fixation.
<table>
<thead>
<tr>
<th>Cervical fixation</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
<th>Total %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ipsilateral to sprain</td>
<td>7</td>
<td>6</td>
<td>2</td>
<td>50</td>
</tr>
<tr>
<td>Contralateral to sprain</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>26.66</td>
</tr>
<tr>
<td>Absent</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>23.33</td>
</tr>
</tbody>
</table>

**Table 17. Correlation of ankle sprain with primary upper cervical spine fixations (C0/C1-C1/C2) at initial consultation**

Table 17 shows that 50% of the patients presented with a primary upper cervical spine fixation, as was found by motion palpation, on the same side as the ankle sprain. 26.66% presented with the fixation contralateral to the side of the sprain. 23.33% presented without a primary upper cervical spine fixation.

<table>
<thead>
<tr>
<th>Position</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
<th>Total %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supination</td>
<td>6</td>
<td>7</td>
<td>4</td>
<td>56.66</td>
</tr>
<tr>
<td>Pronation</td>
<td>4</td>
<td>3</td>
<td>6</td>
<td>43.33</td>
</tr>
</tbody>
</table>

**Table 18. Foot position at heel strike**

Table 18 shows that 56.66% of the patients presented with a supinated gait at heel strike as opposed to the 43.33% who presented with a pronated gait.
<table>
<thead>
<tr>
<th>Treatment</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Cryotherapy</td>
<td>2</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Heat</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>X-ray</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Bracing</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Strapping</td>
<td>1</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Rest</td>
<td>5</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Massage</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Ultrasound</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Chiropractic</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Table 19. Modes of treatment encountered within sample of 30 before entering research project**

Table 19 shows the variety of treatment protocols encountered within the sample of 30 before entering the research project.

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student</td>
<td>8</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>Hairdresser</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Teacher</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Occupational therapist</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Engineer</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Shop/restaurant manager</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Designer</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>I.T. consultant</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

**Table 20. Occupational distributions within sample of 30**

Table 20 refers to the occupational distributions within the sample of 30.
<table>
<thead>
<tr>
<th>Activity</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gymnastics</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Soccer</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Dancing</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Running</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Accident</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Fall/Tripped</td>
<td>7</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Tennis</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Cricket</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Rugby</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Squash</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 21. Activity leading to injury in sample of 30

Table 21 refers to the activity leading to the injury in the sample of 30.
CHAPTER 5 – DISCUSSION

5.1 INTRODUCTION

The results of this study are discussed with reference to the previous chapter. Where possible, results of previous studies are included and applied to explain the outcomes and implications of this study.

5.2 SUBJECTIVE DATA

In reviewing research pertaining to the treatment of inversion ankle sprains, only one reference was found with regards to measuring the subjective changes in the patient’s perception of pain, using either the McGill Pain Questionnaire, and/or the Numerical Pain Rating Scale 101.

5.2.1 NUMERICAL PAIN RATING SCALE 101 RESULTS

In the present study, the overall score for pain severity at the follow-up consultation dropped from 6.0 to 1.2 – an 80% improvement in perceived pain, for group A. Group B had an overall score for pain severity that dropped from 4.5 to 0.2 – a 95.56% improvement. Group C had an overall score for pain severity that dropped from 5.6 to 0 – a 100% improvement (refer to Figure 24).

All three groups fared well with regard to a decrease in the severity of pain experienced in response to the various treatments received (refer to Figure 24). There were statistically significant improvements in the pain rating scores from the initial to the fourth, the initial to the eighth, and the initial to the follow-up consultations (refer to Table 5).

Group A showed a more statistically significant improvement in perceived pain as compared to group B, by means of a more negative mean difference, over the entire treatment period (refer to Table 5). Group B however, showed a more clinically significant improvement in terms of the patient’s response to the pain rating score (95.56%) as compared to group A (80%) (refer to Figure 24). Group C showed the most negative mean difference (refer to Table 5), and had the most clinically significant improvement (100%) over the entire treatment period (refer to Figure 24). A possible explanation is that the soft tissue therapy alleviated and soothed the initial irritation and secondary muscular pathology. The initial pathology that existed in the kinetic chain’s
biomechanical dysfunction, specifically involving the spine and foot joints (mortise and subtalar joints), became prevalent. Soft tissue therapy and ultrasound had a more profound effect on pain than joint function, and therefore had a limited effect in terms of correcting the biomechanical dysfunction, which was believed to be the primary cause of the overloading of the lateral ankle ligaments, which in turn perpetuated the ankle sprain. Group C's treatment protocol incorporated manipulation and mobilization therapy, which specifically would have and did focus on correcting the biomechanical dysfunctions.

Pellow and Brantingham (2001:17-24) studied the efficacy of adjusting the ankle in the treatment of sub-acute and chronic grade I and grade II ankle inversion sprains. Each of the 15 patients in the treatment group received the ankle mortise separation adjustment. Each of the 15 patients in the placebo group received 5 minutes of detuned ultrasound treatment. Although both groups showed improvement, statistically significant differences in favour of the adjustment group were noted with respect to reduction in pain with reference to the Numerical Pain Rating Scale 101. The overall score for pain severity dropped from 2.9 to 0.8 – a 72% improvement in perceived pain.

The present study supports the findings of Pellow and Brantingham (2001:17-24), where the ankle-adjusting group had a 72% improvement in perceived pain. This study further investigated whether adjusting joint complex dysfunction in the ankle and the spine (95.56% improvement in perceived pain), in conjunction with soft tissue therapy (100% improvement in perceived pain), would provide a superior effect than adjusting the ankle alone.

5.2.2 McGill Pain Questionnaire Results

With reference to Pellow and Brantingham (2001:17-24), in their study mentioned previously, to determine the efficacy of adjusting the ankle in the treatment of sub-acute and chronic grade I and grade II ankle inversion sprains, ankle pain intensity according to the McGill Pain Questionnaire decreased by 84.21% in the manipulation group. This decrease was found to be statistically significant.

In this study, the overall score for pain severity at the follow-up consultation dropped from 27.55% to 5.11% – an 81.45% improvement in perceived pain, for group A. Group B had an overall score for pain severity that dropped from 19.11% to 0.88% – a 95.40% improvement. Group C had an
overall score for pain severity that dropped from 28.44% to 0.22% – a 99.22% improvement (refer to Figure 25).

All three groups fared well with regard to a decrease in the severity of pain experienced in response to the various treatments received (refer to Figure 25). There were statistically significant improvements in the pain rating scores from the initial to the fourth, the initial to the eighth and the initial to the follow-up consultations (refer to Table 7). These results once again support the findings of Pellow and Brantingham (2001:17-24), as was discussed in the previous section.

Group A showed a more statistically significant improvement in pain perception as compared to group B by means of a more negative mean difference over the entire treatment period (refer to Table 7). Group B however, showed a more clinically significant improvement in terms of the patients’ response to the pain rating score (95.40%) as compared to group A (81.45%) (refer to Figure 25). Group C showed the most negative mean difference and had the most clinically significant improvement (99.22%) over the entire treatment period (refer to Table 7 and Figure 25 respectively).

The trends followed in the statistical analysis of the McGill Pain Questionnaire were similar to those found in the statistical analysis of the Numerical Pain Rating Scale 101. The motivations for these trends are identical and will not be repeated.

In terms of consistency, group C (a combination of both group A and B’s treatments) was once again the most successful, showing no regression in terms of response to treatment at the follow-up (F/U) consultation, followed closely by group B (manipulation and mobilization therapy). Group A (soft tissue therapy and ultrasound therapy), however, regressed slightly in terms of the patient’s perception of pain being slightly higher at the follow-up (F/U) consultation, than that at treatment eight (Rx8) (refer to Figure 25).

Ultrasound and soft tissue therapy (particularly cross friction therapy) are beneficial in terms of alleviating muscle spasm, and in reducing scar (fibrin) tissue thickening (Norris 1993:138). The treatment given to group A was effective in curing and alleviating the secondary symptomatic pathology and overcompensation of the lateral ankle ligaments and lower limb muscles. This treatment had a limited effect on the underlying primary pathological site (the dysfunctional
biomechanical kinetic chain). This may explain the regression experienced by group A in terms of the patient's perception of pain at the follow-up (F/U) consultation.

It is assumed that correct biomechanical functioning needs to be maintained in order to prevent a reoccurrence of ankle inversion injury. Figures 24 and 25 show that group C's treatment protocol had the best overall effect. This indicates that by maintaining correct kinetic chain mechanics, in conjunction with symptomatic treatment, there may be less overloading and injury of the lateral ankle ligaments.

5.3 OBJECTIVE DATA

With reference to Roebroeck et al. (1998:421-431) in their study on practice patterns by physiotherapists in Dutch primary health care, for patients with lateral ankle sprains, treatment was frequently aimed at pain reduction and improving stability of the ankle joint and muscle power. Treatment was less frequently aimed at improving the ankle range of motion. With reference to Glasoe et al. (1999:395), experimental studies of ligaments after injury have indicated that exercise and joint motion stimulated healing and influenced the strength of ligaments after injury. The present study focused on restoring spinal and ankle biomechanics allowing the kinetic chain's range of motion to be increased and to function maximally.

In reviewing research pertaining to the treatment of inversion ankle sprains, three references were found with regards to measuring the objective changes in the examined ankle's active dorsiflexion range of motion. No standard instrumentation, however, was used in collecting the objective data. No references were found, with regards to recording changes in the examined ankle’s active plantarflexion, inversion, and eversion ranges of motion.

5.3.1 DIGITAL INCLINOMETER RESULTS

5.3.1.1 Dorsiflexion

Normal dorsiflexion of the ankle is usually 20 degrees past the anatomic position, which is with the foot at 90 degrees to the bones of the leg (Magee 1997:624). At the initial assessment in this study,
the examined ankle’s active dorsiflexion movement for groups A (15.8 degrees), B (21.9 degrees), and C (21.2 degrees) were within normal limits. All three groups showed a statistically significant improvement in terms of the examined ankle’s dorsiflexion range of motion at the eighth treatment (Rx8), and at the one-month follow-up (F/U) consultation (refer to Table 10). A mean increase of 3.4 degrees (group A), 4.2 degrees (group B), and 11.7 degrees (Group C) was recorded at the one-month follow-up consultation (refer to Table 9).

With reference to Pellow and Brantingham (2001:17-24) in their study previously mentioned to determine the efficacy of adjusting the ankle in the treatment of sub-acute and chronic grade I and grade II ankle inversion sprains, both groups showed improvement, but statistically significant differences in favour of the adjustment group were noted with respect to increased ankle dorsiflexion range of motion. Mean ankle dorsiflexion (as measured with a Baseline goniometer) at the one-month follow-up consultation showed an overall increase of 7.9 degrees for the adjustment group, compared with the 1.4 degree improvement for the placebo group. These findings were consistent with the present study, in that the groups incorporating talocrural joint manipulation as part of the treatment protocol (both groups B and C) showed a statistically significant improvement in terms of the examined ankle’s dorsiflexion range of motion.

Green et al. (2001:984-993) conducted a randomized controlled trial of a passive accessory joint mobilization on acute ankle inversion sprains. A Lidcombe template was used to measure the examined ankle’s dorsiflexion range of motion. From the baseline measurement before the first treatment session until the start of the second treatment session, the experimental group improved 10.9 degrees compared with an improvement of 5.8 degrees for the control group. It was found that when acute ankle inversion sprains were treated with anterior/posterior mobilization of the talocrural joint in addition to the conventional R.I.C.E (Rest, Ice, Compression and Elevation) protocol, fewer treatments were required for pain-free active dorsiflexion range of movement to improve than when R.I.C.E. alone was administered. These findings were consistent with the present study, in that the combined effects of group C required fewer treatments for pain-free ankle range of movement to improve, than the unidirectional effects of group A and B’s treatment protocols (refer to Figures 26 and 27).

In a randomized, controlled clinical trial involving a single talocrural joint manipulation of high velocity and low amplitude, in a group of 20 asymptomatic subjects, no statistically significant
changes in ankle dorsiflexion range were found in either the experimental group, or the control group. These findings were inconsistent with the present study, in that group B and group C (both incorporating talocrural joint manipulation), showed a statistically significant improvement in terms of the examined ankle’s dorsiflexion range of motion. However, it was suggested that a similar trial be performed in a symptomatic population, in as much as symptomatic patients have often reported a "feeling" of reduced stiffness and subjective improvement in functional abilities after ankle joint manipulation (Nield et al. 1993:161).

5.3.1.2 Plantarflexion

Normal plantarflexion of the ankle is approximately 50 degrees (Magee 1997:624). At the initial assessment in this study, the examined ankle’s active plantarflexion movement for groups A (41.9 degrees), B (44 degrees), and C (54.1 degrees) were within normal limits. Group A showed a statistically significant improvement in terms of the examined ankle’s plantarflexion range of motion at the eighth treatment (Rx8) and at the one-month follow-up (F/U) consultation (refer to Table 10). An overall increase of 5.3 degrees was recorded at the one-month follow-up consultation (refer to Table 9).

Group B and C’s examined ankle’s plantarflexion range of motion showed no statistically significant improvements at the eighth treatment (Rx8) and at the one-month follow-up (F/U) consultation (refer to Table 10). Although there was no statistically significant increase for group C, this group still showed some improvement in plantarflexion (2.2 degrees) at the final visit (refer to Table 9). Group B however, showed a decrease in plantarflexion (-2.2 degrees) at the final visit (refer to Table 9).

5.3.1.3 Inversion

Normal inversion of the ankle is between 45 and 60 degrees (Magee 1997:624). At the initial assessment in this study, the examined ankle’s active inversion movement for groups A (37.2 degrees), B (39.6 degrees), and C (40.2 degrees) were below normal limits, which may be accredited to the loss of subtalar joint play and adhesion formation as was explained in chapter two under important biomechanical and associated principles. All three group’s examined ankle’s inversion range of motion, barring group C’s follow-up (F/U) – treatment one (Rx1) in inversion (IN) (F/U –
Rx1 – IN), showed no statistically significant improvement at the eighth treatment (Rx8) and at the one-month follow-up (F/U) consultation (refer to Table 10). Although there was no statistically significant increase for the three groups, barring group C’s (F/U – Rx1 – IN), groups A (2.1 degrees), B (2 degrees), and C (2.6 degrees) still showed some improvement in inversion at the final visit (refer to Table 9).

5.3.1.4 Eversion

Normal eversion of the ankle is between 15 and 30 degrees (Magee 1997:624). At the initial assessment, the examined ankle’s active eversion movement for groups A (8.9 degrees), B (12.2 degrees), and C (12.1 degrees) were below normal limits, which may once again be accredited to the loss of subtalar joint play and adhesion formation as was explained in chapter two under important biomechanical and associated principles. All three groups showed a statistically significant improvement in terms of the examined ankle’s eversion range of motion at the eighth treatment (Rx8) and at the one-month follow-up (F/U) consultation (refer to Table 10). An increase of 0.9 degrees (group A), 3.3 degrees (group B), and 4 degrees (Group C) was recorded at the follow-up consultation (refer to Table 9).

5.3.1.5 Interpretation of the Data

All three groups, barring group B’s follow-up (F/U) consultation – treatment one (Rx1) in plantarflexion (PF) (F/U – Rx1 – PF), showed an overall increase in range of motion of the ankle and subtalar joints in response to their specific treatment protocols received (Refer to Figures 26 and 27). This indicated that at treatment eight (Rx8) and at the follow-up (F/U) consultation, the range of motion was greater than it was at the first treatment (Rx1) for all three groups (excluding group B’s F/U – Rx1 – PF). Three possible explanations for the generalized increase in the range of motion of all three groups are suggested.

It is possible that the increase in range of motion was due to the home stretches that all three groups received. These towel stretches would have caused an increase in flexibility in the triceps surae whilst concurrently mobilizing the foot into dorsiflexion and eversion.
The improvement in the examined ankle’s active ranges of motion could have been attributed to chiropractic manipulative and mobilization therapy. As only groups B and C received this therapy, it can be deduced that the generalized increase in the range of motion was due to the combination of both the stretches and the manipulation and mobilization therapy.

Soft tissue therapy and ultrasound therapy could have increased the examined ankle’s ranges of motion. As only groups A and C received this therapy, it can be deduced that the generalized increase in the range of motion was due to a combination of both the stretches and the soft tissue and ultrasound therapy.

In order to identify which group responded most favourably to the treatment, and to isolate whether stretching, chiropractic manipulative and mobilization therapy, or soft tissue and ultrasound therapy was the primary cause in increasing the range of motion, the changes noticed at treatment eight (Rx8) and the follow-up (F/U) consultation must be compared.

The examined ankle and subtalar joint’s active ranges of motion of group C, recorded at the follow-up consultation (F/U), barring eversion (EV), increased as compared to the readings taken for this group at treatment eight (Rx8) (refer to Figures 26 and 27).

According to the author, multiple reasons exist for this sudden increase in range of motion. Increased joint motion caused by the manipulation and mobilization therapy in conjunction with the soft tissue therapy’s symptomatic relief, causes a return to normal gait cycle and normal biomechanics of the kinetic chain. The joints can function normally allowing maximum dorsiflexion and plantarflexion of the mortise joint, and inversion and eversion of the subtalar joint to be achieved. As the normal biomechanics are restored, the lateral ankle ligaments and the lower limb muscles are no longer obliged to overload and overcompensate. During the one-month period following the eighth treatment (Rx8), the restored biomechanics allowed the kinetic chain’s range of motion to be increased and to function maximally.

The ranges of motion for group A decreased significantly in terms of active dorsiflexion and eversion, and remained fairly consistent in terms of active plantarflexion and inversion at the follow-up (F/U) consultation, as compared to group A’s readings taken at treatment eight (Rx8) (refer to Figures 26 and 27). This occurred as a result of no soft tissue therapy being received during the one-
month follow-up (F/U) period. The muscle tension perhaps increased, causing an increased restriction in the subtalar and mortise joints.

The ranges of motion for group B decreased significantly in terms of dorsiflexion, plantarflexion and eversion, at the follow-up (F/U) consultation, as compared to group B's readings taken at treatment eight (Rx8). The range of motion in terms of inversion increased at the follow-up (F/U) consultation (refer to Figures 26 and 27). Although stretching the triceps surae (performed by all three groups) increases the agility and muscle flexibility, no soft tissue therapy was incorporated in this treatment, which would have had the effect of decreasing muscle tension that occurred as a result of the injury. The manipulation and mobilization therapy was effective in increasing the examined ankle's ranges of motion, over the course of the treatment protocol, but needed to be supplemented with soft tissue therapy for prolonged effect.

The inversion ankle sprain injury typically occurs when the body's weight lands on the plantar flexed and internally rotated ankle, diminishing the bony stability of the ankle joint at foot strike (Liu and Jason 1994:795). The weaker lateral ligaments, assisted by the peroneus longus and brevis muscles, tend to prevent excessive inversion of the foot (Moore 1992:491). Muscle weakness, particularly in the peroneal muscles, tends to play a significant role in the aetiology of functional instability (Ebig et al. 1997:73). The increased inversion range of motion of group B recorded at the final follow-up (F/U) consultation may have occurred as a result of the injury weakening the lateral ankle ligaments and the peroneal longus and brevis muscles. Transverse friction in particular, breaks the cross linkage in fibrous tissue and, in doing so, contributes further to the successful rehabilitation of soft tissue injuries (Harrison 1992:350). By withholding soft tissue therapy throughout the treatment protocol, the possibility exists that the weaker lateral structures may have contributed to the excessive inversion of the foot.

After the last treatment (Rx8), no manipulative, soft tissue or ultrasound therapy was given whilst patients still continued their stretching. It can be deduced that if group A showed an increase in range of motion at the follow-up (F/U) consultation, and groups B and C showed a regression, stretching, soft tissue therapy and ultrasound therapy are indicated as the attributing factors to the overall increase in the ankle's range of motion. Furthermore, it can be deduced that if group B showed an increase in range of motion at the follow-up (F/U) consultation and groups A and C showed a regression, stretching and chiropractic manipulative and mobilization therapy are
indicated as the attributing factors to the overall increase in the ankle’s range of motion. Lastly, it can be deduced that if group C showed an increase in range of motion at the follow-up (F/U) consultation and groups A and B showed a regression, the combination of all the above therapies are indicated as the attributing factor to the overall increase in the ankle’s range of motion. As discussed previously, group C showed the greatest improvement in ankle and subtalar joint ranges of motion at the follow-up (F/U) consultation, confirming group C’s treatment protocol as the most effective in improving and maintaining range of motion following a sub-acute or a chronic grade I or grade II inversion ankle sprain.

Group C showed the greatest long-term improvement in ankle range of motion, due to the composite effect of treatment received. The soft tissue and ultrasound therapy resulted in a reduction of pain and stiffness, an alleviation of muscle spasm, and an acceleration of the metabolic healing process. Manipulation and mobilization of the injured extremity and the spine helped in establishing normal biomechanical relationships, enabling quicker healing and recovery due to normalized function of the regional anatomy. The home stretching routine rounded off the effective treatment protocol, by maintaining the increase in flexibility of the involved muscles.

5.4 TABLES OF INTERPRETIVE DATA

The data presented in Tables 11-14 and 20-21 were purely incidental, as the patients were randomly allocated to their groups.

Table 13 shows that nine out of the ten patients in group B were diagnosed with chronic ankle inversion sprains. As the majority of the patients had chronic ankle sprains, group B would have been more likely to have taken longer to respond to treatment than the other two groups.

Table 16 correlates the ankle sprain with a sacroiliac joint fixation, found by motion palpation at the initial consultation. 60% of the total fixations found were located contralateral to the ankle sprain. This finding was possibly due to the patient guarding his/her injured ankle during ambulation. This in turn would have resulted in the contralateral limb having to absorb the majority of the impact during this altered gait, resulting in a fixated sacroiliac joint. This statement finds support in Harrison (1992:105), who refers to the changes in foot position or structure as the reason for causing
a mechanical influence on the spine and pelvis, due to the forces imposed by the foot upon the long bones of the lower extremity. This altered gait could explain the 33.33% associated lumbar spine pain seen in Table 15.

Table 17 correlates the ankle sprain with a primary upper cervical spine fixation (Co/C1-C1/C2). Over 65% of the fixations that were found by motion palpation were ipsilateral to the ankle sprain. This finding was possibly due to a biomechanical spinal compensation, occurring as a result of the patient guarding the injured ankle, as is mentioned above. This could explain the 26.66% associated cervical spine pain seen in Table 15.

Table 18 shows that the majority of the patients in the study presented with a supinated gait at the initial consultation. This suggested that individuals with a supinated gait were more prone to inversion ankle sprains than those with a pronated gait.

Table 19 shows the variety of treatment protocols encountered within the sample of thirty before entering the research project. The most common method of treatment used was rest. This indicated that the patients, in general, weren't sufficiently educated in terms of managing ankle inversion sprains.
CHAPTER 6 – CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

Lateral ankle ligament sprain is an injury that frequently occurs. Of serious concern is the high reinjury rate that can arise from inadequate management of such sprains, and which leads to the chronic ankle sprain commonly seen by primary care practitioners. The ability to decrease pain, increase mobility, and improve overall ankle function over short-term and long-term periods is essential when these sprains are being managed. The initial treatment should focus on reducing inflammation and correcting the kinetic chain’s biomechanical dysfunction, that perpetuates the pathomechanics causing the sub-acute and chronic ankle inversion sprain.

All three groups responded favourably overall to their specific treatment protocols. In addition, where all three groups experienced statistically significant advances in objective measurements (ankle ranges of motion), group C had an earlier response to the treatment, and thus an earlier improvement than groups A and B.

With regard to the subjective outcomes, namely, the McGill Pain Questionnaire and the Numerical Pain Rating Scale 101, all three groups demonstrated statistically significant improvements in ankle pain severity. The combined group once again had superior benefits, in that group C’s subjective perception of pain improved sooner than that for group A and group B.

The combination soft tissue therapy, ultrasound therapy, and chiropractic manipulation and mobilization therapy, is therefore the most effective treatment protocol for the management of sub-acute and chronic grade I and grade II inversion ankle sprains. This treatment protocol has a far greater benefit with regard to improving the ranges of motion of the ankle and subtalar joints, and has a similar effect in improving patient’s perception of pain intensity, than manipulation and mobilization of joint complex dysfunction in the foot and spine, or soft tissue and ultrasound therapy alone.

The study’s aim of determining the most efficient means of managing sub-acute and chronic grade I and grade II inversion ankle sprains, was successfully achieved. This indicates that sub-acute and
chonic grade I and grade II inversion ankle inversion sprains, can be successfully managed with the application of chiropractic manipulative and mobilization treatments, in conjunction with existing conservative soft tissue therapies and treatment modalities. This finding can be thought of as encouraging in the field of chiropractic research, especially in the relatively unexplored field of managing extravertebral conditions and with respect to the role that chiropractic can play in such management.

6.2 RECOMMENDATIONS

Validation and improvement of these initial results may be achieved through the following recommendations:

6.2.1 The inclusion of a six-month follow-up period and assessment consultation may be an additional factor in determining the most effective/beneficial protocol in the management of sub-acute and chronic grade I and grade II inversion ankle sprains.

6.2.2 Larger sample groups may provide significant information to help determine the extent to which these preliminary results indicated that the combination of manipulation, mobilization and soft tissue therapy produce superior results than these therapies applied alone in the short and long term management of sub-acute and chronic grade I and grade II inversion ankle sprains.

6.2.3 One group may be treated solely with ultrasound therapy, in future research involving sub-acute and chronic grade I and grade II inversion ankle sprains, in order to determine its effectiveness.

6.2.4 Cross friction therapy may be applied to one group, in future research involving sub-acute and chronic grade I and grade II inversion ankle sprains, in order to determine its effectiveness.
6.2.5 Experimentation of the association between EMG levels of the triceps surae complex, the peroneal muscles and the lateral ankle complex can be conducted, to try determine the exact relationship between these structures in the perpetuation of inversion ankle sprains.

6.2.6 Research involving the correlation between peroneal muscle (eccentric) strength and chiropractic manipulation therapy should be investigated, in terms of the effects on the biomechanics, involving the lateral ankle ligaments. Incorporation of eccentric muscle strengthening in conjunction with chiropractic manipulation can possibly enhance the overall treatment and response to therapy for sub-acute and chronic grade I and grade II inversion ankle sprains.

6.2.7 In reviewing research pertaining to the treatment of inversion ankle sprains, no standard instrumentation was used to collect the objective data. Future research must be consistent in using the *Saunders Digital Inclinometer* to measure ankle ranges of motion.

6.2.8 Two areas of potential error in using the *Saunders Digital Inclinometer* to measure ankle and subtalar joint ranges of motion are examiner error and instrument error. It is recommended that a second method of objective measurement be used to supplement the digital inclinometer readings.

6.2.9 Future research must be consistent in using the *Numerical Pain Rating Scale 101* and the *McGill Pain Questionnaire* to measure the subjective changes in the patient’s perception of pain. In reviewing research pertaining to the treatment of inversion ankle sprains, the patient’s subjective response to his/her pain was not consistently recorded.

6.2.10 Researcher bias can be controlled, if an independent blind observer selects patients, records all the measurements, and aids the patients in the process of completing the questionnaires.
REFERENCES


APPENDIX A: ADVERTISEMENT POSTER

DO YOU HAVE ANKLE PAIN?

DO YOU SUFFER FROM ANY OF THE FOLLOWING ANKLE SYMPTOMS:

- PAIN
- WEAKNESS
- STIFFNESS
- A FEELING OF INSTABILITY OR GIVING WAY

I AM CONDUCTING FREE SUPERVISED TREATMENT FOR INVERSION ANKLE SPRAINS AT THE TECHNIKON WITWATERSRAND CHIROPRACTIC CLINIC IN DOORNFONTEIN, JOHANNESBURG.

FOR FURTHER INFORMATION CONTACT:

CRAIG LYONS

0828550555
APPENDIX B: SUBJECT INFORMATION AND CONSENT FORM

SUBJECT INFORMATION AND CONSENT FORM

THE EFFICACY OF SOFT TISSUE THERAPY IN THE CHIROPRACTIC MANAGEMENT OF SUB-ACUTE AND CHRONIC GRADE I AND GRADE II INVERSION ANKLE SPRAINS

Dear Participant

The purpose of this study is to determine the efficacy of spinal and ankle manipulation and mobilization in conjunction with soft tissue therapy in the management of sub-acute and chronic grade I and grade II ankle inversion sprains.

You will be randomly placed into one of three groups consisting of a soft tissue therapy group A, manipulation group B, and group C, a combination of the aforementioned groups. All subjects are required to be between the ages of eighteen and thirty-five years with a history of a grade I or a grade II ankle inversion sprain and resulting residual lateral ankle symptoms of between ten days and two years duration. Subjects will be required to discontinue any forms of medication or other modes of treatment for their ankle injury for the duration of the study. Subjects who experience reinjury to their ankle during the course of this study will be excluded.

The potential benefits for those who receive the study's treatment are that ankle pain, stiffness and weakness may be diminished or resolved and that normal spinal biomechanical relationships may be established potentially reducing the chance and severity of reinjury to the area. Irrespective of the treatment assigned, all subjects who participate in this study will contribute to medical knowledge, resulting in a greater efficacy in the therapeutic management of subjects with inversion ankle sprains.

Participation in the study is voluntary and you are free to refuse to participate or to withdraw your consent and to discontinue participation at any time. Such refusal or discontinuance will not affect your regular treatments or medical care in any way. A signed copy of this consent form will be made available to you.

I have fully explained the procedures, identifying those, which are investigational, and have explained their purpose. I have asked whether any questions have arisen regarding the procedures and have answered these questions to the best of my ability.

Date: ___________________ Researcher: ___________________

I have been fully informed as to the procedures to be followed, including those that are investigational and have been given a description of the attendant discomforts, risks, and benefits to be expected and the appropriate alternate procedures. In signing this consent form I agree to this method of treatment and I understand that I am free to withdraw my consent and discontinue my participation in this study at any time. I understand also that if I have any questions at any time, they will be answered.

Date: ___________________ Patient: ___________________
# APPENDIX C: McGill Pain Questionnaire

## McGill Pain Questionnaire

Patient name: ____________________  Date: __________

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<th>Moderate</th>
<th>Severe</th>
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<td>1)</td>
<td>2)</td>
<td>3)</td>
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<td>1)</td>
<td>2)</td>
<td>3)</td>
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<td>3)</td>
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<tr>
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Select the words that most accurately describe your pain at this time. If the word does not apply, it must not be chosen. A maximum of 3 for the most severe symptoms in that particular category can be selected.
Patient Name: ____________________  Date: ______________.

Rate the severity of your pain by checking one box on the following scale:

No pain 0 1 2 3 4 5 6 7 8 9 10 Excruciating pain
APPENDIX E: CASE HISTORY

TECHNIKON WITWATERSRAND
CHIROPRACTIC DAY CLINIC

CASE HISTORY

Date: ______________

Patient: ______________ File No: ______________

Age: _____ Sex: _____ Occupation: ______________

Intern: __________________ Signature: ______________

FOR CLINICIAN'S USE ONLY

Initial visit clinician: ______________ Signature: ______________

Case History: _______________________________________________________

____________________________________________________________________

Examination:

Previous: TWR Current: TWR
            Other

X-ray Studies:

Previous: TWR Current: TWR
            Other

Clinical path. lab:

Previous: TWR Current: TWR
            Other

Case status:

PTT: Conditional: Signed off: Final sign out:

Recommendations:
Intern's case history

1. Source of history:

2. Chief complaint: (patient's own words)

3. Present illness:
   - Location
   - Onset
   - Duration
   - Frequency
   - Pain (character)
   - Progression
   - Aggravating factors
   - Relieving factors
   - Associated Sx's & Sg's
   - Previous occurrences
   - Past treatment and outcome

4. Other complaints:
5. Past history:
   - General health status
   - Childhood illnesses
   - Adult illnesses
   - Psychiatric illnesses
   - Accidents/injuries
   - Surgery
   - Hospitalisation

6. Current health status and lifestyle:
   - Allergies
   - Immunizations
   - Screening tests
   - Environmental hazards
   - Safety measures
   - Exercise and leisure
   - Sleep patterns
   - Diet
Current medication

Tobacco

Alcohol

Social drugs

7. Family history:
   Immediate family:
   Cause of death
   DM
   Heart disease
   TB
   HBP
   Stroke
   Kidney Disease
   CA
   Arthritis
   Anaemia
   Headaches
   Thyroid disease
   Epilepsy
   Mental illness
   Alcoholism
   Drug addiction
   Other

8. Psychosocial history:
   Home situation
   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
   Neurological
   Haematological
   Endocrine
   Psychiatric
APPENDIX F: FOOT AND ANKLE REGIONAL EXAMINATION

TECHNIKON WITWATERSRAND

CHIROPRACTIC DAY CLINIC

FOOT AND ANKLE REGIONAL EXAMINATION

Patient: __________________________ File No.: __________ Date: __________
Intern: __________________________ Signature: __________
Clinician: ________________________ Signature: __________

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

______________________________________________________________
Swelling

Haemato dura

Skin

Nails

Shoes

ACTIVE MOVEMENTS

*Weight Bearing:*

Plantarflexion

Dorsiflexion 20°

Supination

Pronation

Toe Dorsiflexion 40° (mtp)

Toe Plantarflexion 40° (mtp)

*Non Weight Bearing:

Big toe dorsiflexion (mtp) (65-70°)

Big toe Plantarflexion (mtp) 45°

Toe abduction + adduction

5° first ray dorsiflexion

5° first ray plantarflexion

RESISTED ISOMETRIC MOVEMENTS

Knee flexion

Plantarflexion

Dorsiflexion

Supination (inversion)

Pronation (eversion)

Toe extension (dorsiflexion)

Toe flexion (plantarflexion)

PASSIVE MOVEMENT MOTION PALPATION

(Passive ROM quality, ROM overpressure, joint play)

Ankle joint: Plantarflexion __________ Dorsiflexion __________

Talocrural: Long axis distraction __________

Subtalar joint: Varus __________ Valgus __________

First Ray: Dorsiflexion __________ Plantarflexion __________
Circumduction of forefoot on fixed rearfoot:
Midtarsal: A-P Glide ___________ P-A glide ___________ rotation ___________
Tarsometatarsal joints: A-P ___________
Intermetatarsal glide: ___________
Metatarsophalangeal dorsiflexion (with associated plantarflexion of each toe)

Interphalangeal joints: long axis distraction ___________ A-P glide ___________
Lat and med glide ___________ rotation ___________

SPECIAL TESTS
Anterior drawer test: ___________
Talar tilt: ___________
Thomson test: ___________
Homans sign: ___________
Tinel's sign: ___________
Subtalar neutral position: ___________
Balance/proproprioeption: ___________
Test for rigid/flexible flatfoot: ___________

ALIGNMENT
Heel to ground: ___________
Feiss line: ___________
Tibial torsion: ___________
Heel to leg (subtalar neutral): ___________
Forefoot to heel (subtalar & midtarsal neutral): ___________
First ray alignment: ___________
Digital deformities: ___________
Digital deformity flexible: ___________

PALPATION
Anteriorly
Medial malleolus: ___________
Med tarsal bones, tibial (post) artery: ___________
Lat. Malleolus, calcaneus, sinus tarsi. and cuboid bones: ___________
Inferior tib/fib joint, tibia, mm of leg: ___________
Anterior tibia, neck of talus, dorsalis pedis artery: ___________

Posteriorly
Calcaneus: ___________
Achilles tendon: ___________
Muscolotendinous junction: ___________

Plantarily
Plantar muscle and fascia: ___________
Sesamoids: ___________
APPENDIX G: PERTINENT PHYSICAL EXAMINATION

Pertinent Physical
( Note: This form can only be used when you have completed 35 new patients)

Student Name--------------------- Signature----------------------

Doctor Name--------------------- Signature----------------------

Patient Information

Name--------------------------- Occupation----------------------

Age--------------------------- Sex-----------------------------

Vitals:

Height------------------------- Weight-------------------------

Pulse Rate--------------------- Respiratory Rate------------

Blood Pressure-----------------

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APPENDIX H: CERVICAL SPINE REGIONAL EXAMINATION

TECHNIKON WITWATERSRAND

CHIROPRACTIC DAY CLINIC

REGIONAL EXAMINATION

CERVICAL SPINE

Date: __________

Patient: ___________________ File No: __________

Clinician: _______________ Signature: __________

Intern: ________________ Signature: __________

OBSERVATION

- Posture
- Size
- Swellings
- Scars
- Discolouration
- Hairline
- Bony and soft tissue contours
- Shoulder level:
- Muscle spasm
- Facial Expression

RANGE OF MOTION

Flexion = 45° - 90°
Extension = 55° - 70°
L/R Rotation = 70° - 90°
L/R Lateral flexion = 20° - 45°
PALPATION

- Lymph nodes
- Trachea
- Thyroid gland
- Pulsae/thrills
- Tenderness
- Muscle tone
- Active MF Trigger Points: SCM, Trapezius, Scaleni, Levator Scapulae, Posterior Cervical musculature

/ = pain-free limitation // = painful limitation
ORTHOPAEDIC EXAMINATION

1. Doorbell Sign
2. Max. Cervical Compression
3. Spurling’s manoeuvre
4. Lateral Compression (Jackson’s test)
5. Kemp’s test
6. Cervical Distraction
7. Shoulder abduction Test
8. Shoulder depression Test
9. Dizziness rotation Test
10. Lhermitte’s Sign
11. O’Donoghue Manoeuvre
12. Brachial plexus Tension
13. Carpal tunnel syndrome:
   a. Tinel’s sign
   b. Phalen’s Test
14. TOS:
   a. Halstead’s test
   b. Adson’s test
   c. Eden’s (traction) test
   d. Hyperabduction (Wright’s) test -- Pec Minor
   e. Costoclavicular test

Remarks: __________________________________________________________

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**MOTION PALPATION**

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APPENDIX I: LUMBAR SPINE AND PELVIS REGIONAL EXAMINATION

TECHNIKON WITWATERSRAND

CHIROPRACTIC DAY CLINIC

REGIONAL EXAMINATION

LUMBAR SPINE AND PELVIS

Date: __________

Patient: ___________________ File No: _________

Clinician: ___________________ Signature: _________

Intern: ___________________ Signature: _________

A) STANDING

1. BODY TYPE
2. POSTURE
3. OBSERVATION
   • Muscle Tone
   • Bony + Soft Tissue Contours
   • Skin
   • Scars
   • Discolouration
   • Step Deformity

4. SPECIAL TESTS
   • Schober’s Test
   • Spinous Percussion
   • Treadmill
   • Minor’s Sign
   • Quick Test
   • Trendelenburg Test
RANGE OF MOTION

Forward Flexion = 40° – 60°
Extension = 20° – 35°
L/R Rotation = 3° – 18°
L/R Lateral flexion = 15° – 20°

/ = pain-free limitation // = painful limitation

6. GAIT

- Rhythm, Pendulousness
- On Toes (S1)
- On Heels (L4, L5)
- Half Squat on one leg (L2, 3, 4)
- Tandem Walking

7. MOTION PALPATION

B. SITTING

1. SPECIAL TESTS

- Tripod Test
- Kemp’s Test
- Valsalva Manoeuvre
MOTION PALPATION

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C) SUPINE

1. OBSERVATION
   - Hair, Skin, Nails
   - Fasciculations

2. PULSES
   - Femoral
   - Popliteal
   - Dorsalis Pedis
   - Posterior Tibial

3. MUSCLE CIRCUMFERENCE

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5. ABDOMINAL EXAMINATION

- Observation
- Abdominal Reflexes
- Auscultation Abdomen and Groin
- Palpation Abdomen and Groin

Comments:
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7. SPECIAL TESTS

- SLR
- WLR
- Braggard’s
- Bowstring
- Sciatic Notch Pressure
- Sign of the Buttock
- Bilateral SLR
- Patrick Faber
- Gaenslen’s Test
- Gapping Test
- “Squish” Test
- Gluteus Maximus Test
- Thomas’ Test
- Rectus Femoris Contracture Test
- Hip Medial Rotation
- Psoas Test

LATERAL RECUMBENT

- Sacroiliac Compression
- Ober’s test
- Femoral Nerve Stretch Test
- Myotomes: - Quadratus Lumborum Strength
  - - Gluteus Medius Strength
PRONE

- Facet joint challenge
- Myofascial Trigger points
  - Quadratus Lumborum
  - Gluteus Medius
  - Gluteus Maximus
  - Piriformis
  - Tensor Fascia Lata
  - Hamstrings

- Skin Rolling
- Erichsen’s Test
- Sacroiliac Tenderness
- Pheasant’s Test
- Gluteal Skyline
- Myotomes:
  - Gluteus Maximus Strength

NON-ORGANIC SIGNS

- Pin-point Pain
- Axial Compression
- Trunk Rotation
- Burns Bench Test
- Flip Test
- Hoover’s Test
- Ankle Dorsiflexion Test
- Pin-Point Pain
### APPENDIX J: SOAP NOTE FORM

<table>
<thead>
<tr>
<th>PATIENT:</th>
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</thead>
<tbody>
<tr>
<td>FILE #:</td>
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<tr>
<td>DATE:</td>
</tr>
<tr>
<td>INTERN:</td>
</tr>
<tr>
<td>CLINICIAN (PTT):</td>
</tr>
</tbody>
</table>

| PAGE: |
| VISIT #: |

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**SPECIAL ATTENTION TO:**

| DATE: |
| VISIT #: |
| INTERN: |
| CLINICIAN (PTT): |

| S: |
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| P: |

**SPECIAL ATTENTION TO:**
APPENDIX K: DIGITAL INCLINOMETER READINGS FOR ANKLE RANGES OF MOTION

DIGITAL INCLINOMETER READINGS FOR ANKLE RANGES OF MOTION

PATIENT NAME: ________________    FILE NUMBER: ________________

ANKLE: L/R

Visit: _____  Visit: _____  Visit: _____  Visit: _____
Date: _____  Date: _____  Date: _____  Date: _____

DORSIFLEXION: ________________    ________________

PLANTARFLEXION: ____________  ____________  ____________

INVERSION: ____________  ____________  ____________  ____________

EVERSION: ____________  ____________  ____________
APPENDIX L: GASTROCNEMIUS AND SOLEUS MUSCLE TOWEL STRETCH

Seated Gastrocnemius Stretch (Seto and Brewster 1994: 699)

Seated Soleus Stretch (Seto and Brewster 1994: 700)