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The Effect of Chiropractic Manipulative Therapy of the Tibiotalar Joint on Endurance of the Triceps Surae Muscle

A dissertation submitted to The Faculty of Health Sciences, University of Johannesburg, in fulfilment of the requirements for the degree of Master of Technology: Chiropractic by:

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Date: Johannesburg, 2015
I, Caitlyn Mae Baüer, declare that this dissertation is my own, unaided work, except where otherwise indicated in the text. It is being submitted for the Masters Degree in Technology: Chiropractic at the University of Johannesburg. It has not been submitted before for any degree or examination in any other University.

Signature of Candidate: _______________________________________________

On this the _________________ day of ________________________ 2015.
DEDICATION

I dedicate this research to my mother, Cherisse Suzanne Baüer. Although you were taken too soon and were not here in body as I travelled this long journey, you have walked with me every step of the way. I love you, miss you and hope I've made you proud.

To my dad Grant, aunt Angie, and beloved family, you all mean so much to me. Your love, support and encouragement has been endless. Thank you and I love you.

To the love of my life, Duncan, thank you for being my person and the one I never have to search for, as you are always standing beside me. I love you and appreciate you more than words could ever say.

"Therefore do not worry about tomorrow, for tomorrow will worry about itself. Each day has enough trouble of its own." – Matthew 6:34
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To Marion Farquhar, for your expertise in the styling and formatting of my dissertation, and for you and your family’s support throughout my studies. Your help saved me hours of painstaking work and your kindness and love never go unnoticed, thank you.

To Laura Soal, more than just a friend, but an inspiration and mentor. Thank you for never being too far away.

To all the volunteers that took the time to participate in my study. Thank you, without you this would not have been possible.
ABSTRACT

OBJECTIVE
The aim of this study was to determine if chiropractic manipulative therapy of the tibiotalar joint has an effect on endurance of the triceps surae muscle. The results of this study may provide an additional resource for the chiropractor. An improvement in triceps surae endurance in the treatment group could add to the current understanding and knowledge of the benefits of chiropractic manipulative therapy of the tibiotalar joint on the endurance of the triceps surae muscles.

METHODOLOGY
Thirty asymptomatic participants that were between the ages of 18 to 25 years were recruited. The participants were placed into two groups of fifteen participants each. The two groups underwent pre-testing of their triceps surae muscles to the point of fatigue. Group One was the treatment group, and they then received an intervention of chiropractic manipulative therapy to the tibiotalar joint. Group Two was the control group and had a rest period with no intervention. Both groups then underwent post-testing of the triceps surae.

The participants completed the study over a period of three weeks. Subjective questionnaires were done and objective measurements were taken by counting the amount of heel raises performed on the Haberometer to the point of fatigue.

RESULTS
The statistical data was analysed using the Mann-Whitney test, Friedman test and Wilcoxin Signed-Ranks test. The results demonstrated that both groups responded with an improvement during the trial between the second and final sets of readings. However, Group One showed a more significant long-term improvement over time. These results highlight the positive effects of chiropractic manipulative therapy.
DISCUSSION

The results of the Haberometer readings proved that there was an improvement in both groups over time, however between visit one and visit seven, the treatment group showed a more substantial statistical and clinical improvement. This improvement may be attributed to a number of theories. The effects of a chiropractic manipulation are considered here, including the reflexogenic effects, which includes a change in muscle tone, excitability and ability to contract to the muscles maximum capacity. The neurological effects of a chiropractic manipulation may be considered in that if the muscles are not able to activate completely, they will not be able to contribute their full power output. With regards to biomechanics, pre-existing joint dysfunction could have been corrected by the chiropractic manipulative therapy and resulted in an increase in the quality of motion of the joint and breaking up of adhesions, allowing for a more free range of motion. This increased range of motion could possibly have contributed to the ease in which the participants were able to perform heel raises.

CONCLUSION

The results from the data collected during the trial showed that, in the short term, chiropractic manipulative therapy was not effective. However, in the long term, there was an improvement in results in the treatment group when compared to the control group.
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CHAPTER ONE - INTRODUCTION

1.1 Introduction

The ankle is the most commonly injured joint in the body (Gutierrez, Jackson, Dorr, Margiotta and Kaminski, 2007). Athletes have reported that they have noticed that more injuries occur late in the game, when fatigue is present. Research was conducted on an elite group of soccer players, and it was found that most of their injuries occurred within the last 15 minutes of the game (Gutierrez et al., 2007). Other studies report that muscular fatigue delays reaction time and neuromuscular control, which also predisposes an athlete to injuries (Santos Silva, Martinez, Pacheco and Pacheco, 2006).

Ankle sprains, particularly lateral ankle sprains, are the most common orthopaedic injuries to occur, resulting in time lost from the workplace and on the sports field. These injuries have been found more likely to occur when one is fatigued due to physical exertion, and may lead to lasting disability, osteoarthritis and articular degeneration (Gutierrez et al., 2007).

When a muscle is fatigued, the muscle spindle function is altered. It has been postulated that the peripheral and central neuromuscular feedback system of the joint will be inhibited when the muscles around a joint are fatigued (Huston, Sandry, Lively and Kotsko, 2005). Normal joint motion or joint play is important for nutrient exchange in order to prevent degeneration. Often, secondary muscle changes are caused by joint dysfunction. When a joint is not free to move, the muscles, which move it, cannot be free to move (Houglum and Bertoti, 2011). Hence, a muscle cannot function optimally, unless the joint it moves is functioning properly. It is therefore apparent that dysfunction in either the joint or the muscle will adversely affect the other. Chiropractic manipulative therapy has an influence on joint and neurophysiologic function (Bergman and Peterson, 2011), correcting biomechanics, decreasing pain and influencing mechanoreceptor functioning (Gatterman, 2005).
Research on the effect of chiropractic manipulative therapy on the strength of the gastrocnemius muscle (Herwill, 2009) has been performed; however, to date no other evidence has been presented on the effects of chiropractic manipulative therapy of the tibiotalar joint on endurance of the triceps surae muscle.

1.2 Aims of the study

The aim of this study was to determine if chiropractic manipulative therapy of the tibiotalar joint had an effect on endurance of the triceps surae muscle, by comparing a treatment group to a control group. Short term and long term effects were measured to determine whether chiropractic manipulative therapy increased triceps surae endurance.

1.3 Possible outcomes and benefits of the study

The possible outcome of this study was to determine whether chiropractic manipulative therapy to the tibiotalar joint may improve triceps surae endurance. The results of this study provide an additional resource for the chiropractor, particularly when dealing with athletic patients. If there was an improvement in triceps surae endurance in the treatment group, this information could add to the current understanding and knowledge of the benefits of chiropractic manipulative therapy of the tibiotalar joint on the endurance of the triceps surae muscles. This information could then possibly be extrapolated to other joints as an alternative approach to the treatment of patients, not only aiming at obtaining the optimum function of the joints, but of the muscles as well.
CHAPTER TWO - LITERATURE REVIEW

2.1 INTRODUCTION

As the most commonly injured joint in the body, the ankle is a common site of restrictions and dysfunction. Hertel (2002) found that the potential causes of mechanical instability of the ankle are adhesions such as scar tissue, restrictions of the arthrokinematic complex, irritation of the synovium and degenerative ankle joint changes. Functional instability has been postulated to be caused by proprioceptive inadequacy, decreased postural or neuromuscular control and insufficient strength (Hertel, 2002). The foot and ankle play an important role in the body’s kinetic chain. The ankle in particular, forms the lowest part of the kinetic chain and is therefore able to cause restrictions in the spine and other joints of the body as a result of the reflex adaptation of the body to biomechanical dysfunction (Broome, 2000). The foot and ankle are important joints as they are a fixed point to the ground, yet they allow positional adjustments of the lower limbs, to maintain posture (Alburquerque-Sendin, Fernández-de-las-Peñas, Santos-del-Ray and Martin-Vallejo, 2009).

Muscular fatigue and endurance plays an important part in an athlete’s life; however it is being increasingly observed in those with disease and health conditions, and is having an impact on their activities of daily living due to the changes in muscle metabolism (Rimmer, Schiller and Chen, 2012). Clark (2009) found that antigravity muscles, such as gastrocnemius and soleus, have been shown to be the types of muscles that undergo the most atrophy during periods of bed rest. Muscle deconditioning, whether as a result of a sedentary lifestyle or illness, limits the capacity to exercise and increases the muscles tendency to reach fatigue faster (Bogdanis, 2012). The call for investigation into the causes of fatigue and methods for improving muscular endurance is therefore important.
2.2 ANATOMY OF TRICEPS SURAE

The triceps surae is the name given to a three-headed group of muscles, namely the gastrocnemius and soleus. The gastrocnemius is the most superficial and has two heads, one medial and one lateral. It attaches proximally to the lateral condyle of the femur. The soleus is located deep to the gastrocnemius and attaches proximally to the posterior aspect of the head of the fibula. Both the gastrocnemius and soleus attach distally via the calcaneal tendon, to the calcaneus and are innervated by branches of the tibial nerve from the spinal roots, S₁ and S₂ (Moore, Dalley and Argur, 2006).

The triceps surae is a powerful mass of muscle, which is responsible for 93% of plantarflexion of the ankle. It also helps maintain one’s upright stance and acts in lifting, propelling and accelerating the weight of the body during walking, running, jumping or toe standing (Moore et al., 2006).

The gastrocnemius is bi-articular, in that it crosses two joints; the knee and the ankle, and therefore has an action on both. It cannot, however, act on both joints with full power simultaneously. The gastrocnemius functions most effectively with the knee extended, and cannot plantarflex if the knee is fully flexed, due to the loss of its optimal length. The soleus only crosses the ankle joint and therefore acts as the prime plantarflexor when the knee is in a flexed position (Pereira, de Oliveira and Nadal, 2011).
Figure 2.1: Superficial dissection of muscles of the leg (Netter, 2006)
2.3 MUSCLE RECEPTORS

There are two types of receptors found in muscles, namely the muscle spindles and Golgi Tendon Organs (GTO). The muscle spindles are found in modified muscle fibres. These
are known as intrafusal muscle fibres and they lie parallel to the other muscle fibres. The intrafusal muscle fibres have a central sensory area that is sensitive to stretch. Muscle spindles have a proprioceptive function in that they monitor the length and the stretch of the muscle in which they are found. Stretch in a muscle causes the muscle spindles to activate contraction of that muscle. When there is a sudden stretch, the sensory nerve of the muscle spindle sends an impulse to the spinal cord, where it synapses with the alpha motor neuron. This, in turn sends a reflex impulse to the muscle, resulting in contraction or shortening of the muscle. This releases the pressure on the spindles (Kraemer, Fleck and Deschenes, 2011).

Golgi Tendon Organs are found in the tendons in such a way that they are able to monitor the contraction of the entire muscle. Their function is to detect tension within the tendon. If the force or tension placed on the tendon is excessive, the GTO is triggered to prevent injury to the muscle or tendon. The sensory neuron of the GTO ascends to the spinal cord and synapses with the alpha motor neurons of the agonist and antagonist muscles. If the tension on the tendon was found to be excessive, the GTO will inhibit the involved muscle and the tension will be decreased (Kraemer, Fleck and Deschenes, 2011). This is a protective mechanism, also known as "autogenic inhibition" (Knutsen and Owens, 2003). Evans (2001) proposed that hypertonic muscles undergo relaxation when chiropractic manipulative therapy is administered as a result of a reduction in alpha motor neuron excitability or a decrease in activation of the innervated muscles. The muscle stretch that is achieved by chiropractic manipulative therapy has been shown to re-establish coordination between the extrafusal and intrafusal muscle fibres. This is said to normalise passive tone in muscles (Knutsen and Owens, 2003).

2.4 ANATOMY OF THE ANKLE JOINT

The ankle joint, also known as the talocrural articulation, is a hinge-type synovial joint. It is made up of the inferior surface of the tibia and the medial and lateral malleoli, which articulate with the trochlea of the talus (Moore et al., 2006). The distal end if the tibia flares and its medial malleolus articulates with the superior surface of the talus. The fibula articulates with the talus laterally. The distal ends of the tibia and fibula form a “mortise”
which resembles a socket that the talus fits into (Platzer, 2011). The configuration of the tibiotalar joint allows for the transmission of torque from the lower leg to the foot and allows for the movements of dorsiflexion and plantarflexion, primarily in the sagittal plane (Hertel, 2002). The anterior surface of the trochlear is wider than the posterior surface. This results in ankle dorsiflexion being more secure than plantarflexion.

Figure 2.3: Distal ends of tibia and fibula showing articular surfaces (Netter, 2006)

Figure 2.4: Articulated foot and ankle (Netter, 2006)
Support for the ankle when fully weight bearing is provided primarily by the articulating surfaces, however the ligamentous support is also very important. The joint capsule and several ligaments provide this fundamental support. These ligaments include the anterior talofibular ligament, posterior talofibular ligament and the calcaneofibular ligament, which provide support laterally; and the deltoid ligament, which provides support to the medial ankle. The distal tibiofibular joint is a syndesmosis, which forms a steady roof for the ankle mortise. The joint capsule and lateral ligaments of the tibiotalar joint have been found to be largely innervated by mechanoreceptors (Hertel, 2002).

Figure 2.5: Posterior view of tibiotalar joint (Netter, 2006)
Figure 2.6: Ligaments of the ankle and foot lateral view (Netter, 2006)

Figure 2.7: Ligaments of the ankle and foot medial view (Netter, 2006)
2.5 JOINT RECEPTORS

Three types of sensory receptors exist in the articular capsule, namely Type I, II and IV receptors. Type III receptors also exist, but are not found within the capsule.

Type I

Type I receptors are static and dynamic mechanoreceptors that are found in the outer layers of the joint capsule. They are highly sensitive and fire continuously. Type I receptors are only inhibited by joint approximation. They function to monitor joint tension, movement and posture and inhibit pain received via pain receptors by the encephalin synaptic interneuron transmitter (Pickar, 2002).

Type II

Type II receptors are found in the deeper layers of the joint capsule and are less sensitive mechanoreceptors than Type I receptors. Type II receptors only fire during movement and function to monitor slight changes in tension. They also inhibit pain via the encephalin synaptic interneuron transmitter (Pickar, 2002).
Type III
The Type III receptors are found in the intrinsic and extrinsic ligaments of the peripheral joints. They are large myelinated fibres and are therefore slowly adapting. Their function is thought to be monitoring of the direction of movement and recognizing potentially harmful movements of the joints. They are thought to have an inhibitory effect on motoneurons (Pickar, 2002).

Type IV
These nociceptors are found in the fibrous portions of the joint capsule and ligament and are made up of a network of free nerve endings and unmyelinated fibres. These fibres are sensitive to the sensations of pain, itchiness and tickle. They are inactive in a normal joint and only activated when there has been injury, inflammation or chemical irritation in the joint. The function of Type IV receptors is the production of pain (Pickar, 2002).

2.6 FATIGUE AND ENDURANCE

Definition of fatigue
Muscular fatigue may be defined as “any reduction in the force generating capacity of the total neuromuscular system” (Porter, Holmberg and Lexell, 2002). Local muscle fatigue may be physiologically defined as “any decline in muscle performance associated with muscle activity” (Allen, Lamb and Westerblad, 2008). When muscle fatigue develops while performing submaximal aerobic exercise, it may not necessarily present as tiredness felt by the participant, but rather as a reduction in ability to generate force and power (Finsterer, 2012). Ledin, Fransson and Magnusson (2004) hypothesised that muscles that are fatigued do not respond as effectively to muscle vibration as non-fatigued muscles; and that muscle fatigue changes the contractile competency of the muscles. This hinders the muscles ability to react with the necessary high frequency, short potential response to disturbances in posture (Ledin et al., 2004). A disturbance in posture could result in a person becoming unsteady on their feet and predispose them to potential injury as a result of not being able to react quickly enough to the said disturbance.
Causes of fatigue

Fatigue has both central and peripheral causes. Peripheral fatigue occurs as a result of variations in the muscle itself, such as neuromuscular junction changes, metabolite accumulation and the exhaustion of fuels. Central fatigue involves a decrease in drive from the neural system, resulting in a decrease in muscular force (Kawakami, Amemiya, Kanehisa, Ikegawa and Fukunaga, 2000). Muscular fatigue that occurs during exercise may be considered as a mechanism of safety, preventing structural damage to muscle cells and supportive tissues (Finsterer, 2012).

Effects of fatigue on joints

Joint movement is achieved by contraction of the muscles that control the joint. Therefore, when muscular fatigue is induced, it will have an effect on the joint, causing some degree of impairment. The amount of effect on the joint is determined by the difference in fatigue responses of the muscles involved. The force generating capacity or ability of the muscles to provide torque is also affected by the position of the joint, which creates another variable when investigating changes due to induced fatigue. Factors to consider are the fibre composition of the muscle, and anatomical attachments (Ghasemi, Olyaei, Bagheri, Talebian, Shadmehr and Jalaei, 2012). For instance, gastrocnemius crosses both the knee and the ankle joint, whereas soleus only crosses the ankle joint; therefore gastrocnemius has a greater torque producing capacity than soleus when the knee is extended. Soleus however is comprised of predominantly slow-twitch Type I muscle fibres. Type I fibres have more oxidative enzymes and the enzymes are also more active in these fibres. These enzymes favour aerobic metabolism (Bogdanis, 2012), which makes soleus more resistant to fatigue than gastrocnemius (Kawakami et al., 2000).

Endurance verses strength

Muscular endurance differs from muscular strength. Muscular strength is the ability of the muscle to exert maximum force against resistance, whereas muscular endurance is the ability of a muscle or muscle group to perform repeated contractions over a period of time (Cespedes, 2013). In this study, fatigue was measured as an indication of muscular endurance. This was done by determining the point at which the participant was no longer
able to maintain the workload that was required of them, and may also be known as "task failure" (Haber, Golan, Azoulay, Kahn and Shrier, 2004).

2.7 FATIGUE AND PROPRIOCEPTION

Proprioception is a specialized form of the sense of touch that involves both kinesthetic and joint position sense. Joint position sense is determined by muscle spindles and cutaneous receptors, which send afferent input to the central nervous system. When exercise induced fatigue is initiated, there is a change in the functioning of the muscle spindle. It has therefore been suggested that fatigue of the muscles around a joint have been shown to cause a decrease in the neuromuscular feedback system of the joint (Huston, Sandrey, Lively and Kotsko, 2005).

The release of metabolites and inflammatory material such as bradykinin, arachidonic acid, prostaglandin E₂, potassium and lactic acid occurs as a result of local muscle fatigue. These substances cause nociceptor activation and have a direct effect on the discharge pattern of the muscle spindles. This represents the peripheral aspect of fatigue. The reflexes from the small diameter muscle afferents (group III and IV); modulate the afferent and efferent neuromuscular pathways. These reflexes originate in the muscle and respond to the metabolites mentioned, resulting in modifications to the central processing of proprioception. This represents the central aspect of fatigue (Forestier, Teasdale and Nougier, 2002).

As fatigue has been shown to influence proprioceptive functioning, it is important to exercise and condition the body to reduce the effects of fatigue. New training methods have now been incorporated for athletes that focus on improving the exchange of information from the muscles to the central nervous system and vice versa. The improvement in these neuromuscular pathways will allow the delay of the onset of fatigue (Kraemer et al., 2011). This is vital to any serious athlete, where maintaining their optimal level of performance is of great importance, especially when competing.
2.8 CHIROPRACTIC MANIPULATIVE THERAPY

Definition of chiropractic manipulative therapy
Chiropractic manipulation is a form of joint manipulation that uses either long lever or short lever techniques with contact over specific anatomical regions. A controlled force is used, as well as controlled leverage, direction, amplitude and velocity to deliver this adjustment to specific joints or regions. These techniques are utilised by chiropractors to influence joint and neurophysiologic function (Bergman and Peterson, 2011).

Chiropractic manipulative therapy has mechanical, soft tissue and neurological effects, as well as an effect on pain.

Mechanical and soft tissue effects
The mechanical effects of chiropractic manipulative therapy include changes in the alignment of joints and dysfunctional joint motion. Dysfunction of the joints may be caused by meniscoid entrapment or extrapment, muscle spasm or periarticular connective tissue adhesions, for example (Gatterman, 2005).

Knutsen and Owens (2003) describe bones as passive structures whose range of motion and positioning is determined by active contraction of muscles and the length of the soft tissue structures surrounding them. Therefore alterations of muscle tone have been suggested to contribute to joint dysfunction. Muscle tone may be described as the stiffness of a muscle or its resistance to passive movement. Irritation of the joint capsule causes activation of nociceptors and a "nocifensive reflex", where the joint is guarded by powerful muscle hypertonicity (Knutsen and Owens, 2003).

Chiropractic manipulative therapy affects soft tissue by changing the strength and tone of the supporting musculature, as well as influencing the capsuloligamentous connective tissue. Manual therapy has been shown to break up adhesions that have formed from abnormal cross-linkages in the connective tissue, allowing for a more free range of motion of the joint (Gatterman, 2005).
Fryer, Mudge and McLaughlin (2002) found that manipulation of the ankle has an effect on the quality of motion of the joint, for example, producing a reduction in resistance to movement in dorsiflexion. During manual therapy, the muscles are also undergoing a stretch, which leads to spindle reflexes. These can in turn decrease the hypertonicity of a muscle (Gatterman, 2005).

**Neurological effects**

A number of researchers have investigated the effects that chiropractic manipulation has on the functioning of the nervous system. Over the last decade, they have discovered that there has been a change in muscle reflexes, cognitive processing, reaction time and the speed at which the brain is able to process information. Niazi, Türker, Flavel, Kinget, Duehr and Haavik (2015) studied the improvements in maximum voluntary contraction of soleus after spinal manipulation was performed. Spinal manipulation proved to prevent the onset of fatigue in the soleus. Along with preventing fatigue, they found that spinal manipulation seemed to affect the net excitability of the low-threshold motor units and improve cortical drive (Niazi et al., 2015). A preliminary study by López-Rodriguez, de-las-Peñas, Alburquerque-Sendin, Rodriguez-Blanco and Palomeque-del-Cerro (2007) showed that manipulation of the talocrural joint resulted in an altered behaviour pattern of loadbearing support at the foot and therefore supported the theory that ankle manipulation affects proprioception.

**Effects on pain**

Type I, II and IV joint receptors are all affected by chiropractic manipulative therapy. The mechanoreceptors are stimulated and medium and large diameter afferent fibres carry the signal to the central nervous system. The pain signals that travel through smaller diameter fibres are then inhibited. The cycle of correction of the arthrokinetic reflex begins with a problem with a joint and its surrounding muscles. This causes an imbalance in the reflex and opens the gate to nociceptive input (pain signals). When manipulative therapy is administered, the muscle tone is normalised and the pain cycle is broken. This results in the normalising of the arthrokinetic reflex (Pickar, 2002).
2.9 CHIROPRACTIC TREATMENT OF EXTREMITIES

Chiropractors are generally known to the public for only treating back related conditions. However, most practitioners will disagree with this, in that they are trained to diagnose and treat extremities as well. It was found that 76.1% of chiropractic practitioners used spinal, as well as extremity procedures in practice, whereas only 18.7% used only spinal procedures (Brantingham, Globe, Pollard, Hicks, Korporaal and Hoskins, 2009). Brantingham et al. (2009) found that the treatment of extremities was the second most common form of treatment by chiropractors.

Marrón-Gómez, Rodríguez-Fernández and Martin-Urrialde (2015) found that mobilisations and high-velocity low-amplitude (HVLA) manipulations have been shown to encourage and restore normal arthrokinematics. This is due partly to the elongation of the periarticular joint capsule and improved kinematics in the accessory joints (Marrón-Gómez et al., 2015).

A study by Hoeksma, Dekker, Ronday, Heering, van der Lubbe, Vel, Breedveld and van den Ende (2004) was conducted using an axial elongation (HVLA) thrust manipulation of the hip joint. This study compared the effects of HVLA manipulation to an exercise protocol, and showed the HVLA procedure to be more effective in the treatment of hip osteoarthritis (Hoeksma et al., 2004). The use of the HVLA thrust is important as it has been proven that this type of thrust is more effective in bringing about activation on surface electromyography when being compared to low velocity mobilisations (Niazi et al., 2015).

Brantingham et al. (2009) discovered through their review, that studies of an increasing quality and quantity are proving manipulative therapy to be safe and effective in the treatment of extremities. The overall beneficial results of extremity manipulative therapy are now paralleling that of spinal manipulative therapy and are postulated to treat any neuromusculoskeletal conditions of the joint, especially where hypomobility is a contributing factor (Brantingham et al., 2009).
CHAPTER THREE – METHODOLOGY

3.1 Introduction

The details of the research study are explained and described in this chapter. This includes the study design, participant recruitment, sample selection and size, randomization and treatment protocol. The chapter then further describes the objective and subjective measurements, the statistical analysis, and data evaluation used in the study.

3.1.1 Study design

This was a comparative study with random group allocation whereby it was determined whether chiropractic manipulative therapy of the tibiotalar joint had an effect on endurance of the triceps surae muscle.

3.1.2 Participant recruitment

The recruitment of individuals was by means of advertisements (Appendix A), which were placed around the University of Johannesburg’s Doornfontein Campus and the Chiropractic Day Clinic, and also through word of mouth.

3.1.4 Sample selection and size

Thirty participants, male or female, between the ages of 18 and 25, were able to partake in this study. Once it was confirmed that they met the inclusion criteria and did not present with any of the exclusion criteria, the participants were assigned to one of two groups, via random allocation. The group allocation was only carried out once the participants had read the information form (Appendix B) and signed the consent form (Appendix C).
3.1.5 Inclusion criteria

In order to participate in this study, the participants were required to meet the following inclusion criteria:

- Be males or females who were healthy and able to perform standing heel raises.
  - The World Health Organization's (WHO) definition of health was accepted in 1948, and has not since been amended: "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (Obtained from WHO official website on www.who.int/about/definition/en/print.html last accessed on 13 June 2015).
  - Participants were considered healthy if they fitted the above definition. Of particular importance was being in good physical condition and not having injuries or conditions that would render them incapable of performing standing heel raises.
- Be between the ages of 18 to 25 years
  - This population age group was chosen as they are less likely to have degenerative musculoskeletal changes, such as osteopenia and sarcopenia (Mitchell, Williams, Atherton, Larvin, Lund and Narici, 2012), which would render them unfit for this study. Keeping the age group small also allowed for fewer variables.

3.1.3 Exclusion criteria

Any volunteer that presented with the following was excluded from this study:

- Those who demonstrated any contra-indications to Chiropractic manipulative therapy of the ankle (Appendix I).
- Participants that experienced lower limb injury in the past twelve months.
  - The dominant leg was tested in this study. However, if the participant's dominant leg had been injured, the non-dominant leg was tested
- Participants that were experiencing any ankle or calf pain
Participants were not to receive any other form of treatment that may have interfered with the results of the study. Other forms of treatment included other manipulative and physical therapies and any anti-inflammatory medication, analgesics or muscle relaxant drugs.

3.1.4 Group allocation

Participants meeting the inclusion criteria were divided into one of two groups. Each group consisted of fifteen participants. Participant allocation to each group was determined by drawing a number out of a hat. The hat contained fifteen pieces of paper with “1” on them, and fifteen pieces of paper with “2” on them, which represented Group One and Group Two. Therefore the total number of pieces of paper was thirty. The number that the participant drew from the hat represented the group that the participant was allocated to.

The participants in Group One received chiropractic manipulative therapy of the tibiotalar joint. The participants in Group Two did not receive manipulative therapy, but had a rest period.
3.2 TREATMENT APPROACH

To provide a clear understanding of the methodology, see Figure 3.1 below:

Figure 3.1: Flow Diagram – Methodology
3.2.1 Initial consultation

The initial consultation included:

- All participants were screened by the researcher by means of the completion of a case history (Appendix D) and full physical examination (Appendix E), as well as a foot and ankle regional examination (Appendix F).

- A consent form was signed (Appendix C).

- A demographic questionnaire (Appendix G) was completed by the participant.

- A physical activity questionnaire (Appendix H) was completed by the participant.

- The participant performed a five minute warm up by running on the spot or around campus.

- The participant then underwent testing of the triceps surae muscle of their dominant leg. In the case of a participant’s dominant leg being injured, their non-dominant leg was tested.

- Group One then received Chiropractic manipulative therapy to the tibiotalar joint (Figure 3.2).

- Group Two had a rest period of the same duration as the Chiropractic manipulative therapy took to perform.

- Participants from both Group One and Group Two then underwent post-test testing of the triceps surae muscle.

3.2.1 Follow-up consultations

Group One: Each participant received a course of six treatments over a three week period and a final seventh consultation where only measurements were taken. Each participant in Group One began by filling out a physical activity questionnaire (Appendix H) at visit one, four and seven. On the first and fourth visits, they performed a five minute warm up. After
the warm up, they underwent pre-testing of the triceps surae. Each participant then received chiropractic manipulative therapy to the tibiotalar joint, followed by post-testing of the triceps surae on the Haberometer. At the second, third, fifth and sixth visit, only the chiropractic manipulative therapy was performed on the tibiotalar joint of the test leg, with no warm up and no testing. The seventh visit involved completion of the questionnaire, a five minute warm up and pre-testing of the triceps surae on the Haberometer.

Group Two: Each participant had three consultations over a three week period. The physical activity questionnaire was completed before testing took place. Their consultations corresponded to the first, fourth and seventh visits of the participants in Group One (see Figure 3.1). The participants did a five minute warm up and then performed pre-testing of the triceps surae to the point of fatigue. They then had a rest period the same duration as the manipulative therapy took to perform, followed by post-testing to the point of fatigue on the Haberometer.

3.2.2 Treatment procedure

The mortise separation technique (ankle mortise distraction) (Broome, 2000) is the chiropractic manipulative technique that was used in this study. It is performed as follows: The participant lies supine. The researcher's indifferent hand grasps either the medial or lateral border of the participant's foot. The thumb is positioned on the sole of the foot and the fingers are placed on the dorsal aspect of the foot. The researcher's contact hand grasped the opposite border of the foot to the indifferent hand in the same manner. The ankle is first dorsiflexed, and then the entire limb is internally rotated. The foot is then everted. Finally, the thrust is delivered straight towards the researcher. The line of drive is parallel to the floor.
3.3 DATA COLLECTION

3.3.1 Objective data

3.3.1.1 Haberometer

Objective data was collected by means of a tool named the Haberometer (Figure 3.3). The Haberometer is a tool that was developed as an apparatus to standardise the standing heel raise test for the testing of the triceps surae muscle. The Haberometer was proven to be a valid and reliable method of testing fatigability of the triceps surae muscle, in participants with no injuries (Haber, Golan, Azoulay, Kahn and Shrier, 2004).

The Haberometer is made up of a platform for the participant's foot, and a rod and foot positioning device that is attached to this platform. The rod and the foot positioning device are both adjustable (Figure 3.3 a).
The participants were first required to stand barefoot on the platform, on the leg to be tested. The test leg had to be fully extended and the non-test leg was flexed or suspended in the air. The test leg had to be extended as the whole triceps surae muscle complex was being tested i.e. gastrocnemius and soleus. If the leg was flexed, the soleus muscle would be isolated. The participant then performed a full heel raise until the navicular touched the rod. The rod and the foot positioning device were adjusted to maintain a limit of the height of the heel lift to 5 cm. The distal end of the participants’ toes had to constantly make contact with the foot positioning device.

A flat hand could be placed lightly against the wall to ensure the participant remained balanced. After completing the set up procedure as described above, the participant began performing standing heel raises, keeping the knee of the test leg fully extended. The knee was to be extended, as the entire triceps surae was being tested. If the knee had been
flexed (particularly at ninety degrees), soleus would have been isolated as the main plantarflexor of the ankle. At the sound of the first beat of a metronome, the participant performed a heel raise to the point that the navicular touched the rod. The heel raise had to be maintained until the second beat of the metronome, and then the heel could be lowered down to the platform. These heel raises were performed at a rate of 46 beats per minute or 23 lifts per minute.

![Figure 3.5: a.) Starting position. b.) Heel raise position](image)

The participant continued performing the heel raises to the beat of the metronome until such a point that either of the following instances occurred: 1) the participant could no longer maintain the pace required by the beat of the metronome (23 lifts per minute), 2) the participant's navicular no longer made contact with the rod when performing the heel raises (i.e. the heel raise fell below 5 cm). If a participant experienced discomfort, he/she received verbal encouragement to continue, but if he/she was in pain, he/she was instructed to stop performing the heel raises. This was explained prior to the commencement of testing. The number of repetitions performed was then recorded by the researcher (Appendix J).
3.3.2 Subjective data

3.3.2.1 Physical Activity Questionnaire

Subjective data was obtained in the form of a physical activity questionnaire. This questionnaire was developed and structured by the researcher and statistician, to obtain subjective data specific to this study. This questionnaire was completed by all participants before measurements were taken, on the first, fourth and seventh consultations. This questionnaire was used to determine the participants’ activity levels pre-testing and how their legs were feeling, pre-testing on the day of testing, i.e. were they feeling normal, weak or sore, before the testing took place.

3.4 ETHICAL CONSIDERATIONS

This study was approved by the Faculty of Health Sciences, Research Ethics Committee on 5 February 2015, UJ Ethics Clearance Number: REC-01-136-2015 (Appendix K). The information form (Appendix B) and consent form (Appendix C) outlined the researchers details, the purpose of the study and the benefits of partaking in the study, participant assessment and the treatment procedure. Any risks, benefits and discomforts related to the treatment involved were also explained as well as that the participant’s safety will be ensured (prevention of harm). The information form and consent form also explained that the participant's privacy would be protected by ensuring their anonymity (all the participants' information was converted into data and therefore cannot be traced back to the participant) and standard researcher/participant confidentiality was kept throughout the study. The participants were also informed that their participation is on a voluntary basis and that they were free to withdraw from the study at any time, without penalty. Additional questions from the participants were answered by the researcher and the researcher's contact details were made available.

Regarding this particular study, the following risks and discomforts that could occur were: slight pain or stiffness in the tibiotalar joint or ankle region. This is a normal response that may occur after Chiropractic manipulative therapy. Slight calf pain or stiffness may also
occur on the tested side as a result of the testing and the induced fatigue of the muscle. This however, is also a normal response and should settle within a day or two.

The participants were required to sign the consent form to show that they understood what was expected of them in this study. The results of the study were made available on request. Participants in the non-treatment group were offered the treatment given to the treatment group once the clinical trials had been concluded, free of charge.

3.5 DATA ANALYSIS

The data was analysed by Lebo Tawane, a statistician working at STATKON (located at the University of Johannesburg Kingsway Campus). STATKON used the objective readings from the Haberometer, and the subjective data from the demographic and physical activity questionnaires for the analysis. Frequencies and descriptive statistics of the whole sample were used to interpret the data, by performing an Exploratory Data Analysis (EDA). Cross tabulations were used to compare groups and the categorical variables within these groups.

The Shapiro Wilk test was used to test for normality and determine which tests to use next, depending on whether the results were significant or not. This determined if the following tests would be parametric or non-parametric. After the Shapiro Wilk test, both the Independent samples t-test (parametric) and the Mann-Whitney test (non-parametric) were used. Intragroup analysis was analysed using the Friedman test. If differences were noticed over time, the Wilcoxon signed ranks test was performed to determine where they occurred. The multiple response questions from the questionnaires was analysed using frequencies and split by groups so that the researcher was able to make her own conclusions for comment.

The following chapter will provide, in detail, the results of the study.
CHAPTER FOUR – DATA ANALYSIS

4.1 INTRODUCTION

This chapter presents the clinical data obtained during the course of the clinical trials conducted for this study. The study consisted of a total of thirty participants that were split into two sample groups. Thus each group contained fifteen participants. Group One, the treatment group, received chiropractic manipulative therapy to the tibiotalar joint. Group Two, the control group, received no intervention, but had a rest period.

Firstly, an Exploratory Data Analysis (EDA) was performed to determine normality and equal variances. The normality and equal variances were tested using the Shapiro-Wilk test, which determined whether parametric or non-parametric testing was to follow. Some data showed normality and equal variances, and some did not. Therefore both parametric and non-parametric testing was utilized. Intergroup analysis was performed using the Independent Samples T-test. This involved using Levene’s Test for equality of variances and the t-test for equality of means. The Mann-Whitney U test was used for the non-parametric results. Intragroup analysis was then conducted using the Friedman Test. If there was statistical significance, the Wilcoxon Signed-Ranks Test was performed. The data that the analysis was performed on included the objective data from the amount of heel raises the participant performed. The subjective data obtained from the demographic questionnaire and the physical activity questionnaire was analysed using frequencies to enable the researcher to make her own conclusions for comment.

4.2 DESCRIPTIVE STATISTICS

The following is a description of the sample size, age and gender, aiming to provide a quantifiable description of the sample. Please see Tables 4.1 - 4.3 below:
4.2.1 Sample Size

Table 4.1: The distribution of the sample size

<table>
<thead>
<tr>
<th>Sample size</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15</td>
<td>15</td>
<td>30</td>
</tr>
</tbody>
</table>

The total sample size was thirty participants, with fifteen participants in each group. It should be noted that the sample size was small; therefore generalisations could not be made for the population as a whole.

4.2.2 Sample Age

Table 4.2: Age distribution within the sample

<table>
<thead>
<tr>
<th>Age distribution</th>
<th>Sample (30 participants)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>21.77</td>
</tr>
<tr>
<td>Median</td>
<td>21.50</td>
</tr>
<tr>
<td>Minimum</td>
<td>18</td>
</tr>
<tr>
<td>Maximum</td>
<td>25</td>
</tr>
</tbody>
</table>

The ages of the participants ranged between 18 and 25 years, with an average age of 21 years. The ages of the participants were therefore appropriate for the study and were comparable between the two groups.
4.2.3 Gender

Table 4.3: Gender distribution within the sample

<table>
<thead>
<tr>
<th>Gender distribution</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>8</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>Female</td>
<td>7</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>15</td>
<td>30</td>
</tr>
</tbody>
</table>

In both Group One and Group Two, eight participants were male and seven participants were female. Therefore, of the total thirty participants in this study, sixteen were male and fourteen were female. The two groups were equally divided and were therefore comparable.

4.3 ANALYSIS OF SUBJECTIVE DATA

4.3.1 Perceived Fitness Level

Figure 4.1: Bar graph representing perceived fitness level of participants

In Group One and Two, none of the participants considered themselves to be "not fit at all". In Group One, five participants said they were "unfit", six said they were of "normal fitness", "relatively fit"...
seven said they were "relatively fit" and five said they were "fit". In Group Two, two participants said they were "unfit", five said they were of "normal fitness", six said they were "relatively fit" and two said they were "fit". The total for the sample as a whole was 0 % for a perceived fitness level of "not fit at all", 23.3 % "unfit", 36.7 % "normal fitness", 23.3 % "relatively fit" and 16.7 % "fit". Although Group One contained more participants that said they were "unfit", and also more that said they were "fit", most participants fell into the average categories of "normal fitness" or "relatively fit", and the groups were therefore comparable.

4.4 ANALYSIS OF OBJECTIVE DATA

4.4.1 Haberometer

Table 4.4: Mean values for heel raises over trial period of three weeks

<table>
<thead>
<tr>
<th>Heel raises</th>
<th>Group 1</th>
<th>Group 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>15</td>
<td>15</td>
</tr>
</tbody>
</table>

Visit 1

<table>
<thead>
<tr>
<th></th>
<th>Pre-1</th>
<th>Post-1</th>
<th>Pre-1</th>
<th>Post-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td>12</td>
<td>10</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>Max</td>
<td>30</td>
<td>29</td>
<td>40</td>
<td>30</td>
</tr>
<tr>
<td>Mean</td>
<td>19.53</td>
<td>17.67</td>
<td>19.87</td>
<td>19.07</td>
</tr>
</tbody>
</table>

Visit 4

<table>
<thead>
<tr>
<th></th>
<th>Pre-4</th>
<th>Post-4</th>
<th>Pre-4</th>
<th>Post-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td>14</td>
<td>9</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>Max</td>
<td>29</td>
<td>30</td>
<td>33</td>
<td>26</td>
</tr>
<tr>
<td>Mean</td>
<td>19.73</td>
<td>18.93</td>
<td>18.87</td>
<td>18.47</td>
</tr>
</tbody>
</table>
Table 4.4 shows the readings taken from the heel raises performed by the participants throughout the trial period. The minimum value for heel raises performed over the three week period in Group One was nine, which occurred after intervention at the fourth visit (Post-4). The minimum value for heel raises performed in Group Two was eleven, which occurred before (Pre-1) and after (Post-1) the rest period at the first visit. The maximum value for heel raises performed over the three week period in Group One was thirty-six, which occurred at the final reading (Pre-7). The maximum value for heel raises performed over the three week period in Group Two was forty, which occurred before the rest period at the first visit (Pre-1).

The mean value for the amount of heel raises performed by Group One was 19.53 at the first reading (Pre-1), and 24.33 at the final reading (Pre-7). The mean value for the amount of heel raises performed by Group Two was 19.87 at the first reading (Pre-1), and 22.93 at the final reading (Pre-7).
Intergroup analysis

The Shapiro-Wilk test was used to determine the normality of the groups. This resulted in the readings at Pre-1 and at Pre-4 being not normal and therefore non-parametric testing was done in the form of the Mann-Whitney Test. The readings at Post-1, Post-4 and Pre-7 were normal, and therefore parametric testing was done, using the Independent Samples t-test.

For all tests in this study, the p-value was set to 0.05, which represents the level of statistical significance of the results. If the p-value is less than or equal to 0.05 (p ≤ 0.05), then the result is statistically significant. If the p-value is greater than 0.05 (p > 0.05), then the result is statistically insignificant. Statistical significance indicates that the given result is unlikely to have occurred simply by chance.

Table 4.5: Table showing the results for the Mann-Whitney Test

<table>
<thead>
<tr>
<th>Mann-Whitney Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-1</td>
</tr>
<tr>
<td>Pre-4</td>
</tr>
</tbody>
</table>
Table 4.5 shows the statistical p-values found using the Mann-Whitney test. The p-value for Pre-1 was 0.97 and Pre-4 was 0.57. These values are greater than 0.05, therefore no statistical significance was noted between the two groups over these readings.

Table 4.6: Table showing the results for the Independent Samples Test

<table>
<thead>
<tr>
<th>Consultation</th>
<th>Levene's Test for Equality of Means</th>
<th>T-test for Equality of Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-1</td>
<td>0.74</td>
<td>0.52</td>
</tr>
<tr>
<td>Post-4</td>
<td>0.12</td>
<td>0.78</td>
</tr>
<tr>
<td>Pre-7</td>
<td>0.82</td>
<td>0.52</td>
</tr>
</tbody>
</table>

Table 4.6 shows the statistical p-values found using the Independent Samples Tests. The p-value for Post-1 was 0.74 (Levene's test) and 0.52 (T-test). The p-values for Post-4 was 0.12 (Levene's) and 0.78 (T-test). The p-values for reading Pre-7 was 0.82 (Levene's) and 0.52 (T-test). These values are greater than 0.05, therefore no statistical significance was noted between the two groups over these readings.
Intragroup analysis

With reference to the intragroup analysis, the following Figure 4.3 may be used:

**Figure 4.3:** Bar graph representing heel raises performed by the fifteen participants in Group One (a) and Group Two (b) that were analysed using the Friedman Test.
The data recorded by the researcher with regards to the amount of heel raises performed (Table 4.4 and Figure 4.3) were analysed using the Friedman test. This is a non-parametric test which compares the first, fourth and final consultations and readings within the two separate groups.

Table 4.7: Results of Friedman test comparing Pre-1, Pre-4 and Pre-7 (final)

<table>
<thead>
<tr>
<th>Friedman Test</th>
<th>Group 1</th>
<th>Group 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comparing Pre-1, Pre-4 and Pre-7</td>
<td>0.00</td>
<td>0.15</td>
</tr>
</tbody>
</table>

The Friedman test was used to determine if there was any improvement between the Pre-1, Pre-4 and Pre-7 readings in both groups. Group One had a p-value of 0.00, which is less than 0.05, and is therefore statistically significant. Group Two had a p-value of 0.15, which is more than 0.05, and is thus statistically insignificant.

The Wilcoxin Signed-Ranks Test was then performed to investigate where the changes occurred within the groups.

Table 4.8: Analysis of results using Wilcoxin Signed-Rank Test

<table>
<thead>
<tr>
<th>Wilcoxin Signed-Ranks Test</th>
<th>Group 1 p-value</th>
<th>Group 2 p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consultations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-1 – Pre-4</td>
<td>0.84</td>
<td>0.51</td>
</tr>
<tr>
<td>Pre-1 – Pre-7</td>
<td>0.00</td>
<td>0.21</td>
</tr>
<tr>
<td>Pre-4 – Pre-7</td>
<td>0.00</td>
<td>0.01</td>
</tr>
</tbody>
</table>

The Wilcoxin Signed-Ranks Test was performed to determine at which point any statistically significant improvement occurred. Table 4.8 represents the resulting p-values. Between Pre-1 (before intervention in Group One and the rest period in Group Two) and
Pre-4, the p-value for Group One was 0.84 and 0.51 for Group Two. Between Pre-1 and Pre-7, the p-value was 0.00 for Group One and 0.21 for Group Two. Between Pre-4 and Pre-7, the p-value was 0.00 for Group One and 0.01 for Group Two.

Neither groups showed a significant change between the first and second readings (Pre-1 - Pre-4). Group One showed a significant change with a p-value of 0.00 between the first and final readings. Both groups showed a significant change between the second and final sets of readings (Pre-4 – Pre-7).

Table 4.9: Results of Friedman test comparing Post 1, Post 4 and Pre 7 (final)

<table>
<thead>
<tr>
<th>Friedman Test</th>
<th>Group 1</th>
<th>Group 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comparing Post-1, Post-4 and Pre-7</td>
<td>0.00</td>
<td>0.18</td>
</tr>
</tbody>
</table>

The Friedman test was used to determine if there was any improvement between the Post-1, Post-4 and Pre-7 in both groups. Group One had a p-value of 0.00, which is less than 0.05, and is therefore statistically significant. Group Two had a p-value of 0.18, which is more than 0.05, and is thus statistically insignificant.

The Wilcoxin Signed-Ranks Test was then performed to investigate where the changes occurred within the groups.
The Wilcoxin Signed-Ranks Test was performed to determine at which point any statistically significant improvement occurred. Table 4.10 represents the resulting p-values. Between Post-1 (after intervention in Group One and the rest period in Group Two) and Post-4, the p-value for Group One was 0.22 and 0.73 for Group Two. Between Post-1 and the Pre-7, the p-value was 0.00 for Group One and 0.13 for Group Two. Between Post-4 and Pre-7, the p-value was 0.00 for Group One and 0.01 for Group Two.

Neither groups showed a significant change between the first and second readings (Post-1 – Post-4). Group One showed a significant change with a p-value of 0.00 between the first and final readings (Pre-1-Pre-7). Both groups showed a significant change between the second and final sets of readings (Post-4 – Pre-7).

<table>
<thead>
<tr>
<th>Consultations</th>
<th>Group 1 p-value</th>
<th>Group 2 p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-1 – Post-4</td>
<td>0.22</td>
<td>0.73</td>
</tr>
<tr>
<td>Post-1 – Pre-7</td>
<td>0.00</td>
<td>0.13</td>
</tr>
<tr>
<td>Post-4 – Pre-7</td>
<td>0.00</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Table 4.10: Results of Wilcoxin Signed Ranks Test comparing Post-1, Post-4 and Pre-7 (final)
CHAPTER FIVE – DISCUSSION

5.1 INTRODUCTION

This chapter contains a discussion about the results that were identified in Chapter Four. The focus will be on the results with statistical and clinical significance. This discussion will involve the descriptive, subjective and objective data. The subjective data included the perceived fitness levels; and the objective data included the Haberometer readings for heel raises performed. Possible explanations, results from other studies and clinical reasoning will be used as part of the discussion. This chapter aims to verify the clinical outcome and effects of this study.

5.2 DESCRIPTIVE STATISTICS

Thirty participants partook in this study. They were between the ages of eighteen and twenty-five, with the median age being 21.77. The gender split between the two groups showed eight male participants and seven female participants in each group (see Table 4.1), thus the two groups were comparable.

5.3 SUBJECTIVE DATA

5.3.1 Perceived fitness level

In the sample as a whole, 36.7 % of the participants considered themselves to be in the category of "normal fitness", making up the majority. 23.3 % said they were "unfit" and 23.3 % said they were "relatively fit". The greatest differences occurred in the "unfit" categories, whereby Group One found 33.3 % of the participants, and Group Two had 13.3 % of the participants in this category. Another significant difference in the groups showed 40 % of the participants in Group Two fall into the "relatively fit" category, and only 6.6 % in Group One fell into this category.
The perceived fitness level was considered in this study to explore whether the participants' fitness could influence their muscle fatigability. A participant that has a fitness level perceived as unfit may show an increase in results due to the ability of the muscles to become more conditioned. Whereas, a participant that has a fitness level perceived as relatively fit or fit, may not show as substantial an improvement as a result of having reached their threshold for muscle conditioning or hypertrophy.

5.4 OBJECTIVE DATA

5.4.1 Haberometer

The mean values for the number of heel raises performed for Group One started at 19.53 and ended at 24.33. The mean values for the number of heel raises performed for Group Two started at 19.87 and ended at 22.93 (Table 4.4).

Group One, who received chiropractic manipulative therapy, showed an increase in the number of heel raises performed of 24.58 %. Group Two, who received no intervention, showed an increase in the heel raises performed of 15.4 %, when comparing the very first (Pre-1) and final readings (Pre-7).

Intergroup analysis was performed using the Independent Samples T-test and the Mann-Whitney Test. These tests resulted in p-values that were greater than 0.05, and therefore were statistically insignificant.

The intragroup analysis was measured using the Friedman test. This was used to determine if there was any improvement between the Pre-1, Pre-4 and Pre-7 readings in both groups. Group One had a p-value of 0.00 and Group Two had a p-value of 0.15 (refer to Table 4.7). The Friedman test was also used to compare Post-1, Post-4 and Pre-7 readings in both groups. Group One had a p-value of 0.00 and Group Two had a p-value of 0.18 (Table 4.9). Therefore only the changes in Group One were found to be statistically significant.
The Wilcoxin Signed-Ranks Test was then performed to determine at which point any statistically significant improvement occurred (refer to Table 4.8). Between Pre-1 (before intervention in Group One and the rest period in Group Two) and Pre-4, the p-value for Group One was 0.84 and 0.51 for Group Two. Between Pre-1 and the Pre-7 readings, the p-value was 0.00 for Group One and 0.21 for Group Two. Between Pre-4 and the Pre-7, the p-value was 0.00 for Group One and 0.01 for Group Two. Neither groups showed a significant change between the first and second readings (Pre-1 - Pre-4). Group One showed a significant change with a p-value of 0.00 between the Pre-1 and Pre-7 readings. Both groups showed a significant change between the second and final sets of readings (Pre-4 – Pre-7).

The Wilcoxin Signed-Ranks Test was also performed to determine at which point any statistically significant improvement occurred between Post-1 (after intervention in Group One and the rest period in Group Two) and Post-4. The p-value for Group One was 0.22 and 0.73 for Group Two. Between Post-1 and Pre-7, the p-value was 0.00 for Group One and 0.13 for Group Two. Between Post-4 and Pre-7, the p-value was 0.00 for Group One and 0.01 for Group Two (Table 4.10). Just as was demonstrated for the "Pre-" readings, neither groups showed a significant change between the first and second readings (Post-1 - Post-4). Group One showed a significant change with a p-value of 0.00 between the first and final readings (Pre-1 – Pre 7). Both groups showed a significant change between the second and final sets of readings (Post-4 – Pre-7).

Therefore, the changes in the groups were consistent between readings pre- and post-intervention or rest. The endurance of both groups improved between the second and final readings, and Group One improved between the first and final readings. The researcher noticed that at the first consultation, the participants seemed nervous and unsure about the Haberometer which was used for testing. This could have affected the results at the first readings as to why there was not a statistically significant improvement at first. After the first consultation they were a lot more comfortable and seemed more relaxed and confident about the trial procedure.
5.5 DISCUSSION

The results of the Haberometer readings proved that there was an improvement in both groups over time, although Group One showed more of an improvement in the long term, percentage wise. Thus between visit one and visit seven, Group One showed a more substantial statistical and clinical improvement. This improvement may be attributed to a number of theories.

A contributing factor to the results could be the reflexogenic effects of chiropractic manipulative therapy. These effects include a change in muscle tone, excitability and ability to contract to the muscles maximum capacity. Chiropractic manipulative therapy also increases work rate and encourages the firing of muscle spindles (Gatterman, 2005). Although improvement was noted over an extended period of time, the immediate effects of chiropractic manipulation did not prove to be statistically significant. In fact, in most cases, the numbers of heel raises the participants were able to perform decreased post-rest or intervention, even more so in Group One than in Group Two.

Group Two did contain more participants that perceived themselves as "relatively fit", and they could therefore have a better understanding of pushing through discomfort to maximise the endurance level of the muscle. This could explain why some of the participants were able to perform more heel raises after the rest period. On this same point, the number of exercise sessions that the participants had and the types of exercise they did could also influence the endurance of their muscles. A lot of the participants in Group Two were dance majors and therefore their general fitness levels were very good, and their lower limbs were very well conditioned as they were used to training for many hours per week.

Many researchers have studied the contribution of type I muscle fibres in athletes compared to non-athletes. These studies showed that there is not a significant difference in the proportion of type I fibres when comparing these groups (Shoepe, Stelzer, Garner and Widrick, 2003; Kesidis, Metaxas, Vrabas, Stefanidis, Vamvakoudis, Christoulas and Mandroukas, 2008). As we know that type I fibres are more resistant to fatigue, one can
deduce that the participants that were "relatively fit" or "fit", did not necessarily begin the trials with an advantage when regarding the types of fibres their muscles contained.

It has been stated that in untrained people or non-athletes, the motor neuron pool may not be completely activated (Baechle and Earle, 2008). Although Group One had more participants that had a perceived fitness level of "unfit", the differences between the minimum and maximum values of heel raises they were able to perform were not far apart from those values in Group Two. Therefore, with regards to the above theory by Beachle and Earle (2008) that the motor neuron pool may not be completely activated, the additional intervention of the chiropractic manipulation in Group One may have improved the activation of the motor neuron pool and therefore enabled the participants to perform the heel raises despite their decreased fitness levels. Bogdanis (2012) stated that if the muscles are not able to activate completely, they will not be able to contribute their full power output. This point highlights the fact that without the proper neural stimulation, the rate of muscle fatigue will be affected. Gill, Teyhen and Lee (2007), described the effect that chiropractic manipulation has on neural pathways as a possible explanation for the improved muscle performance, function and contraction that results post-manipulation. When a joint is manipulated, the Type I and II joint mechanoreceptors, Type III ligament mechanoreceptors or the muscle spindles undergo a stretch reflex. The stretch reflex leads to an inhibition, depression or attenuation of the alpha motor neurons through the central nervous system. This causes muscle relaxation and a break in the cycle of "spasm-ischaemia-spasm" (Gill et al., 2007).

The increase in the amount of heel raises that both groups were able to perform from the first to the last visit may also be attributed to conditioning of the triceps surae, although the standard time period for testing improvements in muscle conditioning is usually six to twelve weeks (Fahey, Insel and Roth, 2007) and this trial only took place over three weeks. The researcher also felt that the participants became more comfortable with the trial protocol and equipment and so they were more relaxed and able to perform better after their initial visit. In a study by Niazi et al. (2015), they found that when comparing the treatment group to the control group, the treatment group was found to display more confidence when it came to testing. This suggests that new neuronal pathways could have
been opened up and this would then allow the participant to apply more force when testing took place. Another reason for the improvement in both groups is the psychological perspective. It was noted that the participants were more motivated at their last visit to perform as many heel raises as possible, as they were happy to be completing the study and wanted to really display their personal best.

The long term effects of the chiropractic manipulative therapy could have included the correction of any biomechanical imbalances that the participants presented with. A few of the participants in Group One that had never had chiropractic manipulative therapy before mentioned that post-manipulative therapy, their ankles felt "different", "good" and more mobile than before they were manipulated. Therefore pre-existing joint dysfunction could have been corrected by the chiropractic manipulative therapy and resulted in an increase in the quality of motion of the joint (Fryer et al., 2002) and breaking up of adhesions, allowing for a more free range of motion (Gatterman, 2005). This increased range of motion could possibly have contributed to the ease in which the participants were able to perform heel raises. The researcher noted during the trial that testing the range of motion at the ankle would have made for an interesting observation when comparing the treatment and control groups.

Muscular strength and endurance is of importance, as improvements in these areas have shown to guard the body against injury, boost physical performance, and improve composition of the body and self-image. Other effects of improving muscular strength and endurance include a reduction of the risk of chronic disease, improved bone and muscle aging and a decreased risk of premature death (Fahey, Insel and Roth, 2007).
CHAPTER SIX – CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

This study was performed to determine the effectiveness of chiropractic manipulative therapy of the tibiotalar joint on endurance of the triceps surae muscle, using a treatment group and a control group.

Intergroup and intragroup analyses were performed, and resulted in statistically significant improvements for both groups between the second and final readings. Only Group One showed a statistically significant difference in the amount of heel raises performed between the first and final readings. The aim of the study therefore was proven, in that there was a difference noted in the treatment group, however the other variables have to be considered because the control group also showed an improvement at one stage.

The subjective data played a part in that it showed the distribution of fitness within the two groups. Group One had fewer participants that were fit, and as a group, their average hours exercised per week were less than that of Group Two.

The analysed data from this study showed that there was an improvement in both groups, however in the group that received chiropractic manipulative therapy there was a greater improvement, particularly when comparing the readings from the first to the final visit. This study therefore provides supporting evidence that chiropractic manipulative therapy may be beneficial to improving the endurance of the triceps surae, and could possibly be extrapolated to other joints and the treatment of the joints in relation to muscle function.

6.2 RECOMMENDATIONS

This study and its results could be improved and validated by the following recommendations:
- The sample size could increase to include a larger group of participants. This would result in a more accurate representation of the general population and would also be more statistically reliable.

- Other age groups could be investigated. This would also improve the accuracy of the results as a representation of the general population.

- A group of participants that all fall into the same fitness group could be used to decrease the variables.

- Range of motion measurements could have been taken at the ankle to determine whether there was an improvement in the groups.

- The entire foot and ankle could have been adjusted according to the restrictions found as a more well-rounded approach to the treatment group and the biomechanics involved in a heel raise.

- The duration of the study could be increased so as to investigate further long term effects, and to possibly allow for a follow-up consultation with the participants to see if the results remained for a sustained period of time.

- The participants could have been given a longer time period to become more familiar with the Haberometer before the initial testing took place, so as to ease their nerves.

- The participant could be used as their own control. Some interesting findings might come out of testing the participants' own dominant and non-dominant leg, and comparing the difference in results.

- Participants that have had a previous injury could be investigated to determine the effects of chiropractic manipulation on endurance when the lower limb has been compromised.

- There was some concern about "verbal encouragement" being given to the participants. As this is possibly a variable that is impossible to quantify, another study could be done without this.
REFERENCES


APPENDIX A      ADVERTISEMENT

Are you between 18-25 years old?
Are you healthy and free of lower limb injury in at least one leg for the last 12 months?
Are you able to perform a calf raise?

You are invited to come and participate in a study aimed at testing the **endurance**
of your calf muscles

The clinical trials will take place at the University of Johannesburg’s Chiropractic Day Clinic.

If you are interested, come and visit me at the University of Johannesburg Chiropractic Day Clinic on Doornfontein Campus: Gate 7, Sherwell Road, Doornfontein

For further information please contact Caitlyn Bauer at 082 610 5950
INFORMATION FORM

Dear Participant,

My name is Caitlyn Baüer, and I am doing my Master’s Degree at the University of Johannesburg. I would like to invite you to consider participating in my research study entitled: The effect of chiropractic manipulative therapy of the tibiotalar joint on endurance of the triceps surae muscle.

Before agreeing to participate, it is important that you read and understand the following explanation of the purpose of the study, the study procedures, benefits, risks, discomforts, and precautions as well as the alternative procedures that are available to you, and your right to withdraw from the study at any time.

Purpose of the study
The purpose of this study is to determine whether chiropractic manipulative therapy of the ankle joint has an effect on improving calf muscle endurance. The type of muscular endurance tested in this study is the ability of a muscle group (triceps surae or calf muscles) to perform repeated contractions over a period of time until the muscle can no longer perform adequately. This knowledge will add to the current knowledge and understanding of the benefits of chiropractic manipulative therapy.
Procedure

Upon deciding that you would like to partake in this study, a full assessment will be performed in the form of a full physical examination as well as the relevant regional examinations. The inclusion and exclusion criteria will also be explained in detail. This is done to ensure that you comply with the specifications needed and that it is safe for you to take part in the study.

Following the screening process, you will be asked to draw a piece of paper out of a hat. The piece of paper will have a number on it, which will indicate which group you are allocated to. You will thus be allocated to one of 2 groups-each group will have 15 participants. This random allocation ensures that the information obtained from this study is as accurate as possible. Group 1 will receive Chiropractic manipulative therapy to the tibiotalar joint. Group 2 will not receive any intervention, but will have a rest period between pre- and post-testing on the Haberometer. Group 2 will have the option of receiving free Chiropractic treatment at the University of Johannesburg Chiropractic Day Clinic, once the study is completed. This will only be done once the information and consent forms have been read and signed.

30 participants will participate in this study and it will only be performed in Johannesburg. The initial screening, as well as the testing and treatments will take place at the University of Johannesburg Chiropractic Day Clinic. The total amount of time required for your participation in this study is as follows: For Group 1: 7 visits including 6 treatments, over a 3 week period. At the final visit no treatment will take place, only measurements. Group 2 will have 3 visits of a 3 week period, where measurements will take place. The initial consultation with screening will take approximately 45 minutes and the testing and intervention or rest period will take approximately 20 minutes.

Chiropractic manipulative therapy involves manipulation of a joint as part of a routine chiropractic treatment and may present a slight risk of discomfort. It is possible that you may experience stiffness around the treatment area or slight discomfort post treatment. You may experience a popping sound during manipulation-this is completely normal. This
sound is as a result of a normal physiological response in which gas in the fluid around the joint being treated is dissolved and forms a bubble/s.

As your participation in this study is entirely voluntary, you can decline to participate or stop at any time, without stating any reason. Your withdrawal will not affect your access to other medical care. If you decide not to take part in this study you may still receive the best current care, from your usual practitioner, this may or may not include this study treatment.

If it is deemed to be in your best interest, I retain the right to withdraw you from the study. Injuries that result in damage to bone, ligaments or other soft tissue could be contraindicated to this type of treatment. If you get diagnosed by another medical practitioner during this trial for any medical condition that was not stated in your original history please notify me.

If at any time between your visits, you feel that any of your symptoms are causing you any problems, or you have any questions regarding the study, please contact me on 082 610 5950.

If you want any information regarding your rights as a research participant, or complaints regarding this research study, you may contact Prof. Marie Poggenpoel of the University of Johannesburg’s Academic Ethics Committee, which is an independent committee established to protect the rights of research participants. Tel: (011) 559 2860.

This study protocol has been submitted to the University of Johannesburg’s Ethics Committee. The committee has granted written approval. The structure of the study is in accordance with the Declaration of Helsinki, which deals with recommendations guiding doctors in biomedical research which involves human participants.

**Confidentiality**

The information obtained during this study will be kept strictly confidential. The recorded data that is statistically analysed by STATKON will not include any information that will
identify you as a participant in this study. The same can be said for any data that may be reported in any scientific journals.

Any information regarding your test results or state if health resulting from participation in this study will be kept strictly confidential. If there are any significant findings regarding your health or ability to continue as a participant in the study, you will be informed and this information will not be disclosed to a third party unless your written consent is given. The only exception that exists is in the case of any communicable diseases. It is a legal duty that I inform the Department of Health should any of these diseases exist. You will, however be informed of my intent to disclose this information.

Thank you for taking your time to read this form and for considering participation in this study. Should you have any queries or concerns regarding the study, please contact the following persons:

Researcher: Caitlyn Baüer
bite@mweb.co.za

Supervisor: Dr Irmarie Landman
dirkiel@uj.ac.za

UJ Ethics Clearance Number: REC-01-136-2015
CONSENT FORM

I have been fully informed as to the procedures to be followed and have been given a description of the discomforts, risks and benefits expected from the treatment. In signing this consent form, I agree to this form of treatment and understand my rights and that I am free to withdraw my consent and participation at any time without any reason. I understand that if I have any questions during the study, they will be answered.

Date ___________________________ Researcher ___________________________

Date ___________________________ Participant ___________________________
APPENDIX D  CASE HISTORY

UNIVERSITY OF JOHANNESBURG
CHIROPRACTIC DAY CLINIC

CASE HISTORY

Date: ________________

Patient: ____________________________  File No: __________

Age: _____  Sex: _______  Occupation: ____________

Student: ____________________________  Signature: __________

Complies with Inclusion criteria of the research:

Clinician: __________________________
Signature: __________________________

Examination:
Previous:  UJ  Current:  UJ
Other    Other

X-ray Studies:
Previous:  UJ  Current:  UJ
Other    Other

Clinical Path. Lab:
Previous:  UJ  Current:  UJ
Other    Other

Case status:
PTT: Conditional:  Signed off:  Final sign out:

Recommendations:
Students 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 and 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
Neurologic
Haematologic
Endocrine
Psychiatric
Underline abnormal findings in RED.

Date: ________________

Patient: ________________  File No: ________________

Clinician: ________________  Signature: ________________

Student: ________________  Signature: ________________

Height: _______  Weight: _______  Temp: _______

Rates: Heart: _______  Pulse: _______  Respiration: _______

Blood pressure:  

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<th>Arms</th>
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<td>Legs</td>
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<td>R</td>
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General Appearance:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
STANDING EXAMINATION

1. Minor's sign
2. Skin changes
3. Posture: Erect
   Adam's
4. Ranges of motion (Thoracolumbar Spine)
   T/L spine:  
   Flexion: 90° (fingers to floor)
   Extension: 50°
   R. lat. flex: 30° (fingers down leg)
   L. lat. flex: 30° (fingers down leg)
   Rot. to R: 35°
   Rot. to L: 35°

/ = pain-free limitation  // = painful limitation

5. Romberg's sign
6. Pronator drift
7. Trendelenburg's sign
8. Gait:  
   - rhythm
   - balance
   - pendulousness
   - on toes
   - on heels
   - tandem
9. Half squat
10. Scapular winging
11. Muscle tone
12. Spasticity/Rigidity
13. Shoulder: skin symmetry
    ROM  
    - glenohumeral
    - scapulo-thoracic
    - acromioclavicular
    - elbow
    - wrist
14. Chest measurement:
   - inspiration
   - expiration

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15. Visual acuity

16. Breast examination:
   Inspection:
   - skin
   - size
   - contour
   - nipples
   - arms overhead
   - hands against hips
   - leaning forward

   Palpation
   - axillary lymph nodes
   - breast incl. tail

**SEATED EXAMINATION**

1. Spinal posture
2. Head
   - hair
   - scalp
   - skull
   - face
   - skin
3. Eyes:
   Observation
   - conjunctiva
   - sclera
   - eyebrows
   - eyelids
   - lacrimal glands
   - nasolacrimal duct
   - position and alignment
   - corneas and lenses

- corneal reflex
- ocular movement

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- visual fields
- accommodation
- Ophthalmoscopic
- Examination
  - iris
  - pupils
  - red reflex
  - optic disc
  - vessels
  - general background
- macula
- vitreous
- lens

4. Ears:
   • Inspection
     - auricle
     - ear canal
     - drum
   • auditory acuity
   • Weber test
   • Rinne test

5. Nose:
   • External
   • Internal
     - septum
     - turbinates
     - olfaction

6. Sinuses (frontal & maxillary):
   - tenderness
   - transillumination

7. Mouth and pharynx:
   • lips
   • buccal mucosa
   • gums and teeth
   • roof
   • tongue
     - inspection
     - movement
     - taste
     - palpation
   • pharynx
     - CN X
     - inspection

9. Neck
   • posture
   • size
   • swelling
   • scars
   • discolouration
   • hair line
Ranges of motion (cervical spine)

The following are normal ranges of motion

- Forward flexion = 45° chin to larynx or sternum
- Extension = 55° forehead parallel to ground
- L/R Rotation = 70°
- L/R Lat Flexion = 40°

Diagram:

- L. Rot
- Flex.
- R. Rot
- L. Lat Flex
- R. Lat Flex
- Ext.

- lymph nodes
- trachea
- thyroid
- carotid arteries (thrills, bruit)
- Cranial Nerves:
  - CN V
  - CN VII
  - CN VIII (nystagmus)
  - CN IX
  - CN XI
  - CN X11
### 9. NEUROLOGICAL EXAMINATION (CERVICAL SPINE)

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<thead>
<tr>
<th>DERMATOMES</th>
<th>Left</th>
<th>Right</th>
<th>MYOTOMES</th>
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<th>REFLEXES</th>
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<tbody>
<tr>
<td>C2</td>
<td></td>
<td></td>
<td>Neck Flexion</td>
<td>C1/2</td>
<td></td>
<td>Biceps</td>
<td>C5</td>
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<td>C3</td>
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<td></td>
<td>Lat. Neck Flexion</td>
<td>C3</td>
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<td>Brachio - radialis</td>
<td>C6</td>
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<td>C4</td>
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<td></td>
<td>Shoulder Elevation</td>
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<td>Triceps</td>
<td>C7</td>
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<td>C5</td>
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<td>Shoulder Abduction</td>
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<td>C6</td>
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<td>Elbow Flexion</td>
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<td>C7</td>
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<td>Elbow Extension</td>
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<td>C8</td>
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<td></td>
<td>Elbow Flexion at 90°</td>
<td>C6</td>
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9. Peripheral vasculature:
   - **Inspection**
     - skin
     - nail beds
     - pigmentation
     - hair loss
   - **Palpation**
     - pulses:
       - femoral
       - popliteal
       - radial
       - post. Tibial
       - brachial
     - lymph nodes
     - epitrochlear
     - femoral (horizontal & vertical)
     - temperature (feet and legs)
   - **Manual compression test**
• Retrograde filling (Tredelenburg) test
• Arterial insufficiency test

10. Musculoskeletal:
   (i) ROM
   • hip

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<td>Actual</td>
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• knee
• ankle

(ii) leg length

• Co-ordination
  - point to point
  - dysdiachokinesia

10. TMJ
• Inspection
  - ROM
  - deviation
• Palpation
  - crepitus
  - tenderness

11. Thorax
• Inspection
  - skin
  - shape
  - respiratory distress
  - rhythm (respiratory)
  - depth (respiratory)
  - effort (respiratory)
  - intercostals/supraclavicular retraction
• Palpation
  - tenderness
  - masses
  - respiratory expansion
  - tactile fremitus

• Percussion
  - lungs (posterior)
  - diaphragmatic excursion
  - kidney punch

• Auscultation
  (i) breath sounds
  - vesicular
  - bronchial
  (ii) adventitious sounds
  - crackles (rales)
  - wheezes (rhonchi)
  - rubs
  (iii) voice sounds
  - broncophony
  - whispered pectoriloquy
  - egophony

• Cardiovascular
  - auscultation (aortic murmurs)
  - Allen's test

SUPINE EXAMINATION

1. JVP
2. PMI
3. Auscultation heart
   (L. lat. Recumbent)
4. respiratory excursion
5. percussion chest
   (anterior)
6. breast palpation
7. Abdominal Examination
   • Inspection
     - skin
     - umbilicus
     - contour
     - peristalsis
     - pulsations
     - hernias (umbilical/incisional)

• Auscultation
  - bowel sound
  - bruit

• Percussion
  - general
  - liver
  - spleen

• Palpation
  - superficial reflexes
  - cough
- light
- rebound tenderness
- deep
- liver
- spleen
- kidneys
- aorta
- intra-/retro-abdominal wall mass
- shifting dullness
- fluid wave

- Acute abdomen
  - where pain began and now
  - cough
  - tenderness
  - guarding/rigidity
  - rebound tenderness
  - roving's sign
  - psoas sign
  - obturator sign
  - cutaneous hyperesthesia
  - rectal exam
  - Murphy's sign

**MENTAL STATUS**

(i) Appearance and behaviour
- level of consciousness
- posture and motor behaviour
- dress, grooming, personal hygiene
- facial expression
- affect

(ii) Speed and language
- quantity
- rate
- volume
- fluency
- aphasia (pm)

(iii) Mood

(v) Memory and attention
- orientation (time, place, person)
- remote memory
- recent memory
- new learning ability

(vi) Higher cognitive functions
- information and vocabulary
- (general and specialised knowledge)
- abstract thinking
## NEUROLOGICAL EXAMINATION (LUMBAR SPINE)

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FOOT AND ANKLE REGIONAL FORM

FOOT AND ANKLE REGIONAL EXAMINATION

Patient: ___________________________ File No.: ___________ Date: ___________
Student: ___________________________ Signature: ________________
Clinician: ________________________ Signature: ________________

OBSERVATION

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

Swelling__________________________
Heloma dura______________________
Skin______________________________
Nails______________________________
Shoes______________________________

ACTIVE MOVEMENTS

Weight bearing: __________________ Non Weight bearing: __________________
Plantar flexion_________ 50°
Dorsiflexion_________ 20°
Supination__________________
Pronation__________________
Toe Dorsiflexion_________ 40° (mtp)
Toe plantar flexion_________ 40° (mtp)
Big toe dorsiflexion (mtp) (65-70°) ______
Big toe plantar flexion (mtp) 45° ______
Toe abduction + adduction ______
5º first ray dorsiflexion ______
5º first ray plantar flexion ______

RESISTED ISOMETRIC MOVEMENTS

Knee flexion______________________
Plantar flexion__________________
Dorsiflexion____________________
Supination (inversion)___________
Pronation (eversion)_____________
Toe extension (dorsiflexion)____
Toe flexion (plantar flexion)____

PASSIVE MOVEMENT MOTION PALPATION

(Passive ROM quality, ROM overpressure, joint play)
Ankle joint: Plantarflexion____________________ Dorsiflexion __________________________
Talocrural: Long axis distraction __________________________ Valgus
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 __________________________
Metatarsal glide: __________________________
Metatarsophalangeal dorsiflexion (with associated plantar flexion of each toe)

Interphalangeal joints: long axis distraction ________________ A-P glide ________________ lat and med glide ________________ rotation __________________________

SPECIAL TESTS

Anterior drawer test: __________________________
Talar tilt __________________________
Thompson test __________________________
Homan sign __________________________
Tinel's sign __________________________
Subtalar neutral position __________________________
Balance/proprorception __________________________
Test for rigid/ flexible flatfoot __________________________

ALIGNMENT

Heel to ground __________________________
Feiss line __________________________
Tibia] torsion __________________________
Heel to leg/ subtalar neutral __________________________
Forefoot to heel (subtalar & Midtarsal neutral) __________________________
First ray alignment __________________________
Digital deformities __________________________
Digital deformity Flexible __________________________

PALPATION

Anteriorly
Medial malleolus __________________________
Medial malleolous, calcaneus, sinus tarsi, and cuboid bones __________________________
Lat. malleolous, calcaneus, sinus tarsi, and cuboid bones __________________________
Inferior, tib/fib joint, tibia, mm of leg __________________________
Anterior tibia, neck of talus, dorsalis pedis artery __________________________

Posteriorly
Calcaneus __________________________
Achilles tendon __________________________
Muscletendinous junction __________________________

Plantarily
Plantar muscle and fascia __________________________
Sesamoids __________________________
APPENDIX G  DEMOGRAPHIC DATA QUESTIONNAIRE

Demographic Data Questionnaire

Please complete the following. Where applicable, please mark the appropriate box with an "X".

1. Date: ________________________________

2. Which is your dominant leg?
   - Right
   - Left
   - Ambidextrous

3. What is your fitness level?
   - Not fit at all
   - Unfit
   - Normal fitness
   - Relatively fit
   - Fit

4. How many times per week do you exercise?
   - 1
   - 2
   - 3
   - 4
   - 5
   - 6
   - 7
   - Other ___

5. How many hours per week do you exercise? This includes gym, sports, etc.
   _____________________

6. Which of the following activity/activities or sports do you like to do? (You may choose more than one)
   - Circuit training
   - Weight training
   - Other gym
   - Jogging
   - Swimming
   - Squash
   - Cycling
   - Cross training
   - Pilates
   - Other (Please specify)

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APPENDIX H  PHYSICAL ACTIVITY QUESTIONNAIRE

Physical Activity Questionnaire

Please complete the following: (Please mark the appropriate box with an "X")

Date: ____________________

1. Did you exercise your legs or do you intend on doing any form of exercise affecting your legs:
   - yesterday
   - today
   - tomorrow

2. If yes, please mark the applicable exercises: (you may choose more than one)
   - Circuit training for legs
   - Cycling
   - Running/jogging
   - Weight training for legs
   - Calf raises
   - Lunges/squats
   - Squash
   - Other (Please specify)

3. How are your legs feeling today?
   - weak
   - normal
   - sore
APPENDIX I CONTRA-INDICATIONS TO CHIROPRACTIC MANIPULATIVE THERAPY

Contra-Indications to Chiropractic Manipulative Therapy (Esposito and Philipson, 2005)

Trauma:
- Fracture
- Instability
- Severe sprains

Arthritides:
- Rheumatoid
- Psoriatic
- Osteoarthritis
- Ankylosing spondylitis

Metabolic:
- Clotting disorders
- Osteoporosis

Neurological:
- Advancing neurological deficit
- Cauda Equina Syndrome

Vascular:
- Tumour
- Osteomyelitis
- Abdominal aortic aneurysm
- Vertebrobasilar insufficiency

Psychological:
- Malingering
- Hysteria
- Dependent personality
### APPENDIX J  DATA CAPTURING FORM

Data capturing form

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APPENDIX K ETHICS COMMITTEE LETTER

FACULTY OF HEALTH SCIENCES
RESEARCH ETHICS COMMITTEE
NHREC Registration no: REC-241112-035

TO WHOM IT MAY CONCERN:

STUDENT: BAUER, C
STUDENT NUMBER: 200801648

TITLE OF RESEARCH PROJECT: "The Effect of Chiropractic Manipulative Therapy of the Tibiotartral Joint on Endurance of the Triceps Surae Muscle"

DEPARTMENT OR PROGRAMME: CHIROPRACTIC

SUPERVISOR: Dr I Landmann
CO-SUPERVISOR:

The Faculty Academic Ethics Committee has scrutinised your research proposal and confirm that it complies with the approved ethical standards of the Faculty of Health Sciences; University of Johannesburg.

The AEC would like to extend their best wishes to you with your postgraduate studies.

Yours sincerely,

[Signature]

Prof M Poggenpoel
Chair: Faculty of Health Sciences REC
Tel: 011 559 6686
Email: mariep@uj.ac.za