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THE EFFECTS OF LUMBAR SPINE MANIPULATION VERSUS LOWER EXTREMITY MANIPULATION ON AGILITY IN ASYMPTOMATIC ATHLETES

A dissertation presented to the Faculty of Health Sciences, University of Johannesburg, as partial fulfilment for the Master's degree in Technology, Chiropractic by

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(Student number: 201029650)

Supervisor: ____________________ Date: ________________
Dr I. Landman
DECLARATION

I, Corné Lindeque, declare that this dissertation is my own, unaided work. It is being submitted in partial fulfilment for the Master's degree in Technology, in the programme of Chiropractic, at the University of Johannesburg. It has not been submitted before for any degree or examination in any other Technikon or University.

___________________________

Corné Lindeque

On this day the ______ of the month of _______________ 2015.
ABSTRACT

**Purpose:** The purpose of this study was to determine the most effective method of pre-event treatment for asymptomatic patients through comparing lumbar spine manipulation, lower extremity manipulation and a combination of both on the effect of explosive power and agility, as a measure of improvement.

**Method:** Thirty asymptomatic athletes of moderate to high activity, indicated by the International Physical Activity Questionnaire (IPAQ) participated in this study. Participants were be randomly allocated into three equal groups. Group 1 received lumbar spine and pelvis manipulation. Group 2 received lower limb manipulation only and Group 3 received a combination of lumbar spine, pelvis and lower extremity manipulation. Participants had to meet the inclusion and exclusion criteria to be part of the study. The study consisted of six consultations over a three week period, with intervention on every consultation and objective data obtained before and after intervention. The intervention period consisted of motion palpation of the specific groups' regions and manipulative therapy of the findings in each region.

**Results:** All three groups showed improvements in jump height, jump pressure output and the Illinois test. Group 1 showed an average increase in jump height of 3.26 cm, 2.5 Pa average increase in pressure output and 1.32 seconds average increase for the run of the Illinois test. Group 2 showed an average increase in jump height of 3.10 cm, 1.7 Pa average increase in pressure output and 1.03 second average increase for the run of the Illinois test. Group 3 showed an average increase in jump height of 3.09 cm, 2.8 Pa average increase in pressure output and 1.86 second average increase for the run of the Illinois test.
Analysis done on the immediate effect of chiropractic manipulative therapy (CMT) on the hang time during the vertical jump test, displayed an overall statistically significant effect 33%. Although some effect was achieved, the intervention had no constant improvement on the jump hang time. The minor result was attributed to the small changes in readings.

**Conclusion:** Although results obtained were not statistically significant ($p>0.05$), it demonstrated from a clinical perspective that interventions caused an improvement in jump height, jump pressure output and the Illinois tests' time in all three groups. Group 3 showed a greater improvement in every aspect, despite being the group with the least demographical advantage. Group 1 had the second best results. It is therefore postulated that the best improvements noted were as a result of the combined treatment protocol, where both the biomechanical and neurological aspects of performance were effected.
DEDICATIONS

I dedicate this research not only to the Chiropractic profession, but also to my family, friends and everyone who has had a profound effect on my life.

This six year journey filled my life with amazing possibilities and has taught me more about myself than I could have ever expected.

Thank you to my parents, Gert and Marie Lindeque, my siblings, Ishka Lindeque, Sulize Pelser and Billy Pelser, for all the support and love. Thank you to all my wonderful friends I’ve made along the way and the ones who became family. It is a true honour to have each one of you in my life.
ACKNOWLEDGEMENTS

To my supervisor, Dr. I. Landman, thank you for all the advice, help and spellchecks. You not only pushed me when I needed it, you became a true friend and someone I look up to.

A special thank you to the University of Johannesburg’s Biokinetics and statistics department. It was a pleasure working together.
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<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>ACL</td>
<td>Anterior cruciate ligament</td>
</tr>
<tr>
<td>ASIS</td>
<td>Anterior superior iliac spine</td>
</tr>
<tr>
<td>CM</td>
<td>Centimetre</td>
</tr>
<tr>
<td>CMT</td>
<td>Chiropractic manipulative therapy</td>
</tr>
<tr>
<td>CNS</td>
<td>Central nervous system</td>
</tr>
<tr>
<td>HAT</td>
<td>Head arms and trunk</td>
</tr>
<tr>
<td>IPAQ</td>
<td>International physical activity questionnaire</td>
</tr>
<tr>
<td>IVD</td>
<td>Inter vertebral disc</td>
</tr>
<tr>
<td>IVF</td>
<td>Inter vertebral foramina</td>
</tr>
<tr>
<td>M</td>
<td>Metre</td>
</tr>
<tr>
<td>MET</td>
<td>Metabolic equivalent of task</td>
</tr>
<tr>
<td>NMC</td>
<td>Neuro-muscular control</td>
</tr>
<tr>
<td>PCL</td>
<td>Posterior cruciate ligament</td>
</tr>
<tr>
<td>PNS</td>
<td>Peripheral nervous system</td>
</tr>
<tr>
<td>PSIS</td>
<td>Posterior superior iliac spine</td>
</tr>
<tr>
<td>ROM</td>
<td>Range of motion</td>
</tr>
<tr>
<td>S</td>
<td>Seconds</td>
</tr>
<tr>
<td>SIJ</td>
<td>Sacroiliac joint</td>
</tr>
<tr>
<td>WHO</td>
<td>World health organization</td>
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</table>
1.1 Introduction

Dr. Andrew Klein, the official Chiropractor for the 2000 United States Olympic team, stated that: “Athletes have come to rely on manual therapy because the list of banned substances is so long, and also because they feel it enhances their performance” (Medscape news, 2000; Brolinson, Smolka, Rogers, Sukpraprut, Gofort, Tilley and Doolan, 2012).

Manipulative treatment has been provided as standard care to athletes at the Olympic Games and other major international multisport games. Pre-competition manipulation may help enhance musculoskeletal function by warming up soft tissues to optimize joint function (Brolinson, et al. 2012).

A scientific study done by Ernst (2003), suggested that by removing spinal fixations, chiropractic manipulative therapy (CMT) improves maximum voluntary erector spinae muscle power output, shown via electromyography (EMG). Dishman, Ball and Burke (2002), stated that CMT increases motor neural pool excitability for 20 - 60 seconds (s) which can be beneficial to performance.

In a study done on footballers by Brolinson et al. (2012), found that pre-competition manipulative treatment was positively associated with improved performance among both offensive and defensive Virginia Tech football players. The associations between these two factors were relatively small and not statistically significant and needed more research.

These studies and various others that will be discussed through the course of this study, suggest that CMT has a positive influence on performance. When looking at the effect that CMT has on the biomechanical and neurological components in athletes, the inclusion of chiropractors within top sporting teams’ medical staff is a necessity.
1.2 Aim of the study

The aim of this study was to find the most effective method of pre-event treatment for asymptomatic patients through comparing lumbar spine manipulation, lower extremity manipulation and a combination of both on the effect of explosive power and agility, as a measure of improvement.

1.3 Benefit of the study

The possible outcome of this research was to indicate that the slightest increase in optimal biomechanics might increase performance. Through comparing the effect of CMT on various regions of the body, this study determined the most effective pre-event chiropractic treatment protocol for optimum performance. Establishing a secure position for the chiropractic profession in the professional sporting institutes.

Chapter two will review the relevant literature in detail. Chapter three will discuss the methodology used during the study. Chapter four reports the findings and statistics, followed by the discussion of these findings in chapter five. Chapter six will conclude the study and provide recommendations to future studies on the topic of pre-event chiropractic treatment.
CHAPTER TWO – LITERATURE REVIEW
2.1 Introduction

With the ever expanding field of professional athletes and the strict laws on banned substances, finding the edge on ones’ opponent has participants looking at alternative methods. In the sporting world a sizable amount of athletes use CMT as part of their pre-event routine. Pre-event CMT is used to prevent injuries before they occur and some studies has proven that this use of pre-event manipulating increases the performance of the athletes (Hoskins, Pollard. 2010).

Definition of chiropractic

Chiropractic is defined as a health care profession concerned with the diagnosis, treatment and prevention of disorders of the neuromuscular system and the effects of these disorders on general health. There is an emphasis on manual techniques, including joint manipulation with a particular focus on subluxation (WHO, 2005).

In order to fully understand what a chiropractor treats and how they benefit the sporting community a few terms needs to be discussed. How these terms relate to biomechanical dysfunction will also be looked at.

According to the World Health Organization (WHO) (2005) a fixation is a state where an articulation has become fully immobile in a certain position, restricting normal physiological movement of the joint. The fixation usually leads to a subluxation. The term subluxation can be defined as a lesion or dysfunction in a joint or motion segment in which alignment, movement integrity and/or physiological function is altered, although contact between joint surfaces remains intact (WHO, 2005). It is essentially a functional entity, which may influence biomechanical and neural integrity (WHO, 2005).
An asymptomatic segmental joint fixation could be one of the causes for altered biomechanics of the spine. This joint fixation is not restricted to only the spine, but can occur in any two or more joint complexes (Vernon and Mrozek, 2005).

*The vertebral subluxation*

The subluxation is core to what chiropractors treat and can be defined as: “A lesion or dysfunction in a joint or motion segment in which alignment, movement integrity and physiological function is altered, although contact between joint surfaces remains intact” (WHO, 2005). According to Esposito and Philipson (2005), a subluxation is based on a dysfunctional neurological component formed by a biomechanical deviation forming a complex clinical pattern.

Mechanical irritation to the tissues in and around joints results in neurogenic or non-neurogenic pain, usually with inflammation as the causative agent. Mechanically the motion segment (joint) behaviour is also affected (Triano, 2001).

At the apex of the subluxation complex (or functional lesion) is kinesiopathology, with the tissue level components (myopathy, neuropathology, connective tissue pathology and vascular pathology) at the next level. For optimal function these components need to work in perfect harmony (Lantz, 2005). A functional lesion is caused by a mechanical overload through either a single traumatic event or by means of an accumulation of small stresses over a series of events (Esposito and Philipson, 2005; Triano, 2001).

When applying chiropractic manipulations, nerve conduction is restored to normal and relieves the pathophysiological processes developing (Haldeman, 2000).
According to Peterson and Bergmann (2011) spinal manipulations is perceived as the foundation of chiropractic practice and the most specialized and significant therapy used by chiropractors. The manipulation improves functionality of the joint, decreases irritability of the nerve and increases range of motion (ROM) of the lumbar spine (Steven, 2009). The universal goal of chiropractic manipulation is to restore normal postural balance so that the athlete is able to perform at the highest level possible. In order to achieve the goal of improving performance, the chiropractic manipulation will restore any restricted movement and improve co-ordination (Miners, 2010).

In a study done by Shrier, Macdonald and Uchacz (2006), it was concluded that the use of pre-event manipulating was beneficial on the explosive power (tested with means of the Vertical Jump) and on running velocity or agility. However post-event manipulating showed signs of soreness that was unfavourable to the athletes’ performance.

The Vertical Jump test expresses explosive power and encompasses the stretch shortening cycle which is composed of two phases: Firstly, the eccentric phase (downward movement before the jump) and thereafter the concentric phase (the vertical jump itself) (Pauole, Madole, Garhammer, Lacrouse and Rozenek, 2000). Predictors of vertical jump performance include eccentric quadriceps muscle force production, calf girth and standing balance (Davisa, Briscoe, Markowskic, Savilled and Taylore, 2004).

Agility is defined as quickness of motion, which is needed in almost all sports. It requires strength, balance, co-ordination and speed. Flexibility is also a major factor affecting agility and a lack of flexibility is a predisposing factor to injury. Good motor co-ordination is reflected in agility testing through the Illinois’ test (Pauole et al., 2000).
According to Brolinson (2003) pre-event CMT has a positive biomechanical and physiological effect. Shrier et al. (2006) indicated that in theory, pre-event manipulation works through a neurological mechanism.

The literature review will look at the anatomy and biomechanics of the lumbosacral spine, leg and the relevant muscular components. The theories related to athletic performance and the enhancement through CMT will also be discussed.

2.2 Anatomy

2.2.1 Lumbosacral joints

The lumbar spine

The joints of the lumbar vertebral bodies are secondary cartilaginous joints with primary functions of weight bearing. The articulating surfaces of the adjacent vertebrae are the intervertebral joints, between the vertebral bodies, and are connected by intervertebral discs (IVD) (Marieb and Hoehn, 2007). Movement does not occur independently in the lumbar spine, but as a coupled motion and produces simultaneous lateral flexion and rotation. Flexion in the lumbar spine is more restricted than extension of the lumbar spine (Frankel and Nordin, 2013).

Movements that occur in the lumbar spine

- Flexion = 40 - 60 degrees
- Extension = 20 - 35 degrees
- Lateral Flexion = 15 - 20 degrees
- Rotation = 45 degrees (Magee, 2008).
The lumbar facet joints are synovial joints which consists of articular cartilage on the adjacent articular surfaces, an inner synovial membrane (synovium), synovial fluid, an outer ligamentous capsule and fibroadipose meniscoid structure (Greene, 2006; Levangie and Norkin, 2005; Thompson, 2002).

The lumbar facet joints are innervated by articular branches that arise from the medial branches of the dorsal primary rami of the spinal nerves. Each articular branch supplies two adjacent joints, therefore each joint is supplied by two nerves (Moore and Dalley, 2006).

**The sacroiliac joints**

The sacroiliac joints (SIJ) are formed by the sacrum and the iliac bones on each side. A number of ligaments connect the lateral borders of the sacrum with the iliac crest. Ligaments from the lumbar spine to the ilia also increases the stability of the pelvis (Marieb and Hoehn, 2007).

*Innervation of the sacroiliac joint*

The SIJ is innervated by the fourth and fifth lumbar ventral rami (L4-L5), superior gluteal nerve and the fifth lumbar vertebra to the second sacral doral rami (L5-S2) (Forst, Wheeler, Fortin and Vilensky, 2006).

**2.2.2 Joints of the lower limb**

*The hip joint*

According to Levangie and Norkin (2005), the hip joint (coxafemoral joint) is a diarthrodial ball and socket joint with $3^\circ$ of freedom, allowing:
Flexion / extension in the sagittal plane
Abduction / adduction in the frontal plane
Medial (internal) / lateral (external) rotation in the transverse plane

Three bones form the pelvis: the ilium, ischium and pubis, contribute to the structure of the acetabulum and the cup-like concave socket of the hip joint. The lunate surface of the acetabulum is covered with hyaline cartilage. Its horse-shoe shaped and articulates with the head of the femur. The inferior aspect or base of the lunate surface is interrupted by the acetabular notch (Levangie and Norkin, 2005). The acetabular notch is spanned by the transverse acetabular ligament which is considered part of the acetabular labrum (Marieb and Hoehn, 2007).

The transverse acetabular ligament form a tunnel beneath which blood vessels run into the central and deepest portion of acetabulum called the acetabular fossa. The acetabular fossa is a non-articular portion and the femoral head does not contact this area (Moore and Dalley, 2006). The girdle is referred to as the innominate or Os Coxa (Moore and Dalley, 2006).

The knee joint

The knee complex comprises of two articulations within a single joint capsule. It includes the tibiofemoral and patellofemoral articulations. The tibiofemoral joint is a double condyloid joint with 2° of freedom. It allows flexion and extension in the sagittal plane, around a coronal axis and medial and lateral rotation in the transverse plane, around a vertical axis (Peterson & Bergmann, 2011).

The patellofemoral joint is comprised of the patella (largest sesamoid bone in body) located on the femoral condyles. The patellafemoral joint is the least congruent joint in body.
The posterior surface of patella is divided into the medial and lateral articular facets (Frankel and Nordin, 2013), with the medial facet further divided into a large and much smaller odd facet (Marieb and Hoehn, 2007).

Articulation of the knee is stabilized by the menisci, the joint capsule, ligaments and surrounding muscles (Thompson, 2002). The menisci can provide some stability, however the capsule and ligaments are critical for restricting movement (Levangie and Norkin, 2005). The muscles also help, however, they are unable to stabilize the joint when any of the passive structures are damaged (Ravell, 2008).

The ankle and foot

The ankle joint, also known as the talocural joint, consists of the tibiotalar and talofibular joints. This is a synovial hinge joint with a joint capsule and associated ligaments. It has a single oblique axis with 1˚ of freedom of dorsiflexion and plantarflexion (Levangie and Norkin, 2005).

The bones of the foot and ankle are divided into three functional segments (Levangie and Norkin, 2005):

- Hindfoot - comprised of the talus and calcaneus
- Midfoot - comprised of the navicular, cuboid and 3 cuneiforms
- Forefoot - comprised of the metatarsals and phalanges

Function of the ankle is dependent on the stability of the tibiofibular joint (the mortise joint), as well as on a certain amount of mobility at the articulation. The fibula serves more a mobility function than stability, as it has little weight-bearing function and it is estimated that no more than 10% of the body weight runs through it (Levangie and Norkin, 2005).
2.2.3 Musculature associated with performing the Illinois’ and Vertical Jump test

Lumbopelvic musculature

The functions of the lumbopelvic muscles include controlled movement and stability to the trunk when the lower extremities are in motion (Levangie and Norkin, 2005). Posterior back muscles can be divided into three groups, the superficial group, the intermediate group and the deep group. The superficial group is only present in the cervical and thoracic spine. The intermediate group (forming the extrinsic back muscles) which produce and control movements and the deep group (forming the intrinsic back muscles) provide vertebral column movements and postural control (Miners, 2010).

The deep group of back muscles are subdivided into four layers, the superficial, intermediate, minor deep and deep layers. All of these are innervated by the dorsal rami of spinal nerves.

The intermediate layer of back muscles are referred to as the sacrospinalis group (erector spinae) divided into the iliocostalis, longissimus and spinalis muscles each subdivided into three components (Moore and Dalley, 2006). The minor deep layer of back muscles are composed of three muscles: the interspinalis, intertransversarii and levatores costarum (excluded as it does not relate to the study). The deep layer of back muscles are referred to as the transversospinalis group. It is composed of the multifidus, rotatores and semispinalis muscles (excluded as it does not relate to the study) (Marieb and Hoehn, 2007).
The quadratus lumborum (QL) muscle is an important muscle in providing lateral movement of the lumbar spine when performing the Illinois’ test for agility and the Vertical Jump test. Bilaterally the QL muscle provides frontal plane stability. Unilaterally it provides lateral flexion of the trunk and also controls rotation (Levangie and Norkin, 2005; Moore and Dalley, 2006).

**Muscles of the Back**

- **Erector spinae group**
  - 3 columns muscle
  - from sacrum to ribs
  - extends vertebral column

- **Semispinalis group**
  - vertebrae to vertebrae
  - extends neck

- **Multifidis**
  - vertebrae to vertebrae
  - rotates vertebral column

- **Quadratus lumborum**
  - ilium to 12th rib
  - lateral flexion

*Figure 2.2.1 Summary of the Erector spinae muscles and Quadratus lumborum muscle (Marieb and Hoehn, 2007).*

**Hip musculature**

The main hip flexors include the psoas and iliacus (iliopsoas), rectus femoris, sartorius and tensor fascia latae muscle (Levangie and Norkin, 2005).

The quadriceps muscle is composed of four muscles: the rectus femoris, vastus lateralis, vastus intermedius and vastus medialis which mainly function as knee extensors (Levangie and Norkin, 2005; Moore and Dalley, 2006).
The main extensors of the hip are the one-joint gluteus maximus muscle and the two joint hamstring muscle group. The hamstring muscle group is composed of the semitendinosus, semimembranosus and bicep femoris muscles. These primary extensors receive support from the posterior fibres of the gluteus medius, adductor magnus and piriformis muscles (Levangie and Norkin, 2005).

The gluteus medius muscle is not a hip extensor but is in close relation to the hip extensors. It is an important pelvic stabiliser when the opposite leg is off the ground, as would be found when performing the Illinois’ test for agility, thus its inclusion (Moore and Dalley, 2006).
Figure 2.2.2 Summery of the muscles acting on the hip and knee joints
anterior view (Netters, 2011).

Leg musculature

The posterior leg muscles are divided into superficial and deep muscle groups. The superficial group is composed of the gastrocnemius, soleus and plantaris muscles (Levangie and Norkin, 2005; Moore and Dalley, 2006).
The gastrocnemius and soleus are the main plantar flexors of the ankle and through the achilles tendon provides a large moment arm for plantar flexion (Levangie and Norkin, 2005; Moore and Dalley, 2006).

Figure 2.2.3 Summery of the muscles acting on the hip and knee joints anterior view (Netters, 2011).
The deep group is composed of the popliteus, flexor hallucis longus, flexor digitorum longus and tibialis posterior muscles. These muscles only produce 5% of the total plantar flexion force at the ankle (Levangie and Norkin, 2005; Moore and Dalley, 2006).

*Figure 2.2.4 Summery of the muscles of the lower leg (Netters, 2011)*
2.3 Lumbosacral neuroanatomy and neurophysiology

The lumbopelvic, hip and leg musculature are supplied with motor innervation by the lumbar and sacral plexus. Sensory input from these muscles and associated structures are detected by primary afferent fibres, which are neurons comprising the peripheral nervous system (PNS).

Primary afferents are divided into four parts: dendrites, cell body, axon and telodendria (receptive endings) (Haldeman, 2005). Table 2.3.1 provides the classification of the primary afferents

<table>
<thead>
<tr>
<th>Type of primary afferent</th>
<th>Classification in muscle and deep tissue</th>
<th>Classification in skin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myelinated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large</td>
<td>I</td>
<td>Not present</td>
</tr>
<tr>
<td>Medium</td>
<td>II</td>
<td>A-β</td>
</tr>
<tr>
<td>Small</td>
<td>III</td>
<td>A-δ</td>
</tr>
<tr>
<td>Unmyelinated</td>
<td>IV</td>
<td>C</td>
</tr>
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</table>

Various types of receptor endings are found throughout the musculature, but for the purpose of this study the focus will be on the mechanoreceptors. Mechanoreceptors detects changes in balance, touch, proprioception and pain. This in normal terms mean they are responsible for noticing any changes in the joint angle, rate of movement, muscle stretch and force and pain (experienced as a burning sensation) (Esposito and Philipson, 2005; Haldeman, 2005).
According to Riemann and Lephart (2002), proprioception can be defined as the afferent input of internal stimuli from proprioceptive fibres within the body, screened from the external environment, responsible for body segment stability, posture control and certain conscious sensations.

It was further stated by Riemann and Lephart (2002), that proprioception is a key component of the sensorimotor system and is responsible for providing the central nervous system (CNS) with afferent information used for neuromuscular control (NMC), while contributing to dynamic joint stability. Lawson (2009) stated that input from these receptors determines the muscle output, which is regulated by proprioceptors. NMC is dependent on proprioception as a component of the sensorimotor system (Riemann and Lephart, 2002).

Alpha motor neurons provide the motor component of the spinal nerves that innervate muscles of the body. Alpha motor neurons are located in the brainstem and spinal cord (gray matter that forms the ventral horn within lamina IX of the Rexed lamina system). The major descending pathways from the brain to the alpha motor neurons are via the corticospinal tract within the spinal cord. Alpha motor neurons receive afferent and efferent innervation connections, which are required to achieve co-ordinated muscle activity. The afferent input originates in the golgi tendon organs, muscle spindles, mechanoreceptors, their motor receptors and other sensory neurons in the periphery. The primary output (efferent) of the alpha motor neurons are to the extrafusal muscle fibres. These connections provide the structure for the neural circuits that underlie reflexes, of which the simplest is the monosynaptic reflex, e.g. the knee jerk reflex (Haines, 2004; Kiernan, 2005). Figure 2.3.2 provides a summary of the spinal reflexes.
Gamma motor neurons are a component of the fusimotor system (the combination of muscle spindles and Gamma motor neurons), the system by which the CNS controls muscle spindle sensitivity. Gamma motor neurons are located in the brainstem and spinal cord and function to regulate the gain of the stretch reflex by manipulating the level of tension in the intrafusal muscle fibres of the muscle spindle (Haines, 2004; Kiernan, 2005).

This mechanism sets the baseline level of activity in alpha motor neurons and helps to regulate muscle length and tone (Haines, 2004).
Figure 2.3.2 Spinal reflex pathways (Netter, Craig and Perkins, 2002).
2.4 Biomechanics

2.4.1 Biomechanics of the lumbar spine

In the spine the basic biomechanical functional “unit” consists of two vertebrae and the associated ligamentous tissue (Huiskes and Mow, 2005). The movements occurring at the lumbar spine are flexion, extension, lateral flexion as well as rotation, which are influenced by the cartilaginous intervertebral joints and the facet joints (Peterson & Bergmann, 2011).

Flexion

During flexion of the lumbar spine, the upper vertebral body moves anteriorly, compressing the IVD anteriorly while moving the nucleus pulposus posteriorly (Thompson, 2002). The fibres of the IVD are stretched posteriorly resisting flexion. The inferior articular processes slides superiorly and attempts to separate from the superior articular facet of the vertebra below (Peterson & Bergmann, 2011). The ligaments of the vertebral arch (ligamentum flavum, interspinous ligament, supraspinous ligament and posterior longitudinal ligament) and the articular capsules are stretched, limiting flexion. Flexion is associated with flattening of the lumbar lordosis (Peterson & Bergmann, 2011).

The range of motion (ROM) is maximal at the L4/L5 vertebral segment and gets progressively less further up the spine. Thus, the lower lumbar spine allows more flexion and extension movement than further up (Levangie and Norkin, 2005). Tilting of the pelvis allows further flexion and extension ability. Flexion is initiated by the abdominal muscles and the iliopsoas muscle and is controlled eccentrically by the erector spinae and the QL. On returning to the neutral position and during extension, the reverse action occurs (Peterson & Bergmann, 2011).

Extension
The vertebral body moves posteriorly, compressing the posterior fibres of the IVD, while moving the nucleus pulposus anteriorly. The articular facets approximate and may lock. The anterior fibres of the IVD are stretched limiting extension (Levangie and Norkin, 2005). Extension is also limited by the bony restriction and tension in the anterior longitudinal ligament (Peterson & Bergmann, 2011).

**Lateral flexion**

The IVD is compressed on the side of lateral flexion and the fibres are stretched on the contralateral side. The nucleus pulposus tends to move in the opposite direction of lateral flexion. The intertransverse ligaments are stretched on the contralateral side and relaxed on the ipsilateral side (Peterson & Bergmann, 2011). The articular facets on the contralateral side are raised in the coronal plane and are lowered on the ipsilateral side in the coronal plane (Levangie and Norkin, 2005). The ligamentum flavum and joint capsules relax on the ipsilateral side and are stretched on the contralateral side (Peterson & Bergmann, 2011). The segmental lateral flexion at L5/S1 is minimal and rapidly decreases with age. Lateral flexion is initiated by contractions of the ipsilateral erector spinae muscles (Levangie and Norkin, 2010).

**Rotation**

The concave superior articular facets face posteriorly and medially. The corresponding inferior articular facets are convex and face anteriorly and laterally (Levangie and Norkin, 2005). The center of rotation of the posterior portion of the functional spinal unit does not exactly correspond with the actual center of rotary movement. Thus, the facets tend to approximate on the contralateral side of rotation and separate on the ipsilateral side (Thompson, 2002). Rotation is the easiest when the facet orientation is parallel to the axis (Peterson & Bergmann, 2011).
The IVD is not directly involved in the rotation, but limits the movement along with the ligaments. Rotation in the lumbar spine itself is minimal as it is a combination of thoracic and lumbar rotation, with the thoracic spine contributing three times more rotation (Levangie and Norkin, 2005). Rotation is initiated by the contraction of the transverse abdominals and the intrinsic muscles of the spine (rotatores and multifidii) (Peterson & Bergmann, 2011).

Although these motions occur independently, a coupled motion will still occur at each spinal level (Levangie and Norkin, 2005). The coupled motion that occurs produces simultaneous lateral flexion and rotation (Thompson, 2002).

2.4.2 Biomechanics of the sacroiliac joint

The movement at the SIJ is commonly considered to be between three and five degrees. The motion at the SIJ is affected by a number of factors; including age, gender of the individual and the congregation of the joint surface (Thompson, 2002). The SIJ can be monitored by observing the change in distance between the posterior superior iliac spines with the patient seated or prone (Levangie and Norkin, 2005).

**Nutation**

During nutation the sacral promontory moves inferiorly and anteriorly, while the apex of the sacrum and the tip of the coccyx moves posteriorly in the sagittal plane. The sacrotuberous and sacrospinous ligaments check the movement of nutation. The iliac crests approximate and the ischial tuberosities move apart, widening the base of support as when assuming a seated position (Kapandji, 2003).
Counter-nutation

During the movement of counter-nutation the sacral promontory moves posteriorly and superiorly, while the apex of the sacrum moves inferiorly and anteriorly. Tension is limited by the anterior and posterior sacroiliac ligaments. The iliac crests move apart and the ischial tuberosities approximate, narrowing the base of support as when lying down (Kapandji, 2003).

Other movements also include anterior and posterior pelvis tilting, lateral tilting and rotation (Haldeman, 2000). If the lumbar spine becomes hypomobile, the spine compensates for the loss of motion by developing hypermobility somewhere else (Gatterman, 2002). Therefore, hypermobility occurs at the SIJ when the lumbar spine is hypomobile (Levangie and Norkin, 2005). During the performance of the Vertical Jump test, the ROM of the SIJ is increased, due to the increased force of the lumbar spine on the sacrum when landing after the jump (Moore and Dalley, 2006).

2.4.3 Biomechanics of the hip joint

Motion of hip joint is best visualized as the femoral head gliding in the acetabulum. This is opposite to movement of the distal end of the femur (Levangie and Norkin, 2005). Flexion and extension happens around a coronal axis and occur as a pure spin of the femoral head. The head spins posteriorly in flexion and anteriorly in extension. Flexion and extension in the other hip joint positions include spin and glide (Peterson & Bergmann, 2011).
Abduction, adduction, medial and lateral rotation include both spin and glide and occur opposite to motion of the distal femur, when the femur is the moving segment. When weight bearing, the pelvis moves on a relatively fixed femur. Thus, the acetabulum moves in the same direction as the pelvis (Peterson & Bergmann, 2011).

**Pelvic motions**

Anterior to posterior pelvic tilt occurs in the sagittal plane around the coronal axis (Levangie and Norkin, 2005). Normal alignment of the pelvis is such that the anterior superior iliac spine (ASIS) is in the same horizontal line as the posterior superior iliac spine (PSIS) and the ASIS and pubic symphysis is on the same vertical line. Anterior pelvic tilt creates hip flexion, while posterior pelvic tilt creates hip extension (Peterson & Bergmann, 2011).

**Lateral pelvic tilt**

This occurs in the frontal plane around an anterior-posterior axis. A line through both the ASIS’ is horizontal. In lateral tilt of the pelvis in unilateral stance, the stance hip acts as the pivot or axis for the opposite side of the pelvis as it elevates (hip hiking) or drops (pelvic drop) (Levangie and Norkin, 2005). The non-weight bearing limb is in an open chain and has no position, but the leg usually hangs straight down (Peterson & Bergmann, 2011). In other words, if one stands on the left leg and hikes the pelvis, the left hip abducts, and right hip adducts. If one stands on left leg and drops the pelvis, the left hip adducts. Therefore, in unilateral stance, the weight bearing hip joint will always be the pivot and the non-weight bearing hip joint defines the motion (Frankel and Nordin, 2013). In bilateral stance, when the weight is shifted to the right, the pelvis drops on the left, the right hip adducts and the left hip abducts (Peterson & Bergmann, 2011).
Pelvic rotation

Pelvic rotation takes place in the transverse plane around a vertical axis. It occurs around an axis of the supporting hip joint in unilateral support. Forward rotation of the pelvis occurs when the side of pelvis, opposite the supporting hip joint, moves anteriorly and forward. Rotation of the pelvis produces medial rotation of the supporting hip joint (Levangie and Norkin, 2005).

Backward rotation of the pelvis occurs when the side of the pelvis opposite the supporting hip moves posteriorly. Posterior rotation of the pelvis produces lateral rotation of the supporting hip joint (Frankel and Nordin, 2013). In bilateral stance, one needs to reference a side because rotation occurs around a vertical axis through the center of the pelvis (Peterson & Bergmann, 2011).

Motion of the femur, pelvis and the lumbar spine (lumbar-pelvic motion)

When the pelvis moves on a relatively fixed femur, there are two possible outcomes: the head and trunk will follow the motion of pelvis, in essence creating an open chain motion (Ravell, 2008). The other possible outcome is for the head to remain relatively upright and vertical despite pelvic motion, in essence creating a closed chain motion (Peterson & Bergmann, 2011).

When the femur, pelvis and spine moves in a co-ordinated manner to produce a larger ROM than is available to one segment alone, the hip joint is participating in an open chain and is known as lumbar pelvic motion (Levangie and Norkin, 2005). This combination of motions at several joints serve to increase range available to the distal segment. In the case of lumbar-pelvic motion, this can be either end of the open chain, the head or the foot (Peterson & Bergmann, 2011).
2.4.4 Biomechanics of the knee

In a closed kinematic chain, the knee works with the hip and ankle to support the body when in a static erect posture (Ravell, 2008). It also works dynamically to move and support the body in sitting and squatting, as well as when supporting the transfer of weight during locomotion. In an open kinematic chain, the knee provides mobility for foot in space (Peterson & Bergmann, 2011).

The primary motion in the knee is flexion and extension and occurs around a horizontal axis through the femoral condyles. Some additional movements in the knee joint are possible. These consists of medial and lateral rotation, anterior and posterior displacement of tibia on femur, as well as some abduction and adduction, but this is achieved through varus and valgus forces acting on the knee (Levangie and Norkin, 2005). These are due to compromise between mobility & stability as a result of the joint incongruency and variations in ligament elasticity (Thompson, 2002).

The axis is lower on the medial side, causing the tibia to move from slightly lateral to the femur in full extension to medial to the femur in full flexion (Levangie and Norkin, 2005). The instant axis of rotation of tibiofemoral joint for flexion and extension forms a semi-circle, moving posteriorly and superiorly on the femoral condyles with increasing flexion. Hip joint position can influence knee ROM, because many muscles crossing the knee also cross the hip (Frankel and Nordin, 2013).

Arthrokineamtics of knee flexion and extension

When the knee starts to flex, the femur rolls on the tibia. If it could only roll, then the femur would roll off the tibia very quickly, therefore the femur rolls posteriorly and glides anteriorly (Levangie and Norkin, 2005).
During the first part of flexion (0° - 25°), there is primarily rolling of the femoral condyles, followed by anterior gliding. The anterior glide results due to tension in anterior cruciate ligament (ACL) and wedge-shaped meniscus (Thompson, 2002).

The menisci moves with the femoral condyles up to a certain point (attached at horns to intercondylar tubercles) but is consider a distortion rather than an actual movement. The lateral meniscus distorts more than the medial because the lateral horns are closer together (Ravell, 2008). Extension is guided by tension in posterior cruciate ligament (PCL) and the shape of the meniscus, which distorts to accommodate femoral motion. If the menisci do not distort, it can the limit movement of the joint (Ravell, 2008).

**Rotation at the knee joint**

There are two types of rotation possible at the knee joint. The first is axial rotation, providing 2 degrees of freedom to the tibiofememoral joint (Frankel and Nordin, 2013). This rotatory movement occurs around a longitudinal axis running through the medial tibial intercondylar tubercle (Levangie and Norkin, 2005). It occurs due to articular incongruence and ligament laxity and depends on the position of knee.

If the knee is fully extended, no axial rotation is possible as the knee is in a closed-packed position. This means that the ligaments are taut, the tibias' tubercles are lodged in the intercondylar notch and the menisci are tightly interposed between the articulating surfaces (Levangie and Norkin, 2005). With an increase in flexion, more rotation is possible because the capsule and ligaments become more lax, with maximum rotation available at 90 degrees and decreasing again with full flexion (Huiskes and Mow, 2005).
The second type of rotation is terminal rotation and occurs with the knee in the closed-packed position, but it does not contribute to the degrees of freedom of the knee joint.

*Locking and unlocking of the knee joint*

As the femur extends to approximately 30 degrees of flexion, the shorter lateral femoral condyle completes its rolling-glide motion (Ravell, 2008). Extension continues and the longer medial condyle continues to roll and glide posteriorly although the lateral side has halted. This results in medial rotation of femur on tibia, pivoting about a fixed lateral condyle. This is most evident in the last 5 degrees of extension (Levangie and Norkin, 2005). This movement may be assisted by the increasing tension in the ligaments as the knee reaches full extension. This medial rotation is automatic as it is not produced by any muscle activity (Ravell, 2008).

It is this rotation that accompanies the end of extension and brings the knee joint into the closed-packed position. It is also known as the locking mechanism or screw home mechanism of the knee (Thompson, 2002).

To initiate flexion, the knee must be unlocked. A flexion force will automatically result in lateral rotation of the femur, because the longer medial side will move before the shorter lateral side of joint (Thompson, 2002). Automatic or terminal rotation occurs in open and closed chain knee joint function (Levangie and Norkin, 2005). In an open chain movement, the tibia will laterally rotate on the fixed femur and in a closed chain movement, the femur will rotate on a fixed tibia. Movements of the knee joint are driven predominantly by muscles, except for terminal rotations discussed earlier (Frankel and Nordin, 2013).
2.4.5 The biomechanics of the ankle and foot joint

Primary ankle motion is dorsiflexion and plantar flexion, around an oblique axis, causing the foot to move across all 3 planes. The ankle joint is capable of some rotation of the talus within the mortise in both the transverse plane (around a vertical axis) known as talar rotation or adduction-abduction movement of the foot. It also allows for movement in the frontal plane (around an antero-posterior axis) called talar tilt or inversion-eversion movement of the foot (Thompson, 2002).

Movement of the ankle joint

In the neutral position, the axis of movement runs through the fibula malleolus, the body of the talus and through or just below the tibial malleolus (Ravell, 2008). The fibular malleolus extends further distally than the tibial malleolus and lies more posteriorly. This is due to the normal torsion (twist) that exists in the distal tibia relative to its proximal plateau (Thompson, 2002).

The distal tibia is rotated laterally, relative to the proximal tibia, therefore accounting for the toe-out position of the foot during normal standing. Given this, the ankle is considered to be rotated laterally 20 – 30 degrees in the transverse plane and inclined 10 degrees down on the lateral side (Frankel and Nordin, 2013).

This axis is inclined more distally on the lateral side, creating a tri-planar motion. Dorsiflexion will thus not only result in the foot being brought up, but also slightly lateral to the leg (increased toe-out), as well as turning it longitudinally away from the midline (pronation and eversion) (Levangie and Norkin, 2005). Thus dorsiflexion can be viewed as a combination of pronation, eversion and abduction.
The opposite occurs with plantar flexion. The foot goes down moving medial to the leg (increased toe-in) and turning the foot longitudinally towards the midline (supination and inversion). Thus, plantar flexion is seen as a combination of supination, inversion and adduction (Frankel and Nordin, 2013). Normal ankle joint ROM is given as 20 degrees dorsiflexion from neutral and 30 – 50 degrees plantar flexion from neutral (Ravell, 2008).

2.4.6 Biomechanics of running and jumping

Normal gait is rhythmic and characterized by alternating propulsive and retropulsive motions of the lower extremities. The lower extremities eccentrically support and carry the head arms and trunk (HAT) ie: 75% of body weight. In gait, the HAT must not only be balanced over one extremity but must also be transferred from one extremity to the other. These activities require co-ordination, balance, intact kinesthetic and proprioceptive senses and integrity of the joints and muscles (Davisa, Briscoeb, Markowskic, Savilled and Taylore, 2004).

The gait cycle includes the activities that occur from the point of initial contact of one lower extremity to the point at which the same extremity contacts the ground again. During one gait cycle, each extremity passes through two phases: a single stance phase and a single swing phase (Davisa, et al., 2004).

The stance phase begins at the instant that one extremity contacts the ground (heel strike) and continues only as long as some portion of the foot remains in contact with the ground (toe off) and makes up 60% of the gait cycle.

The swing phase begins as soon as the toe of one extremity leaves the ground and ceases just before heel strike or contact of the same extremity, making 40% of the gait cycle (Davisa, et al., 2004).
Running

During running, toe off occurs before 50% of the gait cycle is completed. There aren’t any periods where both feet are on the ground. However both feet are airborne twice during the gait cycle: Once during the beginning of the swing phase and once at the end of the swing phase, and is referred to as the double float. Speed determines the timing of toe off. As the athlete moves faster, less time is spent in the stance phase (Novacheck, 1998; Levangie and Norkin, 2010).

Jumping

When performing the Vertical Jump test, there are movements occurring before the actual jump which includes bending of the knees. This is called the counter-movement jump. Eccentric quadricep muscle force production, calf girth and standing balance are all predictors of the performance of the Vertical Jump test (Davisa, et al., 2004).

The manipulation provides optimum muscle function and optimum stability of the spine (Huiskes and Mow, 2005), by improving the ability of the muscle to contract and stretch which provide a biomechanical advantage (Colloca and Keller, 2001).

By manipulating the SIJ and the lumbar spine respectively, one can significantly increase the muscle output of the gluteus maximus and quadriceps muscles (Hertzog, 2010).
2.5 The effect of CMT on asymptomatic athletes

The practice of chiropractic includes establishing a diagnosis, facilitating neurological & biomechanical integrity through appropriate chiropractic case management and promotion of health (Chapman-Smith, 2000). The manipulation opens or gaps the joint to stretch the tissues that causes a restriction. This will provide a local and remote mechanical and neurological affect (Esposito and Philipson, 2005).

Schwartzbauer, Kolber, Schwaeitzbauer, Hart and Zhang (1997) and Ravell, (2008) evaluated athletic performance and physiological measurements following chiropractic treatment of 28 university baseball players. They came to a conclusion that there is a positive correlation between the athletes improved performance and chiropractic treatment.

2.5.1 Mechanical

The force of a manipulation delivered to the dysfunctional joint may alter the segmental biomechanics. The breakdown of the contractile and collagen adhesions in the local soft tissue will guide possible scar tissue and provide an increase in ROM (Pickar and Wheeler, 2001).

Collaca and Keller (2001) proposed that the mechanical forces provided by CMT to the fixated joint stimulates the somatosensory system, inhibits nociception, improves functional ability of muscles and improve ROM.

During a manipulation the dysfunctional zygapophysyal joints’ movement and alignment gets altered. When a spine is under a load, the motion of the segments are altered even if the structure is normal. This is because load forces can originate from any direction. The biomechanics of a joint is changed with a manipulation, affecting the adjacent tissue leading to an increase in motion (Gatterman, 2005).
Chiropractic manipulations are proposed to restore dysfunctional joint segments and the extent of associated inflammation exudates. It also decreases the mechanical stress on the surrounding soft tissue (Huisken and Mow, 2005). Chiropractic manipulations can’t reverse the damage sustained to the facet joints, but has a long lasting effect on pain relief, joint mobility and reoccurrence of dysfunction (Pickar and Wheeler, 2001).

The manipulation provides optimal muscle function of the surrounding tissue improving the ability of the muscle to contract and expand providing a biomechanical advantage (Colloca and Keller, 2001).

According to Haldeman (2000), the chiropractic manipulation has a direct effect on the structures around the joint. The sensory receptors in the muscles, ligaments and joint itself respond to the manipulation becoming hyper-excited. The excitability of those receptors can trigger a central reflex pathway and a somatic reflex, causing relaxation of the muscle and increase the ROM. The chiropractic manipulation changes the tone and strength of the muscles surrounding or acting on a joint, causing a spindle reflex and stretching of a segmental muscle (Gatterman, 2005).

According to Herzog (2010), the adhesions that gets broken within the joints, through the application of a manipulation, could account for the intersegmental motion changes.

2.5.2 Neurological

The biomechanical changes caused by a manipulation affect the nervous systems’ neural activity by removing the aberrant sensory input or providing new input (Leach, 2004). CMT affects primary afferent neurons from paraspinal tissue, the motor system and pain processing system (Pickar, 2002).
These changes induced by the manipulation may affect the central neural integration within nociceptive, autonomic and/or motor neuronal pools, thereby producing changes in the afferent somatomotor and visceromotor activity (Pickar and Wheeler, 2001).

According to Haldeman (2005), abnormal biomechanical relation among vertebrae or joints can cause compression of spine nerve roots. The neural tissue within the intervertebral foramen (IVF) are vulnerable to the effects of mechanical compression due to their properties (Herzog, 2010). The slightest compression applied to the dorsal root ganglia and dorsal roots is sufficient enough to produce large, prolonged increases in the discharge of groups I, II, III and IV afferents (Haldeman, 2005). According to Esposito and Philipson (2005), neural function of the nerve roots can be altered by mechanically changing the compressional pressure of the IVF’s as like with a chiropractic manipulation.

According to Haldeman (2005), the impulses generated by the stimulation of spinal structures by a manipulation presumably activates neural reflex centres in the spinal cord and higher centres. This in turn causes a somato-visceral response in the sympathetic and parasympathetic nerves. Research done by Shuter, McMoroland, Herzog and Bray (2000), demonstrated that these reflexes can be brought on by a manipulation.

Another effect of the manipulation described by Picker (2002), is the increased excitability of the responsiveness of the dorsal horn neurons to afferent input. This is defined as central facilitation. He further explained that the alpha motor neurons could be held in a facilitated state due to sensory bombardment from segmentally related paraspinal structures. These motor reflex thresholds correlate with the pain thresholds suggesting that some pathways were also sensitised in the abnormal segment.
The phenomenon of central facilitation increases the receptive field of central neurons and allows mechanical stimuli to access the central pathway (Herzog, 2010). Thus the mechanical stimuli produced by a manipulation may be beneficial by decreasing the painful stimuli by replacing it with the more accessible mechanical stimuli (Pickar, 2002).

*The effects of chiropractic manipulation on performance*

Haldeman (2005), stated that the mechanical force of a manipulation will provide space and remove joint restrictions. This may change the effect on the nervous system allowing ideal muscular control. The state of optimal muscle function provides the joint with stability leading to optimal joint function (Huiskes and Mow, 2005).

Chiropractic manipulation to the SIJ will provide increased muscle power input, especially to the quadriceps muscle group (Suter et al, 2000). A significant increase of between 15 to 25 percent in gluteus maximus and quadratus muscle output can be achieved by manipulating the lumbar spine (Suter et al, 2000).

The manipulation may also effect the sympathetic hyper-sensitivity often associated with overstimulation of the neurons of hypertonic muscles (Haldeman, 2005). With the removal of the subluxation, muscular skeletal mechanoreceptors are normalised allowing for favourable limb control and proprioception (Haldeman, 2005).

According to Herzog (2010), chiropractic manipulation should lead to increased ROM, increase muscle flexibility and decreased strain on the relative structures in turn resulting in improved performance.

The following chapters will deal with how the study was conducted, the results from the study and a chapter discussing these results.
3.1 Introduction

This chapter serves to discuss the participants’ selection procedure, the treatment approach, how the data was obtained, all ethical considerations and analysis of the data.

3.2 Study Design

This was a comparative study using random group allocation and convenient sampling. The aim of this study was to find the most effective method of pre-event treatment for asymptomatic patients. This was achieved by comparing lumbar spine manipulation, lower extremity manipulation and a combination of both on the effect of explosive power and agility. The Vertical Jump test and Illinois’ test was used to test for explosive power and agility respectfully.

3.2.1 Participant Recruitment

Participants were recruited through word of mouth, distribution of flyers (Appendix C) and contacting various sporting clubs through emails to the respective heads of the clubs. These consisted of:

- UJ athletic department
- UJ rugby department
- Edenvale Panthers Rugby club
- UJ Hockey department
3.2.2 Selection criteria and sample size

Thirty asymptomatic athletes, of moderate to high physical activity training levels, as indicated by the International Physical Activity Questionnaire (IPAQ) (Appendix D), participated in this study. Participants were randomly allocated into three equal groups. The groups consisted of:

- Group 1 (the control group) received lumbar spine and pelvis manipulation only.
- Group 2 received lower limb manipulation only.
- Group 3 received a combination of lumbar spine, pelvis and lower extremity manipulations.

Participants had to meet the inclusion criteria to be part of the study.

Inclusion criteria

- Athletes of any gender between the ages of 18 and 45 (reached athletic maturity).
- Athletes who are asymptomatic with lumbar and or sacral dysfunction.
- Athletes who are asymptomatic with lower extremities dysfunction.
- Completion of demographic data sheet and signing of the participant information and consent forms.
- Athletes with a moderate to high activity score level according to the IPAQ
Exclusion criteria

- Participants that demonstrate any contra-indications to CMT (Appendix E)
- Any history of lumbar spine or lower extremity surgery
- Current Musculoskeletal injury or illness
- Participants that meets a score lower than moderate to high on the IPAQ

3.2.3 Random group allocation

Participants included in the study were randomly allocated into groups by means of a colour system. Three different colour cards of blue, red and green (ten of each representing the three different group’s participants) were placed in a bag. Participants were asked to draw a card from the bag and according to their choice, they were placed into either Group 1 (blue card), Group 2 (red card) or Group 3 (green card). Once the card had been drawn, it was removed from the bag.
3.3 Methodology

3.3.1 Consultation procedure

Each participant was treated twice a week, over a period of three weeks, for a total of six treatments.

The first consultation included:

- Explanation of the study to the participants
- Completion of the IPAQ
- Signing of the participant consent form and reading of the information form (Appendix A & B)
- Completion of a case history and a pertinent physical examination (Appendix F & G)

Depending on the group, additional regional examinations were done

- Group 1 - lumbar spine and pelvis regional examinations (Appendix H)
- Group 2 - hip, knee, ankle and foot regional examinations (Appendix I, J & K)
- Group 3 – lumbar spine and pelvis, hip, knee, ankle and foot regional examinations (Appendix H,I,J & K)

The pre-intervention tests were conducted after a brief time allocated for warm up. Warm up consisted of a 5 min jog followed by hamstring, quadriceps, gastrocnemius and adductor stretches. This warm up routine was designed to target the main muscle groups used in the set of tests that were performed.
The test period consisted of

- Three Vertical Jump tests
- Two Illinois’ tests.

The pre-intervention score was obtained from the test performed prior to manipulation. On commencement of pre-intervention score taking, manipulative therapy was conducted, specific to the allocated groups. The intervention period consisted of motion palpation of the specific group regions and manipulative therapy of the findings in each region.

A second test period was completed after completion of the intervention period. Post-intervention testing consisted of three Vertical Jump tests and two Illinois’ tests. The post-intervention score was obtained from the post-intervention test period. Follow-up consultations were similar to that of the initial consultation with regards to pre-intervention, intervention and post-intervention periods.

Consultation consisted of:

- Allocated warm up time
- Pre-intervention testing
- Intervention
- Post-intervention testing.

All testing periods were constant with that of the initial consultation.
3.4 Subjective Data

Subjective data was collected through the IPAQ. The IPAQ was used as a screening tool to ensure that the participants had a similar level of activity.

The IPAQ instrument is designed primarily for surveillance of physical activity among adults (IPAQ, 2005). The IPAQ score of each participant was calculated using the formula stated in illustration 3.1. In order to be eligible to participate in the study, participants needed to score a minimum of 600 Metabolic Equivalent of Task (MET) – minutes/week.

**Table 3.1 – IPAC scoring formulae (IPAC, 2005).**

<table>
<thead>
<tr>
<th>Level of activity</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking</td>
<td>( \text{MET-minutes/week} = 3.3 \times \text{walking minutes} \times \text{walking days} )</td>
</tr>
<tr>
<td>Moderate</td>
<td>( \text{MET-minutes/week} = 4.0 \times \text{moderate-intensity activity minutes} \times \text{moderate-intensity day} )</td>
</tr>
<tr>
<td>Vigorous</td>
<td>( \text{MET-minutes/week} = 8.0 \times \text{vigorous-intensity activity minutes} \times \text{vigorous-intensity days} )</td>
</tr>
<tr>
<td>Total physical</td>
<td>( \text{MET-minutes/week} = \text{sum of Walking} + \text{Moderate} + \text{Vigorous MET-minutes/week scores}. )</td>
</tr>
</tbody>
</table>

The IPAQ is a reliable test method for physical activity for participants between the ages of 15 and 65 (IPAQ, 2005). According to Lee, Macfarlane, Lam and Stewart (2011), the IPAQ produces repeatable data with Spearman’s clustered at 0.8, the criterion validity had a median of 0.3 and found that the IPAQ questionnaire to have acceptable measurement properties.
3.5 Objective Data

During the clinical trials objective data was collected through means of two tests. These tests consisted of the Vertical Jump test and the Illinois’ test. During the trials a total of 36 Vertical Jump tests were done and 24 Illinois’ tests were completed.

The immediate effect of the intervention was represented by the comparison of the objective data obtained on each consultation. The short term effect was represented by comparing the baseline measurement (first measurement on consultation one) versus the final measurement of consultation six.

3.5.1 Vertical Jump test

The Vertical Jump test was designed to test explosive power of the lower limbs (Markovic, Dizdar, Jukic and Cardinale, 2004). Glatthorn, Gouge, Sylvain, Nussbaumer and Silvio, (2011) concluded that the Vertical Jump test is a reliable test and valid test for explosive power of the lower limbs in physically active individuals with a reliability coefficient of $r = 0.87$.

**Equipment**

The test makes use of a three meter tall extendable swivel stand. The stand was designed to be adjustable to suit the athletes’ height by measuring the athletes’ overhead reach and allowing an additional 100 cm for the jump.

The top of the stick is fitted with one centimetre (cm) spaced swivels, that the athlete taps at his/her peak of the jump. The swivels get displaced, indicating the jump height of the athlete.
To optimise results the athletes were asked to perform the jump on a pressure plate. The plate was able to calculate the athletes jump hang-time and power produced during the jump.

![Figure 3.5.1 - Equipment of Vertical Jump test.](image)

**Vertical Jump procedure**

The test was done by having the participant stand at the base of the swivel stick, with his/her overhead reach measured. The participant then needed to, in one fluent movement, jump as high as possible and displace the swivels at the peak of the jump. The fluent movement was achieved by flexing the knees, hips and spine to displace in a downward direction. To gain some momentum the arms were used to push up past the trunk, while the knees, hips and spine were forced into extension. The participant was not allowed to take any sort of steps prior to the jump. This procedure was repeated three times, each with a short rest in between jumps.
Vertical Jump test score

Jump results for pre-intervention and post intervention testing was documented after each jump. Results consisted of the height of the jump measured in cm, the total jump hang-time, measured in s and the pressure produced by the athletes’ jump measured in Pascal (Pa) (Appendix M & N).

3.5.2 Illinois’ test

According to Raya, Gailey, Gaunaud, Jayne, Campbell, Manrique and Muller (2013), the Illinois’ Agility Test is a commonly used test for agility in sports, and as such there are many norms available (Appendix O). The purpose of the test was to test running agility.

Layout and Equipment

The layout of the test is over a course of 10 meters (m) and the width (distance between the start and finish points) is 5 m. Four cones were used to mark the start, finish and the two turning points.

The SmartSpeed system was used for timing of the runs. Trigger gates were placed at the start and finish points. Another four cones were placed down the center of the course at an equal distance apart. Each canter cone was spaced 3.3 m apart. Equipment required for the test were:

- a flat, non-slip surface (12 by 7 m)
- marking cones
- SmartSpeed system
- SmartSpeed lights
- Smartspeed reflectors
- measuring tape
Illinois’ procedure

The test was done by having the participant lie prone at the start line (head to the start line) and hands by their shoulders. The SmartSpeed system was set to a two gate buzzer protocol. This meant that the participant was set of automatically by the system via a buzzer. The time was started as soon as the participant broke the start gate laser. Time was stopped with breaking of the finish gate laser after the entire course of the test was completed. The course of the test is demonstrated in figure 3.5.2 (Lockie, Schultz and Berry, 2013). The test was run twice before intervention and repeated twice after intervention.

Figure 3.5.2 – Illinois’ Test Layout.

According to Raya, et al., (2013), an excellent score for asymptomatic male athletes, of top performance, is sub 15.5 seconds (s) and Sub 17 s for top preforming asymptomatic female athletes was found to be the bar.
This was a simple test to administer, requiring little equipment. The participant’s ability to turn in different directions and different angles is a good indication of agility and performance with constant results.

According to The Journal of Sports Science and Medicine the Smartspeed system is one of the most reliable tools for assessment of any speed or agility tests, with a criterion validity median of 0.4. (Lockie, Schultz and Berry, 2013).

3.6 Intervention

Group A, B and C all received some form of CMT. Group A, which served as the control group, received lumbar spine and SIJ manipulative therapy. In a pilot study conducted in 2006 by Shrier, Macdonald and Uchacz, this suggested that chiropractic manipulation may improve running velocity and agility but requires further investigation. This theory was proved in a follow up study by Brolinson, et al., (2012), on Virginia tech athletes. They found that pre-event lumbar spine chiropractic treatment of the athletes increased reaction time and agility in 68% of all participants.

Group 2 received lower limb manipulation. This intervention consisted of various manipulative techniques to the hip, knee and ankle joints.

Group 3 received a combination of lumbar spine, pelvis and lower extremity manipulation. This consisted of motion palpation of all the joints from the lumbar spine down to the foot joints and manipulation of any restriction found.

The treatment differed from patient to patient. Recommended by Brolinson, et al., (2012), the optimum biomechanics of entire lower limb unit might have an ever greater influence on performance.
3.6.1 Diversified technique

The diversified technique as described by Esposito and Phillipson (2005), was used by the researcher in this clinical study. Various techniques was used to palpate and correct the subluxation dysfunction.

Diversified manipulation techniques used:

- Thigh Transverso-deltoid
- Thigh Ilio-deltoid
- Spinous hook-pull
- Hip internal/external subluxation technique
- Knee internal/external subluxation technique
- Mortise separation
- Sub-taylor splash

3.7 Data Analysis

The data was collected by the researcher during the clinical trials. Means and standard deviations were calculated as descriptive statistics for age, height and weight. To establish comparability at onset between groups, comparisons was performed on age, IPAQ score, Vertical Jump test and Illinois’ test results. Within (intra) and between (inter) group comparisons were performed to evaluate the short (over six consultations) and immediate (pre-intervention to post-intervention) impact of the intervention. The data collected was initially tested for normality and a normal destitution curve was found. This entitled the use of parametric data analysis test. The Paired Sample T-Test was used to test the immediate effect.

The impact over time or short term effect was tested using the Repeated Measures ANOVA. While the inter group analysis was tested with the One Way ANOVA test.
Chapter 4 will discuss the methods of data analysis in more depth.

3.8 Ethical Considerations

All participants that wished to partake in this particular study was requested to read the information form and sign the consent form specific to this study. The information and consent forms outlined the names of the researcher, purpose of the study and benefits of partaking in the study, participant assessment and treatment procedure; any risks, benefits and discomforts pertaining to the treatments involved was also explained and that the participants safety was to be ensured (prevention of harm). The information and consent forms also explained that the participants’ privacy was protected by ensuring their anonymity and confidentiality when compiling the research dissertation. The participants were informed that their participation is on a voluntary basis and that they were free to withdraw from the study at any stage. Should the participant had any further questions, these had been explained by the researcher and contact details were made available.

The participants were then required to read the information form and sign consent form, signifying that they understood all that was required of them for this particular study. Results of the study were to be made available on request.

With regards to this particular study, risks, benefits discomforts and injury were possible during the performance of the tests. The tests were of a physical nature and required high-end athletes for the best outcomes. Benefits of the study demonstrated the best combined warm-up and pre-event protocol for elite athletes. This, in combination with the input of other sport clinicians might have redefined the approach to the athletes’ medical team.
Some post manipulating discomfort might have been felt by initial new patients, who have not yet been to a chiropractor. Participants were referred when necessary.

This study was approved by the ethics committee of the University of Johannesburg, with the ethics clearance number REC-01-208-2015 (Appendix P).

To ensure that this study was done as original work and plagiarism was prevented by the researcher, it was submitted to and reported on by Turnitin (Appendix Q).
CHAPTER FOUR – RESULTS
4.1 Introduction

The objective data for this study consisted of results obtained through performing of the Vertical Jump test and the Illinois’ test. Three readings were gathered from the Vertical Jump test and one from the Illinois’ test. The Vertical Jump test gave results for the jump height, jump hang time and the jump pressure output. The Illinois’ test gave a time reading for agility. Measurements were taken in cm for the jump height, s for the jump hang time and the Illinois’ test and in Pa for the jump pressure output.

The p-value determined the significance of the statistics. The p-value was set at 0.05. If the p-value was less than or equal to 0.05 ($p \leq 0.05$) then the value was considered to be statistically significant finding. If the p-value was greater than 0.05 ($p > 0.05$) the value was not statistically significance.

Values from the pre-intervention and post-intervention scores, from the same consultation, were used to test the immediate effect of the intervention in all three groups. To determine the short term effect of the intervention, the post intervention values were used. The in-between group analysis tests utilised the post-intervention values of all three groups.

4.2 Demographic analysis

The population group of this study consisted of thirty participants, of any age or gender, that complied with the inclusion and exclusion criteria ($n=30$). Group 1 consisted of ten participants ($n=10$). This group served as the control group. This was based on previous studies, mentioned in the literature review, that support the statement that lumbar spine and SIJ manipulation has a positive effect on performance. Group 1 received CMT to the lumbar and sacroiliac joints.
Group 1, Group 2 and Group 3 were tested before and after they received CMT. Group 2 consisted of ten participants (n=10). This group served as the first experimental group and received CMT to the joints of the lower limb (Hip, Knee and Foot and Ankle Joints). Group 3 consisted of ten participants (n=10). This was the second experimental group and received CMT to the lumbar spine, SIJ and the joints lower limb.

4.2.1 Age

*Figure 4.1 Age distribution between groups.*

Thirty participants were included in the analysis of the study, with a minimum age of 20 years and a maximum age of 35 years. The average age was approximately 23.54 years. The medians for Group 1 and Group 2 were equal at 22 years. Group 3 had a median of 24 years.

Figure 4.1 shows the distribution of the ages of the participants between groups. From the data depicted, it shows that groups 1 and 2 had a very closely related distribution. Group 3 had both the minimum and maximum ages within the group. It also displayed a higher median, indicating an older average age between groups. This, theoretically, predisposed the group to a decreased outcome of results.
4.2.2 Gender

Figure 4.2 Gender distribution between groups

Figure 4.2 displays the gender distribution between groups. The data depicted showed that Group 3 had the highest number of female participants. In total, 23 males and 7 female participants were noted.

4.2.3 IPAQ

The participants’ total IPAQ score ranged from a minimum of 1125 to a maximum of 3097, with an average of 1818.87. There was a 158.87 score difference between the total IPAQ mean of Group 1 and Group 2. A 165.23 score difference between Group 2 and Group 3 was noted, indicating that Group 1 was slightly more active than Group 2 and Group 3 as the most active group.
Table 4.3 Comparison of total IPAQ score variables between groups

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Median</th>
<th>Std. Dev</th>
<th>Min</th>
<th>Max</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>10</td>
<td>1894.99</td>
<td>1692.00</td>
<td>513.71</td>
<td>1193</td>
<td>3097</td>
<td>0.14</td>
</tr>
<tr>
<td>Group 2</td>
<td>10</td>
<td>1736.12</td>
<td>1593.00</td>
<td>481.53</td>
<td>1125</td>
<td>3071</td>
<td>0.22</td>
</tr>
<tr>
<td>Group 3</td>
<td>10</td>
<td>1901.35</td>
<td>1814.30</td>
<td>509.04</td>
<td>1472</td>
<td>3004</td>
<td>0.17</td>
</tr>
</tbody>
</table>

Normality tests

The Kolmogorov-Smirnov test for normality was performed to determine if the data was normally distributed. The statistically significant level was adjusted with the Lilliefors Significance Correction and most variables were found to be normally distributed. Isolated variables were found to be not a constant 0.20. Displayed in Table 4.4 the variants that were found not to be a constant 0.20. The Illinois' test for agility had four variables that differed from the norm. This was still an acceptable margin, as only two were found to be statistically insignificant. The little variant and normally distributed results, allowed for the use of parametric tests for the analysis of the objective data collected.
Table 4.4 Kolmogorov-Sminov test for normality

<table>
<thead>
<tr>
<th>Variable</th>
<th>Statistics</th>
<th>Df</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jump Hang Time</td>
<td>0.09</td>
<td>30</td>
<td>0.07</td>
</tr>
<tr>
<td>Pre-Intervention 6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jump Pressure</td>
<td>0.13</td>
<td>30</td>
<td>0.18</td>
</tr>
<tr>
<td>Output Pre-intervention 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Illinois’ test</td>
<td>0.14</td>
<td>30</td>
<td>0.14</td>
</tr>
<tr>
<td>Pre-intervention 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Illinois’ test</td>
<td>0.19</td>
<td>30</td>
<td>0.04</td>
</tr>
<tr>
<td>Pre-intervention 6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Illinois’ test</td>
<td>0.20</td>
<td>30</td>
<td>0.03</td>
</tr>
<tr>
<td>Post-intervention 4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Illinois’ test</td>
<td>0.14</td>
<td>30</td>
<td>0.11</td>
</tr>
<tr>
<td>Post-intervention 6</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.3 Intra-group analysis

Immediate effect.

The Paired Sample T-test was used to compare the pre- and post-intervention values of each recording. This test was utilised to determine the immediate effect of the intervention period on all four variables. Comparisons were made on each consultation. For the results of the test to be statistically significant the p-value of the results had to have a value equal or less than 0.05.
Table 4.5 Paired Sample T-Test for Jump Height

<table>
<thead>
<tr>
<th>Paired Consultation Variable</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Df</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jump Height Consultation 1</td>
<td>2.66</td>
<td>3.36</td>
<td>29</td>
<td>0.00</td>
</tr>
<tr>
<td>Jump Height Consultation 2</td>
<td>2.40</td>
<td>4.09</td>
<td>29</td>
<td>0.03</td>
</tr>
<tr>
<td>Jump Height Consultation 3</td>
<td>1.43</td>
<td>3.43</td>
<td>29</td>
<td>0.30</td>
</tr>
<tr>
<td>Jump Height Consultation 4</td>
<td>2.47</td>
<td>3.12</td>
<td>29</td>
<td>0.00</td>
</tr>
<tr>
<td>Jump Height Consultation 5</td>
<td>2.03</td>
<td>3.01</td>
<td>29</td>
<td>0.01</td>
</tr>
<tr>
<td>Jump Height Consultation 6</td>
<td>2.40</td>
<td>2.76</td>
<td>29</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Immediate effect on Vertical Jump height

Table 4.5 presents statistical data for the immediate effect of CMT on the Vertical Jump test’s variables and the Illinois’ test’s variables. Five out of the six jump height values had a p-value that was consistently less than 0.05. This indicated that on all consultation, except consultation three, a statistically significant change was noted.

Group 1

Group 1 had a maximum p-value of 0.00 and a minimum of 0.04. Comparing pre- and post-intervention results a maximum increase of 5.83 cm was noted and a minimum increase of 2.43 cm. The average increase of the group was 3.26 cm.
**Group 2**

Group 2 had a maximum p-value of 0.01 and a minimum of 0.03. Comparing pre- and post-intervention results a maximum increase of 4.48 cm was noted and a minimum increase of 2.65 cm. The average increase of the group was 3.10 cm.

**Group 3**

Group 3 had a maximum p-value of 0.00 and a minimum of 0.02. Comparing pre- and post-intervention results a maximum increase of 6.12 cm was noted and a minimum increase of 1.89 cm. The average increase of the group was 3.09 cm.

*Immediate effect on jump hang time.*

Analysis of the immediate effect of CMT on the hang time variable of the Vertical Jump test, displayed that a statistically significant effect was noted in 33 % of the results. The results were scattered throughout the groups with no specific pattern. This indicated that, although the intervention had some effect in isolated instances, no constant improvement on the jump hang time was noted. Group 1 had an average jump hang time p-value of 0.06. Group 2 had an average jump hang time p-value of 0.14 and group 3 had an average jump hang time p-value of 0.06. The minor result was attributed to the small changes in readings. This was considered in statistical analysis as a non-effect.

*Immediate effect on jump power output*

Analysis of the immediate effect of CMT on the pressure output variable of the Vertical Jump test, displayed that a statistically significant effect was noted in 66 % of the results. The statistically significant improvement was
distributed in constant nature, thus could be related back to the effect of the intervention.

*Group 1*

Group 1 showed an increase in the pressure output on the fourth and fifth consultation. An average increase of 2.5 Pa was noted over the time span of the six consultations. Maximum increase in the power output was on the fourth consultation of 2.7 Pa, when compared to the first consultation.

*Group 2*

Group 2 showed an increase in the pressure output on the third and fourth consultations. An average increase of 1.7 Pa was noted over the time span of the six consultations. A maximum increase in the power output was noted on the fourth consultation of 1.8 Pa, when compared to the first consultation.

*Group 3*

Group 3 showed an increase in the pressure output on the second, third and fourth consultations. An average increase of 2.8 Pa was noted over the time span of the six consultations. A maximum increase in the power output was noted on the fourth consultation of 2.9 Pa, when compared to the first consultation.
**Table 4.6 Paired Sample T-Test for Illinois’ Test**

<table>
<thead>
<tr>
<th>Paired Consultation Variable</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Df</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illinois’ Test Consultation 1</td>
<td>0.58</td>
<td>0.64</td>
<td>29</td>
<td>0.00</td>
</tr>
<tr>
<td>Illinois’ Test Consultation 2</td>
<td>0.48</td>
<td>0.73</td>
<td>29</td>
<td>0.01</td>
</tr>
<tr>
<td>Illinois’ Test Consultation 3</td>
<td>0.30</td>
<td>0.50</td>
<td>29</td>
<td>0.03</td>
</tr>
<tr>
<td>Illinois’ Test Consultation 4</td>
<td>0.52</td>
<td>0.48</td>
<td>29</td>
<td>0.00</td>
</tr>
<tr>
<td>Illinois’ Test Consultation 5</td>
<td>0.54</td>
<td>0.54</td>
<td>29</td>
<td>0.01</td>
</tr>
<tr>
<td>Illinois’ Test Consultation 6</td>
<td>0.41</td>
<td>0.37</td>
<td>29</td>
<td>0.02</td>
</tr>
</tbody>
</table>

*Immediate effect on Illinois’ test*

Table 4.6 presents statistical data for the immediate effect of CMT on the Illinois’ test’s variables. For all the Illinois” tests, the p-value was consistently less than 0.05. This indicated that, on all comparisons, the intervention had a statistically significant influence on the Illinois’ test. Between all three groups a maximum p-value of 0.00 and a minimum of 0.03 was noted. Comparing pre- and post-intervention results, a maximum increase of 2.3 s and a minimum increase of 0.83 s was noted. The average increase of Group 1 was 1.32 s, Group 2 was 1.00 s and Group 3 showed a 1.86 s average increase.
Short term effect

Table 4.7 shows the statistical data for the short term effect of CMT on the Vertical Jump test's post-intervention results. Data representing the jump height was compared over the six consultation periods using the Repeated Measures ANOVA test.

The p-value for statistically significance was adjusted via the Bonferroni adjustment to allow for multiple comparisons. A short term improvement was noted between consultation one and four, one and five and one and six. Thus indicating a statistical significant influence of the CMT. This finding was only noted in Group 1 and Group 3.

Table 4.7 Repeated Measure ANOVA Test for Jump Height.

<table>
<thead>
<tr>
<th>Consultation</th>
<th>Mean Difference</th>
<th>Std. Error</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 vs 4</td>
<td>1.56</td>
<td>0.32</td>
<td>0.01</td>
</tr>
<tr>
<td>1 vs 5</td>
<td>1.33</td>
<td>0.31</td>
<td>0.03</td>
</tr>
<tr>
<td>1 vs 6</td>
<td>1.76</td>
<td>0.49</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Vertical Jump test

Comparing the post-intervention Vertical Jump test's hang time variable of consultation three to the post-intervention Vertical Jump test's hang time variable of consultation one, the p-value was found to be not statistically significant (p=0.89). The same outcome was noted with comparison of the post-intervention Vertical Jump test’s hang time variable of consultation six to the post-intervention Vertical Jump test’s hang time variable of consultation (p=0.42). This indicated that the short term effect of CMT on this variable was not statistically significant (p>0.05).
A similar finding for the Vertical Jump test’s pressure output variable was noted. The p-value for this variable was at a constant 1.00, indicating a definite, yet not statistically significant short term effect was noted.

**Illinois’ Test.**

Comparing the Illinois’ test post-intervention results, the short term effect of CMT was statistically insignificant (p<0.05), but an improvement was noted. Comparing the Illinois’ test post-intervention results of consultation one to the Illinois’ test post-intervention results of consultation three, a 0.54 s (5 %) improvement was noted. When the baseline reading (16.45 s) was compared to Illinois’ test post-intervention results of consultation six (15.78 s) a 0.67 s (6 %) improvement was noted in Group 1. Group 2 displayed a 0.34 s (4 %) improvement with comparison of the Illinois’ test post-intervention results of consultation one to the Illinois’ test post-intervention results of consultation three. When the baseline reading (17.59 s) was compared to the Illinois’ test post-intervention results of consultation six (16.88 s) a 0.72 s (8 %) improvement was noted.

Group 3 displayed a 0.88 s (7 %) improvement with comparison of the Illinois’ test post-intervention results of consultation one to the Illinois’ test post-intervention results of consultation three. When the baseline reading (17.59 s) was compared to the Illinois’ test post-intervention results of consultation six (15.01 s) a 0.98 s (9 %) improvement was noted.

**4.4 Inter-group Analysis of Illinois test**

The One-Way ANOVA-All test was used to determine the statistical significance between groups. Statistical significant p-value was set at 0.05. Results showed no statistically significant effect or difference between groups. However a certain effect for each group was noted.
Table 4.8 One Way ANOVA-All results for Jump Height

<table>
<thead>
<tr>
<th>Dependant Variable</th>
<th>Consultation</th>
<th>Group Comparison</th>
<th>Mean Difference</th>
<th>Std. Error</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jump Height Maximum Increase</td>
<td>Consultation 6</td>
<td>Group 1 vs Group 2</td>
<td>1.70</td>
<td>4.92</td>
<td>0.93</td>
</tr>
<tr>
<td></td>
<td>Consultation 6</td>
<td>Group 1 vs Group 3</td>
<td>2.50</td>
<td>4.92</td>
<td>0.86</td>
</tr>
<tr>
<td>Jump Height Minimum Increase</td>
<td>Consultation 4</td>
<td>Group 1 vs Group 2</td>
<td>1.30</td>
<td>4.68</td>
<td>0.95</td>
</tr>
<tr>
<td></td>
<td>Consultation 4</td>
<td>Group 1 vs Group 2</td>
<td>4.00</td>
<td>4.68</td>
<td>0.79</td>
</tr>
</tbody>
</table>

From the data depicted, the Std Error value is compared to 1.00. The value represents the effect of the intervention between groups, through comparing the pre- and post-intervention values to each other. Although none of the respected groups had a statistically significant p-value, a positive Std Error value was noted for the jump height variable between Group 1 and Group 3 and for the jump pressure output variable between Group 1, Group 2, and Group 3. The jump height variable showed the most increase between consultation one and consultation six, when Group 1 and Group 3 were compare to each other. This, in other words, meant that most increase happened over the duration of the six consultations time period.

Table 4.9 shows the results of the One-Way ANOVA-All test for jump pressure output variable. From the data displayed, it was noted that the increase between groups had a double peak representation. In all three groups an increase was noted on consultation three and on consultation six.
Table 4.9 One-Way ANOVA-All test for Jump Pressure Output

<table>
<thead>
<tr>
<th>Dependant Variable</th>
<th>Consultation</th>
<th>Group Comparison</th>
<th>Mean Difference</th>
<th>Std. Error</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jump Pressure Output</td>
<td>Consultation</td>
<td>Group 1 vs Group 2</td>
<td>0.46</td>
<td>1.83</td>
<td>0.96</td>
</tr>
<tr>
<td>Maximum Increase</td>
<td>Consultation</td>
<td>Group 1 vs Group 3</td>
<td>1.08</td>
<td>1.83</td>
<td>0.82</td>
</tr>
<tr>
<td></td>
<td>Consultation</td>
<td>Group 2 vs Group 3</td>
<td>1.88</td>
<td>1.83</td>
<td>0.43</td>
</tr>
<tr>
<td>Jump Pressure Output</td>
<td>Consultation</td>
<td>Group 1 vs Group 2</td>
<td>1.18</td>
<td>1.77</td>
<td>0.78</td>
</tr>
<tr>
<td>Minimum Increase</td>
<td>Consultation</td>
<td>Group 1 vs Group 3</td>
<td>1.04</td>
<td>1.77</td>
<td>0.83</td>
</tr>
<tr>
<td></td>
<td>Consultation</td>
<td>Group 2 vs Group 3</td>
<td>2.22</td>
<td>1.77</td>
<td>0.43</td>
</tr>
</tbody>
</table>

The results of the One-way ANOVA-All test for jump hang time and the Illinois’ test had a Std Error value of less than 1.00. Although statistically insignificant, a slight effect was still noted. Jump hang time showed the least effect with an average Std Error value of 0.03. The Illinois’ test showed an average Std Error value of 0.45.
CHAPTER FIVE – DISCUSSION
5.1 Introduction

Haldeman (2005) stated that chiropractic manipulations can enhance the performance through correcting the biomechanical and neurological alteration. The results of this study will be discussed with reference to the statistical analysis performed in Chapter 4, the aim in Chapter 1 and the theories to explain the possible outcomes which were discussed in Chapter 2. The clinical significance of the short term (over a period of six consultations) and immediate effect (pre- to post-intervention) of interventions was determined by comparing the mean values of consultations for the Vertical Jump test and its variables and Illinois’ test.

Baechle and Earle (2000), proposed that a muscles’ ability to generate force is determined by three things. These consisted of the biomechanics, neurological and muscular factors. They further stated that chiropractic manipulations can affect all three factors to increase the strength of the muscle.

5.2 Demographical analysis

The One-Way ANOVA-All test was used to determine the statistical significance between groups. Results showed statistically significant effects or difference between groups for the IPAQ (p=0.71), Jump Height (p=0.68), Jump Pressure Output (p=0.54), Jump Hang Time (p=0.71) and Illinois’ Test (p=0.62). Although no statistically significant differences between groups were noted, a certain effect for each group was.
5.3 Intra-group Analysis

*Immediate effect on jump height*

Group 1 had an average p-value of 0.02. Group 2 displayed an average p-value of 0.02 and Group 3 had a p-value average of 0.01. This indicated that the intervention had a statistically significant effect on the jump height in all three groups.

*Immediate effect on jump hang time*

Analysis of the immediate effect of CMT on the hang time of the Vertical Jump test, displayed that a statistically significant effect was noted in 33% of the results. The results were abnormally distributed between groups, thus indicating a non-statistically significant influence of the intervention. As previously discussed in chapter 4 under “*Immediate effect on Vertical Jump hang time*” group 1 had an average jump hang time p-value of 0.06. Group 2 had an average jump hang time p-value of 0.14 and group 3 had an average jump hang time p-value of 0.06.

*Immediate effect on jump pressure output*

A statistically significant effect was achieved in 66 % of the results. The statistically significant results were distributed in such a manner that it could be related back to the effect of the intervention (refer to Chapter 4). Group 1 had an average p-value of 0.05. Group 2 displayed an average p-value of 0.07 and Group 3 had a p-value average of 0.04. The results indicated that the two groups that received CMT to the lumbar spine and SIJ (Group 1 and Group 3) had a statistically significant effect.
Immediate effect on Illinois’ test

The Illinois’ tests’ the p-value was consistently less than 0.05, indicating that on all comparisons between groups a statistically significant change was noted. Group 1 had an average p-value of 0.02. Group 2 displayed an average of 0.01 p-value and Group 3 had a p-value average of 0.03.

According to Steven (2009), the CMT improves functionality of the joint, decreases irritability of the nerve and increases ROM of the lumbar spine. The universal goal of chiropractic manipulation is to restore normal postural balance so that the athlete is able to perform at the highest levels possible. In order to achieve the goal of improved performance, the chiropractic manipulation may restore any restricted movement and improve coordination by means of breakdown of adhesions, increased neurological hypersensitivity and increased range of motion (Miners, 2010).

It was stated by Kelsick (2004), that chiropractic manipulations were designed to correct any joint restrictions prior to athletic performance. This may have the added effect of a reduced frustration levels in the athletes.

When biomechanical and neurological components are restored by a chiropractic manipulation, through the breakdown of adhesions, increased neurological hypersensitivity and increased range of motion, it could lead to more proficient performance before and after an event (Haldeman, 2005).

The results obtained from the Repeated Measure ANOVA test on the effectiveness of CMT, clearly showed an immediate improvement on most aspects of the tests. However this could be attributed to either one of the plausible theories that CMT increases performance physiologically or just decreases the frustration levels of the athlete. More investigation on this matter is needed.
Short term effect on jump height

Group 1 had an average p-value of 0.03 Group 2 displayed a p-value average of 0.07 and Group 3 had a p-value average of 0.04. This indicated that Group 1 and Group 2 had a statistically significant effect.

Short term effect on jump hang time

Group 1 had an average p-value of 0.13 Group 2 displayed an average p-value of 0.20 and Group 3 had a p-value average of 0.10. This indicated that none of the groups had a statistically significant effect.

Short term effect on jump pressure output

Group 1 had an average p-value of 0.04 Group 2 displayed an average p-value of 0.65 and Group 3 had a p-value average of 0.06. This indicated that only Group 1 had a statistically significant effect.

Short term effect on Illinois’ test

Group 1 had an average p-value of 0.01 Group 2 displayed an average p-value of 0.05 and Group 3 had a p-value average of 0.03. This indicated that all three groups had a statistically significant effect.

The Repeated Measures ANOVA test results displayed some differences between groups. The experimental group’s improvement may be due to a learned response or due to the chiropractic manipulation restoring joint restriction, therefore improving performance. Diallo, Dore, Duche and van Praagh (2012) stated that by performing the indicators a second time in the control group, the improvement may be due to a learned response as the body makes physiological adaptations.
These adaptations included the muscles increasing their strength and power and increased efficiency of the functional motor patterns for dynamic joint stabilization.

Other adaptations included an increase in reflexes and proprioception to protect against future injuries. Although some between group differences were found, not enough discrepancies were found to eliminate the learnt response of the athletes.

The two groups (Group 1 and Group 3) that received CMT to the lumbar spine and SIJ, had a higher improvement rate than compared to Group 2 whom received CMT to the lower limb only. This could be attributed to the theory stated by Haldemen (2005) that CMT excites the motor neurons at spinal level, increasing the conduction speed of these neurons, leading to improved immediate performance.

5.4 Inter-group analysis

The Inter-group analysis showed none of the findings from the One-way ANOVA-All test was statistically significant. In obtaining mean values for clinical significance through simplistic calculation of results, statistical information was lost and thus had no statistical significance, but important indications for enhancing pre-event performance.

Within all three groups, improvements were made in jump height, jump pressure output and the Illinois’ test. Group 1 showed an average increase in jump height of 3.26 cm, 2.5 Pa average increase in pressure output and 1.32 s average increase in the Illinois’ test.

Group 2 showed an average increase in jump height of 3.10 cm, 1.7 Pa average increase in pressure output and 1.03 s average increase in the Illinois’ test.
Group 3 showed an average increase in jump height of 3.09 cm, 2.8 Pa average increase in pressure output and 1.86 s average increase in the Illinois’ test.

The Vertical Jump test and Illinois’ test were described by Carmelo, Pekka and Paavo (2003), to be a valid and reliable way to test an athlete’s performance. An increased reaction time between opponents is usually the difference between winning and losing (Baechle and Earle, 2002). A statistically significant immediate result for an athlete could yield drastic improvements on the sporting field.

Before participants took part in this study, they were informed about the procedures, protocols and potential benefits. A baseline measurement was taken at the first consultation to prevent the potential influence of the learned response. This, however could not be totally prevented throughout the six consultation time period.

All three test groups showed an increase in most variables, with the small margins of the jump hang time being the only variable to show unreliable results. Group 3, who received CMT to all the joints from the lumbar spine, the SIJ, the hip, the knee and the foot and ankle, outperformed the other groups.

Out of the study that consisted of thirty participants, all of moderate to high activity levels indicated by the IPAQ, only one participant had previously performed the tests. This small margin allowed optimal inter-group comparison. As mentioned previously, the two groups (Group 1 and Group 3) who received CMT to the lumbar spine and SIJ showed better results that Group 2, who didn’t. According to previous studies conducted by Shier (2000) and Shier et al., (2006), showed that a combination of neurological and biomechanical influence, yields best results on performance.
The results obtained from this study suggested that the participants who had both neurological and biomechanical components had dampened performance. The groups that had both the neurological and biomechanical components of dysfunctions addressed and altered by CMT, had a more positive effect.
6.1 Conclusion

The aim of this study was to find the most effective method of pre-event treatment for asymptomatic patients through comparing lumbar spine manipulation, lower extremity manipulation and a combination of both, on the effect of explosive power and agility, as a measure of improvement.

The immediate effect of intervention proved to be clinically beneficial for all three groups, with the exception of the vertical jump hang time. This was attributed to the small changes in the readings. This in statistical analysis was rendered as a non-effect.

The study proved to be beneficial over a short period of time, but only for a few factors of the tests conducted. Statistically significant improvements were seen in the Vertical Jump test’s height and pressure output variables. Although found not to be statistically significant, the Illinois’ test had a positive average improvement of 0.67 s (6 %) in Group 1. Group 2 improved with 0.72 s (8 %) and Group 3 had a 0.98 s (9 %) improvement.

Clinical significance level was set at a p-value of 0.05. The variables used to obtain the clinical significance was derived from the interpretation of the mean values from the Vertical Jump test and Illinois’ test. The immediate effect of the intervention showed best results for the group who received a combination of lumbar spine, SIJ and lower limb CMT. All three groups had a positive result after CMT. On comparing the pre- and post-intervention results, Group 1 had an average increase in jump height of 3.26 cm, 2.5 Pa average increase in pressure output and 1.32 s average increase the Illinois’ test. Group 2 showed an average increase in jump height of 3.10 cm, 1.7 Pa average increase in pressure output and 1.03 s average increase the Illinois’ test.
Group 3 showed an average increase in jump height of 3.09 cm, 2.8 Pa average increase in pressure output and 1.86 s average increase in the Illinois’ test.

This immediate increase in performance for athletes who compete in millisecond to get the edge over their opponents should be very beneficial. The short term effect affected two factors of the Vertical Jump test more than the rest. Group 3 showed the best improvement over time.

This research thus proved that the best method for pre-event treatment is a CMT protocol that effects both the biomechanical and neurological components that has a negative influence on performance. Although some improvements were noted, the results were not conclusive and more research is needed.

The benefit of this study was then to prove, once again, that CMT has a positive effect on performance related to muscle strength, the power generated in a short burst and the agility of athletes. It also served to lay down some ground work for proving the importance of chiropractors as part of any top performing athletes’ medical team.

6.2 Recommendations

The following recommendations may aid in improving and providing statistical significance for future studies in this field.

- Include only participants who partake in the same sport to increase consistency in performing specific performance indicators
- Perform the intervention on sport teams with the same activity level or competing on the same sport level, i.e. club or provincial, as they would have similar exercise programmes, providing similar baseline levels
- Increase the sample size population as to increase the statistical significance
- Implementing a placebo such as detuned non-active performance enhancing stickers applied to muscles to provide a significant placebo effect and improve the psycho-somatic effect
- Have an equal ratio of males to females as participants and compare to the results of this study to determine the effect of CMT in females
- Include a combination of interventions, such as comparing CMT to myofascial needling or active release
- Different performance indicators could be utilised as objective measurement to obtain the spectrum that CMT enhances in sporting performance, i.e. testing spinal flexibility which is a specific performance indicator for certain sports
- Symptomatic participants may be integrated as they have even greater dysfunction, resulting in an increase dampened sport performance, which may show a greater improvement in the study’s results
- Comparisons between symptomatic and asymptomatic participants with the same intervention could be analysed to determine the effect of pre-event CMT.
- Minimise outside variables by ensuring a consistent running surface, environment and the same personal equipment.
REFERENCES


Brolinson, G.P., DO; Smolka M., DO; Rogers M., DO, MA; Sukpraprut S., PhD, MA, MSc; Goforth M.W., MS, ATC; Tilley G., DC; and Doolan K.P., MS, ATC. (2012). JAOA. Precompetition Manipulative Treatment and Performance Among Virginia Tech Athletes During 2 Consecutive Football Seasons: A Preliminary, Retrospective Report. 112 (1), 1-16.


APPENDICES
APPENDIX A

DEPARTMENT OF CHIROPRACTIC
FACULTY OF HEALTH SCIENCES
Telephone: (011) 559 6218

Date: ____________________

INFORMATION FORM

Dear Participant,

My name is Corne Lindeque, 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 a comparative study between the effects of lumbar spine manipulation versus lower extremity manipulation on the effects of agility in asymptomatic athletes.

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.

This information leaflet is to help you to decide if you would like to participate. You need to understand what is involved before you agree to take part in this study. You may find that this form may contain words that you do not understand. If you have any questions, do not
hesitate to ask me. You may also take home a copy of this form before signing the consent form to think about or discuss with family or friends before making your decision.

The aim of this study is to find the most effective method of pre-event treatment for asymptomatic patients through comparing lumbar spine manipulation, lower extremity manipulation and a combination of both on the effect of explosive power and agility, as a measure of improvement.

Procedure
Should you decide to partake in this study you will first be screened for what we call “inclusion and exclusion criteria”. The inclusion criteria for this study is Athletes of any gender between the ages of 18 and 45. Athletes who are asymptomatic with lumbar and or sacral dysfunction (subluxation). Athletes who are asymptomatic with lower extremities dysfunction (subluxation). Athletes with a moderate to high activity score level according to the International Physical Activity Questionnaire (IPAQ). The exclusion criteria for this study is participants that demonstrate any contra-indications to CMT (Appendix B). Any history of lumbar spine or lower extremity surgery. Current Musculoskeletal injury or illness. Participants that meets a score lower than moderate to high on the IPAQ. I would especially like you to note that you may not participate in another research study, nor take any medications that may influence the outcomes of this study. Not all medications may be a problem, so please be open with me regarding any medication or supplements you are using. Also, please be open with me regarding your health history, since you may otherwise harm yourself by participating in this study.

After screening you will be randomly allocated to one or other treatment (i.e. like spinning a coin). This procedure is done to ensure that the information gathered during this study is as accurate as possible. There are three groups in this study. Group one will receive lumbar spine and sacroiliac manipulative therapy. Group two will receive lower extremity manipulative therapy. Group three will receive a combination of both. All three groups be asked to do a set of tests at each treatment. The research will be done over a maximum of four week period, meaning consulting twice a week over a three week period.
Thirty participants will participate in this study and it will only be performed in South Africa. The entire study, including all treatments will take place at the University of Johannesburg’s Chiropractic day clinic. The total amount of time required for your participation in this study will be a maximum of four weeks. You will be asked to visit me six times over a three week period during the study.

Spinal manipulation is a standard procedure that is performed as part of a routine chiropractic treatment and may present a slight risk of discomfort. You may or may not hear a popping sound associated to the treatment. If you do hear this sound it is completely normal and is as a result of a normal physiological response. It is possible that you may feel some discomfort, although this is uncommon.

As this study is investigational there may be other risks or side effects which are unforeseen or unknown. You should immediately contact me if any side effects occur throughout your participation in this study.

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 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 would 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. Some conditions may be contraindicated to this treatment. Also, should you fall pregnant during the study the possible associated ligament laxity would mean you would need to withdraw from this study.

If at any time between your visits, you feel that any of your symptoms are causing you any problems, or you have any questions during the study please do not hesitate to contact me. The 24 hour telephone number through which you can reach me is
If you want any information regarding your rights as a research participant, or complaints regarding this research study, you may contact Prof Marie Poggenpoel Chairperson of the University of Johannesburg’s Academic Ethics committee which is an independent committee established to help protect the rights of research participants. Tel 011 559 2860.

This study protocol has been submitted to the University of Johannesburg’s Academic Ethics Committee and written approval has been granted by that committee. The study has been structured in accordance with the Declaration of Helsinki if 2008, which deals with the recommendations guiding doctors in biomedical research involving human participants. Should any injuries occur as a result of this study the University of Johannesburg has medical insurance that will cover the expenses related to the injury.

This study is sponsored by the University of Johannesburg I do not have any financial or personal interests with this organisation that may bias my actions.

**Confidentiality**
All information obtained during the course of this study will be kept strictly confidential. Recorded data used for the statistical analysis by STATKON will not include any information that identifies you as a participant in this study. Data that may be reported in scientific journals will not include any information that identifies you as a participant in this study.

Any information uncovered regarding your test results or state of health as a result of your participation in this study will be held in strict confidence. You will be informed of any finding of importance to your health or continued participation in this study but this information will not be disclosed to any third party without your written consent. The only exception to this rule will be cases of communicable diseases were a legal duty of notification of the Department of Health exists. In this case, you will be informed of my intent to disclose such information.
Thank you for taking the time to read this form and consider participation in this study. Should you have any concerns or queries regarding the current study, the following persons may be contacted.

Researcher: Corne Lindeque  0829453868
Supervisor: Dr I. Landman  0115596820

APPENDIX B

CONSENT FORM

Dear participant

Before signing this consent form please take your time and read the information form.

Personal doctor/specialist notification option

Please indicate below, whether you want me to notify your personal doctor or your specialist of your participation in this study:

- YES, I want you to inform my personal doctor/specialist of my participation in this study
- NO, I do not want you to inform my personal doctor/specialist of my participation in this study
- I do not have a personal doctor/specialist

Do you have any questions related to this study?
INFORMED CONSENT

- I hereby confirm that I have been informed by the researcher Corne Lindeque about the nature, conduct, benefits and risks of this study with the title a comparative study between the effects of lumbar spine manipulation versus lower extremity manipulation on the effects of agility in asymptomatic athletes.
- I have also received, read and understood the above written information (participant information leaflet) regarding this study.
- I am aware that the results of this study, including personal details regarding my sex, age, date of birth, and diagnosis will be anonymously processed into a study report.
- In view of the requirements of research, I agree that the data collected during this study can be processed.
- I may, at any stage, without prejudice, withdraw my consent and participation in this study.
- I have had sufficient opportunity to ask questions and (of my own free will) I declare myself prepared to participate in this study.

Signed Participant

Printed name                  Signature/Mark/Thumbprint                  Date and time

Signed Researcher

Printed name                  Signature                                 Date and time
Are you an athlete, interested in testing your agility?

A study done at the University of Johannesburg will be testing the effects of lumbar spine manipulation versus lower extremity manipulation on agility in asymptomatic athletes.

UJ Ethics clearance number:

For further information please contact Corne Lindeque
Tel: 0829453868
Email: c.lindeque@hotmail.co.za
APPENDIX D - INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the last 7 days. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the vigorous activities that you did in the last 7 days. Vigorous physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

1. During the last 7 days, on how many days did you do vigorous physical activities like heavy lifting, digging, aerobics, or fast bicycling?
   _____ days per week
   No vigorous physical activities *Skip to question 3*

2. How much time did you usually spend doing vigorous physical activities on one of those days?
   _____ hours per day
   _____ minutes per day
   Don't know/Not sure

Think about all the moderate activities that you did in the last 7 days. Moderate activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

3. During the last 7 days, on how many days did you do moderate physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis?
   Do not include walking.
   _____ days per week
   No moderate physical activities *Skip to question 5*
SHORT LAST 7 DAYS SELF-ADMINISTERED version of the IPAQ. Revised August 2002.

4. How much time did you usually spend doing moderate physical activities on one of those days?

______ hours per day
______ minutes per day

Don't know/Not sure

Think about the time you spent walking in the last 7 days. This includes at work and at home, walking to travel from place to place, and any other walking that you might do solely for recreation, sport, exercise, or leisure.

5. During the last 7 days, on how many days did you walk for at least 10 minutes at a time?

______ days per week
No walking Skip to question 7

6. How much time did you usually spend walking on one of those days?

______ hours per day
______ minutes per day

Don't know/Not sure

The last question is about the time you spent sitting on weekdays during the last 7 days. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

7. During the last 7 days, how much time did you spend sitting on a weekday?

______ hours per day
______ minutes per day

Don't know/Not sure

This is the end of the questionnaire, thank you for participating.
APPENDIX E

Contra-indications to CMT (Peterson and Bergmann, 2011).

Vascular Complications
- Vertebral artery syndrome
- Aneurysms

Tumours
- Primary to bone
- Secondary (metastasise to bone)

Bone infections
- Tuberculosis of the spine
- Osteomyelitis id the spine

Traumatic injuries
- Fractures
- Instabilities
- Dislocations
- Unstable spondylolisthesis

Arthritis
- Ankylosing spondylitis
- Rheumatoid arthritis
- Psoriatic arthritis
- Reiter's syndrome
- Osteoarthritis

Psychological considerations
- Malingering
- Hysteria
- Hypochondriasis
- Pain intolerance
- Dependant personality
- Disability syndromes

Neurological Complications
- Lumbar disc lesions
- Myelopathy
- Nerve root damage
APPENDIX F
Case Summary

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.

Patient: ___________________  File No: ___________

Clinician: ___________________  Signature: ___________

Student: ___________________  Signature: ___________

Height: __________  Weight: _______  Temp: _______

Rates: Heart: _______  Pulse: _______  Respiration: _______

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<th>Legs:</th>
<th>L</th>
<th>R</th>
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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°

5. Romberg’s sign
6. Pronator drift
7. Trendelenburg’s sign 8.

/ = pain-free limitation  // = painful limitation
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

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

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</table>
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
     | L | III | IV | VI | R | III | IV | VI |
     |  III | IV | VI | R | III | IV | VI |
     • 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

- tenderness
- transillumination

7. Mouth and pharynx:

- lips
- buccal mucosa
- gums and teeth
- roof
- tongue
- inspection
- movement
- taste
- palpation

8. 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°

- 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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<td></td>
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<td>Biceps C5</td>
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<td>Brachio – radialis C6</td>
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9. Peripheral vasculature:
- Inspection
  - skin
  - nail beds
  - pigmentation
  - hair loss
• Palpation - pulses: femoral
dorsalis pedis
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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• 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 pectoriloquey
        - 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
  - rosving’s sign
  - psoas sign
  - obturator sign
  - cutaneous hyperaesthesia
  - rectal exam
  - Murphy’s sign

MEITAL 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)

(ii) 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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APPENDIX H

Lumbar Regional Exam

Date: ___________________ Patient: ___________________
File No: ___________________ Signature: ___________________
Clinician: ___________________ Signature: ___________________
Student: ___________________ Signature: ___________________

A. STANDING

1. BODY TYPE
2. POSTURE
3. OBSERVATION: -

• Muscle Tone
• Bony + Soft Tissue Contours
• Skin
• Scars
• Discolouration
• Step deformity

4. SPECIAL TESTS

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

- Forward flexion = 40 - 60° (15cm from floor)
- Extension = 20 - 35°
- L/R Rotation = 3 - 18°
- L/R Lat Flexion = 15 - 20°

/ = Pain free limitation
// = Painful limitation

6. GAIT

- Rhythm, pendulousness
- On Toes (S1)
- On Heels (L4, 5)
- Halt Squat on one leg (L2, 3, 4)
- Tandem Walking

7. MOTION PALPATION – sacroiliac joints

B. SITTING

01. SPECIAL TESTS

- Tripod Test
- Kemp’s Test
- Valsalva Manoeuvre

2. MOTION PALPATION
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C. **SUPINE**

01. **OBSERVATION**

- Hair, Skin, Nails
- Fasciculations

02. **PULSES**

- Femoral
- Popliteal
- Dorsalis Pedis
- Posterior Tibial

03. **MUSCLE CIRCUMFERENCE**

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5. **ABDOMINAL EXAMINATION**

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

Comments:

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**NEUROLOGICAL EXAMINATION**

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7. SPECIAL TESTS

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

LATERAL RECUMBENT

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

- Facet joint challenge
- Myofascial Trigger points:
  - Quadratus Lumborum
  - Gluteus Medius
  - Gluteus Maximus
  - Piriformis
  - Tensor Fascia Lata
  - Hamstrings
- Skin Rolling
- Erichsen’s Test
- Sacroiliac Tenderness
- Pheasant’s Test
- Gluteal Skyline
- Myotomes:
  - Gluteus Maximus strength

NON-ORGANIC SIGNS

- Pin-point pain
- Axial Compression
- Trunk Rotation
- Burn’s Bench Test
- Flip Test
- Hoover’s Test
- Ankle Dorsiflexion Test
APPENDIX I

Hip Regional Exam

OBSERVATION

• Gait
• Posture
• Weight bearing
• Use of support
• Balance
• Proprioception (stork standing test)
• Skin
**ANTERIOR VIEW**

- Bony contours
- Soft tissue contours
- Swelling

**LATERAL VIEW**

- Buttock contour
- Hip flexion deformity
- Lumbar spine lordosis

**POSTERIOR VIEW**

- Lumbar spine scoliosis
- Body contours
- Soft tissue contours

**ACTIVE MOVEMENTS**

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**COMMENTS:**

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**PASSIVE MOVEMENTS** (note end feel and range of motion)

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**RESISTED ISOMETRIC MOVEMENTS**

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**COMMENTS:**

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(Note specific muscle involvement if applicable).
**JOINT PLAY**

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<td>Compression</td>
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<tr>
<td>Lateral distraction</td>
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**COMMENTS:**


**SPECIAL TESTS**

- Patrick – FABER test
- Tredelenberg’s test (assess hip instability)
- Craig’s test (femoral anteversion)
- Sign of the buttock (assess site of lesion)
- Thomas test (rectus femoris hypertonicity)
- Ober’s test (ITB contracture)
- Noble compression test (ITB friction syndrome) □ Piriformis test
- Hamstring contracture test

**DERMATOMES**

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<td>S4</td>
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PALPATION

ANTERIOR ASPECT

• Iliac crest
• Greater trochanter
• ASIS
• Inguinal ligament
• Femoral triangle
• Hip joint
• Symphysis pubis

POSTERIOR ASPECT

• Iliac crest
• PSIS
• Ischial tuberosity
• Greater trochanter
• Sacroiliac joints
• Sacrococcygeal joints

RADIOGRAPHIC EXAMINATION:
DIAGNOSIS:


TREATMENT PROTOCOL:


OBSERVATION

STANDING AND SEATED

ANTERIOR VIEW

• Q-angle
• Genu Varum
• Genu Valgum
• Swelling / Bony enlargements Patella position
• Tibial torsion
• Skin
POSTERIOR VIEW

- Swelling
- Skin

LATERAL VIEW

- Genu Recurvatum
- Patella Alta
- Patella Baja

General comments

ACTIVE MOVEMENTS

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<td>Extension (0° - (-)15°)</td>
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<td>Medial rotation (20° - 30°)</td>
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<td>Lateral rotation (30° - 40°)</td>
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PASSIVE MOVEMENTS
(Note end feel and range of motion)

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<td>Extension</td>
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<td>Lateral rotation</td>
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<td>Patellar movement</td>
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RESISTED ISOMETRICS - KNEE

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RESISTED ISOMETRICS – ANKLE

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<td>Dorsiflexion</td>
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LIGAMENTOUS ASSESSMENT

One - Plane Medial Instability

☐ Valgus stress (Abduction)
  - Extended
  - Resting Position

One - Plane Lateral Instability

☐ Varus stress (Adduction) - Extended
  - Resting Position

One - Plane Anterior Instability

  • Lachman Test
  • Anterior Drawer Test

One - Plane Posterior Instability

  • Posterior "Sag" Sign
  • Posterior Drawer Test
Anterior Medial Rotary Instability

• Slocum Test (Foot laterally rotated 15°)

Anterior Lateral Rotary Instability

• Slocum Test (Foot medially rotated 30°)
• Macintosh Test
• Losee test

Postero-medial Rotary Instability

• Hughston's Drawer Sign

Postero-lateral Rotary Instability

• Jacob Test
• Hughston's Drawer Sign

Tests for Meniscus Injury

• McMurray Test
• "Bounce Home" Test
• O'Donoghue's Test
• Apley's Test
• Helfet Test

Plica Tests

• Mediopatellar Plica Test
• Plica "Stutter" Test
• Hughston's Plica Test

Tests for Swelling

• Brush / Stroke Test
• Patellar Tap Test

Tests for Chondromalacia Patella

• Clarke's Sign
• McConnell's Test
Other Tests

- Wilson's Test (Osteochondritis Dessicans)
- Fairbank's Test (Patella Dislocation)
- Noble Compression Test (ITB Friction)
- Quadriceps Contusion Test
- Leg Length Discrepancy

Joint Play Movements

- Backward Movement of the Tibia on the Femur
- Forward Movement of the Tibia on the Femur
- Medial Translation of the Tibia on the Femur
- Lateral Translation of the Tibia on the Femur
- Depression (Distal Movement) of the Patella
- Antero-posterior Movement of the Tibiofibular Joint

Palpation

- Abnormal Tenderness
- Swelling □ Nodules
- Abnormal Temperature

Reflexes and Cutaneous Distribution

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<td>Medial Hamstring Reflex (L5, S1)</td>
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Dermatomes

- L2
- L3
- L4
- L5
- S1
- S2
- S3
Radiographic Examination


Diagnosis


Treatment Protocol


FOOT AND ANKLE REGIONAL EXAMINATION

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<td>Gait analysis (antalgic limp, toe off, arch, foot alignment, tibial alignment)</td>
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<td>Swelling</td>
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<td>Heloma dura</td>
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<td>Nails</td>
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<td>Shoes</td>
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**ACTIVE MOVEMENTS**

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<th>Weight bearing: Non Weight bearing:</th>
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<td>Plantar flexion <em>50⁰</em></td>
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<tr>
<td>Dorsiflexion  <em>20⁰</em></td>
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<tr>
<td>Supination</td>
</tr>
<tr>
<td>Pronation</td>
</tr>
<tr>
<td>Toe Dorsiflexion <em>40⁰ (mtp)</em></td>
</tr>
<tr>
<td>Toe plantar flexion <em>40⁰ (mtp)</em></td>
</tr>
<tr>
<td>Big toe dorsiflexion (mtp) <em>65-70⁰</em></td>
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<td>Big toe plantar flexion (mtp) <em>45⁰</em></td>
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<tr>
<td>Toe abduction + adduction</td>
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<tr>
<td>5⁰ first ray dorsiflexion</td>
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<tr>
<td>5⁰ first ray plantar flexion</td>
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**RESISTED ISOMETRIC MOVEMENTS**

<table>
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<tr>
<th>Knee flexion</th>
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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 _________________________________
Subtalar joint: Varus __________ Valgus __________________________
First ray: Dorsiflexion ___________ Plantarflexion _______________
Circumduction of forefoot on fixed rearfoot: _________________________
Midtarsal: A-P glide _______________ P-A glide __________________
rotation _____________ P-A glide __________________
Intennetatarsal glide: __________________________________________
Metatarsophalangeal dorsiflexion (with associated plantar flexion of each
toe) ________________________________________
Interphalangeal joints: long axis distration _________________________
A-P glide ___________________ lat and med glide __________________

SPECIAL TESTS

Anterior drawer test:

Talar tilt

Thompson test

Homan sign

Tinel's sign

Subtalar neutral position

Balance/proprcoception

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 maleoli

Med tarsal bones, tibial (post) artery

Lat. malleollous, cacaneus, sinus tarsi, and cuboid bones

Inferior, tib/fib joint, tibia, mm of leg

Anterior tibia, neck of talus, dorsalis pedis artery

Posteriorly
Calcaneus

Achilles tendon

Musculotendinous junction

Plantarily
Plantar muscle and fascia

Sesamoids
CHIROPRACTIC DAY CLINIC SOAP NOTE:

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S:  

O:  

A:  

P:  

Comments: 

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_________________________________________
APPENDIX M

Vertical Jump test Recording Sheet: Pre-Intervention

Participant Number: __________________________

Table 1: Jump Height

<table>
<thead>
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<td>Consultation 4:</td>
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Table 2: Jump Velocity

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<tbody>
<tr>
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Table 3: Jump Torque

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APPENDIX N

Vertical Jump test Recording Sheet: Post-Intervention

Participant Number: __________________________

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Table 2: Jump Velocity

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Table 3: Jump Torque

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APPENDIX O

Illinois' Test Recording Sheet: Pre-Intervention

Participant Number: __________________________

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Illinois' Test Recording Sheet: Post-Intervention

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Appendix P - Ethics Clearance Letter

UNIVERSITY OF JOHANNESBURG

FACULTY OF HEALTH SCIENCES

RESEARCH ETHICS COMMITTEE
NHREC Registration no: REC-241112-035

REC-01-208-2015
31 - JULY- 2015

TO WHOM IT MAY CONCERN:

STUDENT: LINDEQUE, C
STUDENT NUMBER: 201029650

TITLE OF RESEARCH PROJECT: “The Effects of Lumbar Spine Manipulation Versus Lower Extremity Manipulation on Agility in Asymptomatic Athletes”

DEPARTMENT OR PROGRAMME: CHIROPRACTIC
SUPERVISOR: Dr DM Landman CO-SUPERVISOR:

The Faculty Research 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 REC would like to extend their best wishes to you with your postgraduate studies.

Yours sincerely,

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

Turnitin Report

Dissertation BY GC LINDEQUE 9/28/2015

Originality 14% SIMILAR

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