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THE EFFECT OF SPINAL MANIPULATIVE THERAPY ON HOCKEY PLAYERS WITH LUMBO-SACRAL FACET JOINT DYSFUNCTION ON THE SPEED OF A HOCKEY BALL

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

Bernadette Coston
(Student number: 200811208)

Supervisor: _______________________    Date: ___________________

Dr. D.M. Landman

Johannesburg, 2015
DECLARATION

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

I, __________________________________________

(Signature of the candidate)

On this _____ day of __________________, 20___
DEDICATION

I dedicate this dissertation to God for all the talents He blessed me with and to my loving family Herby, Linda, Charne’ and Sean Coston. They have supported and encouraged me, in not only my hockey career, but through all the ups and downs in the years of my studies. Without them I would not be where I am today.

Love You Plenty!

Bernie
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I would like to give a special thank you the University of Johannesburg 1st Team Ladies of 2015 for taking time out of their schedules to be part of my research.

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Thank you Anesu Kuhudzai at STATKON for all the assistance with my stats.
ABSTRACT

Field hockey is becoming an increasingly popular sport amongst men, women and children worldwide. A two-handed swinging motion is used during a field hockey hit to produce high ball velocity making it an effective selection for long distance passing or for shooting at goal. The maximum possible speed needs to be produced, at the end of the distal kinematic chain, during a field hockey hit. The effectiveness of the latter is dependent on the movement of each involved body segment in relation to the next proximal segment.

Purpose: The aim of this study was to determine whether chiropractic spinal manipulation delivered to the lumbar spine (L/S) and/or sacroiliac joint (SIJ), would have an effect on the speed of a hockey ball when hit by a field hockey player. It was postulated that by increasing the lumbar spine and SIJ range of motion in hockey players experiencing dysfunction in either of these areas and therefore decreasing any pain, will allow field hockey players to increase the ball speed during a hockey hit. This would strongly suggest that by restoring the L/S and SIJ dysfunction through a chiropractic manipulation, chiropractic treatment could be a beneficial requirement to the game of field hockey.

Method: The participants for this study were recruited mainly from the University of Johannesburg (UJ) Hockey Club. The players at this institute are currently playing at club, provincial and national levels.

Thirty national, provincial or club participants, that met the selection criteria, were randomly allocated into two equal groups. Group 1: treatment group and Group 2: control group. Group 1 participants were motion palpated and the lumbar and/or sacroiliac restrictions were manipulated, while the Group 2 participants received no chiropractic treatment or manipulation.
Consultations for both groups occurred over a two week period with the treatment group receiving two manipulations per week.

The data was captured during all four consultations over the two week period. Readings were recorded before each consultation followed by motion palpation and manipulation or no treatment, depending on their respective groups. Data capturing consisted of two objective measurements: digital inclinometer measurements (degrees) of the lumbar spine range of motion and radar gun speed (km/h) readings taken once the hockey ball was hit.

**Results:** A majority of the data obtained in this study showed it was not statistically significant for either of the groups. From a clinical perspective there was a definite effect on the lumbar spine range of motion and unfortunately little effect was showed regarding the ball speed.

**Conclusion:** The final results obtained after the completion of the study indicated that chiropractic manipulation applied to a dysfunctional joint/s in the L/S or the SIJ did not have any effect on the speed of the hockey ball when hit by male or female hockey players. Thus, there was no correlation between the biomechanics of the L/S and SIJ alone and the speed at which a hockey ball gets hit.
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CHAPTER ONE:
INTRODUCTION

UNIVERSITY
OF
JOHANNESBURG
1.1 Introduction

Field hockey is becoming an increasingly popular sport amongst men, women and children worldwide. A two-handed swinging motion is used during a field hockey hit to produce high ball velocity making it an effective selection for long distance passing or for shooting at goal (Willmott and Dapena, 2012). The maximum possible speed needs to be produced, at the end of the distal kinematic chain, during a field hockey hit. The effectiveness of the latter is dependent on the movement of each involved body segment in relation to the next proximal segment (Zatsiorsky, 2000).

Little research, if at all, has been done on the effects of increased lumbar spine (L/S) and sacroiliac joint (SIJ) range of motion (ROM) on the speed of a hockey ball. Gorman (2012), suggested that the momentum is transferred from the front foot to the back foot and then back to the front foot again while accompanied by the rotation of the hips and shoulders at the end of the backswing phase. According to Willmott and Dapena (2012), the planar stick face motion of a field hockey hit, consisting of a curved backwards then downwards motion followed by a forward swing in a single oblique plane, appears to be similar to that of the planar club head motion in golf and therefore the biomechanics involved will be similar. During the downswing most of the speed is added to the stick face (Willmott and Dapena, 2012).

Earlier rotation of the hips in a backwards direction towards the target line promotes the stretch-shortening cycle (SSC) activity of the muscles involved and therefore allows the ball to be hit over greater distances (Gorman, 2012). Most of the power produced in a hockey hit is derived from the lower limb, trunk and upper limb rotations respectively (Zatsiorsky, 2000), but according to Tsai (2005), any rotation or bending movement in the trunk will lead to rotation and bending in the L/S.
In the study completed by Rebelo, Pyper and Hollinshead (2010), it stated that biomechanical stresses can be transferred among a kinematic chain and are linked in function and dysfunction. The L/S and SIJ are subjected to large forces due to their location in the body and are therefore more prone to injury and dysfunction. The SIJ, lumbo-sacral joint, pubic symphysis and hip joints are all linked and connected (Moore, Dalley and Agur, 2010) and therefore any abnormality or dysfunction in one unit will lead to a compensatory reaction in another unit, sometimes in a painful manner (Rebelo, Pyper and Hollinshead, 2010).

1.1.1 Aim of the study

The aim of this study was to determine whether chiropractic spinal manipulation delivered to the L/S and/or SIJ, would have an effect on the speed of a hockey ball when hit by a field hockey player.

1.1.2 Possible outcomes

It was postulated that by increasing the L/S and SIJ ROM in hockey players experiencing dysfunction in either of these areas and therefore decreasing any pain, will allow field hockey players to increase the ball speed during a hockey hit. This would strongly suggest that by restoring the L/S and SIJ dysfunction through a chiropractic manipulation, chiropractic treatment could be a beneficial requirement to the game of field hockey.

1.1.3 Benefits of the study

To encourage further research on the effects and benefits that chiropractic manipulation has on field hockey players in order to provide better understanding and insight regarding the biomechanics associated with a hockey swing and the role that the SIJ and lumbar facet joints play during the field hockey hit.
Also to validate the need of chiropractors, not only as general health care practitioners, but in the professional and amateur setting of field hockey to expose the benefits that chiropractic treatment has in the maintenance of their players.
CHAPTER TWO:

LITERATURE REVIEW
2.1 Introduction

Anabolic steroids were started being used in the 1950’s to increase the performance of elite athletes. Today steroids are available to anyone (even children) and can be used to enhance performance in various amounts of sports (Dawson, 2001).

The natural capabilities of athletes are under threat in a way as their natural talent is not enough to compete in certain events anymore due to the use of illegal steroids by other participants (Dawson, 2001). Therefore athletes, who do not use drugs, need to be at an optimum level of performance in order to compete. It is thus important as a chiropractor to look at the athletes’ body as a unit to enhance their performance through a natural approach. Thus, looking at their health and nutrition, but most importantly at their physicality by reducing dysfunctionality related to their biomechanics which may lead to muscular or joint injury causing reactive pain.

It is believed by Rebelo, Pyper and Hollinshead (2010), that biomechanical forces are transmitted among a chain consisting of units. These units are linked in function and dysfunction. The pelvic girdle (two ilia, SIJ and pubic symphysis), lumbo-sacral joint and the two hip joints are all biomechanically linked (Moore, Dalley and Agur, 2010) and therefore any dysfunction in the lumbar or sacroiliac movement will cause a compensatory change in a different motion segment or joint resulting in restricted ROM in a certain plane (Rebelo, Pyper and Hollinshead, 2010).

The purpose of this study was to indicate the major impact that biomechanical function had on the proper functioning of the lumbar vertebral segments, lumbo-sacral joint and SIJ in a hockey swing, considering that these units are linked in both function and dysfunction, therefore dysfunction in one joint or segment would lead to dysfunction in the adjacent joint or segment resulting in decreased ROM, pain and muscle spasm. To
understand these concepts the anatomy, neurology and biomechanics of the L/S and SIJ is explained.

2.2 Anatomy of the Lumbar Spine and Sacroiliac Joint

2.2.1 Structure of the lumbar spine

The L/S consists of 5 vertebrae (L1 – L5) and bears tremendous loads generated by the body weight (Martini and Nath, 2009). The L/S is mainly responsible for trunk mobility increasing the mechanical stress on this region (Peterson and Bergmann, 2011).

Each lumbar vertebra is kidney-shaped but L5 is described as an atypical lumbar vertebra as it has a very large circumference compared to L1 – L4 (Moore, Dalley and Agur, 2010). The L5 vertebra is thicker anteriorly compared to its posterior aspect but its body is somewhat thinner compared to the other lumbar vertebrae (Peterson and Bergmann, 2011) and is therefore responsible for the lumbosacral angle formed between the lumbar region and sacrum (Moore, Dalley and Agur, 2010). The L5 vertebra has bilateral transverse processes, projecting horizontally, that are short and thick in nature (Peterson and Bergmann, 2011), while the L1 – L4 transverse processes are long and slender (Levangie and Norkin, 2011). The spinous process of L5 is also described as being shorter and rounder compared to the L1 – L4 lumbar vertebrae spinous processes (Peterson and Bergmann, 2011).

Lumbar pedicles originate from the superior aspects of each vertebrae and run laterally and posteriorly. The lumbar laminae originating from each pedicle are short and strong and run vertically (Levangie and Norkin, 2011). Each spinous process (excluding L5) is broad and thick and appear hatchet in shape pointing directly posteriorly. Each vertebral transverse process, originating from the junction of the laminae and pedicle, is long and flattened.
anteriorly and posteriorly (Peterson and Bergmann, 2011) and projects posteriorly, superiorly and laterally (Moore, Dalley and Agur, 2010).

The superior articular processes of the lumbar vertebrae face posterior and medially and are concave while the inferior articular processes face anterior and laterally and are convex (Peterson and Bergmann, 2011). Mammillary processes, which are unique to the L/S, originate at the superoposterior edge of each superior articular process (Moore, Dalley and Agur, 2010).

The lumbar facets lie in a sagittal orientation but become more coronal distally at the lumbosacral junction (L5/S1 facets) (Moore, Dalley and Agur, 2010). The union of the inferior articulating facet (faces laterally) of the superior lumbar vertebra and the superior articulating facet (faces medially) of the inferior lumbar vertebra form a facet joint covered by an articular capsule filled with synovial fluid and allows flexion, extension and lateral flexion while limiting rotation (Peterson and Bergmann, 2011).

The intervertebral foramina (IVF) of the L/S are triangular in shape and are larger than the thoracic IVF’s, but smaller than the cervical IVF’s (Levangie and Norkin, 2011).

According to Peterson and Bergmann (2011), between each lumbar vertebrae exists an intervertebral disc (IVD). Due to its disc height-to-body ratio (1:3) the L/S allows for more movement than in the thoracic spine. The layers of fibers of the lamellae forming the discs are arranged in opposite directions leading to resistance of tensile forces in almost all directions (Levangie and Norkin, 2011).

Posteriorly to each vertebral body is a spinal canal containing and protecting the conus medullaris (distal lumbar enlargement of spinal cord) proximally and the cauda equina distally (Peterson and Bergmann, 2011).
2.2.2 Accessory ligaments of the facet joints

*Ligamentum flavum*

These are elastic, thick and pale yellow bands that connect the laminae of adjacent vertebral arches (Standring, 2008). By joining the vertebrae it forms a fan-like arrangement and forms part of the posterior wall of the vertebral canal (Moore, Dalley and Agur, 2010).

These ligaments are mainly responsible for limiting abrupt flexion, therefore decreases the risk of IVD injury, for maintaining the normal curvature of the vertebral column (Moore, Dalley and Agur, 2010) and according to Standring (2008), prevents the partitioning of the adjacent vertebrae during spinal flexion and also helps with the return of the spine to an erect posture.

The ligamentum flavum is quite thin in the cervical spine, becomes thicker in the thoracic spine but is the thickest in the L/S (Moore, Dalley and Agur, 2010). This ligament is weakest in the mid-cervical spine and the strongest in the lower thoracic spine (Levangie and Norkin, 2011).

*Interspinous ligaments*

These ligaments run between and connect the spinous processes of adjacent vertebrae from the apex to the root of each spinous process (Levangie and Norkin, 2011). Occasionally a bursa can also be found between these ligaments (Peterson and Bergmann, 2011). The interspinous ligament runs anteriorly as far as the ligamentum flavum and posteriorly to the supraspinous ligament (Standring, 2008).

In the thoracic spine these ligaments are thin and long compared to the interspinous ligaments in the L/S which are quadrilateral and thick in nature (Standring, 2008). The interspinous ligaments, along with the supraspinous
ligaments, are the first to get damaged during excessive flexion (Levangie and Norkin, 2011).

**Supraspinous ligaments**

The supraspinous ligament is described as being cord-like and runs from the tip of each spinous process (starting at C7) to the sacrum (Levangie and Norkin, 2011). This ligament continues above C7 with the nuchal ligament at the back of the cervical spine (Moore, Dalley and Agur, 2010).

The supraspinous ligament consist of a superficial layer – extending over three or four vertebrae, an intermediate layer – extending over two or three vertebrae and a deep layer of fibers – extending over adjacent vertebrae and is continuous with the interspinous ligament (Standring, 2008).

**Intertransverse ligaments**

According to Peterson and Bergmann (2011), the intertransverse ligaments run between adjacent transverse processes and are quite thin in nature.

These ligaments have scattered fibers in the cervical spine, fibrous cords in the thoracic spine and become thin and membranous in nature in the lumbar region (Moore, Dalley and Agur, 2010).

**2.2.3 Blood supply to the lumbar vertebrae, facet joints and intervertebral disc**

The lumbar vertebrae, facet joints and IVDs’ blood supply (Figure 2.1), is derived from dorsal branches of intersegmental somatic arteries. These dorsal branches continue into the L/S and are now called posterior intercostal and lumbar arteries. The primitive supply is derived from the descending aorta where the lumbar segmental arteries arise in pairs. These
pairs of arteries run around each side of the vertebral body each giving rise to primary periosteal and equatorial branches as well as a major dorsal branch. This dorsal branch gives off a spinal branch which extends into the IVF supplying the facet joints, posterior aspect of the laminae and the overlying musculature and skin. The spinal arteries further splits into 3 branches (Standring, 2008):

- **Post central branch**: supplies the vertebral bodies, dura, anterior epidural tissues and the periphery of the IVD’s
- **Pre laminar branch**: supplies the vertebral arches, majority of the dura, posterior epidural tissues and ligamentum flavum
- **Radicular branch**: supplies the spinal cord and its nerve roots

*Figure 2.1: Blood supply of the lumbar vertebrae (Moore, Dalley and Agur, 2010)*
2.2.4 Innervation of the lumbar facet joint and intervertebral disc

Each facet joint capsule is innervated with both nociceptors, responsible for pain, and mechanoreceptors, responsible for proprioception. The facet joint is thus able to respond to different combinations of tension and compression as a result of different postures or while doing physical activities (Peterson and Bergmann, 2011).

The facet joints are supplied by the dorsal rami of the spinal nerves that gives off medial branches with articular branches which supplies the facet joint above and below (Standring, 2008).

The peripheral third of the lumbar IVD is supplied by the sinuvertebral nerve which will supply the disc at its level of origin as well as the disc above. The inner two-thirds of the disc is not innervated. The anterior annulus fibrosis is not supplied by the sinuvertebral nerve, but by the grey ramus communicans (sympathetic innervation) (Standring, 2008).

2.2.5 Structure of the sacroiliac joint

The SIJ is described by Cohen (2005), as being the largest axial joint in the human body. This joint varies in size, shape and surface contour amongst different individuals and also according to age. During adolescence the iliac surface is dull and rough and coated with fibrous plaques. As a person gets older, around 30 – 40 years of age, the changes accelerate and the iliac surface becomes irregular due to crevice formation and clumping of chondrocytes. These degenerative changes are usually more visible on the iliac side as the ilia are more mobile (Cohen, 2005).

The sacrum consist of five sacral segments, all fused to each other. These sacral segments are triangular in shape giving the sacrum a wedge-shaped appearance inserted between the two ilia. The L5 lumbar vertebra
articulates with two superior facets on the sacral base, whereas the sacral apex articulates with the coccyx inferiorly by means of a small disc which dissipates later in life and the coccyx and apex then fuse. Sacral tubercles are located along the midline of the sacrum and correlate with the spinous processes of the fused vertebrae and are also located posterolateral and correlate with the transverse processes (Peterson and Bergmann, 2011).

The inferior two-thirds of the SIJ is described by Haldeman (2005), as being a true synovial joint while the superior third is fibrous. The articular surface of the sacrum is auricular in shape or C-shaped (Haldeman, 2005) and has different contours for interlocking with the ilia (Peterson and Bergmann, 2011).

According to Haldeman (2005), the anterior capsule has an outer fibrous layer that is well developed. The thickened middle part of this capsule forms the anterior sacroiliac ligament.

The posterior capsule is not as well developed as the anterior part or may even be absent. If the posterior capsule is absent the interosseous ligament lines the posterior aspect of the SIJ (Haldeman, 2005).

The sacrum functions to stabilise and provide strength to the pelvis and it also transmits the body weight through the pelvic girdle (formed by the left and right ilia and the sacrum forming a ring) to the lower limbs. A sacral canal also exists in the sacrum which is a continuation of the vertebral canal and contains the cauda equina. Four pairs of sacral foramina are located in the pelvic and posterior surface of the sacrum and allows the exit of the anterior and posterior rami of the spinal nerves (Moore, Dalley and Agur, 2010).
2.2.6 Capsular and accessory ligaments

The main function of the ligamentous structures around the SIJ (Figure 2.2), is to limit excessive movement in all planes of movement. Most of the ligaments are present posteriorly where they are needed for support and acts as a connecting band between the sacrum and ilia (Cohen, 2005).

Capsular ligaments include: anterior and posterior sacroiliac ligaments and interosseous ligaments while accessory ligaments include: iliolumbar ligaments, sacrospinous and sacrotuberous ligaments (Dutton, 2012).

*Posterior sacroiliac ligament*

This is quite a long ligament with a proximal attachment to the sacrum and a distal attachment to the iliac tuberosity and posterior superior iliac spine (PSIS). This ligament is continuous laterally with the sacrotuberous ligament and also joins the thoracolumbar fascia medially. The main function of the posterior sacroiliac ligament is to limit excessive anterior movement of the sacral base (Peterson and Bergmann, 2011).

According to McGrath and Zhang (2005), the long posterior sacroiliac ligament runs between the PSIS and the 3rd and 4th sacral tubercles posterior to the SIJ and limits rotations at the SIJ. It was found that the sacral blood vessels and dorsal sacral rami separates the posterior sacroiliac ligament from the interosseous ligament (Haldeman, 2005), while the lateral branches of the dorsal rami of S1 (rarely), S2, S3 and S4 penetrates the posterior sacroiliac ligament (McGrath and Zhang, 2005).

*Anterior sacroiliac ligament*

The anterior sacroiliac ligament is located at the lateral edge of the sacrum and runs to the auricular surface of the ilium. This ligament is made up of
multiple bands (Peterson and Bergmann, 2011) and according to Moore, Dalley and Agur (2010), this ligament is thin and makes up the anterior part of the fibrous SIJ capsule and is also in close relation with the anterior fibers of the iliolumbar ligament (Haldeman, 2005).

This ligament is also prone to injury due to its thin nature and therefore is also a source of pain in the SIJ area (Dutton, 2012).

**Interosseous ligament**

This ligament is considered the strongest ligament in the body (Haldeman, 2005). It lies deep to the posterior sacroiliac ligament and is the main connecting structure between the sacrum and ilium and is located between the iliac tuberosity and lateral sacral crest, posterior and superior to the SIJ. This ligament consists of deep fibers running superiorly and inferiorly and superficial fibers connecting the sacrum and ilium superiorly and posteriorly and is described as a fibrous sheet (Dutton, 2012).

The interosseous ligament functions to stabilise the SIJ by limiting anterior and inferior movement of the sacrum (Moore, Dalley and Agur, 2010).

**Sacrospinous ligament**

The sacrospinous ligament is a triangular shaped ligament extending from the lower lateral edge of the sacrum and the superior part of the coccyx to the ischial spine (Peterson and Bergmann, 2011). It lies anterior to the sacrotuberous ligament where it blends with the latter and attaches to the SIJ capsule (Dutton, 2012).

According to Moore, Dalley and Agur (2010), the sciatic notch is divided into a greater and lesser sciatic foramina by the sacrotuberous and sacrospinous ligaments.
**Sacrotuberous ligament**

It runs from the lower sacrum obliquely inferior to attach to the ischial tuberosity. The sacrotuberous ligament is also continuous inferiorly with the biceps femoris tendon (Peterson and Bergmann, 2011) and due its strong nature is able to limit nutation and counteract the superior and posterior movement of the sacral apex during weight bearing (Dutton, 2012).

**Iliolumbar ligament**

According to Haldeman (2005), the iliolumbar ligament is attached to the tip of the TVP of L5 and runs laterally to attach to the pelvis via two bands. The lower band runs from the TVP and body of L5 to the posterior margin of the iliac fossa by crossing the anterior sacroiliac ligament. The upper band forms part of the quadratus lumborum attachment and runs to the iliac crest. This band is also continuous superiorly with the anterior layer of the thoracolumbar fascia.
Figure 2.2: Ligaments of the lumbar spine and sacroiliac joint
(Netter, 2006)
2.2.7 Blood supply to the sacroiliac joint

The sacral plexus, along with the lumbar plexus, is supplied with blood by branches from the internal iliac artery (iliolumbar artery, superior and inferior gluteal arteries and the lateral sacral artery) and by the deep iliac circumflex artery (Dutton, 2012).

2.2.8 Innervation to the sacroiliac joint

The SIJ has nociceptors embedded in the joint capsule and send pain signals via unmyelinated nerve fibers to the spinal cord (Haldeman, 2005).

According to Haldeman (2005), L2 – S4 nerve roots are responsible for segmental innervation of this joint:

- L4 - L5: usually innervates the anterior portion of the SIJ
- S1 - S2 lateral branches of the primary rami: innervates the posterior aspects of the SIJ, the rudimentary capsule as well as the interosseous ligament

The innervation may not be identical bilaterally and can be asymmetrical within the same individual (Haldeman, 2005).

2.3 Lumbar Spine and Sacroiliac Joint Biomechanics

2.3.1 Lumbar spine biomechanics

Lumbar spine biomechanics occur in three different planes (Figure 2.4):

- sagittal plane (flexion and extension)
- coronal plane (lateral flexion or side bending)
- transverse plane (rotation) (Dutton, 2012)
Segmental flexion and extension (Figure 2.3), average 15 degrees per segment and become increasingly more toward the SIJ. Sagittal plane rotation and 2 – 3 mm of translation occurs during lumbar flexion and extension (Peterson and Bergmann, 2011).

When the L/S flexes, the lumbar lordosis straightens and the involved vertebra will slide and tilt anteriorly (Levangie and Norkin, 2011), while the inferior articular facet moves upward (superiorly) and backward (posteriorly) from the superior articular facet of the vertebra below (Dutton, 2012), leading to a resisted separation of the spinous processes, of the vertebra above and below, through the action of the interspinous ligament and supraspinous ligament (Levangie and Norkin, 2011). During flexion the IVD will be compressed anteriorly pushing the nucleus pulposus posteriorly and stretching the posterior aspect of the disc and the posterior longitudinal ligament (Peterson and Bergmann, 2011).

The opposite occurs during extension (Levangie and Norkin, 2011). The inferior and superior articulating facets will approximate while the vertebra slides and tilts posteriorly (Dutton, 2012). The IVD, anterior facet joint capsule and anterior longitudinal ligament will be stretched anteriorly while the posterior aspect of the IVD will be compressed pushing the nucleus pulposus anteriorly (Peterson and Bergmann, 2011).

According to Haldeman (2005), isolated global motions like flexion, extension, lateral flexion and rotation occurs about certain axes (x, y and z) and are explained as coupled segmental motions dominated by rotation around a certain axis.

During flexion and extension of the lumbar spine, segmental rotation occurs about the x-axis and translation occurs along the z-axis (Haldeman, 2005).
Lateral Flexion

Lateral flexion will average about 6 degrees of movement and occurs the least at the lumbosacral junction. During lateral flexion of the L/S, a contra-lateral rotation will occur and is called a coupled movement (Peterson and Bergmann, 2011).

When the L/S laterally flexes, the vertebra will slide and tilt toward the side of lateral flexion (side of concavity) (Levangie and Norkin, 2011), while the IVD gets compressed on the ipsi-lateral side and the annulus fibrosis gets stretched on the opposite side of lateral flexion (Dutton, 2012). The facet joint will approximate on the concave side while the contra-lateral facet joint together with the intervertebral transverse ligament, ligamentum flavum and capsular ligaments will be stretched on the convex side (Peterson and Bergmann, 2011).
As mentioned in flexion and extension, lateral flexion is seen as a coupled segmental motion where segmental rotation occurs about the z and x axes, while translation occurs along the x-axis (Haldeman, 2005). The direction of rotation differs from region to region in the vertebral column as the facets are differently orientated from proximal to distal (Levangie and Norkin, 2011).

Rotation

Rotation is the most limited movement in the L/S averaging 2 degrees of movement per motion segment due to the sagittal orientation of the facet joints (Peterson and Bergmann, 2011).

During rotation, the facet joints will approximate on the opposite side of rotation while they separate on the side of rotation (Dutton, 2012). As mentioned earlier, rotation and lateral flexion is a coupled movement but the coupled movement differs according to the segmental level. L1 – L3: rotation coupled with contra-lateral lateral flexion and L4 – L5: rotation coupled with ipsi-lateral lateral flexion. A transitional change occurs at L4/L5 and therefore this level is predisposed to degenerative changes, increased torsional stress and instability (Peterson and Bergmann, 2011).

Haldeman (2005), explains that rotation dominates the coupled segmental motions and states that segmental rotation occurs about the y-axis and auxillary rotation occurs about the x and y axes.
2.3.2 Sacroiliac joint biomechanics

The movement within the SIJ is very small and is described by Haldeman (2005), as a very stable joint due to its shape and interlocking surfaces and the presence of dense and strong ligaments around the joint. The SIJ acts more like a shock absorber and will therefore transmit and dissipate forces occurring between the trunk and lower limbs (Haldeman, 2005).

Asymmetrical motion also referred to as antagonistic motion occurs during locomotion and unilateral leg stance (Rebelo, Pyper and Hollinshead, 2010). The SIJ is considered to be most active during locomotion where the movement occurs mostly in the oblique sagittal plane. Flexion and extension occurs at the SIJ in unison with the corresponding hip joint (Peterson and Bergmann, 2011).
During the asymmetrical motion of ambulation, two full cycles of flexion and extension occurs at the SIJ (Figure 2.5). When flexion or extension occurs in one joint, the opposite movement will occur at the other SIJ. Compensatory actions also occur at the sacrum and lumbosacral junction for the absorption of the pelvic torsion caused by the opposing flexion and extension movements (Peterson and Bergmann, 2011).

Symmetrical motion also occurs at the SIJ usually while sitting, standing or forward flexion of the trunk and according to Peterson and Bergmann (2011), this is also referred to as pure sagittal plane movements of the SIJ.

Nutation (Figure 2.6), involving the anterior and inferior movement of the sacral promontory and the posterior movement of the coccyx, will lead to a decrease in the anterior to posterior diameter of the pelvic brim and an increase in the anterior to posterior diameter of the pelvic outlet. The opposite occurs in counter-nutation (Figure 2.6), involving the posterior and inferior sacral promontory movement and the anterior movement of the
coccyx, leading to a larger pelvic brim diameter and a smaller pelvic outlet diameter (Levangie and Norkin, 2011).

SIJ movement is summed up by Peterson and Bergmann (2011) as follows:

- Flexion of the innominate (at the SIJ): PSIS moves posterior and inferior and the sacral base moves anterior and inferior.
- Extension of the innominate (at the SIJ): PSIS moves anterior and superior and the sacral base moves posterior and superior.

*Figure 2.6: Illustration of nutation (A) and counter-nutation (B) (Levangie and Norkin, 2011)*
2.4 Biomechanical Actions and Principles Related to the Hockey Swing

2.4.1 Lumbar spine and sacroiliac joint biomechanics in the hockey swing

According to Willmott and Dapena (2012), the planar stick face motion of a field hockey hit, consisting of a curved backwards then downwards motion followed by a forward swing in a single oblique plane, appears to be similar to that of the planar club head motion in golf and therefore the biomechanics involved will be similar. The hockey drive is reported by Bretigny, Seifert, Leroy and Chollet (2008), to be performed in the same manner as a golf swing.

The L/S is able to endure forces related to flexion, bending and rotation movements associated with every day activities. During a golf or hockey swing these forces on the L/S are increased dramatically (Daddio, 2012). Tsai (2005), explained three main forces involved in a golf or hockey swing and they include: compression force, anterior-posterior shear force and lateral shear force.

Rapid bending and rotation of the trunk is required for a proper golf and hockey swing, therefore it will lead to bending and rotation of the L/S. Spinal moments were also identified and they include: flexion-extension, lateral bending and vertical rotation moments especially at the L5/S1 segment (Tsai, 2005).

Tsai (2005), suggested that the upper trunk and body will rotate to the right (in a right handed player) on the hips and pelvis (SIJ) when the backswing occurs followed by a forceful uncoiling during the follow through in order to impact the ball.
The pelvis (SIJ) remains restricted when the upper trunk rotates during the backswing. At the start of the downswing the pelvis rotates forward leading to increased torque caused in the L/S segments. The downswing leads to lateral lumbar bending and an increased rotation moment in the L/S. At the end of the follow through the L/S will be in a hyperextended position (due to trunk hyperextension) (Tsai, 2005).

According to Tsai (2005), reverse trunk inclination (product of the trunk flexion and lateral bending angles) occurs during the downswing and will cause the L/S to react by bending laterally to the right while the hips are pushed back laterally toward the ball. This action will cause the spine and torso to return to its original inclination and will also lead to increased spinal rotation and shear forces acting on the motion segments.

According to Le Roux and Korporeaal (2008), the biomechanics of the golf swing (related hockey swing) can be describe in 3 phases (Figure 2.7):

**Phase 1: The Backswing**

The knees, hips, L/S and shoulders all rotate during the backswing. The arms and shoulders move as a unit due to minimal rotation of the pelvis and minimal body weight shifting to the right. At the most extreme point of the backswing, the L/S will be in a hyper-rotated position with the posterior aspect of the thoracic spine and shoulders facing the ball. Maximal spinal rotation to the right and the transfer of the body weight is achieved at this stage.

**Phase 2: The Downswing**

Described as having a pre-impact and impact phase. During the pre-impact phase the downswing is initiated by the contraction of the right external oblique muscle and leads to rotation ad flexion of the L/S. The L/S is
stabilised during this phase by the action of the left and right paraspinal muscles (multifidus) and also opposes excessive lumbar flexion. Once contact is made with the ball, the left hip (SIJ) rotates.

During the impact phase the left hip is rotated when contact with the ball is made. Further rotation and flexion of the L/S occurs in this phase due to the previously mentioned muscle activities. The L/S has now changed from a hyper-rotated state to an almost neutral position.

**Phase 3: The Follow-Through**

During the follow-through the right hip is medially rotated and therefore completes the hip rotation. The L/S continues to rotate and will now hyperextend while the body weight is completely transferred from the right to the left hand side. The end of this phase is described as the “C”-position due to the hyperextended nature of the spine and maximal rotation of the spine to the left.

*Figure 2.7: Phases of a hockey swing (Bretigny et al., 2008)*
2.5 Chiropractic Related Terms, Effects and Benefits

2.5.1 Chiropractic subluxation

It is defined as an abnormality of the biomechanics between vertebrae leading to compression of spinal nerve roots causing abnormal nerve root function and in turn leading to pain or pathology (Haldeman, 2000). According to Ernst (2008), a chiropractic subluxation is the misalignment of a single vertebrae leading to spinal nerve root impingement.

Gatterman (2005), explained that there are different types of subluxations. He defines a chiropractic subluxation as a lesion that is less than a dislocation. He also states that a manipulative subluxation exists, which is a dysfunction of a joint, treatable by a chiropractor. A subluxation complex is known as a theoretical model illustrating the effects of a subluxation (Gatterman, 2005).

Gatterman (2005), came to a final definition of a chiropractic subluxation and defined it as a motion segment where the ROM, alignment and/or physiological function changes but the joint surfaces still remain in partial contact.

2.5.2 Chiropractic spinal manipulative therapy

A chiropractic manipulation is defined as a high velocity, low amplitude thrust (HVLAT) applied to a specific vertebral segment (Oldham, Potter and McCarthy, 2005).

According to Gatterman (2005), it is when a direct thrust is applied to a joint in order to move it past its physiological ROM without damaging joint structures.
Spinal manipulation is also defined by Peterson and Bergmann (2011), as a technique where the hands are applied to a specific area to mobilise, adjust, manipulate, distract or stimulate the joints.

2.5.3 Effects and benefits related to spinal manipulative therapy

Mechanical effect

Periarticular fibrosis, adhesions and interarticular blocks - Spinal manipulative therapy (SMT) results in the breaking of fibrous adhesions within the joint resulting in increased ROM. It is also believed that entrapped small tags are released from the joint capsule during a manipulation (Dagenais and Haldeman, 2002).

Decreased joint ROM occurs due to internal synovial joint dysfunction. A pinched or entrapped synovial fold or facet joint traction may lead to pain, reactive muscle spasm and decreased joint movement. When a manipulation is applied to the affected area, distraction on the involved joint occurs leading to the release of the previously entrapped fold causing a decrease in the pain and muscle spasm which will result in increased joint ROM (Peterson and Bergmann, 2011).

Cavitation - It is also stated by Oldham, Potter and McCarthy (2005), that distraction (separation) of the joint occurs during SMT leading to a cavitation. A cavitation is an audible cracking or popping sound that can be heard due to peripheral joint gas accumulation within that joint causing the pressure to drop and forming a cavity (Dagenais and Haldeman, 2002).

Muscular spasm - Hypertonic muscles, caused by direct irritation, indirect stimulation or trauma to the myofascial and associated articular structures, may cause joint dysfunction leading to pain. Tearing or overstretching of
these structures will lead to the activation of the nociceptors and will cause protective muscle spasms (Peterson and Bergmann, 2011).

According to Peterson and Bergmann (2011), HVLAT are used to relieve muscle spasm by a reflex response occurring in the muscle and may be due to either direct contact on the muscle or due to joint distraction. Direct action on the muscle causes the stretching of the muscle tendon leading to the activation of the Golgi tendon organ (located in the muscle tendon) causing a reflex muscle relaxation reaction.

Mechanoreceptors and nociceptors are located in the articular soft tissue, muscles and skin and thereby a high velocity manipulation, that induces enough force, will stimulate these structures leading to increase somatic afferent receptor activity and will thus inhibit the segmental motor activity (decrease muscle spasm and pain and increased joint ROM) (Peterson and Bergmann, 2011).

Physiological effect

SMT can alter the perception of pain through three mechanisms including the pain gate mechanism, descending pain mechanism and neurotransmitters (Oldham, Potter and McCarthy, 2005).

Pain gate mechanism - In the pain gate mechanism, any tissue damage, whether it is actual or potential, can cause sensory or emotional pain sensation. The dorsal horn of the spinal cord has a gate-like mechanism responsible for the transmission of afferent nociceptive impulses (Figure 2.8). The pain gate is usually opened by small diameter A-delta and C fibers carrying the afferent nociceptive impulses while the large diameter (non-nociceptive) A-beta fibers (usually from the mechanoreceptors of the joint capsule, muscle spindles afferents and the skin) will close the gate. An inhibitory interneuron is stimulated in lamina II (in the dorsal horn), which
connects with lamina V, when it receives the A-beta afferent impulses. The A-delta and C fibers will enter lamina V and will cause a balance between the opposing stimulations (Oldham, Potter and McCarthy, 2005).

When a HVLAT is applied, an increased input of mechanoreceptor impulses along the large diameter A-beta fibers will lead to a modulation of the pain gate mechanism. Thus, the mechanoreceptor activity will override the nociceptive activity (Oldham, Potter and McCarthy, 2005).

**Descending pain mechanism** - The perception of pain can also be influenced by the descending pathways. Surrounding the 3rd ventricle of the brain exists periaqueductal grey matter (PAG). When the dorsal PAG is stimulated during SMT via the descending pathways it will lead to analgesia of the mechano-nociceptive action (mechanical hypoalgesia) whereas when the ventral PAG is stimulated it will modulate temperature nociception (Oldham, Potter and McCarthy, 2005).

**Neurotransmitters** - Substance P is the most common neurotransmitter associated with pain sensation and is released in response to actions in the C-fibers in the dorsal horn of the spinal cord. It is responsible for accessing the central transmission of nociceptive input. Substance P action is decreased by the release of Beta-endorphins during SMT and has an anti-nociceptive influence (Oldham, Potter and McCarthy, 2005).

Peterson and Bergmann (2011), also explains the analgesic and neurobiological effects.

**Analgesic effect** - According to Peterson and Bergmann (2011), SMT can cause stimulus-produced analgesia by removing the mechanical pain and inflammation (Figure 2.8). During a manipulation the superficial and deep mechanoreceptors, nociceptors and proprioceptors are activated causing a bombardment of sensory afferent impulses into the spinal cord resulting in
the inhibition of the central transmission of pain (decreased pain sensation). A long-lived tonic response (nociceptor activation) and a short-lived phasic response (superficial and deep mechanoreceptor activation) forms the pain gate mechanism (Peterson and Bergmann, 2011).

*Neurobiological effect* - Nerve root compression can lead to a neurobiological response. As defined earlier, a subluxation causes altering in the alignment of vertebrae and may lead to spinal nerve root entrapment in the IVF resulting in the nerve root impulse transmission being decreased. SMT will correct the vertebral alterations in order to minimise the spinal nerve root involvement (irritation, compression or traction) (Peterson and Bergmann, 2011).

*Figure 2.8: Pain inhibition through mechanoreceptor and nociceptor function (Peterson and Bergmann, 2011)*
CHAPTER THREE:

METHODOLOGY
3.1 Introduction

This chapter outlines the procedure that was followed in order to develop the research dissertation. It describes the method of participant selection, the equipment used during the study, how the data for the study was collected, the treatment protocols used and the statistical analysis of the data.

3.2 Study Design

The study was based on a quantitative study using convenient sampling and random group allocation.

3.2.1 Participant recruitment

The participants for this study were recruited mainly from the University of Johannesburg (UJ) Hockey Club. The players at this institute were currently playing at club, provincial and national levels. The hockey clubs’ astro turf was in an optimal condition as it was used for the second leg of the varsity sports hockey competition as well as for premier league club matches that were constantly being played throughout most of the year.

Potential participants were recruited mainly verbally by approaching them at the UJ hockey astro turf during their training sessions and as I was a player at the club myself, the participants were contacted via text message and phone calls. The research study was explained to them in detail and how they would be involved. Recruiting was also done by distributing A5 leaflets (Appendix A) to the players at the hockey club.
3.2.2 Sample selection and size

The research study was explained in detail to all the participants that wanted to participate in the study. Once they had voluntarily agreed to participate they were screened to determine whether they met the standards (inclusion and exclusion criteria) needed for the study. The participants were then asked to read the information form (Appendix B) and sign the consent form (Appendix C) before they could participate in any manner. During each participants’ first consultation a case history (Appendix D), physical examination (Appendix E) and a lumbar/pelvis regional (Appendix F) was completed which was placed in a confidential patient file.

The study required thirty participants, all participating in field hockey. These participants were randomly allocated into two equal groups, one group representing the study (treatment) group and one the control group. Data capturing was conducted in exactly the same manner for both groups with the only difference being that the study group had their lumbar and SIJ dysfunctions corrected with chiropractic manipulation while the control group received no treatment.

3.2.3 Inclusion criteria

- Male or female field hockey players; club, provincial or national level
- Between the ages of 18 and 35 years
- Participants had to have one or more lumbar facet and/or SIJ restrictions determined by motion palpation

3.2.4 Exclusion criteria

- Contra-indications to chiropractic manipulation of the lumbar spine and SIJ (Appendix H)
- Previous or current trauma or injury to the L/S, SIJ, sacrum or hips, including surgery
- Any treatments (including chiropractic treatment) that may have interfered with the study, for the duration of the study
- If the participant had been participating in any other research
- Participants that took any medication which may have interfered with the results of this study (any anti-inflammatories, painkillers or muscle relaxants for example)

3.2.5 Group allocation

The thirty participants that met the inclusion and exclusion criteria were randomly allocated into two equal group. Group 1: treatment group and Group 2: control group. These participants were allocated into their specific groups by placing their names, which were written on a piece of paper, in a non-transparent bag. The first 15 names drawn were placed in Group 1 and the remaining 15 names in Group 2. The researcher measured the L/S ROM in degrees using a digital inclinometer. The individuals in both groups were then asked to hit a hockey ball six times in order to determine an average ball speed (km/h) using a radar speed gun. Group 1 participants were then motion palpated and the lumbar and/or sacroiliac restrictions were manipulated, while the Group 2 participants received no chiropractic treatment or manipulation.

3.3 Treatment Approach

3.3.1 First and follow-up consultations

Each participant had an initial and 3 follow-up consultations over a 2-week period (2 treatments per week) that took place at the University of Johannesburg hockey astro turf. During the initial consultation each participant was asked to read the information form (Appendix B) as well as
sign the consent form (Appendix C). All the participants completed a case history (Appendix D), physical examination (Appendix E) and a lumbar/pelvis regional examination (Appendix F) during their first treatment session.

During all four consultations, Group 1 (study group) participants were asked to do a 5 minute warm-up jog at a steady pace before the start of the tests. After the warm-up the participants’ lumbar ROM were measured in degrees using a digital inclinometer (Appendix J). They were then asked to hit a hockey ball 6 times (3 times, rest 1 minute, another 3 times) in order to determine an average ball speed (km/h) using the 3 best speeds as measured by the a radar speed gun (Appendix I).

The participants’ feet were placed on the same marks indicated on the hockey pitch and were the same distance from the ball with every hit. One standard hockey stick and 3 standard balls were used for all the tests. In order to ensure that the hockey ball got hit as hard as possible during every consultation two motivational prizes (male and female) for the person that hit the ball the hardest was given at the end of the study.

Lastly, the L/S and SIJ were motion palpated for restrictions and manipulated (Appendix K) by the researcher under the supervision of a qualified chiropractor. Group 2 (control group) participants underwent the same process, but received no treatment or manipulation. Participants in Group 2 were offered treatment once the entire study was completed.

Treatment

Lumbo-sacral restrictions were corrected using chiropractic manipulation. More than one manipulation technique was used to correct the motion palpated restrictions. Techniques used (Appendix K) included hypothenar spinous pull (spinous hook/pull), hypothenar mammillary push (thigh
transverso deltoid), hypothenar ilium push (thigh ilio deltoid) and hypothenar ischium push (ischio popliteal deltoid) (Peterson and Bergmann, 2011).

**Table 3.1: Data capture and treatment procedure algorithm**

<table>
<thead>
<tr>
<th>Week 1</th>
<th>Treatment Group</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Measure lumbar ROM</td>
<td>1) Measure lumbar ROM</td>
<td></td>
</tr>
<tr>
<td>2) Measure ball speed (x6)</td>
<td>2) Measure ball speed (x6)</td>
<td></td>
</tr>
<tr>
<td>3) Manipulate restrictions</td>
<td>3) No manipulation/treatment</td>
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<tr>
<td>Treatment 1</td>
<td></td>
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</tr>
<tr>
<td>1) Measure lumbar ROM</td>
<td>1) Measure lumbar ROM</td>
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<td>2) Measure ball speed (x6)</td>
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<td>3) Manipulate restrictions</td>
<td>3) No manipulation/treatment</td>
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<tr>
<td>Treatment 2</td>
<td></td>
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<tr>
<td>1) Measure lumbar ROM</td>
<td>1) Measure lumbar ROM</td>
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<tr>
<td>2) Measure ball speed (x6)</td>
<td>2) Measure ball speed (x6)</td>
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<td>3) No manipulation/treatment</td>
<td>3) No manipulation/treatment</td>
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<tr>
<td>Treatment 3</td>
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<tr>
<td>1) Measure lumbar ROM</td>
<td>1) Measure lumbar ROM</td>
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<tr>
<td>2) Measure ball speed (x6)</td>
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<td>3) Manipulate restrictions</td>
<td>3) No manipulation/treatment</td>
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<tr>
<td>Treatment 4</td>
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<tr>
<td>1) Measure lumbar ROM</td>
<td>1) Measure lumbar ROM</td>
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<tr>
<td>2) Measure ball speed (x6)</td>
<td>2) Measure ball speed (x6)</td>
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<tr>
<td>3) No manipulation/treatment</td>
<td>3) No manipulation/treatment</td>
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</tbody>
</table>

**3.3.2 Objective data**

**Radar Speed Gun**

A radar speed gun (Figure 3.1) is a hand held piece of equipment used to measure the speed of moving objects. Radar speed guns transmits radio waves at the speed of light. These waves bounce back to the radar gun once it encounters an object (Laserguys, 2015).

According to Rebelo, Pyper and Hollinshead (2010), the Doppler Shift Processor acquires information containing the difference between the transmitted and received signals. It then calculates the speed within approximately 1MPH. The optimal position to be in when using the Bushnell...
velocity speed gun is either in front or just behind the moving object (Figure 3.2).

Radar guns provide accurate readings for ball speed (McGinnis, Perkins and King, 2012). According to Williams, Harveson, Melton, Delobel and Puentedura (2013), the Bushnell Velocity Speed Gun measures the velocity of a baseball from up to 27.5 meters away, therefore it was able to measure the speed of a hockey ball as it is of similar size and shape. Radar speed guns are often used by sport enthusiasts at events to measure the speed of thrown or hit balls (Vermillion, 2004). Rebelo (2010), conducted a study on the speed at which a soccer ball was kicked using a Bushnell Velocity Speed Gun and showed its validity and reliability.

For this study the researcher was seated 3m behind the participants (Figure 3.2) as they were asked to hit a stationary ball (4m from goal) into the goal box in order to obtain accurate speed gun readings. The speed gun was held at the same distance and height for all the participants.
Figure 3.1: Bushnell velocity speed gun (Laserguys, 2015)

Figure 3.2: Positioning of Bushnell velocity speed gun behind the participant (Rebelo, Pyper and Hollinshead, 2010)
Digital Inclinometer

Digital inclinometers (Figure 3.3) are easy to handle, light weight and portable instruments used to measure ROM on a 360 degree scale by incorporating gravity (Kolber and Hanney, 2012).

According to Rebelo, Pyper and Hollinshead, (2010), when measuring the L/S ROM the digital inclinometer is placed on the patients lower back on two separate points. The first point is located at the midpoint of the sacrum and the second point located at the thoracolumbar junction (interspinous space of T12 and L1).

The inclinometer was placed on each participants' midsacral point. The inclinometer was zeroed with the participant in an upright standing position and was then asked to flex, extend, laterally flex to the left and right and rotate to the left and right to the end ranges of motion while each reading was taken respectively. The same process was followed for the second, thoracolumbar junction, point and each reading (in degrees) was recorded. The measurement of point two (thoracolumbar junction) was then subtracted from point one (midsacral point) for each spinal movement (e.g. flexion) and the resultant represented the degree of lumbar spinal movement (Rebelo, Pyper and Hollinshead, 2010).

According to validation tests the precision of the inclinometer is high and is easy to use and does not require a lot of time or space (Vergara and Page, 2000).

The reliability of this device, when measuring lumbosacral angle, lumbar standing posture and thoracic standing posture, as reported by MacIntyre and Lorbergs (2014), is excellent. It was also used by (Rebelo, Pyper and Hollinshead, 2010), in his research study testing the effectiveness of a
chiropractic adjustment on the speed of a soccer ball in soccer players with lumbar facet and SIJ dysfunction confirming its validity and reliability.

![Digital inclinometer](image)

*Figure 3.3: Digital inclinometer (Kolber and Hanney, 2012)*

### 3.4 Data Analysis

All the data captured was sent to STATKON for statistical analysis. The differences within (intra) and between (inter) the two groups were compared over four consultations. The Friedman test (intra-group analysis) is a short impact test and the Wilcoxon test is an immediate impact test and both analysed the ball speed and digital inclinometer measurements within each group over time. Between group post.hoc analysis was assessed using the Mann-Whitney U test (inter-group analysis).

### 3.5 Ethical Considerations

All participants that wished to partake in this particular study were requested to read the information form (Appendix B) and sign the consent form (Appendix C) specific to this study. The information and consent forms
outlined the names of the researcher, purpose of the study and proposed 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 participant’s safety was a priority (prevention of harm). The information and consent forms also explained that the participants’ privacy was protected as only the researcher, participant and occasionally the observing doctor would have been in the treatment area and that anonymity was ensured as the patient information was converted into data and therefore cannot be traced back to the individual. The forms also stated that standard doctor/patient confidentiality was adhered to at all times 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 have had any further questions, these would have been explained by the researcher; whose contact details were made available. The participants were then required to read the information form and sign the consent form, signifying that they understood all that was required of them for this particular study.

With regards to this particular study, there were risks, benefits and discomforts associated with chiropractic manipulation. The most common side-effect during L/S or SIJ manipulation included post-adjustment stiffness. There were numerous benefits associated with spinal manipulation including decreasing lower back pain by correcting the vertebral or sacroiliac dysfunction, increasing the ROM of the lower back by restoring the normal biomechanics of the spine, therefore also reducing the associated trigger points and muscle spasm and it also maintains health naturally (Colloca and Keller, 2001).

Participant were referred to other health care practitioners best related to their problem if it were necessary.
This research study was ethically cleared by the research ethics committee of the University of Johannesburg with the ethical clearance number: REC-01-185-2015 (Appendix L).

To ensure no plagiarism occurred during the write up of the study, this dissertation was submitted to Turnitin and accessed for originality (Appendix M).
4.1 Introduction

This chapter reflects the results concluded from the data captured during the clinical trial of the study. Thirty participants, fifteen in the treatment group (Group 1) and fifteen in the control group (Group 2), took part in the study. The participants in Group 1, received a chiropractic manipulation while the participants in Group 2 received no chiropractic manipulations. All the participants (male and female) were field hockey players at either a club, provincial or national level. The statistical results of only a small group of participants were used and therefore no assumptions could be made with regards to the population as a whole. The level of significances that were used differed, in order for the pairwise comparisons to be significant after performing the Bonferroni adjustment. The probability level (p-value) for the Friedmann test, which shows the level of significance, was set at 0.05 for the radar gun readings and ROM readings with the exception of extension (study group) and flexion (both groups) where it was set at 0.10 and for left rotation (both groups) and right rotation (study group) where it was set at 0.01. The p-value for the Mann-Whitney U test was also set at 0.05. The Wilcoxon signed rank test had its p-value set at 0.01, except for the above mentioned exceptions, where 0.03 (extension and flexion) and 0.00 (left and right rotation) was used respectively, to ensure a more precise and accurate statistical assessment from the results obtained from the Friedmann ranks test using the Bonferroni adjustment. A strict significance is illustrated by a p-value lower than the set significance level.

The analysis for this study include:

- Two objective measurements: the radar speed gun (measured the ball speed in km/h) and the digital inclinometer (measured the L/S ROM in degrees).
4.2 Demographic Data Analysis

4.2.1 Mean age values

*Table 4.1: Representation of the mean age values*

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Study Group</th>
<th>Control Group</th>
<th>Total Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>21.33</td>
<td>20.60</td>
<td>20.97</td>
<td></td>
</tr>
</tbody>
</table>

The total mean age for this clinical study was 20.97 years, as the ages of the participants ranged between 18 – 35 years. The study group had a mean age of 21.33 years, while the mean age of the control group was 20.60 years.

4.2.2 Positional distribution

*Table 4.2: Representation of the positional distribution*

<table>
<thead>
<tr>
<th>Position</th>
<th>Number</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strikers</td>
<td>10</td>
<td>33.33</td>
</tr>
<tr>
<td>Midfielders</td>
<td>9</td>
<td>30</td>
</tr>
<tr>
<td>Defenders</td>
<td>11</td>
<td>36.67</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>100</td>
</tr>
</tbody>
</table>

Random allocation of the participants was used in order to place them in either the study or the control group. Out of the thirty participants that completed the clinical study, 10 were strikers, 9 were midfielders and 11 were defenders.
4.2.3 Gender distribution

Table 4.3: Representation of the gender distribution

<table>
<thead>
<tr>
<th></th>
<th>Group 1 (study)</th>
<th>Group 2 (control)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Females</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>15</td>
</tr>
</tbody>
</table>

Two males in Group 1 and three males in Group 2 participated, while thirteen females in Group 1 and twelve females in Group 2 participated in this research study.

4.3 Objective Data Analysis

4.3.1 Ball speed

![Bar graph representing the ball speed mean values](image)

*Figure 4.1: Bar graph representing the ball speed mean values*
The ball speed (km/h) mean values, obtained over the course of the clinical study, are represented by the bar graph above. During treatment 1 (Trx 1), treatment 2 (Trx 2), treatment 3 (Trx 3) and treatment 4 (Trx 4) the ball speed means were taken prior to any chiropractic manipulation at the first to the fourth consultation respectively. The ball speed mean values of the two groups were:

<table>
<thead>
<tr>
<th>Study group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Trx 1 = 79.80 km/h</td>
<td>- Trx 1 = 78.82 km/h</td>
</tr>
<tr>
<td>- Trx 2 = 83.49 km/h</td>
<td>- Trx 2 = 78.71 km/h</td>
</tr>
<tr>
<td>- Trx 3 = 81.69 km/h</td>
<td>- Trx 3 = 76.98 km/h</td>
</tr>
<tr>
<td>- Trx 4 = 79.47 km/h</td>
<td>- Trx 4 = 78.71 km/h</td>
</tr>
</tbody>
</table>

**Intra-group analysis of the ball speed**

The non-parametric, Friedmann test, was used to determine whether there was any change regarding the treatment results within each group over the course of the clinical study. Trx 1 to Trx 4 were compared collectively and a single p-value was represented. The comparison revealed a p-value of **0.08** for the study group and a p-value of **0.16** for the control group.

The non-parametric, Wilcoxon signed rank test, was not conducted as both the study and control groups had p-values above **0.05** and therefore the results were not significant.

**Inter-group analysis of the ball speed**

The non-parametric, Mann-Whitney U test, was conducted in order to compare Trx 1, Trx 2, Trx 3 and Trx 4 from the study group with their counter-parts Trx 1, Trx 2, Trx 3 and Trx 4 from the control group. The p-values for the compared study and control groups were determined as: Trx 1: **0.35**, Trx 2: **0.04**, Trx 3: **0.15** and Trx 4: **0.79**.
The study group showed a 0.42 % decrease, while the control group also showed a 0.14 % decrease over the course of the four consultations and will be explained in more detail in the next chapter.

4.3.2 Range of motion

*Lumbar Spine Flexion ROM*

![Figure 4.2: Bar graph representing the L/S flexion ROM mean values](image)

The L/S flexion ROM (degrees) mean values, obtained over the course of the clinical study, are represented by the bar graph above. During treatment 1 (Trx 1), treatment 2 (Trx 2), treatment 3 (Trx 3) and treatment 4 (Trx 4) the L/S flexion ROM means were taken prior to any chiropractic manipulation at the first to the fourth consultation respectively. The L/S flexion ROM mean values of the two groups were:

<table>
<thead>
<tr>
<th>Study group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trx 1 = 69.0 degrees</td>
<td>Trx 1 = 76.13 degrees</td>
</tr>
<tr>
<td>Trx 2 = 69.11 degrees</td>
<td>Trx 2 = 78.49 degrees</td>
</tr>
</tbody>
</table>
- Trx 3 = 71.07 degrees  
- Trx 4 = 72.27 degrees
- Trx 3 = 81.00 degrees  
- Trx 4 = 86.42 degrees

**Intra-group analysis of L/S flexion ROM**

The non-parametric, Friedmann test, was used to determine whether there was any change regarding the treatment results within each group over the course of the clinical study. Trx 1 to Trx 4 were compared collectively and a single p-value was represented. The comparison revealed a p-value = 0.91 for the study group and a p-value = 0.01 for the control group.

The non-parametric, Wilcoxon signed rank test, was not applied to the study group as it had a p-value above 0.10 and therefore the results were not significant. However, the Wilcoxon signed rank test was conducted to the control group to determine whether the p-value readings obtained from the Friedmann test was precise enough. This was achieved by comparing Trx 1 with Trx 2, Trx 1 with Trx 3, Trx 1 with Trx 4, Trx 2 with Trx 3, Trx 2 with Trx 4 and Trx 3 with Trx 4 within each of the groups. The p-values for the control group were:

<table>
<thead>
<tr>
<th>Control group</th>
<th>p-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trx 1/Trx 2</td>
<td>0.26</td>
</tr>
<tr>
<td>Trx 1/Trx 3</td>
<td>0.03</td>
</tr>
<tr>
<td>Trx 1/Trx 4</td>
<td>0.01</td>
</tr>
<tr>
<td>Trx 2/Trx 3</td>
<td>0.32</td>
</tr>
<tr>
<td>Trx 2/Trx 4</td>
<td>0.01</td>
</tr>
<tr>
<td>Trx 3/Trx 4</td>
<td>0.02</td>
</tr>
</tbody>
</table>

*Table 4.4: Wilcoxon signed rank test p-values for flexion ROM*
Inter-group analysis for L/S flexion ROM

The non-parametric, Mann-Whitney U test, was conducted in order to compare Trx 1, Trx 2, Trx 3 and Trx 4 from the study group with their counter-parts Trx 1, Trx 2, Trx 3 and Trx 4 from the control group. The p-values for the compared study and control groups were determined as: Trx 1: 0.29, Trx 2: 0.05, Trx 3: 0.12 and Trx 4: 0.02.

There was 4.63 % increase in the study groups’ L/S flexion ROM and a 12.67 % increase in the control groups’ L/S flexion ROM, but it will be explained in more detail in the next chapter.

Lumbar Spine Extension ROM

Figure 4.3: Bar graph representing the L/S extension ROM mean values

The L/S extension ROM (degrees) mean values, obtained over the course of the clinical study, are represented by the bar graph above. During treatment 1 (Trx 1), treatment 2 (Trx 2), treatment 3 (Trx 3) and treatment 4 (Trx 4) the L/S extension ROM means were taken prior to any chiropractic
manipulation at the first to the fourth consultation respectively. The L/S extension ROM mean values of the two groups were:

<table>
<thead>
<tr>
<th>Study group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trx 1 = 16.53 degrees</td>
<td>Trx 1 = 20.20 degrees</td>
</tr>
<tr>
<td>Trx 2 = 17.23 degrees</td>
<td>Trx 2 = 20.27 degrees</td>
</tr>
<tr>
<td>Trx 3 = 21.71 degrees</td>
<td>Trx 3 = 20.98 degrees</td>
</tr>
<tr>
<td>Trx 4 = 22.69 degrees</td>
<td>Trx 4 = 18.00 degrees</td>
</tr>
</tbody>
</table>

**Intra-group analysis of L/S extension ROM**

The non-parametric, Friedmann test was used to determine whether there was any change regarding the treatment results within each group over the course of the clinical study. Trx 1 to Trx 4 were compared collectively and a single p-value was represented. The comparison revealed a p-value = **0.04** for the study group and a p-value = **0.48** for the control group.

The non-parametric, Wilcoxon signed rank test, was not applied to the control group as it had a p-value above **0.05** and therefore the results were not significant. However, the Wilcoxon signed rank test was conducted to the study group to determine whether the p-value readings obtained from the Friedmann test was precise enough. This was achieved by comparing Trx 1 with Trx 2, Trx 1 with Trx 3, Trx 1 with Trx 4, Trx 2 with Trx 3, Trx 2 with Trx 4 and Trx 3 with Trx 4 within each of the groups. The p-values for the study group were:

**Table 4.5: Wilcoxon signed rank test p-values for extension ROM**

<table>
<thead>
<tr>
<th>Study group</th>
<th>p-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trx 1/Trx 2</td>
<td>0.73</td>
</tr>
<tr>
<td>Trx 1/Trx 3</td>
<td>0.05</td>
</tr>
<tr>
<td>Trx 1/Trx 4</td>
<td>0.02</td>
</tr>
</tbody>
</table>
Inter-group analysis for L/S extension ROM

The non-parametric, Mann-Whitney U test, was conducted in order to compare Trx 1, Trx 2, Trx 3 and Trx 4 from the study group with their counter-parts Trx 1, Trx 2, Trx 3 and Trx 4 from the control group. The p-values for the compared study and control groups were determined as: Trx 1: 0.36, Trx 2: 0.26, Trx 3: 0.84 and Trx 4: 0.15.

The study group showed a 31.57 % increase while the control group had a 11.50 % increase in L/S extension ROM and will be explained in more detail in the next chapter.

Lumbar Spine Right Rotation ROM

![Bar graph representing the L/S right rotation ROM mean values](image)

*Figure 4.4: Bar graph representing the L/S right rotation ROM mean values*
The L/S right rotation ROM mean values, obtained over the course of the clinical study, are represented by the bar graph above. During treatment 1 (Trx 1), treatment 2 (Trx 2), treatment 3 (Trx 3) and treatment 4 (Trx 4) the L/S right rotation ROM means were taken prior to any chiropractic manipulation at the first to the fourth consultation respectively. The L/S right rotation ROM mean values of the two groups were:

<table>
<thead>
<tr>
<th>Study group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trx 1 = 9.60 degrees</td>
<td>Trx 1 = 10.78 degrees</td>
</tr>
<tr>
<td>Trx 2 = 8.58 degrees</td>
<td>Trx 2 = 10.49 degrees</td>
</tr>
<tr>
<td>Trx 3 = 10.20 degrees</td>
<td>Trx 3 = 10.71 degrees</td>
</tr>
<tr>
<td>Trx 4 = 12.36 degrees</td>
<td>Trx 4 = 12.93 degrees</td>
</tr>
</tbody>
</table>

*Intra-group analysis for L/S right rotation ROM*

The non-parametric, Friedmann test was used to determine whether there was any change regarding the treatment results within each group over the course of the clinical study. Trx 1 to Trx 4 were compared collectively and a single p-value was represented. The comparison revealed a p-value of 0.03 for the study group and a p-value of 0.61 for the control group.

The non-parametric, Wilcoxon signed rank test, was not applied to the control group as it had a p-value above 0.05 and therefore the results were not significant. However, the Wilcoxon signed rank test was conducted to the study group to determine whether the p-value readings obtained from the Friedmann test was precise enough. This was achieved by comparing Trx 1 with Trx 2, Trx 1 with Trx 3, Trx 1 with Trx 4, Trx 2 with Trx 3, Trx 2 with Trx 4 and Trx 3 with Trx 4 within each of the groups. The p-values for the study group were:
Table 4.6: Wilcoxon signed rank test p-values for right rotation ROM

<table>
<thead>
<tr>
<th>Study group</th>
<th>p-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trx 1/Trx 2</td>
<td>0.43</td>
</tr>
<tr>
<td>Trx 1/Trx 3</td>
<td>0.57</td>
</tr>
<tr>
<td>Trx 1/Trx 4</td>
<td>0.03</td>
</tr>
<tr>
<td>Trx 2/Trx 3</td>
<td>0.16</td>
</tr>
<tr>
<td>Trx 2/Trx 4</td>
<td>0.02</td>
</tr>
<tr>
<td>Trx 3/Trx 4</td>
<td>0.06</td>
</tr>
</tbody>
</table>

Inter-group analysis for L/S right rotation ROM

The non-parametric, Mann-Whitney U test, was conducted in order to compare Trx 1, Trx 2, Trx 3 and Trx 4 from the study group with their counter-parts Trx 1, Trx 2, Trx 3 and Trx 4 from the control group. The p-values for the compared study and control groups were determined as: Trx 1: 0.51, Trx 2: 0.28, Trx 3: 0.69 and Trx 4: 0.74.

There was a 25.18 % increase in the right rotation ROM of the L/S of the study group while an 18.36 % increase was showed in the control group, but it will be explained in more detail in the next chapter.
Lumbar Spine Left Rotation ROM

![Bar graph representing the L/S left rotation ROM mean values](image)

The L/S left rotation ROM (degrees) mean values, obtained over the course of the clinical study, are represented by the bar graph above. During treatment 1 (Trx 1), treatment 2 (Trx 2), treatment 3 (Trx 3) and treatment 4 (Trx 4) the L/S left rotation ROM means were taken prior to any chiropractic manipulation at the first to the fourth consultation respectively. The L/S left rotation ROM mean values of the two groups were:

<table>
<thead>
<tr>
<th>Study group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trx 1 = 9.16 degrees</td>
<td>Trx 1 = 12.49 degrees</td>
</tr>
<tr>
<td>Trx 2 = 8.98 degrees</td>
<td>Trx 2 = 11.84 degrees</td>
</tr>
<tr>
<td>Trx 3 = 10.36 degrees</td>
<td>Trx 3 = 11.82 degrees</td>
</tr>
<tr>
<td>Trx 4 = 11.42 degrees</td>
<td>Trx 4 = 13.31 degrees</td>
</tr>
</tbody>
</table>
**Intra-group analysis of L/S left rotation ROM**

The non-parametric, Friedmann test was used to determine whether there was any change regarding the treatment results within each group over the course of the clinical study. Trx 1 to Trx 4 were compared collectively and a single p-value was represented. The comparison revealed a p-value of 0.13 for the study group and a p-value of 0.25 for the control group.

The non-parametric, Wilcoxon signed rank test, was not applied to neither the study nor the control group as it had p-values above 0.01 and therefore the results were not significant.

**Inter-group analysis of L/S left rotation ROM**

The non-parametric, Mann-Whitney U test, was conducted in order to compare Trx 1, Trx 2, Trx 3 and Trx 4 from the study group with their counter-parts Trx 1, Trx 2, Trx 3 and Trx 4 from the control group. The p-values for the compared study and control groups were determined as: Trx 1: **0.06**, Trx 2: **0.05**, Trx 3: **0.26** and Trx 4: **0.28**.

The study group showed a 22.02 % increase, while the control group had a 6.35 % increase in the left rotation ROM of the L/S and will be explained in more detail in the next chapter.
The L/S right lateral flexion ROM (degrees) mean values, obtained over the course of the clinical study, are represented by the bar graph above. During treatment 1 (Trx 1), treatment 2 (Trx 2), treatment 3 (Trx 3) and treatment 4 (Trx 4) the L/S right lateral flexion ROM means were taken prior to any chiropractic manipulation at the first to the fourth consultation respectively. The L/S right lateral flexion ROM mean values of the two groups were:

**Study group**
- Trx 1 = **13.98 degrees**
- Trx 2 = **13.67 degrees**
- Trx 3 = **14.71 degrees**
- Trx 4 = **13.51 degrees**

**Control group**
- Trx 1 = **12.89 degrees**
- Trx 2 = **15.02 degrees**
- Trx 3 = **16.51 degrees**
- Trx 4 = **18.27 degrees**

*Figure 4.6: Bar graph representing the L/S right lateral flexion ROM mean values*
**Intra-group analysis of L/S right lateral flexion ROM**

The non-parametric, Friedmann test was used to determine whether there was any change regarding the treatment results within each group over the course of the clinical study. Trx 1 to Trx 4 were compared collectively and a single p-value was represented. The comparison revealed a p-value of 0.51 for the study group and a p-value of 0.02 for the control group.

The non-parametric, Wilcoxon signed rank test, was not applied to the study group as it had a p-value above 0.05 and therefore the results were not significant. However, the Wilcoxon signed rank test was conducted to the control group to determine whether the p-value readings obtained from the Friedmann test was precise enough. This was achieved by comparing Trx 1 with Trx 2, Trx 1 with Trx 3, Trx 1 with Trx 4, Trx 2 with Trx 3, Trx 2 with Trx 4 and Trx 3 with Trx 4 within each of the groups. The p-values for the control group were:

**Table 4.7: Wilcoxon signed rank test p-values for right lateral flexion ROM**

<table>
<thead>
<tr>
<th>Control group</th>
<th>p-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trx 1/Trx 2</td>
<td>0.10</td>
</tr>
<tr>
<td>Trx 1/Trx 3</td>
<td>0.03</td>
</tr>
<tr>
<td>Trx 1/Trx 4</td>
<td>0.01</td>
</tr>
<tr>
<td>Trx 2/Trx 3</td>
<td>0.87</td>
</tr>
<tr>
<td>Trx 2/Trx 4</td>
<td>0.43</td>
</tr>
<tr>
<td>Trx 3/Trx 4</td>
<td>0.20</td>
</tr>
</tbody>
</table>

**Inter-group analysis of L/S right lateral flexion ROM**

The non-parametric, Mann-Whitney U test, was conducted in order to compare Trx 1, Trx 2, Trx 3 and Trx 4 from the study group with their counter-parts Trx 1, Trx 2, Trx 3 and Trx 4 from the control group. The p-
values for the compared study and control groups were determined as: Trx 1: 0.32, Trx 2: 0.72, Trx 3: 0.62 and Trx 4: 0.03.

The study group showed a 3.4 % decrease in the right lateral flexion ROM of the L/S, while there was a 34.83 % increase in the control group, but it will be explained in more detail in Chapter Five.

**Lumbar Spine Left Lateral Flexion ROM**

![Bar graph representing the lumbar spine left lateral flexion ROM mean values](image)

**Figure 4.7: Bar graph representing the lumbar spine left lateral flexion ROM mean values**

The L/S left lateral flexion ROM (degrees) mean values, obtained over the course of the clinical study, are represented by the bar graph above. During treatment 1 (Trx 1), treatment 2 (Trx 2), treatment 3 (Trx 3) and treatment 4 (Trx 4) the L/S left lateral flexion ROM means were taken prior to any chiropractic manipulation at the first to the fourth consultation respectively. The L/S left lateral flexion ROM mean values of the two groups were:
Intra-group analysis of L/S left lateral flexion ROM

The non-parametric, Friedmann test was used to determine whether there was any change regarding the treatment results within each group over the course of the clinical study. Trx 1 to Trx 4 were compared collectively and a single p-value was represented. The comparison revealed a p-value of 0.48 for the study group and a p-value of 0.02 for the control group.

The non-parametric, Wilcoxon signed rank test, was not applied to the study group as it had a p-value above 0.05 and therefore the results were not significant. However, the Wilcoxon signed rank test was conducted to the control group to determine whether the p-value readings obtained from the Friedmann test was precise enough. This was achieved by comparing Trx 1 with Trx 2, Trx 1 with Trx 3, Trx 1 with Trx 4, Trx 2 with Trx 3, Trx 2 with Trx 4 and Trx 3 with Trx 4 within each of the groups. The p-values for the control group were:

Table 4.8: Wilcoxon signed rank test p-values for left lateral flexion ROM

<table>
<thead>
<tr>
<th>Control group</th>
<th>p-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trx 1/Trx 2</td>
<td>0.00</td>
</tr>
<tr>
<td>Trx 1/Trx 3</td>
<td>0.03</td>
</tr>
<tr>
<td>Trx 1/Trx 4</td>
<td>0.01</td>
</tr>
<tr>
<td>Trx 2/Trx 3</td>
<td>0.69</td>
</tr>
<tr>
<td>Trx 2/Trx 4</td>
<td>0.43</td>
</tr>
<tr>
<td>Trx 3/Trx 4</td>
<td>0.20</td>
</tr>
</tbody>
</table>
**Inter-group analysis of L/S left lateral flexion ROM**

The non-parametric, Mann-Whitney U test, was conducted in order to compare Trx 1, Trx 2, Trx 3 and Trx 4 from the study group with their counter-parts Trx 1, Trx 2, Trx 3 and Trx 4 from the control group. The p-values for the compared study and control groups were determined as: Trx 1: **0.46**, Trx 2: **0.55**, Trx 3: **0.85** and Trx 4: **0.03**.

There was a 2.41 % decrease in the study groups’ L/S left lateral flexion ROM, while the control group had a 29.5 % increase, but it will be discussed in more detail in the next chapter.
CHAPTER FIVE:

DISCUSSION
5.1 Introduction

This chapter outlines the results of the study with possible explanations as to why the results, obtained over the clinical study, appear as they do.

5.2 Demographics

The total mean age was 20.97 years as the participants’ ages ranged between 18 – 35 years with the study group having a mean age of 21.33 years and the control group 20.60 years. The groups were comparable as both groups had very similar mean ages.

The field hockey players used in this particular study, all played different positions on the field and therefore led to an almost equal distribution of players in a certain position within the two groups. Out of the thirty participants, randomly allocated into the respective study or control groups, 10 were strikers, 9 were midfielders and 11 were defenders.

Both male and female field hockey players were used in this particular study as both genders makes up a percentage of South-Africa’s amateur hockey players. Field hockey is not yet a professional sport in South-Africa, but a large number of males and females participate in this sport.

5.3 Objective Data Analysis

5.3.1 Ball speed

Clinical analysis

The mean values of ball speed showed that the study group had a 0.42 % decrease over the course of the four consultations. There was an initial increase of 4.52 % after the first manipulation followed by a 2.18 % drop
after consultation two and a further 2.76 % drop after consultation three. The initial 4.52 % increase can be described as an immediate effect after the first manipulation, but due to the overall decrease of the ball speed, it can be assumed that there had to be a different reason for the drop in ball speed, as the dysfunctional joints were corrected using chiropractic manipulations. The control group had only minor changes with an overall decrease of 0.14 % over the four consultations. There was an initial drop of 0.14 % after the first consultation followed by a further drop of 2.22 % after the second consultation. An increase of 2.22 % occurred after the third treatment. This showed that the control group, not receiving any chiropractic manipulation to any of the dysfunctional joints, had mostly a negative effect on the overall ball speed, implying that the affected joints had become slightly worse over time.

Statistical analysis

The Friedmann test used to analyse the ball speed mean values, produced no statistical changes for neither the study nor the control group. As a result of no significance (high p-values), the Wilcoxon signed by ranks test was not conducted for either of the groups.

According to the Mann-Whitney U test, there was no statistical significant difference between the compared study and control groups. Trx 2 had the only statistical significant p-value (0.04). A larger sample size, for testing the ball speed, might provide better significant p-values for the ball speed group comparisons. The mean ball speed values dropped for both the study and control group over the course of the study. With a more strict analysis (Wilcoxon test) used, neither the study nor the control group showed any statistical significant results, implying that the chiropractic manipulations, given to the study group, had no effect on the ball speed within the fifteen participant sample group.
According to Zatsiorsky (2000), when hitting a hockey ball a sequence of movements occur, starting from the ground up. The movements start at the ground moving proximally to the hips, shoulders, arms and ends at the hands. He also stated that the power obtained during a field hockey hit comes from the lower limb, trunk and upper limb mainly. The ball speed had no significant differences between the study and control group and a possible explanation could be that restoring or increasing the ROM to only one part of the sequence is not enough to have caused a significant difference within the other parts of the sequence and therefore the ball speed would not change drastically.

According to Zatsiorsky (2000), the center of the bodies’ gravity, when hitting the ball, would have an impact on the ball speed. Different participants capable of different levels of skills (club, provincial and national) were used in this study. Lesser skilled players do not have such a large lower trunk rotational speed as the more skilled players (Zatsiorsky, 2000) and thus the bodies’ center of gravities were all different. However, this is just speculative as the center of gravities were never recorded for the purpose of this study.

Spinal manipulation alter tissue stresses leading to the relaxation of hypertonic muscles and also restores normal ROM to the subluxated joint. Thus, restoring the biomechanics of the distal to proximal joints necessary for the power in a hockey hit, as mentioned earlier, should have an effect on the ball speed. The mean ball speed values had no clinical and statistical significance as neither the study nor the control group yielded any positive results over the course of the two weeks.
5.3.2 Lumbar spine range of motion

Clinical analysis

Compensatory changes took place throughout the clinical trial in both the study and control group when looking at the L/S ROM mean values. The study group had mostly increased values (percentages), except for both left and right lateral flexion which decreased over time.

Study group L/S ROM values increased as follow:

- L/S flexion – 4.63 %
- L/S extension – 31.57 %
- L/S right rotation – 25.18 %
- L/S left rotation – 22.02 %

Right lateral flexion had a 3.4 % decrease while left lateral flexion decreased by 2.41 %. The control group also mostly had an increase in the L/S ROM values with the exception of L/S extension.

Control group L/S ROM values increased as follow:

- L/S flexion – 12.67 %
- L/S right rotation – 18.36 %
- L/S left rotation – 6.35 %
- L/S right lateral flexion – 34.83 %
- L/S left lateral flexion – 29.5 %

L/S extension had an 11.5 % decrease over the course of the study.
Statistical analysis

The Mann-Whitney U test applied for group comparisons to the L/S ROM mean values only produced five statistical significant p-values. These include: L/S flexion (Trx 2 and Trx 4), left rotation (Trx 2), right lateral flexion (Trx 4) and left lateral flexion (Trx 4). Through the application of the Friedmann analysis test it revealed that only L/S flexion (control group), extension (study group), right rotation (study group), right lateral flexion (control group) and left lateral flexion (control group) showed statistical significant improvement over the course of the study. The Wilcoxon signed ranks test was used for a more strict analysis on these statistical significant findings. The following was indicated:

- Comparisons between Trx 1 with Trx 4 (0.01), Trx 2 with Trx 4 (0.01) and Trx 3 with Trx 4 (0.02) in L/S flexion (control group) all had statistical significant p-values.
- Comparisons between Trx 1 with Tx 4 (0.02) and Trx 2 with Trx 4 (0.01) in L/S extension (study group) had statistical significant p-values.
- Comparisons between right rotation (study group) had no statistical significant p-values.
- Comparisons between Trx 1 with Trx 4 (0.01) in L/S right lateral flexion (control group) had a statistical significant p-value.
- Comparisons between Trx 1 with Trx 2 (0.00) and Trx 1 with Trx 4 (0.01) in L/S left lateral flexion (control group) had statistical significant p-values.

All of the above had an increase in their ROM percentages over the course of the study.
The ROM mostly increased in the study group as chiropractic manipulation according to Gatterman (2005), restores ROM to a joint by moving it past it physiological barrier without harming the joint.

The L/S ROM mean values increased overall with the exception of right and left lateral flexion. The statistical analysis produced positive statistical significant differences in L/S flexion and left rotation further validating the findings. Although extension and right rotation of the L/S are not statistically significant, it had a clinical increase over the course of the two week period. A possible explanation could be due to the side postures used when applying the chiropractic manipulative technique (Appendix K) for correcting the dysfunctional joints in the L/S and SIJ. These techniques involve a degree of L/S extension and rotation when applied to the affected joint (Peterson and Bergmann, 2011).

The decreased ROM in L/S left and right lateral flexion may be due to other compensatory reactions, for example adhesions or fibrosis that may have developed in the supporting segmental tissues as a result of hypermobile segments (above and below the restricted joint) that were left untreated for a prolonged period, thus falling within the advanced stages of the compensation process.

Due to the lack of ball speed improvement in the study group, no relation can be made regarding the effects of L/S and SIJ ROM and its effect on the ball speed.

The control group also had an overall increase in their L/S ROM, with the exception of the L/S extension. When the L/S is in extension, the facet joints are approximated and impacted on each other (Dutton, 2012), causing pain and lack of movement (Peterson and Bergmann, 2011). The compensatory changes that occurred, although no chiropractic manipulation was given, can be explained by the increase in flexibility of the musculature involved in
the ROM movements of the participant as the study progressed. Once again this is only postulated as flexibility was never recorded for the purpose of this study.

The ball speed mean values for the control group were decreased and also had no statistical significance, therefore the increase in ROM that occurred in the L/S once again shows that an increase of L/S and SIJ ROM have no effect on the ball speed.
6.1 Conclusion

The aim of the study was to determine whether restoring or increasing the ROM of a dysfunctional joint/s in the L/S and/or pelvis (SIJ) would have a resultant effect on the ball speed when hit by a field hockey player.

The final results obtained after the completion of the study indicated that chiropractic manipulation applied to a dysfunctional joint/s in the L/S and/or the SIJ did not have any effect on the speed of the hockey ball when hit by male or female hockey players. Thus, there is no correlation between the biomechanics of the L/S and SIJ alone and the speed at which a hockey ball gets hit.

This study does not completely support that chiropractic manipulative therapy of dysfunctional joints in the L/S and pelvis (SIJ) would have an influence in the ball speed when hit by a field hockey player.

6.2 Recommendations

1. Larger study group for better statistical results as more information would be available.

2. Use one gender only. Males possess testosterone enhancing their skill set and making them stronger.

3. Determine the center of gravity of each participant as it has an effect on the impact at which the ball would get hit.

4. Use hockey players during their off season as they would not be busy with games resulting in stiffness and injuries.
5. Apply chiropractic manipulation to the entire kinematic chain used during a hockey swing.

6. Measure the flexibility of each participant as it would have an effect on the ROM over the course of the study.

7. Use a more enclosed environment such as an indoor field to eliminate outside variables like the weather, noise or people not involved in the study that may distract the participants.

8. Use additional techniques like dry needling in treating the musculature along with the dysfunctional joints.

9. Use one team only. As each participants' training regime would be of a similar intensity.


Vermillion, J. (2004). Speed measurement device with statistic gathering capability, US 6683558 B1


APPENDIX A

HOW HARD CAN YOU HIT A HOCKEY BALL???

INTERESTED IN PARTICIPATING IN A CHIROPRACTIC RESEARCH STUDY IN WHICH THE EFFECT OF SPINAL MANIPULATIVE THERAPY ON HOCKEY PLAYERS WITH LUMBO-SACRAL FACET JOINT DYSFUNCTION ON THE SPEED OF A HOCKEY BALL WILL BE TESTED?

UJ Ethics clearance number: REC-01-185-2015

For more information please contact:
Bernadette Coston
Cell: 076 116 9068
or
Email: berniblitz@yahoo.com
APPENDIX B

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

Date: ____________________

INFORMATION FORM

Dear Participant,

My name is Bernadette Coston, and I am doing my Master’s Degree at the University of Johannesburg. I would like to invite you to consider participating in my research study entitled “The effect of spinal manipulative therapy on the speed of a hockey ball in hockey players with lumbar-sacral facet joint dysfunction”.

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.
Purpose of the study
The purpose of this study is to determine whether chiropractic spinal manipulation delivered to the lumbar spine and/or sacroiliac joint, will have an effect on the speed of a hockey ball when hit by a field hockey player.

Procedure
Should you decide to partake in this study you will first be screened for what we call “inclusion and exclusion criteria” which will be explained in detail by the researcher.

After screening you will be randomly allocated to one of two treatment groups. The participants will be allocated into their specific groups by placing their names, which will be written on a piece of paper, into a dark bag. The first 15 names drawn will placed in Group 1 (lumbar and/or sacroiliac manipulative therapy) and the remaining 15 in Group 2 (no treatment or manipulation). This procedure is done to ensure that the information gathered during this study is as accurate as possible. Treatment, over a two week period (2 x per week), will be taking place at the University of Johannesburg hockey astro.

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. The risks, although rare, during lumbar or sacroiliac manipulation include compression of nerves in the lower spinal column causing numbness and tingling in the legs and post-adjustment stiffness.

As your participation in this study is entirely voluntary you can decline to participate, or stop at any time, without stating any reason. Your withdrawal will not affect your access to other medical care.
If you want any information regarding your rights as a research participant, or complaints regarding this research study, you may contact Prof. M. 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 6686

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. Also, should you fall pregnant during the study the possible associated ligament laxity would mean you would need to withdraw from this study.

Participants will be referred to other health care practitioners best related to their problem when necessary.

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 where 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: Bernadette Coston 076 116 9068
Supervisor: Dr. Irmarie Landman 011 559 6820

UJ Ethics clearance number: REC-01-185-2015
APPENDIX C

DEPARTMENT OF CHIROPRACTIC

Date: _________________

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 Bernadette Coston about the nature, conduct, benefits and risks of this study with the title “The effect of
spinal manipulative therapy on hockey players with lumbo-sacral facet joint dysfunction on the speed of a hockey ball”.

- 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  Date and time

Signed Researcher

________________________________________________________________________
Printed name  Signature  Date and time
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
Haernatologic
Endocrine

Psychiatric
APPENDIX E

UNIVERSITY OF JOHANNESBURG
CHIROPRACTIC DAY CLINIC

PHYSICAL EXAMINATION

Underline abnormal findings in RED.

Date: ____________________

Patient: ____________________  File No: ____________

Clinician: ____________________  Signature: ____________

Student: ____________________  Signature: ____________

Height: _________  Weight: ________  Temp: _________

Rates:  Heart: _________  Pulse: ________  Respiration: _________

<table>
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<th>Blood pressure:</th>
<th>Arms:</th>
<th>L</th>
<th>R</th>
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<tr>
<td>Legs:</td>
<td>L</td>
<td>R</td>
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</table>

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. Gait:
   - rhythm
   - balance
   - pendulousness
   - on toes
   - on heels
   - tandem
9. Half squat
10. Scapular winging
11. Muscle tone
12. Spasticity/Rigidity

/ = pain-free limitation  // = painful limitation
13. Shoulder:  
- skin  
- symmetry  
- ROM  
- glenohumeral  
- scapulo-thoracic  
- acromioclavicular  
- elbow  
- wrist

14. Chest measurement:  
- inspiration  
- expiration

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<td>cm</td>
<td>cm</td>
<td>cm</td>
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15. Visual acuity

16. Breast examination:  
   Inspection:  
   - skin  
   - size  
   - contour  
   - nipples  
   - arms overhead  
   - hands against hips  
   - leaning forward  
   Palpation:  
   - axillary lymph nodes  
   - breast incl. tail

**SEATED EXAMINATION**

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

• corneal reflex

• ocular movement

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<td>IV</td>
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</table>

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

4. Ears:
• Inspection
  - auricle
  - ear canal
  - drum

• auditory acuity
• Weber test
• Rinne test

5. Nose:

• External
• Internal
  - septum
  - turbinates
  - olfaction
6.  Sinuses
   (frontal & maxillary:
   - tenderness
   - transillumination

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

8.  Neck
   - posture
   - size
   - swelling
   - scars
   - discoloration
   - hair line
9. NEUROLOGICAL EXAMINATION (CERVICAL SPINE)

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<tr>
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<th>Left</th>
<th>Right</th>
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<th>REFLEXES</th>
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<td>Neck Flexion C1/2</td>
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<td>Biceps C5</td>
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<td></td>
<td>Elbow Extension C7</td>
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<td>C8</td>
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<td>Elbow Flexion at 90° C6</td>
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10. 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

11. Musculoskeletal:
(i) ROM
   - hip

<table>
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- knee
- ankle

(ii) leg length
- Co-ordination
  - point to point
  - dysdiachokinesia
12. TMJ
- Inspection
  - ROM
  - deviation
  - Palpation
  - crepitus
  - tenderness

13. Thorax
- Inspection
  - skin
  - shape
  - respiratory distress
  - rhythm (respiratory)
  - depth (respiratory)
  - effort (respiratory)
  - intercostals/supraclavicular retraction

- Palpation
  - tenderness
  - masses
  - respiratory expansion
  - tactile fremitus

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

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

- Cardiovascular
  - auscultation (aortic murmurs)
  - Allen's test
SUPINE EXAMINATION

1. JVP
2. PMI
3. Auscultation heart
   (L. lat. Recumbent)
4. respiratory excursion
5. percussion chest
   (anterior)
6. breast palpation

7. Abdominal Examination
   • Inspection
     - skin
     - umbilicus
     - contour
     - peristalsis
     - pulsations
     - hernias (umbilical/incisional)
   • Auscultation
     - bowel sound
     - bruit
   • Percussion
     - general
     - liver
     - spleen
   • Palpation
     - superficial reflexes
     - cough
     - light
     - rebound tenderness
     - deep
     - liver
     - spleen
     - kidneys
     - aorta
     - intra-/retro-abdominal wall mass
     - shifting dullness
     - fluid wave
• Acute abdomen - where pain began and now
  - cough
  - tenderness
  - guarding/rigidity
  - rebound tenderness
  - roving’s sign
  - psoas sign
  - obturator sign
  - cutaneous hyperaesthesia
  - rectal exam
  - Murphy’s sign

8. MENTAL STATUS

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

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

(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

### 9. NEUROLOGICAL EXAMINATION (LUMBAR SPINE)

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CHIROPRACTIC DAY CLINIC
REGIONAL EXAMINATION
LUMBAR SPINE AND PELVIS

Date: ______________________

Patient: _____________________________ File No: ______________________

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

1. SPECIAL TESTS

- Tripods Test
- Kemps Test
- Valsalva
2. MOTION PALPATION

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C. SUPINE

1. OBSERVATION

- Hair, Skin, Nails
- Fasciculations

2. PULSES

- Femoral
- Popliteal
- Dorsalis Pedis
- Posterior Tibial

3. MUSCLE CIRCUMFERENCE

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5. **ABDOMINAL EXAMINATION**

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

Comments:

6. **NEUROLOGICAL EXAMINATION**

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Ankle Plantar Flexion (S1/S2)
Eversion (S1)
Inversion (L4)
Hip Extension (L5/S1)
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
• Pin-point pain
### CHIROPRACTIC DAY
#### CLINIC SOAP NOTE:

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**Comments:**
APPENDIX H

Contraindications to spinal manipulation (Gatterman, 2005)

- Vertebro-basilar insufficiency (VBI)
- Atherosclerosis
- Aneurysm
- Tumours
- Bone infections – Tuberculosis, Osteomyelitis
- Fractures
- Joint instability/hypermobility
- Unstable spondylolisthesis
- Arthritis – Rheumatoid, Psoriatic
- Clotting disorders
- Osteoporosis (Osteopaenia)
- Disc lesions
- Space occupying lesion
- Sacral nerve root involvement
- Disc protrusion
APPENDIX I

Radar Speed Gun Recording Sheet

Participant no: ______________________

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APPENDIX J

Digital Inclinometer Recording Sheet

Participant no: ___________________________

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Lumbar spine **EXTENSION**

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### Lumbar spine **RIGHT LATERAL FLEXION**

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### Lumbar spine **LEFT LATERAL FLEXION**

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APPENDIX K

Chiropractic manipulation techniques for lumbar spine facet joint and sacroiliac joint restrictions (Peterson and Bergmann, 2011)

1. Hypothenar Spinous Pull (Spinous Hook/pull)
2. Hypothenar Mammillary Push (Thigh Transverso Deltoid)
3. Hypothenar Ilium Push (Thigh Ilio Deltoid)
4. Hypothenar Ischium Push (Ischio Popliteal Deltoid)
APPENDIX L

Research Ethics Committee Clearance Letter

REC-01-185-2015
12 JUNE- 2015

TO WHOM IT MAY CONCERN:

STUDENT: COSTON, B
STUDENT NUMBER: 200811208

TITLE OF RESEARCH PROJECT: “The Effect of Spinal Manipulative Therapy on Hockey Players with Lumbo-Sacral Facet Joint Dysfunction on the Speed of a Hockey Ball”

DEPARTMENT OR PROGRAMME: CHIROPRACTIC

SUPERVISOR: Dr DM Landman

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,

[Signature]

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

Turnitin Originality Report

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