THE IMMEDIATE EFFECT OF A LUMBAR MANIPULATION ON THE CLINICAL AND PERFORMANCE MEASURES OF AMATEUR TENNIS PLAYERS SUFFERING FROM LOWER BACK DISCOMFORT ASSOCIATED WITH PLAYING TENNIS.

By

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Dissertation submitted in partial compliance with the requirements for the Master's Degree in Technology: Chiropractic at Durban Institute of Technology.

I, Susan Tyfield, do declare that this dissertation is representative of my own work in both conception and execution.

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DEDICATION

To my Parents and Brother, for your love and support, I appreciated all you have done for me and continue to do every day.

Thank you with all my heart.

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My classmates and friends, thank you for the smiles on the good days and the support on the bad. You have become more than friends, we have become a family and no matter how far apart we may go I know I will always have you in my heart.

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ABSTRACT

Lower back pain and lower back injuries have been documented as one of the most common musculoskeletal problems in both amateur and professional tennis players. It has also been documented that the serve, which may be considered one of the most important strokes of the game, is also the most likely stroke to cause back pain.

A good tennis serve requires considerable trunk rotation. The serve is the highest stress strain action during tennis. In a two set game the minimum number of serves a player may hit is 24 with a maximum excluding deuces and advantages of 96. The "Topspin serve" in particular requires the player to arch their back and this puts the lumbar spine into hyperextension. These movements thus put considerable pressure on the facet joints and multifidi muscles.

It stands to reason that any joint related clinical entity can change biomechanics and affect the serve. In research done on golfers with mechanical lower back pain, it was found that club head velocity as well as pain decreased in symptomatic golfers with mechanical lower back pain after manipulation (Jermyn, 2004). No research has yet been done on manipulation of tennis players with lower back pain.

The aim of this investigation was to determine the immediate effect of a lumbar manipulation on the clinical and performance measures of amateur tennis players suffering from lower back discomfort associated with playing tennis.

The design was that of a prospective randomised pre-post experimental study evaluating the effect of lumbar spine manipulation on tennis serve speed, accuracy and consistency in amateur tennis players suffering from lower back discomfort. Thirty amateur tennis players (15 male and 15 female) suffering from mechanical low back pain were evaluated in an experimental manner. Once the subjects were found suitable for the study a baseline reading of their serve speed, accuracy and consistency was established. They then received a treatment involving spinal manipulative therapy for their mechanical low back discomfort. The subjects were then re-assessed once the treatment protocol was complete for any changes in their serve speed, accuracy and consistency.

Subjective measurements included the Numerical Pain Rating Scale with respect to discomfort, and an Outcomes Expectation Assessment. Objective measurements included Speed, Accuracy and Consistency.

Data analysis was done using the SPSS version 12. The descriptive data (demographics of the participants) were analysed using frequency tables, tables and / or bar charts. Inferential statistics were performed using the paired t-test to compare pre-post readings for each group, with the confidence interval set at 95% and the p-value at 0.05 (level of significance).

A statistically significant effect of the intervention was found for the outcomes of NRS ($p<0.001$) and accuracy ($p=0.050$). There were no factors which influenced the effect of the intervention. Expectation of the intervention was generally high (median 33, range 11 to 40). Accuracy and consistency were strongly positively correlated together, thus as one increased so did the other.

This study suggests that Spinal Manipulative Therapy used as a management for lower back discomfort in amateur tennis players is effective in decreasing pain and increasing the accuracy of the players serve.

These results indicate that the utilisation of Spinal Manipulative Therapy in the management of acute lower back discomfort in tennis players will have a positive outcome on accuracy and pain and should be included in future acute management protocols for tennis players.

Key Words: Lower Back Discomfort, Spinal Manipulative Therapy, Tennis Player.

GLOSSARY

Amateur Tennis Player:

A person who takes part in tennis without receiving money for it. i.e. they are not professionals (Oxford Advanced Learner's Dictionary, 1995:35).

Immediate:

May be defined in many ways, with differences in these definitions being reflected in the type of study, measurement tools and form of intervention utilised within the respective study, therefore for the purposes of this study, the following definition will be utilised: a period that is less than 24 hours(Engel and Graney, 2000).

Flexibility:

Capable of being bent or flexed; pliable. Capable of being bent repeatedly without injury or damage. (American Heritage Dictionary of the English Language, 2000)

Tennis Serve:

To put a ball into play, as in court games (American Heritage Dictionary of the English Language, 2000)

Spinal Manipulative Therapy (SMT):

Specific type of articular manipulation using either long- or short-leverage techniques with specific contacts. It is characterised by a dynamic thrust of controlled velocity, amplitude, and direction. (Bergmann, T.F, Peterson, D.H, Lawrence D.J, 1993:124)

Mechanical lower back pain:

In its use for this study is pain originating from the sacroiliac or lumbar facet joints associated with playing tennis.

Discomfort:

For the purpose of this study refers to a feeling of unease or inability to function to their utmost ability, possibly associated with minor pain.

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CHAPTER ONE

INTRODUCTION

1.1 The Problem:

Lower back pain and lower back injuries have been documented as one of the most common musculoskeletal problems in both amateur and professional tennis players (Mihelic, 2004). It has also been documented that the serve, which may be considered as one of the most important strokes of the game, is also the most likely stroke to cause back pain (Hainline, 1988). By nature, the serve is the most important stroke in tennis because every point starts with a serve, and it is the only stroke in which a player has full control of the outcome (Bahamonde, 2003). The perceived lower back problems are thought to be related to the fact that a good tennis serve requires considerable trunk rotation. In particular, the “Topspin serve” requires the player to arch his/her back and this puts the lumbar spine into hyperextension (Advanced coaches manual ITF, 1996).

The biomechanics of the tennis serve can be summarized as follows: the preparation phase occurs first, there is a transfer of weight onto the back foot of the player to create a push off against the court to generate a ground force. Next there is a backswing or loading phase which is similar to a throwing action. In this movement, the tossing arm leads the hitting arm and there is rotation of the hips to facilitate the turn of the body. The backswing or loading phase is where the energy is generated by an effective leg bend and a good leg drive. This is followed by the forward swing and pre-hitting phase which also requires a good leg drive. The forward swing and contact phase incorporates both deceleration and acceleration of the kinetic chain, while full extension propels the players feet off the ground. Finally there is the follow-through phase which completes the action of the serve (Tiley, 2005).

All these movements put significant stress on the lower back muscles and facet joints, especially in amateur players who biomechanically may not maintain a correct form or a stable base from which to serve, particularly when the individual begins to fatigue.

In a two set game the minimum number of serves a player may hit is 24 with a maximum excluding deuces and advantages of 96. These repetitive movements thus put considerable pressure on the facet joints and multifidi muscles. Therefore, it is reasonable to assume that if a tennis player has mechanical lower back pain due to lumbar spine fixations or muscular hypertonicity both of which may lead to discomfort and biomechanical defects, he/she is likely to serve less effectively.

The action of the golf swing is very similar to that of the tennis serve and in research done on golfers, Lehman and McGill (1999) looked at the influence of spinal manipulative therapy on lumbar kinematics and found that after single rotary manipulations (at the level of fixation), the golf swing increased in all total ranges of motion for each plane of movement, with concomitant muscle responses (i.e. relaxation). This improved movement/ flexibility according to Lindsay and Horton (2002), should be the primary aim of players with low back pain and, in particular, trunk rotational flexibility can be used to reduce their symptoms and decrease the effects of repetitive strain.

In further research done on the relative therapeutic efficacy of vertebral manipulation and conventional treatment (heat, pelvic tilt exercises, postural education, lifting instructions) of back pain management in the general population, it was found that there was a significantly greater increase in lumbar spine flexion, extension, side flexion and rotation in the group receiving manipulation (Nwuga, 1982).

With reference to research on the actual effect of manipulation, Cassidy et al. (1992), found in their research done on the immediate effect of manipulation versus mobilization on pain and range of motion in the cervical spine, that a single manipulation was more effective than mobilization in decreasing pain in patients with mechanical neck pain. Both treatments, however, increase range of motion in the neck to a similar degree. In addition to this, in a qualitative review of studies on manipulation-induced hypoalgesia done by Vernon (2000) it was found that although few studies have investigated the effect of manipulation on pain directly, if the theory of manipulation having a therapeutic effect of inhibiting pain is common to the studies, then the studies were largely consistent in finding that this was true.

Spinal Manipulative Therapy (SMT) has been validated as a safe and effective treatment for low back pain of mechanical origin (Cooperstein et al, 2001) and research has shown that SMT results in improved flexibility, reduced pain and increased joint mobility (Gatterman, 1990).

1.2 Aims and Objectives of the Study:

This study aims to investigate the effect of lower back manipulation on the speed, accuracy and consistency of the serve of amateur tennis players experiencing lower back discomfort.

Sub problem 1:

To determine the immediate effect of a lumbar manipulation on the objective performance measures speed, consistency and accuracy in symptomatic amateur tennis players with regard to mechanical lower back discomfort.

Hypothesis: Spinal manipulative therapy should improve the accuracy and consistency of the serve and increase the speed of the serve.

Sub problem 2:

To determine the immediate effect of a lumbar manipulation on the subjective discomfort rating to gauge discomfort of the participant.

Hypothesis: The patient, in terms of his/her level of discomfort, should improve.

Sub problem 3:

To determine the clinical outcomes expectations of the participant.

Hypothesis: There should be a correlation between the expected outcome of the patient and their actual outcome, and what the patient expected from a chiropractic treatment.

1.3 Benefits of this Study:

This research aims to show that there may be a correlation between the biomechanical status of an amateur tennis player's lower back and the efficacy of his/her serve and that lower back spinal manipulation may have an effect on the serve as well as lower back discomfort levels.

There has been no previous research on the effect of any lower back manipulative therapy in tennis players at any level with or without lower back pain or discomfort.

This research aims to form a basis on which further research can be carried out with respect to this topic and to promote the utilization of chiropractic in the treatment of tennis players with lower back discomfort.

CHAPTER 2

REVIEW OF RELATED LITERATURE:

2. Introduction:

This chapter gives a review of the available literature on lower back pain in tennis players. The information reviewed will provide a clearer understanding of the aetiology of lower back pain in tennis players along with the injury mechanisms, diagnosis and possible treatment.

Anatomy of the Lumbar Spine and Sacroiliac Joints:

The spine is made up of a number of functional units. The functional unit is made up of 2 vertebral bodies**,** 1 superior to the other and separated by an intervertebral disc. The anterior portion of the unit is mainly for supporting, weight-bearing, shock absorbing and to make the structure flexible. The posterior unit of the structure contains and protects the neural structures and has paired joints that function to direct the movement of the joint. Each functional unit has all the tissues needed for total function; therefore, the impairment of any part of the unit may lead to functional impairment of the system (Calliet, 1988).

2.1.1) Lumbar vertebrae:

The lumbar vertebral body is large, heavy and kidney shaped. The body is wider from side to side. The size of each of the bodies increases from L1 to L5 because it must withstand a greater load. It is made of dense cancellous bone incased in a thin cortical shell. The vertebral arch is a u-shaped structure composed of lamina and pedicles. Projecting from these areas are seven processes: 2 superior and inferior articular processes, a spinous process and 2 transverse processes. The pedicles are short and attached to the superior half of the body. The lamina are broad, flat and blend in with the spinous process which is flat, broad, rectangular and project directly backward. The transverse processes project laterally and slightly posteriorly from the lamina and pedicles junction. The transverse processes and spinous processes act as levers for the muscles and ligaments that attach to them. The articular processes project superiorly and inferiorly from the lamina. The superior processes articular surface is slightly concave and faces medialy and posteriorly. While the inferior processes point laterally and anteriorly and have convex articular surfaces (Kirkaldy-Willis and Burton, 1992).

The facet joints are synovial joints. The articular surfaces are covered in hyaline cartilage and have thick fibrous capsules that cover the posterior aspect of the joint. The anterior aspect is made up of part of the ligamentum flavum. On the rim of the joint there may be a fibro-adipose, adipose or miniscoid enlargement (Kirkaldy-Willis and Burton, 1992). The function of the facet joints is to guide and restrain movement between vertebrae and to protect the discs from shear forces and axial rotation. The facets also have the role of preventing the vertebrae from slipping anteriorly. The lumbar vertebrae are weight-bearing vertebrae, with the ability to withstand increasing loads inferiorly to L5, where the L5 vertebra bears weight even in the erect posture (Moore and Dalley, 1999).

2.1.2) The Sacrum and Sacroiliac joints:

The sacrum is a wedge shaped bone made up of 5 fused vertebrae. It has articulations with the 5th lumbar vertebra superiorly, the ilium laterally and the coccyx (3 to 5 variably fused vertebrae) inferiorly (Kirkaldy-Willis and Burton, 1992).

The sacroiliac joint is a strong weight-bearing synovial joint between the sacrum and the ilium. The 2 surfaces are irregular and have elevations that produce some interlocking. The sacrum is attached to the iliac bones by the interosseous and the sacroiliac ligaments.

Movement of this joint is limited because of the interlocking articular bones and the thick interosseous and sacroiliac ligaments. Movements are those of a slight gliding and rotary quality (Moore and Dalley, 1999).
The sacroiliac joint has two functions: to provide elasticity to the pelvic rim and to serve as a buffer between the lumbosacral and the hip joints (Kirkady-Willis and Burton, 1992).

2.1.3) The Intervertebral Disc:

The intervertebral disc (IVD) is a hydrodynamic structure found between 2 adjacent vertebrae. The IVD acts as a shock-absorbing mechanism. It is made up of a central nucleus pulposus which is surrounded by an annulus fibrosis (Kirkaldy-Willis and Burton, 1992). The IVD makes up 1/3 of the length of the lumbar spine. Both endplates are made up of hyaline cartilage which rests on a flat subchondral bone plate which is supported by the spongiosa of the vertebral body (Calliet, 1988).

2.1.4) Ligaments of the spine:

Anterior longitudinal ligament is a fibrous structure which attaches to the anterior part at the base of the occiput and ends at the upper anterior part of the sacrum. The fibers of this ligament run longitudinally and attach to the anterior aspect of all the vertebral bodies. Posterior longitudinal ligament is found on the posterior aspect of the vertebral bodies and arises at the base of the occipital bone at the foramen magnum and attaches to the superior margins of the vertebral bodies and discs. This ligament becomes thinner as it moves down into the lumbar spine (Kirkaldy-Willis and Burton, 1992).

The ligamentum flavum ligament extends almost vertically from 1 vertebral lamina to the next 1 below it. The ligaments bind the vertebrae and form part of the posterior wall of the vertebral column. Interspinous ligaments link adjacent spinous processes, while the supraspinous ligament joins the apices of the spinous processes. Intertransverse ligaments join adjacent transverse processes

(Moores and Dalley, 1999). Articular capsules are strengthened by accessory ligaments, which are either part of their fibrous capsules (intrinsic ligaments), or are separated from them (extrinsic ligaments). The articular capsule and its accessory ligaments are important in maintaining the relationship between the articulating lumbar joints (Moore and Dalley, 1999).

2.1.5) Lumbar spine musculature:

The extensors:

These are arranged in 3 layers. The most superficial is the erector spinae group. It attaches to the posterior part of the iliac crest, the median and lateral sacral crests and the spinous processes of the sacrum and lumbar spine. The muscle divides into 3 columns as it reaches the upper lumbar spine, from lateral to medial these are the iliocostalis, longissimus and spinalis.

The intermediate layer is made up of the multifidi. This muscle originates on the sacrum from the tendinous origins of the sacrospinalis and the medial area of the posterior superior iliac spine. This muscle originates from the mamillary processes. Each fiber is directed superiorly and medialy toward the inferior and medial margin of the lamina and spinous process.

The superficial layer attaches 3 to 4 levels higher, the intermediate 2 levels and the deep layer 1 level above. The multifidi extend and rotate the lumbar spine. The deep layer is made up of the interspinalis muscles which consist of short fascicles attached between spinous processes of adjacent vertebrae. Intertransversarius which are made up of a venterolateral slip which attaches adjacent transverse processes, a dorsolateral slip which bridges the accessory process of 1 vertebra to the transverse process of the other and a medial slip that attaches the accessory process of 1 vertebra to the mamillary process of the next (Kirkaldy-Willis and Burton, 1992).

Deep lateral muscles

Theses muscles are the quadratus lumborum muscle and the psoas major muscle and they both attach to the transverse processes of the lumbar vertebrae. The quadratus lumborum muscle attaches to the last rib, the transverse process of the lumbar vertebrae, and the iliac crest. The psoas muscles origin is the bodies and transverse processes of the lumbar vertebrae and their discs and its attachment is to the lesser trochanter of the femur. When both muscles act together they help in lumbar extension (Gatterman, 1990).

Principal muscles producing movement of the lumbar intervertebral joints: (Moore and Dalley, 1999).

Flexion is produced by bilateral action of :

Rectus abdominis and Psoas Major muscle.

Extension is produced by bilatral action of:

Erector spinae and Multifidi muscles.

Lateral bending is produced by unilatral action of:

Multifidi, external and internal obliques and the quadratus lumborum muscles.

Rotation is produced by unilateral action of:

Rotators, multifidi and external oblique muscles acting synchronously with the opposite internal oblique muscles.

Posterior facet syndrome:

Posterior joint dysfunction is characterized by an overriding of the facets of adjacent vertebrae (Gatterman, 1990:161). Patients usually present with local tenderness in the lower back, muscle spasm and lower back pain referred to the back of the thigh, the mid-calf, or to the ankle: they are considered to have facet syndrome (Giles, 1997). The term**,** mechanical facet syndrome is characterized by back and leg pain because of mechanical irritation of a lower lumbar zygapophyseal joint; this is a clinical diagnosis made by pain provocation tests (Giles, 1997).

Mechanisms of injury:

There are 2 different mechanisms of injury in this area: rotational strains and compressive forces in flexion (Kirkady-Willis and Burton, 1992). Trauma to the posterior facets resulting from hyperextension of the lumbar spine is also an etiology because this trauma to the facet joints produces inflammation of the vertebral joint capsule which gives rise to intraarticular pressure and acute pain (Gatterman, 1990).

There are three phases in the degenerative process as stated by Kirkaldy-Willis and Burton and these are: dysfunction, instability and stabilization.

Phase 1 dysfunction: normal function of the 3 joint complex (1 intervertebral joint composed of 2 posterior facet joints and a disc) is disrupted because of injury. On examination**,** a segment of posterior muscles of the lumbar area will be hypertonic. The normal movement of that level is disrupted. Facet syndrome is primarily found in this phase.

Phase 2 instability: The lumbar spine will demonstrate abnormal increased movement. There will be laxity of the posterior joint capsule and the annulus fibrosis.

Phase 3 stabilization: The unstable joint regains its stability because of fibrosis and osteophyte formation around the posterior joints and inside and around the disc (Kirkady-Willis and Burton, 1992).

Joint dysfunction refers to decreased mobility in a motion segment, but it does not include the pathological and/ or clinical changes that are found in soft tissues as found in facet syndrome, i.e. joint mechanics showing functional disturbances without structural changes (Redwood, 1997). Joint dysfunction affects quality and range of joint motion (Haldeman, 1992).

Symptoms: lower back pain, radiating into the groin, hip buttock and often the leg, usually above the knee. Pain is often localised to 1 area or 1 side. Pain can be referred to the area of the greater trochanter, and to the posterior thigh as far as the knee. The pain should be relieved by rest and aggravated by movement (Kirkady-Willis and Burton).

Signs: Tenderness to pressure on 1 side and at 1 level over the sacrospinalis and multifidi muscles. The muscle in this area will be hypertonic. Bending laterally will be abnormal with hypomobility on 1 or both sides. All movements are restricted, especially extension. Palpation at the lesion level may show 1 spinous process to be out of line with the next spinous process (Kirkaldy-Willis and Burton, 1992). Hyperextension movements of the back increase pain, whereas flexion reduces it. Other activities that may increase pain include sleeping on the abdomen, sitting in an upright position, lifting a load in front of the body, working with the hands and arms above the head and rising from sitting (Gatterman, 1990).

Pain is aggravated by provocation tests, e.g.:
Kemp's test (Gatterman, 1990)
Facet challenge test (Gatterman, 1990)
Hyperextension in a prone position (Gatterman, 1990)

2.3 <u>Sacroiliac syndrome:</u>

Associated Symptoms: Pain is typically found over the back of the sacroiliac joint and varies in its degree of severity, with associated pain that can be referred into the groin, over the greater trochanter, down the back of the thigh to the knee, and / or occasionally down the lateral or posterior calf to the ankle, foot and toes (Kirkady-Willis and Burton, 1992).
Referred pain from the sacroiliac joints is experienced in the posterior dermatomal areas of L5, S1 and S2; over the sacrum; or in the buttocks (Gatterman, 1990).

Associated signs: Tenderness to pressure over the posterior superior iliac spine at the sacroiliac joint or in the buttock. Movement of the joint is usually restricted (Kirkady-Willis and Burton, 1992).

Pain is aggravated by provocation tests and restricted movements which stress the joint (Kirkady-Willis and Burton, 1992) e.g.:
Patrick Faber test (Haldeman, 1992 and Magee, 1992)
Gaenslen’s test (Haldeman, 1992 and Magee, 1992)
Yeoman’s test (Haldeman, 1992 and Schafer and Faye, 1990)

2.4 Serve Biomechanics:

Stance of the serve: In this part of the serve, the person needs to take a position sideways to the net, about three or four feet to the right center mark behind the baseline. The left foot is two to three inches behind the line, the toes pointing toward the net post. The back foot is parallel to the baseline the preparation phase. The execution of the ball toss is performed.

Action phase: The elbow reaches a position slightly higher than the shoulder, then the elbow bends and the racket head drops down behind the back into what is called the back scratching position. The ball should be at its maximum height of the toss before striking it.

Last part of the action phase: The movement of striking the ball is explosive in an upward and forward motion which ends in the contact and the follow through.

Follow through: The action is performed up and out, not down, in the direction of the intended target area. The follow through is a natural continuation of the stroke.

In the beginning of a right handed tennis players serve, during the stance**,** the feet are outwardly rotated. The hips and the trunk are extended. The left shoulder is slightly flexed along with the right shoulder and the shoulder girdles are slightly abducted. Both of the wrists are pronated with the elbows slightly flexed. During the preparation the feet are still in an outwardly rotated position. The hips slightly abduct with the trunk still in full extension. The shoulders are abducted, with slight elevation of the shoulder girdle. Both elbows are extended. During the action the right foot inwardly rotates along with it performing planter flexion but the left foot stays in an outwardly rotated position. The hips are adducted but then they shift to abduction. The trunk starts in hyperextension then becomes fully extended and slightly rotates to the left. Both knees flex but the left knee extends while the right knee stays flexed. The left shoulder goes from flexion to extension**,** while the right shoulder performs high diagonal adduction. The left elbow goes from extension to flexion and the right elbow goes from flexion to extension. Finally, during the follow through the left foot inwardly rotates along with some planter flexion. The right foot inwardly rotates and goes back to a naturally flat position. Both hips are flexed along with the flexion of the trunk and its rotation. The left shoulder remains in an extended position but the right shoulder follows through with the high diagonal adduction, while both shoulder girdles perform abduction. The right elbow slightly flexes but the left elbow extends. The knees go from flexion to a greater degree of flexion (http://hermes.hh).

2.5 Lower Back Injury in the Tennis Player:

Lower back pain and lower back injuries have been documented as one of the most common musculoskeletal problems in both amateur and professional tennis players (Mihelic, 2004). It has been stated that the serve is the most likely stroke to cause back pain (Hainline, 1995). By nature**,** the serve is the most important stroke in tennis because every point starts with a serve, and it is the only stroke in which a player has full control of the outcome (Bahamonde, 2003).

There is anecdotal evidence to support that nearly 40% of tennis players on the ATP tour have had to miss at least 2 weeks because of back problems (Vad, 2001). A survey of the Men's Professional Tennis Tour indicated that 38% of 143 tennis players missed at least one tournament because of low back problems (Marks *et al.*, 1988).

The lower back problems seen are thought to be related to the fact that a good tennis serve requires considerable trunk rotation. In particular, the "Topspin serve" requires the player to arch his/her back (Advanced coaches manual ITF, 1996): this puts the lumbar spine into hyperextension. In addition to this, back problems have been associated with the precipitation of other injuries e.g. sore knees and sprained ankles (Rehe, 2001).

Although the serve is known to cause most lumbar injuries in tennis players, at present there is no data that substantiates this clinical observation. During the serve it is the ball toss, the position of the lower extremities and power generation that determine how much load is placed on the lumbar spine. If the player's ball toss is behind his/her shoulder, the server has to rotate and hyperextend the spine in order to make racquet contact. This effectively uncouples the shoulder and pelvis. After ball impact there is a rapid reversal of the rotation of the lumbar spine from hyperextension and counterclockwise rotation to flexion and clockwise rotation. With this cork-screwing motion there is a transfer of torque to the spinal segments. When there is an improperly placed ball toss, an uncoupled pelvic motion occurs. Insufficient leg drive which uncouples the lower body from the upper body will lead to spinal rotation (Watkins, 1996).

A review of the kinematic and kinetic studies by Elliott (1988) on the serve action does not clearly identify the reason(s) for these injuries. Data from these studies, however, does suggest possible causes of these injuries.

Ground reaction forces found with different serving techniques were compared to those recorded from activities involving running or jumping. The chance of causing injury seems to be related to high internal forces (combination of muscle and joint reaction forces), especially where these forces are associated with poor technique and high segment accelerations. These situations occur when the racket moves behind the body and the vertebral column is laterally flexed and hyperextended.

Electromyographic data from the prime mover muscles involved in the serve have shown that muscle action was greater for amateur tennis players than professional players, because their muscles were active for longer periods of time.

Thus**,** when one considers optimal performance of the tennis serve, it is found to rely on the efficient transmission of forces from the ground, through the leg, trunk, and racket arm and finally to the racket (Advanced coaches manual ITF, 1996).

Similarly**,** in golfers it has been found that in the reversed-C position (rotation and hyperextension of the lumbar spine), the lumbar facets approximate, and in addition torsional stress is placed on the intervertebral disc. With repetitive practice swings and incorrect form, the lumbar facets bear the brunt of the abnormal forces being placed on the lumbar spine (Mackey, 1995). Trauma results in posterior joint strain and with the pronation of the forearm and the forces associated with the swing to the ball, the repetitive small capsular tears, a small degree of joint complex dysfunction takes place and the posterior joint synovium is injured, leading to inflammation synovitis (Gatterman and Goe, 1990, Mense, 1991 and Dvorak, 1985).

The posterior segmental muscles protecting the joint maintain a sustained hypertonic contraction in order to prevent further motion (Korr, 1975). As a result of the sustained contraction, the muscle becomes ischaemic, which causes pain, and metabolite accumulation in the muscle, both of which initiate a pain cycle, which sustains the hypertonic state of contraction. Therefore the posterior joints continue to be splinted and the minor joint complex dysfunction is maintained. Because of the muscles maintaining their contracted state, the joint complex dysfunction of the facet joint is maintained, thus leading to a facet syndrome. These changes later lead to fibrosis and / or ankylosis (Kirkady-Willis and Burton, 1992).

2.6 Current Treatment for Lower Back Injuries in Tennis:

The current thinking on treatment for lower back injuries in tennis revolves around the RICE (rest, ice, compression and elevation) protocol for acute injuries and a rehabilitation prorocol for long term treatment and injury prevention. A specific treatment for lower back pain in athletes is:

- Rest: This must have a specific time limit and be as short as possible.
- Ice (therapeutic) and heat (symptomatic)
- Exercise: General endurance training, stretching, strengthening of back extensors, abdominal and lower extremity muscles.
- Activity
- Medications: Nonsteriodal anti-inflammatory drugs, muscle relaxants and antidepressants for chronic pain sufferers.

5.1) Aspects in rehabilitation are:

Flexibility: Asymmetric hip flexor contractures can lead to lumbar rotation and extension. Tight hip rotators can cause the lumbar spine to absorb all the deceleration forces and thus impart injury. Chronic hyperextension and rotation may lead to facet joint pain, exacerbation of spinal stenosis and shearing of the outer annular disc fibers.

Joint mobility: There should be maximized functional range of motion of the lumbar spine. Manual therapies are useful in this respect, but mobility of the spinal segment without stability and strength may actually cause injury.

Strength: The internal and external oblique abdominal muscles, latissimus dorsi and serratus anterior, along with the thoracolumbar fascia are necessary to stabilize the lumbar spine against rotation (Watkins, 1996).

5.2) Treatment of acute or recurrent LBP:

This begins with control of pain and inflammation. No study has demonstrated specifically the efficacy of nonsteroidal anti-inflammatory drugs in the treatment of LBP, decreased pain and inflammation can permit early and more rapid rehabilitation. Careful use of narcotic analgesics has been used for additional pain control.

Therapeutic modalities such as cryotherapy and electrogalvanic stimulation have also been used to assist in reducing pain and muscle spasm. Superficial heat decreases pain and spasm but increases arterial and capillary blood flow and, therefore, may increase inflammation in the acute setting. Deep heat via ultrasound is contraindicated acutely but may help with soft-tissue and articular inflexibilities further into treatment.

Bed rest should be limited to no more than 2 days for nonspecific LBP. Prolonged inactivity may produce deleterious effects, including decreases in muscle strength, flexibility, cardiovascular fitness, bone density, and disk nutrition. Relative rest with early activity is preferred because longer periods of bed rest have not produced better recovery rates.

Therapeutic exercises should begin early into treatment to control pain, avoid deconditioning, and restore function. Initial exercises should avoid movements that aggravate the patient's symptoms. For patients whose symptoms are aggravated by flexion and reduced by extension of the lumbar spine, extension exercises should be done (extension bias) and vice versa. For some patients with acute or recurrent LBP, a combination of flexion and extension exercises may be tolerated (Drezner, 2001).

Passive local modalities such as ultrasound, electrical stimulation, massage, and heat/cold therapy may be helpful to effect pain relief, stimulate local blood flow, and "retrain the muscle fibers" in the acute phase (Collier, 2004).

2.7 Spinal Manipulative therapy:

Definition: High velocity, low amplitude thrust applied using specific short levers with the aim of restoring mobility to a particular joint (Gatterman, 1990, Haldeman, 1992).

Indications for manipulations are a reversible mechanical derangement to an intervertebral joint which produces a barrier to normal motion. This joint fixation can be determined by motion palpation. Manipulation restores normal physiological motion to joints that have been fixed (Gatterman, 1990).

2.8 Manipulation in the Treatment of Lower Back Pain in Tennis Players:

In research done by Keller and Colloca it was observed that muscle activity in the lumbar spine increased significantly during maximal voluntary isometric contraction following the application of manual therapy, leading to the theory that the stimulation of the mechanoreceptors within the lumbar spine aided in the restoration of spinal muscle synergy through the use of electromyographic recordings after the application of mechanical-force spinal manipulation. The muscle activity was recorded during a maximum voluntary isometric contraction when the subject was instructed to perform trunk extensions before and after manipulation was performed (Keller *et al*., 2000).

In a further study by Sean Hanrahan *et al*. (2005), administration of joint mobilizations decreased sensory components of pain while increasing the ability of the paraspinal musculature to produce force.

In research done on the relative therapeutic efficacy of vertebral manipulation and conventional treatment (heat, pelvic tilt exercises, postural education, lifting instructions) in back pain management, it was found that there was a significantly greater increase in lumbar spine flexion, extension, side flexion and rotation in the group receiving manipulation (Nwuga, 1982). Furthermore, in research done on golfers it was found that there was a significant increase in all 3 axes of motion of the lumbar spine during their golf swing following manipulation (Lehman *et al.*, 2000). In research done by Cassidy *et al.* in 1993**,** it was found that a single manipulation is more effective than mobilization in decreasing pain in patients with mechanical neck pain. Both treatments increase range of motion in the neck to about the same degree.

In a case study by Lehman and McGill (1999), they looked at the influence of spinal manipulative therapy on lumbar kinematics and found that after single rotary manipulations (at the same level), the golf swing increased in all total range of motion for each plane of movement after the adjustment, with concomitant muscle responses (i.e. relaxation).

This study, therefore, is concerned with assessing the possible positive effects of a lumbar adjustment on tennis players with lower back discomfort.

Chapter 3

3.1 Introduction:

The aim of this research is to provide greater insight into the effect of lumbar manipulation on the speed, consistency and accuracy of a tennis serve by an amateur player.

Therefore this chapter gives a description of:

- The primary and secondary data,
- The subjects,
- The design and
- The interventions used.

Each measurement parameter is discussed and an overview of each scale is given. Statistical analysis is also discussed.

3.2 The Data:

The data consisted of primary and secondary data.

3.2.1) The Primary Data:
The primary data consisted of:

Case history
Physical examination
Lumbar Regional Exam
Outcomes Expectation Assessment
Discomfort Scales
ITF Serve Measurements
Speed Camera Readings

3.2.2) The Secondary Data:

The secondary data was obtained from various sources including journal articles, textbooks and medical search engines on the Internet (Mantis, Pubmed, Medscape and Google).

3.3 Study Design:

This is a pilot prospective randomised pre-post experimental study evaluating the effect of lumbar spine manipulation on tennis serve speed, accuracy and consistency in amateur tennis players suffering from lower back discomfort.

3.4 The Subjects:

The subjects consisted of amateur tennis player volunteers from the greater Durban area suffering from lower back discomfort.

3.4.1) Advertisements for Subject Recruitment:

The public was informed of the study by advertisements placed at local tennis clubs, sports shops and on the DIT Campus advertising for free participation in a research program being conducted on tennis players with Lower Back Discomfort associated with tennis. Flyers were also handed to tennis players at various tennis tournaments run in the Durban Metropolitan area.

The advertisement called on patients between the ages of 18 and 35 suffering from Lower Back Discomfort associated with playing tennis.

Upon reply all participants were required to undergo a cursory telephonic discussion with the examiner to exclude subjects that did not fit the criteria for the study.

The following questions were asked during the telephonic interview:
Do you presently have low back pain that is related to playing tennis?
Have you ever had surgery for your low back pain before?
Are you currently being treated for your low back pain?
Can you commit to 1 initial consultation with a follow up treatment shortly afterwards which will be at a venue close to DIT at which time the speed, consistency and accuracy of your serve will be assessed?
Are you an Amateur tennis player?
Do you have discomfort of a mild, moderate or severe level during or shortly after playing tennis?

3.4.2) Sampling And Group Allocation Of Subjects:

A non-probability convenience sampling technique was used.

The first 15 male and 15 female participants were consecutively selected from those successfully complying with the telephonic interview. They were included in the study and received treatment. The participants were then asked to attend the Chiropractic Day Clinic for an initial assessment in terms of the inclusion and exclusion criteria. All patients received a letter of information (Appendix 3) and were required to sign an informed consent form (Appendix 4) before treatment commenced.

3.4.3) Clinic Assessment Procedure:

An initial consultation was scheduled during which a case history, relevant physical examination and lower back regional examination were conducted. The participants were screened for lower back fixations and were also required to complete a clinical outcome expectation assessment.

Acceptance of the candidate was dependant on whether or not they met the specific inclusion criteria indicated below:

3.4.3.1) Inclusion Criteria:

Participants between the ages of 18 and 35 years, to keep the sample homogenous (Mouton, 1996). Kirkaldy-Willis & Burton (1992) state that age is an important factor in lower back pain and that lower back pain tends to begin in the 3rd decade of life and reaches maximum frequency during middle age.

A ratio of 1:1 males:females, to maintain an equal sample of each group.

Experience must include 1 or more professional coaching lesson incorporating the serve.

A discomfort rating of mild, moderate or severe during or shortly after playing tennis in order to maintain sample homogeneity (Mouton, 1996)

Participants suffering from mechanical low back pain including lumbar facet syndrome (LFS) and sacro-iliac syndrome (Kirklady Willis, 1978).

For LFS – 1 of the following 4 tests needed to be positive

Facet joint challenge (Bergman, 1993)

Kemp’s test (Gatterman, 1990)

Palpatory tenderness (Magee, 1992)

Spinous percussion (Bergman, 1993)

For SIJS – 2 of the following 6 tests need to be positive

Sacro-iliac tenderness (Kirkaldy-Willis, 1992)

Gaenslen’s test (Kirkaldy-Willis, 1992)

Patrick Faber (Kirkaldy-Willis, 1992)

Ericksen’s (or Yeoman’s) (Kirkaldy-Willis, 1992)

Sacro-iliac compression (Magee, 1992).

Posterior Shear test (Magee, 1992).

3.4.3.2) Exclusion Criteria:

Contraindications to spinal manipulation included (Gatterman, 1990, Bergmann, 1993) any of the following:

Infections (osteomyelitis, TB of the spine, infectious arthritis),

Malignancies (hemangioma, vertebral malignancy),

Mechanical derangements (disc prolapse and advanced spondylolisthesis),

Previous surgery / acute trauma,

Referred pain syndromes (e.g. renal colic, renal stones),

Physiological causes (pregnancy resulting in ligament laxity),

Participants on anti-inflammatory drugs or medication (Poul et al, 1993) [48 hour clearance period] or those who were receiving treatment for mechanical low back pain at the time were excluded,

Participants undertaking any specific lower back exercise during the study, above and beyond normal exercise/ playing/ practice routines,

Patients who refused to sign the informed consent form or those who were illiterate,

Any diseases affecting spinal flexibility e.g. Ankylosing spondilitis, Osteoporosis, Diffuse Idiopathic Skeletal Hyperostosis.

3.4.4) Clinical Procedure:

Following the initial assessment the most symptomatic joints were identified by motion palpation of the lumbar spine and sacroiliac joints prior to the treatment (Schafer & Faye, 1990). Motion palpation was used to identify in which plane a manipulative technique should be given, allowing the participant to have the least amount of discomfort and to restore maximum joint play to their spine (Schafer & Faye. 1989)

There after the participant was required to complete the following:

A baseline reading of the serve speed taken at a venue close to DIT (The Portuguese club).

At the venue the participants were instructed to warm up as per a standard protocol stated in the Advanced coaches manual (1996) followed by 12 serves.

They then were instructed to hit 12 serves in the International Tennis Federation specified serve assessment rating technique. They could use any first serve technique, so long as the same form was maintained throughout all readings. Once the average speed, accuracy and consistency had been established, discomfort scores were recorded. They received spinal manipulative therapy eight minutes later (in order to avoid fatigue affecting their performance post-manipulation).

The patient was adjusted either seated or side-lying in the direction of the fixation found during motion palpation, using techniques specified by Bergmann (1993).

Directly following manipulation the participant did six warm up serves and then was reassessed for the speed, accuracy and consistency of his/ her serve, in accordance with the same procedure pre manipulation (i.e. 12 serves). A discomfort score was again recorded.

3.5.1) Objective measurements included:

A speed camera

ITF serve measurement for accuracy and consistency (Appendix G)

3.5.2) Subjective measurements included:

Outcomes Expectations Assessment

NRS Rating with respect to discomfort while serving

3.6 Statistical Analysis:

Data analysis was performed using the SPSS version 12 statistical package.
The descriptive data (demographics of the participants and expected outcome assessment) was analysed using frequency tables, tables and / or bar charts. Speed is a continuous variable so mean and standard deviation of the mean were determined and then comparisons were made between the 2 groups using a paired t-test. Discomfort, accuracy and consistency scores are ordinal data and nonparametric tests were applied to compare pre-post scores. The confidence interval was set at 95% and the p-value at 0.05 (level of significance).

3.7 Ethics:

The ethical procedures were adhered to in accordance with the Durban Institute of Technology guidelines.

Each patient was required to complete and sign an informed consent form. The research involved no more than minimal risk and all information was treated as confidential.

CHAPTER FOUR

RESULTS AND DISCUSSION:

4. Introduction:

This chapter involves the discussion of the demographic data and the results after the statistical analysis of the data obtained from the subjective (NRS with respect to discomfort and outcomes expectation assessment) and objective (speed, accuracy and consistency readings) correlation tests.

4.1 Statistical methodology

Data were captured and analysed in SPSS version 11.5 (SPSS Inc, Chicago, Ill, USA). A two-sided p value of <0.05 was considered as statistically significant.

Demographic data were described for the sample as a whole using summary statistics such as mean, standard deviation and range for quantitative variables, and frequency tables and bar charts for categorical variables. The objectives were tested using paired t-tests to compare pre and post intervention measurements for the sample as a whole. The value of the change between pre and post intervention was computed. In order to assess if the magnitude of the change was due to any other factor, mean change was compared between categorical demographic variables using independent t-tests, and Pearson's correlation was done to assess the relationship between changes in outcome measures.

4.2 Demographics:

Thirty participants were enrolled into the study, 15 (50%) males and 15 (50%) females. Their mean age was 25.2 years (SD 4.2, range 18 to 35 years). 90% (n=27) of the sample was White, and there were 2 (6.7%) Coloured participants and one Indian participant (3.3%). In general, especially in the age group used for this study, there are a larger proportion of white players as opposed to a smaller proportion of players of colour in South Africa and Durban. In women particularly there are very few players of colour as opposed to white players. This can perhaps be attributed to the fact that for the age group concerned, at the time that tennis would have been instituted for them because of a lack of equality they wouldn't have been exposed to the sport. There does not however appear to be any statistical data to support this assumption other than experience.

4.3 Assessment of the effect of the intervention on accuracy, consistency and speed:

The objectives of the study were:

1) To determine the immediate effect of a lumbar manipulation on the objective performance measures: speed, consistency and accuracy in symptomatic amateur tennis players.

2) To determine the immediate effect of a lumbar manipulation on the subjective discomfort rating to gauge discomfort of the participant.

3) To determine the clinical outcomes expectations of the participant.

4.3.1) Objective 1:

The null hypothesis was that there was no difference between the pre and post intervention scores for speed, consistency and accuracy. This hypothesis was tested using paired t-tests.

Table 1 shows that for accuracy, consistency and speed there was an overall increase in mean values between pre and post intervention, ie. the intervention resulted in an improvement of these values overall. However, only with accuracy was the improvement statistically significant (p=0.050). Thus the null hypothesis can only be rejected for the outcome of accuracy. For consistency and speed, we cannot be 95% confident that the improvement was real and not due to chance. However, with a larger sample size this improvement would have shown statistical significance. If the mean increase shown can be considered as clinically important, then a type II error was made here (failing to reject a false null hypothesis) due to low power of the study.

Table 1: Paired t-test comparison of mean accuracy, consistency and speed between pre and post intervention

		Mean	N	Std. Deviation	Std. Error Mean	p value
Accuracy	Pre intervention	13.43	30	2.648	.483	0.050
	Post intervention	14.70	30	3.261	.595	
Consistency	Pre intervention	5.50	30	2.255	.412	0.092
	Post intervention	6.23	30	1.736	.317	
Speed	Pre intervention	1162.73	30	322.477	58.876	0.319
	Post intervention	1173.83	30	322.230	58.831	

An explanation for an increase in accuracy may be that post adjustment functional ability is increased, increasing static and dynamic stability, power and strength (Keller *et al.,* 2000), increasing confidence levels, improving time and flexibility (Nwuga, 1982). Although there was no statistically significant increase in speed and consistency, it can be suggested from the results that had there been a larger sample group to remove the type II error, there may have been a statistically significant increase in these two values. As in previous research done on golfers which was similar to the current research, it is possible that the speed and consistency improved because of the spinal manipulation altering the biomechanics of the spine. This alteration may have improved the form of the serve, due to improved postural stability and power therefore making it more effective (Jermyn, 2004).

4.3.2) Objective 2:

The null hypothesis is that there was no difference between the pre and post intervention scores for pain measured by the average of the worst and least NRS score. This hypothesis was tested using a paired t-test.

Table 2 shows a highly significant decrease in NRS between pre and post intervention ($p<0.001$). The mean score decreased from 25.1 to 19.4 (mean decrease of 5.7). Thus the null hypothesis was rejected.

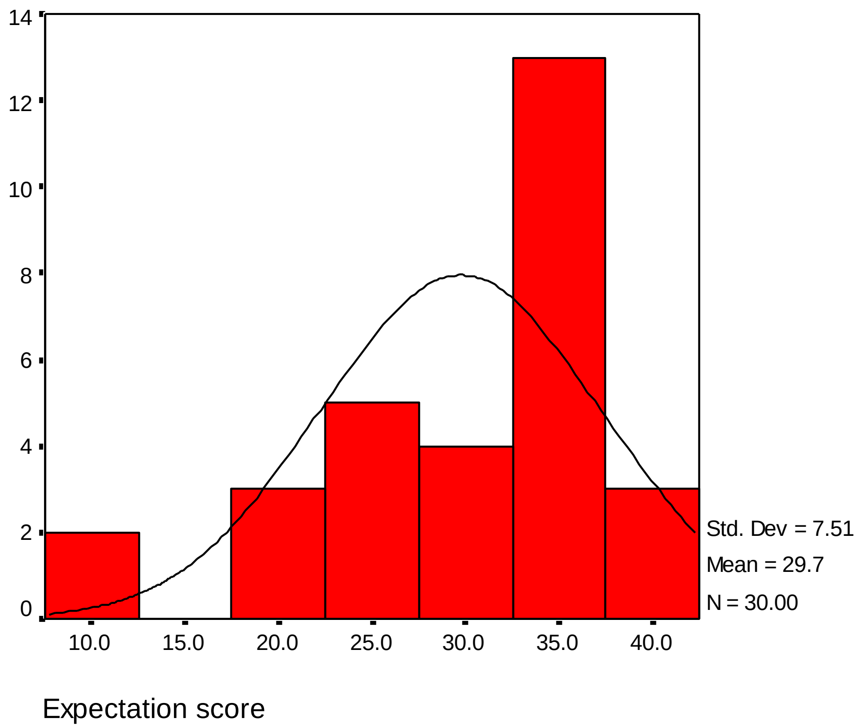
Table 2: Paired t-test comparison of mean NRS between pre and post intervention

		Mean	N	Std. Deviation	Std. Error Mean	p value
NRS	Pre intervention	25.083	30	8.8931	1.6237	<0.001
	Post intervention	19.417	30	11.4411	2.0888	

The reduction in NRS score may be explained by the fact that restricted movement has been found to be improved with Spinal Manipulative Therapy and this in turn induces motion in the articular structures that help to inhibit pain transmissions. This occurs because of closing of the spinal gating mechanism that is found within the substantia gelatinosa by the relaying mechanoreceptors. In other words spinal manipulative therapy causes an increase in proprioceptive input, which will have a reflex inhibition on the transmission of pain due to the decreased movement in the joint (Kirkaldy-Willis and Burton, 1992: 288). Hence it can be said that with increased movement there is decreased pain and there would there for be a likely increase in performance.

4.3.3) Objective 3:

Figure 1 shows the histogram of the expectation score (a value between 0 and 40). The mean score was 29.7 (SD 7.51, range 11 to 40). The histogram suggests that the score values were skewed to the right. Thus, the median would be a more appropriate measure of central tendency to report. The median score was 33. Therefore, expectation was generally quite high.



<u>Figure 1: Histogram of expectation score</u>

As seen from the results the fact that patients had high expectations in terms of the outcome of the treatment did not necessarily improve their outcomes with respect to objective serve scores. It can therefore be assumed that the expectations of the patients had no effect on their objective abilities. This is a positive outcome with respect to the theory that spinal manipulative therapy will improve the functional ability of an athlete because of its effect on the athletes' biomechanics. It showed that there was not necessarily any placebo effect on the participant due to the patients belief that the spinal manipulative therapy would or would not improve their abilities.

4.4 Factors associated with the effect of the intervention

The null hypothesis was that the effect of the intervention was the same in all members of the population, ie. age, gender and expectation did not influence the effect of the intervention.

To test this hypothesis for gender, independent samples t-tests were conducted between males and females on the change in the outcome scores. Table 3 shows that there was no significant difference between the changes from pre to post intervention in males compared with females. However, the trends showed that females improved to a greater degree than males in terms of NRS and speed, while males improved more in terms of accuracy and consistency.

Table 3: Independent t-tests for comparison on mean change in outcome score between males and females

	Gender	N	Mean	Std. Deviation	Std. Error Mean	p value
Change in NRS	male	15	-3.833	6.6054	1.7055	0.177
	female	15	-7.500	7.8490	2.0266	
Change in accuracy	male	15	2.000	3.0938	.7988	0.243
	female	15	.533	3.6227	.9354	
Change in consistency	male	15	1.267	1.6242	.4194	0.210
	female	15	.200	2.7826	.7185	
Change in speed	male	15	.800	68.8717	17.7826	0.356
	female	15	21.400	49.7261	12.8392	

A possible explanation as to why there were different areas of improvement between the males and females may be that the male group tended to be better and more regular players than the female group and thus their accuracy and ability to become more accurate would be greater from the out set. Likewise the males would probably be more likely to push themselves through their pain barriers than the females so that with or without pain they still put the same amount of effort into their serve speed/power. In research done on the influence of athletic status and gender on experimental pain responses it was found that men had higher thresholds and tolerances for cold pain than women (Manning, 2002). Straub *et al.* (2003) concluded that literature supports the premise that pain thresholds do not vary between males and females, but pain tolerance is greater in males.

Table 4 shows that there were no significant correlations between age and changes in outcome scores or between expectation score and changes in outcomes scores. Thus the null hypothesis could not be rejected and neither gender, nor age, nor expectation score significantly influenced any changes in outcome. This would suggest that the effect of spinal manipulative therapy is global. Neither age (within the limits of this study), nor gender nor expectation changes the biomechanical effect of the spinal manipulative therapy on the participant.

Table 4: Pearson's correlation between age, expectation score and change in outcome measurements

		Age in years	Expectation score
Change in NRS	Pearson Correlation	.085	-.326
	Sig. (2-tailed)	.655	.079
	N	30	30
Change in accuracy	Pearson Correlation	-.026	.214
	Sig. (2-tailed)	.893	.256
	N	30	30
Change in consistency	Pearson Correlation	-.083	.221
	Sig. (2-tailed)	.662	.240
	N	30	30

Change in speed	Pearson Correlation	-.312	.058
	Sig. (2-tailed)	.093	.762
	N	30	30

4.5 Correlation between changes in outcome measurements

The null hypothesis was that there were no correlations between changes in outcome scores.

4.5.1) Correlation between Accuracy and Consistency:

Pearson's correlation was done between changes in the outcome scores. Only consistency and accuracy were strongly and significantly positively correlated together ($r=0.896$, $p<0.001$). There were no other correlations between changes in outcomes. This is shown in Table 5.

Accuracy and consistency were originally linked in their scoring in the ITF scoring method for the serve, with the patient receiving a 4 for an accurate serve and a correlating 1 for consistency, while an inaccurate serve which was served into the correct services block received a 2 for accuracy and 0 for consistency (International Tennis Federation, 2004). This may be an explanation as to why accuracy and consistency were so strongly correlated. In order to be accurate over a number of shots the participant would have to be consistent in getting those shots in the right service blocks, which in itself would also have to create a relationship between these 2 readings.

Table 5: Pearson's correlation between changes in outcome measurements

		Change in NRS	Change in accuracy	Change in consistency	Change in speed
Change in NRS	Pearson Correlation	1	.180	.121	-.181
	Sig. (2-tailed)	.	.342	.523	.339
	N	30	30	30	30
Change in accuracy	Pearson Correlation	.180	1	.896(**)	-.190
	Sig. (2-tailed)	.342	.	.000	.314
	N	30	30	30	30
Change in consistency	Pearson Correlation	.121	.896(**)	1	.005
	Sig. (2-tailed)	.523	.000	.	.980
	N	30	30	30	30
Change in speed	Pearson Correlation	-.181	-.190	.005	1
	Sig. (2-tailed)	.339	.314	.980	.
	N	30	30	30	30

** Correlation is significant at the 0.01 level (2-tailed).

4.6 Summary:

Therefore a statistically significant effect of the intervention was found for the outcomes of NRS ($p<0.001$) and accuracy ($p=0.050$). There were no factors which influenced the effect of the intervention. Expectation of the intervention was generally high (median 33, range 11 to 40). Accuracy and consistency were strongly positively correlated together, thus as one increased so did the other.

For the other outcomes where a non significant improvement was found after the intervention, it is possible that a type II error was made due to low power of the study. However, the clinical significance of the magnitude of the change due to the intervention would have to be considered to decide whether this difference is important or not.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS:

5.1 Conclusions:

The diagnosis of posterior facet syndrome and sacroiliac syndrome both of which precipitate lower back pain is currently based on the patients perception of pain and the presence of positive tests for these syndromes eg. Facet joint challenge, Kemps test (Giles, 1997), Sacroiliac Compression, Patrick Faber (Kirkady-Willis and Burton, 1992).

According to current literature posterior facet syndrome can cause lower back pain, radiating into the groin, hip buttock and often the leg, usually above the knee. The muscle in this area will be hypertonic. Bending laterally will be abnormal with hypomobility on one or both sides. All movements are restricted, especially extension (Kirkaldy-Willis and Burton, 1992). In Sacroiliac Syndrome the pain is typically found over the back of the sacroiliac joint with associated pain that can be referred into the groin, over the greater trochanter, down the back of the thigh to the knee, and / or occasionally down the lateral or posterior calf to the ankle, foot and toes (Kirkady-Willis and Burton, 1992).

These pain syndromes along with the decreased functional ability that comes with them can prevent adequate biomechanical function with respect to the tennis serve.

Lower back pain and lower back injuries have been documented as one of the most common musculoskeletal problems in both amateur and professional tennis players (Mihelic, 2004). It has been stated that the serve is the most likely stroke to cause back pain (Hainline, 1995). There is anecdotal evidence to support this since nearly 40% of tennis players on the ATP tour have had to miss at least 2 weeks because of back problems (Vad, 2001).

The results of the current study showed that there was a statistically significant improvement in accuracy especially within the male group, while the female group tended to have greater improvement in speed, however, this improvement was not statistically significant. The results also showed a statistically significant decrease in the participant's numerical pain rating scale with respect to discomfort reading post adjustment.

The outcome of this research would suggest that lower back pain and joint fixation may affect the accuracy of a tennis serve and that because of the improvement seen post spinal manipulative therapy it is probable that this form of intervention may improve the players' performance.

These results indicate that the utilisation of spinal manipulative therapy in the management of acute lower back discomfort in tennis players will have a positive outcome on accuracy and pain at the least and should be included in future acute management protocols for tennis players.

5.2 Recommendations:

a) The fact that participants especially amongst the female group were not very regular players may have affected the readings especially with respect to accuracy. As a result the researcher suggests that the sample group specifications be further narrowed in future to make sure that players participate in tennis on a more regular basis.

b) Further studies should include a larger sample size so as to avoid a type 2 error which may have affected the validity of the statistical outcomes of this research.

c) Further studies should also include a long term follow up and treatment protocol to asses the use of spinal manipulative therapy in the long term management of lower back discomfort in tennis players.

d) The researcher also noted that an indoor venue with a home made tennis court and net was not as effective in the obtaining of readings as an actual indoor tennis court facility may have been and that in future an actual indoor tennis court should be used for the collection of on court data.

e) The use of a sham manipulation or control group should be considered in future studies to increase the validity of the outcome of the research.

f) The possibility of a learned response should also be assessed in future studies.

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APPENDIX 1:

APPENDIX 2:

Questions to be asked during the telephonic interview:

Do you presently have low back pain that is related to playing tennis?

Have you ever had surgery for your low back pain before?

Are you currently being treated for your low back pain?

Can you commit to 1 initial consultation with a follow up treatment shortly afterwards which will be at a venue close to DIT at which time the speed, consistency and accuracy of your serve will be assessed?

Are you an Amateur tennis player?

Do you have discomfort of a mild, moderate or severe level during or shortly after playing tennis?

APPENDIX 3

Letter of information

Dear patient, welcome to this study.

Title of research project:
The immediate effect of a lumbar manipulation on the clinical and performance measures of amateur tennis players suffering from Lower Back Discomfort associated with playing tennis.

Name of supervisors: Nikki Lauren de Busser [M.Tech:Chiropractic (SA)] (031 2042205)
Name of research student: Susan Tyfield (031 2042205)
Name of institution: Durban Institute of Technology

Introduction and Purpose of the study:

This study hopes to show that a lumbar manipulation will positively affect speed, consistency and accuracy in amateur tennis players suffering from mechanical lower back discomfort associated with playing tennis.

This study involves research on 30 participants. There will be 2 groups in my study. Group A (15 females) and Goup B (15 males). Both groups will receive the spinal manipulative therapy for their lower back discomfort. All of you have the option of having free treatment once the study is completed.

Procedures:

The first visit
This consultation will include a case history, relevant physical examination a lower back regional and the completion of a clinical outcomes expectation assessment.
Once you have been accepted onto this study, you will be required to come to a venue close to Durban Institute of Technology over a weekend for your second visit.

The second visit
You will be required to warm up as per a specific protocol, after which an initial speed, accuracy and consistency average of 12 serves will be taken (serve as per 1st serve technique), there after the researcher will intervene with your treatment, then a second average of your post treatment 12 serves will be taken.

Risks/Discomfort:
Please note that spinal manipulative therapy (SMT) can cause some stiffness, but this is a rare side effect.

Benefits:
There will be no charge for any of these consultations. The spinal manipulative intervention provided is in line with normal clinical procedure for the treatment of mechanical lower back pain and you will be given a free serve speed assessment.

New Findings:
You have the right to be informed of any new findings made.

Reasons why you may be withdrawn from the study without your consent:

1. You experience extreme pain while serving.
2. You are free to withdraw from this study at any time, without giving a reason.

Remuneration / Cost of the study:
Please note that there will be no remuneration at all. Your participation in this study is voluntary and all procedures are free of charge.

Confidentiality:
All patient information is confidential and the results will be used for research purposes only, although supervisors and senior clinical staff may be required to inspect records. You will be contacted at the end of the research study and your individual results will be provided.

Persons to contact for problems or questions:
You may ask questions of an independent source (if you wish to contact my supervisor is available at the above number). If you are not satisfied with any area of the study, please feel free to forward any concerns to the Durban Institute of Technology Research and Ethics Committee.

Thank you for your participation in this study.

Susan Tyfield
(Chiropractic intern)

Dr. N. de Busser
(Supervisor)

APPENDIX 4

INFORMED CONSENT FORM

Date **:**

Title of research project: The immediate effect of a lumbar manipulation on the clinical and performance measures of amateur tennis players suffering from Lower Back Discomfort associated with playing tennis.

Name of supervisor: Dr. N. De Busser (031 – 2042205)
Dr. C. Korporaal (031 – 2042205)

Name of research student: Susan Tyfield (031-2042205)

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

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

Patient /Subject Name:_______________________ Signature: ________________

Parent/ Guardian:_____________________________ Signature: _________________

Witness Name:______________________________ Signature:__________________

Research Student Name:_______________________ Signature:___________________

Appendix 5:

DURBAN INSTITUTE OF TECHNOLOGY
CHIROPRACTIC DAY CLINIC
CASE HISTORY

Patient: ____ Date: __________

File # : ____________ Age: __________

Sex : __________ Occupation: ________________________________

Intern : ________________________________ Signature ________________________

FOR CLINICIANS USE ONLY:
Initial visit
Clinician: Signature :

Case History:

Examination:
Previous: Current:

X-Ray Studies:
Previous: Current:

Clinical Path. lab:
Previous: Current:

CASE STATUS:

PTT:	Signature:	Date:

CONDITIONAL:
Reason for Conditional:

Signature: Date:

Conditions met in Visit No:	Signed into PTT:	Date:
Case Summary signed off:		Date:

<u>Intern's Case History:</u>

1. Source of History:

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

3. Present Illness:

	Complaint 1	**Complaint 2**
▸ Location ▸ Onset : Initial: Recent: ▸ Cause: ▸ Duration ▸ Frequency ▸ Pain (Character) ▸ Progression ▸ Aggravating Factors ▸ Relieving Factors ▸ Associated S & S ▸ Previous Occurrences ▸ Past Treatment ▸ **Outcome:**		

4. Other Complaints:

5. Past Medical History:

- General Health Status
- Childhood Illnesses
- Adult Illnesses
- Psychiatric Illnesses
- Accidents/Injuries
- Surgery
- Hospitalizations

6. Current health status and life-style:

- Allergies
- Immunizations
- Screening Tests incl. xrays
- Environmental Hazards (Home, School, Work)
- Exercise and Leisure
- Sleep Patterns
- Diet
- Current Medication
  Analgesics/week:
- Tobacco
- Alcohol
- Social Drugs

7. Immediate Family Medical History:

- Age
- Health
- Cause of Death
- DM
- Heart Disease
- TB
- Stroke
- Kidney Disease
- CA
- Arthritis
- Anaemia
- Headaches
- Thyroid Disease
- Epilepsy
- Mental Illness
- Alcoholism
- Drug Addiction
- Other

8. Psychosocial history:

- Home Situation and daily life
- Important experiences
- Religious Beliefs

9. Review of Systems:

- General
- Skin
- Head
- Eyes
- Ears
- Nose/Sinuses
- Mouth/Throat
- Neck
- Breasts
- Respiratory
- Cardiac
- Gastro-intestinal
- Urinary
- Genital
- Vascular
- Musculoskeletal
- Neurologic
- Haematologic
- Endocrine
- Psychiatric

Appendix 6:

DURBAN INSTITUTE OF TECHNOLOGY
CHIROPRACTIC DAY CLINIC
PHYSICAL EXAMINATION

Patient:____File#:___________Date:________

Clinician:_____________________________________Signature:______________________________

Student:______________________________________Signature:______________________________

1. VITALS

Pulse rate:
Respiratory rate:
Blood pressure: R L Medication if hypertensive:
Temperature:
Height:
Weight: Any change Y/N If Yes : how much gain/loss
Over what period

2. GENERAL EXAMINATION

General Impression:
Skin:
Jaundice:
Pallor:
Clubbing:
Cyanosis (Central/Peripheral):
Oedema:
Lymph nodes - Head and neck:
- Axillary:
- Epitrochlear:
- Inguinal:

Urinalysis:

3. CARDIOVASCULAR EXAMINATION

1) Is this patient in **Cardiac Failure** ?
2) Does this patient have signs of **Infective Endocarditis** ?
3) Does this patient have **Rheumatic Heart Disease ?**

Inspection
- Scars
- Chest deformity:
- Precordial bulge:
- Neck -JVP:

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

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

Percussion: - borders of heart

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

4. RESPIRATORY EXAMINATION

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

Inspection - Barrel chest:
- Pectus carinatum/cavinatum:
- Left precordial bulge:
- Symmetry of movement:
- Scars:

Palpation - Tracheal symmetry:
- Tracheal tug:
- Thyroid Gland:
- Symmetry of movement (ant + post)
- Tactile fremitus:

Percussion - Percussion note:
- Cardiac dullness:
- Liver dullness:

Auscultation - Normal breath sounds bilat.:
- Adventitious sounds (crackles, wheezes, crepitations)
- Pleural frictional rub:
- Vocal resonance
    - Whispering pectoriloquy:
    - Bronchophony:
    - Egophony:

5. ABDOMINAL EXAMINATION

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

Inspection - Shape:
- Scars:
- Hernias:

Palpation - Superficial:
- Deep = Organomegally:
- Masses (intra- or extramural)
- Aorta:

Percussion - Rebound tenderness:
- Ascites:
- Masses:

Auscultation - Bowel sounds:
- Arteries (aortic, renal, iliac, femoral, hepatic)

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

6. G.U.T EXAMINATION

External genitalia**:**
Hernias:
Masses:
Discharges:

7. NEUROLOGICAL EXAMINATION

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

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

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

Evidence of head trauma:

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

Cranial Nerves:

I Any loss of smell/taste:
Nose examination:
II External examination of eye: - Visual Acuity:
- Visual fields by confrontation:
- Pupillary light reflexes = Direct:
= Consensual:
- Fundoscopy findings:
III Ocular Muscles:
Eye opening strength:
IV Inferior and Medial movement of eye:
V a. Sensory - Ophthalmic:
- Maxillary:
- Mandibular:
b. Motor - Masseter:
- Jaw lateral movement:
c. Reflexes - Corneal reflex
- Jaw jerk
VI Lateral movement of eyes

VII a. Motor - Raise eyebrows:
- Frown:
- Close eyes against resistance:
- Show teeth:
- Blow out cheeks:

b. Taste - Anterior two-thirds of tongue:

VIII General Hearing:
Rinnes = L: R:
Webers lateralisation:
Vestibular function - Nystagmus:
- Rombergs:
- Wallenbergs:

Otoscope examination:

IX & X Gag reflex:
Uvula deviation:
Speech quality:

XI Shoulder lift:
S.C.M. strength:

XII Inspection of tongue (deviation):

Motor System:

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

b. Tone
- Shoulder:
- Elbow:
- Wrist:
- Lower limb - Int. & Ext. rotation:
- Knee clonus:
- ankle clonus:

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

Sensory System:

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

Cerebellar function:

Obvious signs of cerebellar dysfunction:
= Intention Tremor:
= Nystagmus:
= Truncal Ataxia:
Finger-nose test (Dysmetria):
Rapid alternating movements (Dysdiadochokinesia):
Heel-shin test:
Heel-toe gait:
Reflexes:
Signs of Parkinsons:

8. SPINAL EXAMINATION:(See Regional examination)

Obvious Abnormalities:
Spinous Percussion:
R.O.M:
Other:

9. BREAST EXAMINATION:

Summon female chaperon.

Inspection	- Hands rested in lap: - Hands pressed on hips: - Arms above head: - Leaning forward:
Palpation	- masses: - tenderness: - axillary tail: - nipple: - regional lymph nodes:

Appendix 7:

REGIONAL EXAMINATION - LUMBAR SPINE AND PELVIS

Patient:_________________________________ File#:______Date:_________
Intern\Resident:__________________________ Clinician:__________________

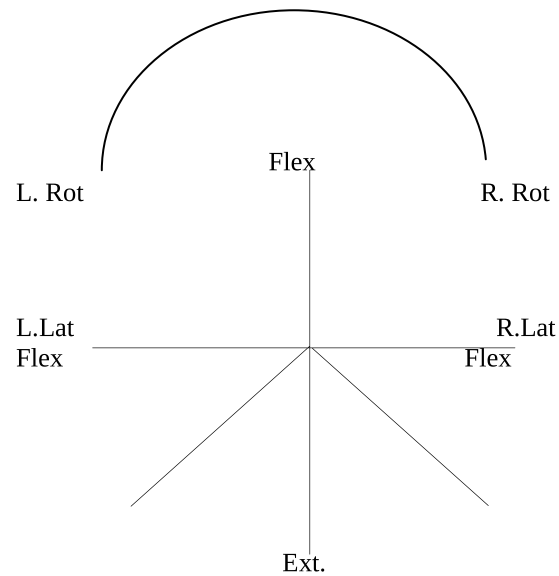
STANDING:

Posture– scoliosis, antalgia, kyphosis
Body Type
Skin
Scars
Discolouration

Minor's Sign
Muscle tone
Spinous Percussion
Scober's Test (6cm)
Bony and Soft Tissue Contours

GAIT:

Normal walking
Toe walking
Heel Walking
Half squat



ROM:

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

Which movt. reproduces the pain or is the worst?

- Location of pain
- Supported Adams: Relief? (SI)
  Aggravates? (disc, muscle strain)

SUPINE:

Observe abdomen (hair, skin, nails)
Palpate abdomen\groin
Pulses - abdominal
- lower extremity
Abdominal reflexes

		Degree	LBP?	Location	Leg pain	Buttock	Thigh	Calf	Heel	Foot	Braggard
SLR	**L**										
	R										

	L	**R**
Bowstring		
Sciatic notch		
Circumference (thigh and calf)		
Leg length: actual -		
apparent -		
Patrick FABERE: pos\neg – location of pain?		
Gaenslen's Test		
Gluteus max stretch		
Piriformis test (hypertonicity?)		
Thomas test: hip \ psoas? \ rectus femoris?		
Psoas Test		

SITTING:

Spinous Percussion
Valsalva
Lhermitte

TRIPOD Sl, +, ++		Degree	LBP?	Location	Leg pain	Buttock	Thigh	Calf	Heel	Foot	Braggard
	L										
	R										

Slump 7 test	L										
	R										

LATERAL RECUMBENT:

	L	R
Ober's		
Femoral n. stretch		
SI Compression		

PRONE:

	L	R
Gluteal skyline		
Skin rolling		
Iliac crest compression		
Facet joint challenge		
SI tenderness		
SI compression		
Erichson's		
Pheasant's		

MF tp's	Latent	Active	Radiation
QL			
Paraspinal			
Glut Max			
Glut Med			
Glut Min			
Piriformis			
Hamstring			
TFL			
Iliopsoas			
Rectus Abdominis			
Ext/Int Oblique muscles			

NON ORGANIC SIGNS:

Pin point pain
Axial compression
Trunk rotation
Burn's Bench test

Flip Test
Hoover's test
Ankle dorsiflexion test
Repeat Pin point test

NEUROLOGICAL EXAMINATION

Fasciculations

Plantar reflex

level	Tender?	Dermatomes		DTR		
		L	R		L	R
T12				Patellar		
L1				Achilles		
L2						
L3				Proproception		
L4						
L5						
S1						
S2						
S3						

MYOTOMES					
Action	**Muscles**	**Levels**	**L**	**R**	
Lateral Flexion spine	Muscle QL	T12-L4			
Hip flexion	Psoas, Rectus femoris	L1,2,3,4			5+ Full strength
Hip extension	Hamstring, glutes	L4,5;S1.2			4+ Weakness
Hip internal rotat	Glutmed, min;TFL, adductors				3+ Weak against grav
Hip external rotat	Gluteus max, Piriformis				2+ Weak w\o gravity
Hip abduction	TFL, Glut med and minimus				1+ Fascic w\o gross movt
Hip adduction	Adductors				0 No movement
Knee flexion	Hamstring,	L4,5:S1			
Knee extension	Quad	L2,3,4			W - wasting
Ankle plantarflex	Gastroc, soleus	S1,2			
Ankle dorsiflexion	Tibialis anterior	L4,5			
Inversion	Tibialis anterior	S1			
Eversion	Peroneus longus	L4			
Great toe extens	EHL	L5			

BASIC THORACIC EXAM

History
Passive ROM
Orthopedic

BASIC HIP EXAM

History
ROM: Active
Passive : Medial rotation : A) Supine (neutral) If reduced - hard \ soft end feel
B) Supine (hip flexed): - Trochanteric bursa

Appendix 8:

Numerical Rating Scale - 101 Questionnaire

With respect to discomfort while serving

Date:_____________ **File no:**_____________ **Visit no:**_________

Patient name: ____

Please indicate on the line below, the number between 0 and 100 that best describes the pain you experience **when it is at its worst**. A zero (0) would mean "no pain at all", and one hundred (100) would mean "pain as bad as it could be".

Please write only **one** number.

0 ____ 100

Please indicate on the line below, the number between 0 and 100 that best describes the pain you experience **when it is at its least**. A zero (0) would mean "no pain at all" and one hundred (100) would mean "pain as bad as it could be".

Please write only **one** number.

0 ____100

Isikali Sokulinganiselwa Kokuphathelene Nezinamba - 101 Imibuzo

Usuku: __________ Inamba yefayela _________ Inamba yokuvakasha

Igama lesiguli:

Cacisa kulomugqa ongezansi inamba phakathi kuka **0** no **100** okuyiyona echaza kangcono ubuhlungu obuzwayo uma busezingeni elibi kakhulu. Uziro (o) uzochaza ukuthi "abukho ubuhlungu", u **100** ikhulu elilodwa lizochaza "ubuhlungu obubi obungaba khona".

Bhala inamba **eyodwa** kuphela.

Cacisa kulomugqa ongezansi, inamba ephakathi kuka 0 no 100 okuyiyona engachaza kangcono ubuhlungu obuzwayo uma bubuncane.

Uziro (0) uzochaza ukuthi abukho nhlobo ubuhlungu, kuthi ikhulu elilodwa (100) lizosho ukuthi "ubuhlungu obubi obungaba khona"

Bhala inamba eyodwa kuphela

Appendix 9:

CLINICAL OUTCOMES EXPECTATION ASSESSMENT:

As a result of my treatment I expect the following to improve or happen:	Not likely	Slightly likely	Somewhat likely	Very likely	Extremely likely
1. Complete pain relief	1	2	3	4	5
2. Moderate pain relief	1	2	3	4	5
3.Won't have to change position frequently to make me more comfortable	1	2	3	4	5
4. Won't have to walk more slowly because of my back.	1	2	3	4	5
5. Won't have to lie down to rest more often because of my back.	1	2	3	4	5
6. Won't have to stand up for shorter periods because of my back pain.	1	2	3	4	5
7. Will be able to bend or kneel down more easily.	1	2	3	4	5
8. Won't have back pain nearly all the time while playing tennis.	1	2	3	4	5
TOTAL: / 40					

Modified from From Roland M, Morris R. A study of the natural history of back pain: Part I: Development of a reliable and sensitive measure of disability in low-back 1983;8:141-144 and

APPENDIX 10: DATA SHEET
(MECHANICAL LOWER BACK PAIN ORTHOPAEDIC TESTS AND MOTION PALPATION)
(SERVE SPEED TABLE)
(ACCURACY AND CONSISTENCY)

Mechanical Lower Back Pain Orthopaedic Tests

	Initial
Facet joint challenge	
Kemp's test	
Palpatory tenderness	
Spinous percussion	
Sacro-iliac tenderness	
Gaenslen's test	
Patrick Faber	
Yeoman's test	
Sacro-iliac compression	
Posterior shear	

Motion Palpation

Side					
Direct					

Serve number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**1**	**12**	**AVERAGE**
Pre intervention													
Post intervention													

Serve Number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total**
Accuracy													**/24**
Consistency													**/12**
													/36