The immediate and short term effect of spinal manipulative therapy on the club head velocity of amateur golfers suffering from mechanical low back pain.

By

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

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DEDICATION

In loving memory of	Paul Vose	1980 -1998
	Dustin Bishop	1980 - 2005
	Garreth Muller	1983 - 2005

Truly great friends are hard to find,
difficult to leave
and impossible to forget.
G. Randolf

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ABSTRACT

The purpose of this study was to evaluate the immediate and short term effects of spinal manipulative therapy on the club head velocity of amateur golfers suffering from mechanical low back pain.

This purpose was identified as low back pain which has been noted as the most common musculoskeletal problem affecting amateur and professional golfers. In the right handed golfer the golf swing produces a distinctly asymmetric trunk motion, involving a combination of left axial rotation and right lateral bending. The significant lateral bending, shear, compression and torsional forces that the lower back contends with during the golf swing causes a peak compression load of more than eight times the body weight. In addition it is found that at the end of the follow through phase the golfer's lumbar spine is rotated and hyperextended. This is known as the reversed C position, in which the facet joints approximate and in addition torsional stress is placed on the annular fibers of the disc. With repetitive swings and incorrect form the lumbar facets bear the brunt of the abnormal forces on the lumbar spine.

In addition to this, during the downswing phase of a golf swing the role of the multifidus is to limit flexion whilst the external oblique muscle induces rotation of the lumbar spine. Together both muscles produce rotation in the lower lumbar spine. Thus the golf swing, particularly during the downswing phase, places a tremendous burden on the multifidus muscle and may cause;

- muscle injury which will contribute to the golfer's low back pain and / or
- joint injury as a result of muscle fatigue.

Furthermore the resultant uncontrolled contractions of the multifidus muscle produces torsion to the facet joints and disc. It is therefore likely that facet syndrome may be the main cause of low back pain in golfers, as modern golf publications urge golfers to use a maximum state of spinal rotation to generate a high club head velocity.

Manipulation has been validated as an effective treatment for certain types of low back pain. It has also been shown to increase all ranges of motion during the golf swing allowing for the golfer to attain the maximum state of spinal rotation as currently required by the golf publications. From the above it can be concluded that manipulation may have a beneficial immediate and short term effect on the club head velocity of amateur golfer suffering from mechanical low back pain.

Therefore this was an applied experimental design consisting of forty male patients between the ages of 25 and 45 years. The patients were randomly allocated into an experimental group of thirty and a control group of ten. The experimental group received four treatments over a two week period with a one week follow up (consultation 5). Subjective and objective findings were recorded at alternate treatments as well as the follow up (viz. consultations 1, 3 and 5). The immediate effects were recorded at consultations 1 and 3 and the short term effects were calculated over the entire research time period. The control group received only one treatment but returned for objective and subjective recordings in congruence with the experimental group. Subjective findings included the numerical pain rating scale and the Roland Morris Disability Questionnaire. Objective findings consisted of non digital algometer, lumbar spine orthopaedic tests and club head velocity. The club head velocity was measured using the Flightscope Pro Swing Analyzer.

The SPSS statistical package was used to assess the immediate and short term effect of the treatment as well as compare the clinical changes between the two groups.

Hypothesis one

The first hypothesis indicated spinal manipulative therapy would decrease the subjective clinical findings[1] and increase or decrease the objective clinical findings[2] as appropriate in the immediate improvement of the clinical syndrome of mechanical low back pain. The non digital algometer had an immediate effect at both time intervals measured viz. consultation 1 and 3. However the effect was much more significant at the third consultation. There was a significant immediate effect on CHV at both time intervals but as with the algometer the effect was more pronounced in the second session. SI percussion and Yeoman's showed a slightly significant immediate effect while Kemps test and Facet challenge showed no immediate effect

Hypothesis two

The second hypothesis indicated spinal manipulative therapy would decrease the subjective clinical findings and increase or decrease the objective clinical findings as appropriate in the short term improvement of the clinical syndrome of mechanical low back pain. All subjective and objective findings were affected by spinal manipulative therapy over the short term.

Hypothesis three

The third hypothesis indicated spinal manipulative therapy would result in better subjective and objective clinical findings in the short term as opposed to the immediate term as appropriate in terms of improvement of the clinical syndrome associated with mechanical low back pain. Both subjective and objective findings improved to a greater extent over the short term when compared to the immediate effects.

Thus the intervention had a significant immediate and short term beneficial effect on club head velocity as well as the other subjective and objective findings when compared to the control group.

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[1] Subjective clinical findings include: NRS; RMQ
[2] Objective clinical findings include: CHV;Non digital algometer; orthopaedic tests.

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Glossary

AMPHIARTHROTIC

A type of synarthrosis in which the union of the bony elements is by intervening cartilage; the two types are synchondrosis and symphysis. (Saunders 1994)

CLUB HEAD VELOCITY(CHV)

CHV is the speed at which the golf club head makes contact with the golf ball (i.e. swing speed). Measured in miles per hour (Stude &Gullickson 2000).

DIARTHRODIAL

synovial joint: a specialized joint permitting more or less free movement, the union of the bony elements being surrounded by an articular capsule enclosing a cavity lined by synovial membrane (Saunders 1994)

IMMEDIATE

Immediate is 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 (Engel and Graney, 2000; Farahat et al, 2003; Webbe and Barth, 2003; MacIntosh et al, 2003, Etminan et al, 2003, Hoiness et al, 2003; van Tulder et al, 2003; Ostelo et al, 2003; Baxter et al, 2003;
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)

ISOMETRIC EXERCISES

Isometric exercise occurs when muscles contract in a static contraction in opposition to a fixed or immovable load. (Luttgens et al 1992)

JOINT COMPLEX DYSFUNCTION

Once spinal tissue injury occurs a pathological process ensues that involves inflammation, nociception and pain which reduce joint mobility. Reduced mobility affects the joint complex by promoting degenerative changes in cartilage, bone, ligaments, synovium, joint capsules, disc, muscles and tendons resulting in joint complex dysfunction (Seaman 1998).

KINEMATICS

The geometry of motion. It describes the motion of bodies in terms of time, displacement, velocity and acceleration (Luttgens et al 1992).

MYOFACIAL TRIGGER POINTS

A myofacial trigger point is a hyperirritable spot in skeletal muscle that is associated with a hypersensitive palpable nodule in a taut band. The activation of a trigger point is usually associated with some degree of mechanical abuse of the muscle in the form of muscle overload, which may be acute, sustained and/or repetitive. The spot is painful on compression and can give rise to characteristic referred pain, autonomic phenomena and motor dysfunctions, (Travell and Simons, 1999:p5).

SHORT TERM

Short term is 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 (MacIntosh et al, 2003, Etminan et al, 2003, Hoiness et al, 2003; Ostelo et al, 2003; Baxter et al, 2003.)
Therefore for the purposes of this study, the following definition will be utilised: a period that is greater than 24 hours, but less than one month (Etminan et al,2003)

SPINAL MANIPULATIVE THERAPY

A passive maneuver in which specifically directed forces are applied to vertebral articulations of the body, with the object of restoring mobility to restricted areas (Gatterman 1990) or a passive manual maneuver during which the three joint complex is suddenly carried beyond the normal physiological range of motion without exceeding the boundaries of anatomical integrity. The usual characteristic is a thrust – a brief sudden and carefully administered impulsion that is given at the end at the normal passive range of movement. It is usually accompanied by a cracking sound (Sandoz 1981).

THORACOLUMBAR FACIA

This is an extensive facial sheet that splits into anterior and posterior layers, enclosing the deep back muscles. It is thin and transparent where it covers the thoracic parts of the deep muscles but is thick and strong in the lumbar region. The lumbar part of the thoracolumbar fascia, extending between the twelfth rib and the iliac crest, attaches laterally to the internal oblique and transverse abdominal muscles (Moore 1999:299).

TORQUE

Torque or moment of force is the ability of any force to produce rotation of a lever, such as that which occurs, for example, during elbow flexion, knee extension, or spinal extension and rotation. In terms of body movements about an axis of rotation, torque refers to the force created by muscle contraction (Seaman 1998).

Chapter One

Introduction

1.1 The Problem and its setting:

Today's golfer will go to any extreme, spending unlimited amounts of money on high tech equipment in the hope of gaining a few extra yards on his drive (Chek, 2003). This desire is accentuated by many modern golf publications who recommend to both amateur and professional golfers to try to achieve a maximum ball distance with each golf club (Seaman, 1998:46 and Bulbulian, Ball & Seaman, 2001:569-579). In this respect modern golf instruction urges players to use a state of maximal spinal rotation in their golf swing in order to achieve maximum ball distance (Seaman, 1998:47-51), as the maximally rotated position is considered ideal for developing optimal club head velocity (CHV) (Seaman, 1998:46). In this respect research done by Stude and Glickson, (2000:173) found an approximate 1:3 relationship between CHV and air travel distance of the golf ball and this relates to an increase in CHV of 1mph to a distance increase of 3 yards.

In order to understand this it is imperative that one understands that the golf swing is a complex movement that is composed of three phases:

- the take away phase,
- the impact phase (or down swing phase) and
- The follow-through phase.

Throughout these phases the golf swing results in both hyper-rotation and hyperextension of the lumbar spine (Mackey, 1995:11-12), usually unilaterally (side dependant on golfer's dominant hand). Therefore, these movements produce a distinctly asymmetric trunk motion, involving a combination of left axial rotation and right lateral bending (in right-handed golfers for an example) (Horton et al, 2001). In furtherance to this, torsional activity and bending loads are present and therefore the lower back must contend with significant lateral bending, shear, and compression forces that, in golf, generate estimated peak compression loads of more than eight times body weight in both amateurs and professionals (Bulbulian, Ball & Seaman, 2001, 569). In congruence with this Lindsay and Horton (2002:605) showed in their investigation of spinal motion in elite golfers with and without low back pain that maximum rotation range of motion was more restricted in the group with mechanical low back pain.

In opposition to this it has been reported that the length of the backswing and extent of torso rotation does not correlate with CHV at ball impact (Bulbulian, Ball & Seaman 2001:570).

But it is not clear whether this decreased rotation reduces stress and strain on the spine and spinal musculature, and there is no concrete data to suggest that a shortened backswing results in decreased spinal rotation (Bulbulian, Ball & Seaman, 2001, 570/574). Further to this the Bulbulian, Ball & Seaman study did not indicate whether maximal rotation was defined in participants with or without lower back pain

In addition to the above and according to Chek (2003) factors that have been identified as influencing CHV, are primarily strength and power of the golf swing and secondarily, muscle balance and flexibility, as it has been hypothesised that these factors all influence the static and dynamic postural stability of the lumbar spine and torso, thereby affecting the CHV.

As a result of this it would seem that low back pain[1] has been identified as the most common musculoskeletal problem affecting amateur and professional golfers (Horton, et al 2001:1647 and Bulbulian, Ball & Seaman, 2001:569), with the repetitive swinging and poor swing motion being identified as the most probable although not definitive cause (Horton et al, 2001:1647 and Grimshaw et al, 2002:657). Thus according to Mackey (1995:10-12), it is likely that joint complex dysfunction associated with myofascial trigger points are the main cause of back pain in golfers. It has further been demonstrated by Seaman (1998:67) that amateurs whose swings may have less efficient mechanics may develop up to 80% more torque around their lumbar spine than professionals, indicating that there may be a preponderance of low back pain among amateur golfers.

[1] Low back pain in this study is defined as patients involved in the dysfunctional phase of posterior facet joint syndrome or sacro-iliac joint syndrome. This will be done according to the Kirkaldy-Willis and Burton (1992:291) classification.

In this respect manipulation has been validated as an effective treatment for certain types of low back pain of mechanical origin (Cooperstein et al, 2001:407), as it results in improved flexibility and reduced pain and increased joint mobility (Gatterman, 1990:40). Furthermore it may address the decreased flexibility, improve motion and address the articular dysfunction that seems to present in golfers (Mackey, 1995:10-12).

Thus Lehman and McGill (1999:576-579) assessed the influence of manipulation on lumbar kinematics and found that after single rotary manipulations (at the same level), the golf swing increased in all total ranges of motion for each plane of movement after the adjustment, with associated muscle relaxation. This improved movement / flexibility according to Lindsay and Horton (2002:604) should be the primary aim of players with low back pain, particularly with respect to trunk rotational flexibility, to reduce their symptoms and decrease the effects of repetitive strain. This is further supported by the outcomes of Jermyn's (2004) study in which he found an increase in club head velocity and distance immediately after a manipulation. There was also a suggestion in his results that objective low back sensitivity decreased immediately after the spinal manipulative therapy.

However the immediate *and* short term effects of spinal manipulative therapy have not been investigated in the literature which has been limited to pre-post intervention studies. Therefore this research was aimed at assessing and evaluating the immediate and short term effects of spinal manipulative therapy on club head velocity in amateur golfers suffering from mechanical low back pain in terms of subjective and objective clinical findings.

1.2 Aims and objectives of this study:

The aim of this study was to evaluate the immediate and short term effects of spinal manipulative therapy on club head velocity (CVH) in amateur golfers suffering from mechanical low back pain in terms of subjective and objective clinical findings.

Objective one:

Was to evaluate the immediate effects of spinal manipulative therapy on subjective and objective clinical findings in amateur golfers suffering from mechanical low back pain.

Hypothesis one

The first hypothesis indicated spinal manipulative therapy would decrease the subjective clinical findings[2] and increase or decrease the objective clinical findings[3] as appropriate in the immediate improvement of the clinical syndrome of mechanical low back pain.

Objective two:

Was to evaluate the short term effects of spinal manipulative therapy on subjective and objective clinical findings in amateur golfers suffering from mechanical low back pain.

Hypothesis two

The second hypothesis indicated spinal manipulative therapy would decrease the subjective clinical findings and increase or decrease the objective clinical findings as appropriate in the short term improvement of the clinical syndrome of mechanical low back pain.

Objective three:

Was to compare the immediate and short term effects of spinal manipulative therapy on subjective and objective clinical findings in amateur golfers suffering from mechanical low back pain.

Hypothesis three

The third hypothesis indicated spinal manipulative therapy would result in better subjective and objective clinical findings in the short term as opposed to the immediate

[2] Subjective clinical findings include: NRS; RMQ
[3] Objective clinical findings include: Non digital algometer; Orthopaedic tests;CHV

term, as appropriate in terms of improvement of the clinical syndrome associated with mechanical low back pain.

1.3 Rationale and benefits:

1. Spinal manipulation has been shown to have a therapeutic effect on mechanical low back pain; however its role in conjunction with golf needs to be investigated, with particular emphasis on the immediate and short term effects of manipulative therapy for low back pain (Jermyn, 2004).

2. It has been documented that low back pain decreases the rotation ability of the spine (Lindsay and Horton, 2002). Manipulation has been shown to increase the rotation ability of the spine (Lehman and McGill, 1999) but it is unclear how this increased rotation of the spine is related to CHV.

3. CHV may be affected by low back pain (Jermyn, 2004) but the correlation between low back pain and CHV has not been studied over the short term, especially not in relation to the effect that manipulation has on this relationship.

4. The study by Jermyn (2004) was limited to the immediate effects of spinal manipulative therapy on CHV, whereby patients received only one treatment and results were not compared to a control group.

5. Research is needed to determine different treatment options in order to decrease low back pain in golfers. This study may show that spinal manipulation can affect the low back pain as well as the performance of the golfer (i.e. CHV or other performance parameters).

Benefits of the study

The results of this study could assist in explaining the relationship between low back pain and the performance of a golfer. Furthermore the study may show the efficacy of using spinal manipulation as a treatment option for golfers with low back pain

Limitations of the study:

It was assumed that the golfers continued with the same level of activity during the research process.

This study did not include the analysis of the mechanical aspects of the golf swing, excepting for the effects on the CHV of the manipulation.

Conclusion

In view of the above introduction, the following chapter (Chapter 2) will discuss the literature in greater detail, followed by a reporting on the methodology utilized in this study in Chapter 3. Chapter 4 goes on to report the results as well as discuss the results of this study, where Chapter 5 presents the conclusions and recommendations based on the outcomes of this study.

Chapter Two

2.0 Introduction

This chapter discusses the anatomy of the thoracolumbar and lumbopelvic region, in relation to the biomechanics of the golf swing as well as the joint dysfunction syndromes (facet joint and sacro-iliac joint) and their effect on the biomechanics. In addition to this the chapter will briefly discuss treatment available for these syndromes and what the possible treatment effects could be for the performance parameters for golfers.

2.1 The Anatomy and Biomechanics of the lumbar spine

The lumbar spine consists of five lumbar vertebrae and makes up 25% of the total length of the vertebral column (Mackey 1995). Lumbar vertebrae are distinguished by their massive bodies, sturdy laminae, and absence of costal facets (Moore 1999:441).

One common factor in all spinal segments is the fact that each has two posterior spinal articulations known as facet joints. Each of the facet facings is lined with hyaline cartilage and these joints have intracapsular fibrocartilagenous discs that separate the joint surfaces (Bergman 1993:38).

The facet joints of the lumbar spine are categorized as diarthrodial and they function to restrict and guide the movement, thus the superior facets of the lumbar spine are concave and face posterior and medial and the inferior facets are convex and face anterior and lateral (Gatterman 1990:130). In this respect the orientation of the lumbar facet joints according to Bergman (1993), facilitates flexion, extension and lateral bending of the vertebral column, however the orientation prohibits rotation.

Shafer and Faye (1990) described the plane of the lumbar facets as being near parallel to the vertical plane. The convex inferior facets mate with the concave superior facets. From L1 to

L5, the planes of the articular facets generally change from saggital facing in the upper lumbar region to more coronal facing in the lower joints (Gatterman 1990:130).

The lumbosacral facet planes are slightly more horizontal than those above and allow greater A-P, P-A and lateral motion but less joint locking as compared to the vertebra above. This horizontal and anterior inclination of L5, spreading out towards the coronal plane, becomes progressively more vertical upward from L4 to L1 (Schafer and Faye 1990:198).

According to Souza (1997), the medial branch of the primary ramus innervates these joints. These arise from the lumbar nerves at each respective level, with each facet joint receiving innervation from both the nerve exiting at that level and the supradjacent nerves (Moore 1999:455).

The facet joints make up two of the three joints of the three joint complex, with the center of motion being near the center of the intervertebral disc (Mackey 1995). Kirkaldy – Willis and Bernard (1999) state that the intervertebral joints of the lumbar spine can be compared to a lever system consisting of the intervertebral disc and two posterior facet joints and is referred to as a three joint complex

The third leg of this complex is the intervertebral disc, which cumulatively constitutes 22 to 33% of the entire vertebral column and is composed of the nucleus pulposis, the annulus fibrosis and the cartilaginous endplate (Mackey 1995). According to Bergman (1993) the unique and resilient structure of the disc allows for its function in weight bearing and motion. The nucleus pulposis is the central core of the intervertebral disc even though it is located more posteriorly than centrally and its high water content adds mobility to the spine as well as even distribution of compressive forces in all directions (Gatterman 1990: 132). This structure also acts like a semi fluid ball bearing during flexion, extension, rotation and lateral flexion of the vertebral column (Moore 1999:451).

The annulus fibrosis as described by Moore (1999) is a ring consisting of concentric lamella of fibrocartilage forming the circumference of the intervertebral disc. The fibers forming each lamella run obliquely from one vertebrae to another, the fibres of one lamellae typically running at right angles to those of the adjacent ones. This arrangement, although allowing some movement between adjacent vertebrae, provides a strong bond between them (Moore 1999:451). The cartilaginous endplate is made of hyaline cartilage and it separates the intervertebral disc from the vertebral end plate (Mackey 1995).

2.2.1 The thoracolumbar region

The most significant structural characteristics in this area according to Bergman (1993) are the change from the coronal facet joint plane in the thoracic region to the saggital plane facets in the lumbar spine. This transition can occur anywhere between T10 and L1 (Bergman 1993:308).

This is an area of transition from a restricted area to a more mobile area (Moore 1999:463) as well as a change from a primary kyphotic curve to a secondary lordotic curve (Bergman 1993:308). In the thoracic region of the spine, protection and function of the thoracic viscera take precedence over intersegmental mobility (Bergman 1993:295). This area is relatively stable due to its connection to the sternum by the ribs and costal cartilage (Moore 1999:462). According to Giles and Singer (1997) these structures permit relatively little motion compared with the lordotic curve of the lumbar spine especially in flexion and extension. In this context, the transition has been classically considered mechanically disposed to trauma, being less capable of attenuating axial and torsional stresses at a point of marked anatomical and mechanical change (Giles & Singer 1997:190).

This area is also an important site of muscle attachment of the thoracolumbar paraspinals such as the erector spinae, transversospinalis, and intersegmental muscles (Moore 1999:470). It is also an attachment site of the lattisumus dorsi, quadratus lumborum and psoas major (Luttgens et al 1992), which play a role in the golf swing (Mackey 1995). Of clinical importance is that this area is the origin of the cluneal nerves which innervate the skin and the superficial structures of the upper posterolateral buttock, posterior iliac crest and groin area (Bergman 1993:310). Due to this innervation the thoracolumbar region can be the cause of low back pain and gives similar signs and symptoms to pathology in the lumbar facet joints (Kirkaldy – Willis and Bernard 1999:129).

Table 1: Muscles of the lumbar spine

Muscle Name	Muscle action	Innervation	Role of muscles in the golf swing
Erector Spinae Iliocostalis Longissimus Spinalis	Acting bilaterally they extend the vertebral column and control. movement during flexion Unilaterally they laterally bend the vertebral column	Dorsal rami of spinal nerves.	Right and left muscles contract nearly symmetrically during the downswing to help with spinal stabilization. These muscles have a spinal protection role in the golf swing (Seaman 1998).
Transversospinalis Multifidi Rotatores	Stabilize movements of the vertebral column and assist with local extension and rotary movements.	Dorsal rami of spinal nerves.	Opposes the flexion effect of the abdominal muscles as they produce rotation (Seaman 1998).
Intersegmental Interspinalis	Aid in extension and rotation in the vertebral column.	Dorsal rami of spinal nerves.	
Intertranversari	Aid in lateral bending of the vertebral column. Bilaterally they stabilize	Dorsal and ventral rami of spinal nerves.	

	the vertebral column.		
Deep Lateral muscles			
Quadratus lumborum	Assists with inspiration by fixing the twelve ribs. Unilateral: laterally flexes the spine ipsilaterally. Bilaterally: extends the spine.	Branches of the lumbar plexus from spinal nerve at T12 and L1 to L4.	Assists with lateral flexion and extension during the golf swing.
Psoas Major	Flexes the spine when sitting up from supine position.	Branches of the lumbar plexus L2 – L4.	Contributes to flexion of the spine and has a role in protecting the spine from torsional forces Mallare (1996).

Latissimus Dorsi	Extends, and rotates the humerus medially Powerful adductor with Pectoralis major	The Thoracodorsal nerve	Contracts bilaterally during the acceleration phase of the golf swing (Tibone et al 1994)
External Oblique	Compress and support abdominal viscera, Flex and rotate trunk	Thoraco-abdominal nerves (Inferior 6 thoracic nerves) and subcostal nerve	In the right handed golfer the left external oblique is primarily responsible for the initial rotation of the spine and torso in the take away phase The right external oblique contracts maximally during the downswing (Seaman 1998)

(Moore, 1999: 470 and Travell & Simmons, 1999: 916)

The above muscles contribute, via their attachments, to the development of an anatomical structure known as the thoracolumbar fascia. This thoracolumbar facia is not a muscle but is important to the deep muscles of the spine and the erector spinae (Luttgens et al 1992:267), where it binds these muscles together, holding them close to the skeletal structure and separating them from the superficial muscles of the back (Luttgens et al 1992:267). In the lumbar region it curves around the lateral margin of the erector spinae and folds in front of it to attach to the tips of the transverse processes of the vertebrae and to the intertransverse ligaments. According to Lutgens et al (1992), its lateral portion provides attachment for the tranverse abdominus and its posterior portion blends with the aponeurosis of the latissimus dorsi.

Harrison et al (1997: 610) state that the ligaments of the sacro-iliac joint and the lumbar spine merge with the thoracolumbar fascia, serving as primary attachment sites for the main movers and stabilizers of the spine and the lower extremity. Some of the muscles involved, according to Harrison et al (1997: 610), include the:

- Gluteus Maximus and Medius
- Multifidus
- Biceps Femoris
- Psoas
- Piriformis

According to Mallare (1996:24), a stabilizing effect comes through tensing the thoracolumbar fascia. This tensing in conjunction with tightening the posterior ligamentous system, acts as a corset to fortify spinal elements against torque and shear forces (Mallare 1996: 24).

2.1.2 The Sacro-iliac joints

These articulations are strong, weight bearing synovial joints between the ear shaped auricular surfaces of the sacrum and the ilium (Moore 1999:340). Schafer and Faye (1990) state that the sacro-iliac joints are uniquely both diarthrotic and amphiarthrotic. The inferior two thirds of each joint are a true synovial articulation, the superior third is fibrocartilagenous amphiarthrosis supported by short but strong sacro-iliac ligaments.

A synovial membrane blankets the whole joint cavity except at its posterior aspect where it is replaced by large ligaments that attach to the articular cartilage (Shafer and Faye 1990:243). Moore (1999) states that the sacro-iliac joints differ from most synovial joints in that they possess little mobility because of their role in transmitting the weight of most of the body to the hip bones.

The slight but important rotating, sliding, gliding and pivoting actions of the sacro-iliac joints serve as a singular link point where the axial skeleton is attached to the pelvis (Schafer and Faye 1990:242)

While some of the strongest muscles of the body such as the quadratus lumborum, erector spinae, gluteus maximus and minimus, piriformis and iliacus surround the sacro-iliac joint, none are intrinsic to it or act upon it directly (Bergman 1993:477). During locomotion the sacro-iliac joints flex and extend in unison with the corresponding hip joint. Movement of flexion or extension in one SI joint is mirrored by the opposite movement in the other SI joint (Bergman 1993:478). Furthermore Harrison et al (1997: 610) state that the ligaments of the sacro-iliac joint and the lumbar spine merge with the thoracolumbar fascia, allowing for primary attachment sites for the main movers and stabilizers of the spine. Therefore, active muscle contraction causes compression of the sacro-iliac joint surfaces thus creating a complex self-bracing mechanism necessary for the stability of the sacro-iliac joints in resisting stresses under various loading conditions.

Thus the muscle's function is not to cause motion at the sacro-iliac joint, but rather to brace the region and create stability for effective load transfer (Harrison et al 1997: 610) and allow for the transmission of energy from the trunk to the lower extremity (Soderberg 1997:414).

2.2 The phases of the golf swing

According to Seaman (1998:52) there are several phases in the golf swing and there is no set system to classify each phase, although generally there are four phases, which include:

- the backswing,
- the transition to downswing,
- the downswing/upswing and
- the follow through.

The backswing or takeaway begins after the golfer has taken his stance aligned over the ball and has gripped his club. The golfer then moves the club to the top of his backswing by rotating his shoulders, hips, knees, lumbar and cervical spine while his head remains fixed (Mackey 1995:10). Seaman (1998) explains that during this phase the shoulders arms and club should move at the same time. This is accomplished by shifting weight and rotating the pelvis to the right side while maintaining a flexed right knee, which prevents a lateral shift of the body to the right. At the top of the golfer's backswing in the right handed golfer the left thumb is hyperabducted, the left wrist is radially deviated, the right wrist is extended, with resultant hyperabduction of the right shoulder. This causes the cervical and lumbar spines to become hyperrotated (Mackey 1995:10).

As the extreme of this position is reached, the arms and club are lifted to the point where the left anterior deltoid touches the chin. At this point, Seaman (1998) recommends that the weight transfer to the left should begin. As the weight transfer is initiated, the arms and club will continue to lift slightly because of the momentum created by the arms and shoulders during the takeaway. This is known as the transition phase of backswing to downswing and serves to prestretch the pectoralis major and latissimus dorsi muscles to create elastic energy for maximum power generation during the downswing / upswing phase (Seaman 1998:52). This energy creation is then thought to be transferred to the thoracolumbar fascia as the downswing / upswing phase occurs, after the weight transference has been initiated. It takes less then one second to swing down and up into the follow through position (Seaman 1998:53) and in this time the energy transfer from the upper extremity to the lower extremity will have taken place. During this phase Mackey (1995) describes a preimpact and impact stage. At preimpact, the golfer begins contact with the ball, and the golfer's right wrist is in maximum extension, the left thumb is in hyperabduction, the left hip is rotated and the knee is in a position of valgus stress. Impact is the phase where the golfer strikes the ball. During this stage the golfers left wrist ulnar deviates, while the right wrist undergoes compression, the right knee is under valgus stress, and left hip is rotated. These two phases attenuate the energy transfer as the energy is lost in the ball as well as the limbs, which is depicted by the final phase of the golf swing which is the follow through. According to Mackey (1995) the golfers left elbow supinates, the right elbow pronates, the hip internally rotates and completes hip rotation, and the knees rotate to the left while the left ankle inverts. The left shoulder hyperabducts, and the cervical and lumbar spine is rotated and hyperextended. Seaman (1998) adds that the body weight should be completely shifted to the left side, and a slightly flexed torso should be resting over a slightly flexed knee. The shoulders and chest should be perpendicular to the target line and the toe line (Seaman 1998:53).

This process (i.e. golf swing) is referred to by Chek (2003) as a neuromechanical system, composed of a complex of interrelated neurological and mechanical operations, which include the nervous, muscular and skeletal systems, which combine to create the fluid neuromechanical movement, allowing for co-ordination and successful completion of the golf swing (Chek 2003).

Chek (2003) goes on to state that that the golfer's neuromechanical system's state of readiness can be determined by assessing the following four factors:

1. Muscle balance and flexibility
2. Static and dynamic postural stability
3. Strength
4. Power

This CHV is primarily affected by strength and power but is also secondarily affected by muscle balance, flexibility as well as static and dynamic postural stability (Chek 2003), all of which, if incongruent with any other element can predispose to low back pain and can also be affected by the presence of low back pain.

2.3 Low back pain amongst golfers

Low back pain has been identified as the most common musculoskeletal problem affecting amateur and professional golfers (Horton et al 2001). According to Bulbulian, Ball and Seaman (2000), the main contributing factors causing low back pain in golfers are the repetitive swing motion and poor swing mechanics, which follows from Chek (2003), who indicated that congruence between the various systems is essential in order to maintain a fluid golf swing.

In this respect the golf swing is a very complex movement that involves a considerable amount of trunk rotation and powerful muscle contractions. Overuse in association with the asymmetrical nature of the golf swing may create repetitive abnormal stresses on the lumbar spine which may lead to injury and pain (Horton et al 2001).

In the right handed golfer the golf swing produces a distinctly asymmetric trunk motion, involving a combination of left axial rotation and right lateral bending (Horton et al 2001). The significant lateral bending, shear, compression and torsional forces that the lower back contends with during the golf swing cause a peak compression load of more than eight times the body weight (Hosea and Gatt 1996:38). The lateral bending force is developed in the lateral – lateral direction, the shear force in the anterior to posterior direction and the compression force in the cranio – caudal direction. With the rotational force being developed as a result of twisting the vertebral motion segments about the long axis of the spine (Hosea and Gatt 1996:38).

According to Seaman (1998), the swing of a professional golfer is a highly efficient mechanism requiring a small amount of activity from muscles to produce sufficient energy. However, comparatively speaking less skilled amateurs with less efficient mechanics may try to generate extra power by unnecessarily forceful movements which may lead to up to 80% more peak torque around their lumbar spine (Seaman 1998:47).

As direct evidence of the role of poor swing mechanics in low back pain for golfers is scarce at very best, it has been intimated that the lower back is susceptible to injury from a number of additional and varied sources (Bulbulian, Ball & Seaman, 2000).

One of these sources occurs at the end of the follow through phase, where the golfer's lumbar spine is rotated and hyperextended. This is known as the reversed C position (Hosea and Gatt 1996). According to McCarrol (1986) this position is essential for proper trajectory and solid impact, as well as body leverage and accuracy. However many amateur golfers exaggerate this position in order to achieve more power and distance. Mackey (1995) further states that in the reversed C position the facet joints approximate and in addition torsional stress is placed on the annular fibers of the disc. With repetitive swings and incorrect form the lumbar facets bear the brunt of the abnormal forces on the lumbar spine (Mackey 1995), especially on the facet joints and the lumbar spine discs.

In addition to this, during the downswing phase of a golf swing the role of the multifidus is to limit flexion whilst the external oblique muscle induces rotation of the lumbar spine. Together both muscles produce rotation in the lower lumbar spine. Thus the golf swing, particularly during the downswing phase, places a tremendous burden on the multifidus muscle and may cause muscle injury (Hosea, Gatt and Gertner, 1994: 97-108 and Seaman, 1998:50). Kirkaldy – Willis and Bernard (1999) state that the uncontrolled contractions of the multifidus muscle produce torsion to the facet joints and disc and are therefore an integral part of facet syndrome.

According to Seaman (1998), once the spinal tissue injury occurs a pathological process ensues that involves inflammation, nociception and pain, all of which can reduce joint mobility. The reduced mobility can dramatically affect the joint complex by promoting degenerative changes in cartilage, bone, ligaments, synovium, joint capsules, disc, muscles and tendons resulting in joint complex dysfunction. It is therefore likely that joint complex dysfunction is the main cause for back pain in golfers (Seaman 1998).

The above explanations on the cause of lower back pain in golfers is reinforced by Grimshaw et al (2002) who state that back pain in golfers is probably likely to emanate from the rotation of the lumbar spine at the top of the backswing , through uncoiling with energy transfer and hyperextension during the downswing and follow through.

In support of this claim the examination of a golfer with lower back pain, commonly reveals hypomobility of the lower three vertebral levels of the lumbar spine together with marked spasm of the bilateral extensors. Movement of the golfer's lumbar spine has been noted to be restricted in flexion, extension, rotation and lateral flexion (Grimshaw et al 2002:659) or a variant combination of these movements.

By understanding the stresses placed on the spine during the golf swing as well as the concomitant results, it is therefore not surprising that approximately 62% golfers sustain injuries directly related to their sport (Bulbulian, Ball & Seaman 2000:569). According to Seaman (1998) it is estimated that 10 – 33% of touring professionals play while injured, and it is likely that half the group will develop chronic problems. Data for professional golfers indicate that 30 % suffer from lower back injuries while 27% of amateur golfers incur the same type of injury (Grimshaw et al 2002:657).

The following section of the chapter will discuss two of the mechanical syndromes that have been thought to present in golfers with low back pain.

2.4 The syndromes

2.4.1 Facet syndrome

The term facet syndrome refers to posterior joint dysfunction characterized by an overriding of the facets of adjacent vertebrae, whereby the intervertebral foramina are narrowed from the superior to the inferior (Gatterman 1990:161).

Pain arising from the posterior joints of the lumbar spine is very common (Plaugher 1993:216), where it is thought that the facet and the capsule may be the source of pain, as each facet receives innervation from two spinal levels specifically the medial branch of the spinal nerve (Plaugher 1993:131). Etiological factors producing lumbar facet syndrome include trauma, degeneration, and faulty posture, all of which can result from the repetitive golf swing (Mackey, 1995; Hosea and Gatt, 1996 and Adlington, 1996:14), especially trauma which results from hyperextension of the lumbar spine (Gatterman 1990:161) in both the take away (Seaman 1998)and follow through (reverse C) positions (Seaman 1998).

These assertions support Mackey (1995), who stated that low back pain in golfers is probably caused by the development of facet syndrome. Such injury to the facet joints produces inflammation and pain (Gatterman 1990:161). According to Souza (1997), the golfer often complains of well localized low back pain with some hip, groin, buttock or leg pain above the knee, which mimics the recorded localization and referral of pain by the facet joints (Souza 1997:131).

- Clinically hyperextension increases the pain, whereas flexion reduces it (Gatterman 1990:162). Gatterman (1990) also states that pain is increased in sitting upright and lying in the prone position. When the symptoms are acute, sneezing and coughing may accentuate the pain (Gatterman 1990:162). For more chronic complaints, low back stiffness, especially in the morning or with inactivity, is common (Gatterman 1990:162). In addition the classic signs of posterior joint syndrome are palpable muscle spasm with focal tenderness over the affected facet joint (Helbig and Lee, 1988: 61-64).

2.4.2 SI Syndrome

Dreyfuss et al. (1994: 1138) define sacro-iliac dysfunction or sacro-iliac syndrome as a state of relative hypomobility within a portion of the joint's range of motion with subsequent altered structural (positional) relationships between the sacrum and ilium. In essence sacro-iliac dysfunction occurs when the ilium slips on the sacrum and an irregular prominence of one articular surface becomes wedged upon the prominence of an opposed articular surface (Hendler et al 1995: 171). The ligaments become taut, and the reflex muscle spasm and pain are intense, severe, and continuous (Hendler et al 1995: 171).

According to Plaugher (1993) sacro-iliac pain may be characterized by low back pain in addition to pain and localized tenderness over the joint, extending into the buttock, groin, genitalia, trochanteric region, mainly posterior, but also medial and anterior. It may also cause thigh pain, pain that extends to the heel and lateral border of the foot (Plaugher 1993:161). This pain is characterized by various descriptions ranging from sharp to aching, or dull, and is aggravated by bending, sitting or riding in a car and relieved by standing or walking (Bernard and Cassidy, 1991: 2115).

The symptoms of sacro-iliac dysfunction are generally exacerbated by activities that tend to load the pelvis asymmetrically (e.g. stair climbing, bicycle riding (Daum, 1995: 477) or the golf swing (Seaman 1998)) and the golfer appears most comfortable while sitting on the unaffected buttock, and, in order to remove the tension from the hamstrings that apply traction to the diseased joint, the golfer may also assume a typically forward flexed posture while sitting (Hendler et al 1995: 171). However, while standing, forward bending is limited and painful as a result of the forward excursion of the pelvis being limited by the tension of the hamstrings (Hendler et al 1995: 171). Bearing weight or lying on the affected side often increases the pain, and often the pain is reproduced by external rotation of the hip (Hendler et al 1995: 171). The presentation is nearly always chronic or subacute and rarely acute (Hendler et al 1995: 171).

It is thought that the sacro-iliac syndrome that could be a cause of the low back pain is affected by the presence of a load / energy transfer that occurs from the shoulder through the thoracolumbar fascia to the hips and lower extremities (Mould 2003). This is especially true when one realizes that the large muscles of the low back do not have a function in movement of the sacro-iliac joint but rather act as a strut through the thoracolumbar fascia in order to brace the joint and allow for the sacro-iliac joints to be compressed in order to facilitate load / energy transfer (Harrison et al 1997: 610).

Thus in regards of managing low back pain in golfers the literature generally describes prevention and treatment.

2.5 Prevention

Preventing low back injuries in golfers is a multifaceted undertaking, where Mackey (1995) describes proper technique, stretching, strengthening and endurance exercises as all being part of a complete preventative management system. Exercise therapy and in particular a dynamic exercise program which incorporates golf functional rehabilitation is a modern and accepted method by both the golfer and the clinician (Grimshaw et al, 2002:655), where stretching exercises should be geared towards maintaining full ranges of motion, especially in the back, hips hamstrings and shoulders (Mackey 1995:12). According to Chek (2003) a golfer can make significant gains towards a better swing and prevent injuries simply by stretching tonic muscles before play.

Strengthening exercises are thought to allow the lower back to better withstand the biomechanical stresses of the full recoil swing (Bulbulian, Ball, and Seaman 2001:570). In a case study described by Grimshaw et al (2002), strengthening exercises centered on the conditioning of the transverses abdominus muscle. Although this muscle is not considered to be paraspinal, it has particularly important implications in the maintenance of spinal stability so that other more specific golf functioning exercises and rehabilitation can be performed (Grimshaw et al 2002:656). Thus strengthening exercises of the back, hips, legs, shoulders and wrists will also allow for more explosive shots over a longer period of time (Mackey

1995) and it is thought that cross training, such as jogging, walking and riding a bicycle will help a golfer increase his endurance on the golf course (Mackey 1995:12).

2.6 Treatment

Considering that the literature seems to implicate facet joint and sacro-iliac joint syndrome as significant sources of low back pain, it is important to consider the various components of the syndromes as have been hypothesized by Gatterman (1995), who describes three main components: kinesiopathophysiology, neuropathophysiology and histopathology; and Leach (1994) who adds biochemical changes and myopathology.

In essence kinesiopathophysiology refers to the lack of mobility or hypomobilty of the joint while neuropathophysiology includes neural irritation (with resultant changes in clinical findings that mimic increased neural stimulation – e.g. hyperaesthesia) and neural pressure (with resultant changes in clinical findings that mimic decreased neural stimulation – e.g. hypoaesthesia). The histopathology involves changes within the cells and is closely related to biochemical changes such as inflammation and inflammatory processes (Gatterman 1995:163). Myopathology indicates that the clinical presentation implies a muscle involvement which is usually seen as muscle tonicity or spasm (Gatterman 1995:160)

In addition Farfan (in Leach, 1994:47) describes the formation of joint capsule adhesions as a result of the above syndromes as a primary factor in joint dysfunction and maintenance of the dysfunction (Vernon and Mrozek, 2005). Immobilisation of joints clearly leads to adhesion formation as a result of a prior inflammatory response (Gatterman 1995:163) and resultant restriction.

Gatterman (1995) proposed the following summary of effects of spinal manipulative therapy on facet joints:

1. Release of trapped meniscoids
2. Reduction in articular cartilage displacement by chronically entrapped meniscoid
3. Pain relief by coactivation of various receptors
4. Reduced weight bearing
5. Reduction of intervertebral foramen stenosis caused by segmental hyper extension
6. Reduced intracapsular or exrtacapsular adhesions
7. Relief of abnormal tension on joint capsule
8. Reduction of post immobilization collagen cross linking
9. Reduction of local vascular stasis
10. Release of osseous mechanical locking

Thus it would stand to reason that Mackey (1995) suggests that the treatment of a golfer with low back pain is no different than it is for the rest of the public. During the acute stage protection is utilized to avoid reinjury to the area (Peterson and Renstrom 2001) modified rest is utilized to assist with decreased stress on the lower back (Peterson & Renstrom 2001), ice for its local pain-relieving effect and contraction of blood vessels to reduce bleeding (Peterson & Renstrom 2001:92) , compression is utilized to provide a counter pressure to the bleeding developing in the injured area (Peterson & Renstrom 2001) and elevation is utilized to improve venous drainage (Peterson & Renstrom 2001), all of which are important in ensuring increased healing.

After the acute phase has passed isometric exercises, painless passive ranges of motion performed by the doctor and golfer, as well as physiotherapy modalities such ultrasound and interferential current can all be utilized (Mackey 1995:12) to relieve pain, promote healing and increase blood flow (Kitchen & Bazin 1996). Non steroidal anti inflammatory drugs and, on occasion anti spasmodic medication may be used (Hosea and Gatt, 1996) to inhibit cyclo-oxygenase (COX) thereby inhibiting prostaglandin synthesis giving the non-steroidal anti inflammatory drugs their anti inflammatory and analgesic effects (Neal 1997:71).

Spinal manipulation to relieve areas of joint dysfunction can also be introduced at this time (Kirkaldy – Willis and Bernard 1999). In this respect manipulation has been validated as a safe and effective treatment for certain types of mechanical low back pain (Cooperstein et al 2001:407).

As stated earlier Seaman (1998) describes a pathological process started by spinal tissue injury which ends in reduced joint mobility (Seaman 1998:46). In congruence with this Bergman (1993) describes that manipulation is a physical maneuver designed to induce joint motion through thrust techniques. Thus manipulation is intended to treat disorders of the neuromusculoskeletal system by improving joint alignment, range of motion, and quality of movement (Bergman 1993, 123). This leads to the common application of manipulation in the treatment of joint hypomobility.

Bernard and Cassidy (1991: 21-26) further hypothesize that manipulation forcefully stretches hypertonic muscles against their muscle spindles leading to a barrage of afferent impulse signals to the central nervous system. This results in reflex inhibition of gamma and alpha motor neurons which may lead to readjustment of muscle tone and relaxation (Korr, 1975 as cited in Leach, 1994: 99).

Thus where golfers with low back pain have been found to have a restricted maximum rotation range of motion when standing in a neutral posture (Lindsay and Horton 2002: 605), manipulation has been employed to relieve their symptoms:

> During an examination of a golfer with lower back pain Grimshaw and Giles (2002) found hypomobility of the lower three vertebral levels as well as restriction of movement in the lumbar spine in flexion, extension, lateral bending and rotation. When the golfer was placed in an under pressure "end of backswing position" there was considerable discomfort and pain (Grimshaw and Giles 2002:659). This is as a result of the modern swing which emphasizes a backswing that is characterized by a large shoulder turn with a restricted hip turn. This places the spine in a maximal state of rotation and amateur and professional golfers are urged by instructors to assume

this position in order to generate power and maximum club head velocity (Seaman 1998:47).

In addition a study done by Neighbors (1996) indicated that the length of the back swing and extent of torso rotation did not correlate with CHV at ball impact. He also found that a shorter backswing with minimal rotation produced a more consistent CHV at ball impact than a long backswing with maximum torso rotation. Seaman (1998) found that shortening the backswing reduced the amount of back muscle activation but there was no concrete data that this swing decreased the amount of spinal rotation, although it would seem to reduce the rotation of the shoulders and the movement of the arms. Thus the relationship between trunk muscle EMG and dynamic axial torque is described in literature but the relationship does not approach unity (Seaman 1998:574). It is therefore unclear to what extent the reduced torques on the spine and trunk musculature may prevent injury in golf, if at all.

Interestingly Seaman (1998) also found that that there was an increase in muscle activation of the lattisimus dorsi and pectoralis muscle during the shortened backswing and this could increase the possibility of a shoulder injury, as well as place more stress across the thoracolumbar fascia (Mould 2003), which is intimately related to the function of the latissimus dorsi (Luttgens 1992) and which places indirect compressive forces of the sacro-iliac joints (Harrison et al 1997: 610), thereby predisposing them to dysfunction and precipitating the development of low back pain in the golfer, in another joint not necessarily affected by the hyperrotation or extension (as seen for the facet joints), which the shortened backswing is meant to address.

In addition to the above clinical symptomatology, which is often used as a measure in clinical trials, it has been found that the single plane measurement tools utilized to assess improvement have been ineffective as they have not been able to record mutli-plane ability of the golfer (Lehman and McGill 1999). Thus as most of this literature (Burton et al 1990 and Shambaugh 1987) is based on using simple measures of movement kinematics such as one plane motion to assess the effect of manipulation or the restriction of motion in a syndrome, these measures may be insufficient according to Lehman and McGill (1999), to accurately record any change or effect . Their study presented documentation of the influence of a manipulation on lumbar spine kinematics about all three axes (flexion-extension, lateral bend and axial twist) while performing motions of forward flexion, lateral bend, and axial twist, as well as during a complex motor task – the golf swing (Lehman and McGill 1999:576). The study also included the assessment of trunk muscle activity before and after the manipulation during these tasks. The authors found an increase in all ranges of motion after the manipulation as well as a decrease in trunk muscle activity. The subjects however showed no changes in peak range of motion during simple flexion or axial twists and a very slight decrease in muscle activity during the downward phase of forward flexion only (Lehman and McGill 1999:579).

They concluded that future studies should concentrate on the effect of manipulation on complex tasks which consist of a greater number of biological interactions to effect movement and involve greater interaction among neural control and kinesthetic elements (Lehman and McGill 1999:580).

In addition to the restriction placed on the measurements utilized in previous studies, there is also a large proportion of studies (Lehman & McGill 1990 and Jermyn 2004) that focus only on the immediate effect of manipulation, based on pre-post clinical or experimental intervention trials. These types of trials produce vast amounts of information regarding the immediate effect of manipulation on the golfer / golf swing, but they assume that the effects as produced by manipulation are related solely to a neurological parameter that can be addressed in one treatment (Engel and Graney (2000) and Etminan et al (2003)), which implies that the effect is immediate and that the results are measurable within a relatively short period after the intervention has been employed.

This assumption can be seen in the study by Jermyn (2004) where the CHV of golfers with mechanical low back pain was measured before and immediately after spinal manipulative therapy. Jermyn (2004) found that spinal manipulative therapy had an immediate positive influence on CHV and CHV consistency as well as the subjective and objective findings of the golfer's mechanical low back pain. However no conclusive correlations could be made regarding the sustainability of the results, until further research into the long–term effects of spinal manipulative therapy are explored (Jermyn 2004).

Thus the pre-post clinical or experimental intervention trials are limited in explaining the physiological effects (e.g. reduction in muscle hypertonicity (Korr, 1975 as cited in Leach, 1994: 99) and inflammation surrounding the joint) as well as the effects of the biomechanical changes which are initiated along with the neurological changes at the time of intervention as they take longer to manifest in terms of clinical symptomatology. In addition with the majority of low back pain being chronic in nature, these effects require time and a number of treatments in order to be effective. According to DeFranca (1996: 401), treatment of chronic joint and muscle conditions takes weeks and even months to restore function satisfactorily.

Thus this trial has been structured to assess and evaluate the immediate and short term effects of spinal manipulative therapy CHV in amateur golfers suffering from mechanical low back pain in terms of subjective and objective clinical findings

2.7 Summary

We could therefore summarise the current literature as follows:

- Mechanical low back pain in amateur golfers is a result of joint complex dysfunction (Seaman, 1998).
- This dysfunction then causes reduced spinal motion(Grimshaw and Giles 2002:659)
- Evidence suggests that increased spinal flexibility should be the primary aim of golfers with low back pain, to reduce their symptoms and decrease the effects of repetitive strain on CHV (Lehman and McGill, 1999:576-579, and Lindsay and Horton, 2002:604).
- As a result restricted spinal motion may or may not have an effect on CHV (Bulbulian, Ball & Seaman, 2001, 569)
- Manipulation has been shown to be effective in the context of low back pain treatment (Cooperstein et al, 2001), however the immediate and short term effects of spinal manipulative therapy have however not been investigated in the context of performance indicators in golf.

Thefore the aim of this study was to assess the immediate and short term effects of spinal manipulative therapy on the club head velocity of golfers suffering from mechanical low back pain.

CHAPTER THREE

3.0 INTRODUCTION:

This chapter gives a description of the primary and secondary data, the patients, the design and the intervention used. A brief explanation of the statistical methods used for interpretation of the data is also provided in this chapter.

3.1 THE DATA:

3.1.1 The Primary Data consisted of

- Case history (Appendix A)

  Demographic data recorded included the following:

  - Age
  - Handicap
  - Golf rounds per month
  - Practice at range per month

- Physical examination (Appendix B)
- Lumbar regional examination (Appendix C
- Specific diagnosis and objective evaluation of mechanical low back pain syndromes included; Kemp's test, Facet Challenge test, Sacro-iliac (SI) Percussion test and Yeomans test (Appendix D).

- Non digital algometer (Appendix D)
- Roland Morris Questionnaire (Appendix E)
- Numerical pain rating scale (Appendix F)
- Flight Scope Pro swing analyzer (Appendix D)

3.1.2 And secondary Data

These came from many different sources including:

- Textbooks
- Journal articles
- Internet search engines

3.2 Study Design

This was an applied experimental design evaluating the effect of spinal manipulation in the treatment of mechanical low back pain in amateur golfers and its influence on club head velocity.

3.3 Advertisements for patient recruitment:

Patients for this study were referred from advertisements mainly at golf clubs, pro shops and driving ranges (Appendix G). There was also a general distribution of advertisements through a distribution network. Patients that responded to the advert were required to undergo a cursory telephonic interview with the examiner to exclude any patients that did not fit the study criteria.

3.4 Telephonic procedure:

The following questions were asked during the telephonic interview:

- Do you presently have low back pain that is related to playing golf?
- Are you between the ages of 25 and 45?
- Have you ever had surgery for your low back pain before?
- Are you currently being treated for your low back pain?
- Can you commit for four treatments over two weeks with a follow up consultation one week later?
- Are you an amateur golfer? Patients had to be amateur golfers - a person who takes part in golf without receiving money for it (i.e. they

are not professionals (Oxford Advanced Learner's Dictionary, 1995:35)).

- Do you have an official handicap? Patients who have an official handicap have to play golf on a more regular basis in order to maintain their handicap.

Once the researcher had ascertained that the patient was highly likely to fit the inclusion and exclusion criteria, he explained the nature of the study and scheduled an appointment at The Pro Shop in Springfield Park for further assessment. The Pro Shop had agreed to work with the researcher.

3.5 The patients

The study included male patients who suffered from low back pain related to playing golf. Patients with an official handicap were accepted, as opposed to non handicapped players as this ensured that the patients played golf on a regular basis and allowed greater sample homogeneity (Mouton, 1996).
The study was limited to patients residing in the KwaZulu- Natal province.

3.6 Sampling procedure:

3.6.1 Sample Method

Non-probability sampling was employed in the study design and therefore inferences drawn were casual.

3.6.2 Sample size

A minimum sample group of forty golfers was required, in order to remain within the budget constraints and to attain statistically viable results within this parameter (Esterhuizen, 2005).

3.6.3 Sample allocation

The patients were divided into an experimental group consisting of thirty patients known as group A and a control group of ten patients known as group B.
Random allocation was utilised to assign the patients to their respective groups, with the patients drawing a letter (A or B) out of an envelope.
The patients were then assigned into group A or group B depending on which letter was drawn.

3.6.4 Sample Characteristics

A case history (appendix A), physical exam (appendix B) and low back regional examination (appendix C) were performed to assess for any conditions that may have excluded the patient from the study.

3.6.4.1 Inclusion criteria

- No patient younger than 25 or older than 45 years was considered. Kirkaldy-Willis and Burton (1992) state that age is an important factor in low back pain and that low back pain tends to begin within the third decade of life and reaches maximal frequency during middle age (Kirkaldy-Willis and Burton, 1992:4). The researcher wanted to exclude degenerative changes as much as possible and according to Brandt (2002) degenerative changes do not usually occur before the age of 45.
- Patients had to be male in order to create homogeneity within the study group. (Mouton, 1996)
- Patients suffering from mechanical low back pain incorporating Lumbar Facet Syndrome and / or Sacro-iliac Syndrome (Kirkaldy-Willis and Burton, 1992:291; Riggien 2003), as per the literature specified criteria were included.

3.6.42 Exclusion criteria

- Contraindications to spinal manipulation included but were not limited to such conditions as osteomyelitis, TB of the spine, infectious arthritis, disc prolapse, haemangioma, vertebral malignancy and advanced spondylolisthesis. (Gattermann, 1990:55-68)
- The patients were asked to refrain from any other treatment protocol for low back pain such as drugs or manual interventions (Poul et al, 1993) as medicinal interventions would obscure the results obtained, especially those related to the reporting of pain ratings.
- If patients on anti-inflammatory drugs or medication, where to have considered participating in this study, a minimum of a 48 hours clearance / wash out period had to be adhered to prior to acceptance onto the study, otherwise the patient was excluded (Poul et al, 1993).
- Patients currently receiving treatment for mechanical low back pain were excluded, as this could add or detract from the results that would have been obtained in this study giving a skewed result not reflective of the methodology utilized leading to incorrect deductions based on the results.
- Illiterate patients were excluded as they would not have been able to read the consent form.
- Patients undertaking any specific lower back exercise during the study, above and beyond normal exercise/ playing/practice routines were excluded as this may have affected the patient's symptomatology.
- If the patients had, or the physical examination suggested that they had cardiovascular, respiratory, gastrointestinal or systemic diseases that could refer pain to the lower back they were excluded, especially if these required further clinical tests in order to confirm / refute the diagnosis.

3.6.5 Diagnostic criteria for inclusion

At the first consultation the following assessments were performed in order to make a diagnosis of mechanical low back pain:

1. To standardize the extent of the clinical diagnosis during the orthopaedic low back regional examination, specific tests were performed to diagnose mechanical low back pain (appendix D). The following orthopaedic tests were used:
    - Kemp's test and
    - Facet challenge was used to make a diagnosis of lumbar facet syndrome while
    - Yeoman's and
    - SI percussion was used to make a diagnosis of Sacro-iliac syndrome.

    This was done according to the Kirkaldy-Willis and Burton (1992: 291) classification.
2. The classification involved patients being diagnosed as having dysfunction of the low back joints viz. posterior facet joint syndrome and / or sacro-iliac joint syndrome as classified by Kirkaldy – Willis and Bernard (1999). Therefore these patients would need to present in the unstable phase of low back pain development (according to age), however present in this phase with a joint dysfunction as defined above.

The orthopaedic tests are described as follows:

3.6.6 Lumbar facet tests

Lumbar facet joint challenge

The patient was lying prone. “Springing” the spinous process discerns the status of the facet joints. The examiner placed one thumb on the spinous process above and one on the spinous process below. The force was applied horizontally in opposite directions (Gatterman, 1990:141)

Kemp’s test

The patient was in the seated position. The examiner reached around the patients shoulder from behind and laterally bent, rotated and extended the patient to the right and then left while applying an axial force. Pain in the lumbar region indicated a positive test. (Gatterman, 1990:141)

3.6.7 Sacroilac tests

Yeoman’s test (Erichson’s test)

The patient was prone. One hand applied pressure to the effected SI joint, while the other hand lifted the ipsilateral leg into hyperextension, with the knee flexed to 90°. Pain in the SI joint indicated a positive test (Schafer and Faye, 1990:271).

SI Percussion – compression

This test was applied like a "kidney punch" over the individual sacro-iliac joints. A positive test was that which produced pain – sharp or dull directly under the hand or over the sacro-Iliac joint.

3. The most symptomatic joints were identified by motion palpation of the lumbar spine and sacro-iliac joints prior to the treatment (Schafer and Faye, 1990:211-217, 256-259). Motion palpation was used to identify the segments in the lumbar spine and sacro-iliac joints with restricted and/or abnormal motion (Schafer and Faye, 1989:211-216). The above findings were used by the researcher to identify in which plane a manipulative technique should be given, allowing the patient to have the least amount of discomfort and to restore maximum joint play to their spine (Schafer and Faye, 1989:7). Bergman (1993) states that motion palpation had a high level of intra-examiner reliability. The research on inter-examiner reliability is less conclusive (Bergman 1993:739).

3.7 Clinical procedures

After the clinical evaluation against the inclusion and exclusion criteria, the patients were given a letter of information (Appendix H) and asked to sign an informed consent form (Appendix I) once they had asked the researcher any questions pertaining to the study. This then allowed the patients to participate in the study or continue as an out-patient in the Chiropractic Day Clinic (unrelated to the research)

Forty patients, who had to meet the inclusion and exclusion criteria in order to be part of the study, were chosen to participate and all of them underwent an initial consultation at the Pro Shop in Springfield Park. The researcher was accompanied by a supervisor from the Durban Institute of Technology (DIT) Chiropractic Day Clinic. The patients were asked to bring their own seven iron club and to use the same club at every consultation. This was done to ensure that the player was comfortable and confident with the club that he was using. All patients used Topflight practice balls which were supplied by The Pro Shop.

3.8 Intervention Type

Once a patient was accepted onto the study, a baseline reading of their CHV was made using a Flight Scope Pro swing analyzer at The Pro Shop in Springfield. The patient would then undergo the first spinal manipulative therapy and his CHV would then be reassessed at the same consultation. This process at the initial consultation was the same for group A and group B

3.9 Clinical treatment plan / intervention frequency

Group A

- Patients in group A received spinal manipulative therapy (including the sacro-iliac joints) (SMT) in accordance to the treatment protocol of Thompson (2002). This manipulation involved a left-to-right or a right-to-left lateral recumbent manipulation (Lehman and McGill, 1999:577) or seated manipulation to the lumbar spine. Additional procedures as named in Schafer and Faye (1989: 283,284) where utilized if the previous manipulations where unsuccessful.
- The sacro-iliac manipulation was also done in the lateral recumbent position but differs to the lumbar manipulation by emphasizing traction and tension on the sacro iliac joint through the contact hand (Bergman 1993:499)

- In Group A manipulations involved four treatments over a two week period Thompson (2002), with a follow up consultation one week later. This follow up consultation was used for the final assessment of objective and subjective clinical findings only and no spinal manipulative therapy having taken place.

Visit	Group A	Venue
1	CHV analysis and treatment	The Pro shop
2	Treatment only	D.I.T
3	CHV analysis and treatment	The Pro shop
4	Treatment only	D.I.T
5	CHV analysis	The Pro shop

Table 2 – Group A treatment

Group B

- Patients in group B received no further treatment after the initial consultation (which was the same as for Group A), but were required to come for follow up measurements at one week intervals in congruence with consultations 1, 3 and 5 of group A. The changes in measurements were recorded in the exact same way as group A but no manipulation took place.

Visit	Group B	Venue
1	CHV analysis and treatment	The Pro shop
2	CHV analysis	The Pro shop
3	CHV analysis	The Pro shop

Table 3 – Group B treatment

- Visit 1: This initial visit at The Pro Shop was exactly the same as for Group A

- Visit 2: This was one week later in congruence with visit 3 of Group A. The subjective and objective findings (Numerical pain rating scale (NRS), Roland Morris Questionnaire (RMQ), Orthopaedic tests and CHV) were assessed as in Group A but there was no spinal manipulative therapy. The patient sat with the researcher or moved around the Pro Shop for a few minutes between the "pre" and "post" measurements to remain as similar as possible to Group A.
- Visit 3: This final follow up visit occurred in congruence with, and was exactly the same as visit 5 of Group A

3.10 Measurements

3.10.1 Subjective data

- The ***Numerical Pain Rating Scale*** (NRS) (Appendix F) was used to assess the patient's perception of their pain intensity. This information was taken before any clinical intervention took place in order to establish the baseline norm; thereafter the scale was applied as indicated on table 4.

  The questionnaire consisted of a numerical scale from zero to one hundred, with zero representing "no pain" and one hundred representing "the worst pain imaginable". The participant was required prior to treatment to indicate the intensity of their pain by means of a percentage from 0 to 100 when the pain was at its most severe and then give another percentage value for their pain when it was at its least severe. The average between these two percentages is an indication of the participants' pain level. Jensen et al. (1986) states that the NRS is a reliable method of rating pain intensity.

- The ***Roland Morris Questionnaire*** (RMQ) was used, as this is a commonly utilized scale that is well established and a reliable instrument used for measuring spinal disability (Yeoman, 2000: 70-71). The validity is strong, with the RMQ showing the strongest or equal to the highest correlation of all scales. There are 24 questions in the scale. Recently a revised version of the RMQ, the RM-18 has been introduced. This revised version met reliability and validity criteria in a pre-test-post test design. An item analyses suggested that 6 items could be deleted from the 24-item tool without changing the measurement property when compared to the longer version. A true-negative rate was 87%, identical to that of the 24-item version (Yeoman, 2000: 70-71). The scoring system consisted of one point per circled item giving a maximum total of 24. The statements in this questionnaire primarily focused on physical function or dysfunction with only one question pertaining to mood or emotion. However, some aspects of physical action such as lifting and twisting or turning are not included. According to Yeomans (2000:71-72) the RMQ is beneficial from the point of view that it covers certain domains thoroughly and makes the analysis of the scores easily comprehensible, and it is ideal for use in settings where patients had mild to moderate disability. (Appendix E).

3.10.2 Objective data

- ***Flightscope Pro swing analyzer.***

The Flightscope Pro swing analyzer is a 3D tracking radar system that measures CHV. This device is based on phased array technology to measure projectiles in flight. The makers of this product use similar technology in their military branch to measure ballistic characteristics. The Flightscope Pro has a launch velocity range of 1.2 to 250 miles per hour within 0.5 % accuracy and can give the landing position of the ball with a standard error of 5 % of actual flight distance. The club head velocity strike is accurate to 2 %. The device is also used to track tennis serves and has been tested and approved for use by the All England Lawn Tennis Club and the Association of Tennis Professionals (ATP) (http://www.edh.co.za/, 2005).

This device measures many aspects of the golfers swing including; ball speed, angle of the club head, distance and swing paths. For the purpose of this study CHV was the main concern. Ball distance was also recorded for statistical analysis only (appendix D). Stude and Gullickson (2000) state that there is a 1:3 relationship between CHV and distance which suggests that for every 1 mph increase in CHV there is a subsequent 3 yard increase in air travel distance.

At The Pro Shop the patients were instructed to hit 10 golf balls as warm-up from an artificial indoor "tee-mat" into a suspended net using a 7-iron golf club. They were also instructed to warm up by stretching (Bulbulian, Ball and Seaman, 2001:570 and Stude and Gullickson, 2000:168).

The patients were not shown or instructed to warm up or stretch in a particular way. They were then requested to hit 10 warm-up golf balls and stretch as they would normally if they were going to practise or play golf. This non-intervention approach to the warm-up allowed for a more accurate and specific simulation of the patients' golfing habits. This allowed for a better chance to note any changes in CHV after there had been a clinical intervention. At least 3 minutes were permitted for recovery between warm up and actual swing analysis to prevent fatigue from affecting the outcome (MacIntosh et al. 2002).

They were then instructed to hit a specified number of golf balls (5) for "maximal distance" (Bulbulian, Ball and Seaman, 2001:570) to determine an average CHV.

The researcher did not watch the patient during the warm up or CHV analysis. This was in order to minimize the Hawthorne effect (Mouton, 2002:152). According to the Hawthorne effect if the researcher was to watch the patients in the study it could influence their performance knowing that they are being watched by the researcher.

Once the average CHV had been established the patients in both groups underwent the appropriate clinical procedure.
Swing analysis data were recorded at the Pro Shop in Springfield Park in Durban.

- ***Non-digital algometer***

The non-digital algometer was used to assess tenderness at the most symptomatic joints (appendix D). This instrument measured the number of kilograms the patient could withstand before complaining of pain. The measurements were taken by placing the rubber tip over the symptomatic facet or sacro-iliac joint, and were measured in kilograms per square centimeter (kg/cm). Fisher (1986) states that the algometer's ability to measure pressure sensitivity and to identify aberrant tender areas provides a means of quantifying treatment, so as to identify patient improvement (Fischer, 1986).

3.11 Measurement frequency

- The severity of low back pain in group A was assessed at treatments 1, 3 and 5. Both objective and subjective measurements were recorded at these consultations. The algometer, CHV and positive orthopaedic test results were recorded pre and post manipulation (immediate effects) while RMQ and NRS were assessed pre manipulation only (short term effects). ***Treatments 2 and 4*** took place at the Durban Institute of Technology Chiropractic day clinic in Berea. These treatment sessions included spinal manipulative therapy according to motion palpation findings. No objective or subjective findings were recorded at these consultations.

Visit	Group A	Visit	Group B	Venue
1	**CHV analysis, objective and subjective findings recorded and treatment**	**1**	**CHV analysis, objective and subjective findings recorded and treatment**	**The Pro shop**
2	***Treatment only. No objective or subjective findings recorded***			*D.I.T*
3	**CHV analysis, objective and subjective findings recorded and treatment**	**2**	**CHV analysis only**	**The Pro shop**
4	***Treatment only. No objective or subjective findings recorded***			*D.I.T*
5	**CHV analysis only**	**3**	**CHV analysis only**	**The Pro shop**

Table 4 – Comparison of Group A vs Group B

3.12 Statistical analysis

All Data was analysed using SPSS version 11.5 (SPSS Inc, Chicago, Ill, USA) and Stata version 8 (StataCorp LP, USA). A p value of <0.05 was considered as statistically significant.

Baseline data were described using means and standard deviations, or frequencies and proportions where appropriate. Baseline exposure and outcome comparisons between the two treatment groups were achieved using chi square tests or Fisher's exact tests in the case of categorical data, and t-tests in the case of quantitative dependant variables.

The effect of the treatment intervention was assessed in the immediate term and short term using repeated measures ANOVA for quantitative dependant variables. Five time points were used, and repeated contrasts were obtained and compared to assess and compare the immediate effects of the intervention between time points 1 and 2, and between time points 3 and 4. Short term effects were assessed from the time by group interaction over the entire 5 time points.

For binary dependant variables GEE models were generated in STATA using the cross –sectional time series module (Generalized estimating equations for cross-sectional time series data). Robust standard errors clustered on patient ID were generated to account for the intra-patient correlation over time. The time by group interaction over 5 time periods was used to assess the significance of the short term effects of the intervention. The immediate effects of the intervention were compared between time points 1 and 2 (session 1) and between time points 3 and 4 (session 2) using McNemar's chi square tests.

Chapter Four

4.0 Statistical Results

4.1) Introduction

The statistical findings and results obtained from the data will be presented and discussed in this chapter. At the conclusion of this chapter the hypotheses presented in chapter one will be revisited and accepted or rejected based on the data generated in this study as presented to that point.

The primary data in this study consisted of:

1. Demographic data consisting of age, handicap, practice sessions per month, golf rounds played per month.
2. Objective and subjective findings consisting of Algometer, CHV, NRS and RMQ

The secondary data consisted of information gleaned from the literature as found in books, journal articles, commentaries and internet sources.

Abbreviations as appropriate in this chapter include the following:

CHV - club head velocity

mph - miles per hour

yds - yards

kg	- kilograms
NDA	- non-digital algometer
NRS	- numerical pain rating scale
T	- thoracic vertebra
L	- lumbar vertebra
SI	- sacro-iliac
RMQ	- Roland Morris Questionnaire
SD	- Standard Deviation

4.2) Demographics

Forty golfers who met eligibility criteria were randomized into two groups:

- Treatment and
- Control.

Demographic characteristics were compared between the two groups to ensure that the randomization process was complete in eliminating confounding variables between the groups, therefore increasing homogeneity. The purpose of ensuring group homogeneity is that it allows for more reliable data comparison if the groups at the outset have congruence and therefore fewer confounding variables that may influence the results achieved (Mouton, 1996).

4.2.1 Age

Table 1: Sample statistics for age (n=40)

N	Valid	40
	Missing	0
Mean		31.25
Median		32.00
Std. Deviation		4.887
Minimum		25
Maximum		43
Percentiles	25	26.00
	50	32.00
	75	34.75

Mean age of the forty golfers in the study was 31.25 years (SD 4.9 years), with the minimum age being 25 years and the maximum 43 years. This is in congruence with a study done by Horton and Lindsay (2001) who had a mean age of 29.4 years, but somewhat higher than the study done by Bulbulian, Ball and Seaman (2001) who had a mean age of 26.5 years.

In terms of the general population age is an important factor in low back pain and that low back pain tends to begin within the third decade of life and reaches maximal frequency during middle age (Kirkaldy-Willis and Burton, 1992:4). The researcher wanted to exclude degenerative changes as much as possible and according to Brandt (2002) degenerative changes do not usually occur before the age of 45. This should have influenced the age group to a lower mean average as compared to the international studies of Horton and Lindsay (2001) and Bulbulian, Ball and Seaman (2001); however this does not seem to have been the result making this study's outcomes comparable to these.

4.2.2 Handicap, hours of practice and hours of playing

Table 2: Sample statistics for handicap, hours of practice and hours of playing

		HANDICAP	PRACTICE	PLAY
N	Valid	40	40	40
	Missing	0	0	0
Mean		12.63	2.00	2.93
Median		12.00	1.00	2.00
Std. Deviation		7.034	2.909	2.505
Minimum		0	0	0
Maximum		24	12	12
Percentiles	25	7.00	.00	1.00
	50	12.00	1.00	2.00
	75	17.50	3.50	4.00

4.2.2.1. Handicap

A player's handicap is the average number of shots over par that he plays during a round of golf. This means that the lower the player's handicap, the more skilled he is.

The sample statistics for handicap ranged from 0 to 24 with a median of 12. This is consistent with a study done by Batt (1992) who received 193 completed questionnaires from amateur golfers and found a mean handicap of 14,2.
The median handicap of 12 is lower than the average of 16 in South Africa (Bagley, 2005), but this may have benefited the results of the study because more proficient players have less variations in swing patterns (Hosea & Gatt 1996).

4.2.2.2 Practice sessions per month

Practice sessions ranged from 0 to 12 monthly, with a mean of 2 sessions per month (SD 2.9). This means that each golfer had at least one practice session during the research process, which standardized the effect of the practice sessions influence on the golfers symptomatology.

4.2.2.3 Rounds played per month

The subjects averaged 2.93 rounds per month (SD 2.5) which is in congruence with the survey done by Batt (1992) who found the mean number of rounds per month to be 3.2. This shows that the sample group reflected the general golfing population in terms of frequency of play (Batt, 1992).

4.2.3 Intergroup – Age, Handicap, hours of practice and hours of playing

Table 3 shows a comparison of mean age, handicap, times practiced per month and times played per month between the two groups. There were no significant differences between the groups. Age was slightly higher in the treatment groups than the control, but the difference was not statistically significant (p=0.093).

Table 3: Comparison of mean age, handicap, hours of practice and play between treatment and control participants (n=40).

	GROUP	N	Mean	Std. Deviation	Std. Error Mean	p value
AGE	treatment	30	32.00	5.119	.935	0.093
	control	10	29.00	3.399	1.075	
HANDICAP	treatment	30	13.00	6.400	1.169	0.566
	control	10	11.50	8.972	2.837	
PRACTICE	treatment	30	2.10	3.089	.564	0.712
	control	10	1.70	2.406	.761	
PLAY	treatment	30	3.00	2.652	.484	0.748
	control	10	2.70	2.111	.667	

Even though patients were randomly allocated into their respective groups – treatment and control – they attained a very similar participant profiles with respect to age, handicap, hours of practice and hours of play. This is significant as it is important to compare the baseline characteristics of the research groups to ensure that there are no differences in the research groups at baseline which could have accounted for possible differences in the research results. Thus this study has achieved homogeneity between the two research groups and the interpretations of the results therefore hold greater validity and reliability (Mouton, 1996).

4.3 Patient Diagnosis / Fixations

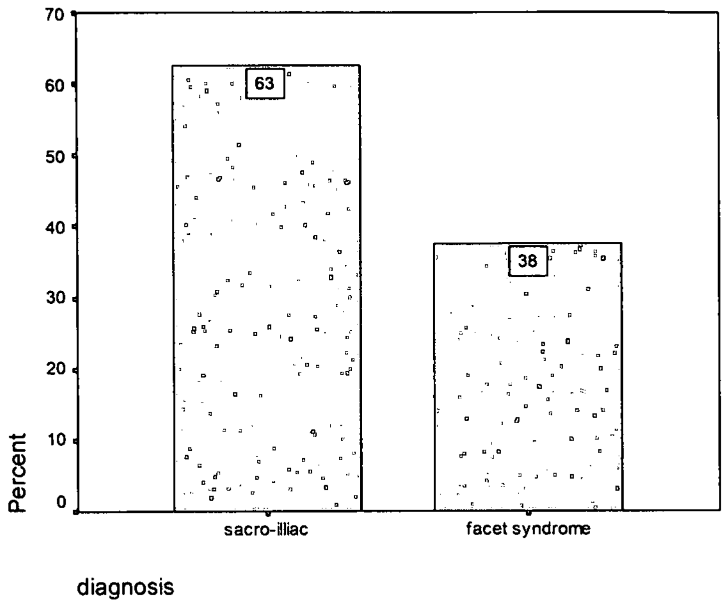

Figure 1: Diagnosis of participants (n=40)

In order to be accepted into this study patients had to be suffering from mechanical low back pain incorporating lumbar facet syndrome and / or sacro-iliac syndrome (Kirkaldy-Willis and Burton, 1992:291; Riggien 2003), as per the criteria set out in chapter three (materials and methods) of this study.

As a result Figure 1 shows the percentage of patients with a diagnosis / fixation of lumbar facet syndrome (n=15, 37.5%) and with a diagnosis of sacro-iliac syndrome (n=25, 62.5%).

This seems to be contradictory to Mackey (1995) and Seaman (1998) who indicate that ***facet syndrome*** is the most likely cause of low back pain in golfers. They along with other authors indicate that the causes of facet syndrome in golf are attributed to:

- The position at the end of the follow through where the lumbar spine is rotated and hyper extended in a "reversed C" position (Hosea & Gatt 1996).
- That the facets approximate in this position and with repetitive swinging bear the brunt of the forces caused by the golf swing in the lumbar spine (Mackey 1995).

In addition the downswing which has been related to the co-contraction of the multifidi and external oblique are thought to result in pathological joint mechanics as a result of fatigue of one or both muscles (Horton, Lindsay and MacIntosh 2001). This may be due the role of the multifidus muscle in low back pain in golfers, where the lumbar multifidus is thought to be particularly important in the stabilisation of spine (Hides et al 1994) and that in instances where the spine is unstable, the mutifidus which has both a stabilisation effect as well as a antagonist effect to the external oblique, is overloaded and fatigues, leaving the facet joint vulnerable to injury.

Furthermore Hides et al (1996) states that when compared to other muscles in close proximity to L4-L5, the multifidus muscle contributed two thirds of the increased stiffness imparted by contraction of the muscles. He concluded from this that the multifidus muscle is an important muscle for lumbar segmental stability (Hides et al 1996).

This is important in the golf swing as during the downswing phase of a golf swing the role of the multifidus is to limit flexion whilst the external oblique muscle induce rotation and flexion of the lumbar spine, thus together they produce rotation in the lower lumbar spine (Horton et al, 2001). Therefore the golf swing, particularly during the downswing phase, places a tremendous burden on the multifidus muscle, which stabilises the spine during this motion (Hosea, Gatt and Gertner, 1994: 97-108)

In this relationship one of two consequences are possible

- The trunk muscle (external oblique) coordination may be compromised by muscle fatigue and result in decreased trunk stability, with an increased risk of injury to the lower back (O'Brien and Potvin, 1997). In support of this it has been hypothesized that the abdominal muscles tend to fatigue more easily than the low back muscles, especially in individuals with chronic low back pain (Sugaya et al, 1999).

  This would indicate that the course of intervention would be to strengthen the trunk muscles (e.g. the external oblique) in order to increase its effectiveness in assisting with the stabilization of the spine.

- Unilateral wasting of the multifidus (on the symptomatic side) was found using ultrasound in patients with low back pain (Hides et al 1994). Indicating that there may be a compromise of the multifidus through the same mechanism of fatigue / overload, resulting in decreased use of the muscle as well as atrophy. This is significant as once the multifidus muscle is injured there is no spontaneous muscle recovery even on remission of painful symptoms (Hides et al 1996).

  This means that many golfers suffering with low back pain may have wasted multifidi muscles which cause instability of the lumbar spine. This indicates that further strengthening of the trunk muscles (e.g. external oblique) is contra-indicated in such golfers, as the external oblique will inevitably place more load on the fatigued multifidus rendering it even more dysfunctional.

The literature however is silent on the role of the **sacro-iliac joint** in the presentation of low back pain in golfers, although the literature alludes to possible mechanisms which could implicate this joint. These include:

- The transfer of weight from the right to the left leg in the right handed golfer, requires the stabilization of the gluteus medius muscle (Seaman, 1998), which if overused has been linked to the development of a sacro-iliac syndrome (Thompson, 2002).
- In addition the use of the lattisimus dorsi as one of the principle muscles of force transfer between the lower and the upper extremity (Seaman 1998), could cause an imbalance between the lattisimus dorsi and its antagonists, the gluteus medius and maximus on the contralateral aspect of the thoracolumbar fascia (Mould, 2003). This imbalance could result in the development of restricted motion within the sacro-iliac joints as one of the functions of the thoracolumbar fascia is that of sacro-iliac compression as an aid for energy transfer (Harrison et al 1997: 610). Unrelated to the joint structures of the low back, the use of non-contractile tissues in energy transfer (Seaman, 1998), with the resultant changes due to creep and hysteresis (Foreman & Croft 1995), will ultimately place more stress on the joints which these non-contractile structures are to protect, thereby precipitating the presence of low back pain in either the facet joints or the sacro-iliac joints.
- Furthermore it is suggested by such authors as Gatterman (1990) that if an area becomes hypomobile an area of hypermobility develops elsewhere. If the sacro-iliac joints were to be restricted, as a result more flexibility is demanded from the lumbar spine and it would result in an increased likelihood of symptoms developing in the lumbar spine and producing the literature (Mackey, 1995) described facet syndromes.

It would therefore seem that the literature has focused principally on the facet joints as the debate related directly to the degree of trunk rotation (Seaman,

1998) as opposed to the energy transfer structures that may be more directly involved.

Table 4 shows the comparison of percentage with each diagnosis between the treatment and control groups. There was no association between the diagnosis and group (p=0.135), indicating that the diagnosis where evenly spread within the groups under study.

Table 4: Diagnosis / fixation by treatment group (n=40)

			Diagnosis / Fixation		Total
			Sacro-iliac syndrome	Facet syndrome	
GROUP	treatment	Count	21	9	30
		Row %	70.0%	30.0%	100.0%
	control	Count	4	6	10
		Row %	40.0%	60.0%	100.0%
Total		Count	25	15	40
		Row %	62.5%	37.5%	100.0%

Fisher's exact p value 0.135

4.4 Number of diagnoses fixations

In addition to the even spread of diagnoses / fixations, there was no significant difference in the number of diagnoses / fixations at baseline between the participants from each group (p=0.302). This is shown in Table 5.

Table 5: Group by number of fixations at baseline (n=40)

			no of fixations			Total
			1	2	3	
GROUP	treatment	Count	8	16	6	30
		% within GROUP	26.7%	53.3%	20.0%	100.0%
	control	Count	3	7	0	10
		% within GROUP	30.0%	70.0%	.0%	100.0%
Total		Count	11	23	6	40
		% within GROUP	27.5%	57.5%	15.0%	100.0%

Pearson's chi square 2.4, p =0.302

Graphically this is shown as indicated in figure 2 below, where the majority of participants (n=23, 57.5%) had two fixations at baseline. 11 (27.5%) had one fixation, and 6 (15%) had 3 fixations.

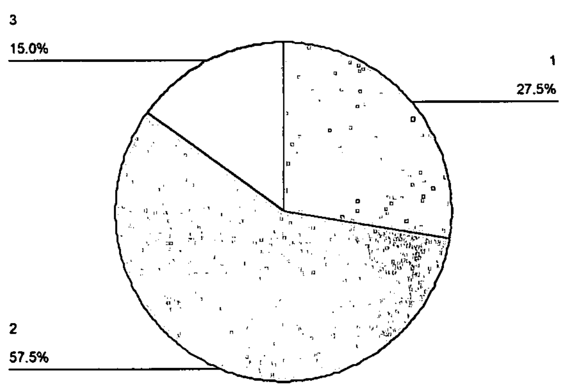

Figure 2: Number of fixations at baseline (n=40)

4.5 Baseline measures

4.5.1 RMQ, NRS, Non digital algometer, Club head velocity and Distance

Sample statistics for quantitative outcome measurements at baseline are shown in Table 6.

Table 6: Sample statistics for baseline outcome measurements in n=40 participants

		RMQ	NRS	ALGOMETER	Club head velocity (MPH)	Distance (yards)
N	Valid	40	40	40	40	40
	Missing	0	0	0	0	0
Mean		2.83	29.75	6.498	78.85	150.60
Median		2.00	30.00	6.250	79.00	148.50
Std. Deviation		2.183	11.334	1.4127	8.874	29.380
Minimum		0	5	4.0	62	89
Maximum		11	55	9.2	95	203
Percentiles	25	1.00	20.00	5.500	72.75	135.25
	50	2.00	30.00	6.250	79.00	148.50
	75	4.00	37.50	8.000	84.75	172.75

It can be seen from the above table that the mean values for the subjective and objective findings were the following:

RMQ - 2.83 (available range 0 – 24) (Yeomans, 2000: 70-71)

NRS - 29.75 (available range 0 – 100) (Jensen et al 1986)

ALGOMETER – 6.498 (available range 0 – 10) (Fischer, 1986).

The above scores are relatively low when compared to the available range. This implies that the pain experienced by the players was not very severe which may rule out acute traumatic injuries and rather suggests exacerbations of chronic injuries.

The standard deviations of these measurements are also relatively low (small) which enforces the homogeneity of the sample group and strengthens the efficacy of the results obtained (Mouton 1996).

CLUB HEAD VELOCITY – 78.85 MPH
DISTANCE – 150.60 Yards

The club head velocity and distance recordings are congruent with the speeds and distances most amateur golfers can attain using a seven iron club (Bagley, 2005).

Table 7: Comparison of mean baseline outcomes between treatment and control group (n=40)

	GROUP	N	Mean	Std. Deviation	Std. Error Mean	p value
RMQ	Treatment	30	3.07	2.258	.412	0.230
	Control	10	2.10	1.853	.586	
NRS	Treatment	30	31.42	9.993	1.824	0.108
	Control	10	24.75	14.066	4.448	
ALGOMETER	Treatment	30	6.430	1.3857	.2530	0.607
	Control	10	6.700	1.5492	.4899	
Club head velocity	Treatment	30	78.30	8.832	1.613	0.504
	Control	10	80.50	9.265	2.930	
Distance	Treatment	30	147.30	30.539	5.576	0.223
	Control	10	160.50	24.291	7.682	

Table 7 shows that there were no significant differences between the two groups with regard to the tests performed at baseline.

4.5.2 Orthopedic tests

At baseline the percentages of patients who were positive for each of the tests is shown in Figure 2. Sixty eight percent (n=27) were positive for the facet challenge test, while 63% (n=25) were positive for both the SI percussion and Yeoman's tests. Only 45% were positive for Kemp's test at baseline.

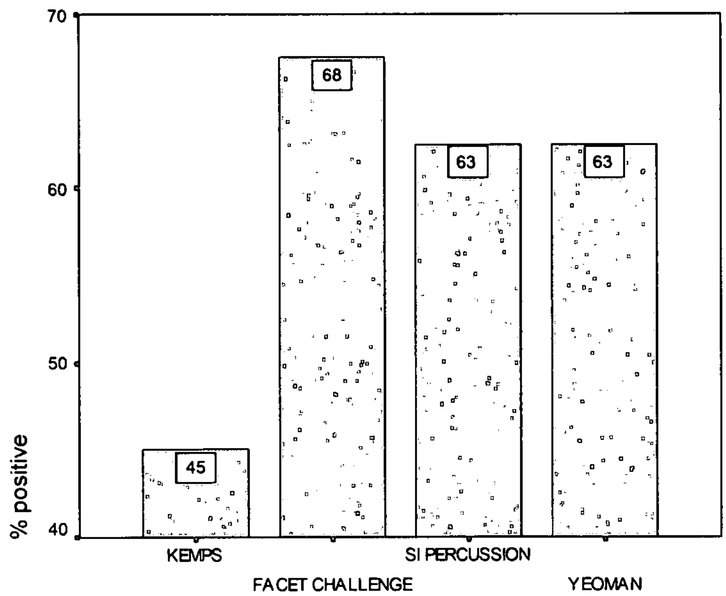

Figure 3: Baseline test results for n=40 participants

Based on the literature, the high percentage of positive results for the facet challenge is expected due to the stress placed on the facet joints during the golf swing. According to McCarrol (1986) at the end of the follow through the patients lumbar spine is rotated and hyperextended in a "reversed C" position. This position causes the facet joints to approximate (Kirkaldy – Willis and Burton 1992), which means that the lumbar facets bear the brunt of the abnormal forces being placed on the lumbar spine during the golf swing (Mackey 1995). Yet, the impaction during the golf swing has greater similarity to the mechanics of the approximation of the facet joint surfaces in the Kemp's test (Magee, 1997:525); therefore one would expect a high number of Kemp's tests to reflect a positive recording. This apparent inconsistency however cannot be explained based on the current literature available and requires future research.

Suggestions for this difference could however be linked to the test's sensitivity and / or specificity which have been linked to the acuity or chronicity of the presenting syndrome (Yeomans, 2000).

This inconsistency is however not apparent for the sacro-iliac joint syndrome, where equal numbers of positive tests where recorded. The researcher used SI percussion test and Yeoman's test to diagnose sacro-iliac syndrome.

Both tests would have had to be positive in order to make the diagnosis of a specific syndrome. All patients with a positive Yeoman's had a positive SI percussion test , which means that of the total research sample 63% of the participants had a diagnosed SI syndrome and 45% had facet syndrome, as this number corresponds to there being 45 % positive facet challenge and Kemp's tests. This means that there are a remaining 23% positive facet challenges which indicated localized pain in either group.

This could concur with both the previous suggestions (see discussion under 4.3 above) – i.e.:

- Golfers have a high degree of facet involvement, up to 68 %. However only 45% show positive tests for facet syndrome.
- Golfers have a high prevalence of sacro-iliac syndrome, which if associated with lumbar instability (Gatterman, 1990) may be the reason for localized pain on facet challenge indicating that the joints are tender as a result of damage associated with their hypermobility (Foreman and Croft, 1995).

The above discussion seems to support the presence of more sacro-iliac syndromes in golfers than facet syndromes.

Table 8: Fisher's exact tests for the comparison of test results at baseline between the treatment groups (n=40)

Test	Fisher's exact p value
Kemp's tests	0.140
Facet challenge test	0.700
SI percussion test	0.135
Yeoman's test	0.135

Table 8 shows that there were also no significant differences between the two groups with regard to the tests performed at baseline which again signifies homogeneity within the two sample groups (Mouton, 1996).

4.5.3 Diagnosis / fixation frequency

Frequencies of levels of fixations in the 40 participants are shown in Figure 4. The majority of fixations were at the SI level (n=31). There were a total of 75 fixations in the 40 participants.

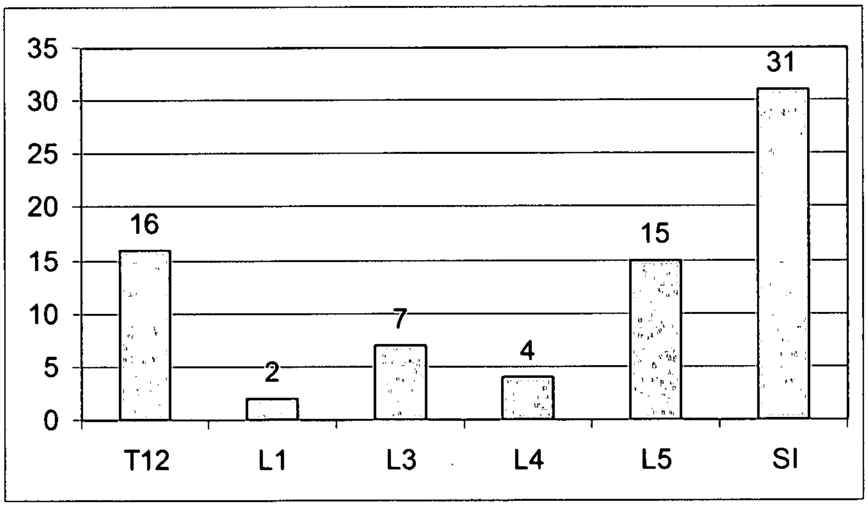

Figure 4: Frequency of levels of fixations in n=40 participants (75 fixations)

It can be seen by the above graph that SI and T12 fixations were more common than the lumbar spine fixations.

The above graphic representation (figure 4) supports the suggestions made so far, as the most common fixation indicated is the sacro-iliac joint, as associated with sacro-iliac syndrome. Therefore it would seem that hyper and hypomobility of different sections of the spine (Gatterman, 1990) and / or the transfer of energy through the thoracolumbar fascia seem, at least in this study to play a greater role than the degree of rotation that the golfer has through the take away phase as well as through the follow through phase of the golf swing.
This is further supported by the fact that the attachment of the latissimus dorsi over T12 through to the sacro-iliac joints (Moore 1999:691) may have a relationship with the level of the fixations that presented as these fixations present mostly at the extremes of the lattisimus dorsi attachments.

4.5.4 Side of fixations

As shown in figure 5, the fixations were mostly on the right side (n=34).

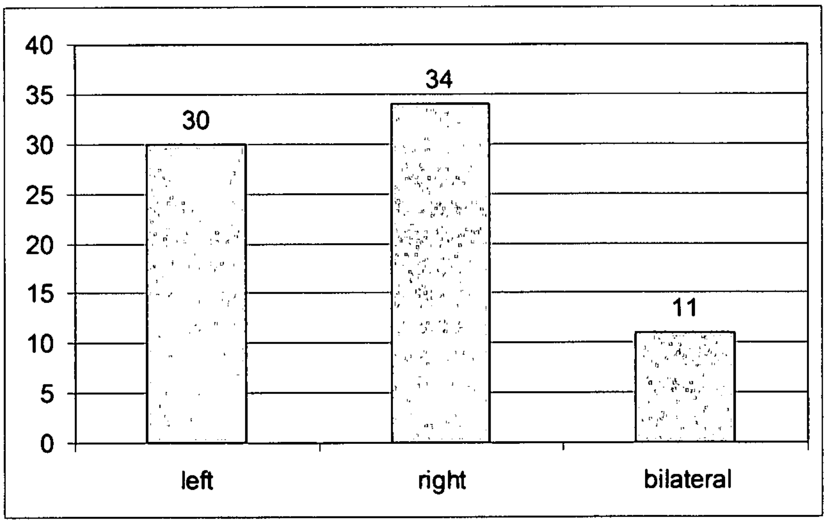

Figure 5: Frequency of side for fixations (n=40) (75 fixations)

This could be related to the fact that the right side of the body (right leg in the right handed golfer) is the weight bearing leg and the one on which the golfer both balances and generates that forces required for the golf swing (through contraction of the external oblique muscles and the co-contraction of the multifidi) (Seaman, 1998; Richardson and Jull, 2000; Grimshaw et al, 2002; Lindsay and Horton, 2002).

This presentation further supports the suggestion that the presence of sacro-iliac syndrome should be common in golfers, as especially with right sided golfers, energy is generated on right side which requires transmission to the left lattisimus dorsi in order that the energy is transferred to the left shoulder for an effective pre-impact, impact and follow through phase of the golf swing.

In addition to this the weight transfer from the left to the right, the use of the gluteus medius muscles to effectively transfer the weight, by stabilising the pelvis, could be related to overuse of this muscle. This together with the transfer of energy over the thoracolumbar fascia whereby the gluteus medius and maximus play a role as antagonists to the lattisimus dorsi, may be the two reasons why the energy transfer system is disrupted. In addition the overuse of the gluteus medius has been linked to the development of sacro-iliac syndrome on the ipsilateral side (Thompson, 2002).

This suggestion based on the results obtained are hypothetical as only right handed golfers were used in the study. The Flightscope swing analyzer was not able to measure the swing of left handed golfers. It is suggested that future studies take this into account in order to verify the suggestions made in this research.

4.5.5 Direction of the fixations

Figure 6 shows the frequency of direction of fixations. The most common direction was posterior to anterior (33 fixations). Upper flexion was the second most common direction.

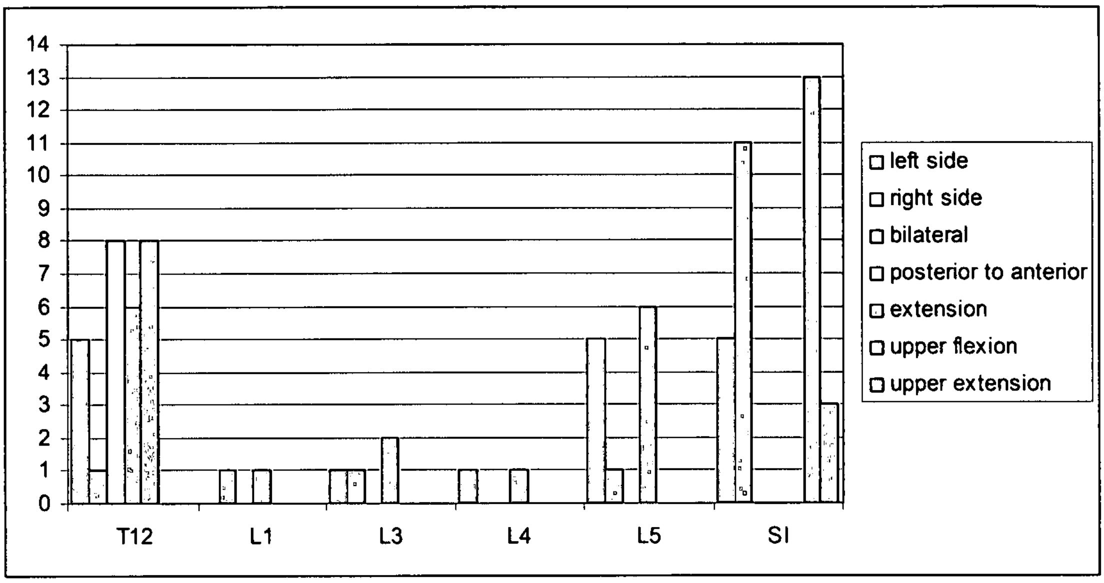

Figure 6: Side and direction of fixations at each level

Figure 6 above shows the most frequent side and direction for each level of fixation noted.

T12 fixations were most frequently bilateral (n=8) and fixated in extension (n=8). This can be attributed to the anatomy of the thoracolumbar region, where the joints reach an approximated joint position when the thoracolumbar column is extended, as a result of the medial taper of the facet joints (Giles & Singer 1997:189). This extension is further enhanced by the bilateral contraction (therefore bilateral fixations) of the multifidi muscles as a stabilizing force during the downswing, where force is generated by the strong external oblique muscles (Seaman, 1998), in order to limit the degree of flexion that is induced by the external oblique (Moore, 1999:184).

In addition to this the region of T12 is the area in which the uppermost fibers of the lattisimus dorsi are found (Moore, 1999:691). These muscle fibers attempt to transfer energy from the thoracolumbar fascia to the shoulder and therefore require that the thoracolumbar junction be stable and not mobile. This causes the region to be a point of conflicting requirements and demands throughout the process of the golf swing.

To further complicate this, the T12 – L1 region, as a transition from the relatively inflexible thoracic region to the much more mobile lumbar region occurs abruptly which makes this area susceptible to injury (Moore1999:463).

Thus there are a number of possible reasons that could account for the high numbers of T12 fixations found in the sample group in this research.

There was only one L1 fixation, which was on the right side and fixated in anterior to posterior direction and the single L4 fixation was on the left side in a posterior to anterior direction. Similarly there were only two L3 fixations, which were equal on the left and right sides, and all in posterior to anterior direction. These statistics may be related to the fact that L3 is a transitional vertebral level of the lumbar spine and therefore may not be aligned with either of the above (Moore, 1999: 462/3).

L5 was mainly left (n=5) in posterior to anterior direction (n=6). This may be due to the fact that the facets of the lower lumbar spine are in the coronal plane allowing more flexion and extension than rotation (Moore 1999) making the lower lumbar spine more susceptible to rotation injuries. This observation concurs with Seaman (1998) who stated that spinal rotation begins at the lumbosacral junction, where he indicated that the limits of rotation for the L5-S1 joint are 0°-2°, and for the L4-L5 through T10-T11, rotation is limited to 1°-3° (Seaman 1998:49).

This rotation may however be complicated by the limitations that the iliolumbar ligaments place on the L5 level (Moore 1999), which may make the L5 presentation relate more directly with the sacro-iliac joint fixations than to the mechanics specific to the region of L5. This seems to be particularly so on the left side, where the left sacro-iliac restrictions and the left sided fixations of the L5 correlate in number. This is however not true of the right side, indicating that the relationship is not linear and could therefore be subject to confounding variables.

The sacro-iliac fixations were mainly on the right side (n=11) and fixated mostly in upper flexion (n=13), with only three upper extension fixations being found in sacro-iliac joints. These high numbers of fixations as found in the right sacro-iliac joints seem to support the suggestions made in section 4.5.4 above, with respect to the motion restrictions or fixation direction, in addition the following needs to be remembered:

- Lindsay and Horton (2002:603) state that powerful anterior trunk muscles (e.g. external oblique) contractions on the downswing may cause an initial posterior tilting of the pelvis and an apparent increase in localized spinal flexion rather than true flexion of the trunk. Jermyn (2004) postulated that this "pseudo-flexion" could be the cause of the predominance of flexion restrictions in the SI joint or at the very least the inability of the sacro-iliac joint to move from the flexed position into the extended position.

4.6 Treatment effects

4.6.1 Quantitative outcomes

4.6.1.1. NRS

NRS was evaluated at 3 time points, with no pre and post manipulation recordings for each session: thus, the short terms effects were evaluated.

Table 9: Within and between subjects effects for NRS

Effect	Statistic	p value
Time	Wilk's lambda=0.580	<0.001
Group	F=0.038	0.846
Time*group	Wilk's lambda=0.656	<0.001

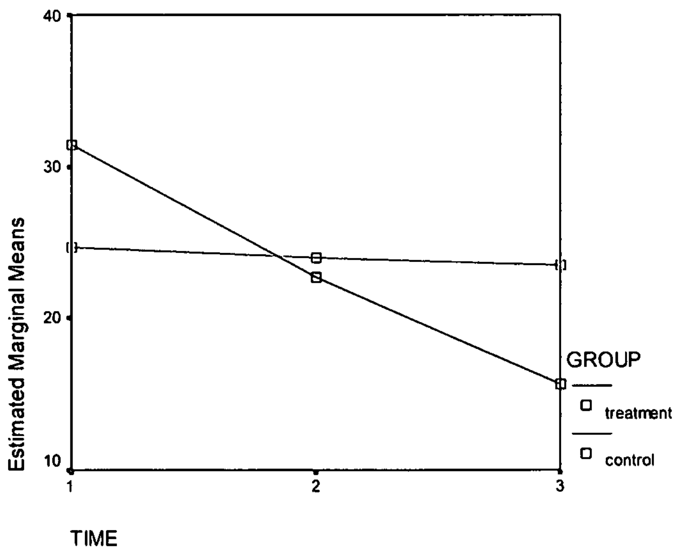

Figure 7: Profile plot of mean NRS by group over time

There was a significant interaction between time and treatment group (p<0.001) for NRS. Figure 7 shows that the mean NRS values in the treatment group decreased while those in the control group remained constant. Thus there was a significant beneficial treatment effect for NRS. This effect is in congruence with the literature (Kirkaldy-Willis and Burton, 1992: 249; Cassidy and Mierau, 1992: 223) that indicates a decrease in pain is expected post manipulation or after a course of manipulative treatments. We can conclude that the manipulation provided significant pain relief to the patients in the treatment group. In addition to this it can be noted that a single intervention (as per the control group) does not affect the pain cycle nearly as greatly (if at all) as multiple interventions, which supports the theories espoused by Patterson and Steinmetz (1986) and Leach (1994).

Furthermore the decrease in reported pain (through the NRS) indicates that the manipulation of the fixated joints plays a large role in the reduction of pain. In the case of this study, the golfers were manipulated most often for restrictions of the sacro-iliac joints, indicating that either these joints or the compensations as a result of the fixations in these joints are the principle cause of the pain in these patients.

4.6.1.2. RMQ score

RMQ score was also evaluated at 3 time points, with no pre and post manipulation recordings for each session, thus the short terms effects were evaluated. The subjects had to state which (if any) of 24 lower back pain disabilities they experienced.

Table 10: Within and between subjects effects for RMQ score

Effect	Statistic	p value
Time	Wilk's lambda=0.839	0.039
Group	F=0.027	0.871
Time*group	Wilk's lambda=0.847	0.047

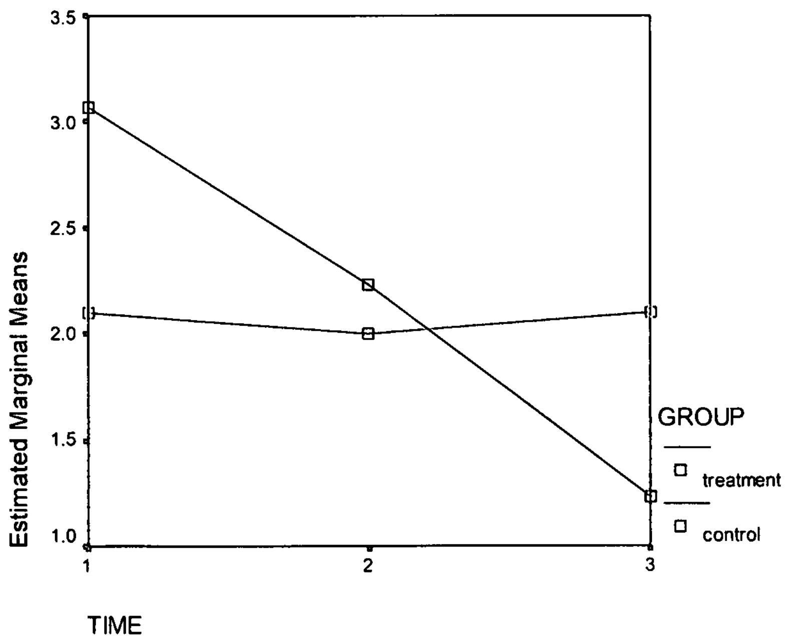

Figure 8: Profile plot of mean RMQ score by group over time

There was a just significant time*group interaction for RMQ score (p=0.047). Figure 8 shows that the mean score for the treatment group decreased over time, while the control group remained almost constant. Thus there was a significant beneficial treatment effect for RMQ, with the multiple treatments being more effective than the single interventions as supported by Patterson and Steinmetz (1986) and Leach (1994).

Patterson and Steinmetz as cited by Leach (1994) stated that in an area of spinal joint dysfunction with accompanying motion disorder and muscle tension, if the initial stimulus is sufficient or lasts long enough, there may be segmental facilitation even after the initial stimulus is removed (Leach 1994:101). The resultant abnormal segmental reflex circuit participates in maintaining the symptoms, thus creating a cycle of increased output with any sensory input (Leach 1994:101). Once the excitability changes were fixated in the cord, a "neural scar" of subliminally exited neurons would remain, which would be abnormally responsive to additional stimuli (Leach 1994:101). Alterations in these spinal reflex circuits would not be easy to remove and therefore multiple treatments would be needed.

It can be seen by relatively low scores on the graph that the low back pain experienced by golfers was not very debilitating and is in congruence with the pain reporting and demographic variables reported earlier in this chapter. In addition this may also indicate the need for the development of a golf specific disability questionnaire, as the low scores correlate with Lett (2002) who stated that most golfers carry on playing while injured.

It is of particular interest that the following questions on the RMQ were those most commonly answered:

1 Changing position frequently to get back comfortable (54%).
2 Standing up only for short periods (20%).
3 Avoiding heavy jobs (10%).
4 Less comfort during sleep (10%),

Which correlate well to the presentation of sacro-iliac syndrome as found in clinical practice.

4.6.1.3 Non Digital Algometer

Algometer measurements were taken at 5 time points (i.e. pre and post to each of the first two sessions and once at the last session). Thus immediate effects compare the pre and post at the first and second sessions. Short term effects examine the change over the 5 time points.

In terms of the treatment effects it needs to be noted that at session one both groups received an intervention and therefore both where expected to improve, however at session two, only the treatment group received manipulation and therefore an improvement was only expected in this group as compared to the control group.

Table 11: Within and between subjects effects for Algometer

Effect	Statistic	p value
Time	Wilk's lambda=0.396	<0.001
Group	F=0.843	0.365
Time*group	Wilk's lambda=0.576	0.001

Table 11 shows that there was a significant time* group interaction for algometer (p=0.001). The profile plot in Figure 9 shows that the mean values for the treatment group increased at a faster rate than those for the control group over the time points. Thus there was a significantly beneficial short term treatment effect measured by algometer measurements. It is further noted that the immediate effects (time 1 and time 2) were not significantly different. However this could be related to the fact that both groups received the initial intervention and therefore responded in the same manner.

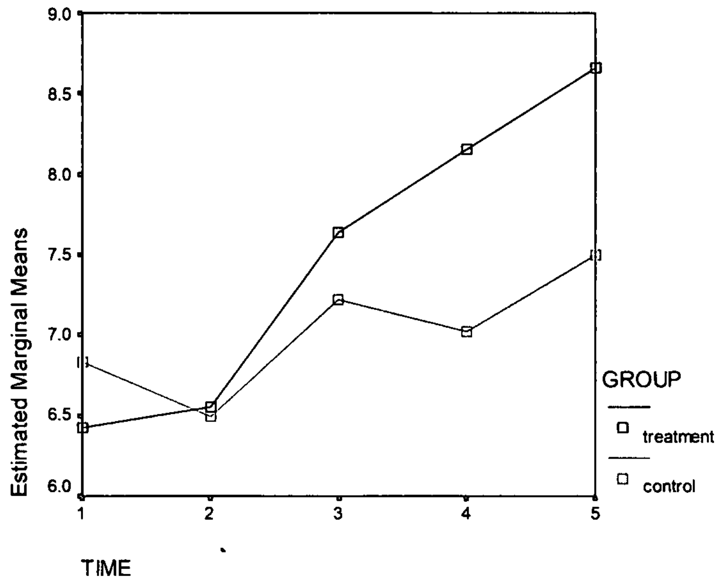

Figure 9: Profile plot of mean algometer measurement by group over time

4.6.1.3.1 Immediate versus short term for the algometer

Table 12: Within-subject repeated contrasts for time by group interaction for algometer measurements

Source	TIME	Type III Sum of Squares	df	Mean Square	F	P value
TIME * GROUP	Level 1 vs. Level 2	1.444	1	1.444	2.000	0.166
	Level 2 vs. Level 3	.903	1	.903	.481	0.492
	Level 3 vs. Level 4	3.589	1	3.589	5.979	0.019
	Level 4 vs. Level 5	.007	1	.007	.008	0.928

4.6.1.3.1.1 Immediate effects (i.e. changes post session one and session two):

Table 12 shows the results of repeated contrasts for the time by group interaction. This table gives a p value for each adjacent time point comparison, allowing us to see that the interaction was only significant at time 3 to time 4 ($p=0.019$).

It could therefore be stated that there was no immediate effect between pre and post manipulation at the first session. This might be because the treatment and control subjects were very similar to each other in terms of mean algometer measurement before the first session as well as both receiving an intervention at the first visit, thereby allowing for similar effects to be noted at Level 1 versus Level 2 readings.

At time three it can be seen that the treatment effect seems to have been greater in the treatment group as opposed to the control group (See Figure 9). This along with the intervention that only the treatment group received seems to have been responsible for the immediate effect significance (p=0.019) found at this treatment time.

The suggestion here is that there seems to be a cumulative effect in terms of the interventions (manipulation), making the immediate responses more marked with time. This suggestion supports the work of Patterson and Steinmetz (1986) and Leach (1994), where they indicate that the presence of a neural scar requires several interventions in order to remove pathological neurological patterns associated with the syndrome that is present and that increased interventions allow for increased normalcy of firing patterns. This would therefore allow for the immediate effect to be greater after the 3rd intervention.

4.6.1.3.1.2 Short term effects:

The overall effect of the intervention in the treatment group indicates that several inventions are more beneficial than a single intervention, whereby the total time * group interaction is significant (p = 0.001).

Furthermore the effect of the intervention also could have been as a result of the restoration of mechanical restrictions (Gatterman, 1990 and Bergman, 1993), whereby the increased movement within the restricted joints would have allowed for normal movement and the stimulation of mechanoreceptors within the now mobile joint. This increased stimulation of the mechanoreceptors would have lead to an improvement in pain levels, which is attributed to Melzack and Wall's 'Gate Control Theory' (1965). Input from the small nerve fibers (nociceptors) is blocked at the substantia gelatinosa (SG) by sensory input from the large nerve fibers (Melzack and Wall, 1965:971). Therefore, increasing large fibre inputs through interventions such as manipulation can result in a decrease in pain. As mentioned in Chapter two, manipulation also seems to be able to elicit reflexes which have the potential to reduce hypertonicity (spasm) in the surrounding muscles (Korr, 1975 as cited in Leach, 1994: 99 and Kirkaldy-Willis and Burton, 1992: 250). This reduction of muscle hypertonicity is supported by (Suter et al 2000), who described arthrogenic muscle inhibition (AMI) as the inability of a muscle to recruit all motor units of a muscle group to their full extent during a maximal effort voluntary muscle contraction (Hopkins 2000). Spinal manipulative therapy on a joint has been proposed to activate mechanoreceptors from structures in and around the manipulated joint, with the stimulation of these receptors causing an altered afferent input which is thought to cause changes in the motor neuron excitability, with a subsequent decrease in AMI (Suter et al 2000 and William 1997). Taking this into account it can be concluded that spinal manipulative therapy has an effect on pain (in congruence with the previously reported NRS scores seen under 4.6.1.1), muscle hypertonicity and muscle weakness which may explain its effect on the club head velocity of golfers with mechanical low back pain. This however will only be addressed in results presented later in this chapter.

4.6.1.4 Club head velocity

Table 13: Within and between subjects effects for CHV

Effect	Statistic	p value
Time	Wilk's lambda=0.571	<0.001
Group	F=0.115	0.736
Time*group	Wilk's lambda=0.447	<0.001

This table shows that there is a significant (<0.001) effect for the time * group interaction which refers to a treatment effect for the treatment group over the control group. This is further demonstrated in the figure below (10), where a marked difference is noted at time 5 or the last reading that was taken.

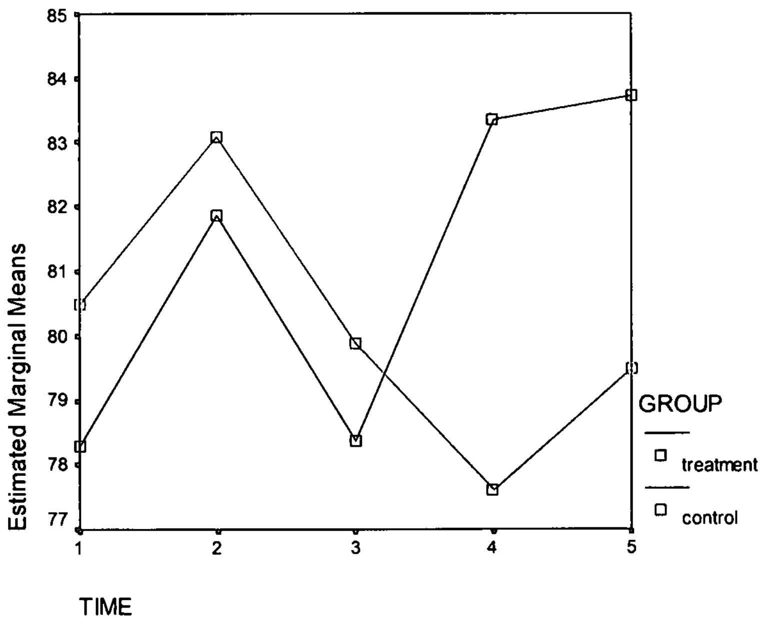

Figure 10: Profile plot of mean CHV measurement by group over time

4.6.1.4.1 Immediate versus short term effects on CHV

Table 14a: Within-subject repeated contrasts for time by group interaction for CHV measurements

Source	TIME	Type III Sum of Squares	df	Mean Square	F	Sig.
TIME * GROUP	Level 1 vs. Level 2	7.008	1	7.008	.472	0.496
	Level 2 vs. Level 3	.675	1	.675	.035	0.853
	Level 3 vs. Level 4	399.675	1	399.675	33.594	<0.001
	Level 4 vs. Level 5	17.633	1	17.633	1.279	0.265

Table 14b: Descriptive statistics for CHV at each time point by group

GROUP		CHV PRE Level 1	CHV POST Level 2	CHV PRE Level 3	CHV POST Level 4	CHV Level 5
treatment	Mean	78.30	81.87	78.37	83.37	83.73
	N	30	30	30	30	30
	Std. Deviation	8.832	8.295	8.604	8.869	8.246
control	Mean	80.50	83.10	79.90	77.60	79.50
	N	10	10	10	10	10
	Std. Deviation	9.265	7.738	9.219	8.369	8.580
Total	Mean	78.85	82.18	78.75	81.93	82.68
	N	40	40	40	40	40
	Std. Deviation	8.874	8.079	8.667	9.003	8.426

Table 14c: Descriptive statistics for change in CHV at each time point by group

GROUP		change in CHV Level 1 vs Level 2	change in CHV Level 2 vs Level 3	change in CHV Level 3 vs Level 4	change in CHV Level 4 vs Level 5
treatment	Mean	3.5667	-3.50	5.0000	.3667
	N	30	30	30	30
	Std. Deviation	4.10788	4.125	3.48395	3.61494
control	Mean	2.6000	-3.20	-2.3000	1.9000
	N	10	10	10	10
	Std. Deviation	2.87518	5.203	3.33500	4.01248
Total	Mean	3.3250	-3.43	3.1750	.7500
	N	40	40	40	40
	Std. Deviation	3.82561	4.349	4.67337	3.72621

4.6.1.4.1.1 Immediate effects:

These results are congruent with the algometer findings where the most significant changes caused by spinal manipulative therapy are found between time 3 and 4 (Pre and post for the second session). Therefore the same suggestions as to the mechanisms involved would be applicable here. These can be referred to under section 4.6.1.3.1.1.

In addition to previously suggested mechanisms, the greater change in both readings on visit three may be due to the short term effects of manipulation. At visit one the manipulation may only be affecting neurological mechanisms within the joint, however by visit three (time 3) the patients in the treatment group are receiving their third treatment and the physiological effects (e.g. resolution of inflammation, muscle spasm) of manipulation may be taking effect as well as the cumulative effect of having three treatments.

This seems to indicate a definite relationship between algometer (which records pain sensitivity) and CHV, indicating that the decrease in pain may increase CHV for a number of reasons:

1. The player is less tentative.
2. The player feels more confident.
3. The player is more relaxed so his timing may improve.
4. The player is able to finish a full follow through.

With respect to the changes in the CHV, there are two points at which the immediate effect was measured with respect to the intervention. This was between time periods 1 and 2 (session 1) and then again between time periods 3 and 4 (session 2). According to Table 13c the interaction relative to immediate improvement was only significant between time 3 and 4 (pre to post for the second session). Thus this is where the greatest immediate effect lies.
The mean change in CHV at session 1 was an increase of 3,5667 mph for the treatment group and an increase of 2,6 mph for the control group. Both groups received manipulation at this session. At session two the treatment group had an *increase* in CHV of 5 mph while the control group had a *decrease* in CHV of 2,3 mph. The control group did not receive manipulation at this session and it could therefore be assumed that the significant difference in CHV between the two groups is due to the intervention used (i.e. spinal manipulative therapy) over time.

4.6.1.4.1.2 Short term effects:

Table 14 shows that there was a significant time*group effect ($p<0.001$). Figure 10 shows that both groups showed an increase in parallel between pre and post treatment of session 1 (time 1 and 2). However, they both decreased in parallel between treatments at time 2 to 3. The real difference between the groups is shown between pre and post treatment of the second session (time 3 and 4). However, overall there was a significant short term benefit of treatment which correlates with the previous argument that spinal manipulative therapy has a cumulative effect (Patterson and Steinmetz, 1986 and Leach, 1994). This therefore indicates that a course of spinal manipulative therapy is conclusively better than a single manipulation relative to short term effect on CHV.

4.6.1.5 Distance

Table 15: Within and between subjects effects for distance

Effect	Statistic	p value
Time	Wilk's lambda=0.515	<0.001
Group	F=0.216	0.664
Time*group	Wilk's lambda=0.395	<0.001

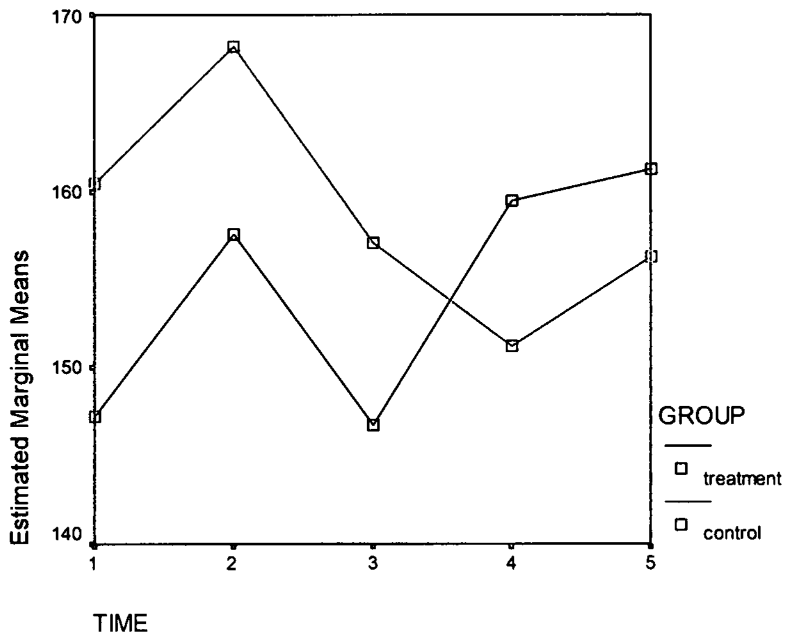

Figure 11: Profile plot of mean distance by group over time

4.6.1.5.1 Immediate and short term effects

Table 16a: Within-subject repeated contrasts for time by group interaction for distance measurements

Source	TIME	Type III Sum of Squares	df	Mean Square	F	Sig.
TIME * GROUP	Level 1 vs. Level 2	48.133	1	48.133	.297	.589
	Level 2 vs. Level 3	.675	1	.675	.004	.953
	Level 3 vs. Level 4	2613.333	1	2613.333	53.556	.000
	Level 4 vs. Level 5	85.008	1	85.008	.481	.492

Table 16b: Descriptive statistics for distance at each time point by group

GROUP		DISTANCE PRE 1 Level 1	DISTANCE POST 1 Level 2	DISTANCE PRE 2 Level 3	DISTANCE POST 2 Level 4	DISTANCE PRE 3 Level 5
treatment	Mean	147.30	157.53	146.73	159.50	161.23
	N	30	30	30	30	30
	Std. Deviation	30.539	27.215	26.594	26.886	26.261
control	Mean	160.50	168.20	157.10	151.20	156.30
	N	10	10	10	10	10
	Std. Deviation	24.291	18.444	22.378	22.939	20.293
Total	Mean	150.60	160.20	149.33	157.42	160.00
	N	40	40	40	40	40
	Std. Deviation	29.380	25.517	25.732	25.927	24.749

Table 16c: Descriptive statistics for change in distance at each time point by group

GROUP		change in distance (Level 1 Vs Level 2)	change in distance (Level 2 Vs Level 3)	change in distance (Level 3 Vs Level 4)	change in distance (Level 4 Vs Level 5)
treatment	Mean	10.233	-10.800	12.767	1.733
	N	30	30	30	30
	Std. Deviation	13.8357	13.7775	6.8112	13.9332
control	Mean	7.700	-11.100	-5.900	5.100
	N	10	10	10	10
	Std. Deviation	8.2064	13.4862	7.5196	10.9995
Total	Mean	9.600	-10.875	8.100	2.575
	N	40	40	40	40
	Std. Deviation	12.6142	13.5328	10.7030	13.2082

4.6.1.5.1.1 Immediate effects:

At session one the treatment group had an increase in distance of 10,233 yds while the control group had an increase in distance of 7,7 yds. At session 2 the distance recorded for the treatment group increased by 12,767 yds while the control group had a decrease in distance of 5,9 yds. This follows the same trend as CHV (as discussed earlier (4.6.1.4)) and which is expected due to the relationship between CHV and distance which will be discussed later (4.9).

Table 16a shows that the immediate treatment effect of the second manipulation (time 3 to time 4) was highly significant ($p<0.001$), while that for the first manipulation ($p=0.589$) was not significant. Again this may be related to the fact that the initial visit encompassed a manipulative intervention for both groups. Therefore similar trends and conclusions are drawn between the CHV and distance for immediate changes.

4.6.1.5.1.2 Short term effects:

There was a significant overall time by group interaction ($p<0.001$). Figure 16c shows that from time 1 to 3 the groups behaved similarly but from time 3 to 5 the treatment group increased in mean distance while the control group decreased and then showed a slight increase. Thus overall there was a significant short term effect towards a benefit in the treatment group, which reflects the previous trends reflected under the CHV discussion.

4.7 Binary outcomes

4.7.1 Kemp's

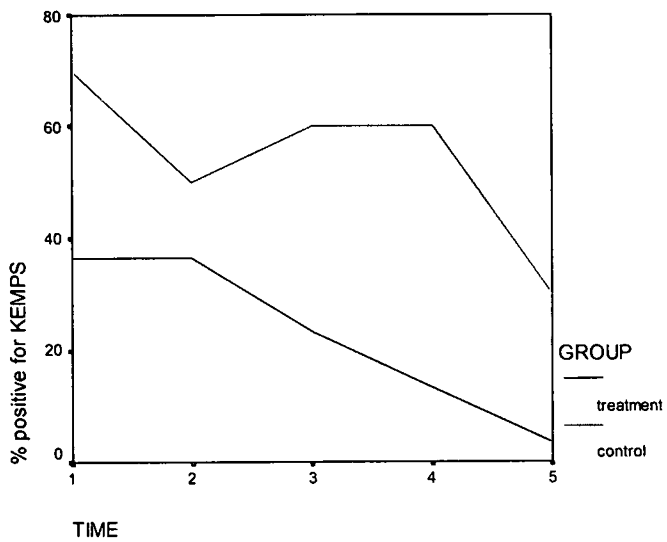

Figure 12: Percentage positive for Kemp's tests by group over time

4.7.1.1 Immediate effects:

Table 17: McNemar's chi square test results for the comparison of immediate effects in treatment and controls by session for Kemp's tests

Session	Group	McNemar's p value
1	Treatment	1.00
	Control	0.50
2	Treatment	0.25
	Control	1.00

Pre and post tests were compared at session one (time 1 vs. time 2) and session two (time 3 vs. time 4) by McNemar's chi square tests. A significant test indicated a significant change from pre to post. Table 17 shows that there were no significant immediate changes either in session 1 or session 2, either in the treatment group or in the control group. However it is noted that the greatest treatment effect was seen at visit two, where the treatment group showed the greatest improvement. This is in line with the changes that were seen prior to this in terms of the CHV (4.6.1.4.1.1) and distance (4.6.1.5.1.1), implying that the treatment effect has some relationship with the changes in Kemp's test readings.

What is of interest here is that the Kemp's test position is very similar to that of the reverse C position found at the end of the golf swing (at follow through). This close correlation may be the reason for the clinical correlation between these outcomes is evident from the trends of improvement.

4.7.1.2 Short term effects:

Figure 12 shows that the percentage of patients who were positive for Kemp's test decreased over time in both groups, but the rate and extent of decrease was higher in the treated group compared to the control. In the case of the patients diagnosed with sacro-iliac syndrome this may be due to the restoration of normal movement caused by the manipulation (Bergman, 1993) which may decrease the burden placed on the lumbar facet joints allowing the inflammation to resolve, as it restores that normal mechanical relationship between the sacro-iliac joints and the lumbar spine (Gatterman 1990). This further supports the assertions made for the immediate effect in changes with respect to the Kemp's test.

Table 18 shows that the interaction between time and group was not significant (p=0.373). Thus the rate of decrease in positivity for Kemp's test was not significantly different in treated or control subjects. There was however a significant time effect (p=0.023), meaning that regardless of group to which the participant belonged, there was a significant decrease in positivity over time.

This concurs with the previous discussions, but further implies that the effect is not necessarily a direct treatment effect, but one of altered mechanics in the region, which takes time to resolve but is an independent process with respect of treatment.

Table 18: Effect parameters for GEE model for Kemp's test

Effect	Odds ratio	95% CI	p value
Group	1.084	0.083 – 14.181	0.951
Time	0.303	0.108 – 0.848	0.023
Time*group	1.35	0.697 – 2.614	0.373

4.7.2 Facet challenge

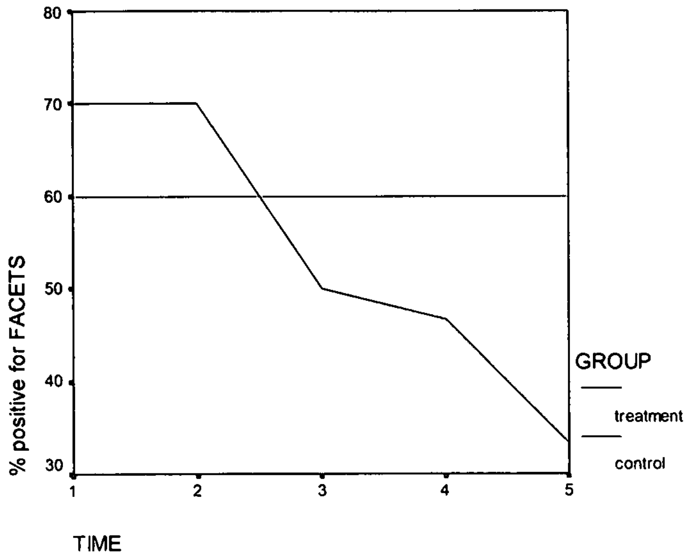

Figure 13: Percentage positive for Facet challenge tests by group over time

4.7.2.1 Immediate effects:

Table 19: McNemar's chi square test results for the comparison of immediate effects in treatment and controls by session for facet challenge tests

Session	Group	McNemar's p value
1	Treatment	1.00
	Control	1.00
2	Treatment	1.00
	Control	1.00

Table 19 shows that there was no change between pre and post at session 1 or 2 in both treatment and control group. In fact only one subject in the treatment group changed from being positive to negative in the second session. Thus there were no significant immediate effects in either of the treatment or control groups or either of the sessions. The positive test for facet challenge could be as a result of the sensitivity of the tissues (due to the concurrent hypermobility in the lumbar spine). Thus in this case a change in the test would not be expected immediately, as the restoration of the normal mechanical relationship as well as the resolution of inflammatory responses present in the joint would need time to resolve (literature indicates that this should be between 72 hours and 5 days (Vizniak and Carnes, 2004)). This would be congruent with the resolution of positive tests after day 1 and / treatment 1 in the study with a progressive decrease thereafter, as shown in Figure 13.

4.7.2.2. Short term effects:

Figure 13 shows that the treatment group showed a steep rate of decrease in percentage positive over time, while the control group remained constant over time. Table 20 shows that there was a significant time*group interaction for facet challenge, (p=0.003). Thus the short term effect was significantly beneficial for the treatment group compared to the control group. This may be due to the same process explained for Kemps test (4.7.1.2), whereby manipulation restores the normal movement in the sacro-iliac joint (Bergman, 1993) which decreases the strain on the lumbar facet joints and allows the resolution of the inflammation affecting the lumbar spine facets over a period of time (Vizniak and Carnes, 2004).

<u>Table 20: Effect parameters for GEE model for Facet challenge test</u>

Effect	Odds ratio	95% CI	p value
Group	0.145	0.035 – 0.598	0.008
Time	0.395	0.212 – 0.736	0.003
Time*group	1.591	1.166 – 2.172	0.003

4.7.3 SI Percussion

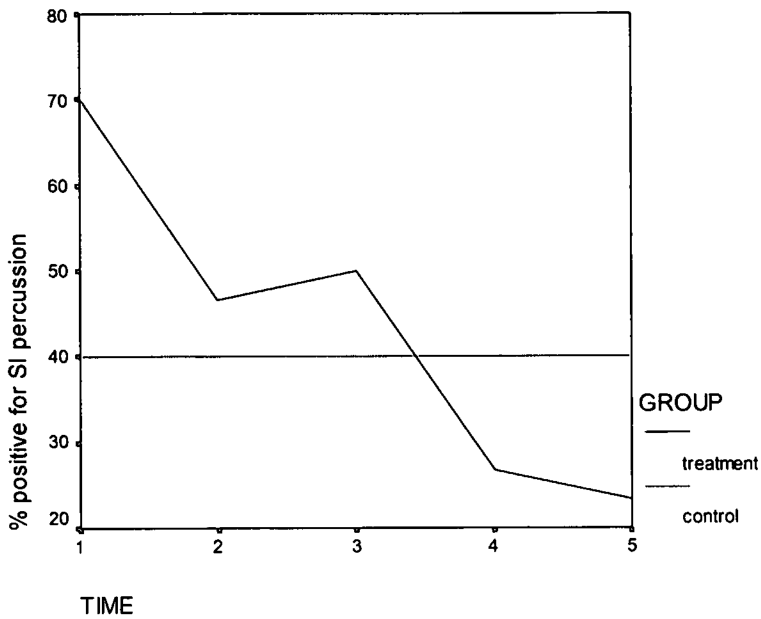

Figure 14: Percentage positive for SI Percussion tests by group over time

4.7.3.1 Immediate effects:

Table 21: McNemar's chi square test results for the comparison of immediate effects in treatment and controls by session for SI Percussion tests

Session	Group	McNemar's p value
1	Treatment	0.016
	Control	1.000
2	Treatment	0.016
	Control	1.000

Table 21 shows that the treatment group showed a significant change between pre and post manipulation in both session 1 and session 2 (p=0.016). The control group showed no change. Thus there were significant immediate benefits to the treatment group in terms of the SI challenge test. The immediate benefit was identical in the first and second sessions (as both groups received an intervention).

The effect that manipulation has on pain, as discussed earlier, may be due to the restoration of mechanical restrictions (Gatterman, 1990 and Bergman, 1993) which stimulates the mechanoreceptors within the joint. These large fibre inputs as described by Melzack and Wall (1965), block input from the small nerve fibres at the substantia gelatinosa reducing pain, thereby allowing a restoration of movement. This would also account for the immediacy of the changes.

4.7.3.2 Short term effects:

Figure 14 shows that there was a decrease in the percentage of positive subjects in the treatment group over time but no change in the control group. There was a significant time*group interaction for SI percussion test, meaning that there was a significantly beneficial short term effect for the treatment group relative to the control group. This further supports the theory that the improvement of participants with respect to these tests is reliant on an immediate short term mechanism, which could easily be related to immediate (or simultaneous) neurological changes at those times when treatment is affected.

Table 22: Effect parameters for GEE model for SI Percussion test

Effect	Odds ratio	95% CI	p value
Group	0.994	0.112 – 8.836	0.996
Time	0.200	0.106 – 0.377	<0.001
Time*group	2.234	1.628 – 3.063	<0.001

4.7.4 Yeoman's test

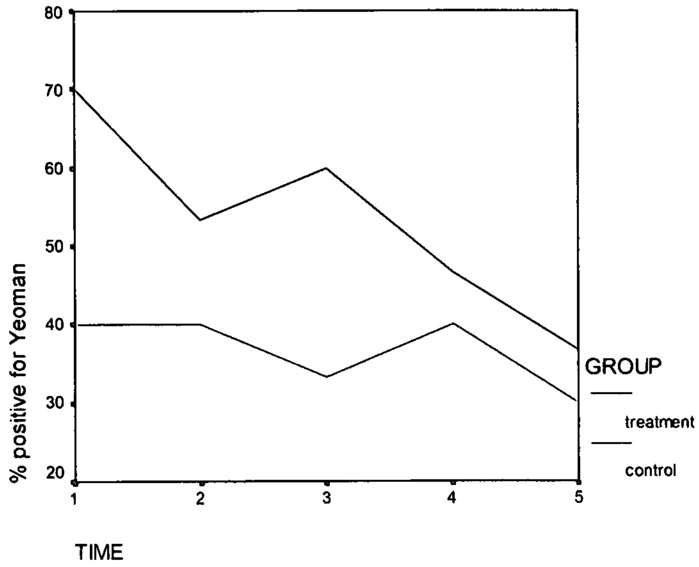

Figure 15: Percentage positive for Yeoman's tests by group over time

4.7.4.1 Immediate effect:

Table 23: McNemar's chi square test results for the comparison of immediate effects in treatment and controls by session for Yeoman's tests

Session	Group	McNemar's p value
1	Treatment	0.063
	Control	1.000
2	Treatment	0.125
	Control	1.000

Table 23 shows that there was a marginally significant change from pre to post manipulation in the first session in the treatment group (p=0.063). There was no change in the control group (p=1.000). In the second session the change in the treatment group was not significant (p=0.125). Thus there was a slight immediate effect in the first session in the treatment group for the Yeoman's tests.

This result supports the suggested neurological changes effected and measured through the SI challenge tests, but does not stay congruent with this, as the second session does not reflect the same p-value change. This may well be as a result of the SI joints being more tender as movement load increases with time (as motion is restored), with discomfort or pain being reported at the extremes of motion (as Yeoman's would elicit) (Magee, 1997). This would then also differentiate the response from that of SI challenge.

4.7.4.2. **Short term effects:**

There was a marginally significant time * group interaction for Yeoman's test in Table 24 (p=0.052). The profile plot in Figure 15 shows that the treatment group decreased in percent positivity over time to a greater extent than the control group, but this difference was not marked. Thus the short term effect of the treatment for the Yeoman's test was marginally significantly beneficial (p=0.052)

What must be considered at this point is that although Yeoman's is a specific and sensitive test (Riggien 2003) the hyperextension of the leg may indirectly cause extension of the lumbar spine causing pain originating from the lumbar facets. This could result in false positive tests where patients report that pain is aggravated; however indicate incorrect pain position or isolation to the joints in the low back. In order to minimize this, the researcher ensured as best as possible to localize the pain produced. However being patient reliant, one can only assume that the area of reported pain was accurately indicated by patients.

Table 24: Effect parameters for GEE model for Yeoman's test

Effect	Odds ratio	95% CI	p value
Group	0.280	0.601 – 1.299	0.104
Time	0.626	0.439 – 0.893	0.010
Time*group	1.224	0.998 – 1.500	0.052

4.8 Correlations between factors and changes in outcome values

4.8.1 In all participants from the treated group

Table 25: Spearman's correlation analysis within treated group (n=30)

		AGE	HANDCAP	delta CHV	delta distance	delta algometer	delta NRS	Delta RMQ
AGE	Correlation Coefficient	1.000	-.245	.214	-.081	.202	.197	-.127
	Sig. (2-tailed)	.	.191	.257	.669	.285	.298	.503
HANDCAP	Correlation Coefficient	-.245	1.000	.052	.211	-.286	-.086	-.168
	Sig. (2-tailed)	.191	.	.783	.264	.125	.651	.376
delta CHV	Correlation Coefficient	.214	.052	1.000	.736(**)	-.117	.246	-.052
	Sig. (2-tailed)	.257	.783	.	.000	.539	.190	.785
Delta distance	Correlation Coefficient	-.081	.211	.736(**)	1.000	-.233	.025	-.139
	Sig. (2-tailed)	.669	.264	.000	.	.216	.895	.464
Delta algometer	Correlation Coefficient	.202	-.286	-.117	-.233	1.000	-.367(*)	-.404(*)
	Sig. (2-tailed)	.285	.125	.539	.216	.	.046	.027
delta NRS	Correlation Coefficient	.197	-.086	.246	.025	-.367(*)	1.000	.467(**)
	Sig. (2-tailed)	.298	.651	.190	.895	.046	.	.009

Delta RMQ	Correlation Coefficient	-.127	-.168	-.052	-.139	-.404(*)	.467(**)	1.000
	Sig. (2-tailed)	.503	.376	.785	.464	.027	.009	.

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

* Correlation is significant at the 0.05 level (2-tailed).

Table 25 shows the correlations between variables.

Age and handicap were not significantly correlated with any outcome variables. However it is noted that there were negative relationships between:

- Age and handicap
- Age and delta distance and
- Age and delta RMQ
- As well as
- Handicap and delta algometer
- Handicap and delta NRS
- Handicap and delta RMQ.

Age implies that with increased age the ability of the golfer increases and there is thus an association with a decreased (improved) handicap, yet there seems to be a decrease in the distance achieved by the golfer. Furthermore the golfer seems less able to respond in terms of pain and discomfort with respect to measured daily changes as noted in the RMQ. The latter could be related to the fact that the older the golfer, the longer it takes for inflammation resolution, tissue repair and return to former physical ability (if at all).

Handicap implies that the poorer the golfer is (in terms of a higher handicap), then less response was noted in terms of the changes in algometer, NRS and RMQ.

Delta CHV was significantly positively correlated with delta distance (rho = 0.736, p<0.001). Thus as CHV increased, so did distance which complies with the literature norm of a ratio of 1:3 (Stude and Gullickson 2000). In addition with increased CHV, there is a decrease in the delta algometer. According to the proposals put forward in this research, it stands to reason that with constant exposure of the multifidus to external oblique muscle contraction, the multifidus is loaded by both the antagonist function as well as the lumbar stabilization function that it has in the low back. Overloading the multifidus results in aberrant joint movement (due to its inability to stabilize) and thus joint restriction. With the removal of joint restrictions through manipulation (as in this study), the load is inadvertently placed on the multifidus again, thereby not allowing for the algometer readings to change with time, but allowing the golfer a greater range of motion and therefore external oblique contractility giving them increased delta CHV. This would therefore also be applicable to the RMQ findings in these correlations.

As the CHV is related to distance (1:3) (Stude and Gullickson 2000), the same argument is proposed for delta distance related to delta algometer and delta RMQ.

Delta algometer and delta NRS were significantly negatively correlated (rho = -0.367, p = 0.046) and delta algometer was also significantly negatively correlated with delta RMQ (rho = -0.404, p = 0.027). On the assumption that the pain structures are either muscular or joint related, it would stand to reason that if the joint pain decreased the muscle pain could increase (relationship of the multifidus to the joint function). As the patient perceives only overt pain and records this, increased movement may result in decreased pain (Melzack and Wall, 1965), but may not be associated with decreased muscular tenderness (as in the overloaded multifidus).

Delta NRS and delta RMQ were significantly positively correlated (rho = 0.467, p = 0.009). Thus as NRS decreased, so did RMQ scores indicating that a decrease in pain resulted in a decrease in disability or increased functional ability. This supports the assumptions made above where functional ability (joint range of motion) increases, but tenderness remains.

4.8.2 Subgroup analysis

4.8.2.1 T12 and SI fixations

Because T12 and SI fixations were the most common and provided adequate sample size, subgroup analysis was done on participants who were in the treated group and had T12 or SI fixations.

4.8.2.1.1 T12 fixations

Table 26 shows correlation analysis for subjects with T12 fixations within the treated group. Handicap or age did not affect any outcome measurement. Delta CHV and delta distance were highly positively correlated (rho = 0.853, p = 0.001). This means that as CHV scores increased, so did distance values. There were no other significant correlations within this subgroup.

Table 26: Spearman's correlation analysis of subjects with T12 fixations within treated group (n=11).

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

		AGE	HANDCAP	delta CHV	delta distance	delta algometer	delta NRS	delta RMQ
AGE	Correlation Coefficient	1.000	-.316	.081	-.149	.374	-.252	-.318
	Sig. (2-tailed)	.	.344	.813	.662	.257	.454	.341
HANDCAP	Correlation Coefficient	-.316	1.000	.192	.273	-.109	-.025	-.362
	Sig. (2-tailed)	.344	.	.571	.417	.749	.941	.274
delta CHV	Correlation Coefficient	.081	.192	1.000	.853(**)	-.390	.214	.089
	Sig. (2-tailed)	.813	.571	.	.001	.235	.528	.796
delta distance	Correlation Coefficient	-.149	.273	.853(**)	1.000	-.303	-.078	-.102
	Sig. (2-tailed)	.662	.417	.001	.	.365	.819	.766
delta algometer	Correlation Coefficient	.374	-.109	-.390	-.303	1.000	-.397	-.316
	Sig. (2-tailed)	.257	.749	.235	.365	.	.226	.344
delta NRS	Correlation Coefficient	-.252	-.025	.214	-.078	-.397	1.000	.503
	Sig. (2-tailed)	.454	.941	.528	.819	.226	.	.114
delta RMQ	Correlation Coefficient	-.318	-.362	.089	-.102	-.316	.503	1.000
	Sig. (2-tailed)	.341	.274	.796	.766	.344	.114	.

The findings as for table 25 stand with respect to table 26, with the exception of:

- Increased in age = decrease in delta NRS. This implies that with increased age there is a decrease in the amount of change over time with respect to the NRS.

- An increased in delta distance = decreased delta NRS, as a result of the fact that greater force through the low back (loading the facet joints) is required to generate a further distance, thereby reducing the ability of the golfer to improve clinically (i.e. pain).

4.8.2.1.2 Sacro-iliac joint fixations

Table 27 shows the correlations within the treated group for participants with SI fixations (n=24). There was still a moderate positive correlation between delta CHV and delta distance (rho = 0.673, p<0.001). Delta algometer and delta RMQ were negatively correlated (rho = -0.467, p =0.022), and delta RMQ and delta NRS were significantly positively correlated (rho = 0.637, p=0.001). Thus as algometer measurement increased, RMQ scores decreased. As RMQ scores decreased, NRS scores also decreased in this group.

Table 27: Spearman's correlation analysis of subjects with SI fixations within treated group (n=24)

		AGE	HANDCAP	delta CHV	delta distance	delta algometer	delta NRS	delta RMQ
AGE	Correlation Coefficient	1.000	-.332	-.092	-.324	.229	.138	-.014
	Sig. (2-tailed)	.	.113	.668	.123	.282	.520	.950
HANDCAP	Correlation Coefficient	-.332	1.000	.098	.173	-.230	-.079	-.168
	Sig. (2-tailed)	.113	.	.648	.418	.279	.715	.433
delta CHV	Correlation Coefficient	-.092	.098	1.000	.673(**)	-.209	.302	.095
	Sig. (2-tailed)	.668	.648	.	.000	.327	.151	.658
delta distance	Correlation Coefficient	-.324	.173	.673(**)	1.000	-.244	-.027	-.038
	Sig. (2-tailed)	.123	.418	.000	.	.251	.899	.860
delta algometer	Correlation Coefficient	.229	-.230	-.209	-.244	1.000	-.317	-.467(*)
	Sig. (2-tailed)	.282	.279	.327	.251	.	.132	.022
delta NRS	Correlation Coefficient	.138	-.079	.302	-.027	-.317	1.000	.637(**)
	Sig. (2-tailed)	.520	.715	.151	.899	.132	.	.001
delta RMQ	Correlation Coefficient	-.014	-.168	.095	-.038	-.467(*)	.637(**)	1.000
	Sig. (2-tailed)	.950	.433	.658	.860	.022	.001	.

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

* Correlation is significant at the 0.05 level (2-tailed).

The findings as for table 25 stand with respect to table 27, with the exception of:

- Increased age = decreased delta CHV. It is interesting to note that only with respect to the SI joint we find that the CHV changes with time are decreased, especially when considering age. The implication being that the SI joint is an important aspect of the ability of the golfer to generate CHV and therefore possibly also distance.

- Increased delta distance = decreased delta NRS, as a result of the fact that greater force energy transfer through the low back (thoracolumbar fascia) is required to generate a further distance, thereby reducing the ability of the golfer to improve clinically (i.e. pain).

4.9 Delta CHV and delta distance relationship as pertains to this study.

Table 28: One sample t-test for the comparison of mean ratio between delta CHV and delta distance with a hypothesized value of 0.33.

N	Mean	Std. Deviation	Std. Error Mean	P value
40	.4081	1.48664	.23506	0.751

Stude and Gullickson (2000) state that there was an approximate 1:3 relationship between change in CHV and change in distance. This suggests that for every 1-mph increase in CHV there is a subsequent 3-yd increase in air travel distance (Stude and Gullickson 2000). The ratio between change in CHV and change in distance can therefore be quantified as 0.333.

The mean ratio in the sample was found to be 0.408 (SD 1.49, range -6.00 to 4.00).This was tested with a one sample t-test for whether it was significantly different to the hypothesized value of 0.333. The result was that it was not significantly different (p=0.751). The 95% confidence interval for the sample mean was from -0.4003 to 0.5506. Thus the population value of 0.33 was within the range of the 95% CI for the sample (as shown in Table 27), which is congruent with the study of Stude and Gullickson (2000).

4.10 Anecdotal Data capture

The participants were encouraged to comment on any changes to their pain or to there golf swing post manipulation. No specific questions were asked but the most common comments recorded were:

1.	Golf swing felt easier	58%
2.	Low back felt looser	50%
3.	Felt less pain after swinging	38%
4.	Backswing felt less restricted	22%
5.	Follow through position felt more comfortable	19%
6.	Felt no change in the golf swing	8%
7.	Golf swing felt more uncomfortable	8%

4.11 Summary and conclusion

The treatment and control groups were comparable in every aspect at baseline, (i.e. there were no significant differences between the groups in any of the possible confounders or baseline outcomes measurements). Thus any differences post treatment and follow up were due to the intervention applied.

There was a significantly beneficial short term treatment effect (in favour of the treatment group over the control) for the following outcomes: NRS, RMQ, algometer, CHV, distance, facet challenge test, and SI percussion test. The Yeoman's test was marginally significant, and the Kemp's test was not significant but showed a trend towards a more beneficial reaction in the treatment group than the control group.

Immediate effects were found only in the second session (time 3 vs. time 4) for algometer, CHV and distance. In addition SI percussion tests showed a significant immediate effect in both the first and second sessions in the treatment group.

Furthermore there was a significant correlation between change in CHV measurements and change in distance measurements which depended to a certain extent on the type of fixation present. Subjects with SI fixations tended to show a stronger relationship between these two outcomes than subjects with T12 fixations. Within the treatment group as a whole, an increase in algometer measurements was correlated with a decrease in NRS and RMQ; however this relationship was not seen within the subgroup with T12 fixations, only in the subgroup with SI fixations.

In congruence with the literature, the mean ratio of delta CHV to delta distance was not significantly different to the hypothesized value of 0.33.

Therefore with respect to the hypotheses at the outset:

Hypothesis one

The first hypothesis indicated spinal manipulative therapy would decrease the subjective clinical findings[1] and increase or decrease the objective clinical findings[2] as appropriate in the immediate improvement of the clinical syndrome of mechanical low back pain.

This is accepted in terms of CHV where there was an immediate significant effect at both sessions with the most marked effect seen at session 2.

This is also accepted with respect to SI percussion which showed an immediate effect at session 1 and session 2.

[1] Subjective clinical findings include: NRS; RMQ

[2] Objective clinical findings include: Non digital algometer; Orthopaedic tests;CHV

It is accepted with reservation with respect to Yeoman's test which showed a slight immediate effect in the first session in the treatment group while showing no immediate effect in the second session, and the non digital algometer which showed no significant effect at the first session but a marked immediate effect in the second session.

The above hypothesis is rejected with respect to Kemps and Facet challenge which showed no immediate effect at either session one or session two.

Comments on NRS and RMQ are reserved as these were not utilized in order to determine immediate improvement.

Hypothesis two

The second hypothesis indicated spinal manipulative therapy would decrease the subjective clinical findings and increase or decrease the objective clinical findings as appropriate in the short term improvement of the clinical syndrome of mechanical low back pain.

This is accepted with respect to CHV, non digital algometer, Kemps test, Facet challenge, Yeoman's and SI percussion which significantly improved over the short term period when compared to the control group. The above hypothesis is also accepted in terms of NRS and RMQ which also showed a significant beneficial effect over the short term when compared to the control group.

Hypothesis three

The third hypothesis indicated spinal manipulative therapy would result in better subjective and objective clinical findings in the short term as opposed to the immediate term, as appropriate in terms of improvement of the clinical syndrome associated with mechanical low back pain.

This is accepted in terms of all objective and subjective findings as short term effects showed a greater improvement when compared to the immediate effects.

CHAPTER FIVE

5.0 Conclusions and Recommendations

5.1) Introduction

In summary, this study comprised of forty amateur golfers suffering from mechanical low back pain. The patients were randomly allocated into a treatment group of thirty and a control group of ten who underwent respective intervention protocols as delineated.

Visit	Group A	Visit	Group B	Venue
1	**CHV analysis and treatment**	1	**CHV analysis and treatment**	**The Pro shop**
2	***Treatment only***			***D.I.T***
3	**CHV analysis and treatment**	2	**CHV analysis**	**The Pro shop**
4	***Treatment only***			***D.I.T***
5	**CHV analysis**	3	**CHV analysis**	**The Pro shop**

Subjective and objective findings were recorded using the NRS, RMQ and NDA.
CHV was measured using The Flightscope Pro.

5.2) CONCLUSIONS

Patient diagnosis

Sacro-iliac syndrome was diagnosed in 62.5% of the patients while 37.5% of patients were diagnosed with lumbar facet syndrome. The most common areas of fixation were noted as at T12 and the Sacro-iliac joint.

Numerical pain rating scale (NRS)

NRS was evaluated at three time points, with no pre and post for each session, thus the short terms effects were evaluated. NRS values in the treatment group decreased while those in the control group remained constant. Thus there was a significant beneficial treatment effect for NRS.

Roland Morris Questionnaire score (RMQ)

RMQ score was also evaluated at three time points, with no pre and post manipulation recording for each session, thus the short terms effects were evaluated. The mean score for the treatment group decreased over time, while the control group remained almost constant. Therefore there was a significant beneficial treatment effect for RMQ score, with the multiple treatments being more effective than the single interventions.

Non Digital Algometer

Algometer measurements were taken at five time points (i.e. pre and post to each of the first two sessions and once at the last session). Thus immediate effects compare the pre and post at the first and third sessions. Short term effects examine the change over the five time points. There was no immediate effect between pre and post manipulation at the first session. The second session had a much more significant immediate effect. It can thus be concluded that there seems to be a cumulative effect in terms of the interventions, making the immediate responses more marked with time. The mean values for the treatment group increased at a faster rate than for the control group over the time points. Thus there was a significantly beneficial short term treatment effect for algometer measurements.

Club head velocity (CHV)

There was both an immediate and short term effect on CHV with the treatment group improving significantly more than the control group. As with the algometer the immediate effect was more pronounced in the second session.

Distance

Distance showed a relationship with CHV of 3:1. There was also an immediate and short term effect on distance with the treatment group improving significantly more than the control group. The immediate effect was also more pronounced at the second session.

Orthopedic Tests

Kemp's test showed no significant immediate changes in either session one or three for the treatment group and the control group. There was however a short term effect with the treatment group improving at a better rate and extent than the control group.

With the Facet Challenge Test there was no change between pre and post manipulation at session one or three in both treatment and control group, showing that there were no significant immediate effects on facet challenge. The treatment group showed a steep rate of decrease in percentage positive over time, while the control group remained constant over time which shows the treatment had a significant short term effect.

In respect of the SI Percussion Test, the treatment group showed a significant immediate effect in both sessions one and two. The control group showed no change. There was a decrease in the percentage of positive subjects in the treatment group over the short term but no change in the control group.

And lastly with the Yeoman's Test, there was a slight immediate effect in the first session in the treatment group while there was no change in the control group. Session 3 showed no immediate effect for both groups. The treatment group decreased in percentage positivity over time to a greater extent than the control group, but this difference was not marked. Thus the short term effect of the treatment for the Yeoman's test was marginally significantly beneficial.

In final conclusion

The researcher has found that spinal manipulative therapy has an immediate and short term effect on the club head velocity of amateur golfers suffering from mechanical low back pain and it can therefore be concluded that spinal manipulative therapy is a valuable and effective treatment option for golfers suffering from mechanical low back pain.

In addition the research results question the emphasis of the literature on the presentation of facet syndrome within the golfing population, as it seems apparent (at least from the results obtained in this research), that the involvement of the sacro-iliac joint would seem to play a greater role and possibly a predisposing role in the development of either lumbar instability and therefore facet syndromes. Alternatively, because of pelvic restriction in motion, an increased need for use of the lumbar spine to maintain motion becomes necessary predisposing the golfer to facet syndromes related to the degree of rotation required in order to facilitate an ideal golf swing. However as this research is currently the only one to suggest this presentation, it would be advised that future research look at developing a profile of joint restrictions within the golfing population in order to validate or refute the suggestions made on the basis of this research.

Therefore the hypotheses as follows where accepted:

Hypothesis one

The first hypothesis indicated spinal manipulative therapy would decrease the subjective clinical findings[1] and increase or decrease the objective clinical findings[2] as appropriate in the immediate improvement of the clinical syndrome of mechanical low back pain. With the exception of NRS, RMQ, Kemps and Facet joint challenge.

Hypothesis two

The second hypothesis indicated spinal manipulative therapy would decrease the subjective clinical findings and increase or decrease the objective clinical findings as appropriate in the short term improvement of the clinical syndrome of mechanical low back pain.

Hypothesis three

The third hypothesis indicated spinal manipulative therapy would result in better subjective and objective clinical findings in the short term as opposed to the immediate term, as appropriate in terms of improvement of the clinical syndrome associated with mechanical low back pain.

[1] Subjective clinical findings include: NRS; RMQ
[2] Objective clinical findings include: CHV;Non digital algometer; orthopaedic tests.

Notwithstanding the acceptance of the above hypotheses based on the results of this study there are several recommendations that also stem from this research.

5.3 Recommendations

Sample Size

The sample size was forty. A larger sample size, especially in the control group, would increase the validity of any study as the results generated would center more readily on a given trend(s) and improve / highlight significance levels more clearly.

Age

All the patients that took part in this study were under the age of 45. Future studies could include older patients to compare the results obtained in this study.

Handicap

The handicaps of the golfers in this study ranged from 0 to 24.

A study which included only elite or professional golfers would be valuable because their consistent swing patterns allow for a more accurate assessment of the effect of the intervention used i.e. spinal manipulative therapy.

RMQ

This questionnaire is not aimed specifically at golfers and it is highly recommended by the researcher that a specialized golf questionnaire is developed in a future research study. This would allow for a better understanding of the how the golfer's low back pain affects his game.

Non digital algometer

This instrument is a useful tool but it is very difficult to be certain that this device is placed at the exact same spot at each consultation.

Flight Scope Pro

The Flightscope Pro was used inside a retail golf shop during office hours. This meant that players were sometimes rushed by other customers or put under pressure by interested onlookers. Using this machine in an isolated area would be preferred.

Based on the above recommendations as well as the results of this study future studies could include:

- The role of the thoracic spine in the golf swing and the effect of thoracic pain treatment on CHV.
- Assessment of the lattisimus dorsi and the thoracolumbar fascia in golfers with low back pain.
- The effect of strengthening the core stabilizing muscles of the spine on CHV, objective and subjective low back pain.
- The role of the sacro-iliac joint and surrounding musculature in the mechanical low back pain experienced by golfers.
- The exact mechanism by which spinal manipulative therapy increases CHV.

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APPENDIX A: CASE HISTORY

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:

Intern's Case History:

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 B: PHYSICAL EXAMINATION

PHYSICAL EXAMINATION: SENIOR/RESEARCH

Patient Name :________________________ **File no :**___________ **Date :**
Interns Name : **Signature :**

<u>VITALS:</u>
Pulse rate:
Respiratory rate:
Blood pressure: R L
Temperature:
Height:
Weight: Recent change: Yes No

<u>GENERAL EXAMINATION:</u>

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

Urinalysis:

Clinicians Name: Signature :

<u>SYSTEM SPECIFIC EXAMINATION</u>

<u>CARDIOVASCULAR EXAMINATION:</u>

<u>RESPIRATORY EXAMINATION:</u>

<u>ABDOMINAL EXAMINATION:</u>

<u>NEUROLOGICAL EXAMINATION:</u>

<u>COMMENTS:</u>

Clinicians Name: Signature :

APPENDIX C: LOW BACK PAIN REGIONAL

REGIONAL EXAMINATION - LUMBAR SPINE AND PELVIS

Patient:______________________________ File#:______Date:_________

Intern\Resident:___________________________ Clinician:_________________

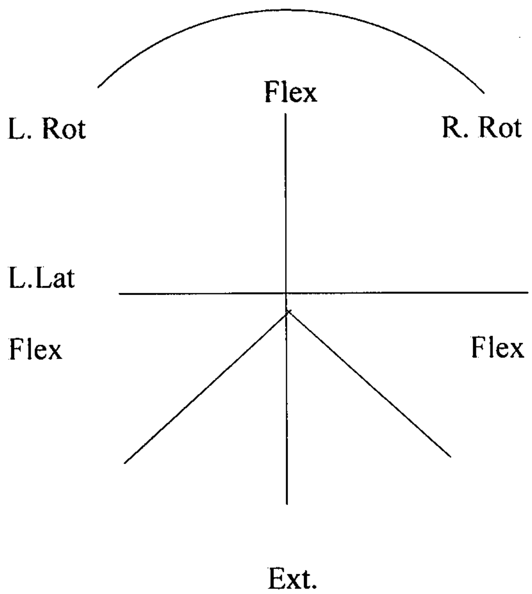
STANDING:

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 walk
Toe walk
Heel Walk
Half squat



ROM:

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

		Degree	LBP?	Location	Leg pain	Buttock	Thigh	Calf	Heel	Foot	Braggard
TRIPOD SI, +, ++	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						
L1						
L2						
L3						
L4				Patellar		
L5				Med h\s		
S1				Achilles		
S2				Incont?		
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 D: DATA SHEET
(MECHANICAL LOW BACK PAIN RATING SCALE AND MOTION PALPATION)
(CHV and DISTANCE DATA)
(NON-DIGITAL ALGOMETER)

Name: File No.

	Pre intervention	Post intervention
Non – digital algometer		

Mechanical Low Back pain modified rating scale

	Pre intervention	Post intervention
Kemp's test (2)		
Facet joint challenge (1)		
Sacrioliac percussion test (1))		
Yeoman's test (2)		
Combined score		

Motion Palpation

Side					
Direction					

Swing Number	1	2	3	4	5	Average
CHV– Pre intervention						
Distance– Pre intervention						
CHV– Post intervention						
Distance– Post intervention						

APPENDIX E: ROLAND-MORRIS QUESTIONNAIRRE (RMQ)

LOW BACK PAIN AND DISABILITY QUESTIONNAIRE

NAME:__________________________ DATE:________ AGE:____ SCORE:_______

When your back hurts, you may find it difficult to do some of the things you normally do. Mark only the sentences that describe you today by circling the corresponding number:

1. I stay at home most of the time because of my back.
2. I change position frequently to try and get my back comfortable.
3. I walk more slowly than usual because of my back.
4. Because of my back, I am not doing any jobs that I usually do around the house.
5. Because of my back, I use a handrail to get up stairs.
6. Because of my back, I lie down to rest more often.
7. Because of my back, I have to hold onto something to get out of an easy chair.
8. Because of my back, I try to get other people to do things for me.
9. I get dressed more slowly than usual because of my back.
10. I stand up for only short periods of time because of my back.
11. Because of my back, I try not to bend or kneel down.
12. I find it difficult to get out of a chair because of my back.
13. My back is painful almost all the time.
14. I find it difficult to turn over in bed because of my back.
15. My appetite is not very good because of my back.
16. I have trouble putting on my socks (or stockings) because of pain in my back.
17. I walk only short distances because of my back.
18. I sleep less well because of my back.
19. Because of back pain, I get dressed with help from someone else.
20. I sit down for most of the day because of my back.
21. I avoid heavy jobs around the house because of my back.
22. Because of my back I am more irritable and bad tempered with people than usual.
23. Because of my back, I go up stairs more slowly than usual.
24. I stay in bed most of the time because of my back.

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 pain. 1983; 8:141-144.

The original 24 item Roland-Morris Questionnaire is displayed. The RM-18 deletes 2, 15, 17, 19, 20 and 24 without affecting it quality.

APPENDIX F: NUMERICAL PAIN RATING SCALE (NRS)

Numerical Rating Scale - 101 Questionnaire

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 G: ADVERTISEMENT

Do you suffer from

Low back pain

that is related to playing

GOLF

Are you aged between 25 and 35 years?

You may qualify for research being conducted at the Durban Institute of Technology

CHIROPRACTIC DAY CLINIC and THE PRO SHOP

FREE TREATMENT

is available during the study as well as free swing analysis at the pro shop

For more information contact:

Robby Delgado

031- 204 2205 or 031-204 2515

at the Chiropractic Day Clinic

APPENDIX H: LETTER OF INFORMATION

LETTER OF INFORMATION

Dear patient, welcome to this study.

Title of research project:
"The immediate and short term effects of Spinal Manipulative Therapy on Club Head Velocity in Amateur Golfers suffering from Mechanical Low Back Pain"

Name of supervisors: Dr. C. Korporaal [M.Tech:Chiropractic (SA), CCFC (SA), CCSP (USA), ICCSD (USA)] (031 – 2042611)
Name of research student: Robert Delgado (031 - 204 2205)
Name of institution: Durban Institute of Technology

Introduction and Purpose of the study:

This study hopes to show that spinal manipulative intervention on low back pain in golfers will positively affect the golf swing in terms of Club Head Velocity (CHV).

This study involves research on 40 participants. There will be two groups in my study. Group A and Group B. Group A will receive spinal manipulative therapy for their mechanical lower back pain. Group B will be assessed in the same manner but will only be manipulated on the first consultation. All of you have the option of having free treatment once the study is completed.

Procedures:

The first visit
You will be required to undergo an initial examination at The Pro Shop

This consultation will include a case history taking, relevant physical examination and a lower back regional examination.

Once you have been accepted onto study, you are required to have your CHV analyzed (Visit 1). The Pro Shop is situated at Shop 20, Value Centre, Springfield (opposite Macro).
Address: 45 Electron Road (off Umgeni Road, Durban)
Here you will undergo a specified warm-up routine before determining your average CHV. A 7-iron will be the club used in the assessment.

Once the average CHV has been determined the researcher will intervene with the relevant spinal manipulative intervention. You will then be reassessed for any change in CHV.
Once the CHV has been determined, the subjects in group A will continue their treatment protocol over the next three weeks which is summarised in the following table:

Visit	Time	Date	Venue
1 CHV analysis and treatment			The Pro shop
2 Treatment only			D.I.T
3 CHV analysis and treatment			The Pro shop
4 Treatment only			D.I.T
5 CHV analysis			The Pro shop

Group B will be having their CHV analyzed one week after the initial manipulation. You will then need to wait the duration of the treatment protocol i.e. 2 weeks, before having your follow up consultation and third and final CHV reading for this study.

Visit	Time	Date	Venue
1 CHV analysis and treatment			The Pro shop
2 CHV analysis			The Pro shop
3 CHV analysis			The Pro shop

Risks/Discomfort:
Please note that spinal manipulative therapy (SMT) can cause some stiffness but 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 low back pain and you will be given a free club head velocity assessment.

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

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

1. You experience extreme pain whilst CHV testing
2. You are free to withdraw from the 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 clinic 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 of questions:
You may ask questions of an independent source (if you wish to contact my supervisors are available on the above numbers). 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.

Robert Delgado
(Chiropractic intern)

Dr. C. Korporaal
(Supervisor)

APPENDIX I: LETTER OF INFORMED CONSENT

INFORMED CONSENT FORM

(To be completed by patient / subject)

Date	:	
Title of research project:		**The immediate and short term effects of spinal manipulative therapy on club head velocity in amateur golfers suffering from mechanical low back pain.**
Name of supervisor	:	**Dr C. Korporaal**
Tel	:	**031-2042611**
Name of research student	:	**Robert Delgado**
Tel	:	**031-2042512/2205**

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? Yes No

at any time
without having to give any a reason for withdrawing, and
without affecting your future health care.

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

Please Print in block letters:

Patient /Subject Name:____________________Signature: ________________

Parent/ Guardian:________________________Signature:________________

Witness Name:__________________________Signature:________________

Research Student Name:___________________Signature:________________

USHICILELO Cii

INCWADI EGUNYAZAYO

Usuku :

Isihloko socwaningo :

Igama lika Supervisor :
? :
Igama lomfundi ongumcwaningi :
? :

Uyacelwa ukuba ukhethe impendulo	**Yebo**	**Cha**
1. Ulifundile yini iphepha elinolwazi ngocwaningo?	Yebo	Cha
2. Ube naso yini isikhathi sokubuza imibuzo mayelana nocwaningo?	Yebo	Cha
3. Wanelisekile yini izimpendulo ozitholile emibuzweni yakho?	Yebo	Cha
4. Ube nalo yini ithuba lokuthola kabanzi ngocwaningo?	Yebo	Cha
5. Uyithole yonke imininingwane eyanele ngalolucwaningo?	Yebo	Cha
6. Uyayiqonda imiphumela yokuzimbhandakanya kwakho kulolucwaningo?	Yebo	Cha
7. Uyaqonda ukuthi ukhululekile ukuyeka lolucwaningo? **noma inini** ngaphandle kokunika isizathu sokuyeka ngaphandle kokubeka impilo yakho ebungozini	Yebo	Cha
8. Uyavuma ukuvolontiya kulolucwaningo?	Yebo	Cha

9. .Ukhulume nobani? ---

Uma uphendule ngokuthi cha kokungaphezulu, sicela uthole ulwazi ngaphambi kokusayina.

BHALA NGAMAGAMA AMAKHULU:

Igama lesiguli:______________________________ Sayina:__________________

Umzali/Umgad:______________________________ Sayina: __________________

gama Witness:______________________________ Sayina: __________________

Igama lomfundi ongumcwaningi:__________________ Sayina: __________________

APPENDIX J: FLIGHTSCOPE PRO SWING ANALYZER

Specifications: FlightScope Pro ™

Description

Patented golf ball tracking system that provides shot statistics and performance reports for professional golf club comparison and club calibration applications.
FlightScope Pro can be used in outdoors or indoors at driving ranges and pro shops.

Components

FlightScope Pro comprises a sensor, application software, and installation parts as follows:

Sensor Unit

Power Cable (3m/ 10 ft)

Communications Cable with interface converter (10m/ 32ft)

DB25/DB9 Adapter Cable

FlightScope Pro™ Application Software

Installation Accessories

User Manual

OPTIONAL EQUIPMENT

Protective Cover (Outdoor installations only)

Notebook computer (IBM compatible P4) with XP Pro O/S

Pelican shipping case

Capabilities

Balls and Clubs
All regulation tournament balls and most practice range balls
All woods and most other clubs
Measurement Zone
The sensor measures in a spatial volume of 20 degrees by 20 degrees around its pointing direction
Launch Velocity
From 2 to 400 km/h (1.2 to 250 mph) within 0.5% accuracy.
Horizontal and Vertical Launch Angles
To within 0.5 degrees.
Landing Position
The x,y coordinate of the ball with a standard error of 5% of the actual flight distance.
Trajectory Height
The height the ball will reach through its flight path.
Club Head Speed
The club head strike speed accurate to 2%.

Physical Characteristics

Dimensions (approximate)

330 x 460 mm x 305 mm (13" x 7" x 12") Height x Width x Depth

Mass (approximate)

Sensor 3 kg (6.6 lbs)

Cover 2 kg (4.5 lbs)

Cables & Accessories 10 kg (22 lbs)

Environmental Characteristics

Ambient Temperature

Operates between 0 to 40 degrees C (32 to 104 degrees F).

Ingress Protection Level

IP54 / NEMA-4.

Electrical Characteristics

Electrical Supply:	**100-260 Volt AC @ 0.5 Amp**
Communications Interface:	**RS422/RS232 serial interface, at up to 115 kbps**
FCC and CE:	**Certified to FCC and CE requirements**

Installation Recommendations

The typical minimum requirements to use the system are as follows:

- Tee mat or grass tee
- Screen or net for indoor locations
- Work surface for notebook computer
- Sensor located 3 metres (10 ft) behind tee for outdoors and 4.5 metres (15 ft) behind screen/net for indoor facilities
- Mains power outlet
- Suitable protection against weather and other environmental factors
- Optional printer

THE IMMEDIATE AND SHORT TERM EFFECT OF SPINAL MANIPULATIVE THERAPY ON THE CLUB HEAD VELOCITY OF AMATEUR GOLFERS SUFFERING FROM MECHANICAL LOW BACK PAIN.

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From the Department of Chiropractic, Durban Institute of Technology, South Africa.

C. Korporaal (M.Tech: Chiropractic, CCFC, CCSP, ICSSD)

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ABSTRACT

Objectives: To evaluate the immediate and short term effects of spinal manipulative therapy on subjective and objective clinical findings in male amateur golfers suffering from mechanical low back pain.

Methods: 40 patients diagnosed with either lumbar facet syndrome and/ or sacroiliac syndrome were allocated into one of two groups. An experimental group (group A) consisting of thirty patients and a control group (group B) consisting of ten patients. Group A received four treatments over a two week period with a one week follow up while group B received only one treatment on the first visit, but returned for objective and subjective readings in congruence with group A . Subjective findings included NRS and RMQ while objective findings consisted of algometer, club head velocity and orthopaedic tests. Both the immediate and short term effects on objective findings were recorded while only the short term effects on subjective findings were recorded.

Results: NRS and RMQ scores of the treatment group improved over the research time period to a greater extent than the control group. The treatment group showed an immediate and short term improvement in terms of Algometer and CHV readings while the control group did not. Orthopaedic tests showed an immediate and short term improvement in the treatment group, to a greater extent than the control group.

Conclusion: This study demonstrated the beneficial immediate and short term effects of spinal manipulative therapy on the CHV of amateur golfers suffering from mechanical low back pain. Secondly, spinal manipulative therapy was found to be beneficial in terms of immediate and short term effects on subjective and objective clinical findings.

Key Indexing Terms: Low back pain, golf, club head velocity, spinal manipulative therapy

INTRODUCTION

Low back pain has been identified as the most common musculoskeletal problem affecting amateur and professional golfers (1). Approximately 62% golfers sustain injuries directly related to their sport (2). According to Seaman (3) it is estimated that 10 – 33% of touring professionals play while injured, and it is likely that half the group will develop chronic problems. Data for professional golfers indicate that 30 % suffer from lower back injuries while 27% of amateur golfers incur the same type of injury (4).

The presence of low back pain has been related to the golf swing, which according to Seaman (3) has several commonly agreed phases although there is no set system to classify each phase, which include (3):

- the backswing,
- the transition to downswing,
- the downswing/upswing and
- the follow through.

At the end of the follow through phase the golfer's lumbar spine is rotated and hyperextended. This is known as the reversed C position (5). According to McCarrol (6) this position is essential for proper trajectory and solid impact, as well as body leverage and accuracy. However many amateur golfers exaggerate this position in order to achieve more power and distance. Mackey (7) further states that in the reversed C position the facet joints approximate and in addition torsional stress is placed on the annular fibers of the disc. With repetitive swings and incorrect form the lumbar facets bear the brunt of the abnormal forces on the lumbar spine (7), especially on the facet joints and the lumbar spine discs.
In the right handed golfer the golf swing produces a distinctly asymmetric trunk motion, involving a combination of left axial rotation and right lateral bending (1).The significant lateral bending, shear, compression and torsional forces that the lower back contends with during the golf swing causes a peak compression load of more than eight times the body weight (5).

In addition to this, during the downswing phase of a golf swing the role of the multifidus is to limit flexion whilst the external oblique muscle induces rotation of the lumbar spine. Together both muscles produce rotation in the lower lumbar spine. Thus the golf swing, particularly during the downswing phase, places a tremendous burden on the multifidus

muscle and may cause muscle injury (8,3). Kirkaldy – Willis and Bernard (9) state that the uncontrolled contractions of the multifidus muscle produces torsion to the facet joints and disc and is therefore an integral part of facet syndrome.
Therefore it is not surprising that Mackey (7) stated that joint complex dysfunction is the most likely cause of low back pain in golfers.

Lindsay and Horton (10) showed in their investigation of spinal motion in elite golfers with and without low back pain that maximum rotation range of motion was more restricted in the group with mechanical low back pain. Modern golf instruction urges players to use a state of maximal spinal rotation in their golf swing in order to achieve maximum ball distance (3), as the maximally rotated position is considered ideal for developing optimal club head velocity (CHV) (3).

In opposition to this it has been reported that the length of the backswing and extent of torso rotation does not correlate with CHV at ball impact (2). But it is not clear whether this decreased rotation reduces stress and strain on the spine and spinal musculature, and there is no concrete data to suggest that a shortened backswing results in decreased spinal rotation (2). Further to this the Bulbulian, Ball & Seaman (2) study did not indicate whether maximal rotation was defined in participants with or without lower back pain.

In terms of treatment, manipulation has been validated as an effective treatment for certain types of low back pain of mechanical origin (11), as it results in improved flexibility and reduced pain and increased joint mobility (12). Furthermore it may address the decreased flexibility, improve motion and address the articular dysfunction that seems to present in golfers (7). Thus Lehman and McGill (13) assessed the influence of manipulation on lumbar kinematics and found that after single rotary manipulations (at the same level), the golf swing increased in all total ranges of motion for each plane of movement after the adjustment, with associated muscle relaxation. This improved movement / flexibility according to Lindsay and Horton (14) should be the primary aim of players with low back pain, particularly with respect to trunk rotational flexibility, to reduce their symptoms and decrease the effects of repetitive strain. This is further supported by the outcomes of Jermyn's (15) study in which he found an increase in club head velocity and distance immediately after a manipulation. There was also a suggestion in his results that objective low back sensitivity decreased immediately after the spinal manipulative therapy.

However the immediate *and* short term effects of spinal manipulative therapy have not been investigated in the literature which has been limited to pre-post intervention studies. Therefore this research was aimed at assessing and evaluating the immediate and short term effects of spinal manipulative therapy on club head velocity (CVH) in amateur golfers suffering from mechanical low back pain in terms of subjective and objective clinical findings with respect to one intervention and multiples interventions.

MATERIALS AND METHODS

This was an applied experimental design evaluating the effect of spinal manipulation in the treatment of mechanical low back pain in amateur golfers and its influence on club head velocity. The study consisted of forty male amateur golfers between the ages of 25 and 45 suffering from low back pain. A diagnosis of mechanical low back pain (lumbar facet syndrome and/or sacroiliac syndrome) was made based on the following orthopaedic tests:

1. Lumbar facet syndrome – Kemps test and Facet challenge test
2. Sacroiliac syndrome – Yeoman's and SI percussion test

Both tests for either syndrome had to be positive in order to make a diagnosis and be accepted into the study. Only golfers with an official handicap were accepted into the study.

The golfers were randomly allocated into an experimental group (Group A) consisting of thirty patients and a control group (Group B) consisting of ten patients. Once a patient was accepted onto the study, a baseline reading of their CHV was made using a Flight scope pro swing analyzer at The Pro Shop in Springfield. The patient then underwent the first spinal manipulative therapy and his CHV was then reassessed at the same consultation. This process at the initial consultation was the same for group A and group B.

Group A received four treatments over a two week period with a one week follow up. Subjective findings were recorded before each treatment while objective findings were recorded both before and after treatment. This was done at the first, third and fifth consultation. Treatment two and four took place at the Durban Institute of Technology and consisted of spinal manipulative therapy only. No subjective and objective recordings took place at these consultations. Group B received no further treatment after the initial consultation but had their subjective and objective findings recorded at the same periods as group A i.e. In congruence with consultation 1, 3 and 5 of group A.

Visit	Group A	Visit	Group B	Venue
1	**CHV analysis and treatment**	**1**	**CHV analysis and treatment**	**The Pro shop**
2	***Treatment only***		**N/A**	***D.I.T***
3	**CHV analysis and treatment**	**2**	**CHV analysis**	**The Pro shop**
4	***Treatment only***		**N/A**	***D.I.T***
5	**CHV analysis**	**3**	**CHV analysis**	**The Pro shop**

Subjective data included Numerical pain rating scale (NRS) and the Roland Morris Disability Questionnaire (RMQ). This was recorded before each CHV analysis so the short term effects could be analyzed over the research time period.
Objective data included the Non digital algometer, positive orthopaedic tests and CHV. This was recorded before and immediately after the spinal manipulative therapy at consultations 1, 3 and 5 so the immediate and short term effects could be analyzed.

Data were analysed using SPSS version 11.5 (SPSS Inc, Chicago, Ill, USA) and Stata version 8 (StataCorp LP, USA). A p value of <0.05 was considered as statistically significant.

Baseline data were described using means and standard deviations, or frequencies and proportions where appropriate. Baseline exposure and outcome comparisons between the two treatment groups were achieved using chi square tests or Fisher's exact tests in the case of categorical data, and t-tests in the case of quantitative dependant variables.

The effect of the treatment intervention was assessed in the immediate term and short term using repeated measures ANOVA for quantitative dependant variables. Five time points were used, and repeated contrasts were obtained and compared to assess and compare the immediate effects of the intervention between time points 1 and 2, and between time points 3 and 4. Short term effects were assessed from the time by group interaction over the entire 5 time points.

For binary dependant variables GEE models were generated in STATA using the cross –sectional time series module (Generalized estimating equations for cross-sectional time series data). Robust standard errors clustered on patient ID were generated to account for the intra-patient correlation over time. The time by group interaction over 5 time periods was used to assess the significance of the short term effects of the intervention. The immediate effects of the intervention were compared between time points 1 and 2 (session 1) and between time points 3 and 4 (session 2) using McNemar's chi square tests.

RESULTS AND DISCUSSION

In order to be accepted into this study patients had to be suffering from mechanical low back pain incorporating lumbar facet syndrome and /or sacro-iliac syndrome (16,17).The percentage of participants with a diagnosis / fixation of lumbar facet syndrome was 37.5 % while 62.5 % of the participants were diagnosed with sacro-iliac syndrome. This seems to be contradictory to Mackey (7) and Seaman (3) who indicate that ***facet syndrome*** is the most likely cause of low back pain in golfers. This may be due the role of the multifidus muscle in low back pain in golfers, where the lumbar multifidus is thought to be particularly important in the stabilisation of spine (18) and that in instances where the spine is unstable, the mutifidus which has both a stabilisation effect as well as a antagonist effect to the external oblique, is overloaded and fatigues, leaving the facet joint vulnerable to injury.

Furthermore Hides et al (19) stated that when compared to other muscles in close proximity to L4-L5, the multifidus muscle contributed two thirds of the increased stiffness imparted by contraction of the muscles. He concluded from this that the multifidus muscle is an important muscle for lumbar segmental stability (19).
Unilateral wasting of the multifidus (on the symptomatic side) was found using ultrasound in patients with low back pain (18). Indicating that there may be a compromise of the multifidus through the same mechanism of fatigue / overload, resulting in decreased use of the muscle as well as atrophy. This is significant as once the multifidus muscle is injured there is no spontaneous muscle recovery even on remission of painful symptoms (19).

This means that many golfers suffering with low back pain may have wasted multifidi muscles which is associated with instability of the lumbar spine. The literature however is silent on the role of the ***sacro-iliac joint*** in the presentation of low back pain in golfers, although the literature alludes to possible mechanisms which could implicate this joint. These include:

- The transfer of weight from the right to the left leg in the right handed golfer, requires the stabilization of the gluteus medius muscle (3), which if overused has been linked to the development of a sacro-iliac syndrome (20).

- In addition the use of the lattisimus dorsi as one of the principle muscles of force transfer between the lower and the upper extremity (3), could cause an imbalance between the lattisimus dorsi and its antagonist, the gluteus medius and maximus on the contralateral aspect of the thoracolumbar fascia (21). This imbalance could result in the development of restricted motion within the sacro-iliac joints as one of the functions of the thoracolumbar fascia is that of sacro-iliac compression as an aid for energy transfer (22). Unrelated to the joint structures of the low back, the use of non-contractile tissues in energy transfer (3), with the resultant changes due to creep and hysteresis (23), will ultimately place more stress on the joints which these non-contractile structures are to protect, thereby precipitating the presence of low back pain in either the facet joints or the sacro-iliac joints.
- Furthermore it is suggested by such authors as Gatterman (12) that if an area becomes hypomobile an area of hypermobility develops elsewhere. If the sacro-iliac joints are restricted, as a result more flexibility is demanded from the lumbar spine, it would result in an increased likelihood of symptoms developing in the lumbar spine.

It would therefore seem that the literature has focused principally on the facet joints as the debate related directly to the degree of trunk rotation (3) as opposed to the energy transfer structures that may be more directly involved.

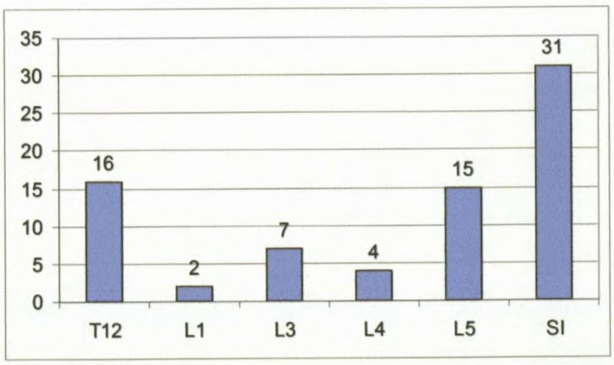

Figure 1: Frequency of levels of fixations in n=40 participants (75 fixations)

This is supported by the above graph (figure 1) which shows the SI and T12 were the most common fixations. Therefore it would seem that the literature as related to hyper and hypomobility of different sections of the spine (12) and / or the transfer of energy through the thoracolumbar fascia seem, as seen in this study to play a greater role than the degree of rotation that the golfer has through the take away phase as well as through the follow through phase of the golf swing, are applicable in this respect.

This is further supported by the fact that the attachment of the latissimus dorsi over T12 through to the sacro-iliac joints (24) may have a relationship with the level of the fixations that presented as these fixations present mostly at the extremes of the lattisimus dorsi attachments.

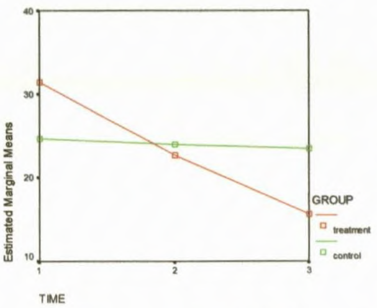

Figure 2a:NRS

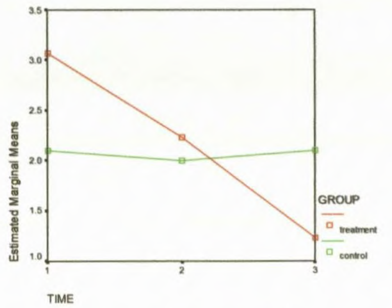

Figure 2b:RMQ

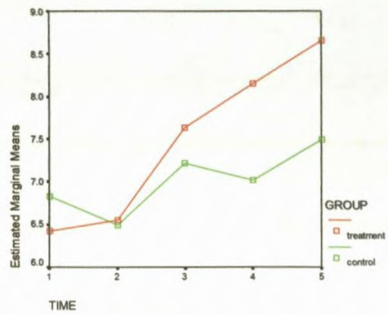

Figure 2c: Algometer

NRS

NRS was evaluated at 3 time points, with no pre and post for each session, thus the short terms effects were evaluated. There was a significant interaction between time and treatment group ($p<0.001$). NRS values in the treatment group decreased while those in the control group remained constant. Thus there was a significant beneficial treatment effect for NRS. This is in congruence with the literature (16,25) that indicates a decrease in pain is expected post manipulation or after a course of manipulative treatments. We can conclude that the manipulation provided significant pain relief to the patients in the treatment group. In addition to this it can be noted that a single intervention (as per the control group) does not affect the pain cycle near as greatly (if at all) as multiple interventions, which supports the theories espoused by Patterson and Steinmetz (26) and Leach (27).

Furthermore the decrease in reported pain (through the NRS) indicates that the manipulation of the fixated joints plays a large role in the reduction of pain. In the case of this study, the golfers were manipulated most often for restrictions of the sacro-iliac joints, indicating that either these joints or the compensations as a result of the fixations in these joints are the principle cause of the pain in these patients.

RMQ score

RMQ score was also evaluated at 3 time points, with no pre and post for each session, thus the short terms effects were evaluated. The subjects had to state which (if any) of 24 lower back pain disabilities they experienced. There was a just significant time*group interaction for RMQ score (p=0.047). The mean score for the treatment group decreased over time, while the control group remained almost constant. Thus there was a significant beneficial treatment effect for RMQ score, with the multiple treatments being more effective than the single interventions as supported by Patterson and Steinmetz (26) and Leach (27).

Non Digital Algometer

Algometer measurements were taken at 5 time points (i.e. pre and post to each of the first two sessions and once at the last session). Thus immediate effects compare the pre and post at the first and second sessions. Short term effects examine the change over the 5 time points. There was a more significant

Club head velocity

There was a significant (<0.001) effect for the time * group interaction which refers to a treatment effect for the treatment group over the control group. This is further demonstrated in the figure below (3), where a marked difference is noted at time 5 or the last reading that was taken.

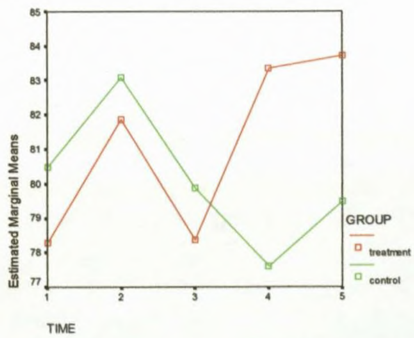

Figure 3: Profile plot of mean CHV measurement by group over time

With respect to the changes in the CHV, there are 2 points at which the immediate effect was measured with respect to the intervention. This was between time periods 1 and 2 (session 1) and then again between time periods 3 and 4 (session 2). The interaction relative to immediate improvement was only significant between time 3 and 4 (pre to post for the second session). Thus this is where the greatest immediate effect lies. The mean change in CHV at session 1 was an increase of 3,5667 MPH for the treatment group and an increase of 2,6 MPH for the control group. Both groups received manipulation at this session. At session two the treatment group had an *increase* in CHV of 5 MPH while the control group had a *decrease* in CHV of 2,3 MPH. The control group did not receive manipulation at this session and it can therefore be assumed that the significant difference in CHV between the two groups is due to the intervention used i.e. spinal manipulative therapy. These results are congruent with the algometer findings where the most significant changes caused by spinal manipulative therapy are found between time 3 and 4 (Pre and post for the second session). Therefore the same suggestions as to the mechanisms involved would be applicable here. The greater change in both readings on visit three may be due to the short term effects of manipulation. At visit one the manipulation may only be effecting neurological mechanisms within the joint, however by visit three (time 3) the patients in the treatment group are receiving their third treatment and the physiological effects (e.g. resolution of inflammation, muscle spasm) of manipulation may be taking effect as well as the cumulative effect of having three treatments.

Overall there was a significant short term benefit of treatment which correlates with the previous argument that spinal manipulative therapy has a cumulative effect. This therefore indicates that a course of spinal manipulative therapy is conclusively better than a singe manipulation relative to short term effect on CHV.

Distance

Distance showed a relationship with CHV of 3:1. There was also an immediate and short term effect on distance with the treatment group improving significantly better than the control group. The immediate effect was also more pronounced at the second session.

Orthopaedic Tests

Kemp's test showed no significant immediate changes in either session one or two for the treatment group and the control group. There was however a short term effect with the treatment group improving at a better rate and extent than the control group.

With Facet Challenge Test there was no change between pre and post at session 1 or 2 in both treatment and control group showing that there were no significant immediate effects on facet challenge. The treatment group showed a steep rate of decrease in %

positive over time, while the control group remained constant over time which shows the treatment had a significant short term effect.

In respect of the SI Percussion Test, the treatment group showed a significant immediate effect in both session 1 and session 2. The control group showed no change. There was a decrease in the percentage of positive subjects in the treatment group over the short term but no change in the control group.

And lastly with the Yeoman's Test, there was a slight immediate effect in the first session in the treatment group while there was no change in the control group. The second session showed no immediate effect for both groups. The treatment group decreased in % positivist over time to a greater extent than the control group, but this difference was not marked. Thus the short term effect of the treatment for the Yeoman's test was marginally significantly beneficial.

CONCLUSIONS

The researcher has found that spinal manipulative therapy has an immediate and short term effect on the club head velocity of amateur golfers suffering from mechanical low back pain and it can therefore be concluded that spinal manipulative therapy is a valuable and effective treatment option for golfers suffering from mechanical low back pain. Furthermore the study has found that lumbar spine instability may be the cause of low back pain in golfers as apposed to lumbar facet syndrome. Areas such as the sacro-iliac joints and thoracolumbar region must be assessed for hypomobilty and possible sources for pain referral.

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APPENDIX 10

ALGOMETER READINGS

Treatment	1st Reading	2nd Reading	3rd Reading
Superior SCM - Right			
- Left			
Middle SCM - Right			
- Left			
Trapezius insertion - Right			
- Left			