THE IMMEDIATE EFFECT OF SPINAL MANIPULATIVE THERAPY ON CLUB HEAD VELOCITY IN AMATEUR GOLFERS SUFFERING FROM MECHANICAL LOW BACK PAIN

BY

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I**,** Gareth John Jermyn do herby declare that this dissertation is representative of my own work.

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APPROVED FOR FINAL SUBMISSION

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DEDICATION

I dedicate this to my family….

To my parents, for their tireless devotion and endless caring. Your love and support has shone the way for me to travel. Thank you. This is a result of your belief in me!

To Chandre’ and Brendon, for all that you have done for me in what may have seemed to be endless days of a “student career”. Your support has been unwavering and always assuring. Thank you for being my best friends…… and to little Jordan, we have been waiting for you!

To my Gran and uncle Louis, whose values I shall keep close to my heart forever!!

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ABSTRACT

Background: Back pain among the golfing population is considered endemic as it has been recommended to golfers that they should attempt to use a state of maximal spinal rotation in their golf swing in order to achieve maximum ball distance. Evidence suggests that maximum spinal rotation range of motion will be more restricted in the golfers with low back pain, even though this maximum rotated position has been considered ideal for developing optimal Club Head Velocity (CHV).

Research has demonstrated an approximate 1:3 relation between CHV and air travel (i.e. distance) of the golf ball. An increase in 1mph in CHV would increase air travel of the golf ball by approximately 3 yards. If one considers that CHV is primarily influenced by the strength and power of the torso (low back and abdominal muscles), muscle balance and flexibility, which are responsible for the static and dynamic postural stability of the golf swing, it stands to reason that low back pain, which has been identified as the most common problem affecting amateur golfers, will affect CHV.

Objective: The purpose of this investigation was to evaluate the immediate effect of spinal manipulative therapy on club head velocity in amateur golfers suffering from mechanical low back pain in terms of subjective and objective measures.

Methods: Forty golfers suffering from mechanical low back pain were recruited through advertising for this study. They underwent a single consultation where a diagnosis of mechanical low back pain was made. The participants were then required to complete a golf ball hitting protocol where CHV and corresponding distance was measured pre and post spinal manipulative therapy. Subjective measurements were taken using the Numerical Pain Rating Scale (NRS), and Roland Morris Questionnaire (RMQ). Anecdotal evidence was also captured. Objective measurements were taken using a Non-Digital Algometer (NDA), and

The Golf Achiever "Laser" Swing Analyzer (measuring CHV, distance and accuracy). Further objective measurements were obtained through specific orthopaedic tests, which established a rating scale for a clinical diagnosis of facet and / or sacroiliac syndrome. All subjective and objective data collection took place pre and post intervention. The Roland Morris Questionnaire (RMQ) data was captured at the pre intervention stage only. Anecdotal data was obtained once all other data capturing was completed. Statistical analysis included various statistical methods and correlation analyses, by means of the SPSS package.

Results: There was a significant average increase in CHV (2.61 mph per shot) after spinal manipulative therapy per participant and a concomitant significant average increase in distance of (8.025 yards per shot) after spinal manipulative therapy per participant. There was also a significant decrease in objective pain sensitivity after spinal manipulative therapy. Spinal manipulative therapy also suggested to have had an influence on the accuracy of a golf shot.

Conclusions: Spinal manipulative therapy appears to have a positive influence in amateur golfers suffering from mechanical low back pain in terms of golfing performance (i.e. CHV, ball distance and accuracy), and mechanical low back pain sensitivity. However this study only looked at the immediate effects of spinal manipulative therapy in amateur golfers suffering from mechanical low back pain and no long terms effects of spinal manipulative were measured.

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CHAPTER ONE: INTRODUCTION

1.1 INTRODUCTION

Modern golf literature suggests to both amateur and professional golfers to use a state of maximal spinal rotation in their golf swing in order try and achieve a maximum ball distance with each golf club (Seaman, 1998:47 and Bulbulian, Ball & Seaman, 2001,569-70). This maximum rotated position is considered ideal for developing optimal Club Head Velocity (CHV) (Seaman, 1998:46-51).

Research has demonstrated an approximate 1:3 relation between CHV and air travel (i.e. distance) of the golf ball. An increase in 1mph in CHV would increase air travel of the golf ball by approximately 3 yards (Stude and Glickson, 2000:173).

CHV is the speed at which the golf club head makes contact with the golf ball (i.e. swing speed), and is primarily influenced by the strength and power of the golf swing. Secondary factors that affect CHV include; muscle balance and flexibility, all of which affect static and dynamic postural stability (Chek, 2003).

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.

These three phases result in hyper-rotation and hyperextension of the lumbar spine (Mackey, 1995:11-12). These movements produce a distinctly asymmetric trunk motion, involving a combination of left axial rotation and right lateral bending [in right-handed golfers] (Lindsay and Horton, 2002:604).

It is during the downswing phase that CHV is generated (Stude and Glickson, 2000:173). Researchers have identified the downswing, rather than the backswing, as the key part of the golf swing during which most stresses and injuries occur (Linday & Horton, 2002:603).

Low back pain has been identified as the most common musculoskeletal problem affecting amateur and professional golfers (Horton, Lindsay & Macintosh, 2001:1647 and Bulbulian, Ball & Seaman, 2001,569). The most common cause of this lower back injury in both professional and amateur golfers is believed to be repetitive swinging (Seaman, 1998:46), as well as the overuse associated with the asymmetrical nature of the golf swing which is thought to create abnormal repetitive stresses on the lumbar spine, which leads to injury and pain (Horton, Lindsay and Macintosh, 2001:1647). According to Mackey (1995:10-12), it is likely that joint complex dysfunction associated with myofascial trigger points is the main cause of back pain in golfers who are treated by both chiropractors and medical doctors (Seaman, 1998:46/53).

As a result Lindsay and Horton (2002:605) investigating spinal motion in elite golfers with and without low back pain, found that maximum rotation range of motion was more restricted in the group with low back pain.

Therefore Lehman and McGill (1999:576-579) looked at the influence of spinal manipulative therapy on lumbar kinematics and found that after single rotary manipulations (at the same level), that the golf swing increased in all total range of motion for each plane of movement after the spinal manipulative therapy, with concomitant muscle responses (i.e. relaxation). This improved movement / flexibility according to Lindsay and Horton (2002:604), which should be the primary aim of players with low back pain, particularly trunk rotational flexibility, to reduce their symptoms and decrease the effects of repetitive strain.

In respect of this spinal manipulative therapy has been validated as a safe and effective treatment for low back pain of mechanical origin (Cooperstein et al, 2001:407), as spinal manipulative therapy results in improved flexibility and reduced pain and increased joint mobility (Gatterman, 1990:40).

It was thus hypothesised that mechanical low back pain in amateur golfers is a result of joint complex dysfunction. This dysfunction is related to reduced spinal motion (Seaman, 1998:46, Mackey, 1995:11), which may or may not have an effect on CHV (Bulbulian, Ball & Seaman, 2001,569). Evidence suggests that increased spinal flexibility should be the primary aim of players 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).

1.2 THE STATEMENT OF THE PROBLEM

The aim of this study is to evaluate the immediate effect of spinal manipulative therapy on CHV in terms of subjective and objective clinical findings in amateur golfers suffering from mechanical low back pain.

1.3 OBJECTIVES OF THE STUDY

1.3.1 OBJECTIVE ONE

The first objective was to determine the immediate effects of spinal manipulative therapy on CHV.

1.3.2 OBJECTIVE TWO

The second objective was to assess the immediate effect of spinal manipulative therapy on subjective clinical findings in amateur golfers suffering from mechanical low back pain.

1.3.3 OBJECTIVE THREE

The third objective was to assess the immediate effect of spinal manipulative therapy on objective clinical findings in amateur golfers suffering from mechanical low back pain.

1.3.4 OBJECTIVE FOUR

The fourth objective was to compare the results obtained in CHV, subjective and objective clinical findings in amateur golfers suffering from mechanical low back pain in order to assess the immediate effect of spinal manipulative therapy.

CHAPTER TWO: LITERATURE REVIEW

2.1 INTRODUCTION

This chapter is concerned with reviewing literature that is related to the core of the research. Due to the dynamics of the golf swing (i.e. the mechanics and the anatomy involved), the chapter has been constructed as follows:

Part A: This covers the basic anatomy, biomechanics and manipulation of the lumbar spine (Part A).

Part B: This covers literature related to golf, golf mechanics, basic muscle involvement and mechanisms of injury that are related to low back pain, and that are relevant to golfing (Part B).

PART: A

2.2 THE LUMBAR SPINE: RELEVANT ANATOMY AND BIOMECHANICS

2.2.1 THE VERTEBRAL BODY

The lumbar spine consists of five vertebrae, which make up 25% of the total length of the vertebral column. The lumbar vertebrae are distinguished by their massive bodies, sturdy laminae, and absence of costal facets. The body of the lumbar vertebrae is short and cylindrical, with a kidney shaped cross section. The lumbar vertebrae increase in size from L1 to L5, with L5 being the largest of all movable vertebrae. Their transverse processes project somewhat posteriosuperiorly as well as laterally. The articular processes of the lumbar vertebrae facilitate flexion, extension and lateral bending of the vertebral column. On the posterior surface of the superior articular processes are mamillary processes, which give attachment to the multifidus and intertransverse muscles (Moore and Dalley, 1999: 441/2 and Kirkady-Willis and Burton, 1992:7/27).

2.2.2 INTERVERTEBRAL JOINTS

The intervertebral joints of the lumbar spine consist of an intervertebral disc and two posterior facet joints, and are referred to as a three-joint complex (Kirkady-Willis and Burton, 1992:55).

2.2.3 INTERVERTEBRAL DISCS

Intervertebral discs link two adjacent vertebral bodies, and the discs constitute one third of the length of the lumbar spine. The intervertebral discs consist of the following components (Moore and Dalley, 1999: 451, Kirkady-Willis and Burton, 1992:11 and Gatterman, 1990:13/14 & 28/29):

- The first component is a centrally located nucleus pulposus, which is a gel like substance that forms 40% of the total cross sectional area of the disc. It acts like a shock absorber for axial forces and like a semifluid ball bearing during flexion, extension, rotation and lateral flexion of the vertebral column (Moore and Dalley, 1999: 451).

- The nucleus is surrounded by fibrocartilagenous lamellae of the annulus fibrosus, which forms the second component of the outer boundaries of the disc. The annulus fibrosus is composed of up to 90 sheets of collagen fibers, which form adjacent sheets running at about thirty degrees to each other. In axial compression, an increase in intradiscal pressure is counteracted by annular fibre tension and disc bulge. Whereas in a rotary movement, the annular fibers are stretched in one direction, whereas those in the opposite direction are shortened. Due to the above functions, the thickness of the lamellae increases gradually toward the periphery, with the fibers of the outermost annular lamella attaching to the vertebral body by periosteal fibrils. Further to this the outer two thirds of the annulus fibrosus anchors firmly to the vertebral body above and below with penetrating Sharpey's fibers, while the inner third attaches loosely to the cartilaginous end plate.

- The endplate is made of hyaline cartilage, which makes up the third component of the disc.

2.2.4 LIGAMENTS

Movement of the lumbar spine is restricted via the following lumbar ligaments (Moore and Dalley, 1999: 457 and Bogduk, 1999:43):

- The anterior and posterior longitudinal ligaments, which interconnect the vertebral bodies anteriorly and posteriorly respectively.
- The ligamentum flavum, interspinous ligaments and supraspinous ligaments, which are responsible for maintaining the relationship of the posterior elements of the successive lumbar vertebrae. The ligamentum flavum bind the lamina of the adjoining vertebrae together, forming part of the posterior wall of the vertebral canal, and is thickest in the lumbar region. Adjacent spinous processes are joined by weak interspinous and strong cord like supraspinous ligaments. The intertransverse ligaments connect adjacent transverse processes and are thin and membranous in the lumbar region (Moore and Dalley, 1999 :457).
- Articular capsules are strengthened by accessory ligaments, which are either part of their fibrous capsules (intrinsic ligaments), or are separated from them (extrinsic ligaments). The articular capsule and its accessory ligaments are important in maintaining the relationship between the articulating lumbar joints (Moore and Dalley, 1999 :23)

2.2.5 THE LUMBAR FACET (ZYGAPOPHYSIAL) JOINTS

2.2.5.1 ANATOMY

The facet joints of the lumbar spine are catagorized as diarthrodial[1] joints (Mackey, 1995:11).

With the facet joints being typical synovial joints (Moore and Dalley, 1999:23 and Bogduk, 1999:33):

- the articulating surfaces are made of hyaline cartilage,
- a synovial membrane surrounds / covers the internal aspect of the joint
- and the joint is encompassed by a fibrous joint capsule.

In the lumbar spine, facet joint capsules are thick and fibrous over the dorsal aspect of the joint, whereas the ventral capsule is made of an extension of ligamentum flavum.

A deltoid space, which is determined by the capsule or ligamentum flavum on one side, and the junction of the rounded edges of the superior and inferior articular cartilaginous surfaces on the other side, is filled by a similarly shaped fibrous rim. On this rim, mostly at the proximal and distal poles, fibro-adipose or adipose enlargements (meniscoids) may be found (Kirkady-Willis and Burton, 1992:7/8). The meniscoids act as a space fillers underneath the capsule and are thought to be responsible for increasing the joint surface area thereby transmitting some load and serving a protective function for the joint, due to there ”wedge-shaped projection” into the joint capsule or synovium onto the joint. (Bogduk, 1999:38).

As the joints are synovial, the synovial membrane supplies the joint surfaces with synovial fluid. It is speculated that this fluid serves as a joint lubricant and

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[1] Diarthrodial joints are defined as specialized joints permitting more or less free movement and are surrounded by an articular capsule enclosing a cavity lined by synovial membrane (Saunders, 1994:143).

provides nutrition for the avascular cartilage. Regular compression and distraction of the joint surfaces must occur for adequate exchange of nutrients and waste products to take place. Immobilized joints have been shown to undergo degeneration of the articular cartilage (Bergman et al, 1993:38).

The lumbar facet joints are the result of the articulation of the inferior articular process of one lumbar vertebra with the superior articular process of another vertebra. The inferior articulating facet on the superior articular process of the lumbar vertebra are concave and face posterior and medial, and the superior articulating facets on the inferior articular process are convex and face anterior and lateral (Moore and Dalley, 1999:437).

2.2.5.2 FUNCTION

The function of the facet joints is to guide and restrain movement between vertebrae and to protect the discs from shear forces and axial rotation. The facets also prevent the vertebrae from slipping anteriorly. The lumbar vertebrae are weight-bearing vertebrae, which increases inferiorly to L5, where the L5 vertebra bears weight even in the erect posture (Moore and Dalley, 1999: 437 and Giles, 1997).

2.2.5.3 INNERVATION

Innervation of the lumbar facets come from the medial branches of the dorsal rami of spinal nerves. Each articular branch supplies two adjacent joints; therefore each joint is supplied by two nerves. (Moore and Dalley, 1999: 455).

Gatterman (1995) describes three types of sensory receptors within the facet joints:

1. Type I: Sensitive static and dynamic mechanoreceptors that are continuously firing due to continual joint motion.
2. Type II: Less sensitive mechanoreceptors which fire only on motion.
3. Type III: Slow conducting mechanoreceptors.

2.2.6 BIOMECHANICS OF THE LUMBAR SPINE AND FACET JOINTS

(Kirkady-Willis and Burton, 1992 :27-29).

The basic functional unit of the spine is termed the motion segment, which consists of two adjacent vertebral bodies with intervening soft tissue structures. Each segment is controlled actively by muscles and passively by ligaments and joint capsules.

A motion segment can be divided into anterior and posterior elements:

- The anterior elements are made up of; the vertebral body, an intervertebral disc, the anterior longitudinal ligament and the posterior longitudinal ligament. These structures provide stability and shock absorption.
- The posterior elements are made up of the pedicles, the facet joints, the posterior ligamentous and muscular attachments. These posterior elements allow for control of spinal movements.

Facet joints allow for normal spinal motion and also serve as constraints because of their spatial / vertical orientation in the lumbar spine. The facets are important for resisting torsion, shear and compression. Normally facets and discs contribute 80% of torsional resistance, with the facets contributing to half the amount (i.e. 40 %). It has been approximated that 25% of an axial compression load is transmitted through the facets.

2.2.6.2 MUSCLES OF THE LUMBAR SPINE

i) Erector Spinae (Sacrospinalis)

The sacrospinalis muscle splits to form three columns in the upper lumbar region; laterally it becomes the illiocostalis, intermediately the longissimus, and medially the spinalis. The erector spinae are extensors of the spinal column. The iliocostalis and longissimus muscles, in addition to extending the spine, assist in lateral flexion of the trunk (Gatterman, 1990: 133/4).

ii) Transversospinalis and Intrasegmental Muscles

This group of muscles consists of the multifidus, interspinalis intertransversarri (medius and lateralis) muscles. These muscles are thought to act as postural stabilizers, steadying vertebral motion segments during motion of the vertebral column as a whole and ensuring the efficient action of the long spinal muscles (Gatterman, 1990: 133/4).

iii) Deep Lateral Muscles

This pair of muscles is made up of the quadratus lumborum and psoas major muscles. The quadratus lumborum muscle assists in inspiration, and if the pelvis is fixed, it flexes the trunk to the same side. Bilateral action of these muscles assists in lumbar spine extension. The psoas muscle assists in flexion of the thigh upon the pelvis, and increases lumber lordosis during flexion (Gatterman, 1990: 134).

2.2.6.2.1 PRINCIPAL MUSCLES PRODUCING MOVEMENT OF THE LUMBAR INTERVERTEBRAL JOINTS: (Moore and Dalley, 1999: 473).

1. **Flexion** is produced by bilateral action of:
    - rectus abdominis and psoas major muscles.
2. **Extension** is produced by bilatral action of:
    - erector spinae and multifidus muscles.
3. **Lateral bending** is produced by unilatral action of:
    - multifidus, external and internal oblique and quadratus lumborum muscles.
4. **Rotation** is produced by unilateral action of:
    - rotators, multifidus, external oblique acting synchronously with opposite internal oblique muscles.

2.2.6.2.2 THE MULTIFIDUS MUSCLE

ANATOMY:

The multifidus muscle fibers cross 2 to 4 segments throughout the thoracic and lumbar spines, and sometimes extend to the fourth sacral segment (S4). The fibers of the lumbar multifidus are divided by distinct cleavage planes into five segmental bands, and are arranged in such a way that the fibers that move a particular segment are innervated by the nerve of that segment. (Simons, Travell and Simons, 1999:917-8).

FUNCTION:

The importance of the multifidi are, that they act stabilizers rather than prime movers of the vertebral column as a whole. (Simons, Travell and Simons, 1999: 921).

The mechanism of their stabilizing action is relevant due to the fact that the multifidus muscle opposes the strong contraction primarily of the oblique muscles. Repetitive strain and overload of the multifidus muscle has been linked to the formation of trigger points in the multifidi muscle group, which induces joint dysfunction involving two or three adjacent segmental levels (Simons, Travell and Simons,1999: 922-5).

2.2.7 MECHANISM OF INJURY OF THE FACET JOINTS

It has been emphasised that symptoms caused by multifidus muscle can mimic those of lumbar facet or sacroiliac syndromes, by causing a segmental motion block and joint complex dysfunction (Simons, Travell and Simons, 1999: 922-5), thus promoting facet joint injury.

The facet joints are susceptible to injury and / or damage for a variety of reasons, which include three categories of causes: traumatic, pathologic (degenerative) and postural (Hourigan and Bassett, 1989: 293). However the exact cause / causation and its pathogenesis of facet syndrome[2] is uncertain (Bogduk, 1999: 200-1).

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[2] Facet syndrome is defined as a posterior joint dysfunction characterized by an overriding of the facets of adjacent vertebrae, whereby intervertebral foramina are narrowed from superior to inferior (Gatterman, 1990: 161).

Nonetheless, Kirkaldy-Willis and Burton (1992:55) outline three phases of degeneration involving the three joint complex:

- The dysfunctional phase,
- The unstable phase and
- The stabilization phase.

Facet syndrome is said to arise primarily in the dysfunctional phase (Phase 1), although it can occur in the unstable phase (Phase 2) due to adaptive changes in the posterior joints (Kirkaldy-Willis and Burton, 1992: 122).

According to Giles et al. (1997: 89), the effect of joint dysfunction[3] on associated soft tissue structures are possible venous stasis, nerve ischaemia, and soft tissue entrapment, which have been postulated as a potential mechanism for causing low back pain of a mechanical nature. The soft tissue structures that could theoretically be involved in low back pain of mechanical origin are (Giles et al., 1997: 89):

- Large intra-articular synovial folds of the zygapophyseal joints.
- The fibrous tissue within the joint capsules becomes attached to the adhesions, to the adjacent hyaline cartilage.
- The distorted and tractioned blood vessels within the intervertebral foramen.
- The neural structures that become attached by adhesions to densely fibrotic intra-articular synovial folds.
- Stenosis of the intervertebral foramen due to hypertrophy of the ligamentum flavum with or without posterolateral intervertebral disc herniation.

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[3] Joint dysfunction refers to decreased mobility within a motion segment, however it does not include the pathological and / or clinical changes that are apparent in soft tissues as found in facet syndrome, i.e. joint mechanics showing functional disturbances without structural changes (Redwood, 1997: 338). Joint dysfunction affects quality and range of joint motion (Haldeman, 1992: 623).

2.2.8 LUMBAR (POSTERIOR) FACET SYNDROME

2.2.8.1 ASSOCIATED SYMPTOMS:

Pain is often classically localized over the facet joint by local tenderness and is unilateral. There is paraspinal muscle spasm, and pain may be referred to the buttock, groin, greater trochanter and posterior thigh as far as the knee (Gatterman, 1990: 161; Kirkaldy-Willis and Burton, 1992: 106, and Giles, 1997: 89).

There is an absence of neurological deficits (Plaugher, 1993: 216-217)

Further to this, when symptoms are acute, sneezing and coughing may accentuate the pain (Gatterman, 1990: 161/2).

2.2.8.2 ASSOCIATED SIGNS:

There is tenderness to pressure (manual palpation or spinous percussion), usually unilateral and at same level over the sacrospinalis and multifidus muscle. The muscle at the site of the lesion is normally in a hypertonic state (Kirkaldy-Willis and Burton, 1992: 106).

Hyperextension movements of the back increase pain, whereas flexion reduces it. Other activities that may increase pain include sleeping on the abdomen, sitting in an upright position, lifting a load in front of the body, working with the hands and arms above the head and arising from sitting (Gatterman, 1990: 161/2).

Pain is aggravated by provocation tests, e.g.:

- Kemp's test (Gatterman, 1990: 141).
- Facet challenge test (Gatterman, 1990: 84)
- Hyperextension in a prone position (Gatterman, 1990: 162).
- Palpable muscle spasm with focal tenderness over the affected joint (Helbig and Lee, 1988: 61-64)

A triangulation of the above signs and symptoms would indicate facet syndrome.

The symptoms and signs may be complicated by those of a concomitant sacroiliac syndrome (Kirkaldy-Willis and Burton, 1992: 122).

2.3 THE SACRO-ILIAC JOINT: RELEVANT ANATOMY AND BIOMECHANICS

2.3.1 ANATOMY

The sacroiliac (SI) joints are formed by the articulation between the sacrum and the ilia of the pelvis (Hendler et al.1995:169). The sacroiliac joint is usually auricular or C-shaped with the convex contour facing anterior and slightly inferior. The sacroiliac joint is an atypical synovial articulation with a well-defined joint space and two opposing cartilage surfaces. It is atypical because the iliac surface has the appearance of fibrocartilage rather than hyaline cartilage (Haldeman, 1992:211-215).

The sacroiliac joint is a weight-bearing joint that is stabilised by the following ligaments:

- The sacrospinous,
- The sacrotuberous,
- The interosseus,
- The posterior sacroiliac ligament, and
- The anterior sacroiliac ligament.

These ligaments serve to bind the sacrum between the two ilia (Haldeman, 1992:211-215). The most important of these ligaments is interosseus ligament, because of its ability to bind the respective ilium strongly to the sacrum, and allowing the interlocking mechanism of the SI joint to function effectively. In addition to this, the posterior ligament prevents flaring of the joint and counter-nutation of the sacrum with respect to the ilium, whereas the anterior ligament prevents anterior separation of the joint and helps bind the joint together (Haldeman, 1992:211-215).

The ligaments surround the joint so comprehensively that the joint capsule is said to merge with the ligaments (Bogduk, 1999:181). The sacroiliac joints are contained by a fibrous joint capsule that is well developed anteriorly, but poorly developed posteriorly (Bogduk, 1999:181).

2.3.2 FUNCTION

The sacroiliac joint has two functions: to provide elasticity to the pelvic rim and to serve as a buffer between the lumbosacral and the hip joints (Kirkady-Willis and Burton, 1992 :123).

2.3.3 INNERVATION

It is generally accepted in literature that the pattern of posterior innervation is via the lateral branches of the posterior lateral rami of L4 to S3 and the anterior innervation from L2 to S2 (Bogduk, 1999: 182).

2.3.4 BIOMECHANICS OF THE SACRO-ILIAC JOINT

The sacroiliac joint allows a small amount of anteroposterior rotatory movement around a transverse axis, while still giving the pelvis the stability to take the weight of the body (Hendler et al.1995:169). There are no muscles, which produce active movement of the SI joint, as all muscles crossing the joint act on the lumbar spine or hip (Bergmann: 1993:478).

Full range of motion is less than 4 degrees in the SI joint. This small movement is vital for the joint to be distorted in three dimensions (around the x, y and z axes). Without the SI joints these torsional stresses in the pelvis would otherwise be transmitted to the sacrum resulting in fractures (Bogduk, 1999:178).

2.3.5 MECHANISM OF INJURY

The sacroiliac joint allows for a small degree of movement up until middle age. Thereafter movement is reduced by articular cartilage degeneration, by fibriosis and bony ankylosis. It is possible that minor dysfunction of this joint and sustained contraction of muscle overlying the joint, could lead to pain and the development of sacro-iliac syndrome (Kirkady-Willis and Burton, 1992 :123). This is supported by Corrigan and Maitland (1998: 123), who more recently stated that it has been considered possible that up to 30% of low back pain may arise in the sacro-iliac joint.

2.3.6 SACRO-ILIAC SYNDROME

2.3.6.1 ASSOCIATED SYMPTOMS

Typically pain is over the back of the sacroiliac joint that varies in its degree of severity, with associated pain that can be referred into the groin, over the greater trochanter, down the back of the thigh to the knee, and / or occasionally down the lateral or posterior calf to the ankle, foot and toes (Kirkady-Willis and Burton, 1992 :124).

Referred pain from the sacroiliac joints is experienced in the posterior dermatomal areas of L5, S1 and S2; over the sacrum; or in the buttocks. Pain produced by pathologic changes in the anterior sacroiliac ligaments radiates into the anterior dermatomal areas of L1 and L3, particularly into the thigh region immediately below the groin (Gatterman, 1990: 115).

2.3.6.2 ASSOCIATED SIGNS:

Tenderness or pressure over the posterior superior iliac spine at the region of the sacroiliac joint or in the buttock. Movement of the joint is usually restricted (Kirkady-Willis and Burton, 1992 :124).

Pain is aggravated by provocation tests and restricted movements which stress the joint (Kirkady-Willis and Burton, 1992 :124 and McCulloch and Transfeld, 1997: 180) e.g.:

- Patrick Faber test (Haldeman, 1992: 218-220 and Magee, 1992: 343)
- Gaenslen’s test (Haldeman, 1992: 218-220 and Magee, 1992:319)
- Yeoman’s test (Haldeman, 1992: 218-220 and Schafer and Faye, 1990: 271)

A triangulation of the above sign as symptoms would indicate a sacroiliac syndrome.

2.4 SPINAL MANIPULATIVE THERAPY

Gatterman (1990: 49) describes spinal manipulative therapy as using specific short levers to which a high-velocity thrust of controlled amplitude is directed, with the aim of restoring mobility to individual articulations. This form of manual therapy moves a joint past its normal end range of motion but not past its anatomic range of motion and often results in an audible click or pop (Shekelle, 1994: 858).

Spinal manipulative therapy has been validated as a safe and 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).

2.4.1 INDICATIONS FOR SPINAL MANIPULATIVE THERAPY (SMT)

The primary indication for spinal manipulative therapy is a reversible mechanical derangement of the intervertebral and / or paravertebral (e.g. SI joints) joints that produces a barrier to normal motion. The movement restriction has been referred to as joint fixation, joint locking, or joint blockage that can be determined clinically by motion palpation and stress radiographs (Gatterman, 1990: 50/1).

Intraexaminer motion palpation for assessing lumbar motion with passive palpatory tests was confirmed by Jull and Bulllock (1987) as cited by Leach (1994: 129). Motion palpation is one of the most commonly used techniques by chiropractors for detecting a restricted motion segment, and has been shown to have good ‘face validity’ [i.e. the proposed measure seems to be a reasonable measure of the concept it intended to measure] (Walker and Buchbinder, 1997: 585-586). However, Panzer (1992:522), in his review of lumbar motion palpation demonstrated poor interexaminer reliability and good to moderate intraexaminer reliability. Similar results have been obtained for motion palpation of the sacroiliac joint (Herzog et al. 1989: 86 and Meinje et al. 1999:4). Panzer (1992: 523) and Hendler et al. (1995: 173) suggest that motion palpation be combined with multiple diagnostic tests to improve reliability.

2.4.2 THE EFFECTS OF SPINAL MANIPULATIVE THERAPY

Currently little is known about the specific effects of spinal manipulative therapy. The therapeutic effect of spinal manipulative therapy for low back pain has been explained on the grounds of mechanical and reflex mechanisms (Kirkady-Willis and Burton, 1992: 288), which are:

- The central transmission of pain can be blocked by increased proprioceptive input. The articular capsules of the spinal facet joints are densely populated by mechanoreceptors. These encapsulated nerve endings relay proprioceptive information on joint position and mobility through large myelinated fibers to the substansia gelatinosa of the dorsal horn of the spinal cord. These impulses then compete for central transmission with impulses from smaller unmyelinated pain fibers from adjacent tissues. Thus increased proprioceptive input in the form of spinal mobility tends to decrease the central transmission of pain from adjacent spinal structures.

  Restricted joint movement is increased by spinal manipulative therapy and therefore induces motion into articular structures that helps to inhibit pain transmission by means of closing the spinal gating mechanism within the substantia gelatinosa, i.e. manipulation causes an increase in proprioceptive input, which has a reflex inhibition on the transmission of pain (Kirkady-Willis and Burton, 1992: 288).

- Articular mechanoreceptor stimulation has also a reflexogenic effect on motor unit activity in the muscles over the joint being stimulated. Stretching the apophyseal joint capsules can reflexedly inhibit facilitated motoneuron pools that are responsible for the increased excitability, which results in muscular spasm that is commonly associated with low back pain (Kirkady-Willis and Burton, 1992: 288).

- Arthrogenic muscle inhibition (AMI) is 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 (Suter et al. 2000). Mechanoreceptor activity plays the primary role in AMI, which is a natural response, designed to protect a joint from further damage (Hopkins 2000). Muscle weakness has been attributed to AMI (Suter et al. 2000), this weakness results from the activity of many different mechanoreceptors within a joint, namely: Ruffini endings, Golgi-like endings and Pacinian corpuscles, as these mechanoreceptors act on inhibitory interneuron's, synapsing on the motor neuron (MN) pool of the joint musculature. The information from inhibitory interneuron’s decreases the ability of recruitment within the MN pool, and therefore decreases the force of any contraction stemming from that MN pool (Hopkins 2000). These mechanoreceptors are located in joint capsules, ligaments and tendons (Levangie and Norkin, 2001:71). Spinal manipulative therapy on a joint has been proposed to activate mechanoreceptors from structures in and around the manipulated joint. The altered afferent input arising from the stimulation of these receptors is thought to cause changes in the motor neuron excitability, with a subsequent decrease in AMI (William 1997: 144 and Suter et al. 2000). Suter et al. (1994) showed that the reflexogenic effects, which can facilitate motor unit activity, are only associated with a high velocity, low amplitude, manual thrust and not with slow applications of the same treatment force (mobilizations). Wyke (1985) noted that articular mechanoreceptor afferent nerve fibers give off collateral branches that are distributed both intersegmentally and segmentally. Therefore, spinal manipulative therapy of an individual joint amongst other affects the motor unit activity in the muscles operating over the joint being manipulated.

- There is a suggestion that spinal manipulative therapy may have an influence on the vasomotor tone of the neuromuscular structures via the autonomic nervous system (Kirkady-Willis and Burton, 1992: 288).

Additional effects of spinal manipulative therapy according to Calliet (1981: 129-130) are as follows:

- Spinal manipulative therapy may stretch or break intra-articular adhesions that form from immobilised facet joints due to acute synovial reactions.
- Spinal manipulative therapy allows entrapped menisci to exit the facet joint in which it became entrapped.
- If the capsule of the facet joint becomes lodged between two adjacent articular surfaces, the spinal manipulative therapy process allows this to be freed.
- The malaligned spinal segments are aligned to conform to the centre of gravity.

It is possible that several or all of these effects come into play when treating low back pain due to joint complex dysfunction with associated muscle syndromes by manipulation (Kirkady-Willis and Burton, 1992: 288).

Joint complex dysfunction is present in the lumbar facet and sacroiliac syndromes and the above explains why spinal manipulative therapy could be effective in the treatment of these syndromes (Kirkady-Willis and Burton, 1992: 122-126) The use if spinal manipulative therapy with emphasis on restoring joint mobility has been proven to be one of the most effective and cost effective approaches in the management of low back pain of a mechanical origin (Di

Fabio, 1992). In a critical review of related literature Di Fabio (1992) found studies demonstrating the efficacy of spinal manipulative therapy in treating low back pain. These studies showed particularly good symptomatic short-term relief of pain, flexibility, and disability status in the patient.

McMorland (2000) showed in a study of 199 patients, that spinal manipulative therapy resulted in an average of 52.5% and 52.9% reduction in low back pain and disability. This supported Panzer and Gatterman (1995:464), who stated that the treatment of choice for sacroiliac syndrome is specific spinal manipulative therapy directed at the sacroiliac articulation.

Shekelle et al. (1992) conducted a literature review of all the studies reporting the use of and complications of spinal manipulative therapy and of all controlled trials on the efficacy of spinal manipulative therapy. They concluded that spinal manipulative therapy hastens the recovery of acute uncomplicated low back pain, but its long term effect either in preventing the development of chronic or in preventing the recurrence of acute low back pain is unknown. Borenstein et al. (1995) stated that spinal manipulative therapy is only associated with transient relief, lasting hours. This is in contrast to Manga et al. (1993), who reviewed 28 randomised clinical trials and found that more than two thirds concluded that spinal manipulative therapy had significant beneficial outcomes in the treatment and management of low back pain, and more importantly the studies gave greater credibility to the effectiveness of spinal manipulative therapy

Manga et al (1993) is supported by Read (1995), who states that spinal manipulative therapy is most effective in the treatment of facet problems, but can also help small disc lesions and sacroiliac problems. He (Read, 1995) emphasises that spinal manipulative therapy is not the correct treatment for all back problems.

Literature therefore suggests that spinal manipulative therapy is an effective treatment for conditions such as facet and sacroiliac syndrome.

2.4.3 SIDE EFFECTS OF SPINAL MANIPULATIVE THERAPY

Leboeuf-Yde et al. (1997: 514) concluded the following:

1. Treatment reactions are common after spinal manipulative therapy, but they are benign and of short duration. Treatment reactions could be one or more of the following:
    a. Local discomfort in the area of treatment is the most likely type of reaction to occur (two-thirds).
    b. Less common reactions are fatigue, pain outside the area of treatment (about 10% each).
    c. Nausea, dizziness or ‘other’ reactions are uncommon (less than 5%).
2. Approximately half of all new chiropractic patients report at least one treatment reaction during the course of the treatment.
3. Treatment reactions appear soon after treatment (within a few hours to the next day), are mild and of short duration (gone within 48 hours).

PART: B

2.5 GOLF

2.5.1 INTRODUCTION

Back pain among the golfing population is considered endemic as a result of the adoption of the “modern” golf swing, which is considered to be a source of injury for both amateurs and professionals. The modern golf swing calls for restricted pelvic rotation and maximal torso rotation, which results in the generation of significant injury-promoting forces within spinal structures of the lumbar spine, as opposed to the classic swing of yesteryear which produced significantly less torsion on the back (Seaman, 1998:45).

Golfing literature has recommend to both amateur and professional golfers, to try and achieve a maximum ball distance with each golf club, thus encouraging golfers to use a state of maximal spinal rotation in their golf swing in order to achieve maximum ball distance (Seaman, 1998:46-51 and Bulbulian, Ball & Seaman, 2001,569-70). This maximum rotated position is considered ideal for developing optimal Club Head Velocity (CHV) (Seaman, 1998:46).

If one considers that CHV is primarily influenced by:

- the strength and power of the torso (low back and abdominal muscles) (Chek, 2003)
- muscle balance and flexibility, which are responsible for the static and dynamic postural stability of the golf swing (Chek, 2003)

it therefore stands to reason that low back pain, which has been identified as the most common problem affecting amateur golfers, will affect CHV. This is especially true when a golfers muscle balance and postural alignment are not optimal and there is disruption of motor command sequence, which increases the chance of orthopaedic injury (Chek, 2003).

2.5.2 THE GOLF SWING

It is critical that the clinical practitioner has a fundamental knowledge of normal swing mechanics and a working knowledge of the musculoskeletal requirements needed to swing a golf club in order to address low back pain (LBP) in golfers, as an understanding of the golf swing will aid in the understanding of the biomechanics behind low back injuries in golf.

However, the general injury profile for golf is problematic. Elite golfers differ from recreational golfers; male golfers differ from female golfers and senior golfers need their own special consideration; therefore injuries apparent in golfers are often further correlated to age, ability, amount of play, warm-up, and individual swing mechanics (Mackey, 1995: 10 and Grimshaw et al, 2002: 655/6), creating a diverse number of subfields that need to be considered.

2.5.2.1 THE CLASSIC GOLF SWING vs THE MODERN GOLF SWING

There are two types of golf swings (Seaman, 1998:45):

- the classic swing of yesteryear
    - The classic swing was characterised by considerable pelvic rotation in the backswing, which was made possible by lifting the heel of the front foot almost to the point at which only the toes made contact with the ground. This swing reduced the chance of injury by generating less torsion in the back.

- the ‘modern’ golf swing of today
    - The ‘modern’ golf swing is thought to be a source of injury for both amateur and professionals, as it is characterised by restricted pelvic rotation and maximal torso rotation, which results in the generation of significant injury-promoting forces within spinal structures.

2.5.2.2 THE BOIMECHANICS OF THE MODERN GOLF SWING

Please note that this discussion pertains only to right-handed golfers.

The golf swing is a complex movement that is composed of three phases:

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

(Mackey, 1995:10-11 and Seaman, 1998:47 and Grimshaw et al, 2002:658).
These will be individually discussed below.

PHASE ONE:

The take-away phase: is the initial phase of the golf swing.

This consists of the player :

1. Taking his grip of the golf club,
2. Taking his stance and
3. Aligning himself over the golf ball.

These factors above result in the static address position of a golf shot and have varying degrees of trunk (i.e. lumbar) flexion.

The player then begins his backswing and moves the club to the top of his backswing by rotating his shoulders, hips, knees, lumbar, and cervical spine while his head remains fixed. The player should always try and maintain his head in a fixed position throughout the golf swing to try and assure a proper trajectory.

At the top of the backswing the left arm will be perpendicular to the ground, the left thumb is hyperabducted, the left wrist is radially deviated, the right wrist is extended, the right shoulder is hyperabducted and the cervical and lumbar spines are hyperrotated (i.e. the upper thoracic spine and the back of the shoulders will point toward the target).

At this point maximal spinal rotation to the right will have been achieved by the golfer.

During the take-away phase of the club from the address position, (i.e. the start of the backswing) the left external oblique muscle is primarily responsible for the initial twisting of the trunk, with the activity of the external oblique muscle being directly proportional to the load on the lumbar spine. From this twisted position the player will strongly contract certain torso (in particular the right external oblique muscle) and shoulder muscles (latissimus dorsi, subscapularis, pectoralis major, supraspinatus, infraspinatus, teres minor and deltoid muscles) to initiate the next phase of the golf swing (i.e. the impact-phase).

PHASE TWO:

The impact-phase consists of two portions,

- The preimpact phase
    - From the top of the backswing to impact the muscles on the right side of the trunk (right external oblique) lead the swing. The right external oblique fires maximally during this phase. During this phase peak spinal loading coincides with peak muscle activity. When the obliques contract to produce rotation, they simultaneously cause flexion of the lumbar spine. During this downswing phase the left and right paraspinal muscles (particularly the multifidus muscle) contract nearly symmetrically reflecting their spine stabilizing action to oppose the lumbar flexion movement during the downswing phase of the golf swing (Hosea, Gatt and Gertner, 1994: 97-108). At preimpact the player begins contact with the ball. The players' right wrist is in maximum extension, the left thumb is hyperabducted, the left hip is rotated, and the right knee is in a position of valgus stress.

- The impact phase
    - At impact the players left wrist ulnar deviates, while the right wrist undergoes compression, the right knee is under valgus stress, and the left hip is rotated. Impact is when the player strikes the ball. The lumbar spine in this phase is subjected to peak muscle activity from the right external oblique and opposing paraspinal (ie. multifidus) muscles.

The lumbar spine has thus moved from a point of maximal rotation to the right, to a relatively neutral position in terms of spinal rotation at the impact phase, before proceeding to the follow-through phase which induces a maximal spinal rotation to the left and hyperextension of the lumbar spine.

PHASE THREE:

The follow-through phase is the final phase of the golf swing.

During this phase the players left elbow supinates, the right elbow pronates, the hip internally rotates and completes hip rotation, the knees rotate to the left, the left ankle everts, the left shoulder hyperabducts, and the cervical and lumbar spine rotate and hyperextend, while all of the players weight shifts from right to left.

The resultant follow-through or finish position is characterised by a right shoulder that points toward the target, (i.e. a position of maximal spinal rotation to the left). This finished position is referred to in golf as the reverse “C” position and is often characterised by hyperextension of the spine.

2.5.3 CLUB HEAD VELOCITY (CHV)

CHV is the speed at which the golf club head makes contact with the golf ball (i.e. swing speed), and is primarily influenced by the strength and power of the golf swing (Chek, 2003). It is during the downswing phase of the golf swing that CHV is generated (Stude and Glickson, 2000:173). Secondary factors that affect CHV include; muscle balance and flexibility, all of which affect static and dynamic postural stability (Chek, 2003).

Wiren (1990) as cited by Stude and Gullickson (2000: 168) identified five factors that influence golf ball flight:

- *club head velocity (this study only addresses CHV)*,
- club angle of approach,
- club face position,
- centerness of contact and
- golf fundamentals (eg. stance, grip, swing position and posture).

It has been assumed that that by strengthening the muscles used during the golf swing, more power will be generated and CHV will subsequently increase. However research has not been conducted to address this problem (Stude and Gullickson, 2000: 168).

Research at the United States Golf Association Technical Department demonstrated an approximate 1:3 relation (2.5 –yard increase in air travel of the golf ball for every 1-mph increase in CHV) between increase in CHV and subsequent driving distance (rounded to the nearest yard). However all balls have slightly different characteristics, and variables such as wind influences air travel distance. This relation suggests for every 1-mph increase in CHV, there is a subsequent three-yard increase in air travel distance (Stude and Gullickson, 2000: 173).

2.5.3.1 OPTIMISING CHV: “GOOD vs BAD”

To achieve a maximum ball distance with each golf club golfers attempt to use a state of maximal spinal rotation in their golf swing in order to achieve this maximum ball distance (Seaman, 1998:46-51 and Bulbulian, Ball & Seaman, 2001,569-70). This maximum rotated position is considered ideal for developing optimal Club Head Velocity (CHV) (Seaman, 1998:46).

McLean as cited by Bulbulian, Ball & Seaman (2001, 70) states “ to increase your differential and add power to your golf swing, you must turn your shoulders as far as possible while restricting the turn of your hips”.

The term known as “the X-factor” is used to describe the differential between the degree of shoulder turn and hip turn. Such a twisted position at the top of the backswing positions the golf club at least parallel to the ground is said to promote optimal CHV. Evidence however suggests that such a rotated and twisted backswing and follow-through position instead promotes injury (Seaman, 1998:47).

It has been reported by Neighbors (1996) as cited by Seaman (1998: 49) that the length of the backswing and the extent of torso rotation does not correlate with CHV at ball impact. A short backswing with minimal rotation provides a similar CHV and a more consistent CHV at ball impact than a long backwing with maximum torso rotation (Bulbulian, Ball & Seaman, 2001: 570). The results of the study by Bulbulian, Ball & Seaman (2001, 569-575) investigating *the short golf backswing* confirms previous reports that a shorter backswing does not significantly diminish CHV or stroke accuracy. The “X factor” or shoulder to hip “differential” promoted to establish an “optimal backswing” probably serves to increase the risk of injury to the spine. A short backswing is believed to prevent excessive spinal rotation in the lumbar spine and lower thoracic spine, which is limited by the sagittal orientation of the facets to allow a maximum 23º rotation of the spine. However there is no concrete data from Bulbulian, Ball & Seaman's study (2001) to support the suggestion that the shorter golf backswing results in a decreased spinal rotation, and it is unclear to what extent the reduced torques on the spine and trunk musculature may prevent injury in golf (Bulbulian, Ball & Seaman, 2001: 570-574).

It should also be pointed out that a shortened backswing may be back sparing, but it may be possible that increased loading and activation of shoulder musculature may increase the possibility of shoulder injury in the golfers, (i.e. a shortened backswing may demand increased muscle activity in the upper extremities). Thus a possibility of reduced risk for low back injury and pain may promote an increase risk for shoulder injury and pain (Bulbulian, Ball & Seaman, 2001: 574\5).

2.6 GOLF AND LOW BACK PAIN

2.6.1 EPIDEMIOLOGY

2.6.1.1 INCIDENCE AND PREVALENCE OF LOW BACK PAIN IN GOLFERS

It has been estimated that 62% of all golfers incur an injury directly related to their sport (Seaman, 1998:65). Low back pain has been identified as the most common musculoskeletal problem affecting amateur and professional golfers (Horton, Lindsay & Macintosh, 2001:1647 and Bulbulian, Ball & Seaman, 2001,569), with the most common cause of this lower back injury believed to be repetitive swinging, and in the case of amateurs poor swing mechanics are considered to be the second most frequent cause of injuries (Seaman, 1998:46). Surveys have shown between 27% and 36% of injuries sustained by amateur golfers and 63% by professional were to the low back area. This can be attributed to a professional golfers repetitive play and more consistent swing mechanics (Horton, Lindsay & Macintosh, 2001:1647 and Grimshaw et al, 2002:657) repetitively affecting the same area (low back).

Thus according to Mackey (1995:10-12), it is likely that joint complex dysfunction associated with myofascial trigger points is the main cause of back pain in golfers who are treated by both chiropractors and medical doctors, and at present time less than 2% of the golfing population seek chiropractic care for their golf related injuries (Seaman, 1998: 53).

In addition many golfers who have an acute episode of back pain will attempt to play anyway (Lett, 2002:62), which is especially true of professional golfers as 10-33% of touring golf professionals play while injured, with half the group likely to develop chronic problems (Bulbulian, Ball & Seaman, 2001,569). It has been found that except for compressive loads, professional golfers produce less spinal loads than amateur golfers (Lindsay and Horton, 2002:604). This is supported by research that has demonstrated, that in certain situations, amateurs may develop up to 80% more torque around their lumbar spine than professionals (Seaman, 1998:67). The low back, in addition to torsional and bending loads, must contend with significant lateral bending, shear, and compressive forces that in golf can generate peak loads of more than 8 times body weight in both amateurs and professionals (Bulbulian, Ball & Seaman, 2001,569).

2.6.2 SWING FACTORS PROMOTING LOW BACK INJURIES IN GOLF

The three phases of the golf swing result in hyper-rotation and hyperextension of the lumbar spine (Mackey, 1995:11-12). These movements produce a distinctly asymmetric trunk motion, involving a combination of left axial rotation and right lateral bending [in right-handed golfers] (Lindsay and Horton, 2002:604). It is well known that flexion-rotation movements, such of that in the golf swing, are the most common cause of back injury (Bulbulian, Ball & Seaman, 2001: 574). This is supported by Sugaya et al. (1999) as cited by Lindsay and Horton (2002: 600), when they concluded that both the repetitive and asymmetric nature of the golf swing contributed to low back pain and injury in elite golfers

Researchers have identified the downswing, rather than the backswing, as the key part of the golf swing during which most stresses and injuries occur (Lindsay & Horton, 2002:603). The downswing is likely to cause joint complex dysfunction due to the fact the left and right paraspinal muscles (particularly the multifidus muscle) contract nearly symmetrically reflecting their spine stabilizing action during the downswing phase of the golf swing (Hosea, Gatt and Gertner, 1994: 97-108), thus opposing the strong contractions of the right external oblique muscle, and reducing the lumbar spinal flexion caused by the contraction of the oblique muscles during the downswing phase (Seaman, 1998: 50). Repetitive strain and overload of the multifidus muscle has been linked to the formation of trigger points in the multifidi muscle group, which induces joint complex dysfunction involving two or three adjacent segmental levels (Simons, Travell and Simons,1999: 922-5).

Overuse and poor form during the follow-through phase is the most probable cause of lumbar facet joint injury. It is in the reversed "C" position that the lumbar facets approximate and torsional stress is placed on the intervertebral disc by rotation and hyperextension (Mackey, 1995:11). Morgan et al. (1997) as cited by Lindsay and Horton (2002: 599) used the term "crunch factor" to describe the instantaneous product of lumbar side bend angle and axial rotational velocity. They postulated a high crunch factor was damaging to the lumbar spine (i.e. during the impact phase), resulting in injury and pain. McCarrol as cited by Mackey (1995: 11) goes on to state that the reversed "C" position is essential for proper trajectory and solid impact, as well as leverage and accuracy. However many players exaggerate this position in order to achieve more power and distance when striking the golf ball.

Thus we can conclude it is likely that two mechanisms exists by which a facet syndrome can occur as a result of a golf swing. It seems that injury caused during the downswing phase is likely to be related to an increased stress and strain on opposing paraspinal (particularly the multifidus) muscles, and resultant joint complex dysfunction. Injury during the follow-through phase is likely to be a result of lumbar facet approximation and torsional stress placed on the intervertebral discs by rotation and hyperextension.

However, these two mechanisms can be related. The follow-through position, which involves rotation and hyperextension of the lumbar spine, may cause repetitive strain and shortening of the paraspinal muscles (ie. multifidus) muscle, and resultant joint complex dysfuntion adding to the repetitive muscle usage in the downswing placing more load on the facet joints.

2.6.3 GOLFERS WITH LOW BACK PAIN

2.6.3.1 LUMBAR SPINAL MOTION: IN RELATION TO THE "MODERN GOLF SWING"

The purpose of pelvic and spinal rotation is to place the upper extremities in an optimal position to deliver an effective golf swing. There is a large degree of movement in flexion and extension, however rotation of the lumbar spine is limited by the sagittal orientation of the facets. Spinal rotation begins at the lumbosacral junction, and is limited to 0º-2º for the L5-S1 joint and from L5-L1 rotation is limited to 1º-3º per level (Mackey, 1995: 11 and Seaman, 1998: 49).

In a case study by Grimshaw et al. (2002: 655-666), looking at lower back injuries in golf, they reviewed a 32 year old, 7 handicap patient with a 10 year history of low back pain and found that during palpation and examination of the lumbar spine there was clear evidence of hypomobility of the lower three vertebral levels together with marked spasm of the lumbar extensors bilaterally. Movement of the lumbar spine was further restricted by stiffness into flexion and rotation, and limited into extension and side flexion. In addition rotation in the thoracic \ lumbar spine was significantly restricted.

In a study by Lindsay and Horton (2002: 599-605) comparing spinal motion in elite golfers with and without low back pain, they found that the golf swing maximum rotation angles did not vary between the two groups, but maximun rotation range of motion was more restricted in the group with low back pain. This resulted in these players using a relative "supramaximal" rotation of their spine when swinging, which could contribute to ongoing irritation of the spinal structures and shoulder musculature. There were no differences in peak "crunch factors" observed for the trunk region between golfers with and without low back pain (Lindsay and Horton, 2002: 603). Those golfers with low back pain tended to address the ball with considerably more spinal flexion than the controls. Since increased flexion is associated with increased lumbar disc pressure and risk of injury, this difference in set up posture could contribute to aggravation of low back pain and degeneration in the long term. In their study pain free golfers demonstrated twice as much flexion velocity on the downswing (Lindsay and Horton, 2002: 603). McTeigue et al. (1994) as cited by Lindsay and Horton (2002: 603), also observed considerable changes in spinal flexion during the downswing of elite professional golfers. One explanation could be that powerful anterior trunk muscle contractions on the downswing may cause an initial posterior tilting of the pelvis and apparent increase in localized spinal flexion rather than true flexion of the entire trunk. If this is the case, it is possible that golfers without low back pain may use their anterior trunk muscles more on the downswing than golfers with low back pain (Lindsay and Horton, 2002: 603). Another possible explanation would be the inability of the multifidi muscles to counteract the flexion moment induced by the abdominal muscles due to the presence of myofascial trigger points (as a result of overload to the muscle) or due to the fact that the multifidi muscles acting as splints for injured facet joints therefore resulting in its inability to perform its normal functions (Simons, Travell and Simons,1999: 922-5).

Further to this, the left side bend (which occurs during the backswing of right-handed golfers) was significantly greater for golfers suffering from low back pain (Lindsay and Horton, 2002: 603).

2.6.3.2 MUSCLE INVOLVEMENT

The golf swing is a very complex movement that involves a considerable amount of trunk rotation and powerful muscular contractions. Although many different muscle groups contribute to the initiation and completion of the golf swing, the abdominal muscles are known to contribute considerably to the generation of power during the acceleration phase of the golf swing. The right side abdominal muscles are particularly active during the rotation of the trunk in the downswing / acceleration and impact phases of the golf swing (in right-handed golfers). The golf swing also produces a significant degree of right-side lateral bending during the impact phase. The generation of axial torque coupled with lateral bending is produced by synergistic activity of various trunk muscles; namely right and left external oblique and paraspinal (i.e. multifidus) muscles (Horton, Lindsay and Macintosh, 2001: 1647).

Due to the repetitive nature of the game it is possible that muscular fatigue could develop during a typical game or practice session. A lack of endurance of the these trunk muscles appears to be a significant risk factor in the development and occurrence of chronic low back pain (Horton, Lindsay and Macintosh, 2001: 1647). McGill (1998) as cited by Horton, Lindsay and Macintosh (2001: 1647), believes that endurance of the trunk muscles may be more important than strength alone. Weakening of the trunk muscles because of fatigue is particularly relevant if the type of movement performed involves rapid repetitive movement of the extremities [which typifies the golf swing] (Hodges and Richardson, 1999).

Both the abdominal and low back muscles, the right and left external oblique and paraspinal (i.e. multifidus) muscles work together to contribute to the rotation of the trunk and stability of the spine. The abdominal muscles however tend to fatigue more easily than the low back muscles, especially in individuals with chronic low back pain (Sugaya et al, 1999). Trunk muscle coordination may be compromised by muscle fatigue and result in decreased trunk stability and increased risk of injury to the lower back (O'Brien and Potvin, 1997).

Evans and Oldrieve (2000) as cited by Lindsay and Horton (2002: 603) reported that golfers with low back pain have a reduced ability to maintain a static contraction of the transverse abdominus muscles and it is unclear whether this translates to differences in golf swing activity patterns. However, conditioning of the transverse abdominus muscle has an important role in the control and maintenance of spinal stability during the golf swing and is a more efficient spinal stabilizer than the larger more phasic erector spinae and abdominal muscles (Grimshaw et al. 2002: 660). The transverse abdominus and multifidus muscles have been found to be related through a co-contraction pattern. Recruiting muscles in co-contraction is considered to provide support and joint stabalisation even when contractions occur at low levels of maximun voluntary contraction (Richardson and Jull, 2000). Therefore it would seem likely that a decreased conditioning of the transverse abdominus muscle could cause an increased workload on the multifidus muscle.

Pink et al. (1993) as cited by Horton, Lindsay and Macintosh (2001: 1652) investigated trunk muscle activity during the golf swing using amateur players and concluded that the abdominal muscles were very active during what they considered the forward swing, acceleration (i.e. backswing) and early follow-through phases. Further to this Watkins et al. (1996) as sited by Horton, Lindsay and Macintosh (2001: 1652) believed the trunk muscles are important as stabilizers of the lumbar spine during the golf swing and speculated that trunk muscle activity patterns might be different in injured golfers than in uninjured golfers.

In the study investigating *abdominal muscle activation of elite male golfers with chronic low back pain* by Horton, Lindsay and Macintosh (2001: 1652), they showed that it was possible to measure external and internal oblique muscles independently during the golf swing. The predominant activity of the lead (left) external oblique during the backswing is consistent with the fiber orientation and function of this muscle (i.e. right axial rotation). Conversely, the fiber orientation of the lead internal oblique is more suited to the downswing direction (i.e. left axial rotation).

Horton, Lindsay and Macintosh (2001: 1652), concluded that activation patterns of different parts of the abdominal musculature during the golf swing were consistent with that which would be expected, considering the fiber orientation of the oblique muscles and the direction of rotation movement. Significant differences in external oblique muscle activity onset times between asymptomatic and chronic low back pain subjects therefore suggests inappropriate recruitment of these abdominal muscles in chronic low back subjects during the golf swing.

Thus, given the important functional contribution of the trunk muscles (i.e. the right and left external oblique and paraspinal [multifidus] muscles) during the golf swing and that trunk muscle coordination may be compromised by muscle fatigue and result in decreased trunk stability and increased injury risk, it stands to reason that poor conditioning and / or weakness of abdominal muscles could predipose to spinal overload (muscular and osseous) and spinal injury.

2.6.4 THE PROPOSED MECHANISM OF INJURY

Overuse in association with the asymmetrical nature of the golf swing is also thought to create abnormal repetitive stresses on the lumbar spine, which might lead to injury and pain (Horton, Lindsay and Macintosh, 2001:1647). Because of the repetitive nature of the game, golfers are prone to low back injuries such as facet syndrome (Mackey, 1995:11). Therefore with the repetitive stress and loading of the golf swing, an abnormal asymmetrical load is placed onto the articular structures of the lumbar spine. This abnormal load could then lead to articular damage with repetitive use resulting in joint complex dysfunction and therefore mechanical low back pain (Mackey, 1995:11).

2.6.4.1 MECHANISM OF JOINT COMPLEX DYSFUNCTION IN THE GOLFER

2.6.4.1.1 "THE DOWNSWING": THE ROLE OF THE MULTIFIDUS MUSCLE IN THE DEVELOPMENT OF JOINT COMPLEX DYSFUNCTION AND LOW BACK PAIN

The role of the multifidus in rotation of the lumbar spine is not to produce rotation, but to oppose the flexion effect of the abdominal muscles as they produce rotation. Thus the golf swing, particularly during the downswing phase, places a tremendous burden on the multifidus muscle ((Hosea, Gatt and Gertner, 1994: 97-108 and Seaman, 1998:50) and therefore also the lumbar spine especially, if the abdominal muscles have an abnormal recruitment pattern based on fatigue due to overuse.

The attempt, by the golfer, to achieve maximal spinal rotation is probably the main cause of spinal injury in golfers, because powerful contraction of the external oblique during the downswing phase produces tremendous loads on a spine that has been forced into a backswing position of maximal spinal rotation. (Seaman, 1998:50).

The overload of the multifidus has been linked to the formation of trigger points in the multifidi muscle group, which induces a joint complex dysfunction involving two or three adjacent segmental levels. It has been emphasised that symptoms caused by multifidus can mimic those of lumbar facet or sacroiliac syndromes, by causing a segmental motion block and resultant joint complex dysfunction.

2.6.4.1.2 "THE FOLLOW-THROUGH"

In the reversed-C position (rotation and hyperextension of the lumbar spine), the lumbar facets approximate, and in addition torsional stress is placed on the intervertebral disc. With repetitive practice swings and incorrect form, the lumbar facets bear the brunt of the abnormal forces being placed on the lumbar spine (Mackey, 1995: 11). Trauma results in posterior joint strain and with repetitive small capsular tears, a small degree of joint complex dysfunction takes place and as the posterior joint synovium is injured, leading to inflammation synovitis (Gatterman and Goe, 1990, Mense, 1991 and Dvorak, 1985).

The posterior segmental muscles protecting the joint maintain a sustained hypertonic contraction in order to prevent further motion (Korr, 1975). As a result of the sustained contraction, the muscle becomes ischaemic, which causes pain, and metabolites accumulation in the muscle, both of which initiate a pain cycle, which sustains the hypertonic state of contraction. Therefore the posterior joints continue to be splinted and the minor joint complex dysfunction is maintained. Because of the muscles maintaining their contracted state, the joint complex dysfunction of the facet joint is maintained, thus leading to a facet syndrome. These changes later lead to fibrosis and / or ankylosis (Kirkady-Willis and Burton, 1992:105).

Once spinal injury occurs as a result of the golf swing, a pathological process ensures that involves inflammation, nociception, and pain, all of which reduce joint mobility (Gatterman and Goe, 1990, Mense, 1991 and Dvorak, 1985).

Research has demonstrated that 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 and chronic pain (Seaman, 1998: 46/7).

2.6.4.2 KORR'S MODEL

According to the Korr model, focus is on the muscle spindle as the coordinator that may increase or decrease muscle contraction according to the direction of motion of the joint. The reflex muscle contraction can then produce joint motion by its action or prevent joint motion in an area of segmental dysfunction (Leach,1994:98-9).

In Korr's (1975) hypothesis the central nervous system (CNS) orders skeletal muscle contraction (which carries with it "low-gain" gamma motorneuron activity). At the same time vertebral attachments are suddenly approximated (by external forces or loads) which result in slackening of the muscle spindles, and thereby silencing annulospiral and flowerspray activity. Without annulospiral or flowerspray report, the CNS assumes that the gamma motor "gain" is not set high enough for the primary receptor endings to transmit the impulses for the contraction. The CNS then turns up the "gain" to compensate, increasing the gamma motor activity, which results in increased fusiform activity, and the muscle is contracted further. As the body recoils from the forced motion, and the vertebral attachments attempt to return to their normal position, they are now opposed in this by the resistant muscle. The joint surfaces are now approximated and increased frictional resistance prevents normal motion within the affected motion unit (Korr, 1975).

Gravity and postural reflexes tend to stretch the muscles to resting length, and the joint receptors continue to report their true position. The “high gain” activity causes the muscle to resist, and the muscle is in “spasm”. Afferent input could be expected to create segmental facilitation at this level of segmental dysfunction and perpetuate the condition (Leach, 1994:98-9).

Korr (1975) therefore proposed two mechanisms whereby manipulation would successfully turn down the fusimotor “gain” and thereby relax the muscle spasm.

- First, by stretching the intrafusal fibers by forcefully stretching the muscle against it spindle-maintained resistance would produce a barrage of afferent impulses intense enough to signal the CNS to reduce the gamma motorneuron discharge.

- Second, the Golgi tendon organs would be stimulated by forced stretch of the skeletal muscle causing both gamma and alpha motorneuron inhibition.

Korr (1975) predicted that both the slow-range-of–motion, long-lever and the rapid, high-velocity-short-lever type of spinal manipulative therapy would be successful in stretching the muscles against their resistance (Leach, 1994:98-9).

2.6.6 THE INFLUENCE OF SPINAL MANIPULATIVE THERAPY ON LUMBAR KINEMATICS IN GOLFERS

In a case study by Lehman and McGill (1999:576-581), they looked at the influence of spinal manipulative therapy on lumbar kinematics and found that after single rotary manipulations (at the same level), that the golf swing increased in all total range of motion for each plane of movement after the adjustment, with concomitant muscle responses (i.e. relaxation). They used full 3-dimensional analysis of spine kinematics. Lehman and McGill (1999:576-581) assessed the influence of spinal manipulative therapy on lumbar spine kinematics about all three axes, (i.e. flexion-extension, lateral bend and axial twist). Instead of using simple static tasks (i.e. about one plane or axis of motion), which may overlook motion about the other two axes, they used the golf swing as a more complex motor control task to better elucidate the short-term influence of spinal manipulative therapy on spinal motion. This was assessed because it was possible that the total effects of spinal manipulative therapy on spinal motion could be overlooked in simple one-axis motions, as apposed to a complex task such as that of the golf swing. The total effects of spinal manipulative therapy on spinal motion would not be manifested until a complex task was assessed, that required a large amount of coupled motion with the integration of kinaesthetic components.

This single case study (Lehman and McGill, 1999:576-581), proved that documenting just a single axis of motion, may overlook clinically significant changes after spinal manipulative therapy in a subject's lumbar kinematics. Lehman and McGill (1999) also stated that simple movement tasks may not reveal all kinematic changes caused by spinal manipulative therapy. As related to the golf swing and the complex motor task, there were changes most evident in the transverse and frontal planes during peak flexion, as well as in all planes of movement. It was also found that complex motor tasks, (i.e. golf swing), in which a great number of biological variables need to be coordinated to effect movement, demonstrated greater changes in muscle activity after spinal manipulative therapy compared with simple task movements (Lehman and McGill, 1999:579-581).

Complex tasks involving greater interaction among neural control and kinaesthetic elements and anatomic factors may be necessary to elucidate the possible effects that spinal manipulative therapy may produce in the muscoluskeletal system and the influence of an spinal manipulative therapy may not be seen during the majority of simple movement tasks because the muscles dysfunction (spasm) may be buried under the necessary activation required for movement (Lehman and McGill, 1999:579-581).

Therefore improved movement / flexibility according to Lindsay and Horton (2002:604) should be the primary aim of players with low back pain, particularly trunk rotational flexibility, to reduce their symptoms and decrease the effects of repetitive strain. The management of facet syndrome in athletes is no different than it is for the rest of the public and corrective spinal manipulative therapy should be used to relive areas of joint dysfunction (Mackey, 1995: 12).

2.7 CONCLUSION

Back pain among the golfing population is considered endemic (Seaman, 1998:45). Golfing literature recommends to both amateur and professional golfers to try and achieve a maximum ball distance with each golf club and to use a state of maximal spinal rotation in their golf swing in order to achieve this maximum ball distance (Seaman, 1998:46-51 and Bulbulian, Ball & Seaman, 2001,569-70). This maximum rotated position is considered ideal for developing optimal Club Head Velocity (CHV) (Seaman, 1998:46).

CHV is the speed at which the golf club head makes contact with the golf ball (i.e. swing speed). It is during the downswing phase of the golf swing that CHV is generated (Stude and Glickson, 2000:173). A relation of a 1-mph increase in CHV is approximately proportional to a three-yard increase in air travel distance of the golf ball (Stude and Gullickson, 2000: 173).

Further it has been reported by Neighbors (1996) as cited by Seaman (1998: 49) that the length of the backswing and the extent of torso rotation does not correlate with CHV at ball impact (Bulbulian, Ball & Seaman, 2001: 570). But there is no concrete data to support that a shorter golf backswing results in decreased spinal rotation (Bulbulian, Ball & Seaman, 2001: 570-574). In a study by Lindsay and Horton (2002: 599-605) comparing spinal motion in elite golfers with and without low back pain, they found that the maximum rotation range of motion was more restricted in the group with low back pain. This resulted in these players using a relative “supramaximal” rotation of their spine when swinging, which could contribute to ongoing irritation of the spinal structures.

The golf swing is a very complex movement that involves a considerable amount of trunk rotation and powerful muscular contractions. Although many different muscle groups contribute to the initiation and completion of the golf swing, the abdominal muscles are known to contribute considerably to the generation of power during the acceleration phase / downswing of the golf swing (Horton, Lindsay and Macintosh, 2001: 1647). Researchers have identified the downswing, rather than the backswing, as the key part of the golf swing during which most stresses and injuries occur (Lindsay & Horton, 2002:603). The role of the right external oblique in the downswing (in right handed golfers) is to initiate rotation. The downswing particularly places stress and strain on the multifidus muscle, where the role of the multifidus in rotation is not to produce rotation, but to oppose the flexion effect of the abdominal muscles as they produce rotation. Thus the golf swing, particularly during the downswing phase, necessarily places a tremendous burden on the multifidus muscle and the lumbar spine as well (Hosea, Gatt and Gertner, 1994: 97-108). Trigger points in the multifidi are more likely to induce articular dysfunction and it has been emphasised that symptoms caused by multifidus can mimic those of lumbar facet or sacroiliac syndromes, causing a segmental motion block (Simons, Travell and Simons, 1999: 922-5). Thus this could be a possible cause of joint complex dysfunction in the golfer.

The follow-through phase is characterised by the reversed “C” position (rotation and hyperextension of the lumbar spine). In this position the lumbar facets approximate and in addition torsional stress is placed on the intervertebral disc. With repetitive practice swings and incorrect form, the lumbar facets bear the brunt of the abnormal forces being placed on the lumbar spine (Mackey, 1995: 11). This over time could lead to joint complex dysfunction of the facet joint.

Thus the attempt to achieve maximal spinal rotation is probably the main cause of spinal injury in golfers (Seaman, 1998:50), because powerful contractions of the external oblique muscle during the downswing phase, or the hyperextension and rotation of the lumbar spine during the follow-through phase produces tremendous loads onto the spine that has already been forced into a backswing position of maximal spinal rotation.

According to the Korr model, focus is on the muscle spindle as the coordinator that may increase or decrease muscle contraction according to the direction of motion of the joint. The reflex muscle contraction can then produce joint motion by its action or prevent joint motion in an area of joint complex dysfunction (Leach,1994:98-9). Korr (1975) predicted that both the slow-range-of–motion, long-lever and the rapid, high-velocity-short-lever type of spinal manipulative therapy would be successful in stretching the muscles against their resistance (Leach,1994:98-9).

Lehman and McGill (1999:576-581) looked at the influence of spinal manipulative therapy on lumbar kinematics and found that after single rotary manipulations (at the same level), that the golf swing increased in all total range of motion for each plane of movement after the adjustment, with concomitant muscle responses (i.e. relaxation).

Improved movement / flexibility according to Lindsay and Horton (2002:604) should be the primary aim of players with low back pain, particularly trunk rotational flexibility, to reduce their symptoms and decrease the effects of repetitive strain. The use if spinal manipulative therapy with emphasis on restoring joint mobility has been proven to be one of the most effective approaches in the management of low back pain of a mechanical origin (Di Fabio, 1992).

At the present time, less than 2% of the golfing population seeks chiropractic care for their golf related injuries. This is unfortunate because golfers represent a population with spinal problems, such as muscular strains and joint complex dysfunction, that responds to chiropractic care (Seaman, 1998:53).

It may be that one does not require a maximum spinal rotation to achieve an optimal CHV, however there is the suggestion that the word “maximum” spinal rotation should be replaced with the word “optimal” rotation. The essence of this is that one should try to allow for a back-friendly golf swing.

Thus this study is concerned with the immediate effects of spinal manipulative therapy on CHV in amateur golfers suffering from mechanical low back pain.

CHAPTER THREE: MATERIALS AND METHODS

3.1 INTRODUCTION

This chapter is concerned with the study design, the subjects, methods employed in data collection, methodology and interventions used in this study. A brief explanation of the statistical methods used for interpretation of the data is also provided in this chapter.

3.2 STUDY DESIGN

This study was a Pre Post Quasi-experiment with clinical intervention that investigated the immediate effect of spinal manipulative therapy on CHV in terms of subjective and objective clinical findings in amateur golfers suffering from mechanical low back pain.

3.3 SUBJECTS

The proposed sample size was forty participants. Participants for this study were referred from advertisements primarily at golf clubs, pro shops and driving ranges (Appendix H), and by word of mouth.

Prospective participants underwent a brief telephonic interview to assess their suitability for the study prior to their being accepted for a consultation.

The following questions were asked during the telephonic interview:

- Do you presently have low back pain that is related to playing golf?
- Are you male and between the ages of 23 to 35 years old?
- Are you currently being treated for your low back pain?
- Have you ever had surgery for your low back pain before?
- Can you commit to a consultation at the The Pro Shop for the study, intervention and CHV analyses?
- Are you an Amateur golfer? Participants have 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? Participants who have an official handicap have to play golf on a more regular basis in order to maintain their handicap.

The nature of the study was also explained to them at this point. All subjects who were telephonically compatible and wished to take part in the study were required to schedule an appointment with the researcher at The Pro Shop for further assessment to determine a diagnosis of mechanical low back pain. Consecutive convenience sampling was used. Golfers with official handicaps were considered before those without a handicap. This was due to the rationale that handicaped golfers would have a more consistent golf swing in terms of biomechanics, and thus produce more consistent results.

3.4 THE DATA

3.4.1 THE PRIMARY DATA

The primary data was obtained directly from the patients and consisted of:

- A Case History (Appendix A)
- Physical Examination (Appendix B)
- Low Back Regional Examination (Appendix C).
- The Numerical Pain Rating Scale (NRS) (Appendix F).
- Non-digital Algometer Reading (Appendix D).
- Specific diagnosis and objective evaluation of mechanical low back pain syndromes included; Kemp's test, Facet Challenge test, Sacroiliac (SI) Percussion test and Yeomans test (Appendix D).
- Roland-Morris Disability Questionnaire (RMQ)(Appendix E).
- Objective data was taken from The Golf Achiever "Laser" Swing Analyzer to determine CHV (Appendix D).

3.4.2 THE SECONDARY DATA

The secondary data was obtained from various sources of related literature, including journal articles, textbooks and the Internet.

3.5 INCLUSION AND EXCLUSION CRITERIA

3.5.1 INCLUSION CRITERIA

- No subject younger than 23 or older than 35 years was considered. Kirkady-Willis and Burton (1992:4) 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.
- Subjects suffering from mechanical low back pain in the Dysfunctional Phase of low back pain, incorporating lumbar facet syndrome and/or Sacroiliac Syndrome. (Kirklady-Willis and Burton, 1992:121/2).
- Subjects had to be male in order to create homogeneity within the study group.

3.5.2 EXCLUSION CRITERIA

- Contraindications to spinal manipulation that included; Vascular complications (including Abdominal Aortic Aneurysms), Tumours, Bone infections, Traumatic injuries, Arthritides, Psychological overlay and Neurological complications (including Cauda Equina Syndrome, Disc lesions and Nerve root damage) (Gattermann, 1990:55-68)
- Subjects on anti-inflammatory drugs or medication (Poul et al, 1993) [48 hour clearance period].
- Patients that were currently receiving treatment for mechanical low back pain
- Illiterate patients
- Patients undertaking any specific lower back exercise during the study, above and beyond normal exercise/ playing/practice routines.

3.6 ETHICAL CONSIDERATIONS

- All participants in the study participated voluntarily and there was no involved financial benefit.
- Participants were supplied with a patient information sheet informing them of the study and the procedures that were to be administered.
- Informed consent was obtained from each participant.
- The rights and welfare of the participants were protected.
- Participants were exposed to minimal risk in the research.
- Confidentiality was maintained.
- The participants were free to withdraw from the study at any time.

3.7 METHODOLGY

During the consultation at The Pro Shop, the participants were provided with a letter of information (Appendix G), and an informed consent form(Appendix I). All participants were required to read the letter of information and sign the informed consent form. This was to establish an understanding for the participants partaking in the study in order protect their interests and to make sure that they understood the research completely. The participants could then question any area of concern.

3.7.1 CLINICAL ASSESSMENT

At the consultation a case history (Appendix A), physical examination (Appendix B) and regional low back examination (Appendix C) were then performed at The Pro Shop by the researcher. This was to assess for any conditions that may exclude the participant from the study. The researcher was accompanied at The Pro Shop by a supervisor from the Durban Institute of Technology Chiropractic Day Clinic.

During the orthopaedic low back regional examination the following assessments were performed in order to make a diagnosis of mechanical low back pain:-

1. To standardise the extent of the clinical diagnosis of mechanical low back pain the following clinical tests were used; Kemp,s test, Facet Challenge test, Sacroiliac (SI) Percussion test and Yeoman's test (Riggien 2003). (Appendix D).
2. Kemp's test and Facet challenge tests would indicate a Facet Syndrome. SI percussion and Yeoman's tests would indicate a SI Syndrome. Kemp's test and Yeoman's test are the most specific and sensitive of the above tests (Riggien, 2003). Therefore Kemps and Yeoman's tests will have a rating of 2 out of 3. The Facet challenge test and SI percussion will have a rating of 1 out of 3. A participant would therefore have needed to have a rating of 3 out of 3 for either facet or sacroiliac syndrome in order to participate in the study.
3. The most symptomatic joints were identified by motion palpation of the lumbar spine and sacroiliac joints prior to intervention (Schafer and Faye, 1990:211-217, 256-259). Motion palpation was used to identify the segments in the lumbar spine and sacroiliac joints with restricted and/or abnormal motion (Schafer and Faye, 1989:211-216). Motion palpation is used 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).

3.7.2 CLUB HEAD VELOCITY (CHV) PROCEDURE

Due to this study being a Pre Post Quasi-experiment with a clinical intervention, a baseline reading of each subjects CHV will have to be made. The analyses of the CHV will be made using a Golf Achiever “Laser” Swing Analyzer (Appendix K).

The Golf Achiever “Laser” Swing Analyzer was used on the premises of The Pro Shop golf shop that is situated at the Value Centre in Springfield, Durban. The Pro Shop had agreed to work with the researcher for the duration this study (Appendix J).

The design protocol for the actual hitting of the golf balls for this research has been adapted from similar past research ideas. It has however been changed to suite the requirements of this study.

At The Pro Shop once the subjects were ready to participate in the study they 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, 2000:169). The participants were not shown or instructed to warm up or stretch in a particular way. They were told to hit 10 warm-up golf balls and stretch as they would normally if they were going to practice or play golf. This non-intervention approach to the warm-up would allow for a more accurate and specific simulation of the subjects golfing habits. Thus allow for a better chance to note any changes in CHV after there had been clinical intervention.

The 7-iron golf club used in the study was the same for all participants. The 7-iron used was a Callaway TM Big Bertha X16. This was fitted with a regular flex shaft. A regular flex shaft was chosen because it would accommodate the majority of the golfers used in the study, ie it would not be too flexible or too stiff and offered the greatest consistency for standardization purposes, thus allowing for minimal discrepancy between the participants.

The balls used in the study were TopFlite XL3000 balls. They were supplied by The Pro Shop. The same ball was used throughout the research process to allow for standardization and consistency.

Participants once they had completed their warm-up were instructed to hit a specified number of golf balls (5) for "maximal distance" (Bulbulian, Ball and Seaman, 2001:570) to determine an average CHV. Once the average CHV had been established the participants in the group then underwent clinical intervention as the consultation and clinical findings had established.

- This experimental group were treated using spinal manipulative tharapy. This spinal manipulative tharapy involved a left-to-right or a right-to-left lateral recumbent (Lehman and McGill, 1999:577) or seated spinal manipulation, or spinal manipulative tharapy outlined by Schafer and Faye (1989: 283,284). Seated spinal manipulative tharapy was considered because the position of the set up is similar to that of the address position a golfer uses when addressing to strike a golf ball. Ie, hyper-rotation and hyperextension of the lumbar spine (Mackey, 1995:11-12).

Directly after the participants had received their clinical intervention they were required to repeat the procedure that determined their average CHV. ie. they were instructed to hit 5 more golf balls for "maximal distance". Before determining there final CHV average they were allowed a 3 minute rest period for recovery which is sufficient to prevent fatigue from affecting the outcome (MacIntosh, Rishaug and Svedhal, 2002:574). Thus this allowed us to see any immediate and significant changes in CHV.

To assess the immediate effects and any significant changes one would to have to assess the participant, treat the participant and then reassess the same data directly after intervention (Cowie 2003). “Very short term” or immediate effects are measured within 6 hours of intervention (Farahat et al, 2003). According to Engle and Graney (2000) immediate effects occur within the first 24 hours of intervention. Webbe and Barth (2003) defined “short term” as 5 – 10 days. Therefore we can assume that the immediate effect is sooner.

In order to maintain accurate data collection from the study the researcher did not watch the participants during their warm-up or during their CHV average determining procedure. This would aid the data collection procedure by attempting to minimalize the Hawthorne effect (Mouton and Marais, 1994:86-89). According to the Hawthorne effect if the researcher was to watch the participants in the study it could influence the their performance knowing that they are being watched by the researcher. Thus the researcher was absent during their warm-up and during their CHV average determining procedure.

3.7.3 DATA COLLECTION PROCEDURE

All subjective and objective data collection took place pre and post intervention. The Roland Morris Questionnaire (RMQ) data was captured at the pre intervention stage only. Anecdotal data was obtained at post intervention and after data collection.

3.7.3.1 SUBJECTIVE DATA

- The **Numerical Pain Rating Scale (NRS)** (Appendix F) was used to assess the participants' perception of their pain intensity. The participant was required prior to treatment to indicate the intensity of their pain by means of a percentage from 0 to 100, where zero represents 'no pain' and 100 represents 'pain as bad as it could get'. The average between these two percentages is an indication of the participants' pain level. Jensen *et al.* (1986) states that the NRS is a superior and reliable method of rating pain intensity. Bolton and Wilkinson (1998) stated that the results of their study of three well-established pain measures to detect changes in pain levels in patients following chiropractic treatment indicated that the NRS was easy to use and was sensitive to the pain levels as the more complicated measures.

- The **Roland Morris Questionnaire (RMQ)** was used. This is a commonly utilized shorter scale that is well established and a reliable instrument used for measuring spinal disability. 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 (Yeomans, 2000: 70-71). The scoring system consists of one point per circled item giving a maximum total of 24. The statements in this questionnaire primarily focus 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).

- Anecdotal data included comments from the participants on how they felt during their golf swing once they had received spinal manipulative therapy.

3.7.3.2 OBJECTIVE DATA

- A **non-digital algometer** was used to assess the tenderness of the most symptomatic facet and/or sacroiliac joint(s). This instrument measures the number of kilograms the patient can withstand before complaining of pain. This measurement is taken in kilograms per square centimetre (kg/cm^2) and is taken by placing the rubber tip over the symptomatic facet and/or sacroiliac joint. 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). (Appendix D)

- Objective data will be taken from **The Golf Achiever "Laser" Swing Analyzer** to determine the CHV. This device measures CHV as well as several other options for the golfer (Appendix K). For the purpose of this study CHV was of main concern and was measured in miles per hour (mph). A distance recording was also taken with the corresponding CHV for each shot and was measured in yards (yds). Accuracy was also a factor that was recorded subjectively off the computerised simulation of each golf shot. A shot was regarded as being accurate if the simulated ball path fell within computerised markers on the computer screen. These markers simulated a "fairway" on a typical golf hole. The Golf Achiever "Laser" Swing Analyzer is a computerised swing analyser that uses laser technology. How this works is:
    - The player simply takes their golf shot off the Golf Achiever mat. Laser beams are shot across the mat where critical swing points are measured. The data is processed instantaneously after each shot on the Golf Achiever software.

- Further objective measurements were obtained through the following orthopaedic tests to establish a rating scale for the facet and/or sacroiliac syndrome.

These tests included:

Lumbar facet tests:

Kemp’s test: This test is designed to place the facet joints under maximum stress. This involves a combination of lateral flexion and extension over the facet joints while the patient is seated (Giles 1997:346). The examiner reaches around the patients shoulder’s from behind and laterally bends, rotates and extends the patient to the right and then to the left while applying an axial force. Pain in the lumbar region or pain localised over the particular facet joint indicates a positive test (Corrigan and Maitland, 1998: 35 and Gatterman, 1990:141).

Facet Challenge test: This test is conducted with the patient lying prone. A posterior to anterior force is applied on each spinous process of the lumbar vertebrae, to ‘spring’ or approximate each joint. The examiner places one thumb on the spinous process above and one on the spinous process below. The force is applied horizontally in opposite direction. A positive test is indicated by pain over the joint being tested (Gatterman, 1990:84).

Sacroiliac tests:

Sacroiliac (SI) Percussion test: SI percussion test would indicate a SI Syndrome (Riggien, 2003; Vizniak and Carnes, 2004).

Yeoman's test: This test is conducted with the patient lying prone. The examiner stabilizes the pelvis over the crest of the ilium on the affected side by pressing downwards with their hand whilst grasping the thigh above the knee of the test leg and pulling the hip into extension. A positive test is characterised by pain over the sacroiliac joint (Magee, 1992:320 and Schafer and Faye 1990:271).

3.8 STATISTICAL ANALYSIS OF DATA

Intra–group analysis consisted of a combination of both Parametric and Non-Parametric testing. Various correlation statistics where utilised in order to high light possible relationships between the various factors analysed and compared.

Statistical analysis where performed using the SPSS package. Summary statistics have been utilised to present all relevant data in the following chapter.

All data analysis was all done at 95% level of confidence, if significance was found at level, a 99% level of confidence was run in order to ascertain whether the significance could be pegged at a higher level.

3.9 SUMMARY

Forty amateur golfers suffering from mechanical low back pain, which included facet and/or sacroiliac syndrome were selected for the study.

The group all received spinal manipulative therapy, and each patient was assessed in terms of objective and subjective clinical findings. All the necessary data was obtained for statistical analysis.

CHAPTER FOUR: RESULTS

Statistical Analysis of the subjective and objective data obtained from the subjects who participated in this study.

ABBREVIATIONS USED IN DATA ANALYSIS AND DISCUSSION:

CHV/CHVEL - club head velocity
GRP - group
PRACC - pre accuracy
PSACC - post accuracy
MPH - miles per hour
YDS - yards
KG - kilograms
M - meters
NDA - non-digital algometer
NRS - numerical pain rating scale
L - lumbar vertebra
SI - sacroiliac
RMQ - Roland Morris Questionnaire
PREB - pre best
PREW - pre worst
PRED - pre difference
PSTD - post difference
PRVEL - Pre velocity
PRDIS - Pre distance
PSVEL - Post velocity
PSDIS - Post distance
KEMPRE - Kemp’s test pre
KEMPOS - Kemp’s test post
FCTPRE - Facet challenge pre
FCTPST - Facet challenge post

SCPPRE - Sacroiliac percussion pre
SCPPST - Sacroiliac percussion post
YEOPRE - Yeoman’s test pre
YEOPST - Yeoman’s test post

4.1 INTRODUCTION

i) DATA LAY OUT

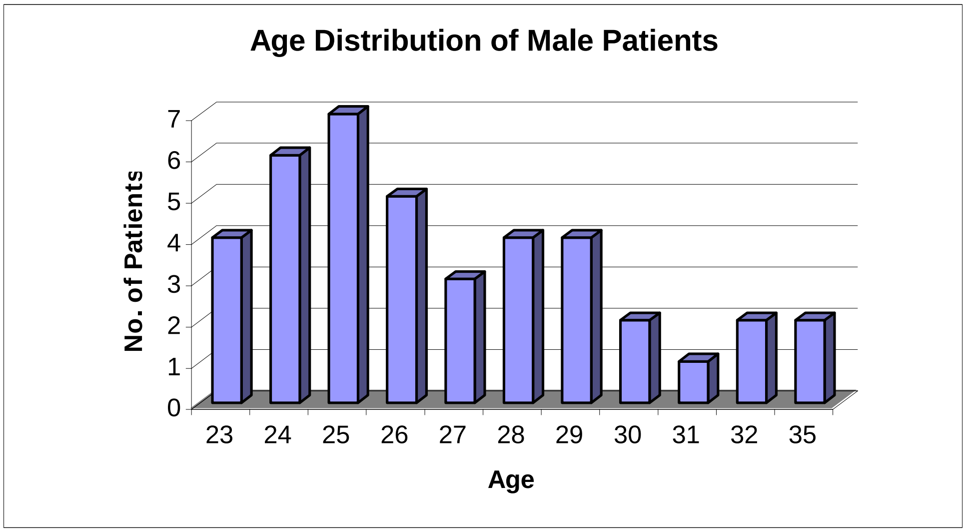
The following information was collected for each of 40 male amateur golfers, with the ages of the group ranging from 23 to 35.

- General information e.g. age, weight (kg), height (m), handicap, rounds of golf per week and number of practice sessions per week.
- Information relating to discomfort/pain experienced before and after spinal manipulative therapy.
- Club head velocity (CVH), [measured in mph] and distance [measured in yds], (of shots) achieved before and after spinal manipulative therapy.

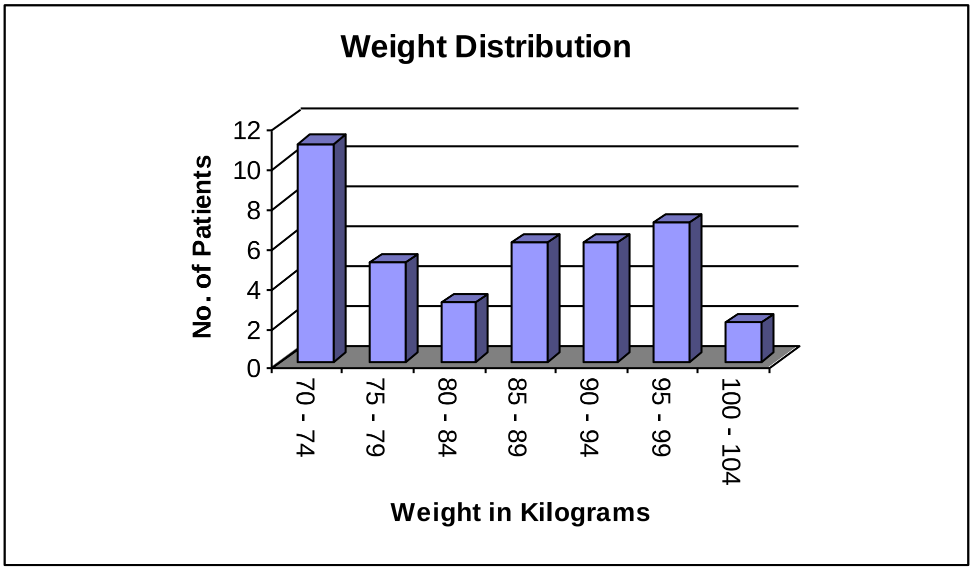
The purpose of the analysis is to compare the immediate golf performance/discomfort before and after spinal manipulative therapy.

4.1.2 DEMOGRAPHIC DATA

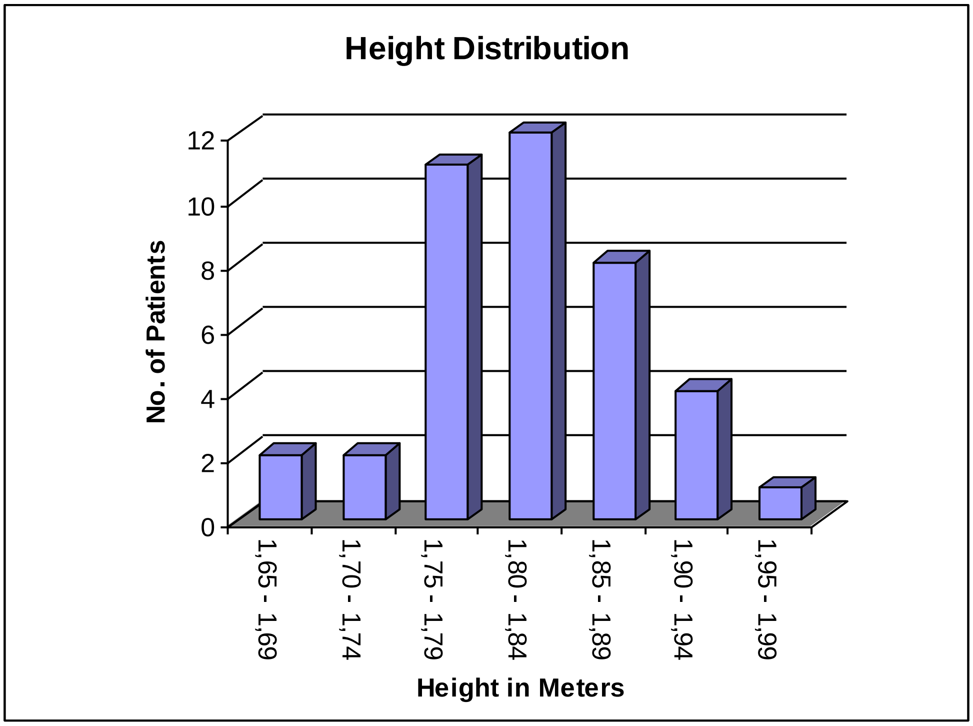
4.1.2.1 Figure A: Age distribution (Average age of a participant: 26,9)



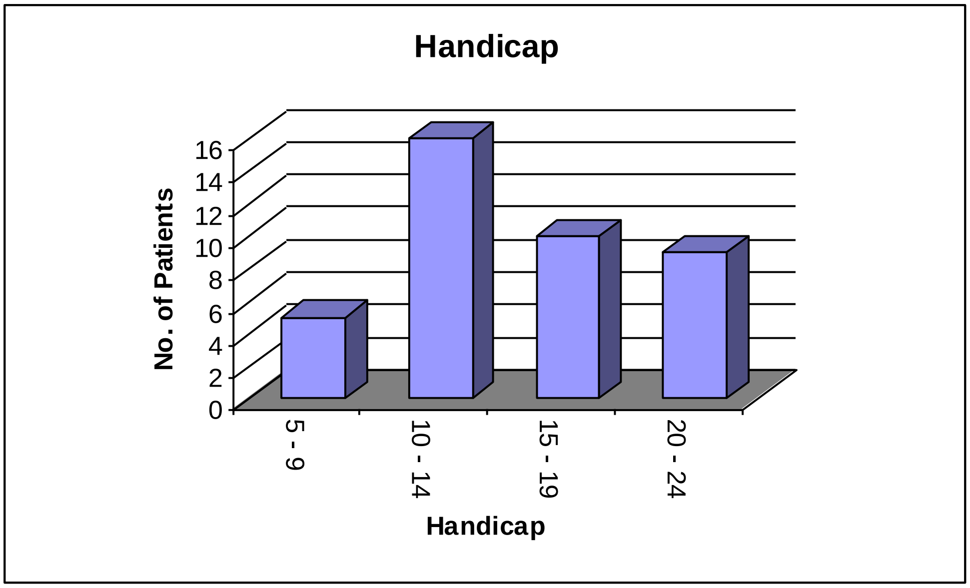
4.1.2.2 Figure B: Weight distribution (Average weight of participant: 84,5kg's)



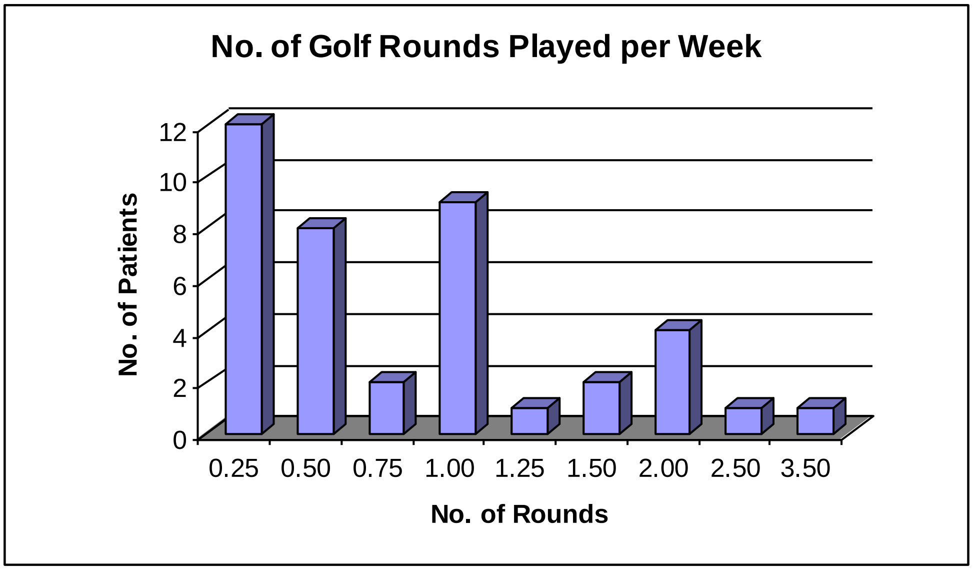
4.1.2.3 Figure C: Height distribution (Average height of a participant: 1,80m)



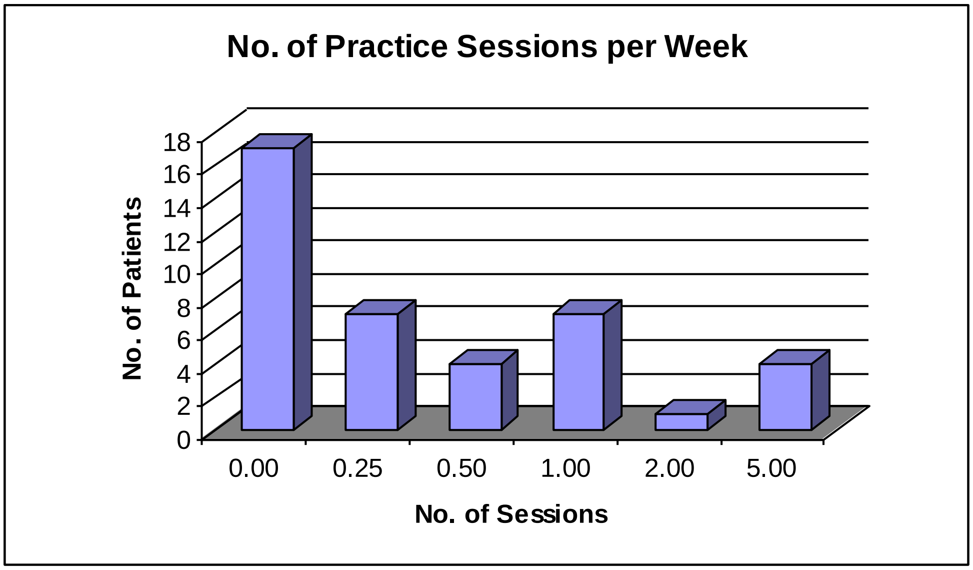
4.1.2.4 Figure D: Handicap distribution (Average height of a participant: 15,1)



4.1.2.5 Figure E: Number of golf rounds played per week:(Average per participant: (0.9)



4.1.2.6 Figure F: Number of golf practice sessions per week:(Average per participant: 0.8)



4.2 DATA ANALYSIS

4.2.1 COMPARISON OF CLUB HEAD VELOCITY (CHV) BEFORE AND AFTER SPINAL MANIPULATIVE THERAPY

A repeated measures analysis of variance (ANOVA**)** of velocity, with shots the within-subjects factor and group (before spinal manipulative therapy or after spinal manipulative) the between-subjects factor, was carried out. The relevant results of the analysis are shown in table 1 and figures 1(a) and 1(b).

Table 1 – ANOVA tables for tests concerning club head velocity (CHV)

Tests of Within-Subjects Effects

Measure: CHVEL

Source		Type III Sum of Squares	Df	Mean Square	F	Sig.
Shots	Sphericity Assumed	266.815	4	66.704	3.597	.007
	Greenhouse-Geisser	266.815	3.755	71.058	3.597	.008
	Huynh-Feldt	266.815	4.000	66.704	3.597	.007
	Lower-bound	266.815	1.000	266.815	3.597	.062
SHOTS * GROUP	Sphericity Assumed	41.015	4	10.254	.553	.697
	Greenhouse-Geisser	41.015	3.755	10.923	.553	.686
	Huynh-Feldt	41.015	4.000	10.254	.553	.697
	Lower-bound	41.015	1.000	41.015	.553	.459
Error(Shots)	Sphericity Assumed	5786.170	312	18.545		
	Greenhouse-Geisser	5786.170	292.881	19.756		
	Huynh-Feldt	5786.170	312.000	18.545		
	Lower-bound	5786.170	78.000	74.182		

Tests of Between-Subjects Effects

Measure: CHVEL
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	2321356.960	1	2321356.960	13464.317	.000
GROUP	681.210	1	681.210	3.951	.050
Error	13447.830	78	172.408		

Mean velocity : Before spinal manipulative therapy = 74.875

After spinal manipulative therapy = 77.485

Figure 1 (a) – Graph of mean velocity (CHV) per shot

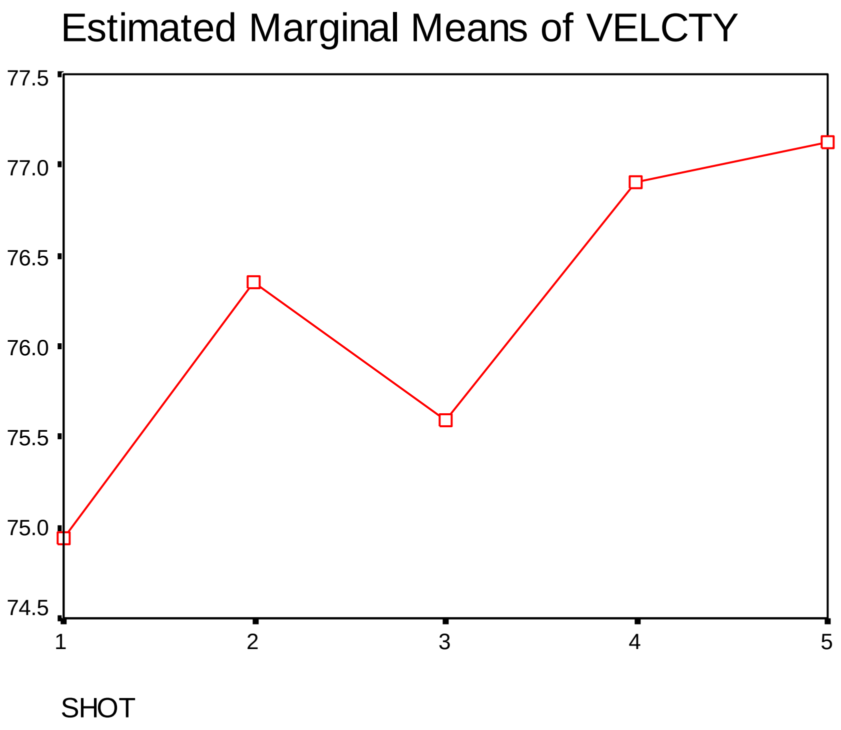
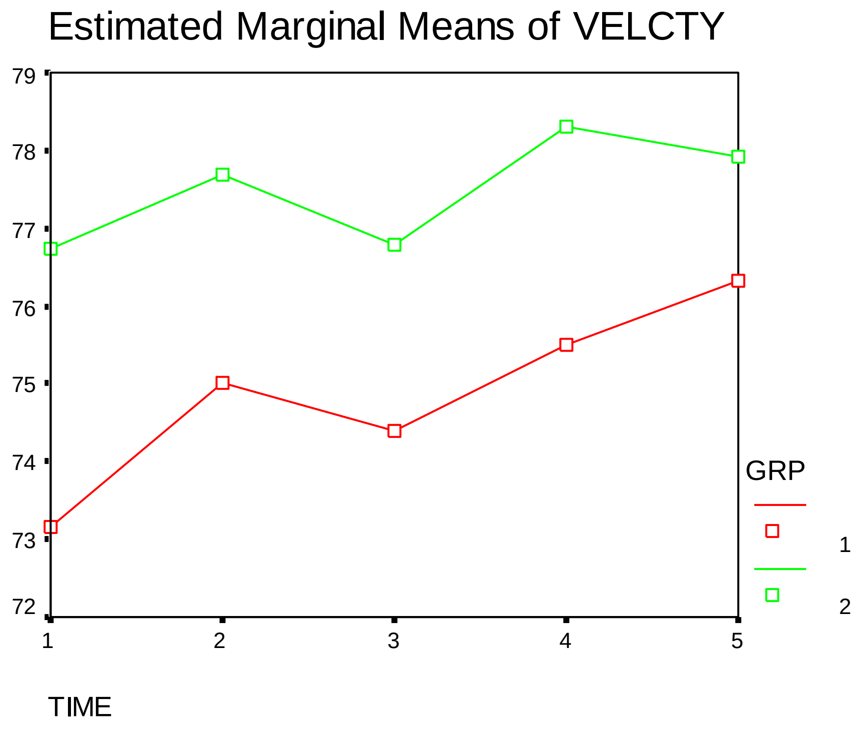


Figure 1 (b) – Graph of mean velocity (CHV) per shot for the two groups



GRP 1 – Before spinal manipulative therapy
GRP 2 – After spinal manipulative therapy

The mean club head velocity after spinal manipulative therapy is higher than that before spinal manipulative therapy. Figures 1 (a) and 1(b) show that the club head velocity increases with the number of shots. Figure 1(b) shows the separate plots of the means for group 1 (before spinal manipulative therapy) and group 2 (after spinal manipulative therapy). It can be seen that the plot patterns for the 2 groups are the same i.e. there is no interaction effect between the 2 groups.

4.2.2 COMPARISON OF DISTANCE BEFORE AND AFTER SPINAL MANIPULATIVE THERAPY

A repeated measures analysis of variance (ANOVA) of distance, with shots the within-subjects factor and group (before spinal manipulative therapy or after spinal manipulative therapy) the between-subjects factor, was carried out. The relevant results of the analysis are shown in table 2 and figure 2.

Table 2 – ANOVA tables for tests concerning distance

Tests of Within-Subjects Effects

Measure: DISTANCE

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
SHOT	Sphericity Assumed	1513.150	4	378.287	3.220	.013
	Greenhouse-Geisser	1513.150	3.380	447.678	3.220	.019
	Huynh-Feldt	1513.150	3.597	420.683	3.220	.017
	Lower-bound	1513.150	1.000	1513.150	3.220	.077
SHOT * GROUP	Sphericity Assumed	1128.300	4	282.075	2.401	.050
	Greenhouse-Geisser	1128.300	3.380	333.817	2.401	.061
	Huynh-Feldt	1128.300	3.597	313.688	2.401	.057
	Lower-bound	1128.300	1.000	1128.300	2.401	.125
Error(SHOT)	Sphericity Assumed	36652.950	312	117.477		
	Greenhouse-Geisser	36652.950	263.640	139.027		
	Huynh-Feldt	36652.950	280.557	130.643		
	Lower-bound	36652.950	78.000	469.910		

Tests of Between-Subjects Effects

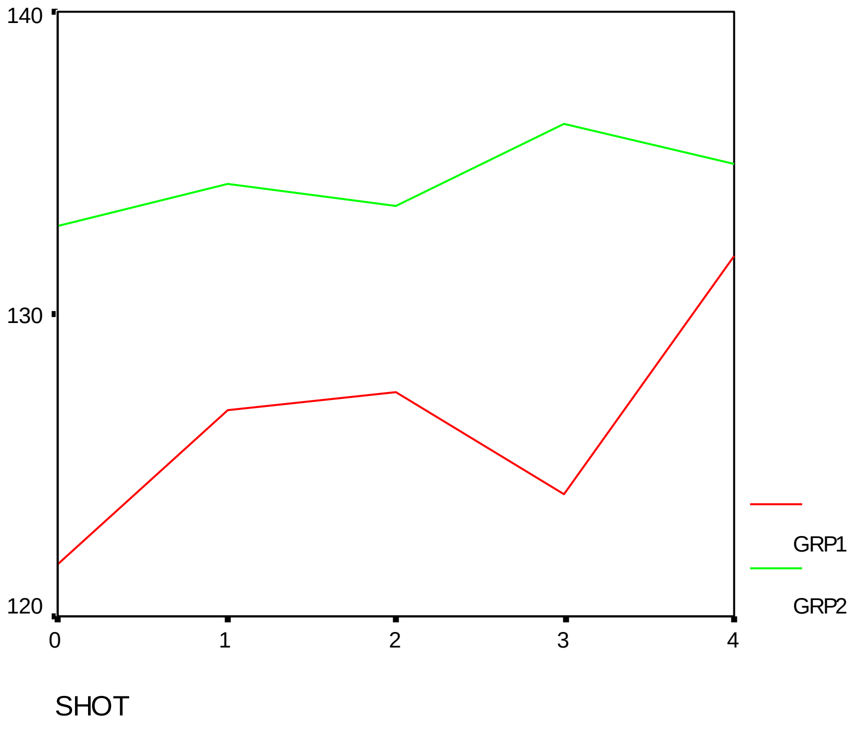
Measure: DISTANCE
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	6802968.063	1	6802968.063	7473.844	.000
GROUP	6440.063	1	6440.063	7.075	.009
Error	70998.475	78	910.237		

Mean : Before spinal manipulative therapy = 126.4

After spinal manipulative therapy = 134.425

Figure 2 – Plots of mean distance per shot for pre and post-manipulation shots



(please note: 0 denotes the first shot on the x- axis)

GRP1 – pre-spinal manipulative therapy

GRP2 – post-spinal manipulative therapy

The distance achieved after spinal manipulative (group 2) is higher than that before spinal manipulative therapy (group 1). The within-subjects effects ANOVA table shows a significant interaction between shots and groups. For both the groups (before and after spinal manipulative therapy) the distance increases with an increase in the number of shots, but for the before spinal manipulative therapy group this increase is greater than for the after spinal manipulative therapy group (see figure 2).

4.2.3 COMPARISON OF ACCURACY BEFORE AND AFTER SPINAL MANIPULATIVE THERAPY

Table 3 below shows no change after spinal manipulative therapy in 26 cases, an increase in accuracy in 13 cases and a decrease in only 1 case. It is clear from this information and the highly significant chi-square value that overall there is an improvement in accuracy after spinal manipulative therapy.

Table 3 – Cross tabulation and chi-square calculation of pre and post spinal manipulative therapy accuracy

PRACC * PSACC Crosstabulation

Count

		PSACC			Total
		3	4	5	
PRACC	2	0	0	1	1
	3	0	3	0	3
	4	1	3	9	13
	5	0	0	23	23
Total		1	6	33	40

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	24.336(a)	6	.000
Likelihood Ratio	22.293	6	.001
Linear-by-Linear Association	9.235	1	.002
N of Valid Cases	40		

a) 10 cells (83.3%) have expected count less than 5. The minimum expected count is .03.

4.2.4 COMPARISON OF NDA BEFORE AND AFTER SPINAL MANIPULATIVE THERAPY

The NDA before and after spinal manipulative therapy are highly correlated (correlation coefficient = 0.761). The post-nda mean is 1.3 units higher than the pre-nda one. This indicates that the subjects are less sensitive to pain after spinal manipulative therapy. The post- spinal manipulative therapy mean is significantly higher than the pre- spinal manipulative therapy mean (t-statistic = 6.181 with a p-value of 0.0000).

4.2.5 RELATIONSHIPS BETWEEN VELOCITY (CHV), DISTANCE, ACCURACY, PAIN SENSITIVITY AND HANDICAP

4.2.5.1 VELOCITY (CHV) AND DISTANCE

The table below shows the correlations between the velocity (CHV) and distance variables.

Table 4 – Correlations between pre and spinal manipulative therapy velocities (CHV) and distances

Correlations

		PRVEL	PSVEL	PRDIS	PSDIS
PRVEL	Pearson Correlation	1	.816(**)	.848(**)	.704(**)
	Sig. (2-tailed)	.	.000	.000	.000
	N	40	40	40	40
PSVEL	Pearson Correlation	.816(**)	1	.727(**)	.797(**)
	Sig. (2-tailed)	.000	.	.000	.000
	N	40	40	40	40
PRDIS	Pearson Correlation	.848(**)	.727(**)	1	.852(**)
	Sig. (2-tailed)	.000	.000	.	.000
	N	40	40	40	40
PSDIS	Pearson Correlation	.704(**)	.797(**)	.852(**)	1
	Sig. (2-tailed)	.000	.000	.000	.
	N	40	40	40	40

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

Table 4 shows that velocity and distance are strongly positively correlated. This means that the higher (lower) the club head velocity, the higher (lower) the distance achieved. There is also a moderately strong positive correlation (0.677) between the club head velocity movement (post score – pre score) and the distance movement (post score–pre score).

4.2.5.2 VELOCITY (CHV), DISTANCE, PAIN SENSITIVITY AND HANDICAP

A stepwise regression was performed on distance before and after spinal manipulative therapy. The results are shown in table 5.

Table 5(a) – Results of a stepwise regression performed on distance (before spinal manipulative therapy)

ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5590.765	1	5590.765	97.409	.000(a)
	Residual	2180.995	38	57.395		
	Total	7771.760	39			

a Predictors: (Constant), PRVEL

b Dependent Variable: PRDIS

Coefficients(a)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-15.686	14.446		-1.086	.284
	PRVEL	1.898	.192	.848	9.870	.000

a Dependent Variable: PRDIS

Table 5(b) – Results of a stepwise regression performed on distance (after spinal manipulative therapy)

ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4085.386	1	4085.386	66.272	.000(a)
	Residual	2342.549	38	61.646		
	Total	6427.935	39			

a Predictors: (Constant), PSVEL

b Dependent Variable: PSDIS

Coefficients(b)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-12.450	18.085		-.688	.495
	PSVEL	1.896	.233	.797	8.141	.000

a Dependent Variable: PSDIS

The results in tables 5(a) and 5(b) show that of the variables considered only club head velocity (not handicap or resistance to pain) can be used to predict distance.

4.2.5.3 RELATIONSHIP BETWEEN ACCURACY AND VELOCITY (CHV), DISTANCE, HANDICAP AND PAIN SENSITIVITY

Accuracy is not related to any of the other variables. The reason for this is that virtually all the accuracy figures are 4 or 5 (36 out of 40 for the pre manipulation group and 39 out of 40 for the post manipulation group). Since the other variables vary considerably more, a wide range of values for other variables apply to a 4 or 5 accuracy score and therefore are not related to accuracy.

4.2.6 RELATIONSHIP BETWEEN THE SITE OF PAIN, MOVEMENT AND VELOCITY (CHV)

4.2.6.1 VERTEBRAE – VELOCITY (CHV)

Five different vertebrae sites of pain (denoted L1 to L5) and two types of movements (denoted E[extension] and LPA[left posterior to anterior]) were identified. Velocity before spinal manipulative therapy was classified into 4 categories (category 1 – less or equal to 69.9, category 2 – 70 to74.9, category 3 – 75 to 79.9, category 4 – 80 or more). The velocities after spinal manipulative therapy were also classified into 4 categories, but with each "after" category an amount of 2.5 (difference between before and after means) higher than the corresponding "before" category. Each movement was classified as restricted (yes) or not restricted (no). For each of the 40 combinations of sites with velocity categories, a count of the number of "yes" and "no" classifications were recorded. Table 6(a) is a summary of these counts for the velocity before spinal manipulative therapy and table 6(b) a summary of the counts for the velocity after spinal manipulative therapy.

Table 6(a) – Counts for vertebrae pain and velocity (CHV) before spinal manipulative therapy

Velocity category

		1		2		3		4	
	Restriction	yes	no	yes	no	yes	no	yes	no
Site	Movement type								
L1	E	6	0	10	4	10	0	7	3
	LPA	1	5	5	9	5	5	6	4
L2	E	4	2	10	4	10	0	6	4
	LPA	1	5	6	8	5	5	7	3
L3	E	0	6	0	14	0	10	1	9
	LPA	3	3	2	12	2	8	4	6
L4	E	1	5	0	14	0	10	0	10
	LPA	6	0	14	0	8	2	8	2
L5	E	1	5	0	14	0	10	0	10
	LPA	4	2	10	4	7	3	9	1

Best fitting log-linear model : Interaction effect (site * movement * restriction) and main effect (velocity).

Chi-square = 31.03331

p-value = 0.9980

Table 6(b) – Counts for vertebrae pain and velocity (CHV) after spinal manipulative therapy

Velocity category

		1		2		3		4	
	Restriction	yes	no	yes	no	yes	no	yes	no
Site	Movement type								
L1	E	7	1	9	0	13	4	4	2
	LPA	2	6	2	7	8	9	5	1
L2	E	6	2	7	2	12	5	5	1
	LPA	3	5	2	7	8	9	6	0
L3	E	0	8	0	9	0	17	1	5
	LPA	3	5	2	7	4	13	2	4
L4	E	1	7	0	9	0	17	0	6
	LPA	8	0	8	1	15	2	5	1
L5	E	1	7	0	9	0	17	0	6
	LPA	5	3	8	1	12	5	5	1

Best fitting log-linear model : Interaction effect (site * movement * restriction) and main effect (velocity).

Chi-square = 27.54277

p-value = 0.9997

The best fitting model is the same for the pre and post spinal manipulative therapy velocities. The variables site, movement and restriction affect each other but not velocity. The type of interaction between these 3 variables can be seen from the following marginal table.

Table 7 – Marginal counts for vertebrae pain

Site	L1		L2		L3		L4		L5	
Movement type	E	LPA	E	LPA	E	LPA	E	LPA	E	LPA
restriction										
yes	33	17	30	19	1	11	1	36	1	30
no	7	23	10	21	39	29	39	4	39	10

From the above table it can be seen that

- At sites L1 and L2 the type E movement is more restricted than the type LPA movement
- At sites L4 and L5 the type E movement is virtually unrestricted, while the type LPA movement is considerably restricted.
- At site L3 the type E movement is virtually unrestricted, while the type LPA movement is unrestricted to lesser degree.

4.2.6.2 VERTEBRAE – DISTANCE

The data layout is the same as that for velocity. The distances before spinal manipulative therapy were classified into 4 categories (category 1 – less or equal to 114.9, category 2 – 115 to 124.9, category 3 – 125 to 134.9, category 4 – 135 or more). The distances after spinal manipulative therapy were also classified into 4 categories, but with each “after” category an amount of 8 (difference between after and before means) higher than the corresponding “before” category. Tables 8(a) and 8(b) are summaries of the counts for the various categories.

Table 8(a) – Counts for vertebrae pain and distance before spinal manipulative therapy

Distance category

		1		2		3		4	
	Restriction	yes	no	yes	no	yes	no	yes	no
Site	Movement type								
L1	E	7	1	10	3	7	1	9	2
	LPA	3	5	4	9	3	5	7	4
L2	E	6	2	10	3	6	2	8	3
	LPA	2	6	7	6	3	5	7	4
L3	E	0	8	0	13	0	8	1	10
	LPA	3	5	3	10	1	7	4	7
L4	E	1	7	0	13	0	8	0	11
	LPA	8	0	12	1	7	1	9	2
L5	E	1	7	0	13	0	8	0	11
	LPA	5	3	10	3	5	3	10	1

Best fitting log-linear model : Interaction effect (site* movement * restriction) and main effect (distance).

Chi-square = 15.46397

p-value = 1.0000

Table 8(b) – Counts for vertebrae pain and distance after spinal manipulative therapy

Distance category

		1		2		3		4	
	Restriction	yes	no	yes	no	yes	no	yes	no
Site	Movement type								
L1	E	6	1	9	1	11	2	7	3
	LPA	3	4	2	8	7	6	5	5
L2	E	5	2	8	2	11	2	6	4
	LPA	4	3	1	9	8	5	6	4
L3	E	0	7	0	10	0	13	1	9
	LPA	2	5	4	6	1	12	4	6
L4	E	1	6	0	10	0	13	0	10
	LPA	7	0	9	1	11	2	9	1
L5	E	1	6	0	10	0	13	0	10
	LPA	5	2	7	3	10	3	8	2

Best fitting log-linear model : Interaction effect (site * movement * restriction) and main effect (distance).

Chi-square = 23.01776

p-value = 1.0000

As for the case of velocity, the variables site, movement and restriction affect each other but not distance. The marginal counts will be the same as those shown in table 7 and the comments on the nature of the interaction the same as before.

4.2.6.3 SI JOINTS - VELOCITY (CHV)

One of two responses (“yes” for restricted movement or “no” for unrestricted movement) was recorded for each of the two sides (left and right) of SI joints, two different types of movement (flexion and extension) and two locations (upper and lower). The categories of velocity were defined as described under 4.2.6.1. The tables 9(a) and 9(b) below show a summary of the counts for the various categories for the “before” and “after” manipulation experiments.

Table 9(a) – Counts for SI joints movements and velocity (CHV) before spinal manipulative therapy

			Velocity category							
			1		2		3		4	
		Restriction	yes	no	yes	no	yes	no	yes	no
Side	Movement	Location								
Right	Flexion	Upper	6	0	13	1	8	2	9	1
Right	Flexion	Lower	0	6	2	12	0	10	1	9
Right	Extension	Upper	3	3	7	7	6	4	8	2
Right	Extension	Lower	0	6	0	14	0	10	0	10
Left	Flexion	Upper	3	3	10	4	6	4	5	5
Left	Flexion	Lower	0	6	0	14	0	10	0	10
Left	Extension	Upper	1	5	5	9	1	9	1	9
Left	Extension	Lower	0	6	0	14	0	10	0	10

Best fitting log-linear model : Interaction effects (location * side, location * movement, restriction* side, restriction * movement, restriction * location) and main effect (velocity)

Chi-square = 14.21129
p-value = 1.0000

Table 9(b) – Counts for SI joints movements and velocity (CHV) after spinal manipulative therapy

			Velocity category							
			1		2		3		4	
		Restriction	yes	no	yes	no	yes	no	yes	no
Side	Movement	Location								
Right	Flexion	Upper	8	0	8	1	14	3	6	0
Right	Flexion	Lower	0	8	1	8	1	16	1	5
Right	Extension	Upper	4	4	3	6	12	5	5	1
Right	Extension	Lower	0	8	0	9	0	17	0	6
Left	Flexion	Upper	4	4	7	2	9	8	4	2
Left	Flexion	Lower	0	8	0	9	0	17	0	6
Left	Extension	Upper	3	5	1	8	3	14	1	5
Left	Extension	Lower	0	8	0	9	0	17	0	6

Best fitting log-linear model : Interaction effects (location * side, location * movement, restriction* side, restriction * movement, restriction * location) and main effect (velocity)

Chi-square = 16.61286

p-value = 1.0000

Since the number of subjects in the study are fixed the location * side and location * movement interactions are not considered. The table below shows a cross classification of the interactions involving restriction.

Table 10 – Marginal totals involving restriction, side, movement and location

	Side		Movement		Location	
	Right	Left	Flexion	Extension	Upper	Lower
Restriction						
yes	63	32	63	32	92	3
no	97	128	97	128	68	157

From the above table it can be seen that

- Movement on the right side is more restricted than on the left side.
- Flexion movement is more restricted than extension movement.
- Movement in the upper location is far more restricted than in the lower section.

4.2.6.4 SI JOINTS - DISTANCE

The variables and data layout are the same as for the velocity data. The distance categories are described in 4.2.6.2. The tables 11(a) and 11(b) below show a summary of the counts for the various categories for the “before” and “after” spinal manipulative therapy data.

Table 11(a) – Counts for SI joints movements and velocity (CHV) before spinal manipulative therapy

		Distance category	1		2		3		4	
		Restriction	yes	no	yes	no	yes	no	yes	no
SI	Movement	Location								
Right	Flexion	Upper	8	0	11	2	7	1	10	1
Right	Flexion	Lower	0	8	1	12	1	7	1	10
Right	Extension	Upper	3	5	7	6	5	3	9	2
Right	Extension	Lower	0	8	0	13	0	8	0	11
Left	Flexion	Upper	5	3	9	4	4	4	6	5
Left	Flexion	Lower	0	8	0	13	0	8	0	11
Left	Extension	Upper	1	7	5	8	1	7	1	10
Left	Extension	Lower	0	8	0	13	0	8	0	11

Best fitting log-linear model : Interaction effects (location * side, location * movement, restriction* side, restriction * movement, restriction * location) and main effect (velocity)

Chi-square = 14.6637
p-value = 1.0000

Table 11(b) – Counts for SI joints movements and velocity (CHV) after spinal manipulative therapy

		Distance category	1		2		3		4	
		Restriction	yes	no	yes	no	yes	no	yes	no
SI	Movement	Location								
Right	Flexion	Upper	7	0	9	1	11	2	9	1
Right	Flexion	Lower	0	7	1	9	1	12	1	9
Right	Extension	Upper	2	5	4	6	9	4	9	1
Right	Extension	Lower	0	7	0	10	0	13	0	10
Left	Flexion	Upper	4	3	8	2	7	6	5	5
Left	Flexion	Lower	0	7	0	10	0	13	0	10
Left	Extension	Upper	2	5	2	8	4	9	0	10
Left	Extension	Lower	0	7	0	10	0	13	0	10

Best fitting log-linear model : Interaction effects (location * side, location * movement, restriction* side, restriction * movement, restriction * location) and main effect (velocity)

Chi-square = 20.62502
p-value = 1.0000

The comments on the model will be the same as those at the end section 4.2.6.2. As for the case of club head velocity in the lumbar spine; the variables site, movement and restriction affect each other but not distance with respect to the SI joints. The marginal counts will be the same as those shown in table 10 and the comments on the nature of the interaction the same as before.

4.2.6.4.1 RESULTS OF FITTING LOGISTIC REGRESSION MODELS

Various logistic regression (logit) models were fitted to the vertebrae and SI joints data using velocity (distance) categories together with each of the other variables as independent variables and restriction (“yes” or “no”) as the dependent variable. This was done for the before and after spinal manipulative therapy velocity and distance classifications. For each fitted model a chi-square value and associated p-value was calculated. The results are summarized in the table below.

Table 12 – Summary of results for logistic regression models

Abbreviations used for vertebrae:

- *spinal manipulative therapy* (SMT)
- *vertebrae* (v)
- *site* (s)
- *movement* (m)

(a) Vertebrae : Velocity (CHV)

	Before SMT		After SMT	
	Chi-square	p-value	Chi-square	p-value
Independent variables				
v , s and m	34.3625	0.0000	34.3269	0.0000
v and m	23.3209	0.0000	23.2863	0.0000
v and s	11.1352	0.0038	11.1016	0.0039

Table 12(b) Vertebrae : Distance

	Before SMT		After SMT	
	Chi-square	p-value	Chi-square	p-value
Independent variables				
d , s and m	34.1033	0.0000	33.5795	0.0000
d and m	23.0688	0.0000	22.5589	0.0000
d and s	10.8909	0.0043	10.3978	0.0055

Table 12(c) SI joints : Velocity (CHV)

Abbreviations used for SI joints:

- *spinal manipulative therapy* (SMT)
- *vertebrae* (v)
- *side* (s)
- *movement* (m)
- *location* (l)

	Before SMT		After SMT	
	Chi-square	p-value	Chi-square	p-value
Independent variables				
v , s , m and l	192.3681	0.0000	192.9709	0.0000
v and m	14.6032	0.0007	14.8697	0.0006
v and l	141.2703	0.0000	141.6738	0.0000
v and s	14.6032	0.0007	14.8697	0.0006

Table 12(d) SI joints : Distance

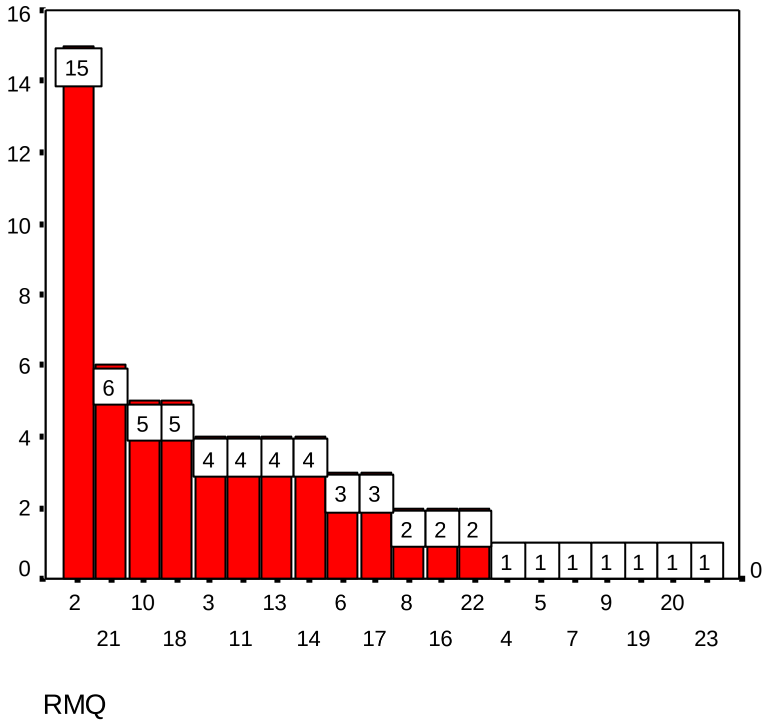
	Before SMT		After SMT	
	Chi-square	p-value	Chi-square	p-value
Independent variables				
d , s , m and l	165.8736	0.0000	129.0681	0.0000
d and m	14.6871	0.0006	14.7420	0.0006
d and l	141.3977	0.0000	141.4806	0.0000
d and s	14.6871	0.0006	14.7420	0.0006

In all the above cases the p-value is small. This means that the model is a poor fit to the data. This indicates that velocity and distance are not related to restricted movement.

4.2.7 RMQ RESULTS

The subjects had to state which (if any) of 24 lower back pain disabilities they experienced. Figure 3 is a summary (in the form of a Pareto chart) of their responses.

Figure 3 – Pareto chart of RMQ data



From the Pareto chart it can be seen that the 4 most commonly occurring disabilities are

1 Changing position frequently to get back comfortable.
2 Avoiding heavy jobs.
3 Standing up only for short periods.
4 Less comfort during sleep.

4.2.8 COMPARISON OF PRE AND POST SPINAL MANIPULATIVE THERAPY NRS

Figure 4 shows a plot of the worst versus the best pre-spinal manipulative therapy NRS scores. Figure 5 shows a plot of the worst versus the best post-spinal manipulative therapy scores. Figure 6 shows a plot of the differences (worst – best) for the pre- spinal manipulative therapy NRS scores versus that for the post- spinal manipulative therapy NRS scores. None of the plots reveal any relationship between the variables. Plots of the pre-worst versus the post-worst and the pre-best versus the post-best (not shown) do not reveal any relationship either. Scatter plots (not shown here) of pre-NDA versus pre-NRS scores and post-NDA versus post-NRS scores indicate that scores measured on the NDA scale are not related to the NRS (subjective) scores.

Figure 4 - Worst versus the best pre-manipulation NRS scores

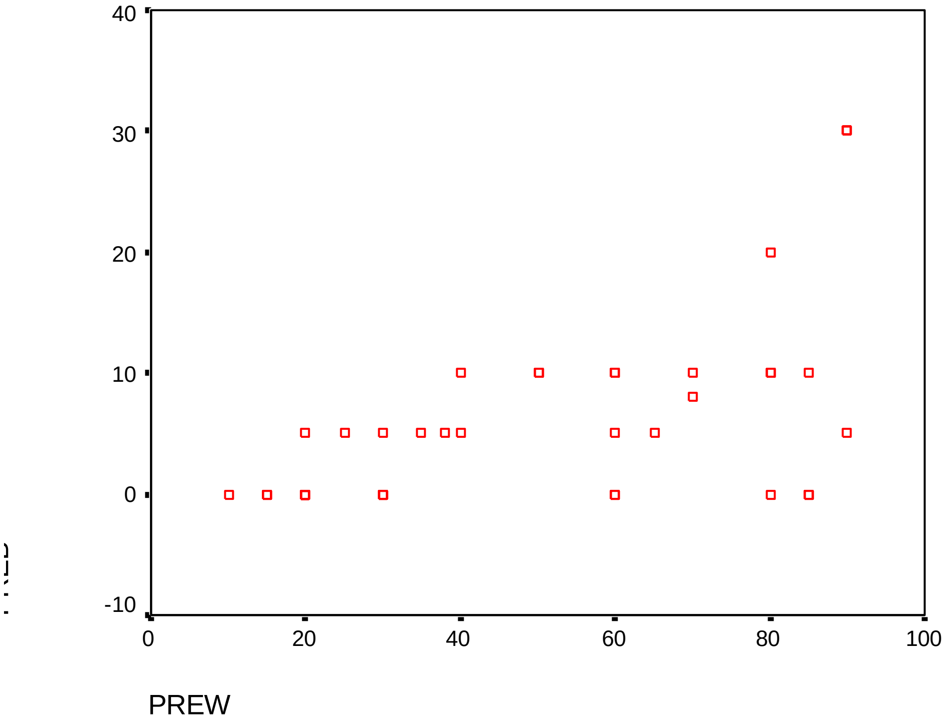


Figure 5 - Worst versus the best post-manipulation NRS scores

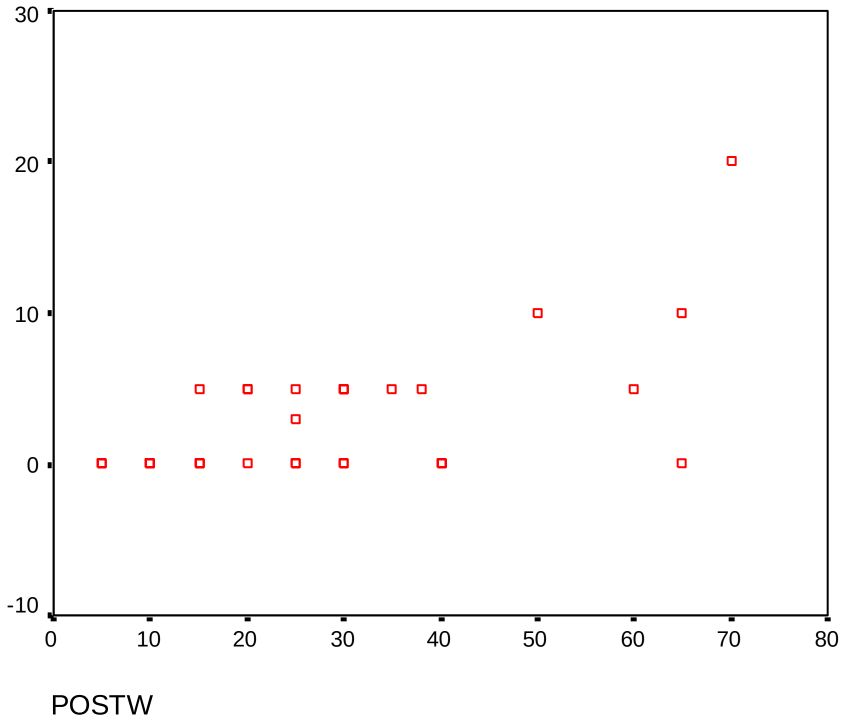
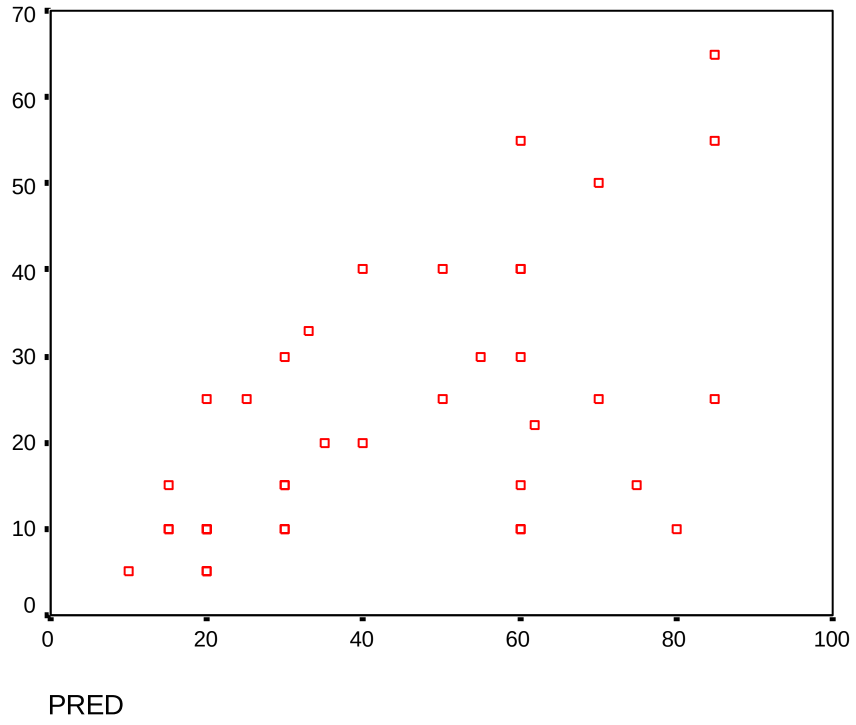


Figure 6 – Differences for the pre- spinal manipulative therapy NRS scores versus that for the post- spinal manipulative therapy NRS scores.



4.2.9 RESULTS OF TABULATIONS OF ORTHOPAEDIC TESTS

- 100% of the participants in the study had a clinical diagnosis of lumbar facet syndrome, while only two participants had a diagnosis of lumbar facet and sacroiliac syndrome.

Tables 13(a) to 13(d) show cross tabulations of the pre and post readings for the 4 different orthopaedic tests.

Table 13(a) – Results for the Kemp's tests

KEMPRE * KEMPST Crosstabulation

Count

		KEMPST			Total
		0	1	2	
KEMPRE	2	14	25	1	40
Total		14	25	1	40

Table 13(b) – Results for the Facet Challenge tests

FCTPRE * FCTPST Crosstabulation

Count

		FCTPST		Total
		0	1	
FCTPRE	1	22	18	40
Total		22	18	40

Table 13(c) – Results for the Sacroilaic Percussion tests

SCPPRE * SCPPST Crosstabulation

Count

		SCPPST		Total
		0	1	
SCPPRE	0	36	0	36
	1	2	2	4
Total		38	2	40

Table 13(d) – Results for the Yeoman's tests

YEOPRE * YEOPST Crosstabulation

Count

		YEOPST		Total
		0	1	
YEOPRE	0	36	0	36
	1	2	0	2
	2	1	1	2
Total		39	1	40

The Kemp's test shows the most difference between the pre and post scores. For this test 39 out of the 40 scores changed. In the Facet challenge test 22 out of the 40 scores changed. On the other hand the Sacroiliac Percussion (2 changes in score out of the 40 scores) and Yeoman's (4 changes in score out of the 40 scores) tests show little changes between pre and post scores.

4.3 ANECDOTAL DATA ANALYSIS

The following anecdotal data was captured during the study. It consisted of various feedback statements that related low back pain with playing golf, and the patient's feedback on their golf swing mechanics after they had received spinal manipulative therapy. (The percentages are expressed for the group of forty participants).

Feedback regarding low back pain and playing golf:

There were no specific questions asked, but the participants were prompted to give feedback about their low back pain they experience in relation to playing golf. The following percentages are a reflection of the most common associations that the participants made:

- pain at the end of 18 holes	(32,5%)
- experience stiffness before the game	(17.5%)
- pain worse during the round and after the game	(12.5%)
- pain at the beginning of the game	(12.5%)
- pain at half way and towards the end of the game	(7.5%)
- pain worse in the car on the way home	(7.5%)
- pain worse after the first hole then eases up	(5%)
- pain and stiffness the day after playing golf	(5%)

Feedback regarding the participant’s golf swing after spinal manipulative therapy:

There were no specific questions asked, but the participants were prompted to give feedback about their golf swing once they had received spinal manipulative therapy. The following percentages are a reflection of the most common associations that the participants made:

accuracy improved	(50%)
golf swing felt looser	(45%)
timing felt better	(37.5%)
golf swing felt easier	(22,5%)
felt significant release in their golf swing/ felt less restricted	(22.5%)
golf swing felt more flexible	(20%)
backswing felt looser/smooth	(17.5%)
follow-through felt better	(15%)
golf swing felt more comfortable	(12.5%)
golf swing felt more smooth	(10%)
golf swing felt great	(7.5%)
felt a decrease in pain and discomfort/ stiffness	(7,5%)
golf swing felt as if there was greater shoulder turn and more rotation	(7.5.%)
golf swing felt the same	(7.5%)
felt that they could hit the ball harder with more power	(5%)

CHAPTER FIVE: DISCUSSION OF THE RESULTS

5.1 INTRODUCTION:

The aim of this study was to evaluate the immediate effect of spinal manipulative therapy on CHV in terms of subjective and objective clinical findings in amateur golfers suffering from mechanical low back pain. This chapter is a discussion of the results of the subjective and objective data presented in chapter four concerning the aim of this study.

5.2 DEMOGRAPHIC DATA

All the participants in the study had a clinical diagnosis of lumbar facet syndrome, while only two participants had a diagnosis of lumbar facet syndrome and sacro-iliac syndrome.

The age distribution of the participants was between 23 and 35 years of age, with an average age of 26,9. The average weight and height of the participants were 84,5 kg's and 1,80 m respectively. The sample group handicap resulted in a group handicap that ranged between 5 and 24, with an average handicap of 15,1. The demographic data was consistent with values previously reported in literature for amateur golfer samples (Bulbulian, Ball and Seaman, 2001). The average number of golf rounds per week was 0.9 per participant, and the average number of practice sessions per week was 0.8 per participant.

5.3 DATA ANALYSIS

5.3.1 COMPARISON OF CLUB HEAD VELOCITY (CHV) BEFORE AND AFTER SPINAL MANIPULATIVE THERAPY

A repeated measures analysis of variance (ANOVA**)** of velocity, with shots the within-subjects factor and group (before spinal manipulative therapy or after spinal manipulative) the between-subjects factor, was carried out. The relevant results of the analysis are shown in table 1 and figures 1(a) and 1(b).

The mean club head velocity after spinal manipulative therapy (77.485 mph) was higher than that before spinal manipulative therapy (74.875 mph). The difference in mean club head velocity before and after spinal manipulative therapy was 2.610 mph.

Figures 1 (a) and 1(b) show that the club head velocity increases with the number of shots. The increase in club head velocity with the number of shots is could be attributed to numerous factors such as;

- Increased static and dynamic postural stability,
- Increased power and strength,
- Increased confidence,
- Repetition, resulting in improved timing of the golfswing at ball impact,
- Improved muscle balance and flexibility etc Chek (2003).

The warm up protocol of 10 shots attempted to minimize this effect, however this was consistent for all participants, yet the individuals as well as the group had improved CHV indicating an effect beyond the standardisation procedures supporting the hypotheses above.

Figure 1(b) shows the separate plots of the means for group 1 (before spinal manipulative therapy) and group 2 (after spinal manipulative therapy). It can be seen that the plot patterns for the 2 groups are the same i.e. there is no interaction effect between the 2 groups. It does however appear that group 1(before spinal manipulative therapy) does not have as a consistent range of club head velocity as compared to that of group 2 (after spinal manipulative therapy). [i.e. there is a larger range of club head velocities in group 1 (before spinal manipulative therapy) than group 2 (after spinal manipulative therapy)].

This suggests that after spinal manipulative therapy there was a more constant range of club head velocities, indicating that spinal manipulative therapy could influence the consistency of club head velocity.

In figure 1(b) it can be seen that the plot of group 2 (after spinal manipulative therapy) is substantially above that of the plot of group 1 (before spinal manipulative therapy). This would indicate that spinal manipulative therapy would positively influence club head velocity. The group 2 (after spinal manipulative therapy) plot suggests that after spinal manipulative therapy there is a superior club head velocity.

Therefore figure 1 (b) supports the hypotheses of

- Increased static and dynamic postural stability,
- Increased power and strengh,
- Increased confidence,
- Repetition, resulting in improved timing of the golfswing at ball impact,
- Improved muscle balance and flexibility etc Chek (2003),

which indicates that there seems to be a positive influence of spinal manipulative therapy on club head velocity and consistency of club head velocity.

5.3.2 COMPARISON OF DISTANCE BEFORE AND AFTER SPINAL MANIPULATIVE THERAPY

A repeated measures analysis of variance (ANOVA) of distance, with shots the within-subjects factor and group (before spinal manipulative therapy or after spinal manipulative therapy) the between-subjects factor, was carried out. The relevant results of the analysis are shown in table 2 and figure 2.

The mean distance after spinal manipulative therapy (134.425 yds) is higher than that before spinal manipulative therapy (126,4). The difference in mean distance before and after spinal manipulative therapy was 8.025yds.

The distance achieved after spinal manipulative (group 2) is higher than that of before spinal manipulative therapy (group 1). The within-subjects effects ANOVA table shows a significant interaction between shots and groups. For both the groups (before and after spinal manipulative therapy) the distance increases with an increase in the number of shots, but for the before spinal manipulative therapy group (group 1) the range of distances achieved is greater than for the after spinal manipulative therapy group (group 2) (see figure 2) which has a smaller more consistent range of distances. This indicates that there is a wider range of distances achieved before spinal manipulative therapy (group 1), and indicates inconsistency in ball distances. The after spinal manipulative therapy (group 2) plot shows a more consistent ball distance achieved after spinal manipulative therapy as there is a smaller range of distances, and indicates a greater consistency in ball distances achieved.

In figure 2 it can therefore be seen that the plot of group 2 (after spinal manipulative therapy) is substantially above that of the plot of group 1 (before spinal manipulative therapy). This would indicate that spinal manipulative therapy would positively influence ball distance achieved. The group 2 (after spinal manipulative therapy) plot suggests that after spinal manipulative therapy there is a superior ball distance achieved.

In these results it appears that spinal manipulative therapy positively influences ball distances, and their consistency of ball distances.

5.3.3 COMPARISON OF ACCURACY BEFORE AND AFTER SPINAL MANIPULATIVE THERAPY

Table 3 shows no change after spinal manipulative therapy in 26 cases (65%), an increase in accuracy in 13 cases (32,5%) and a decrease in only 1 case (2.5%). It is clear from this information and the highly significant chi-square value that overall there is an improvement in accuracy after spinal manipulative therapy.

These results suggest that spinal manipulative therapy can positively increase accuracy in golfers.

However it must be noted that the way in which accuracy was recorded did not determine ball/ shot groupings in a particular line/ ball flight path or target point on the Golf Achiever simulator software. Accuracy was determined if the participant hit the golf ball onto the simulated fairway, i.e. between two markers that were simulated on the Golf Achiever computer screen. The majority of recordings of accuracy after spinal manipulative therapy showed greater consistency in line / ball flight path and target point accuracy. Thus it is the researcher’s opinion that the influence of spinal manipulative therapy on accuracy would have been greater than 32,5% if the above method of ball flight path or target point accuracy was used in the study to determine accuracy.

5.3.4 COMPARISON OF NDA BEFORE AND AFTER SPINAL MANIPULATIVE THERAPY

The NDA before and after spinal manipulative therapy are highly correlated (correlation coefficient = 0.761). The post-nda mean is 1.3 units higher than the pre-nda one. This indicates that the subjects are less sensitive to pain after spinal manipulative therapy. The post- spinal manipulative therapy mean is significantly higher than the pre- spinal manipulative therapy mean (t-statistic = 6.181 with a p-value of 0.0000).

These results indicate that spinal manipulative therapy decreases pain sensitivity in amateur golfers suffering from mechanical low back pain.

Arthrogenic muscle inhibition (AMI) is 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 (Suter et al. 2000). Muscle weakness has been attributed to AMI (Suter et al. 2000), this weakness results from the activity of many different mechanoreceptors within a joint.

Mechanoreceptor activity plays the primary role in AMI, which is a natural response, designed to protect a joint from further damage (Hopkins 2000). Spinal manipulative therapy on a joint has been proposed to activate mechanoreceptors from structures in and around the manipulated joint. The altered afferent input arising from the stimulation of these receptors is thought to cause changes in the motor neuron excitability, with a subsequent decrease in AMI (William 1997: 144 and Suter et al. 2000) (e.g. joint restriction will increase muscle inhibition).

Restricted joint movement is increased by spinal manipulative therapy and therefore induces motion into articular structures that helps to inhibit pain transmission by means of closing the spinal gating mechanism within the substantia gelatinosa by relaying mechanoreceptors (i.e. spinal manipulative therapy causes an increase in proprioceptive input, which has a reflex inhibition on the transmission of pain (Kirkady-Willis and Burton, 1992: 288)).

Thus with an increase in movement, there is decrease in pain, and a likely increase in performance. Therefore it is likely that spinal manipulative therapy decreases pain, weakness and muscle spasm (and as a result AMI), as indicated by the NDA results above. With pain, muscle weakness and muscle spasm reduced there could be a subsequent increase in muscle balance, flexibility, strength and power that will positively affect CHV (Chek, 2003), thus positively influencing golfing performance.

5.3.5 RELATIONSHIPS BETWEEN VELOCITY (CHV), DISTANCE, ACCURACY, PAIN SENSITIVIYTY AND HANDICAP

5.3.5.1 VELOCITY (CHV) AND DISTANCE

Table 4 shows that CHV and distance are strongly positively correlated. This means that the higher (lower) the club head velocity, the higher (lower) the distance achieved. There is also a moderately strong positive correlation (0.677) between the club head velocity movement (post score – pre score) and the distance movement (post score–pre score).

The mean average increase in club head velocity was **2.610 mph** per golf shot, and the mean average increase in ball distance was **8.025 yd's** per golf shot.

Research at the United States Golf Association Technical Department demonstrated an approximate 1:3 relation (2.5 –yard increase in air travel of the golf ball for every 1-mph increase in CHV) between increase in CHV and subsequent driving distance (rounded to the nearest yard). This relation suggests for every 1-mph increase in CHV, there is a subsequent three-yard increase in air travel distance (Stude and Gullickson, 2000: 173).

If we had to use this 1:3 relation we could approximately determine the distance achieved in yards.

Thus: 2.610 mph X 3 = 7.830 yds. (rounded off to the nearest yard = 8yd’s)
This would be consistent with the result of an 8.025yd increase in ball distance achieved in the study.

From the above results it is suggested that an approximate 8-yard per golf shot increase in ball distance was directly related to the increase in club head velocity. In conclusion, it appears both the increases in club head velocity and ball distances were indirectly / directly related to the spinal manipulative therapy. This suggests that spinal manipulative therapy could indirectly through increasing club head velocity potentially influence the distance one would want to achieve from a golf club, and ultimately golf club selection for hitting a required distance.

The above results indicate that a player may be able to increase their club length. A club length is the distance that a particular golf club should hit a golf ball (e.g. 4-iron), and varies for each golfer. (E.g. If Tiger Woods hits his 4 iron on average 212 yards, his club length for his 4-iron would be 212 yards). The above research would suggest that spinal manipulative therapy could potentially increase his club length by approximately 8 yards. This would then allow for the selection maybe of a club length down, i.e. a 5-iron to hit the same distance. The main aim of this example is to understand that one could potentially increase their ball distances, and improve their overall golf round score.

However this study only involved the immediate effects of spinal manipulative therapy. No conclusive correlations can be made until further research into the long–term effects of spinal manipulative therapy are explored.

5.3.5.2 VELOCITY (CHV), DISTANCE, PAIN SENSITIVITY AND HANDICAP

A stepwise regression was performed on distance before and after spinal manipulative therapy. The results are shown in table 5.

The results in tables 5(a) and 5(b) show that of the variables considered only club head velocity (not handicap or resistance to pain) can be used to predict distance.

5.3.5.3 RELATIONSHIP BETWEEN ACCURACY AND VELOCITY (CHV), DISTANCE, HANDICAP AND PAIN SENSITIVITY

Accuracy is not related to any of the other variables. The reason for this is that virtually all the accuracy figures are 4 or 5 (36 out of 40 for the pre manipulation group and 39 out of 40 for the post manipulation group). Since the other variables vary considerably more, a wide range of values for other variables apply to a 4 or 5 accuracy score and therefore are not related to accuracy.

As mentioned in 5.3.3 above, it must be noted that the way in which accuracy was recorded did not determine ball/ shot groupings in a particular line/ ball flight path or target point on the Golf Achiever simulator software. Accuracy was determined if the participant hit the golf ball onto the simulated fairway, i.e. between two markers that were simulated on the Golf Achiever computer screen. The majority of recordings of accuracy after spinal manipulative therapy showed greater consistency in line / ball flight path and target point accuracy. Thus it is the researcher’s opinion that the influence of spinal manipulative therapy on accuracy would have been greater than 32,5% if the above method of ball flight path or target point accuracy was used in the study to determine accuracy.

5.3.6 RELATIONSHIP BETWEEN THE SITE OF PAIN, MOVEMENT AND VELOCITY (CHV)

5.3.6.1 VERTEBRAE- VELOCITY (CHV)

The best fitting model is the same for the pre and post spinal manipulative therapy velocities. The variables site, movement and restriction affect each other but not velocity. The type of interaction between these 3 variables can be seen from the following marginal table (Table 7).

Abbreviations: E- *extenxion;* LPA- *left posterior to anterior rotation*

Table 7 – Marginal counts for vertebrae pain

Site	L1		L2		L3		L4		L5	
Movement type	E	LPA	E	LPA	E	LPA	E	LPA	E	LPA
restriction										
yes	33	17	30	19	1	11	1	36	1	30
no	7	23	10	21	39	29	39	4	39	10

From the above table it can be seen that

- At sites L1 and L2 the type E movement is more restricted than the type LPA movement – this could be attributed to the anatomical movements available in the upper lumbar vertebrae, which have a sagittal plane facet orientation. There is a large degree of movement in flexion and extension, however rotation movement is limited by the sagittal orientation of the facets in the lumbar spine and lower thoracic spine to allow a maximum 23º of spinal rotation. Therefore the upper lumbar vertebrae will have a greater predisposition to extension – flexion injury (Moore, 1999: 462/3 and Bulbulian, Ball & Seaman’s, 2001).

- At sites L4 and L5 the type E movement is virtually unrestricted, while the type LPA movement is considerably restricted. This could be attributed to the anatomical movements available in the lower lumbar vertebrae which have a coronal plane facet orientation – therefore will have a greater predisposition to rotation injury (Moore, 1999: 462/3). Spinal rotation begins at the lumbosacral junction, and is limited to 0º-2º for the L5-S1 joint and from L5-L1 rotation is limited to 1º-3º per level (Mackey, 1995: 11 and Seaman, 1998: 49).
- At site L3 the type E movement is virtually unrestricted, while the type LPA movement is unrestricted to lesser degree. 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).

These results suggest that the lumbar spine during a golf swing is more restricted in E movement in the upper lumbar spine and the lower lumbar spine is more restricted in LPA rotation movement. This would be consistent with the "modern golf swing" biomechanics where there is hyperextension and rotation of the lumbar spine.

If we had to determine the probable treatment indications of a lumbar facet syndrome at a particular site in the lumbar spine we could consider the following taking Table 7 into account: L1 and L2 are primarily restricted in E, and L4 and L5 are primarily restricted in LPA movement.

The follow-through position of the golf swing is characterised by the reversed-"C" position (rotation and hyperextension of the lumbar spine). In this position the lumbar facets approximate and with repetitive practice swings and incorrect form, the lumbar facets bear the brunt of the abnormal forces being placed on the lumbar spine (Mackey, 1995: 11). It is thus likely that the cause of facet syndrome in the upper lumbar spine (L1 and L2) is primarily due to the follow-through phase of the golf swing with associated hyperextension of the lumbar spine and approximation of the facet joints.

During the downswing phase of a golf swing the role of the multifidus in limiting flexion whilst the external oblique muscle induce rotation of the lumbar spine, together produces rotation in the lower lumbar spine. Thus the golf swing, particularly during the downswing phase, places a tremendous burden on the multifidus muscle (Hosea, Gatt and Gertner, 1994: 97-108 and Seaman, 1998:50). Due to the very high number of LPA restrictions found at L4 and L5 levels, it would suggest that the multifidus muscle is the main cause of restriction at these levels because of its attachments (Moore, 1999: 470) and apparent dysfunction (Simons, Travell and Simons, 1999:917-8).

This would also suggest that the cause of facet syndrome in the lower lumber spine (ie. at L4 and L5) is a result from the downswing phase of the golf swing where the multifidus opposes the flexion effect of the contraction of the external oblique muscle.

However the above is only a consideration into the many causes of lumbar facet injury and low back pain in amateur golfers and therefore further research into the specific causes / effects of lumbar facet joint dysfunction is warranted.

5.3.6.2 VERTEBRAE- DISTANCE

As for the case of velocity (CHV) above, the variables site, movement and restriction affect each other but not distance. The marginal counts will be the same as those shown in table 7 and the comments on the nature of the interaction the same as before.

5.3.6.3 SI JOINTS- VELOCITY (CHV)

Since the number of subjects in the study are fixed the location * side and location * movement interactions are not considered. The table below (table 10) shows a cross classification of the interactions involving restriction.

Table 10 – Marginal totals involving restriction, side, movement and location

	Side		Movement		Location	
	Right	Left	Flexion	Extension	Upper	Lower
Restriction						
yes	63	32	63	32	92	3
no	97	128	97	128	68	157

From the above table it can be seen that

- Movement on the right side is more restricted than on the left side.

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 mutifidi) (Seaman, 1998; Richardson and Jull, 2000; Grimshaw et al, 2002; Lindsay and Horton, 2002).

- Flexion movement is more restricted than extension movement.

According to the literature (Lindsay and Horton, 2002:603), there is an initial posterior tilting of the pelvis and increased localised spinal flexion rather than true flexion of the trunk, which occurs due to muscular contraction of the anterior trunk muscles, during the downswing. This “pseudo-flexion” that occurs in the spinal structures may be a causative agent in the predominance of flexion restrictions in the SI joint. This is further supported by McTeigue et al. (1994) as cited by Lindsay and Horton (2002: 603).

In addition to this the attachments of primarily the multifidi, external oblique are over the superior aspect of the SI joint, which would induce and sustain restrictions within the joints (Moore, 1999:184/470).

5.3.6.4 SI JOINTS – DISTANCE

The tables 11(a) and 11(b) below show a summary of the counts for the various categories for the "before" and "after" spinal manipulative therapy data.

As for the case of velocity (CHV) in respect of the lumbar facet joint restrictions noted in5.3.6.2, the variables:

- site,
- movement and
- restriction

affect each other but not distance. The marginal counts will be the same as those shown in table 8 and the comments on the nature of the interaction the same as before.

5.3.6.4.1 RESULTS OF FITTING LOGISTIC REGRESSION MODELS

The results are summarized in the Table 12. In all the cases the p-value is small. This means that either the model is a poor fit to the data or there is a significant relationship between the factors.

However, from previous tests that where run, there is a tendency towards indicating that velocity (CHV) and / or distance are not related to restricted movement, site and location for either the lumbar joint dysfunctions or sacro-iliac syndromes.

This is possible because of lack of an independent variable, which would allow for consistent and accurate comparison of the variables currently under consideration. The independent variable would have to take into account the following hypothesis for the development of restrictions of movement, site of lesion and location of lesion:

1. McTeigue et al. (1994) as cited by Lindsay and Horton (2002: 603), observed considerable changes in spinal flexion during the downswing of elite professional golfers. One explanation could be that powerful anterior trunk muscle contractions on the downswing may cause an initial posterior tilting of the pelvis and apparent increase in localized spinal flexion rather than true flexion of the entire trunk (Lindsay and Horton, 2002: 603). This could result in the development of flexion restrictions within the SI joint as opposed to extension restrictions. Further to this the attachments of the multifidi and abdominal oblique muscles (Moore, 1999:184/470), would result in rotation of the ilium around the x-axis such that the development of the flexion fixation is facilitated.
2. The fatique of the multifidi and abdominal oblique muscles and / or resultant spasm in respect of lower back pain may further aggravate the

presence of a fixation as the relative movement of the SI joint will be further restricted (Simmons, Travell and Simmons, 1999:917-8)

The 2 possible causative factors for the development of facet syndrome in the lumbar spine are related to

3. The facet orientation (Moore, 1999:437/441)
4. The mechanism of injury – i.e.
    a. The downswing related to the co-contraction of the multifidi and external oblique resulting in potentially aberrant joint mechanics due to fatique of one or both mucles. 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). Trunk muscle coordination may be compromised by muscle fatigue and result in decreased trunk stability and increased risk of injury to the lower back (O'Brien and Potvin, 1997).
    b. The reverse "C" hyperextension and right lateral flexion, causing impaction of the facet joints and possible restriction of the facets due to trauma as opposed to muscle fatique (Seaman, 1998).

Therefore as a result of multiple causative factors being responsible for the pathology, it is not possible to indicate relationships between the factors unless the factor(s) responsible are utilised as comparative data (i.e. only the upper lumbar spine segments are correlated to the improvement with treatment with spinal manipulative therapy and other restrictions present are not manipulated). Therefore further research is needed to elucidate the factor(s) responsible and then only will it be possible to quantify the relationships between restricted movement, site and location and CHV and / or distance.

Further to this the individual golfer’s swing is dependant on variables such as (list not limited to that given below) (Lehman and McGill, 1999) :

- Handicap,
- Height,
- Weight,
- Stance and
- Practice,

Which could further influence the results obtained if these results have not been rectified (statistically) in order to prevent them from skewing the data.

5.3.7 RMQ RESULTS

The subjects had to state which (if any) of 24 lower back pain disabilities they experienced. Figure 3 is a summary (in the form of a Pareto chart) of their responses.

From the Pareto chart it can be seen that the 4 most commonly occurring disabilities are

1. Changing position frequently to get back comfortable 15 (37.5%).
2. Avoiding heavy jobs 6 (15%).
3. Standing up only for short periods 4 (10%).
4. Less comfort during sleep 4 (10%).

The RMQ was not golfing specific. From the above results it can be seen that mechanical low back pain in amateur golfers is not debilitating, as a low percentage of questions were answered by the participants in the study. These findings would be consistent with the fact that many golfers with low back pain attempt to play anyway (Lett, 2002:62).

The above results do however possibly suggest to the practitioner that in order to manage golfers with low back they need to look at other factors other than golfing related mechanisms of injury in order to treat and prevent further aggravation or cause of the problem.

5.3.8 COMPARISON OF PRE AND POST SPINAL MANIPULATVE THERAPY NRS

Figure 4 shows a plot of the worst versus the best pre-spinal manipulative therapy NRS scores. Figure 5 shows a plot of the worst versus the best post-spinal manipulative therapy scores. Figure 6 shows a plot of the differences (worst – best) for the pre- spinal manipulative therapy NRS scores versus that for the post- spinal manipulative therapy NRS scores. None of the plots reveal any relationship between the variables. Plots of the pre-worst versus the post-worst and the pre-best versus the post-best (not shown) do not reveal any relationship either. Scatter plots (not shown here) of pre-NDA versus pre-NRS scores and post-NDA versus post-NRS scores indicate that scores measured on the NDA scale are not related to the NRS (subjective) scores.

5.3.9 RESULTS OF TABULATIONS OF ORTHOPAEDIC TESTS

Tables 13(a) to 13(d) show cross tabulations of the pre and post readings for the 4 different orthopedic tests.

The Kemp's test shows the most difference between the pre and post scores. For this test 39 out of the 40 scores changed. In the Facet challenge test 22 out of the 40 scores changed. On the other hand the Sacroiliac Percussion (2 changes in score out of the 40 scores) and Yeoman's (4 changes in score out of the 40 scores) tests show little changes between pre and post scores.

All participants in this study had a diagnosis of facet syndrome, with only two having both facet syndrome and sacroiliac syndrome. Due the a very small portion of the sample group having sacroiliac syndrome, this would explain the little changes in pre and post score of the Sacroiliac percussion and Yeoman's tests. The high number of changes that occurred from the Kemp's test and Facet challenge test pre and post spinal manipulative therapy suggest a decrease in pain sensitivity post spinal manipulative therapy.

The above results indicate that Kemp's test and Facet challenge tests are good indicators of diagnosing lumbar facet syndrome, with their sensitivity before and after spinal manipulative therapy being good indicators of decreased pain sensitivity, and indicate subjectively improvement of their mechanical low back pain.

5.3.10 ANECDOTAL DATA ANALYSIS

Feedback regarding low back pain and playing golf:

The top 5 percentages were:

- pain at the end of 18 holes	(32,5%)
- experience stiffness before the game	(17.5%)
- pain worse during the round and after the game	(12.5%)
- pain at the beginning of the game	(12.5%)
- pain at half way and towards the end of the game, and worse in the car on the way home	(7.5%)

Low back pain appeared to effect the participants towards the end of 18 holes of golf (32,5%). This suggests that fatigue could play a role in the development of low back pain, supporting the development of joint dysfunction due to altered or incongruent firing patterns and therefore contraction (Richardson and Jull, 2000, Horton, Lindsay and MacIntosh, 2001). Trunk muscle coordination may be compromised by muscle fatigue and result in decreased trunk stability and increased risk of injury to the lower back (O'Brien and Potvin, 1997), resulting in aberrant joint movement and the development of restrictions (Bulbulian, Ball and Seaman, 2001).

Feedback regarding the participants golf swing after spinal manipulative therapy:

The top 5 percentages were:

- Improvement in accuracy	(50%)
- golf swing felt looser	(45%)
- timing felt better	(37.5%)
- golf swing felt easier	(22,5%)
- felt significant release in their golf swing/ felt less restricted	(22.5%)

These reported improvements post spinal manipulative therapy, correlates with the improved performance in terms of CHV and distance, indicating that these results indicate a subjective reporting of:

- Improved timing (Richardson and Jull, 2000 and Lehman and McGill, 1999).
- Increased feedback (proprioceptive or mechanoreceptive), which indicates that a complex movement may be a better indicator of improvement than simple range of motion techniques (ROM) techniques normally applied in a clinical setting (Lehman and McGill, 1999).

These hypotheses support the suggestion by Korr (1975), Gatterman and Goe (1990), Mense (1991) and Dvorak (1985); that the effect of the manipulation has effects that improve the performance in more than one manner indicating that research should either be multifaceted or there should be multiple research studies addressing various facets.

However this research did not utilise these findings as a focus for the study and therefore further research is required to substantiate these subjective claims and suggested hypotheses.

CHAPTER SIX: RECOMMENDATIONS AND CONCLUSIONS

6.1 RECOMMENDATIONS

Study Design:

The study was a pre-post intervention study that looked at the immediate effects of spinal manipulative therapy on club head velocity in amateur golfers suffering from low back pain. An asymptomatic group could be used as a control group in future studies to highlight differences between the natural history (of low back pain) and experimental group.

Sample Size

The sample size was forty. A larger sample size 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

The age of the participants were between 23 and 35 years of age. A study into different age groups would allow for a comparison of differences that would be directly related to age.

Handicap

For this study, golfers with official handicaps were preferred. Handicaps ranged from 0 to 24 for male golfers. Future studies should try and incorporate golfers with lower handicaps, e.g. golfers with a handicap of 10 or below or more consistent handicaps (i.e. with all golfers presenting with a 10 handicap). This follows the rationale that a better-handicapped golfer will have a more biomechanically sound golf swing. They would be more consistent with their golf swing and club head velocity, thus increasing the validity of any chances that could occur because of intervention (i.e. spinal manipulative therapy).

Gender

This study only included male golfers to create homogeneity. A study involving female golfers would allow for comparability between male and female golfers as well as assess factors particular to female golfers.

Questionnaires

The Roland Morris Questionnaire (RMQ) was used in this study. This was not a golfing specific questionnaire in regards to low back pain. A golfing sensitive questionnaire should be generated / considered if further studies of this nature. More specific questions are needed to better understand each individual’s habits when it comes to playing or practicing golf.

Here are questions that could act as a guideline:

- How long have you played golf for?
- What is your handicap?
- How many times do you play golf a week/month?
- How many times do you practice golf a week/month?
- How long have you experienced low back pain that is related to playing golf?
- Do you experience stiffness because of your low back pain when playing golf?
- When do you experience pain while playing golf? i.e. at the beginning, during, at half way, towards the end, after 18 holes, in the car on the way home, the next day?
- Do you warm up/ stretch before playing golf? If so, for how long?
- What relieves your pain from playing golf?
- What golf shots aggravate your low pain the most? Driving, iron play, chipping, putting?

- Do you experience low back from carrying a golf bag/ pulling a golf cart?

Post intervention: Questions related to how the participants subjectively felt after their treatment (manipulation) with regards to their golf swing should be asked. Here are questions that could act as a guideline:

- Could you feel any difference in your golf swing? If so, was it in the backswing, or the follow through or both?
- Did your swing feel easier, more comfortable, more flexible, smoother, less restricted, or there was a greater range of motion?
- Did you feel that your timing of the ball felt better?
- Did you feel your consistency in striking the golf ball improved?
- Did you feel your accuracy was better?
- Was there any change in low back pain, if so did it increase or decrease?

Diagnosis of Lumbar facet and Sacroiliac syndrome

Although a low back regional examination was completed for each subject participating in the study, the study only required two out of two orthopaedic tests to make a diagnosis of mechanical low back pain (i.e. Kemp’s, Facet Challenge for facet syndrome and Yeoman’s and Sacroiliac Percussion tests for sacro-iliac syndrome). The incorporation of a larger number of orthopaedic tests into the study would aid in determining a more conclusive diagnosis, thus aiding in the validity and reliability of diagnosing these two syndromes.

However as the diagnostic criteria for these two syndromes are still questionable, further specificity and reliability in this study were unobtainable and it is therefore suggested that until strict and more validated diagnostic criteria are established, the reliability and validity of these orthopaedic tests are questionable.

Further studies should utilise a more diversified approach to orthopaedic testing for these syndromes and orthopaedic testing validity and reliability should be investigated or alternative validated / reliable scales should be sought.

Further to this I would recommend that if a similar study were to be researched, the consideration of thoracic facet syndrome should be considered, as the thoracolumbar region is a transitional region of the spine. Due to the biomechanics of the golf swing and the rotation involved, it would seem evident to assess this region in conjunction with the lumbar and sacroiliac areas. Each of the above syndromes could react differently to the treatment protocols.

Accuracy of Golfing Measurements

The Golf Achiever “Laser” Swing Analyzer determined the club head velocity and ball distance. The study allowed for a 10 ball warm up before partaking in the data capturing procedure. They did this on the Golf Achiever tee mat, or from the adjacent hitting mat within the hitting enclosure. I would suggest that the for the entire warm up, the participants be allowed to hit off the Golf Achiever tee mat before they undergo their required golf shots so that they will become accustomed and comfortable with the procedure. An increase in the number of golf shots pre and post manipulative intervention would allow for greater validity and reliability of results.

Follow up studies

A similar study into the long-term effects of spinal manipulative therapy on club head velocity in golfers suffering from low back pain.

Further Research

Further research should investigate:

- treatment protocols that would prove best for golfers suffering from low back pain and who wish to enhance their performance in terms of club head velocity, ball distance, accuracy, handicap etc.
- and incorporate all factors that control the biomechanics of the golf swing.
- core stabilisation, as well as rehabilitation and strengthening of dysfunctional muscles should be considered as a primary area of research. This would allow for greater scope into the understanding and mechanism of low back disorders in the golfing population, and how it influences an individual's performance on the golf coarse.

6.2 CONCLUSIONS

This study attempted to determine the immediate effect 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. A group of forty amateur golfers took part in the study.

The results of the group showed that there was an overall increase in club head velocity and distance immediately after spinal manipulative therapy. The results also suggested that spinal manipulative therapy could the influence accuracy of a golf shot. There was also suggestion in the results that objective low back pain sensitivity decreased immediately after spinal manipulative therapy.

The results provide a strong case that the inclusion of spinal manipulative therapy in the treatment of mechanical low back pain in golfers should be considered. This consideration should not only be from a clinical pain perspective, but also should be seen from a golfing performance perspective. However the long-term effects of spinal manipulative therapy in the treatment of amateur golfers suffering from mechanical low back pain needs to be investigated before any conclusive evidence is revealed. There will always be room to improve and expand on existing research.

Therefore, further investigation involving a better study design and longer periods of investigation, may yield more conclusive results.

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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 :**

VITALS:

Pulse rate:
Respiratory rate:
Blood pressure: R L
Temperature:
Height:
Weight: Recent change: Yes No

GENERAL EXAMINATION:

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

Urinalysis:

Clinicians Name: **Signature :**

SYSTEM SPECIFIC EXAMINATION

CARDIOVASCULAR EXAMINATION:

RESPIRATORY EXAMINATION:

ABDOMINAL EXAMINATION:

NEUROLOGICAL EXAMINATION:

COMMENTS:

Clinicians Name: **Signature :**

APPENDIX C: LOW BACK PAIN REGIONAL

REGIONAL EXAMINATION - LUMBAR SPINE AND PELVIS

Patient:________________________________ File#:______Date:_________

Intern\Resident:__________________________ Clinician:__________________

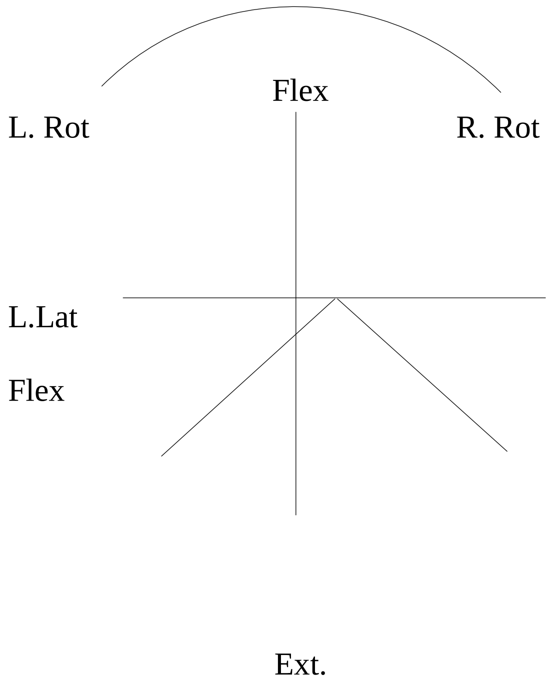
STANDING:

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°
Flex

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 Sl, +, ++	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: LETTER OF INFORMATION

LETTER OF INFORMATION

Dear patient, welcome to this study.

Title of research project:
The immediate effect 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:	Gareth Jermyn (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 effect the golf swing in terms of Club Head Velocity (CHV).

This study involves research on 40 participants

Procedures:

The visit

You will be required to undergo an initial examination at The Pro Shop. The Pro Shop is situated at Shop 20, Value Centre, Springfield (opposite Macro).
Adress: 45 Electron Road (off Umgeni Road, Durban)

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 at The ProShop in Springfield. 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. This will then be followed by a final CHV average analyses.

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.

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. All procedures are free of charge and your participation is voluntary.

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.

Persons to contact for problems of questions:

You may ask questions of an independent source (if you wish to 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.

Gareth Jermyn
(Chiropractic intern)

Dr. C. Korporaal
(Supervisor)

APPENDIX H: ADVERT

DO YOU PLAY

GOLF

and have

Low back pain

Are you aged between 23 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

For more information contact:

Gareth Jermyn

031- 204 2205 or 031-204 2515

at the Chiropractic Day Clinic

APPENDIX I: LETTER OF INFORMED CONSENT

INFORMED CONSENT FORM

(To be completed by patient / subject)

Date	:	
Title of research project:		**The immediate effect 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	:	**Gareth Jermyn**
Tel	:	**031-2042512/2205**

<u>Please circle the appropriate answer</u> **YES /NO**

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

9. Who have you spoken to? ____

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

<u>Please Print in block letters:</u>

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? Yebo Cha
   noma inini
   ngaphandle kokunika isizathu sokuyeka
   ngaphandle kokubeka impilo yakho ebungozini
8. Uyavuma ukuvolontiya kulolucwaningo? Yebo Cha
9. **.Ukhulume nobani? ---**

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

<u>BHALA NGAMAGAMA AMAKHULU:</u>

Igama lesiguli:____Sayina:__________________________

Umzali/Umgad:_______________________________________Sayina: __________________________

gama Witness:____Sayina: __________________________

Igama lomfundi ongumcwaningi:_________________________Sayina: __________________________

APPENDIX J: LETTER FROM THE PRO SHOP

THE PRO SHOP

Shop 20
Value Centre
Springfield
45 Electron Road
Off Umgeni Road
Durban
4091
PO Box 74151
Rochdale Park
4034
Tel (031) 263 0034
Fax (031) 263 0048

To Whom It May Concern:

Re: Permission to facilities at The Pro Shop

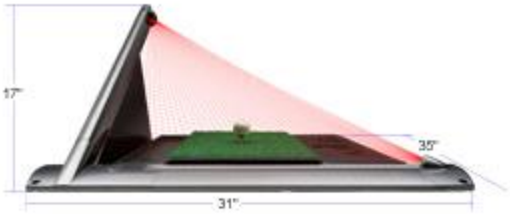
This is to confirm that Gareth Jermyn (6th Year Chiropractic Intern from the Durban Institute of Technology) has been granted permission to use the premises of The Pro Shop and Electronic Swing Analyser, to evaluate the subjects participating in his study. (Titled: The effectiveness of Spinal Manipulative Therapy on Club Head Velocity in Amateur Golfers suffering from Mechanical Low Back Pain.)

This is subject to the arrival and installation of the Analyser from the suppliers in the USA.

There will be no costs involved for the use of the above facility from The Pro Shop.

Wayne Bagley
The Pro Shop Manager
Durban
(031) 263-0034

APPENDIX K: GOLF ACHIEVER “LASER” SWING ANALYSER INFORMATION



PATENTED LASER TECHNOLOGY

GolfAchiever's Patented Laser Technology[1] is arranged in a portable L-Frame weighing less than 10 pounds. The L-Frame features two opposing lasers, base and post, which saturate opposite laser detector assemblies on the post and base, respectively. When a golf shot is taken, GolfAchiever instantly captures precise optical data and converts it to ultra high-speed electronics. The digital data is then sent to the computer where GolfAchiever's Proprietary Algorithms calculate shot parameters.

GolfAchiever software calculates and displays the results of GolfAchiever Proprietary Algorithms in an easy to understand Graphical User Interface. Getting started is as easy as selecting player name, club to be used, tee height, and hitting the play button.

GolfAchiever L-Frame Measurement Range

Launch Angle - 2 degrees to 65 degrees
Azimuth - Closed (Pull) -30 degrees to Open (Push) +30 degrees
Ball Speed - 5 MPH to 250 MPH
Swing Path - Outside-In -20 Degrees to Inside-Out +20 degrees

There are three main screens in GolfAchiever Software: Analysis, Down Range, and Data. (The Analysis screen [figure 1] was the screen used in this study for data capture)

Outside In 2"

Open Face 1°
SideSpin -36 rpm

Angle 10.2°
BackSpin 4137 rpm

Player: Matt Frelich
Club: 1W-SChamp
Tee: 3.00"
Ball: Wound
Wind: None

Club Speed: 113 mph
Ball Speed: 164 mph
Flight Time: 7.4 sec
Face Impact: Center area
Distance: 247 yards
Off Line: 2 yards
Max Height: 38 yards
Dist.to Pin: 11 feet

Figure 1: Analysis screen

The Analysis Screen graphically and statistically reports the following data after each shot:

- Ball Speed
- Launch Angle
- Azimuth
- **Club Speed ie. Club head velocity (CHV)**
- Club Path
- Face Angle
- **Carry Distance**
- Off Line, RPMs
- Distance to Pin
- Flight Time
- Face Impact
- Position

GOLFACHIEVER PRODUCTION

GolfAchiever assembly is outsourced to Universal Microelectronics Co., Ltd. (UMEC), a Focaltron business partner. UMEC is an ISO-9001/14001 certified company headquartered in Taichung, Taiwan. One of the world's leading manufacturers with expertise in the area of high-tech OEM assemblies and over 2000 employees, UMEC has worked tirelessly with the Focaltron development team to build world class products.

[1] GolfAchiever Patents include the following:
USA Patents #5,626,526 and #6,302,802
ROC Patents #NI092656 and #143688
Japan Patent #3126658
Additional Patents Pending