The core stability, club head velocity (CHV) and ball carry in golfers with and without low back pain – a comparative study.

BY:

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I, Guy Bower do declare that this dissertation is representative of my own work.

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DEDICATION

I dedicate my research to my loving family.
Their constant love, support and encouragement have made this possible.

To those members of my family, who have since passed on and did not get to see me reach this milestone.
My thoughts and prayers are with you always.

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A big thank you to my parents, you have given me the foundation and opportunity to make a success of my life and your unfailing love and support have carried me through. I cannot thank you enough for this opportunity.

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ABSTRACT

The core stability, club head velocity and ball carry in golfers with and without low back pain – a comparative study.

Objective: The aims of this study was to establish whether an observable difference exists in the abdominal core stability of two comparable groups of golfers: one asymptomatic and the other suffering from low back pain, and whether an observable reduction of performance, expressed as club head velocity and ball carry can be observed in those with low back pain.

First Objective was to differentiate the groups at baseline with respect to core stability strength between asymptomatic golfers and golfers suffering from low back pain. Whereas the Second Objective was to establish whether a relationship exists between abdominal core stability, CHV and ball carry in the two population groups under study. Following the above the Third Objective was to establish which other factors besides core stability strength have an effect on CHV and ball carry. And lastly the Fourth Objective was to establish the correlation between CHV and ball carry.

Design: A comparative study was carried out between the two sample groups. A sample of forty patients were selected for this study, where twenty patients were asymptomatic and had no current episode of low back pain and were able to maintain a core contraction; and the other twenty patients low back pain and could not maintain a core contraction. Because the patients presented in a random manner, the patients were matched as close as possible according to age, so as to have better comparative value between the groups (the maximum age difference of a year was instituted). This allowed for comparisons among similar ages, with the difference being their low back pain and core contraction status.

Outcome Measure: Each golfer was required to hit 5 balls using a standard club (in this study, a standard driver was used), after which an average value was calculated for CHV and ball carry. All measurements were carried out using the Flightscope Pro machine at the Durban Pro Shop.

Results: Core stability and low back pain did not influence CHV. However there was a non significant trend which indicated higher ball carry in the group with better core stability and no low back pain than in the group with low back pain and poor core stability. Increasing age and handicap reduced the CHV and ball carry values significantly. Ball carry and CHV were positively correlated together in both groups.

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DEFINITION OF TERMS

Asymptomatic

Showing or causing no symptoms (Dorland's Illustrated Medical Dictionary, 1994).

Ball Carry

The distance traveled by a hurled or struck ball (Stude and Gullickson, 2000; www.thefreedictionary.com/carry, 2008).

Club Head Velocity (CHV)

CHV is the speed with which the club head is traveling. The speed at impact (point where the club head makes contact with the ball) influences the distance the ball will be propelled, as well as the angle of the trajectory and direction of the resulting shot (Stude and Gullickson, 2000; www.improve-golf-swing.com/biomechanics.html, 2008).

Core Stability/Strength

The muscular control required around the lumbar spine to maintain functional stability (Akuthota and Nadler, 2004).

Handicap

A handicap is a numerical measure of an amateur golfers ability to play over 18 holes. A handicap generally represents the number of strokes above par (the total number of shots the course should be completed in) that a player will achieve on an average day (Stude and Gullickson, 2000; http://en.wikipedia.org/wiki/golf, 2008).

Low Back Pain

According to the Merck Manual (1999), low back pain is pain in the lower lumbar, lumbosacral, or sacroiliac regions; possibly accompanied by pain radiating down one or both buttocks or legs in the distribution of the sciatic nerve (sciatica) (Merck Manual, 1999). A more recent definition defines low back pain as pain that extends from the thoracic diaphragm to the pelvic diaphragm (noted as the area on the body surface being between the 12^{th} ribs bilaterally and the gluteal folds bilaterally) (Nyland *et al*., 2003).

Patient

A person who is ill or who is undergoing treatment for disease (Dorland's Medical Dictionary, 1994).

Subject

A person or animal which has been the object of treatment, observation, or experiment (Dorland's Medical Dictionary, 1994 and Johnson, 2005).

Symptomatic

1. Pertaining to or of the nature of a symptom.
2. Indicative of a particular disease or disorder.
3. Exhibiting the symptoms of a particular disease but having a different cause.

(Dorland's Illustrated Medical Dictionary, 1994).

CHAPTER ONE: INTRODUCTION

1.1. INTRODUCTION

According to Horton et al., 2001 and Bulbulian et al., 2001, low back pain is the most common musculoskeletal condition to affect both amateur and professional golfers. The golf swing has been identified as the cause of adding excessive strain on the low back, Bulbulian et al., (2001), document that there are excessive torsional and bending loads apparent in the golf swing, with the low back specifically having to contend with significant lateral bending, shear and compressive forces. It is estimated that the golf swing can generate peak compression loads of around 8 times the individual's body weight in both amateur and professional golfers. This is particularly seen in the quest for achieving increased ball carry (distance) with the modern golf swing that utilizes a state of maximal spinal rotation, as this maximally rotated position is deemed ideal for generating optimal CHV (Seaman, 1998).

It has been shown that amateur golfers with less efficient swing mechanics can develop up to 80% more torque around their lumbar spine when compared with professional golfers. It is for this reason that one finds an increased incidence of low back pain in amateur golfers (Seaman, 1998).

Furthermore Van Dillen et al., (2001), suggests that a decrease in spinal stability is hypothesized to place stress and excessive load on the spinal joints and tissues which ultimately results in the onset and development of low back pain. In this respect Hodges et al., 1996(b), suggests that an increasing number of the general population suffer from low back pain which can be directly linked to a dysfunction of the core stabilizers, namely the transverse abdominis muscle (TA), multifidus and deep fibres of the quadratus lumborum muscles. In continuation with this premise Davis and Laskowski, 1998, stated that the abdominal muscles, specifically the transverses abdominis, are considered primarily essential in preventing back injury and ensuring optimal performance in physical activity. Thus it stands to reason that in golfers who have a greater predisposition to low back pain (Horton et al., 2001 and Bulbulian et al., 2001), that either they compound their ability to have low back pain as a result of a weakened core as well as the normal golf forces that act on their spines; or they have a weaker core as a result of the low back pain, which aggravates the pain induced by playing golf.

1.2. AIM AND OBJECTIVES

It was therefore the aim of this study to compare the relative CHV and ball carry in golfers with low back pain who could not initiate and maintain a core contraction (experimental Group), with an asymptomatic (group without low back pain) who could initiate and maintain a core contraction (control Group).

Objective One: To differentiate the groups at baseline with respect to core stability strength between asymptomatic golfers and golfers suffering from low back pain.

Hypothesis One: It was hypothesized that the asymptomatic group would have a stronger core and be able to maintain a core contraction when compared to the golfers suffering from low back pain.

Objective Two: To establish whether a relationship exists between abdominal core stability, CHV and ball carry.

Hypothesis Two: It was hypothesized that the asymptomatic group would have a greater CHV and ball carry when compared to the low back pain group.

Objective Three: To establish if age and handicap besides core stability strength have an effect on CHV and ball carry.

Hypothesis Three: It was hypothesized that age and handicap may have an effect on CHV and ball carry.

Objective Four: To establish the correlation between CHV and ball carry in the 2 groups.

Hypothesis Four: It was hypothesized that CHV may effect ball carry in varying degrees amongst the 2 groups.

1.3. RATIONALE:

This study was compiled to determine and further inform the discourse related to core stability, from a clinical as well as a sporting performance perspective, in particular, core stability and its effect on CHV and ball carry.

1.4. BENEFITS:

Should it be observed that golfers with low back pain and a weak abdominal core is associated with poor performance indicators, a stronger argument can be made for the development of training programs specifically aimed at maintaining and improving sporting performance using core stability as a base (Panjabi, 1992).

1.5. LIMITATIONS:

As with all studies that utilize subjective outcomes as part of the measurement and reporting process, it is assumed that all subjects were open and honest and therefore reflected their handicap and condition accurately at the time of measurement (Mouton, 1996).

1.6. ASSUMPTIONS MADE IN THIS STUDY

1. There is a clinical correlation between poor core stability and the presence of low back pain as indicated in the literature (Hodges and Richardson, 1996a). Linked to Objective One and Hypothesis One.
2. Similarly the assumption was made that those with poor core stability would have lesser CHV and ball carry readings than those with good core stability readings. This is linked to objective two and hypothesis two above.
3. That the LBP group would have a lesser CHV and ball carry than the non LBP group. This is linked to objective two and hypothesis two above.

1.7. CONCLUSION:

In the remaining chapters the researcher will review the literature (Chapter Two), describe the methodology of the study in detail and present the statistics (Chapter Three), the results (Chapter Four). Conclusions and future recommendations will then be made (Chapter Five).

CHAPTER TWO: LITERATURE REVIEW

2.1 INTRODUCTION

This chapter reviews the available literature, with a discussion on core stability and the role it plays in the golf swing to promote CHV and ball carry. The biomechanics associated with the golf swing in relation to LBP will also be discussed.

2.2 ANATOMY OF CORE STABILITY

Core stability can be described as the muscular control required around the lumbar spine to maintain function, with or without limb movement (Akuthota and Nadler, 2004). The muscles that make up the core region can therefore be described as a muscular "corset" that serves to stabilize the lumbar spine (Panjabi, 1992).

Hedrick (2000) states that a well developed core allows for improved force output, increased neuromuscular efficiency and decreased incidence of overuse injuries. Hedrick (2000) builds on this by further suggesting that with strengthening the core, one enhances the ability to better utilize the musculature of the upper and lower body to perform a task, resulting in more efficient, accurate and powerful movements and a lessened likelihood of developing low back pain.

For the purpose of this study, core muscles include the following components (Moore, 1992; Moore and Dalley, 1999; Hedrick, 2000):

The Abdominal Component:

- Rectus abdominis muscle,
- External oblique muscle,
- Internal oblique muscle and
- TA muscle.

The Lumbar Component :

- Multifidus muscle,
- Quadratus lumborum muscle,

- Superficial and deep erector spinae muscles,
- Intertransversarii muscles and
- Interspinales muscles.

Recent studies have advocated the importance of these core muscles in the stability and movement of the lumbar spine, specifically the TA and multifidi, to promote functional ability (Hodges and Richardson 1996a; Hodges and Richardson, 1996b; Akuthota and Nadler, 2004), that enables people to perform tasks such as walk, sit and write (Wilcock, 1999).

2.2.1. THE ABDOMINAL COMPONENT

According to Hedrick 2000, the abdominal component of the core muscles consists of:

- Rectus abdominis muscle,
- External oblique muscle,
- Internal oblique muscle and
- TA muscle.

Research has shown that the rectus abdominis muscle is a prominent, strap like muscle, which is vertically orientated. These muscles are separated by the linea alba and lie close together inferiorly (Moore, 1992; Moore and Dalley, 1999). The origin is at the pubic symphysis and the pubic crest and inserts at the xiphoid process and the fifth to seventh costal cartilages. The rectus abdominis is three times as wide superiorly as inferiorly; it is narrow and thick inferiorly and broad and thin superiorly. The rectus abdominis is innervated by the ventral rami of the inferior six thoracic nerves (Moore and Agur, 1995; Moore and Dalley, 1999). The rectus abdominis stabilizes the pelvis during walking and during lower limb lifts from the supine position. In addition, the action of this muscle is to flex the trunk and compress the abdominal viscera as well as prevents tilting of the pelvis by the weight of the limbs (Moore, 1992; Moore and Dalley, 1999).

The external oblique is a superficial flat muscle, which is located in the anterolateral aspect of the abdominal wall (Moore, 1992; Moore and Dalley, 1999). Its fleshy part forms the anterolateral portion and its aponeurosis forms the anterior part. The origin of this muscle is at the external surfaces of the fifth to twelfth ribs. The external oblique inserts at the linea alba, pubic tubercle and the anterior half of the iliac crest. The fibers of this muscle pass inferomedially (Moore and Agur, 1995; Moore and Dalley, 1999). The innervation is by the inferior six thoracic nerves and the subcostal nerve. The action of the external oblique is also to compress and support the abdominal viscera as well as to flex and rotate the trunk which is required in the golf swing (Moore and Agur, 1995; Moore and Dalley, 1999).

The internal oblique is the intermediate flat muscle, the fibers of which run at right angles to the external oblique. The origin of this muscle is at the thoraco-lumbar fascia, the anterior two-thirds of the iliac crest and the lateral half of the inguinal ligament. The insertion of the internal oblique is at the inferior borders of the tenth to twelfth ribs, the linea alba and the pubis via the conjoint tendon. The innervation is supplied by the ventral rami of the inferior six thoracic nerves and the first lumbar nerve. The action of the internal oblique is to compress and support the abdominal viscera as well as to flex and rotate the trunk, which is required in the golf swing (Moore and Agur, 1995; Moore and Dalley, 1999).

The TA is the innermost flat muscle of the anterolateral abdominal wall. Its fibers, except for the most inferior ones, run horizontally. Its origin is the internal surfaces of the seventh to twelfth costal cartilages, thoraco-lumbar fascia, iliac crest and the lateral third of the inguinal ligament. The insertion is at the linea alba with the aponeurosis of the internal oblique muscle, pubic crest and pectin pubis via the conjoint tendon. It is innervated by the ventral rami of the inferior six thoracic nerves and the first lumbar nerve Similarly to the rectus abdominis, the function of this muscle is to compress and support the abdominal viscera (Moore and Agur, 1995; Moore and Dalley, 1999).

Together, the internal oblique, external oblique and TA increase the intra-abdominal pressure via the thoraco-lumbar fascia, that strengthens the core muscular control promoting functional stability of the lumbar spine that enables the movements required from a golf swing (Akuthota and Nadler, 2004).

2.2.2 <u>THE LUMBAR COMPONENT</u>

Research by Moore (1992), Moore and Dalley (1999) and Hedrick (2000), have shown that the lumbar component includes the:

- Multifidus muscle,
- Quadratus lumborum muscle,
- Superficial and deep erector spinae muscle,
- Intertransversarii muscle and
- Rotatores muscle.

These studies have shown that the multifidus is the most medial of the lumbar muscles and has vertebra to vertebra attachments between the lumbar and sacral vertebrae. This muscle has five separate bands, each consisting of a series of fascicles that stem from spinous processes and laminae of the lumbar vertebrae. Each lumbar vertebra gives rise to one group of fascicles, which overlap those of the other levels. The fascicles from a given spinous process insert into mamillary processes of the lumbar or sacral vertebrae, four or five levels inferiorly. The longest fascicles, from L1, L2 and L3, have some attachments to the posterior superior iliac spine (Richardson et al., 1999). The multifidus is innervated by the dorsal rami of spinal nerves and functions to stabilize the vertebrae during movements of the vertebral column (Moore and Agur, 1995; Moore and Dalley, 1999).

Moore and Agur (1995), and Moore and Dalley (1999) state that the origin of the rotatores muscles is from the transverse processes. The fibres of these rotatores pass superomedially and attach at the junction of the lamina and transverse process of the vertebra of origin, or they attach to the spinous process above the vertebra of origin, spanning one to two vertebral segments. Innervation is supplied by the dorsal rami of the spinal nerves. The function of these muscles is to stabilize vertebrae and assist with extension and rotation movements of the vertebral column, which are important movements in the golf swing.

Furthermore, Moore and Agur (1995) and Moore and Dalley (1999) indicate that the intertransversarii muscle originate at the transverse processes of the cervical and lumbar vertebrae, and insert at the transverse processes of adjacent vertebrae. The innervation of these muscles is supplied by the dorsal and ventral rami of the spinal nerves.The principle actions of these muscles are to assist in lateral flexion of the spine, and when they act bilaterally, they serve to stabilize the spine.

Literature states that the quadratus lumborum is located on the posterior abdominal wall. Superiorly, it attaches at the medial half of the twelfth rib and the tips of the lumbar spinous processes. The inferior attachments are at the iliolumbar ligament and the internal lip of the iliac crest (Moore and Agur, 1995; Moore and Dalley, 1999). The actions of the quadratus lumborum are to control lateral flexion when a person is standing. The stabilizing function of this muscle of the lumbar spine on the pelvis is so important that with bilateral paralysis of this muscle makes walking impossible (Travell and Simons (b), 1993). When acting unilaterally, with the pelvis fixed, the quadratus lumborum acts mainly as a lateral flexor of the spine to the ipsilateral side. With the spine in the fixed position, unilateral contraction of the quadratus lumborum results in elevation of the ipsilateral hip. When acting bilaterally, the quadratus lumborum extends the spine (Travell and Simons (b), 1993).

The erector spinae muscle consists of three components that span the cervical, thoracic and lumbar regions (Moore and Agur, 1995; Moore and Dalley, 1999). These are the:

- Iliocostalis muscle (lumborum, thoracis and cervicis),
- Longissimus muscle (thoracis, cervicis and capitis) and
- Spinalis muscle (thoracis, cervicis and capitis).

The erector spinae muscle lies in a trough on either side of the spinous processes, forming a prominent bulge on either side of the median plane. This muscle arises from the broad tendon of the posterior aspect of the iliac crest, and the sacrum, as well as the sacral, inferior lumbar spinous processes and the supraspinous ligament. The fibers of the iliocostalis lumborum run superiorly and attach at the angles of the lower ribs. Innervation is supplied by the dorsal rami of the spinal nerves. Bilateral contraction of this muscle results in extension of the lumbar spine. Unilateral contraction of this muscle results in lateral flexion of the lumbar spine. The function of this muscle enables extension and lateral flexion of the lumbar spine through unilateral and bilateral contraction. These movements are of great importance in swing generation.

2.2.3. THORACO-LUMBAR FASCIA

According to Young, 1996, the thoraco-lumbar fascia is primarily made up of 3 layers, the anterior, middle and posterior layers. The posterior layer is seen to play the most important role in supporting the lumbar spine and abdominal musculature (Akuthota and Nadler, 2004). In this position, the thoraco-lumbar fascia is described as a tough fibrous sheath encasing the spinal extensors and continues inferiorly from the posterior thoracic spine to the ilial and sacral attachments of the hip extensor musculature.

The posterior layer is made up of 2 laminae:

I. Superficial laminae with fibres passing downward and medially;
II. Deep laminae with fibres passing downward and laterally.

Akuthota and Nadler (2004), describe the TA as having large attachments to the middle and posterior layers of the thoraco-lumbar fascia. The thoraco-lumbar fascia extends anteriorly from its central portion from the lateral border of the erector spinae to interdigitate with the fibres of the muscles of the abdominal wall such as the internal oblique and serratus posterior inferior (Young, 1996).

Coupled together with the contraction of the surrounding musculature, the thoraco-lumbar fascia acts as an activated proprioceptor providing feedback in lifting activities (Akuthota and Nadler, 2004).

The core muscles are further categorized into local and global muscle systems based on their main mechanical roles in stabilization. The local system includes deep muscles and the deep portions of some muscles that have their origin or insertion on the lumbar vertebrae (Richardson et al., 1999). These muscles are capable of controlling the stiffness and intervertebral relationship of the spinal segments and the posture of the lumbar spine. The lumbar multifidus muscle, with its vertebrae to vertebrae attachments is a prime example of a muscle of the local system. The TA, which is the deepest muscle, has direct attachments to the lumbar vertebrae through the thoraco-lumbar fascia and the decussations with its opposite in the midline and can also be considered a local muscle of the abdominal muscle group (Richardson et al., 1999).

The local muscle system therefore includes the following muscles (Beeton, 2003):

- Lumbar multifidus muscles,
- Quadratus lumborum muscles,
- Lumbar parts of the lumbar iliocostalis and longissimus muscle,
- TA and,
- Posterior fibres of the obliquus abdominis internus muscles.

Beeton (2003) states that these muscles are primarily responsible for providing segmental stability as well as directly controlling the lumbar segments.

The global muscle system as a result includes the large superficial muscles of the trunk. These include the:

- Internal oblique muscles,
- External oblique muscles,
- Rectus abdominis muscles,
- Lateral fibers of the quadratus lumborum muscles and
- Portions of the erector spinae muscles.

These muscles are responsible for moving the spine as well as transferring load directly between the thoracic cage and the pelvis. The primary function of these global muscles are to balance the external loads applied to the trunk so that the residual forces transferred to the lumbar spine can be dealt with by the local muscles (Richardson et al., 1999).

According to Ray (2002), the facet joints are found at every lumbar spinal level, and are described as being able to provide approximately 20% of the torsional stability to the low back. Thus in the low back, forward-backward bending is limited to about 12 degrees and lateral bending to about 5 degrees. Rotation in the low back however, is limited to approximately 2 degrees per segment, thus excessive rotation in this region could lead to facet impaction as well as nerve damage as the nerve roots pass through the intervertebral foramina (Ray, 2002).

Ray (2002) elaborates on the orientation of the facets by stating that at each given spinal level, the angle of the facets-relative to a plane running through the body from front to back-varies from more parallel to more perpendicular. Each facet joint is thus positioned at each level to provide the needed limits to motion, especially to rotation and to prevent forward slipping of that vertebra over the one below.

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

Facet joint syndrome refers specifically to pain that occurs in the facet joints. This syndrome most often affects the low back in golfers. Lumbar facet syndrome might cause referred pain to the buttocks and thigh (Magee, 2002).

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

2.3 BIOMECHANICS AND PHASES OF THE GOLF SWING

According to Seaman (1998) there are four phases in the golf swing, these include:

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

The entire golf swing is referred to by Chek (2003) as a neuromechanical system, composed of a complex of interrelated neurological and mechanical operations, which include the central nervous, muscular and skeletal systems that combine to create fluid co-ordinated movements that allows for successful function such as completion of the golf swing. This means that the golfer's neuromechanical systems are required to be intact and in a state of readiness, which can be determined by assessing the following four factors:

- Muscle balance and flexibility,
- Static and dynamic postural stability,
- Strength and
- Power.

2.3.1 THE BACKSWING

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

As the extreme of this position is reached, the arms and club are lifted to the point where the left anterior deltoid touches the chin. At this point, Seaman (1998) recommends that the weight transfer to the left should begin.

2.3.2 THE TRANSITION PHASE TO DOWNSWING

As the weight transfer is initiated, the arms and the club will continue to lift slightly because of the momentum created by the arms and shoulders during the backswing. This is known as the transition phase of the backswing to downswing and serves to pre-stretch the pectoralis major and latissimus dorsi muscles to create elastic energy for maximum power generation during the downswing/upswing phase (Seaman 1998).

2.3.3 THE DOWNSWING/UPSWING

This energy creation is then thought to be transferred to the thoraco-lumbar fascia as the downswing/ upswing phase occurs, after the weight transference has been initiated. It takes less then one second to swing down and up into the follow through position, and in this time the energy transfer from the upper extremity to lower extremity will have taken place (Seaman 1998).

During this phase Mackey (1995) describes a pre-impact and impact stage. At pre-impact, the golfer begins contact with the ball, and the golfers right wrist is in maximum extension, the left thumb is in hyperabduction, the left hip is rotated and the knee is in a position of valgus stress. Impact is the phase where the golfer hits/ strikes the ball. During this stage the golfers left wrist ulnar deviates, while the right wrist undergoes compression, the right knee is under valgus stress, and left hip is rotated.

2.3.4 THE FOLLOW THROUGH

According to Mackey (1995) the golfers left elbow supinates, the right elbow pronates, the right hip internally rotates and completes hip rotation, and the knees rotate to the left while the left ankle inverts. The left shoulder hyperabducts, and the cervical and lumbar spine is rotated and hyperextended. Seaman (1998) adds that the body weight should be completely shifted to the left side, and a slightly flexed torso should be resting over a slightly flexed knee. The shoulders and chest should be perpendicular to the target line and the toe line (Seaman 1998).

Balance involves a complex system of neuromuscular communication (Chek, 2003). It relies on feedback from the central nervous system, the eyes, the inner ear, and tiny message receptors in the joints of soft tissues (Guyton and Hall, 1997; Arnold, 1998; Schmitz 1998; Murphy 2000; Nakata 2001; Magee, 2002; Gatterman, 2004; della Volpe 2005 and Ionescu, 2006). Balance is necessary in maintaining appropriate positions for a golfers spine (trunk and torso) throughout the swing (Hopkins and Ingersoll, 2000) because if it is not maintained during the swinging action, shoulder turn, weight shift, and the force transfer may be affected and the CHV and ball carry may be compromised. Research has shown that as people grow older, the sensory organs begin to fail and balance systems are reduced (Sharma et al., 1997; Vilensky, 2003; Panjabi, 2006). Therefore, it might be advantageous to everyone to make better postural balance one of the primary parts of a conditioning program (Draovitch and Simpson, 2007).

Draovitch and Simpson (2007) state that joint flexibility is another component of fitness that has been appreciated by golfers for many years. Furthermore, the authors suggest that joint flexibility is determined by a golfers movement ability and dictates the safe ranges for their swing patterns. However, studies have shown that excellent flexibility alone does not guarantee a good golf swing (Draovitch and Simpson, 2007).

According to Price (2003), dynamic postural stability is the concept of maintaining a desired alignment against external forces and loads throughout an entire movement (e.g. hitting the golf ball). In addition to this Dill (2006) states that a stable dynamic posture is critical to being able to play golf, especially in a pressurized situation. This is because Dill (2006) found that most golf swing faults are caused from not being able to maintain a stable dynamic posture, which these studies show is essential for generating power and maintaining a consistent golf swing (Jackson et al., 2003; Price, 2003). Jackson (2003) has proposed that postural deviations may limit the shoulder motion that could lead to a dramatic decrease in generating the power of the golf swing leading to a possible decrease in CHV and ball carry.

Draovitch and Simpson (2007) suggest that the golfer’s hips and legs are required to produce most of the force for a powerful golf swing. This momentum must be transferred through a stable trunk to the upper body, which simultaneously delivers and counteracts the forceful striking action of the club. In addition, these authors state that a successful swing requires sufficient strength and coordinated actions among the major muscles that make up these different body segments. Strong muscles are essential for proper posture; this increases the consistency of the swing deliveries, and a stable head that maintains constant eye contact with the golf ball (Draovitch and Simpson, 2007).

2.4 THE INCIDENCE OF LOW BACK PAIN AMONGST GOLFERS

Research has found that approximately 62% of golfers sustain low back injuries because of the stresses placed on the spine during the golf swing (Bulbulian, Ball and Seaman, 2000). According to Seaman (1998) it is estimated that 10-33% of touring professionals continue to play while injured, and it is likely that half the group will develop chronic problems. Data for professional golfers indicate that 30% suffer from low back injuries and 27% of amateur golfers incur a similar injury (Grimshaw et al., 2002).

According to Horton et al. (2001), low back pain has been identified as the most common musculoskeletal condition affecting amateur and professional golfers. According to Bulbulian, Ball and Seaman (2000), the main contributing factors causing low back pain in golfers are a combination of repetitive swing motions and poor swing biomechanics.

Furthermore, Horton et al. (2001) states that the golf swing is a very complex movement that involves a considerable number of trunk rotations and powerful muscle contractions. Overuse in association with the complex movement of the golf swing may create repetitive abnormal stresses on the lumbar spine which may lead to injury and low back pain (Horton et al., 2001).

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

As direct evidence of the role of poor swing mechanics in low back pain for golfers is scarce it has been suggested that the low back is susceptible to injury from a number of additional and varied sources (Bulbulian, Ball and Seaman, 2000). One of these sources occurs at the end of the follow through phase, where the golfer’s lumbar spine is rotated and hyperextended. This is referred to as the reversed C position (Hosea and Gatt, 1996). According to McCarrol (1986) this position is essential for proper trajectory and solid impact, as well as body leverage and accuracy. However, many amateur golfers exaggerate this position in order to achieve more power and distance. Mackey (1995) states that in the reversed C position the facet joint spaces are reduced and in addition torsional stress is placed on the annular fibers of the lumbar spine disc. Furthermore, combined with repetitive swings and incorrect form, the lumbar facets bear the stress of abnormal forces on the lumbar spine, especially on the facet joints and the lumbar spine discs leading to subsequent degeneration.

2.5 PREVENTION OF LOW BACK PAIN IN GOLFERS

According to Mackey (1995), preventing low back injuries in golfers is a multifaceted undertaking, where proper technique, stretching, strengthening and endurance exercises should all be part of a complete preventative management system. Grimshaw et al., (2002) states that a more current exercise program incorporating a functional rehabilitation method which is agreed upon by golfer and the clinician. This includes stretching exercises that are geared towards maintaining full ranges of motion, especially in the back, hips, hamstrings and shoulders (Mackey, 1995; Grimshaw et al., 2002). Studies by Chek (2003) found that a golfer can prevent injuries as well as make significant gains towards a better swing simply by stretching muscles before play.

According to Bulbulian, Ball and Seaman (2001), strengthening exercises enable the low back to better withstand the biomechanical stresses of the full recoil swing. Grimshaw et al., (2002), stated that although the TA muscle is not considered to be paraspinal, it is particularly important in the maintenance of spinal stability, allowing more specific golf functioning exercises to be performed, without posing a risk to the stability of the low back. So, according to Mackey (1995) strengthening exercises of the back, hips, legs, shoulders and wrists will also allow for more explosive shots over a longer period of time as well as cross training exercises, such as jogging, walking and riding a bicycle will help a golfer increase his endurance on the golf course.

Similarly Watkins et al., (1996) speculated that abdominal muscle activity might be different in golfers suffering with low back pain. Evans and Oldreive (2000) reported that golfers with low back pain have a reduced ability to maintain a static contraction of the TA muscle, although it is unclear whether this translates to differences in golf swing activity patterns. In addition to this, Watkins (1996) also showed that the oblique abdominal muscles on both sides of the trunk are very active in golf swings of asymptomatic players.

In spite of this, it is assumed that as a result of strengthening the muscles used during the golf swing, more power could be generated and the CHV would subsequently increase. This is based on the observation by Stude and Gullickson (2001) that a stable base of support will allow a player to generate more acceleration during the downswing, with a subsequent increase in CHV and a greater ball carry. Stude and Gullickson (2001) continue by stating that players who have poor balance show less consistency in properly contacting the ball, which negatively affects ball carry.

Therefore, Lindsay and Horton (2002) suggested that future research should be done to compare abdominal muscle forces of contraction during the 4 phases of the golf swing, in golfers with and without low back pain to determine if differences exist in the ability to protect the lower back between these groups. They continued to state that prospective long term studies are needed to determine if spinal motion characteristics or abdominal muscle activity are affected by, or contribute to, the onset of golf related low back pain.

CHAPTER THREE: MATERIALS AND METHODS

3.1 INTRODUCTION

In this chapter, the main methodological factors will be discussed in order to substantiate the basis for the data collection process. Specifically, this chapter will be divided into the following sub-headings:

- Study design,
- Method,
- Inclusion criteria,
- Exclusion criteria,
- Assessment or procedure,
- Data collection and
- Statistical analysis.

3.2 STUDY DESIGN

A comparative study between two sample groups was employed for this study to compare any differences that may exist between golfers with and without low back pain concerning their core stability, CHV and ball carry.

Based on this design, the research proposal was approved by the Faculty of Health Science Research and Ethics committee, which declared that this research complied with the Declaration of Helsinki, 1975 (see Appendix I – Ethics Clearance Certificate).

3.3 METHOD

Recruitment was by means of advertisements informing golfers of the study. These were placed at various golf clubs, golf driving ranges and golf stores in and around the Greater Durban Metropolitan area (Appendix F).

3.3.1 SAMPLING METHOD

Golfers who responded to the advertisements were age matched, as close as possible, as to have had a better comparative value. A maximum age difference of 1 year was approved. Golfers were also all male, had a handicap of 10 - 20 and were between the ages of 25 – 45.

3.3.2 SAMPLING SIZE

This study included 40 male golfers. Twenty golfers were asymptomatic with regards to low back pain and could initiate and maintain a core contraction, whilst the other 20 golfers had low back pain and could not initiate or maintain a core contraction.

3.3.3 GOLFER SCREENING AND EVALUATION

Golfer screening and subsequent selection or exclusion, was initially conducted via telephonic communication with the researcher. The following questions were asked by the researcher:

- Are you male and between the ages of 25 and 45?
- Do you suffer from any form of low back pain (if yes, the pain must have been present for at least 3 weeks prior to consultation), or are you pain free?
- Do you have a handicap between 10 - 20?
- Do you play golf at least twice a month?
- Are you currently receiving any form of treatment for your low back pain?
- Do you currently suffer from any of the following conditions:
    - Glaucoma?
    - Hypertension?
    - Osteoporosis?
    - Spinal Tumours?
    - Any form of Impaired Circulation?
    - Any known disc pathology?
- Are you currently on any form of medication?
-

Golfers successfully accepted from the telephonic screening were evaluated at an initial consultation. At this initial consultation, the golfer received a Letter of Information (Appendix 2) and signed an Informed Consent Form (Appendix 3). Once they agreed to participate in the study they then underwent a Medical Case History (Appendix 5), a relevant Physical Examination (Appendix 6) and a Lumbar Regional Examination (Appendix 7) to establish whether they were eligible for this study and therefore met the inclusion criteria:

3.4 INCLUSION CRITERIA

1. Golfers had to be male between the ages of 25 and 45. Kirkaldy-Willis and Burton (1992), state that age is an important risk factor in low back pathology which tends to begin during the third decade of life and reaches maximal frequency during middle age. This is often confused with pain due to degenerative changes (Yochum and Rowe, 1996), and so older golfers were excluded from this study.
2. Golfers who had no current episode of low back pain and were able to maintain a core contraction. This group was to be used as the control group.
3. Golfers with low back pain (the episode of low back pain must have been present for 3 weeks or more) and who could not maintain a core contraction. This group was the experimental group.
4. Golfers had to have a handicap of between 10 - 20 (this handicap ensures that only players of a certain calibre will be eligible for the study).

3.5 EXCLUSION CRITERIA

1. Golfers receiving treatment for mechanical low back pain. It was decided that golfers who were receiving treatment for existing back pain may influence their level of perceived pain and adversely affect the results of this study.
2. Any contraindications to abdominal muscle strengthening (including but not limited to) were excluded: Glaucoma, Hypertension, Osteoporosis, Spinal Tumours and Impaired Circulation (Harms-Ringhdal, 1993); resulted in the golfer being excluded.
3. Golfers with extreme discomfort on contracting the abdominal muscles were excluded.
4. Any golfers taking any form of medication were excluded unless they were prepared to consider a wash out period of greater than 72 hours (Poul et al., 1993 and Seth, 1999).
5. Any golfer who did not return to the Durban Pro Shop for testing on the FlightScope Monitoring System within 2 days of their initial consultation. This was instituted for practical purposes.
6. Any golfer who developed low back pain in the 2 day period between the initial consultation and testing on the Flight Scope Monitoring System.

3.6 INSTRUMENTS

An objective measurement was obtained by utilizing the **Pressure Biofeedback Unit (PBU)**. This is a visual feedback device that optimizes the golfers muscle control. The unit consists of a combined gauge/inflation bulb connected to a pressure cell, which is inflated to a baseline pressure of 70 mmHg. The device registers changing pressure in an air filled pressure cell. It allows for body movement, especially spinal movement, to be detected during exercise. (Chattanooga Group, A Division of Encore Medical, 2002).

3.6.2. A **stopwatch** measuring maximal contraction time (s) of the TA muscle.

3.6.3 **Flightscope Pro swing analyzer**.

The Flightscope Pro swing analyzer is a 3D tracking radar system/device that measures many aspects of the golfers swing, including; CHV, ball speed, ball carry/distance, angle of the club head and swing paths. This device is based on phased array technology to measure projectiles in flight. The Flightscope Pro has a launch velocity range of 1.5 to 250 miles per hour within 0.5% accuracy and can give the landing position of the ball (ball carry) with a standard error of 5% actual flight distance. The CHV strike is accurate to 2% (http://www.edh.co.za/, 2005).

3.7 ASSESSMENT PROTOCOL

All golfers that were eligible for the study, underwent a thorough Case History (appendix A), Physical (appendix B) and Low Back Regional (appendix C) Examination. Those golfers who presented as having low back pain were required to rate the severity of their pain using the Numerical Pain Rating Scale 101 (Appendix E), (Jenson et al., 1986), as a subjective measure. The handicap of each golfer was also noted and recorded.

Following this, a measurement of core stability muscle (specifically the TA) activation and endurance in both groups was performed, using a Pressure Biofeedback Unit. In accordance with Richardson et al., (1999), before formal testing begins golfers are taught to activate the TA in the four-point kneeling position. This position provides a facilitated stretch to the deep abdominals and leads to an inhibitory effect on the superficial muscles, particularly the rectus abdominis, allowing for a more accurate measurement of the TA (Richardson and Jull, 1995).

Golfers were then instructed to lie prone on a gym mat with their head turned to one side. The Pressure Biofeedback Unit was then placed under their abdomen, with the centre at the navel and the distal edge at the level of the anterior superior iliac spine. It was then inflated to a baseline pressure of 70 mmHg.

Golfers were then tested to observe if they could initiate and maintain a contraction of the TA muscle for a minimum of 30 seconds in the prone position. A drop in pressure of 6-8 mmHg was seen with a correct contraction and a cycling (increase and decrease of pressure) of ± 2 mmHg was normal during breathing, however, a gradual or sudden rise in pressure indicated fatigue/weakness of the TA muscle (Evans and Oldreive, 2000).

According to Robertson (2005), the golfer's contraction was also closely monitored for any compensation mechanisms which would affect the readings obtained from the unit. Breath holding, rib elevation, movements of the pelvis or spine and abdominal bracing using the oblique muscles were all deemed as compensatory mechanisms. Breath holding and rib elevation would result in a drop in pressure of 1-2 mmHg, whilst abdominal bracing would have a resultant rise in pressure of 1-2 mmHg. Contraction of the rectus abdominis would also result in a rise in pressure.

According to the results found during testing and the presence or absence of low back pain, the golfers were placed into 2 groups, Group A or B, of 20 golfers in each group.

Group A: All golfers were asymptomatic (no low back pain symptoms) and could maintain a core contraction of 30 seconds in the prone position.

Group B: All golfers in this group had low back pain, and could not initiate or maintain a core contraction of 30 seconds in the prone position.

Golfers were then required to report to the Durban Pro Shop within two days of the initial consultation for testing on the FlightScope Pro Monitoring System available at the store. Each golfer was required to hit 5 balls using a standard club (in this study, a standard driver was used), after which an average value was calculated for CHV and ball carry.

All data obtained was recorded on the data capture sheet (appendix J).

3.8 DATA COLLECTION

3.8.1 FREQUENCY

Golfers were first screened at a private practitioners practice and if time allowed, measurements would be done at the Durban Pro Shop on the same day. For those golfers who could not complete the entire procedure on the same day, they were followed up within 2 days of the initial consultation at the Durban Pro Shop.

3.9 STATISTICAL ANALYSIS

- To compare core stability strength between asymptomatic golfers and golfers with low back pain. The contraction time of TA in seconds will be compared between the two groups (asymptomatic group and experimental group) using an independent samples t-test.
- To establish the relationship of core stability muscle strength on CHV and ball distance, intra group correlational analyses will be done using Pearson's correlation coefficient. A correlation coefficient above 0.7 will be considered as a clinically important correlation.

SPSS version 15.0 (SPSS Inc., Chicago, Ill) and Stata 9.0 (Stata Corporation, Texas) were used to analyse the data. In terms of bi-variate analysis, the median of 5 CHV values and 5 ball carry measurements for each golfer was calculated, resulting in a single value for CHV and for ball carry for each golfer.As parametric testing was used, outcomes were approximately normally distributed. Independent samples t-tests were done to compare quantitative data between the two treatment groups. Pearson's correlation coefficients were used to assess intra-group correlations between CHV and ball carry.

For multivariate analysis, all 5 measurements for each golfer were used to increase the power of the study. The intra-subject correlation of measurements was dealt with using generalized linear models and specifying clustering on study number using robust standard errors. Although 200 records were processed in the multivariate analysis, the data were treated as originating from 40 individual golfers (5 records per individual). Covariates used in the models were age and handicap, while the group of the individual (core stability group) was the factor of interest (Group A vs. Group B).

CHAPTER FOUR: RESULTS

4.1. INTRODUCTION:

This chapter represents the statistical analysis of the data collected. The data is discussed in four study objectives:

Objective One: To differentiate the groups at baseline with respect to core stability strength between asymptomatic golfers and golfers suffering from low back pain.

Objective Two: To establish whether a relationship exists between abdominal core stability, CHV and ball carry.

Objective Three: To establish whether age and handicap, besides core stability strength have an effect on CHV and ball carry.

Objective Four: To establish the correlation between CHV and ball carry.

4.2. DATA SOURCES:

Data sources utilized to compile this chapter were from both primary and secondary sources of information. Primary sources included information collected from the golfers of the study in the form of a Pressure Biofeedback Unit and the Flightscope Pro Machine at the Durban Pro Shop.

Secondary data sources included various books on statistical analysis (Bland, 1996; Swinscow, 1996; Wright, 1997; Tropper, 1998; Campbell and Machin, 1999; Hinton, 2001), personal communications with the statistician (Esterhuizen, 2007) and the supervisor of the research project (White, 2007) and Korporaal (2008).

4.3. ABBREVIATIONS PERTINENT TO THE CHAPTER:

- “p” refers to the p-value which indicates the data statistical significance (Bland, 1996; Swinscow, 1996; Wright, 1997; Campbell and Machin, 1999; Hinton, 2001).
- “r” refers to Pearson's correlation.
- “n” refers to the to the sample size. Sample in this case is defined as *“A subset of a population”* (Tropper, 1998).
- “CHV” is the abbreviation for club head velocity
- “mph” is the abbreviation for miles per hour
- “%” = percentage.
- “<” refers to a figure “less than” the figure reported.
- “=” implies “equals to.”

4.4. RESULTS

Before the results are presented in this chapter, the significance of the p-value is discussed below.

4.4.1. SIGNIFICANCE OF THE P-VALUE:

If data collected during the research process is not consistent with the null hypothesis, it means that the null hypothesis would be rejected and the alternative hypothesis would probably be true. In addition the data is represented as being either statistically significant or insignificantly different from the null hypothesis. When a small p-value is calculated, the data is said to be statistically significant. This means that the data collected provided enough information to reject the null hypothesis, therefore an effect was detected in the research process and the alternative hypothesis would probably be true. Conversely, if the p-value were large, the data collected did not provide sufficient information to reject the null hypothesis, which means that there is not enough evidence to support the alternative hypothesis, therefore indicating further research is required.

The significance level of the p-value is usually selected before the collection of data and is usually set at $p=0.05$ or $p=0.01$, which renders the probability of the p-value at a significant level. The smaller the p-value ($p<0.001$) the higher the significant level (Bland, 1996; Swinscow, 1996; Wright, 1997; Campbell and Machin, 1999; Hinton, 2001).

4.4.2 PEARSON'S CORRELATION:

For this study the researcher did not use Spearman's rho correlation, rather Pearson's correlation where the coefficient is r rather than rho. This is because the measurement values were normally distributed, thus parametric testing was used. R values closer to 1 or -1, specifically those greater than -0.8 or 0.8 are considered as indicative of strong correlations, while those between 0.5 and 0.8 (0r -0.5 and -0,8) are considered moderate correlations and those below 0.5 or -0.5 indicate the absence of a correlation (Esterhuizen, 2008).

4.5 RESULTS CONTINUED

4.5.1 DESCRIPTIVE ANALYSIS OF THE DEMOGRAPHICS OF THE GOLFERS:

Twenty golfers were assessed per group, forty in total. Their mean age was 28.4 years (SD 3.1 years) with a range from 25 to 38 years. The mean handicap of the whole group was 17.5 (SD 3.6, range 10 – 20).

The difference between the two core stability groups in terms of age and handicap were not statistically significant, as shown in Table 1.

Table 1: Comparison of mean age and handicap between the two groups (n=40)

	GROUP A		GROUP B		P value
	Mean	Standard Deviation	Mean	Standard Deviation	
AGE	28.2	3.2	28.6	3.1	0.726
HANDICAP	17.0	3.7	18.2	3.5	0.281

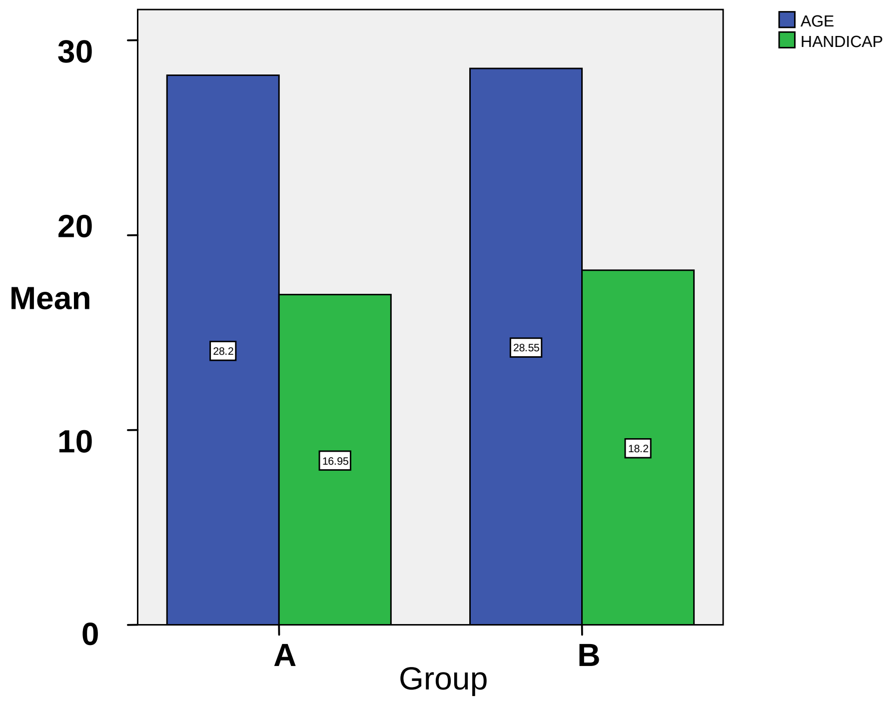

Figure 1: Mean age and handicap by group

4.5.2 STATISTICAL ANALYSIS OF THE OBJECTIVES

4.5.2.1 OBJECTIVE ONE: To differentiate the groups at baseline with respect to core stability strength between asymptomatic golfers and golfers suffering from low back pain.

At baseline, groups were selected and differentiated according to low back pain status and core stability strength. Group A consisted of golfers without low back pain who could maintain a core contraction, and Group B consisted of golfers with low back pain who could not maintain a core contraction.

Discussion:

Watkins et al., (1996) speculated that abdominal muscle activity might be different in golfers suffering with low back pain. In addition to this, Watkins (1996) showed that the oblique abdominal muscles on both sides of the trunk are very active in golf swings of healthy players. It is therefore possible that the considerably lower flexion velocity observed for the golfers with low back pain in this study was due to differences in the force of contraction of the abdominal muscles (Watkins et al., 1996). This was supported by Evans and Oldreive (2000) who reported that golfers with low back pain have a reduced ability to maintain a static contraction of the TA muscle, although it is unclear whether this translated to differences in golf swing activity patterns. Further to Watkins et al., (1996) and Evans and Oldreive's (2000) findings, Horton et al., (2001) described the golf swing as being a very complex movement that that involves a considerable amount of trunk rotation and more importantly, powerful muscle contractions of amongst others the trunk flexors. So an association between overuse (asymmetrical nature of the golf swing) and abnormal stressors was thought to create repetitive abnormal stresses on the lumbar spine which may lead to injury and pain (Horton et al., 2001).

Bulbulian et al., (2001) therefore highly recommended that strengthening exercises aimed at the core musculature would enable the lower back to better withstand the biomechanical stresses placed on it during the golf swing and reduce the risk of injury.

Akuthota and Nadler (2004) advocated the importance of the core musculature and its need for optimum stabilization and performance. It was further noted that the TA and multifidus muscles were identified as vital in the stability and movement of the lumbar spine (Akuthota and Nadler, 2004).

This selection process at baseline allowed the researcher to compare a “control group” (Group A) to an “experimental group” (Group B).

4.5.2.2 <u>OBJECTIVE TWO:</u> To establish whether a relationship exists between abdominal core stability, CHV and ball carry.

There was no significant difference between the mean CHV (p=0.455) and the mean ball carry measurement of the two groups (p=0.071), although the latter measurement showed a relatively large observed difference (215.4 in Group A and 197.95 in Group B).

Table 2: Comparison of mean CHV and ball carry between the two groups(n=40)

	GROUP	N	Mean	Std. Deviation	Std. Error Mean	P value
CHV	A	20	95.03	9.639	2.155	0.455
	B	20	92.85	8.586	1.920	
Ball carry	A	20	215.40	29.950	6.697	0.071
	B	20	197.95	29.354	6.564	

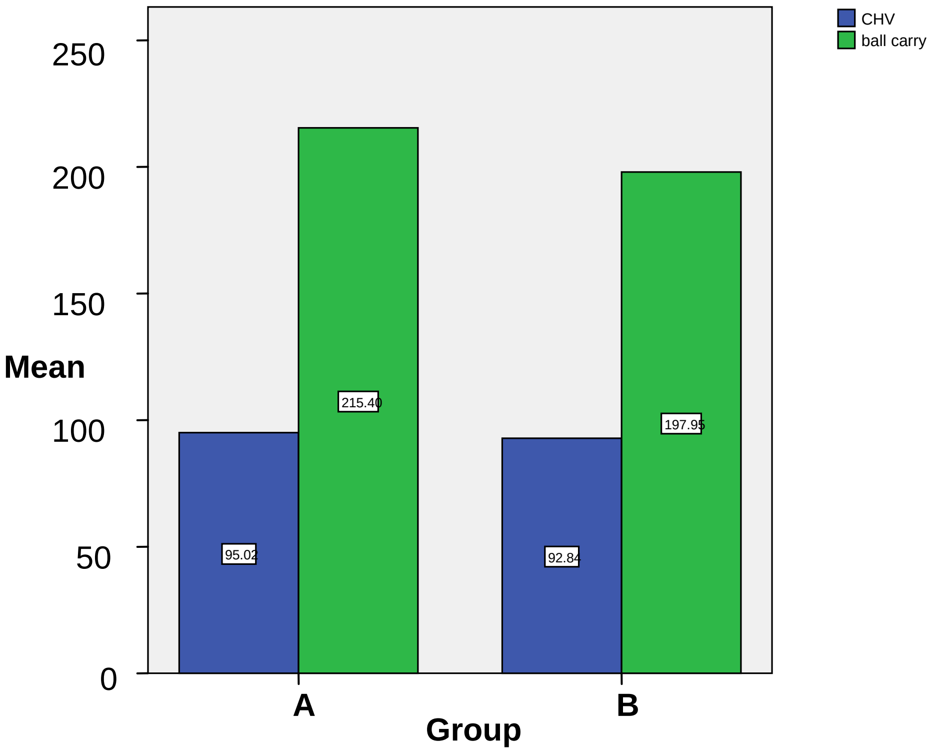

Figure 2: Mean CHV and ball carry by group

Discussion:

According to Table 2, the ball carry measurement between the two groups showed that Group A had a greater ball carry when compared to Group B. However the statistical significance was borderline p = 0.071.

This demonstrates that Group A golfers, with no low back pain and good core stability showed an increased ball carry when compared to Group B, golfers with low back pain and a weak core.

The results from this study can be aligned to a finding by Chek (2003), who suggested that CHV is primarily affected by strength and power, but is also secondarily affected by muscle balance, flexibility as well as static and dynamic postural stability. In addition, these results concur with Stude and Gullickson (2000) who suggested that players with observably weaker core stability are more prone to developing low back pain. Therefore, these results indicate that a stable base of support will allow a player to generate more acceleration during the downswing, with a subsequent increase in CHV and a greater ball carry (Stude and Gullickson 2001, Chek 2003).

However, Stude and Gullickson (2001), assumed that power and so CHV could only begenerated as a result of strengthening the muscles used during the golf swing as a relationship exists between CHV and ball carry which is expressed as a ratio of 3:1. This means that an increase of 1 mph in the CHV, would result in an increase in ball carry of approximately 3 yards in length (Stude and Gullickson, 2000: 173). This assumption however did not take into account that pain as a result of a musculoskeletal syndrome may impact on the strength and power of the golf swing and thus ultimately the CHV and ball carry.

Therefore it is interesting to note the results observed in Table 2 which shows that golfers with a weaker core stability and low back pain tend to demonstrate a decreased ball carry and CHV because of decreased strength and power. Therefore these results concur with studies by Stude and Gullickson (2001) that demonstrated that players with weak core stability and LBP have reduced ball carry and CHV.

It is recommended however that a larger study be undertaken based on these outcomes of this study in order to allow for a stronger more highly powered study, which would be able to substantiate the validity of these statistical outcomes obtained and detect if a relationship exists between abdominal core stability, CHV and ball carry.

4.5.2.3. OBJECTIVE THREE: To establish whether age and handicap, besides core stability strength have an effect on CHV and ball carry.

4.5.2.3.1. CHV

Table 3 shows the results of the multivariate generalized linear model analysis for CHV.

Analysis of the statistics reveals that the control group (Group B) had no significant influence on CHV values (p=0.957). Further analysis of the results showed that it was in fact age (a decrease of on average 0.939 mph of CHV with every 1 year increase in age, p=0.001), and handicap (a decrease of 1.386 mph of CHV with every 1 stroke increase in handicap, p<0.001) of the golfer that significantly affected the CHV.

Therefore it can be said that the age and handicap of golfers are negatively correlated with respect to CHV. This implies that an increase in both age and handicap resulted in a decrease in overall CHV.

Table 3: Generalised linear model for CHV

Effect	Coefficient	Robust std. error	P value
Group (A vs. B)	-0.112	2.094	0.957
Age	-0.939	0.274	0.001*
Handicap	-1.386	0.215	<0.001*
Constant	144.827	7.96	<0.001*

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

4.5.2.3.2 Ball carry

Table 4 shows the results of the multivariate generalized linear model analysis for ball carry.

Group B had a non significant effect on ball carry values (p=0.118). Group A had an average of 11.275 meters higher mean ball carry than Group B after controlling for age and handicap. There was a non significant result between core stability and increased ball carry.

The age of the golfer (a decrease of on average 2.448 meters of ball carry with every 1 year increase in age, p=0.048) and handicap (a decrease of 3.735 meters of ball carry with every 1 stroke increase in handicap, p<0.001) were statistically significant determinants of ball carry. So, similarly with the result on CHV, age and handicap were negatively correlated with ball carry.

Table 4: Generalised linear model for ball carry

Effect	Coefficient	Robust std. error	P value
Group (A vs. B)	11.275	7.207	0.118
Age	-2.448	1.239	0.048*
Handicap	-3.735	0.840	<0.001*
Constant	358.842	32.542	<0.001*

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

Discussion:

The results from the outcomes of Objective Three indicate that golfers with a lower handicap have a better golfing average as compared to golfers with a higher handicap. This means that a lower handicap should in theory naturally exhibit a greater CHV and also ball carry.

Chek (2003) suggested that CHV is primarily affected by strength and power but is also affected by muscle balance, flexibility as well as static and dynamic postural stability.

Table 4 however, suggested that core stability / presence and absence of low back pain has no significant effect on ball carry and CHV, instead age and handicap have a far more significant influence. This is enumerated in Table 4 where it is shown that for every 1 year increase in age there was a decrease of 2.448 meters in ball carry, and for every 1 stroke increase in handicap there was a decrease of 3.735 meters in ball carry. Again this shows a negative correlation between handicap and age when compared to ball carry.

Similarly Table 3 shows that for every 1 year increase in age there was a decrease of 0.939 mph in CHV, and for every 1 stroke increase in handicap there was a decrease of 1.386 mph in CHV. Again this shows a negative correlation between handicap and age when compared to CHV.

Similar to the results from studies by Stude and Gullickson (2001), the outcomes of these results also indicate that there is a relationship between age and handicap as well as between the CHV and ball carry.

4.5.2.4. OBJECTIVE FOUR: To establish the correlation between CHV and ball carry

4.5.2.4.1 GROUP A:

Results from Table 5 show there was a highly significant positive correlation between CHV and ball carry in Group A (r=0.835).

Table 5: Pearson's correlation between CHV and ball carry in Group A

		Ball Carry
CHV	Pearson Correlation	0.835*
	Sig. (2-tailed)	<0.001
	N	20

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

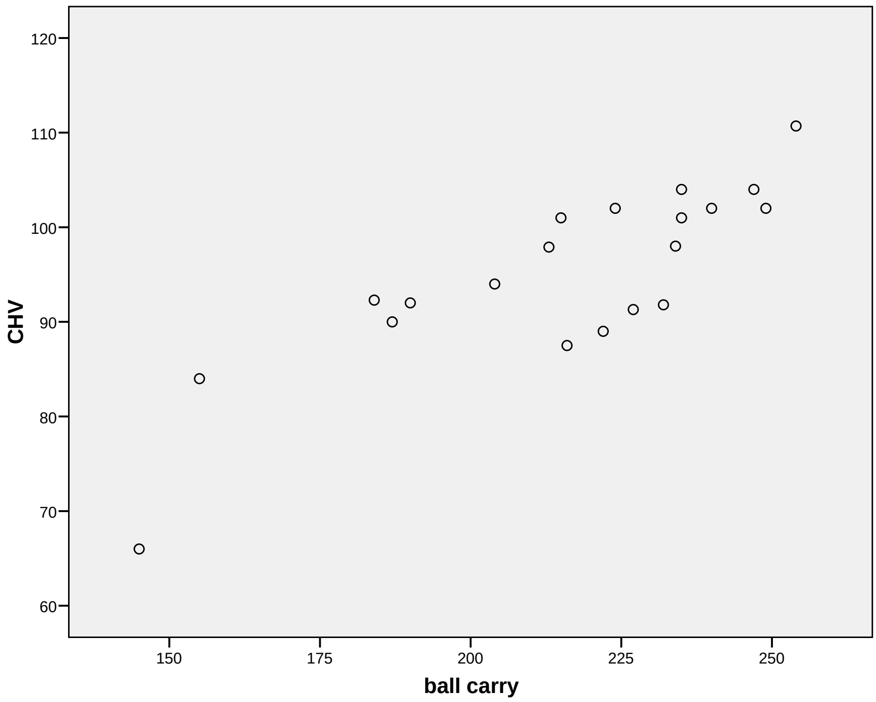

Figure 3: Scatterplot of CHV and ball carry in Group A

4.5.2.4.2 GROUP B:

Results from Table 6 show there was a highly significant positive correlation between CHV and ball carry in Group B (r=0.741).

Table 6: Pearson's correlation between CHV and ball carry in Group B

		ball carry
CHV	Pearson Correlation	0.741*
	Sig. (2-tailed)	<0.001
	N	20

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

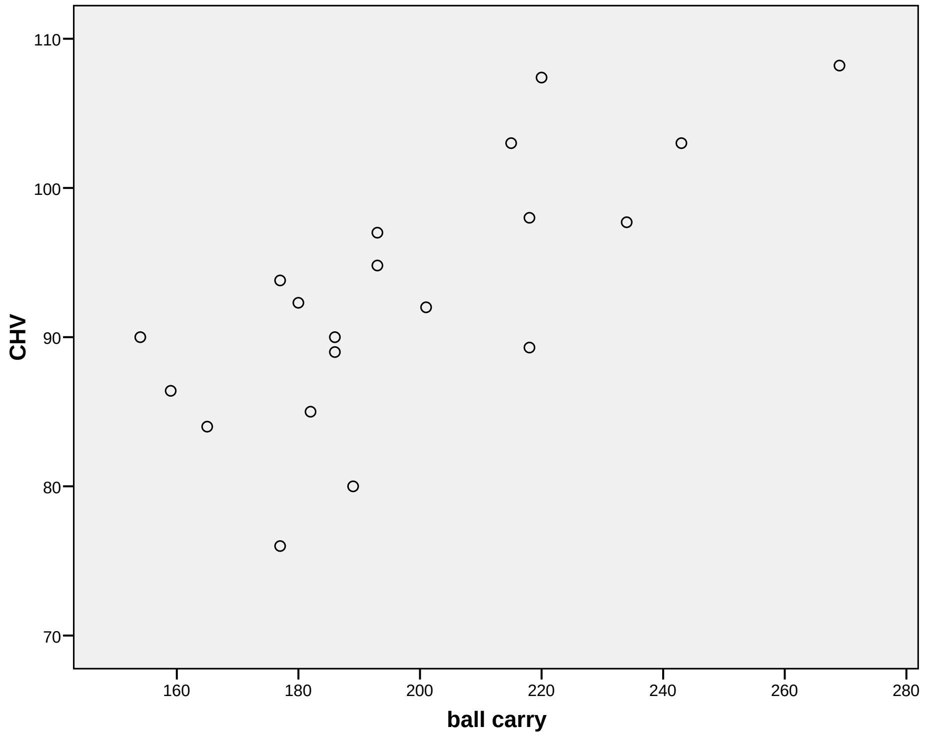

Figure 4: Scatterplot of CHV and ball carry in Group B

Discussion:

Tables 5 and 6, along with Figures 3 and 4, show that there was a significant correlation between CHV and ball carry in both Group A and Group B.

It is however noted that Group A showed a greater degree of significance with respect to the strength of the relationship between the CHV and ball carry when compared with Group B.

The results support previous research by Stude and Gullickson (2000) that has found that a relationship exists between CHV and ball carry which has been expressed as a ratio of 3:1. This means that an increase of 1 mph in the CHV, would result in an increase in ball carry of approximately 3 yards in length. This study however cannot verify whether the ratio attributed to the relationship is indeed true, although it can be established from the scatterplots (Figures 3 and 4) that the relationship between CHV and ball carry is in the region of 2-2.5:1.

DISCUSSION OF THE HYPOTHESES

Hypothesis One: It was hypothesized that asymptomatic golfers would have a stronger core and be able to maintain a core contraction when compared to the golfers suffering from low back pain.

At baseline the golfers of this study were selected and differentiated at baseline so a comparison could be made between golfers with LBP and golfers without low back pain as to their core stability strength.

Group A consisted of golfers without low back pain who could maintain a core contraction for 30 seconds, and Group B consisted of golfers with low back pain who could not maintain a core contraction for 30 seconds.

This was based on findings by Evans and Oldreive (2000), who found that golfers with low back pain do in fact have a reduced ability to maintain a static contraction of the TA muscle.

Upon initial consultation, it was found that this did in fact hold true to the findings of Evans and Oldreive (2000) and groups could therefore be divided as discussed above.

Hypothesis Two: It was expected that there would be greater abdominal core stability, CHV and ball carry in the asymptomatic group when compared to the low back pain group.

The greater abdominal core stability was determined by the outcomes of Hypothesis One.

Analysis of the statistics showed no significant difference between the mean CHV and the mean ball carry measurement of the two groups. Therefore based on the statistical analysis the hypothesis is rejected and the alternative hypothesis is accepted indicating that there is no difference between the groups.

However, it is indicated that a future study with a larger sample size would be required in order to ascertain whether this outcome is indeed valid, as the ball carry measurement showed a relatively large observed difference between the groups (215.4m in Group A and 197.95m in Group B).

Hypothesis Three: It was hypothesized that age and handicap may have an effect on CHV and ball carry.

This hypothesis was accepted as it was found that age and handicap were negatively correlated to both CHV and ball carry. This meant that golfers who were older or had a higher handicap, showed a decrease in both their CHV and ball carry.

Furthermore the above findings suggested that there is a relationship between age and handicap as well as CHV and ball carry. This supports the findings of Stude and Gullickson (2000) that an increase in CHV resulted in an increase in overall ball carry.

Hypothesis Four: It is has been shown in a previous study that there is a correlation between CHV and ball carry at a ratio of 1:3. Therefore, for every 1mph increase in CHV there is an increase in ball carry of 3 yards (Stude and Gullickson, 2000:173).

The study did in fact reveal a correlation between CHV and ball carry in both Group A and B. The relationship tended towards a 2-2.5:1 ratio according to the outcomes of the scatterplots (Figures 3 and 4). Therefore the hypothesis is accepted in that there is a definite relationship between CHV and ball carry, however a common ratio between CHV and ball carry remains unanswered.

Although it was not significant, there was a tendency that showed that the control group (Group A), had a greater CHV and ball carry when compared to the experimental group (Group B). It is however acknowledged that the sample size in this study may have negatively influenced the outcomes of this parameter even after having controlled for age and handicap.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION AND RECOMMENDATIONS:

5.1.1 INTRODUCTION

This chapter deals with the outcomes of the research and makes recommendations with regards to future studies.

5.1.2 CONCLUSION

The purpose of this study was to compare core stability, CHV and ball carry in golfers with and without low back pain.

The results from this study suggested that core stability and low back pain did not influence CHV.

However, with respect to ball carry, there was a non significant trend which indicated higher ball carry in the group with a greater level of core stability and no LBP than in the group with LBP and reduced level of core stability.

The results also showed that increasing age and handicap reduced the CHV and ball carry values significantly. However when these effects were controlled using a multivariate model there was still no effect of the presence or absence of core stability on CHV, and a non significant positive effect of core stability on ball carry was evident.

Ball carry and CHV were positively correlated in both groups, irrespective of the presence / absence of core stability and / or low back pain.

5.1.3 RECOMMENDATIONS

- For future research, a smaller variation in handicap should be used in to decrease parameters between amateur and more experienced golfers in terms of their ability. If this is not possible then the sample should be stratified according to handicap as well as age.

- More emphasis should be placed on age criteria to gain a closer correlation between groups and therefore compare golfers of a similar age group.

- Further research with a larger study group is needed to confirm these findings as this study may have been underpowered and therefore statistically significant differences may not be overt.

- For more accurate results the sample groups should be divided further into those that can and cannot maintain a core contraction in the asymptomatic and low back pain groups. Therefore future research should consider having four sample groups compared to only two groups as used in this study to validate associations between the various parameters.

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Appendix A:

DURBAN UNIVERSITY 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		
(a) **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: 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:

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

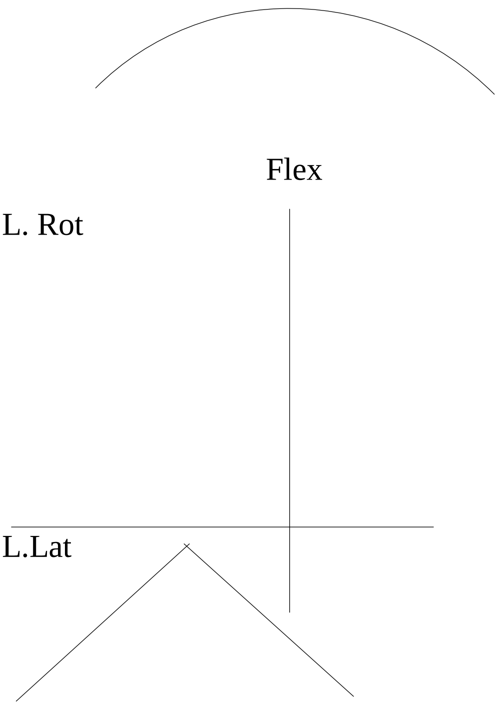
GAIT:

Normal walk

Toe walk

Heel Walk

Half squat



Flex

L. Rot

R. Rot

ROM:

Forward Flexion = 40-60° (15 cm from floor)

Extension = 20-35°

L/R Rotation = 3-18°

L.Lat

R.Lat

L/R Lateral Flexion = 15-20° Flex

Flex

Ext.

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	**L**										

Sl, +, ++	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
Trunk rotation
Flip Test
Ankle dorsiflexion test

Axial compression
Burn's Bench test
Hoover's 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

DU UNIV TECH

Appendix D
DURBAN UNIVERSITY OF TECHNOLOGY

Patient Name: ***File #:*** ***Page:***

Date: ***Visit:*** ***Intern:***
Attending Clinician: ***Signature:***

S: ***Numerical Pain Rating Scale (Patient)*** ***Intern Rating*** ***A:***
Least 0 1 2 3 4 5 6 7 8 9 10 Worst

0: ***P:***

E:

Special attention to: ***Next appointment:***

Date: ***Visit:*** ***Intern:***
Attending Clinician: ***Signature:***

S: ***Numerical Pain Rating Scale (Patient)*** ***Intern Rating*** ***A:***
Least 0 1 2 3 4 5 6 7 8 9 10 Worst

O: ***P:***

E:

Special attention to: ***Next appointment:***

Date: ***Visit:*** ***Intern:***
Attending Clinician: ***Signature***

S: ***Numerical Pain Rating Scale (Patient)*** ***Intern Rating*** ***A:***
Least 0 1 2 3 4 5 6 7 8 9 10 Worst

O: ***P:***

E:

Special attention to: ***Next appointment:***

Appendix E:

Numerical Pain Rating Scale –101 Questionnaire

Patient name: ____________________ File No.: __________________

Date: ______________

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

APPENDIX F: RECRUITMENT FLYER

GOLF RESEARCH

Males between the age of 25-45, with a handicap of 10-20 are required for research being conducted.

Both asymptomatic (no low back pain) and low back pain sufferers are required…

You may qualify for research being conducted at Durban University of Technology

CHIROPRACTIC DAY CLINIC

WHICH INCLUDES:

A FREE ASSESSMENT ON THE LATEST FLIGHTSCOPE TECHNOLOGY AT THE DURBAN PRO SHOP

For more information contact:

GUY BOWER

031-2042205

Appendix G:

INFORMED CONSENT FORM

(To be completed by patient / subject)

Date:

Title of research project:

The core stability, club head velocity and ball carry in golfers with and without low back pain – a comparative study.

Name of supervisor:

Dr. RH White (M.Tech:Chiropractic)

Name of research student:

Guy Bower

Please circle the appropriate answer

		YES /NO
1. Have you read the research information sheet?	Yes	No
2. Have you had an opportunity to ask questions regarding this study?	Yes	No
3. Have you received satisfactory answers to your questions?	Yes	No
4. Have you had an opportunity to discuss this study?	Yes	No
5. Have you received enough information about this study?	Yes	No
6. Do you understand the implications of your involvement in this study?	Yes	No
7. Do you understand that you are free to withdraw from this study?	Yes	No

at any time

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

8. Do you agree to voluntarily participate in this study Yes No
9. Who have you spoken to? ____

Please ensure that the researcher completes each section with you

If you have answered NO to any of the above, please obtain the necessary information before signing

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

Patient /Subject Name:_______________________________ Signature: ______________

Parent/ Guardian:____________________________________ Signature:______________

Witness Name:_______________________________________ Signature:______________

Research Student Name:_______________________________ Signature:______________

Appendix H:

Letter of information

Dear Golfer

Welcome to my study. Thank you for your interest.

The title of my study is: **The core stability, club head velocity and ball carry in golfers with and without low back pain – a comparative study.**

Name of supervisors: Dr Rowan White (033) 342 2649
(Master's degree in.Tech: Chiropractic)
Name of student: Guy Bower (031) 309 7355
Name of institution: Durban University of Technology

This study will involve research on 40 male golfers between the ages of 25-45 years of age, and who have a handicap of between 10-20. Golfers will be divided into two groups of 20 each, one group comprising those golfers with low back pain and the other group will be those golfers who are asymptomatic (ie. Currently do not suffer any form of low back pain). On initial consultation you will be required to complete a thorough case history, and a full physical and low back regional exam will be carried out by the researcher. Following this, you will be instructed on how to perform an abdominal contraction to isolate the transverses abdominis muscle specifically. The strength and endurance of this muscle will be tested using a pressure biofeedback unit, which will give the researcher an indication of your core muscle strength and endurance. You will then be required to undergo testing on the FlightScope machine at the Durban Pro Shop, within 2 days of the initial consultation, where club head velocity and ball carry will be measured.

It is hoped that the above process will show some form of relationship between core stability muscle strength, club head velocity and ball carry.

This study will be conducted at the Chiropractic Day Clinic subsequent to the completion of your participation in the initial study. You may be removed from the study without your consent if any of the exclusion criteria are met. You will also be required to attend an assessment at the Durban Pro Shop using the Flightscope machine within 2 days of the initial consult. Failing to return within the 2 day window period will esult in termination from the study.The initial consultation and assessment should take approximately 90 minutes, and the follow up assessment at the Pro Shop should be no longer than 30 minutes, depending on availability of the machine. This information will be gathered for the purpose of establishing correlations between core abdominal muscle strength and low back pain in golfers and their subsequent effect on club head velocity and ball carry (distance).

All patient information is confidential and the results will be used for research purposes only, although supervisors and senior clinic staff may be required to inspect records. You have the right to be informed of any new findings that are made. 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 University of Technology Research Ethics Committee.

Thank you for your interest and participation.

Yours faithfully,

Guy Bower	Dr. R. White(M.Tech: Chiropractic)
(Chiropractic intern)	(Supervisor)

Appendix H:

Ethics Clearance Certificate

Appendix J:

DATA CAPTURE SHEET

Patient Name: ……………………………………… Date:………………..

Age: ……………….

Handicap: ……………………

Does the golfer have any low back pain YES / NO

Core Contraction:

Can the core contraction be initiated: YES / NO

Was the contraction maintained for 30 seconds: YES / NO

Group Allocation:

A / B

Flightscope Readings

	Club Head Velocity (m/h)	Distance (m)
1		
2		
3		
4		
5		
Ave.		