The effectiveness of spinal manipulative therapy compared to core muscle strengthening on club head velocity and ball carry in asymptomatic amateur male golfers

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I, Ranen Rambrij do declare that this dissertation is representative of my own work.

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DEDICATION

I dedicate my research to my parents, Nad and Roshni. Thank you for your love and support during this journey and for moulding and grooming me into the man that I have become. Without you achieving this milestone would not have been possible.

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ABSTRACT

Background:

Performance of the golf swing is mainly influenced by the strength and power of the torso i.e. the low back and abdominal muscles (Gluck, Bendo and Spivak 2008). As rotary velocities increase, muscle force is absorbed by deforming connective tissue, allowing for increased rotation (Gluck *et al.* 2008). Therefore any decrease in range of motion of the spine in the golfer, could affect performance (Nordin and Frankel 2001).

The cause of poor range of motion is often a result of a physical restriction or mechanical dysfunction within the joints (Blanchard 2004). Spinal manipulative therapy (SMT) has been found to bring about biomechanical effects such as an increase in range of motion (ROM) (Millan *et al.* 2012) by releasing trapped meniscoids and connective tissue adhesions (Pickar 2002). A lack of core muscle strength is also thought to result in an inefficient technique, which predisposes individuals to poor performance (Asplund and Ross 2010). According to Kibler (2006) core muscle strengthening (CMS) is essential for efficient biomechanical function, to maximise force generation and minimise joint loads in all types of activities.

The effects of SMT on golfing performance are well documented (Jermyn 2004; Delgado 2006) however, the effects of CMS on golfing performance are unknown. By improving physiological and biomechanical function through CMS, performance indicators maybe maximised (Pickar 2002; Kibler 2006).

Aim:

Therefore, the purpose of this study was to determine the effectiveness ofSMT compared to CMS on performance indicators club head velocity (CHV) and ball carry (BC) in asymptomatic amateur male golfers.

Methods:

Fifty-two asymptomatic amateur male golfers were recruited for this study, but seven withdrew leaving a final sample size of forty-five. Participants were randomly allocated to either the Core Muscle Strengthening (CMS, n=20) or the spinal manipulative group (SMT, n=25).

The SMT (n=25) group received a single session of SMT while CMS (n=20) underwent a four week CMS exercise program. Core muscle strength and indicators of performance were taken before and after the intervention using the Bio-pressure feedback unit (BPU) and GC2 Foresight (swing analyser) respectively. Statistical analysis included paired t-tests to assess change in duration of contraction in the CMS group, Pearsons correlation analysis was used to assess the correlation between changes in CHV and BC intra-group and profile plots were used to show direction and trend of the effect by means of the latest version of SPSS software.

Results:

The main findings show that CMS will improve following a four week CMS program (p= <0,001).When compared over time both SMT and CMS have the same effect on CHV (p= 0.127), whereas CMS has a more profound effect over time compared to SMT on BC (p=<0.001).

Conclusion:

Core muscle strengthening appears to have a positive influence on CHV and BC in asymptomatic amateur male golfers, however it is still uncertain which intervention is more effective. Therefore future studies of this nature should look to increasing the duration of the study or the sample size.

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DEFINITION OF TERMS

Asymptomatic

Presenting with no symptoms of disease i.e. for this research study, low back pain (www.merriam-webster.com/dictionary/asymptomatic, 2016).

Symptomatic

Showing that a particular disease is present, i.e. for this research study, low back pain (www.merriam-webster.com/dictionary/symptomatic, 2016).

Participant

A person who participates in an activity or event (www.merriam-webster.com/dictionary/participant, 2016)

Amateur Golfer

An amateur golfer, whether he plays competitively or recreationally is one who plays golf for the challenge it presents, not as a profession and not for financial gain *(*www.randa.org/en/Rules-and-Amateur-Status, 2016).

Handicap

A handicap is a numerical representation of a golfer's playing ability. The lower the golfer's handicap, the better the golfer is. A 1 handicapper is better than a 5 handicapper who is better than a 10 handicapper (http://golf.about.com/cs/golfterms/g/bldef_handicap, 2016).

Club Head Velocity (CHV)

A measure, of how fast the club head of a golf club is traveling at the point it impacts the golf ball. This 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; http://golf.about.com/od/golfterms/g/clubheadspeed, 2016).

Ball Carry

The distance travelled by the golf ball from the point of contact with the club head to the point at which it hits the ground. (Stude and Gullickson, 2000; http://golf.about.com/cs/golfterms/g/bldef_carry).

Core Strength

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

CHAPTER 1
INTRODUCTION

1.1 INTRODUCTION TO THE STUDY

Current golfing literature advises golfers to achieve maximum performance with each stroke by using what is referred to as the 'modern' golf swing. This encourages golfers to add power to their swing by turning their shoulders as far as possible, while restricting the turn of their hips (Gluck *et al*. 2008). This twisted position is said to develop an increased Club Head Velocity (CHV) (Gluck *et al*. 2008). Club Head Velocity is the speed at which the golf club head makes contact with the golf ball, and may directly affect the distance travelled by the golf ball (Stude and Gullickson 2000; Chek 2016).

The golf swing involves a number of loading patterns, such as axial rotation coupled with lateral bending to produce torque. This is made possible by synergistic activity of several trunk muscles (Horton, Lindsay and Macintosh 2001). Horton, Lindsay and Macintosh (2001) described those muscles as the transverse abdominus, right and left external oblique and paraspinal (i.e. multifidus) muscles. As explained by Gluck *et al*.2008), these muscles assist in rotating the trunk while simultaneously stabilising the lumbar spine. Due to the repetitive nature of the golf swing it is possible that these muscles could fatigue over time, thereby resulting in muscular deconditioning, characterised by atrophy (Seaman 1998). Seaman (1998) further stated that muscular deconditioning can occur prior to the onset of micro- or macro-trauma, which may be characterised by pain or weakness. He described this phenomenon as asymptomatic muscular dysfunction. It was posited by Hibbs *et al*. (2008) that this may predispose muscular imbalances, resulting in restricted compensatory movement patterns which are less efficient. In turn, this may directly affect the performance of the golfer.

Core strengthening is a fitness trend that has become popular amongst athletes and medical practitioners alike, due to its effect on improving athletic performance (Akuthota *& Nadler* 2004). Core strength training programmes target muscular strengthening and motor control, which results in maximum force generation by the core muscles and proper force distribution to the extremities (Akuthota *& Nadler* 2004; Hibbs *et al.* 2008). Research has shown spinal manipulative therapy to have a positive effect on golfing performance (Jermyn 2004; Le Roux 2008). No published studies show the effect of core strengthening on golfing performance, therefore based on the information above it stands to reason that a core strengthening programme may affect the performance of a golfer.

1.2 AIM

The aim of the study was to determine the effectiveness of a once-off SMT intervention compared to a four-week CMS programme, on CHV and BC in asymptomatic amateur male golfers.

1.3 OBJECTIVES

Objective One:

To determine the effect of a single session of SMT on CHV and BC.

Objective Two:

To determine the effect on core muscle strength following four weeks of CMS exercises.

Objective Three:

To determine the effect of CMS on CHV and BC.

Objective Four:

To compare the effect of SMT and CMS on CHV and BC.

1.4 HYPOTHESES OF THE STUDY

Hypothesis One:

That a single session of SMT will significantly increase both CHV and BC when measured immediately after the intervention.

Hypothesis Two:

That a four-week CMS programme will significantly increase core muscle strength.

Hypothesis Three:

That a four-week CMS programme will significantly increase CHV and BC.

Hypothesis Four:

That a four week CMS programme will have a greater effect on CHV and BC than a single session of SMT.

1.5 RATIONALE AND BENEFITS

Stability and movement around the lumbar spine is reliant on the organisation of all the muscles that support lumbar spine. Research has shown the importance of the transversus abdominis and multifidi, however all core muscles are needed for optimum stabilisation and performance (Akuthota & Nadler 2004). The utilisation of a core strengthening programme which targets the specific muscles involved in the golf swing may therefore not only improve spinal stabilisation, but may prevent injury to muscles ensuring constant optimum performance (Hibbs *et al.* 2008)

Despite the widespread use of core strengthening programmes by athletes, including golfers, there is a lack of literature on the effects of core strengthening on sporting performance. The benefits of this study were therefore to gain a formally tested conclusion on the effects of core muscle strengthening on golfing performance in asymptomatic male golfers.

1.6 LIMITATIONS

Participants were requested to conduct the exercise programme once a day over the four-week period. This was controlled by telephonic consultations once a week to monitor the participant's progress. Due to human error it is possible, however, that not all the participants complied, thereby resulting in days being missed. This may in turn have resulted in an ineffective intervention and inaccurate data collection. The demonstration and monitoring of participants adhering to the CMS was absent. This would also influence the findings of the study.

1.7 FLOW OF THE DISSERTATION

The researcher will elaborate on the current literature in Chapter 2. The methodology will be explained in detail in Chapter 3. The results will be presented in Chapter 4, with the conclusion and recommendations presented in Chapter 5.

CHAPTER 2
LITERATURE REVIEW

2.1 INTRODUCTION

This chapter reviews the available literature, including a discussion on the anatomy of core muscles and the role they play in the golf swing to promote CHV and BC.

2.2 THE ANATOMY OF CORE MUSCLES

Core muscle strength can be described as the "muscular control required around the lumbar spine to maintain functional stability" (Akuthota & Nadler 2004). Functional stability can be defined as "the ability to utilise the body's structures in the safest, most efficient positional relationship for the functional demands of the body" (Elphinston 2008). Panjabi (2003) stated that the spinal stability system consists of the following symbiotic elements:

- Neuromuscular control (neural elements).
- Passive sub-system (osseous and ligamentous elements).
- Active sub-system (muscular elements).

The muscular elements may be further divided into two systems 'local' and 'global', dependent on the muscles' mechanical role in stabilisation (Richardson 2002). The 'local' muscles influence the inter-segmental relationship between lumbar vertebrae; 'global' muscles influence spinal orientation and control the external forces on the spine (Richardson 2002).

The local stabilising system includes the deep muscles and some deep portions of muscles, with insertions on the lumbar vertebrae. These muscles are responsible for maintaining lumbar posture and stability between the spinal segments

(Richardson2002). The multifidus muscle is considered to be part of the local system as it assists in segmental stabilisation as a result of its vertebrae to vertebrae attachments. Similarly, the transversus abdominis is considered a key muscle in the local stabilising system. This is due to its direct attachment to the lumbar vertebrae via the thoraco-lumbar fascia, and decussations with its opposite muscle in the midline (Richardson 2002).

The global muscle stabilising system includes the internal oblique; external oblique; rectus abdominis; gluteus maximus; lateral fibres of quadratus lumborum; and portions of erector spinae. These are the larger, more superficial, torque producing muscles that enable an upright position. They are responsible for movement, as well as balancing and controlling external loads applied to the trunk by reducing the resultant forces on the spine and transferring residual forces to the local muscles (Richardson . 2002).

As outlined by Hedrick (2000), good core strength may improve force output, increase neuromuscular efficiency and decrease the incidence of overuse injuries. Furthermore, strong core muscles enhance the torque transmission up and down the kinematic chain.(Hedrick 2000). This would result 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 abdominal and lumbar components as indicated in Table 2.1 below (Hedrick 2000; Moore, Dalley and Agur 2014).

Table 2.1 Core Musculature Components

Core Musculature Component	Muscles
Abdominal Component	Rectus abdominis External oblique Internal oblique Transversus abdominis
Lumbar Component	Multifidus Quadratus lumborum Rotatores Superficial and deep erector spinae Intertransversarii Interspinales

2.2.1 *The Abdominal Component*

The rectus abdominus muscle is a paired muscle running vertically on either side of the anterior abdominal wall, separated by a midline band of connective tissue called the linea alba. It extends from the pubic symphysis, pubic crest inferiorly, to the xiphoid process and costal cartilage of ribs five to seven superiorly. The rectus abdominis is three times as wide superiorly as inferiorly; it is narrow and thick inferiorly and broad and thin superiorly. Three bands of connective tissue (called tendinous intersections) transverse the rectus abdominus, separating the parallel muscle into eight distinct muscle bellies that can be viewed in individuals with low body fat. The rectus abdominis is innervated by the ventral rami of the inferior six thoracic nerves. The rectus abdominus is an important postural muscle responsible for flexion of the trunk and erection of the pelvis (Moore, Dalley and Agur 2014).

The external oblique is the largest and most superficial of the anteriolateral group of abdominal wall muscles. Its muscular portion forms the anterolateral part and its aponeurosis forms the anterior part. It arises from the external surfaces and inferior borders of the fifth to twelfth ribs inserting at the linea alba, pubic tubercle and the anterior half of the iliac crest with the muscle fibres running inferomedially. The innervation is by the inferior six thoracic nerves and the subcostal nerve. The external oblique functions in both flexion and rotation vertebral column, which is essential in the golf swing (Moore, Agur and Dalley 2011; Moore, Dalley and Agur 2014).

The internal oblique lies below the external oblique and just above the transverse abdominus muscle. Its fibers run perpendicular to the external oblique, originating at the thoracolumbar fascia, anterior two-thirds of the iliac crest and lateral half of the inguinal ligament. The fibres then run superiomedially to insert at the inferior borders of the tenth to twelfth ribs and the linea alba. The innervation is supplied by the ventral rami of the inferior six thoracic nerves and the first lumbar nerve. The internal oblique functions in both flexion and rotation vertebral column, which is essential in the golf swing (Moore, Agur and Dalley 2011; Moore, Dalley and Agur 2014).

The transverse abdominus (TA) is the deepest muscle of the anterolateral abdominal wall, with its fibers running transverse medially, except for the inferior pennation that runs parallel to the internal obliques.. Its fibres run transverse medially, except for the inferior which run parallel to the internal oblique. The TA originates at the lateral third of the inguinal ligament the inner lip of the iliac crest, the inner surfaces of the seventh to twelfth costal cartilages and the thoraco-lumbar fascia. Inserting at the linea alba with the aponeurosis of the internal oblique muscle, pubic crest and pectin 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 function of this muscle is to compress and support the abdominal viscera (Moore, Dalley and Agur 2014).

Working as a unit the TA, internal oblique and external oblique provide functional stability to the lumbar spine which facilitates the movements of the golf swing (Akuthota & Nadler 2004).

2.2.2 *The Lumbar Component*

The multifidus muscle originates at the sacrum, ilium and transverse processes of T1-T12 and articular processes of C4-C7, inserting at the spinous process of the vertebrae above, spanning 2-4 segments. The multifidus muscles plays an important role in the local stabilising system of the vertebrae by stabilising the joints during movements of the vertebral column. Innervation is supplied by the dorsal rami of spinal nerves (Moore, Dalley and Agur 2014).

Located in the posterior abdominal wall, the quadratus lumborum (QL) is large, thin and quadrangular in shape. Originating at the iliolumbar ligament and internal lip of the iliac crest, it inserts at the medial half of the twelfth rib and the ends of the lumbar spinous processes. Working bilaterally, the main function of the QL is to stabilise the lumbar spine on the pelvis; dysfunction of this muscle bilaterally may adversely influence swing phase of the gait cycle (Travell and Simons 1983). Working unilaterally the QL facilitates lateral flexion of the lumbar spine, which may work in one of two ways. On a fixed pelvis, the QL flexes the spine to the ipsilateral side. With the spine in the fixed position, unilateral contraction of the QL results in elevation of the ipsilateral hip (Travell and Simons 1983).

The rotatores muscle lie beneath the multifidus muscle and are quadrilateral in shape (Moore, Dalley and Agur 2014). Arising at the transverse processes of the vertebrae, the rotator muscles travel supero-medially to attach to the junction of the lamina and transverse process or spinous process of the vertebra above, spanning 1-2 segments. The rotatores muscle functions in stabilising the vertebrae with extension and rotary movements of the vertebral column. Innervation is supplied by the dorsal rami of spinal nerves (Moore, Dalley and Agur 2014).

The erector spinae is not one muscle, it is three, which extend the cervical, thoracic and lumbar regions of the spinal column (Moore, Dalley and Agur 2014). These are as follows:

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

For the purpose of this study, the longissimus muscle will be described. It originates at the broad tendon from the posterior part of the iliac crest, sacrum, sacral and inferior lumbar spinous processes and the supraspinous ligament. The longissimus fibres run superiorly to attach at the angles of the lower ribs and cervical transverse processes. Working bilaterally the longissimus aids in extension of the vertebral column and head. Unilateral contraction results in lateral flexion of the vertebral column. Innervation is supplied by the dorsal rami of spinal nerves (Moore, Dalley and Agur 2014).

Intertransversarii are small muscles placed between the transverse processes of vertebrae. Originating at the transverse process of cervical and lumbar vertebrae, the intertransversarii extends to attach to the transverse process of the adjacent vertebrae (Moore, Dalley and Agur 2014). Acting bilaterally the intertransversarii stabilise the vertebral column, and unilateral contraction results in lateral flexion of the vertebral column. Innervation is supplied by the dorsal and ventral rami of spinal nerves.

The interspinales are small muscles placed between the spinous processes of contiguous vertebrae. Originating at the superior surface of spinous processes of cervical and lumbar vertebrae, the interspinales extends to attach to the inferior surface of the spinous process of the vertebrae above (Moore, Dalley and Agur 2014). Extension and rotation of the vertebral column are the main functions of the interspinales, with innervation supplied by the dorsal rami of spinal nerves.

2.2.3 *The Thoraco-Lumbar Fascia*

The thoraco-lumbar fascia has been described as a retinacular band that supports the lumbar spine musculature (Akuthota & Nadler 2004). Covering the thoracic and lumbar muscles, the fascia provides a connection between the upper body and lower limbs (Kibler, Press and Sciascia 2006; Moore, Dalley and Agur 2014). The thoracolumbar fascia is made up of the anterior, middle and posterior layers (Drake, Vogl and Mitchell 2005), with the posterior layer being the most significant as it provides stability to the lumbar spine and abdominal musculature (Akuthota & Nadler 2004). Merging at the lateral margin of the erector spinae, the middle and posterior layers join the anterior layer at the lateral border of the quadratus lumborum forming the aponeurotic attachment for the transversus abdominis (Drake, Vogl and Mitchell 2005; Moore, Dalley and Agur 2014).

Contraction of the transversus abdominis, internal oblique and external oblique together increase intra-abdominal pressure from the hoop created via the thoracolumbar fascia; this has been shown to add stability to the spine (Akuthota Ferreiro, Moore and Fredericson 2008). With contraction of the muscular elements the thoracolumbar fascia provides proprioception with respect to trunk position, providing feedback in lifting movements (Akuthota & Nadler 2004; Drake, Vogl and Mitchell 2005; Moore, Dalley and Agur 2014).

The trunk muscles transmit forces through the thoracolumbar fascia between the spine, pelvis and limbs. This assists in rotating the trunk while simultaneously stabilising the lumbar spine. Through the thoracolumbar fascia the abdominal muscles are able to transmit stabilising forces that reduce stress at the intervertebral joint (Gluck *et al.* 2008).

2.3 THE GOLF SWING

With the progress of science and technology the golf swing has evolved over time, progressing from what was referred to as the ‘classic’ golf swing to the ‘modern’ golf swing (McHardy and Pollard 2005). The ‘classic’ golf swing is characterised by a large upper body rotation with a large pelvic rotation. This is accomplished by raising the front heel during the backswing. This reduces the degree of the hip-shoulder separation angle, limiting the torque in the lumbar spine (McHardy and Pollard 2005; Gluck *et al*. 2008).

The golf swing then underwent a fundamental change from the ‘classic’ to ‘modern’ swing style in the 1960’s (McHardy and Pollard 2005). The ‘modern’ golf swing encourages a large shoulder turn with a restricted hip turn. The restricted hip turn is accomplished by keeping the front foot flat on the ground throughout the swing. This increases the hip-shoulder separation angle and hence the torsional load in the spine. Potential energy is stored by stretching the viscoelastic elements, thereby contributing to an increased rotational velocity which translates to an increased CHV in an efficient swing. The reason for this change is because the ‘modern’ golf swing generates more power during the swing, which achieves a greater BC (distance) (McHardy and Pollard 2005).

To understand the performance of a golfer, however, we first need to understand the biomechanics of the golf swing. The golf swing is a complex movement made up of several phases, which may be described as follows (Mackey 1995; Seaman 1998):

- Phase 1 - the back swing.
- Phase 2 - the downswing.
- Phase 3 - the follow through.

The golf swing starts by the golfer taking his grip on the golf club, then taking his stance and aligning himself over the ball; this is known as the address position (Mackey 1995; McHardy and Pollard 2005). This is illustrated in Figure 2.1 below.

Figure 2.1 The Address position.

(Source: R Rambrij)

2.3.1 *The Backswing*

The backswing is characterised by a large rotation of the shoulder, lumber and cervical spine while the hips and head remain fixed (Mackey 1995; Seaman 1998). Seaman (1998) posited that it is essential for the shoulders, arms and club to move at the same time during this phase; in a right-handed golfer this may be possible by shifting weight and rotating the pelvis to the right side while maintaining a flexed right knee. It was explained by Mackey (1995) that the left external oblique muscle is responsible for the initial rotation of the trunk from the address position to the top of the backswing. At the end of the backswing the golfer will achieve maximum spinal rotation when the back of the shoulders and the golf club point towards the target, and the anterior deltoid of the left arm touches the chin. As described by Seaman (1998), the golfer will then contract his right external oblique muscle, both rotator cuff muscles (supra- and infraspinatus, teres minor and subscapularis muscles), as well as other shoulder muscles (lattisimus dorsi, pectoralis major and deltoid muscles). It is at this point that the shift of weight from right to left should begin to start the next phase of the golf swing (Mackey 1995). Figure 2.2 below illustrates the backswing.

Figure 2.2 The Backswing

(Source: R Rambrij)

2.3.2 *The Downswing*

As body weight is transferred from the right to the left, the golfer's arms and club will continue to rise due to the momentum created by the upper limb during the backswing. This is termed the transition phase and serves to create elastic energy in the pectoralis major and latissimus dorsi muscles which provides power during the downswing

(Seaman 1998). At the hight of the backswing the right external oblique muscle contracts to facilitate the downswing to impact (Mackey 1995). Maximum force generation during this phase produces rotation and simultaneously causes flexion of the lumbar spine (Moore, Dalley and Agur 2014). Mackey (1995) described this as the pre-impact stage, where the golfer begins contact with the ball with the right wrist in maximum extension, the left thumb in hyperabduction, and the left hip is rotated and the knee is in a position of valgus stress.

During the downswing phase the left and right paraspinal muscles (especially multifidus muscle) contract almost symmetrically, providing spinal stability to resist the lumbar flexion movement of the downswing (Hosea, Gatt and Gertner 1994). Mackey (1995) described this as the impact phase, where the golfer strikes the ball. The golfer's left wrist ulnar deviates, while the right wrist undergoes compression; the right knee is under valgus stress, and the left hip is rotated. The lumbar spine has now moved from a state of maximal rotation to the right, to a relatively neutral position in terms of spinal rotation. Figure 2.3 below illustrates the downswing.

Figure 2.3 The Downswing

(Source: R Rambrij)

2.3.3 *The Follow Through*

Mackey (1995) affirmed that the golfer's left elbow supinates, the right elbow pronates, the right hip internally rotates and completes hip rotation, the knees rotate to the left and the left ankle inverts. The left shoulder hyperabducts while the cervical and lumbar spine rotate and hyperextend. The body weight should shift from right to left and with the torso resting over a slightly flexed left knee (Seaman 1998). At the end of the follow-through phase the right shoulder should point toward the target (i.e. a position of maximal spinal rotation to the left). This position is referred to in golf as the reverse 'C' position and is often characterised by hyperextension of the spine (Seaman 1998). Mackey (1995) reported that this position is essential for correct trajectory and accuracy. The follow-through is illustrated in Figure 2.4 below.

Figure 2.4 The Follow through

(Source: R Rambrij)

2.4 THE MODERN GOLF SWING AND PERFORMANCE

Gluck *et al.* (2008) specified that the purpose of the back swing is not only to get the golf club to the top point, but it also encourages more shoulder rotation with limited hip movement. By maximising the hip-shoulder separation angle one aims to increase the torsional load in the spine; this is referred to as the 'power coil' (Gluck *et al*. 2008; Seaman 2008). The separation angle is also known as the 'X-factor' due to the 'X' made by lines drawn along the axial orientation of the shoulders and hips at the transition between the end of the backswing and start of the downswing (Gluck *et al*. 2008). This twisted position acts as a spring, storing potential energy that contributes to an increased rotational velocity to be released in the downswing (Bulbulian 2001; Gluck *et al.* 2008; Seaman 2008). The increase in rotational velocity is said to optimise the CHV on the down swing (Bulbulian 2001; Gluck *et al* 2008; Seaman 2008). Figure 2.5 below illustrates the 'X-factor'.

Figure 2.5 The 'X-factor': the yellow line indicates the angle of the shoulders; the blue line indicates the angle of the hips.

(Source: R Rambrij)

Club Head Velocity is defined as 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 2016). Secondary factors that affect CHV include muscle balance and flexibility, which affect static and dynamic postural stability (Chek 2016). Research has showed an approximate 1:3 relation between CHV and BC. It must be taken into consideration that all golf balls have slightly different dynamics, and variables such as wind speed may also influence BC. This relationship suggests that for every 1-mph increase in CHV, there is a subsequent 3-yard increase in BC (Stude and Gullickson 2000).

2.4.1 ***Asymptomatic Joint Dysfunction and its effect on performance***

Hosea, Gatt and Gertner (1994) specified that during the downswing increased amounts of stress on the lumbar spine and sacro-iliac joints may result in injury. This may be the most likely cause of joint complex dysfunction. Bergmann, Lawrence and Peterson (1993) defined the joint complex dysfunction (joint dysfunction) as subtle changes affecting not only the quality of the joint, but also its range of motion.

The lumbar spine is made up of five vertebra which constitutes 25% of the vertebral column (Moore, Dalley and Agur 2014). As presented by Kirkady-Willis and Burton (1992), the intervertebral disc and two posterior facet joints make up a three-joint complex. The two posterior spinal articulations, known as the facet or zygapophyseal joints, lie between each of the successive vertebrae. The joint surface is lined with hyaline cartilage and has an intracapsular fibrocartilagenous disc that separates the joint surfaces (Bergmann, Lawrence and Peterson 1993). The facet joints of the lumbar spine are therefore classified as diarthrodial joints (Moore, Dalley and Agur 2014). The superior articulating processes are concave and face posterior and medial, while the inferior articulating processes are convex and face anterior and laterally; this allows flexion of the trunk and restricts rotation (Gatterman 1990). As the L5 superior facets face more posteriorly and the inferior facets face more anteriorly, there is greater antero-posterior (A-P), postero-anterior (P-A) and lateral motion and therefore less joint locking occurs at this level (Schafer and Faye 1990). As we progress upward from L5 to L1, the horizontal and anterior inclination of the vertebrae become progressively more vertical (Schafer and Faye 1990), which may result in decreased and altered motion parameters.

These changes within the lumbar spine articulations are unique to each individual, hence the application of a particular technique for all golfers may not allow for the optimal performance of a particular golfer. It therefore stands to reason that golfers with a particular anatomical composition may be more predisposed to motion restrictions more readily than others (Leach, Phillips and Lantz 1996), resulting in an inefficient technique and hindering their optimal performance.

Providing elasticity to the pelvic rim, the sacro-iliac (SI) joint acts as a buffer between the lumbosacral and hip joints (Kirkady-Willis and Burton1992). The SI joint is an auricular or C-shaped joint formed by the articulation of the sacrum and the ilium,with the convex contour facing anteriorly and slightly inferiorly. The shapes, sizes and contours that exist within the SI joint are unique to each individual. Male SI joints have extra- and intra-articular tubercles for strength and weight bearing, whereas the female articulation is built for mobility and parturition (Moore, Dalley and Agur 2014),

Schafer and Faye (1990) articulated that the SI joints are both diarthrodial (the union of two or more bones in the body) (Moore, Dalley and Agur 2014), and amphiarthrodial (a form of articulation in which the body surfaces are connected by cartilage) (Moore, Dalley and Agur 2014). The inferior two-thirds of each joint are a true synovial articulation and the superior third of the joint a fibrocartilagenous amphiarthrosis. The inner surface of the joint capsule is lined by a synovial membrane that produces synovial fluid for lubrication of the joint cavity (Moore, Dalley and Agur 2014). This makes the SI joints prone to restriction and/or external (asymmetrical) force-induced locking (Cramer and Darby 2005).

Stability of the SI joint is essential for optimal functioning (Pool-Goudzwaard 2003). This comes from the joint articular surfaces and the compression of body weight (form closure), as well as muscle action and ligament force (force closure), (Pool-Goudzwaard 2003). Therefore, inadequate form or force closure coupled with any alteration in sacral movement (e.g. nutation which is the anterior-inferior movement of the sacral base) which occurs with trunk flexion or hip extension and counter-nutation (superior-posterior movement of the sacral base) which occurs with trunk extension or hip flexion can lead to SI joint dysfunction due to compressive forces on the joint surfaces (Pool-Goudzwaard 2003, 2004, Alderink 1991).

The development of sacro-iliac dysfunction has been linked to the overuse of the gluteus medius and maximus muscle (Thompson 2002), which is essential in facilitating the change from the backswing to the downswing. According to Vleeming (1995) activation of the latissimus dorsi and contralateral gluteus maximus and medius creates a force perpendicular to the SI joint. Along with force closure of the SI joint, it functions to assist with proper load transfer between the spine, pelvis, and legs. It therefore stands to reason that any weakness of the gluteus medius and maximus may result in weakness of its agonist, the lattisimus dorsi, which is one of the principle muscles used to transfer force between the upper and lower extremity (Seaman 1998). Based on the information above, we can assume that this may result in an inefficient swing due to a loss of range of motion and a decrease in force generation.

Vernon and Mrozek (2005) asserted that the phenomenon of joint complex dysfunction can present itself in the asymptomatic individual, showing decreased range of motion without the presence of any clinical indicators (e.g. pain). They termed the above phenomenon asymptomatic segmental joint dysfunction. This being said, due to the aggressive nature of the golf swing any change in biomechanics as a result of asymptomatic joint dysfunction of the lumbar spine and/or SI joints can affect the performance indicators of amateur golfers.

2.4.2 *Treating Asymptomatic Joint Dysfunction to Improve Performance*

Gatterman (2005) and Cooperstein *et al*. (2001) described SMT as a manual therapeutic technique which makes use of specific short levers, to which a high velocity thrust of controlled amplitude is applied with the aim of restoring joint mobility. SMT has been found to bring about biomechanical effects (Millan *et al*. 2012). Kirkaldy-Willis and Bernard (1999) explained the mechanical effects of SMT on the grounds of the following mechanisms:

- SMT may stretch or break intra-articular adhesions that form from immobilised facet joints due to acute synovial reactions (Bergmann *et al.* 1993; Leach, Phillips and Lantz 1996; Vernon and Mrozek 2005).
- SMT allows entrapped menisci to exit the facet joint (Bergmann, Lawrence and Peterson 1993; Leach, Phillips and Lantz 1996).

- If the capsule of the facet gets lodged between two adjacent articular surfaces, the SMT process could allow this to be freed (Bergmann, Lawrence and Peterson 1993; Leach, Phillips and Lantz 1996).
- SMT re-aligns misaligned spinal segments to conform to the centre of gravity (Gatterman 1990; Bergmann, Lawrence and Peterson 1993; Cooperstein *et al*. 2001; Gatterman 2005).

It therefore stands to reason that SMT should alter biomechanics such as trunk rotation and muscle flexibility, and decrease strain on the relevant spinal structures, leading to an increase in performance in the asymptomatic individual (Herzog, Scheele and Conroy 1999; Nansel, Waldorf and Cooperstein 1993). Le Roux (2008) evaluated the immediate and short term effect of SMT on asymptomatic amateur golfers in terms of performance indicators (CHV and BC). It was found that SMT had a positive immediate effect on performance indicators in asymptomatic amateur golfers.

2.4.3 *Asymptomatic Muscular Dysfunction and its effect on performance*

Trunk rotation, coupled with powerful muscular contractions, make the golf swing a very unique movement. Research shows that multiple muscle groups facilitate the golf swing through its many phases (Seamen 1998). The abdominal muscles play an important role in the generation of power during the down swing phase of the golf swing. The golf swing involves a number of loading patterns, such as axial rotation coupled with lateral bending to produce torque. This is made possible by synergistic activity of the transverse abdominus, right and left external oblique and paraspinal (i.e. multifidus) muscles (Horton, Lindsay and Macintosh 2001).

Trunk muscle co-ordination may be compromised by muscle fatigue, thereby resulting in decreased trunk stability and an increased risk of injury to the lower back (O'Brien and Potvin 1997). The transverse abdominus muscle is the most effective of the abdominal muscles in spinal stabilisation, and thus plays an important role in the control and maintenance of spinal stability during the golf swing (Grimshaw *et al.* 2002). Together with the multifidi muscle, the tranverse abdominus forms an agonist/antagonist relationship through a co-contraction pattern. The role of the multifidus muscle in the golf swing is to oppose flexion created by the abdominals as they produce rotation, protecting the spine against injury from excessive flexion and rotation forces (Seaman 1998). A decrease in functioning of the transverse abdominus could therefore increase the work load on the multifidus muscle and *vice versa*. This may result in muscular dysfunction, thereby predisposing the golfer to injury and poor performance.

Horton, Lindsay and Macintosh (2001) investigated the functioning of the external and internal oblique muscles independently during the golf swing. In the right-handed golfer, the activity of the lead (right) external oblique during the backswing is consistent with the fibre orientation and function of this muscle (i.e. right axial rotation). Conversely, the fibre orientation of the lead (left) internal oblique is more suited to the downswing direction (i.e. left axial rotation). Horton, Lindsay and Macintosh (2001) also found that the lead external and internal oblique activated significantly earlier in asymptomatic individuals, when compared with individuals who had chronic low back pain.

The right and left external oblique, transverse abdominus and paraspinal (multifidus) muscles play a vital role during the golf swing in trunk muscle co-ordination. Due to the repetitive swinging motion of the golf club it is possible that muscular fatigue could develop during a typical game or practice session (Horton, Lindsay and Macintosh 2001). Seaman (1998) highlighted that prolonged overuse of a muscle and/or repetitive posture may lead to spinal musculature deconditioning, prior to either micro- or macro-traumatic injury. Furthermore, Seaman (1998) described this as asymptomatic muscle dysfunction.

Weakening of the trunk muscles because of fatigue is particularly relevant if the type of activity performed involves rapid repetitive movement of the extremities (Hodges and Richardson 1999). As Hibbs *et al*. (2008) declared, if a muscular imbalance occurs it can result in compensatory movement patterns that are less efficient. Club Head Velocity is primarily influenced by the strength and power of the golf swing. Any change in local and global muscle balance and flexibility that provides not only stability and distribution and absorption of forces in the body, but also provides rapid movement, force and power which typifies the golf swing, may affect the performance of the golfer (Hibbs *et al*. 2008; Chek 2016).

2.4.4 ***Treating Asymptomatic Muscular Dysfunction to improve performance***

Core strengthening is a well-known fitness trend in the world of sports medicine. Core strength can be defined as muscular control required around the lumbar spine to maintain functional stability. The core can be described as a muscular box with the abdominals in the front; paraspinals and gluteals in the back; the diaphragm as the roof; and the pelvic floor and hip girdle musculature as the bottom. This forms a powerful muscular corset used to stabilise the body and spine, with or without limb movement. Core strengthening has been found to enhance athletic performance by providing "proximal stability for distal mobility", essentially it is the powerhouse of all limb movement (Akuthota & Nadler 2004; Akuthota *et al.* 2008: 39; Hibbs *et al.* 2008).

Core strengthening is the process of activating trunk musculature to improve function of the axial and appendicular skeleton in various sporting situations (Asplund and Ross 2010; Akuthota *et al*. 2008; Hibbs *et al*. 2008; Akuthota & Nadler 2004). Current research shows many exercise regimes aimed at targeting these muscles for an improved performance, however a relationship between these regimes and objective measurements in performance enhancement is required (Asplund and Ross 2010; Akuthota *et al*. 2008; Hibbs *et al*. 2008; Akuthota & Nadler 2004). No published study has shown how improvement in golf-specific physical characteristics can influence swing mechanics and thus affect performance following a golf-specific training programme (Lephart *et al.* 2007).

The core exercises selected **(Appendix A)** for the purpose of this study are the power bridge, the plank, the transverse plank and quadruped reach. Each exercise is specifically designed to develop isolated and co-contraction muscle patterns to stabilise the lumbar spine, thereby improving the stability of the pelvis (Liebenson 2007; Hodges *et al.* 1999). Each exercise was held for a period of ten seconds for ten repetitions (Liebenson 2007).

The power bridge is indicated for gluteal insufficiency, and is suggested to strengthen the link between the lower back and the gluteal muscles (Liebenson 2007). As expounded by Gluck *et al*. 2008), the gluteus maximus plays an important role in hip stabilisation and the generation of power in the down swing phase of the golf swing.

The plank is designed to build strength and endurance by activating the TA and multifidus (Liebenson 2007). Richardson and Jull (1995) stated that the deep core musculature, particularly the TA and multifidi, are extremely important in spinal stability. As described above, the TA and multifidi share an agonist/antagonist relationship (Richardson *et al*.1995). They have been shown to contract 30 milliseconds before movement of the shoulder and 110 milliseconds before movement of the leg in healthy people, theoretically to stabilise the lumbar spine (Hodges *et al*. 1999).

The transverse plank is indicated to improve abdominal endurance, with activation of the TA and internal and external obliques (Liebenson 2007). The internal and external obliques not only contribute to postural stability during the golf swing (Hibbs 2008), but show maximum activity during the backswing and downswing phase of the golf swing (McHardy and Pollard 2005; Gluck *et al.* 2008).

The quadruped reach is indicated to improve trunk extensor endurance. The quadruped reach improves balance, primarily as a result of a strengthened corset effect of the core musculature (Liebenson 2007; Hodges *et al*. 1999). Gluck *et al*. (2008) asserted that the erector spinae show maximum activity and function mainly in counteracting gravity during the down swing phase of the golf swing.

Research has shown a molecular, biological, and physiological improvement in skeletal muscle tissue after four weeks of a structured exercise programme. In addition, statistically significant results have been recorded after four weeks of core strengthening exercise (DeFreitas *et al*. 2011; Camera *et al*. 2010; Clarke 2009; Kendall *et al.* 2009; Kuszewski, Gnat and Saulicz 2009; Smit 2009; Spangenburg 2009; Campbell 2007; Cosio-Lima *et al*. 2003; Boden 2002; Staron *et al*. 1994). Exercise involving co-contraction of the abdominal and lumbar component of the core assists in stabilisation. Simultaneous isometric co-contraction of the transversus abdominis and the multifidus muscles, whilst maintaining a neutral position of the spine, can ensure re-education and reinforcement of the stabilisation roles of these muscles (Richardson *et al*. 1995).

2.5 CONCLUSION

The effects of SMT on performance enhancement of the skeletal system are well documented. The popularity of CMS as a performance enhancement tool in the sporting world is rising at a rapid rate. Its effect on performance in the world of golf is relatively unknown. This study will therefore aim to investigate the effects ofSMT, when compared to CMS on CHV and BC in asymptomatic amateur male golfers.

CHAPTER 3
METHODOLOGY

3.1 STUDY DESIGN

A randomised clinical trial based on a quantitative paradigm. Participants were randomly assigned to two groups, the SMT group attended one session at The Pro Shop during which they were assessed for eligibility, gave consent, did the pre-performance assessment, received a single SMT intervention then repeated the performance assessment. In contrast the CMS group attended two sessions at The Pro Shop. At session one, participants were assessed for eligibility, gave consent, underwent the pre-performance assessment and core muscle strength test. Participants were then taught four CMS exercises to conduct over a four week period, following which they underwent a post-performance assessment test and core muscle strength test.

3.2 POPULATION

Fifty-two asymptomatic amateur male golfers aged between 18 and 45 years, residing in the eThekwini (defined by the “031” telephone code) area who met the inclusion criteria were recruited for this study

3.3 RECRUITMENT

Advertisements **(Appendix B)** were placed at various golf clubs, driving ranges and golf stores in and around the eThekwini area informing golfers of the study. All prospective participants who responded to the advertisement were screened telephonically **(Appendix C)** to determine their eligibility to participate in the study.

3.4 INCLUSION AND EXCLUSION CRITERIA

3.4.1 *Inclusion criteria*

- All participants agreed to sign a Letter of Information and Informed Consent **(Appendix D)**

- Golfers between the ages of eighteen and 45 years. Kirkaldy-Willis and Burton (1992) indicated that age is an important risk factor in low back pain, as it 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), therefore older golfers were excluded from this study.
- Golfers had to be amateur and male in order to create homogeneity within the study sample (Mouton 1996).
- All participants had to be asymptomatic in regions of the lumbar spine and pelvis to the lower extremity, including the hip, knee and ankle. This ensured that the effects of the core muscle strengthening were not obscured due to the inhibition of muscles as a result of arthrogenic muscle inhibition (Hopkins and Ingersoll 2000).
- Golfers were required to show segmental spinal dysfunction in the lumbar spine and/or SI joints, detected by motion palpation (Schafer and Faye 1990; Bergmann, Lawrence and Peterson 1993).

3.4.2 *Exclusion criteria*

- Golfers receiving treatment for mechanical low back pain. This may alter their level of pain tolerance and negatively affect the results of the study.
- Participants on anti-inflammatory drugs or medication, as this may indicate that they are not asymptomatic (Martens 1997) wash out period of seven days.
- Contra-indications to SMT that include vascular complications (Abdominal Aortic Aneurysm); tumours; bone infection; traumatic injury; arthritides and neurologic complications (Cauda Equina, Disc leisions, Nerve root damage) (Gattermann 1990), as determined by physical examination **(Appendix E)**.

- Any complication to abdominal muscle strengthening including but not limited to glaucoma; hypertension; osteoporosis; spinal tumours and impaired circulation (Harms-Ringhdal 1993).
- During the orthopaedic low back regional examination, the following assessments were performed: Kemp's test; Erichson's/Yeoman's test (Schafer and Faye 1990); facet joint challenge test; sacro-iliac percussion/compression test (Bergmann, Lawrence and Peterson 1993). Participants were required to have a true negative result for each of these tests, indicating that they did not have mechanical low back pain.

3.5 SAMPLE SIZE

A sample size of forty male participants were divided into two groups of 20, using a randomisation table (Email communication on 1 September 2015, Statistician, Tonya Esterhuizen).

3.6 SAMPLE ALLOCATION

Participants were randomly allocated via the randomisation table into one of two groups:

- SMT Group
- CMS Group.

3.6.1 CMS program

- The power bridge is indicated for gluteal insufficiency, and is suggested to strengthen the link between the lower back and the gluteal muscles.

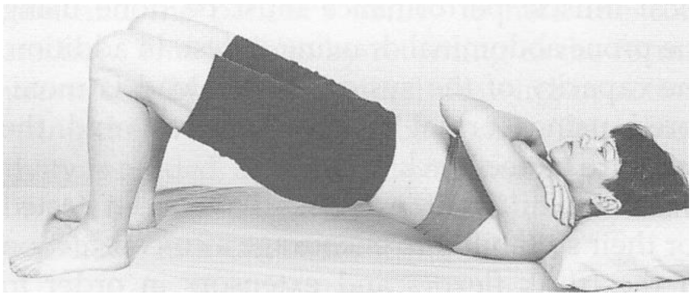

Figure 3.1 Power bridge.

- The plank is designed to build strength and endurance, by activating the TA and multifidus.

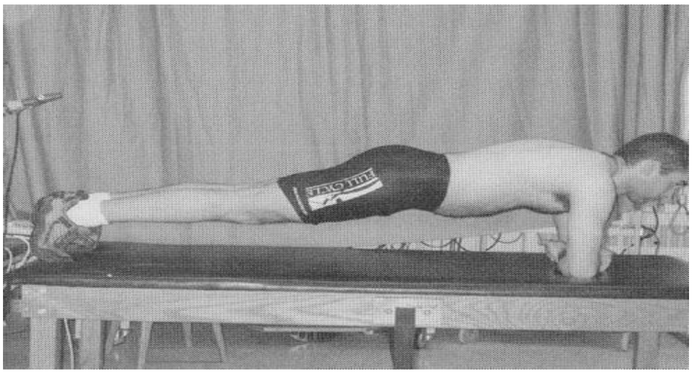

Figure 3.2 Plank.

- The transverse plank is indicated to improve abdominal endurance, with activation of the TA and internal and external obliques.

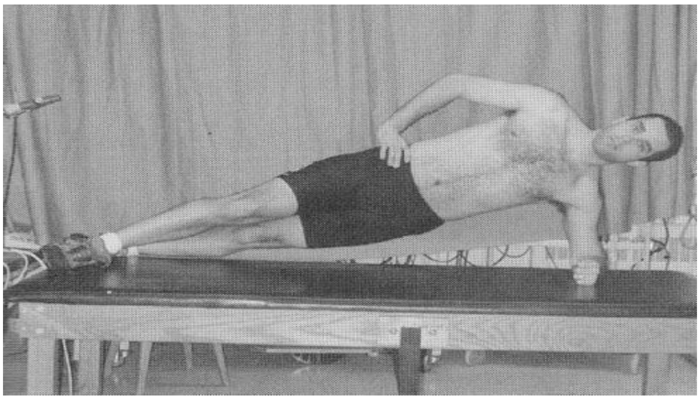

Figure 3.3 Transverse plank.

- The quadruped reach is indicated to improve trunk extensor endurance. The quadruped reach improves balance, primarily as a result of a strengthened corset effect of the core musculature (Liebenson 2007).

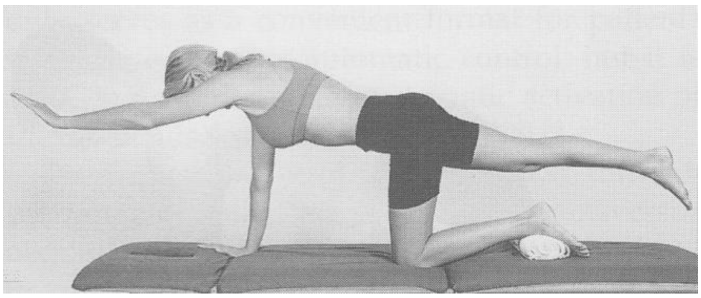

Figure 3.4 Quadruped reach.

(Liebenson 2007; Richardson 2002)

3.7 INTERVENTION FREQUENCY

3.7.1 *Location*

The consultations took place at The Pro Shop. Permission to use the facilities was grated verbally by the General Manager Mr. Deon Ragavan, this was in accordance to the protocol of the The Pro Shop. The Pro Shop is a golf superstore stocking golf clubs, golf equipment and golf balls, specialising in the fitment of correct golf clubs for each golfer. The Pro Shop is located at the La Lucia mall in the suburb of La Lucia in the Durban Metropolitan area, South Africa. A private area was set aside inside the premises away from the public eye, in order to maintain patient comfort and confidentiality whilst performing the consultations and/or evaluations.

3.7.2 *The Consultation*

The SMT group was assessed once off, pre-intervention and post-intervention at The Pro Shop. The CMS group was assessed at the start of week one at The Pro Shop. This was followed by telephonic consultations once a week to ensure compliance and to address any concerns by the participant, followed by a post-intervention assessment at week five at The Pro Shop.

3.8 MEASUREMENT TOOLS

3.8.1 *Subjective measurement tools:*

No subjective data was collected, as following the telephonic interview it was established that participants were asymptomatic with regards to pain.

3.8.2 *Objective measurement tools:*

a. **GC2 Foresight**

   The GC2 Foresight functions by taking measurements using a high resolution camera which captures 10,000 frames per second. It records the movement of the golf ball and golf club using stereoscopic lens arrangement that emulates the human eye. State-of-the-art image processing assured reliable information was fed back to the computer to be analysed. This information was then displayed through various measurements such as CHV and BC. The reliability and validity of the GC2 Foresight is based on its use by professional golfers on the PGA tour.

b. Bio-feedback pressure unit

The bio-pressure feedback cuff functioned by evaluating the activity of the transverse abdominis muscle indirectly. This device is shown in Figure 3.5 below. Depending on the pressure exerted on the air-filled chamber, the reading on the dial changes. The chamber was inflated to 70mm/hg when core co-contraction was initiated. A drop of 6-10 mmHg with contraction was considered a normal reading; if pressure increased then the pelvis was tilted and lumbar lordosis had flattened. Pedro (2011) found moderate to good reproducibility (intra-class correlation coefficients from 0.47 to 0.82) and acceptable construct validity (intra-class correlation coefficients from 0.48 to 0.90).

Figure 3.5 Bio-pressure feedback unit
(Source: R Rambrij)

3.9 PROCEDURE

Permission for an off-campus clinician was obtained **(Appendix F).** Following the telephonic screening **(Appendix C),** 52 participants who met the inclusion criteria were randomly allocated via a randomisation table into one of two groups : SMT, n=25 and CMS, n=20 .

3.9.1 *Off-campus*

Participants then underwent a case history **(Appendix G),** physical examination **(Appendix E),** and lumbar spine regional examination **(Appendix H)**. These were done to assess for any conditions that may exclude the participant from the study. During the orthopaedic low back regional examination the following assessments were performed:

- Kemp's test; Erichson's/Yeoman's (Schafer and Faye 1990).
- Facet joint challenge test (Bergmann, Lawrence and Peterson 1993).
- Sacro-iliac percussion/compression test (Bergmann, Lawrence and Peterson 1993).

Kirkaldy-Willis and Burton (1992) stated that true positive results obtained when applying the above tests were utilised in the diagnosis of low back pain of mechanical origin. Participants were required to have a true negative for each of these tests, indicating that they did not have low back pain of mechanical origin.

Participants then underwent an initial performance assessment at The Pro Shop to identify performance indicators CHV and BC, using the GC2 Foresight. Participants were asked to bring their own club (5 iron) and to use the same club for the duration of the study. This ensured player comfort and confidence as well as maintaining a standard throughout the study. All participants used the same ball (Titleist – Pro V1) to ensure there were no changes in ball dynamics.

3.9.1.1 Performance Assessment (GC2 Foresight)

- The instrument selected for this study was the 5 iron golf club. The reason for this selection was that in order to test CHV, a club needed to be used that was neither too easy nor too difficult to hit. In a set of golf clubs the 5 iron lies in the middle of the difficulty spectrum.
- The ball used for the duration of the study was a Titleist – Pro V1. The reason for this selection was the high quality of the ball's composition. This allowed a

more consistent response from the ball on impact, compared with a cheaper ball having a lower quality, which may respond sporadically under impact.

- Each participant was then asked to assume their golfing stance in front of the GC2 launch monitor and commence their swing when ready.
- After each swing, the movement of the ball was projected onto a screen by means of a golf simulator, with information on the golf ball sent back to the computer to be analysed and presented in various measurements. For the purpose of this study the two measurements recorded were the CHV and BC.
- Participants had five swing attempts, after which an average of the CHV and BCwere calculated and used as the pre- and post-intervention readings. Data was recorded on the Data Capture Sheet **(Appendix I)**

Figures 3.6, 3.7 and 3.8 below display the equipment and positioning used for the individual assessment.

Figure 3.6 GC2 Foresight

(Source: R Rambrij)

Figure 3.7 Computer screen used for the visual analysis of data

(Source: R Rambrij)

Figure 3.8 Setup of the golfer and GC2 Foresight

(Source: R Rambrij)

3.9.1.2 SMT Group

1. Participants showed asymptomatic joint dysfunction with decreased range of motion in the relevant spinal segments. This was achieved by means of motion palpation (Schafer and Faye 1990).
2. Participants were motion palpated to find restrictions in left and right rotation, flexion, extension and left band right lateral flexion within the lumbar spine, and restrictions within the SI regions.
3. Following the above, participants received a lateral recumbent (Lehman and McGill 1999) or seated manipulation to the lumbar spine.
4. The SI manipulation was also done in the lateral recumbent position but differs from the lumbar manipulation by emphasising traction and tension on the SI joint through the contact hand (Bergmann, Lawrence and Peterson 1993).
5. Participants were then re-assessed immediately after manipulation using the GC2 foresight to determine the effects on CHV and BC.

3.9.1.3 CMS Group

1. The four-point kneeling procedure **(Appendix J)** was used to demonstrate how to perform a core muscle contraction, as indicated in Figure 3.8 below. The participant was taught to maintain normal thoracic and lumbar spine curves. The participant was then instructed to 'draw your naval towards your spine'. The rib cage and pelvis had to remain still and the participant continued to breathe in normally during the exercise (Richardson *et al*. 1995) .

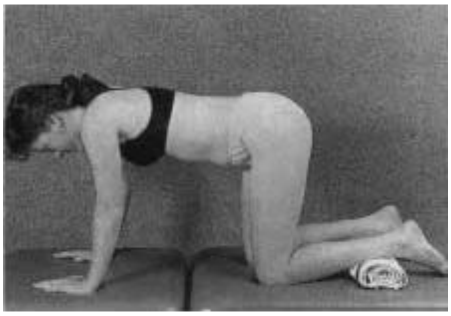

Figure 3.9 The four point kneeling position
(Richardson *et al*. 1995)

2. The participant was then assessed using the Pressure Bio-Feedback Unit (PBU) to determine the endurance of the transvers abdominus muscle (abdominal draw-in test), which can be seen in Figure 3.9 below.

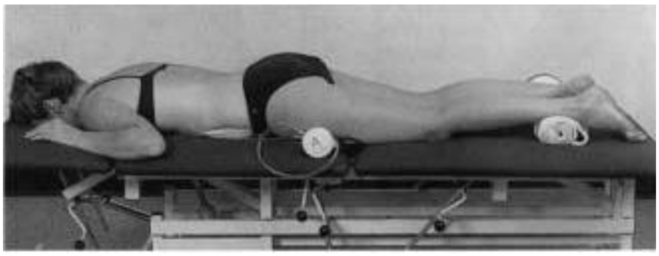

Figure 3.10 Abdominal draw in test
(Richardson *et al* 1995)

3. The PBU was placed under the abdomen of the participant, with the umbilicus in the centre of the bag, and the inferior distal margins of the bag in line with the right and left anterior superior iliac spines.

4. The pressure bag was inflated to 70 mmHg; participants were then instructed to perform a contraction as taught in the four-point kneeling position. A drop of 6-10 mmHg with contraction was considered normal. While the researcher monitored the pressure gauge to observe any compensatory mechanisms, the contraction time was measured using a stopwatch and the results recorded **(Appendix I)** (Richardson *et al.* 1995; Richardson 2002).
5. Participants then had the core exercises demonstrated, with an opportunity to practice them to ensure correct technique. The participants also received an exercise hand-out sheet detailing the core training exercises **(Appendix A)**.
6. The core exercises selected for the purpose of this study **(Appendix A)** were specifically designed to develop isolated and co-contraction muscle patterns to stabilise the lumbar spine, thereby improving the stability of the pelvis (Liebenson 2007; Richardson 2002). Each exercise was held for a period of ten seconds, for ten repetitions.
7. Participants were contacted telephonically once a week to ensure compliance and to address any concerns they may have had.
8. At week five and the final consultation, the participants were re-assessed at The Pro Shop, using: 1) the PBU to assess core strength; and 2) the GC2 foresight to determine the effects on CHV and BC.

3.9.2 *Data Analysis*

The data were analysed using IBM SPSS version 22. A p value <0.05 was considered as statistically significant. Repeated measures ANOVA within and between groups analysis was used to compare the changes over time within and between treatment groups. A significant time x group interaction indicated a significant difference in treatment effect over time between the two groups. Paired t-tests were used to assess change in duration of contraction in the CMS group, Pearsons correlation analysis was used to assess the correlation between changes in CHV and BC intra-group and profile plots were used to show direction and trend of the effect by means of the latest version of SPSS software. (Email communication on 9 April 2016, Statistician, Tonya Esterhuizen).

3.9.3 *Ethical Considerations*

The following ethical processes were implemented prior to, and during, the study:

- Ethics approval from the Institutional Research Ethics Committee (IREC), ethical clearance number (096/15).
- The study was registered on clinicaltrials.gov website.
- Informed consent following distribution and reading of the participant information sheet. This ensured that the research participant understood what the research process entailed and consented to the allocated treatment protocol.
- The SMT and CMS techniques are non-invasive and were applied within the safety procedure parameters of the Durban University of Technology Chiropractic Day Clinic (DUT CDC).
- The research data will be filed at the DUT CDC for a period of five years, after which it will be incinerated as per the DUT CDC protocol.
- Participants were not coerced into participating in the study, as per the participant information sheet and informed consent.
- Participation was voluntary and did not involve any financial benefits.
- Should any adverse event have occurred during or after the procedure, the participant would have been advised to visit their personal healthcare provider. Should the participant not have a personal healthcare provider, a referral letter would have been issued to them, as well as directions to the nearest local hospital.

CHAPTER 4
RESULTS AND DISCUSSION

4.1 INTRODUCTION

This chapter will discuss the statistical analysis of the data collected, according to the four study objectives.

Objective One:

To determine the effect of a single session of SMT on CHV and BC.

Objective Two:

To determine the effect on core strength following four weeks of CMS exercises.

Objective Three:

To determine the effect of CMS on CHV and BC.

Objective Four:

To compare the effect of SMT and CMS on CHV and BC.

4.2 DATA SOURCES

Primary data was obtained directly from the participants in the form of the Bio-pressure Feedback Unit and the GC2 Foresight machine at The Pro Shop, La Lucia, Durban. Secondary data was obtained from various sources of related literature such as journal articles, text books and appropriate internet sites.

4.3. ABBREVIATIONS USED IN THIS CHAPTER

CHV	Club head velocity
p	p-value
r	Pearson's correlation coefficient
BPU	Bio-pressure feedback unit
SMT	Spinal manipulative therapy
N	sample size
Row N%	row count and percentage
Sig. (2 – tailed)	Significance two tailed
Sig.	Significance
t	t statistic
df	Degrees of freedom

4.4 RESULTS

Of the total number of participants in the study, seven withdrew due to their inability to make the follow-up consultation within the stipulated time period for the CMS group. This resulted in their replacement by new participants, who were allocated via the same randomisation process.

4.5 DEMOGRAPHIC DATA

The Descriptive characteristics of the two groups are presented in Table 4.1. The groups were matched for all variables except age; the SMT group was older than the CMS group (p=0.012).

Table 4.1: Descriptive characteristics of the SMT and CMS groups

	SMT (n=25)	CMS (n=20)	p-value
Age (y)	31.4 ± 7.5	25.9 ±3.4	0.012
Handicap (Yes:No)	17:8 (68:32)	10:10 (50:50)	0.221

Data are presented as mean (SD) or counts (percentage). SMT- spinal manipulative group, CMS – core muscle strengthening group. The p-values represent significance as determined using independent t-tests or a chi-squared tests.

4.6 BASELINE OUTCOMES

Table 4.2: correlation between CHV and BC in SMT and CMS groups

	SMT (n=25)	CMS (n=20)
CHV:BC	0.316	0.334

Data are presented as p-values. The p-values represent significance as determined using independent t-tests or a chi-squared tests. SMT- spinal manipulative group, CMS – core muscle strengthening group.

<u>Discussion:</u>

Research has shown an approximate 1:3 relation between CHV and BC (Stude and Gullickson 2000). This relation suggests that for every 1-mph increase in CHV, there is a subsequent three-yard increase in BC (Stude and Gullickson 2000). This study cannot verify whether the ratio attributed to the relationship is indeed true. However, the relationship between CHV and BC shows a general trend of a positive relationship (improvement in CHV meant improvement in BC). There were a few outliers where they improved in one outcome but worsened in another.

4.7 STATISTICAL ANALYSIS OF THE OBJECTIVES

4.7.1 *Objective One:* To determine the effect of a single session of SMT on CHV and BC.

Table 4.3 CHV and BC before (Pre) and after (Post) the SMT intervention

	Pre (n=25)	Post (n=25)	p-value
CHV (mph)	90.2±7.8	90.7±8.9	p=0.528
BC (yards)	146.3±36.3	146.9±36.6	p=0.860

Data are presented as mean (SD). CHV – Club head velocity. mph – miles per hour. BC – ball carry. The p-values represent significance as determined using independent t-tests or a chi-squared tests.

<u>*Discussion*</u>:

As espoused by Seaman (1998), in the right handed golfer the transition from the backswing to the downswing requires a weight transfer from the right to the left. This is facilitated by the stabilisation of the gluteus medius muscle. Thompson (2002) further stated that overuse of the gluteus medius muscle is related to SI dysfunction. Gatterman (1990) indicated that it is possible an area of hypomobility (spine/pelvis) will lead to another area becoming hypermobile (spine/pelvis). This means that a loss of range of motion in the SI joint will lead to compensation of the lumbar spine to maintain a full range of motion (Mackey 1995).

Additionally, Mackey (1995) posited that the change of biomechanics could develop into joint dysfunction in either the lumbar spine or pelvis. This may lead to changes associated with joint dysfunction such as a pain and a loss in range of motion (ROM), either globally or within the motion segment (Leach, Phillips and Lantz 1996). This may, however, be present at a sub-clinical level in the asymptomatic amateur golfer. Based on the current literature surrounding the development of joint dysfunction, the treatment of joint dysfunction using SMT and the subsequent significant effect of SMT on CHV and BC in symptomatic golfers raised the expectation of a similar significant effect on asymptomatic golfers. Statistical analysis revealed, however, a minimal yet statistically insignificant effect on both CHV and BC.

It may also be safe to say that according to this study, SMT had no benefit in asymptomatic golfers. A possible reason for this and the difference in the treatment efficacy between this study and previous studies, is the presentation of the golfer. A symptomatic golfer may have greater room for improvement due to the treatment outcome (i.e. a decrease in pain, guarding and increased ROM), compared with a golfer who is asymptomatic at the onset. This means that SMT relieves the symptoms in a symptomatic golfer and has an indirect effect on performance, but does not make an asymptomatic golfer a better golfer in terms of CHV and BC.

It therefore stands to reason that the relationship between CHV and BC, as previously described, may be purely affected by the golfer's experience (i.e. inhibition of action due to pain, guarding and loss of ROM) rather than a mathematical relationship that has been described in literature. This is purely speculation, however, as due to the small sample size further research is required on this aspect.

It is thus difficult to extrapolate any meaning from the data. This is supported by the fact that the literature is unclear as to the methods of action regarding SMT on the asymptomatic amateur golfer. At best, the outline of the discussion above indicates what is known hypothetically and in terms of theory (Leach 1994).

4.7.2 ***Objective Two:*** **To determine the effect on core strength following four weeks of CMS exercises.**

Table 4.4: CMS before (Pre) and after (Post) the CMS program

	Pre (n=20)	Post (n=20)	p-value
Duration of contraction (seconds)	21±16.5	40±22	p<0.001

Data are presented as mean (SD). The p-values represent significance as determined using independent t-tests or a chi-squared tests.

<u>*Discussion*</u>:

The PBU was used to assess the core strength of the participants' pre- and post-intervention. Strengthening of the trunk musculature by following a core strengthening exercise programme has been recommended to improve performance of the axial and appendicular skeleton in various sporting environments (Hedrick 2000; Akuthota & Nadler 2004; Akuthota *et al.* 2008; Hibbs *et al*. 2008; Asplund and Ross 2010). Bulbulian (2001) recommended core strengthening exercises aimed at the musculature that would facilitate the golf swing. The effects of core strengthening on golfing performance, however, have not been directly measured.

The TA plays an important role in the control and maintenance of spinal stability during the golf swing (Grimshaw 2002). Together with the multifidi muscles the TA forms a co-contraction relationship, providing support and joint stabilisation (Richardson *et al*. 1995). During the downswing phase of the golf swing, maximum force generation produces rotation with simultaneous flexion of the lumbar spine (Seaman 1998). The job of the TA and multifidi is to work simultaneously to stabilise the spine and prevent flexion, thereby allowing the golfer to maximally rotate resulting in an efficient swing technique (Seaman 1998). It can therefore be postulated that deconditioning of either the TA or multifidi, or both, will result in flexion of the spine and an inefficient technique, which may affect the performance of the golfer.

Participants were required to conduct the abdominal draw test in the prone position. Core strength measurements were analysed using paired sample correlation *t*-tests, to compare the pre- and post- intervention measurements. The abdominal draw showed a highly significant change from pre- to post-intervention ($p=<0.001$) when age was held constant. This suggests that participants were able to contract the TA independently of the global muscles, as well as display an increase in endurance of the core musculature post-intervention (Richardson *et al*. 1995: Richardson 2002).

Based on the above and the current literature surrounding core strengthening exercises, and the subsequent effect on core muscle strengthening, it is indicative that the correct exercises were chosen for this study to target the TA, multifidi and core muscle groups. Mention must be made that there was no clear indication in the literature of an optimal duration for the core strengthening exercises. Significantly, it must be highlighted that the duration of the intervention chosen for this study was long enough to obtain a significant result. This would not have been possible, however, without compliance from the sample group, which is a defining factor in a research study of this kind. Further research is required to define this optimal training duration.

As previously indicated, if the optimum functioning of the TA and multifidi is essential for an efficient swing technique, it stands to reason that by increasing the endurance of the core musculature it may be possible to improve the performance of the golfer. It must also be mentioned that research on the effects of a core strengthening programme on golfing performance have never been conducted.

4.7.3 *Objective Three:* To determine the effect of CMS on CHV and BC.

Table 4.5: CHV and BC before (Pre) and after (Post) the CMS intervention

	Pre (n=20)	Post (n=20)	p-value
CHV (mph)	87.1±9	89.8±7.4	0.015
BC (yards)	129±35.6	164±31.6	p<0.001

Data are presented as mean (SD). CHV – Club head velocity. mph – miles per hour. BC – ball carry. The p-values represent significance as determined using independent t-tests or a chi-squared tests.

Discussion:

Hibbs *et al.* (2008) affirmed that if a muscular imbalance occurs it can result in compensatory movement patterns that are less efficient. Taking this into account, any change in local and global muscle balance and flexibility may affect the performance of the golfer. This is because local muscle balance and flexibility provides not only stability but also the distribution and absorption of forces in the body for rapid movement and power, which characterises the golf swing (Hibbs *et al.* 2008; Chek 2016).

This is supported by the statistical analysis above, which indicates that core muscle strengthening can improve the performance i.e. CHV and BC of the golfer. A possible reason for this is that by improving core muscle strength, and hence the stability around the lumbar spine, the golfer will have a greater ability to not only generate power but to distribute the force accordingly through the hips and shoulders for a more efficient swing. Akuthota *et al.* (2008) and Hibbs *et al.* (2008) described this as 'proximal stability for distal mobility'. Essentially this means that the core musculature provides power for all limb movemen

Stude and Gullickson (2000) explained that CHV can only be generated by strengthening the abdominal muscles involved in the golf swing (i.e. the transverse abdominus, obliques and paraspinal i.e. multifidus). In light of this, we can also assume that the correct exercises were chosen to have an effect on those abdominal muscles involved in the golf swing, and to bring about the improvement in performance indicators. The type of exercises chosen and their effect on performance indicators have been noted, although what is extremely important is the duration over which the intervention occurred. We can confirm that a four-week period is a significant time frame over which an asymptomatic amateur golfer can improve performance. Taking all the above into account, it can be confidently stated that by implementing a core strengthening programme targeting the muscles involved in the golf swing, an asymptomatic amateur golfer can improve performance in terms of CHV and BC over a four-week period.

4.7.4 *Objective Four:* To compare the effect of SMT and CMS on CHV and BC.

Table 4.6: The effect of SMT compared to CMS on CHV and BC over time

	Post (n=25)	Post (n=20)	p-value
CHV (mph)	90.6±8.9	89.8±7.4	0.127
BC (yards)	146.9±36.6	164±31.6	p<0.001

Data are presented as mean (SD). CHV – Club head velocity. mph – miles per hour. BC – ball carry. The p-values represent significance as determined using independent t-tests or a chi-squared tests.

Discussion:

The effect of SMT on golfing performance is well documented (Jermyn 2004; Delgado, 2006; Le Roux 2008; Bower 2008). The effect of core muscle strengthening on golfing performance, however, is not well documented. The aim of this study was therefore to compare the effectiveness of SMT and core muscle strengthening on performance indicators. The performance indicators chosen for this study were CHV and BC.

The results from Table 4.6 show that over time, with age held constant, the effects of SMT and core muscle strength on CHV were statistically equivalent. This means that SMT and core muscle strengthening had the same effect on CHV. There are two possible reasons for this: the first is the intervention time, i.e. the duration over which each treatment intervention was conducted. The SMT group was conducted once off; The CMS group was conducted over a four-week period. The intervention response time was therefore different, as the SMT group was immediate whereas the CMS group was short-term. This means that over a long period the SMT group may have a greater effect on CHV than the CMS group. The second reason is the effect of each intervention over time. Due to the longer time period required for core muscle strengthening to have a physiological effect, The CMS group took a longer time period to have an effect on CHV when compared with the SMT group. Based on the effects of each intervention over their respective time, both groups therefore improved to the same degree.

CMS was shown to have a greater effect on BC when compared with SMT (Table 4.6). There are two possible reasons for this: the first is the 'immediate vs short- term' effect of each intervention. The immediate effect of SMT was to improve range of motion and thus performance, while the short-term effect of CMS was to improve spinal strength and stability, and thus improve performance. It therefore stands to reason that the immediate effect of SMT may not have had the same influence on the anatomical structures required to enhance BC, when compared with the short- term effect of CMS.

The second possible reason is that BC is not only velocity driven. By improving core muscle strength the golfer has a more stable platform through which power can be transferred into the upper limbs. The golfer does not need to swing the club faster during the downswing phase in order to develop more power in the swing. This creates a more efficient swing technique by facilitating a return of the club face to its starting position and allowing more consistent ball striking (Gluck *et al.* 2008). It therefore allows the mechanics of the club head to work, rather than using brute force.

4.8 DISCUSSION OF HYPOTHESES

4.8.1 Hypotheses One:

It was hypothesised that SMT would show a significant effect on CHV and BC. Statistical analysis revealed a small but statistically insignificant increase in CHV and BC. As a result, hypothesis one had to be rejected. Further research is required with a larger sample size.

4.8.2 *Hypotheses Two:*

It was hypothesised that CMS would show a significant effect on core strength. Based on the proposed theory of effect of core strengthening exercises on core muscle strength over a four week period, this study showed a highly significant increase in core muscle strength. As a result, hypothesis two was accepted.

4.8.3 *Hypotheses Three:*

It was hypothesised that CMS would show a significant effect on CHV and BC. Having established the effect of core strengthening exercises on core muscle strength according to the current literature, it was expected that an improvement in core muscle strength would have an effect on CHV and BC. This study showed a highly significant increase in CHV and BC following core muscle strengthening. As a result, hypothesis three was accepted.

4.8.4 *Hypotheses Four:*

It was hypothesised that CMSwould have a greater effect on CHV and BCthanSMT.

The biomechanical effect of CMSon sporting enhancement is well documented (Hibbs *et al.* 2008; Lust *et al*. 2009; Wiseman 2014). The biomechanical effect of SMT on golfers is also well documented (Jermyn 2004; Delgado 2006). Based on the difference in the proposed effect on golfers between SMT (range of motion) and CMS(strength and stability), it was hypothesised that CMSwould have a greater effect. This study found, however, that the effect of SMT and CMSstrengthening on CHV was statically equivalent, while CMShad a statistically greater effect on BCthan SMT. As a result, hypothesis four was rejected

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

The results show that asymptomatic golfers cannot employ SMT as an ergogenic intervention to enhance their CHV AND BC distance. However literature demonstrates that SMT has been proven to be successful as a therapeutic intervention that subsequently enhances symptomatic golfers' CHV and BC. The results do indicate positive trends that a four-week CMS program does serve as an ergogenic intervention to enhance asymptomatic golfers' CHV and BC distance.

5.2 RECOMMENDATIONS

5.2.1 Recommendations for the amateur golfer and the golfing population at large

The effects of SMT on golfing performance in asymptomatic amateur golfers is unclear. It was difficult to extrapolate any meaning from the data collected in this study. This is based on the statistical analysis which indicates that there is an effect, although the extent of which is not significant. The immediate and short-term effects of SMT on golfing performance in symptomatic participants, however, is well documented. Should a golfer present acutely with low back pain and need relief from pain and guarding with the added benefit of performance enhancement, SMT would therefore be a good immediate option.

The implementation of a four-week CMS programme to improve core muscle strength was highly successful. The effect on golfing performance was also highly successful. The use of this exercise programme is uncomplicated and comprises of five basic exercises. It targets the essential muscles involved in the golf swing and provides all golfers with the ability to improve their performance without having to make contact with a skilled health professional.

During the time spent collecting the data, it was noted by the researcher that golfers tend to spend large amounts of money purchasing golfing apparel, or building a tailor-made golf club to improve their performance. The utilisation of an exercise programme may be a cost effective method of improving performance, which is currently being overlooked. Setting aside the effect of golfing performance, the benefit of a CMS programme is injury prevention by preventing the deconditioning of muscle and the development of joint dysfunction syndrome (Seaman 1998; Vernon and Mrozek 2005). Further research on the long term effect of CMS is required.

In conclusion, although further research is required to clearly separate the more effective treatment protocol, symptomatic golfers seeking immediate relief should consider SMT. For the asymptomatic golfer who is considering a method of injury prevention and performance enhancement, the CMS programme in this study should be considered.

5.2.2 Recommendations for future research

- This study could be repeated using professional golfers, with more focus on the intervention frequency of the SMT group, in order to show any relationship that may exist between spinal manipulation and performance indicators. Professional golfers may have better golf swing mechanics and this may have an effect on their performance.
- This study could be repeated with more consistent influence on performance indicators.
- This study could be repeated using symptomatic golfers to compare the effect of spinal manipulative therapy and core muscle strengthening on pain and performance indicators.
- A follow-on study could be implemented focusing on core muscle strengthening and its effects on performance indicators over six or eight weeks (Lephart *et al.* 2007; Lust *et al.* 2009), in order to investigate the optimal length of time for the greatest benefit.
- A follow-on study could be effected focusing on core muscle strengthening and its effects on performance indicators, in order to investigate the short- and long-term effect of core muscle strengthening. After four weeks the participants then stop the intervention and are reassessed after twelve weeks.

- A follow-on study can be conducted using the same four-week core strengthening programme but including exercises that target flexibility and balance. This may aid in developing other physical characteristics that may be involved in an efficient swing technique and optimum performance (Lephart *et al.* 2007).
- A follow-on study can be done comparing the effect of core muscle strengthening between symptomatic and asymptomatic golfers.
- Future studies assessing core muscles should use EMG to assess muscle activity, as this may be more accurate than the bio-pressure feedback unit which is open to human error.
- Follow-on studies should use a larger sample size, as this may aid in obtaining more accurate results.
- Follow-on studies should increase the amount of swing attempt, i.e. from five to ten, with the two or three worst swing attempts discarded. This may aid in obtaining more consistent results.
- Follow-on studies should use a True Control group. This will increase the validity of the study design.

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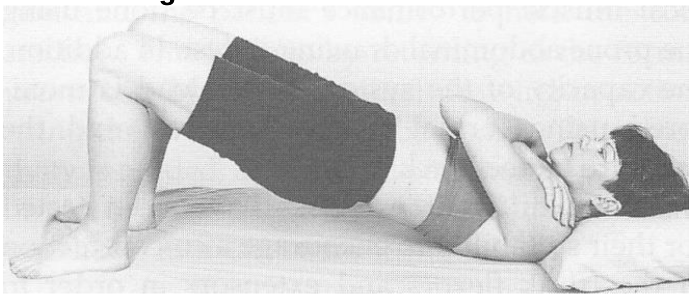
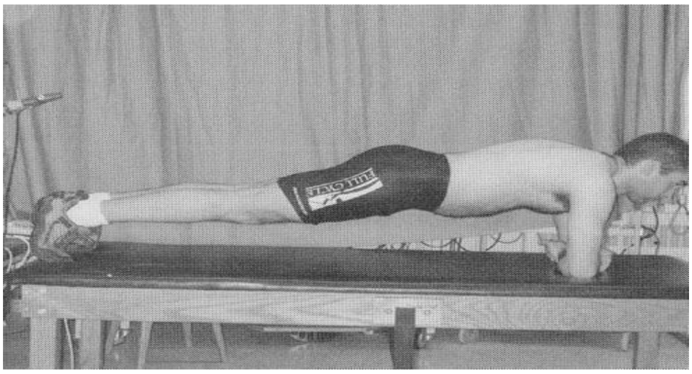
APPENDIX A

Core Training Exercises

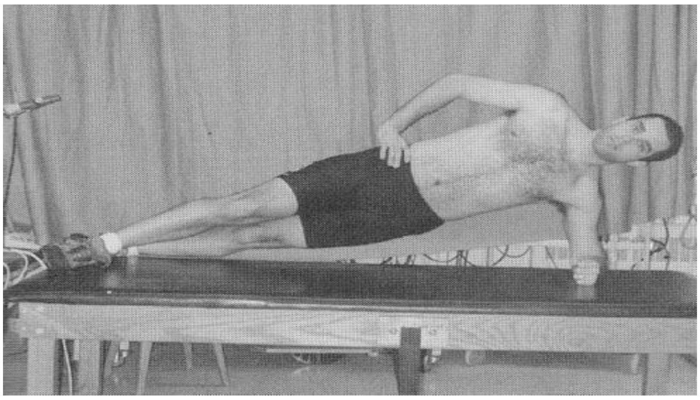
1. **Power Bridge**



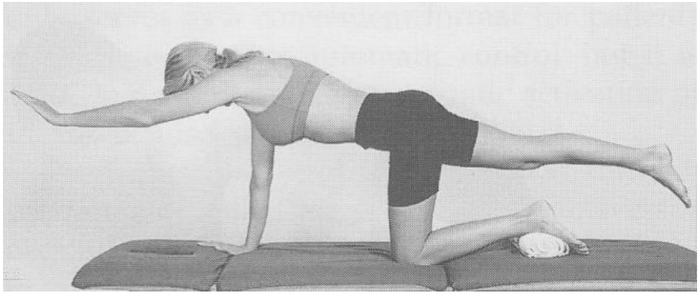
2. **Plank**



3. **Transverse Plank**



4. **Quadruped Reach**



(Liebenson, 2007. Richardson *et al*, 1999)

1. Power Bridge

 Lying on your back, with knees bent, feet flat and shoulder width apart, toes pointing straight ahead and arms at your side with palms facing down.

 In one smooth motion, activate your core and squeeze your gluteal muscles, and lift your hips off the floor so that your body forms a straight line from shoulders to knees.

 Hold for 10 seconds and then lower down slowly.

 Repeat for 10 sets.

2. Plank

 Lying on your stomach, place your elbows under your shoulders, with forearms and hands on the floor.

 Lift your hips off the floors, resting on your toes, keeping your core activated, back straight.

 Hold for 10 seconds and then lower down slowly.

 Repeat for 10 sets.

3. Transverse Plank

 Lie on your right side, with your right elbow under your right shoulder, and forearm in front to stabilise, and place your left foot on top of your right.

 Activate your core, and lift your body in one smooth motion, to create a straight line down your left side.

 Hold for 10 seconds and then lower down slowly.

 Repeat for 10 sets.

4. Quadruped Reach

 Kneeling on all fours, place your hands flat on the floor, directly under your shoulders, and your knees directly under your hips.

 Activate your core, and extend your right arm forward and your left leg back, holding in line with your body.

 Hold for 10 seconds and then lower down slowly.

 Repeat for 10 sets.

APPENDIX B

PLAY GOLF?

Are you male between the ages of 18-45 and have no low back pain?

Research is currently being conducted at the Durban University of Technology (DUT)

Participants who qualify will receive free Chiropractic treatment aimed at improving golfing performance.

FREE GOLF SWING ANALYSES

Is available for the duration of the study

For more information, please contact

Ranen Rambrij

031 373 2205 or 061 199 7404

At the DUT Chiropractic Day Clinic

APPENDIX C

Telephonic Screening

Name :…………………………………Date :………………….. Accepted into study : **YES/NO**

Date of Consultation : ………………......

PARTICIPANTS MUST PRODUCE ID ON FIRST CONSULTATION

Questions asked of respondents	**Answers from respondents to qualify to participate**
Are you male between the ages of 18 and 45?	Yes
Are you currently pain free in the lower back and lower limb regions, including the hip, knee and ankle?	Yes
Are you receiving treatment for low back pain?	No
Have you had surgery for low back pain?	No
Do you have an official handicap?	Yes
Are you an amateur golfer?	Yes
Can you commit to a consultation at The Pro Shop and D.U.T for the study?	Yes
Are you on anti-inflammatory drugs or medication?	No

APPENDIX D

Letter of information and informed consent

Title of the Research Study:

The effectiveness of spinal manipulative therapy compared to core muscle strengthening, on club head velocity and ball carry in asymptomatic male golfers.

Principle Investigator: Ranen Rambrij

Supervisor: Dr G Harpham (M.Tech:Chiropractic)

Brief Introduction and Purpose of the Study:
This study will involve research on 40 male golfers between the ages of 18-45 years of age, and who have a registered handicap. Golfers will be divided into two groups of 20 each, group one will be treated with spinal manipulative therapy, group two will be treated with core muscle strengthening.

Outline of the Procedures:

On initial consult you will be required to complete a through case history, and a full physical and low back regional examination carried out by the researcher. You will then be required to undergo testing on the GCS Foresight machine at the Durban Pro Shop, where club head velocity and ball carry will be measured. Following this, group two will be instructed on how to perform an abdominal contraction to isolate the transverse 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 one's core strength and endurance.

It is hoped that the above process will show some form of relationship between spinal manipulative therapy alone, core stability training alone and a combination of spinal manipulative therapy and core stability training to club head velocity and ball carry.

This study will be conducted at The Pro Shop (LaLucia Mall) and the Chiropractic Day Clinic subsequent to the completion of your participation in the study. You may be removed from the study without your consent if any the exclusion criteria are met. 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 spinal manipulative therapy alone, core muscle strengthening alone and their subsequent effect on club head velocity and ball carry (distance).

Risks or Discomforts to the Subject:
There are no risks. You may feel a localized discomfort over the area being treated. If the sensation becomes intolerable, you may request to have the treatment stopped and withdraw from the study.

Benefits:

This study will help to determine the effect of spinal manipulative therapy compared to core muscle strengthening on club head velocity and ball carry in asymptomatic male golfers.
Reason/s why the Subject May withdraw from the study:
You are free to withdraw from this study at any stage without any negative repercussions.

Remuneration:
You will not be offered any form of remuneration for taking part in the study.

Costs of the Study:
The initial consultation and the follow up treatments are free of charge.

Confidentiality:
All your medical records will be kept confidential and will be stored in the Chiropractic Day Clinic for 5 years, after which it will be shredded. Your name will not appear on any of the data sheets or thesis.
Please don't hesitate to ask questions on any aspect of this study. Should you have any complaints or queries, please do not hesitate to contact my research supervisor at the above details or the Constitutional Research Ethics Committee Administration: 031 373 2900

Research-related injury:
There will be no compensation in the event of an injury.

Persons to contact in the Event of Any Problems or Queries:

Head of Department: Dr. A. Docrat **Contact number:** 031 373 2589

Supervisor: : Dr G Harpham **Contact number:** 0845452345

CONSENT

Statement of Agreement to Participate in the Research Study:

- I hereby confirm that I have been informed by the researcher, ____________ (name of researcher), about the nature, conduct, benefits and risks of this study - Research Ethics Clearance Number: ___________,
- I have also received, read and understood the above written information (Participant Letter of Information) regarding the study.
- I am aware that the results of the study, including personal details regarding my sex, age, date of birth, initials and diagnosis will be anonymously processed into a study report. In view of the requirements of research, I agree that the data collected during this study can be processed in a computerised system by the researcher.
- I may, at any stage, without prejudice, withdraw my consent and participation in the study. I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.
- I understand that significant new findings developed during the course of this research which may relate to my participation will be made available to me.

____________________ __________ ______ _______________

Full Name of Participant Date Time Signature / Right Thumbprint

I, ______________ (name of researcher) herewith confirm that the above participant has been fully informed about the nature, conduct and risks of the above study.

_________________ __________ ___________________

Full Name of Researcher Date Signature

_________________ __________ ___________________

Full Name of Witness (If applicable) Date Signature

_________________ __________ ___________________

Full Name of Legal Guardian (If applicable) Date Signature

DUT DURBAN UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF CHIROPRACTIC AND SOMATOLOGY

APPENDIX E

CHIROPRACTIC PROGRAMME

PHYSICAL EXAMINATION: SENIOR

Patient Nam ____ **File no:**_______ **Date:**__________

Student: **Signature:**

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

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

SYSTEM SPECIFIC EXAMINATION:
CARDIOVASCULAR EXAMINATION
RESPIRATORY EXAMINATION

ABDOMINAL EXAMINATION
NEUROLOGICAL EXAMINATION
COMMENTS
Clinician: **Signature:**

APPENDIX F

Permission for an off-campus Clinician

I Ranen Rambrij (6th year Chiropractic Intern) currently completing my Master's research entitled : The effects of spinal manipulative therapy compared to core muscle strengthening on club head velocity and ball carry in asymptomatic male golfers, request your services as an off campus clinician. Research will be conducted at The Pro Shop LaLucia mall, where the measurement tool (GC2 Foresight) is located. Your services will entail looking over and signing of on the Case History, Physical examination, Regional examination and SOAPE note. Consultations will be one hour long and carried out one to two times a week. This will also depend on the number of patients booked for that day. The research is comprised of two groups of forty participants and will be carried out over a four week period. Participants will be assessed twice at The Pro Shop, once at the initial consultation and a second time at the final consultation. This will mean a total of eighty consultation over the four week period. You will be notified of the time and date of proposed consultations at least one week in advance to allow for adequate preparation.

Ranen Rambrij Signature :_____________________ Date:____________________

(6th year Intern)

Dr Greame Harpham Signature :_____________________ Date:__________________

(Supervisor)

I Dr ______________________________ understand the requirements of the research topic and volunteer my services as an off campus Clinician for the duration of the study.

Signature :_____________________ Date:____________________

APPENDIX G

CHIROPRACTIC PROGRAMME

CHIROPRACTIC DAY CLINIC CASE HISTORY

Patient: ______________________ Date: __________

File # __________ Age: __________

Sex: __________ Occupation: ______________________

Student ______________________ 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:

Student's Case History:

1. Source of History:

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

3. Present Illness:

	Complaint 1(principle complaint)	**Complaint 2 (additional or secondary complaint)**
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. x-rays

Environmental Hazards (Home, School, Work)

Exercise and Leisure

Sleep Patterns

Diet

Current Medication
Analgesics/week:
Other (please list):

Tobacco
Alcohol
Social Drugs

7. Immediate Family Medical History:

Age of all family members
Health of all family members
Cause of Death of any family members

	Noted	Family member		Noted	Family member
Alcoholism			Headaches		
Anaemia			Heart Disease		
Arthritis			Kidney Disease		
CA			Mental Illness		
DM			Stroke		
Drug Addiction			Thyroid Disease		
Epilepsy			TB		
Other (list)					

8. Psychosocial history:

Home Situation and daily life
Important experiences
Religious Beliefs

9. Review of Systems (please highlight with an asterisk those areas that are a problem for the patient and require further investigation)

General

Skin

Head

Eyes

Ears

Nose/Sinuses

Mouth/Throat

Neck

Breasts

Respiratory

Cardiac

Gastro-intestinal

Urinary

Genital

Vascular

Musculoskeletal

Neurologic

Haematological

Endocrine

Psychiatric

APPENDIX H
CHIROPRACTIC PROGRAMME
REGIONAL EXAMINATION
LUMBAR SPINE AND PELVIS

Patient: ______________________________ File#: ______________ Date: __________

Student: ______________________________ Clinician:________________

STANDING:

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

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

GAIT:

Normal walking
Toe walking
Heel Walking
Half squat

ROM:

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

Extension = 20-35°
L/R Rotation = 3-18°
L/R Lateral Flexion = 15-20°

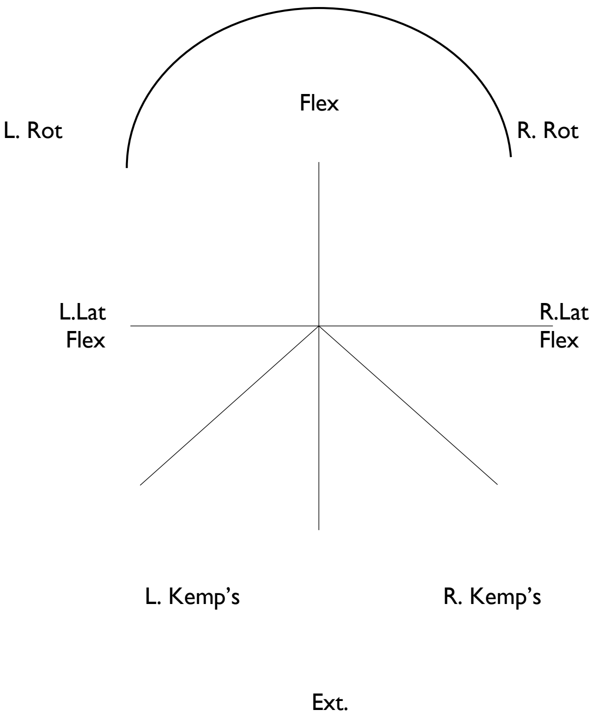
Which movement reproduces the pain or is the worst?

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

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

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

SITTING:

Spinous Percussion

Valsalva

Lhermitte

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

SLUMP 7 TEST	**L**										
	R										

LATERAL RECUMBENT:	**L**	**R**
Ober's		
Femoral n. stretch		
SI Compression		

PRONE:	**L**	**R**
Gluteal skyline		
Skin rolling		
Iliac crest compression		

Facet joint challenge		
SI tenderness		
SI compression		
Erichson's		
Pheasant's		

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

NON ORGANIC SIGNS:

Pin point pain

Trunk rotation

Flip Test

Ankle dorsiflexion test

Axial compression

Burn's Bench test

Hoover's test

Repeat Pin point test

NEUROLOGICAL EXAMINATION

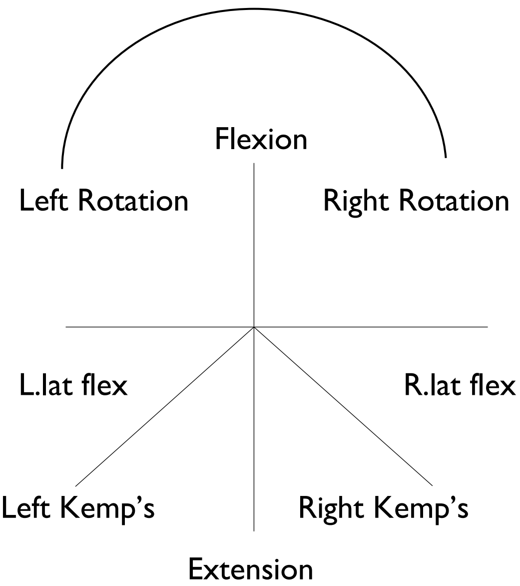
Fasciculations						
Plantar reflex						
level	**Tender?**	**Dermatomes**		**DTR**		
		L	**R**		**L**	**R**
T12				Patellar		
L1				Achilles		
L2						
L3				Proprioception		
L4						
L5						
S1						
S2						
S3						

MYOTOMES

Action	**Muscles**	**Levels**	**L**	**R**	
Lateral Flexion spine	Muscle QL				
Hip flexion	Psoas, Rectus femoris				5+ Full strength
Hip extension	Hamstring, glutes				4+ Weakness
Hip internal rotation	Glutmed, min, TFL, adductors				3+ Weak against grav
Hip external rotation	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,				
Knee extension	Quad				W - wasting
Ankle plantarflexion	Gastrocnemius, soleus				
Ankle dorsiflexion	Tibialis anterior				
Inversion	Tibialis anterior				
Eversion	Peroneus longus				
Great toe extensor	EHL				

BASIC THORACIC EXAM

Passive ROM



History :

Orthopedic assessment:

BASIC HIP EXAM

History

ROM: Active

Passive: Medial rotation: A) Supine (neutral) If reduced - hard \ soft end feel

B) Supine (hip flexed):

- Trochanteric bursa

MOTION PALPATION AND JOINT PLAY	**L**	**R**
Thoracic Spine		
Lumbar Spine		
Sacroiliac Joint		

APPENDIX I
Data Capture Sheet

Patient name: ....Date: ....File number: ....

Visit: .... Handicap: .... Group allocation: **1 / 2**

Core Assessment – Abdominal Draw-In Test
(Pressure Biofeedback Unit - PBU)

Able to initiate contraction: yes / no

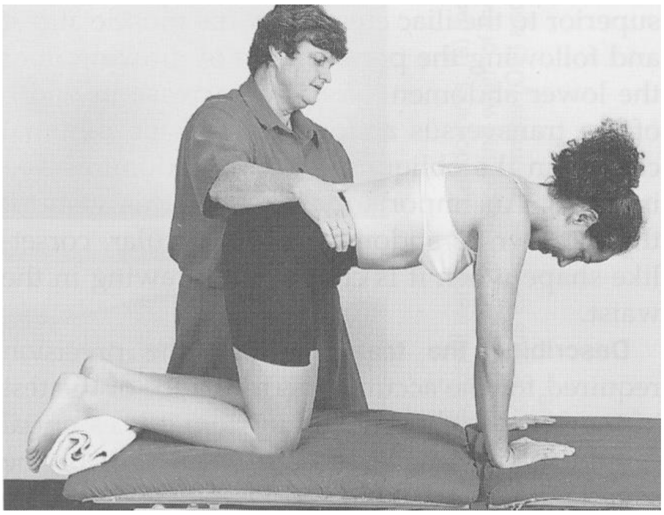
Duration of contraction : …………...

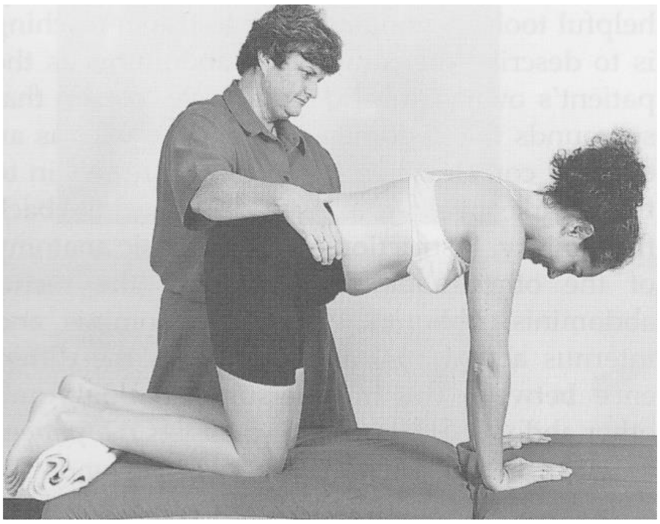
GC2 Foresight readings

Swing Number	1	2	3	4	5	Average
CHV pre-intervention						
Ball carry pre-intervention						
CHV post-intervention						
Ball carry post-intervention						

APPENDIX J

Four Point Kneeling – Procedure and Position





- The position assumed is such that the hips should be over the knees and the shoulders directly over the hands
- Abdomen should be relaxed and the spine should be in neutral position
- Avoid deep inspiration to prevent abdominal wall movement
- Take a relaxed breath in and out, and then without breathing in, slowly draw the abdomen up and in towards the spine.
- Once contraction has been performed, continue breathing slowly, whilst maintaining the contraction for 10 seconds.

(Richardson *et al,* 1999)