A comparison study between core stability and trunk extensor endurance training in the management of acute low back pain in field hockey players

by

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I, Lloyed Irwin Clarke, do declare that this dissertation is representative of my own work in both conception and execution.

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DEDICATION

It is with immense pleasure that I dedicate this dissertation to:
My parents: thank you for your continued sacrifice, support and encouragement. Your undying love has been my pillar of strength and inspiration and will continue to be my guiding light.

Thank you to Gail for your unwavering love and belief in me.

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The Lord, for his unconditional love and peace throughout my life.

ABSTRACT

Objectives: When we consider the body position of a field hockey player, the lumbar spine is always in a flexed position, which combined with rotational movements during various hitting and pushing techniques, increases the strain upon the spine and surrounding muscles, thus leading to low back pain. To determine the relationship between core strength and trunk extensor endurance relating to the incidence of acute low back pain in field hockey players.

Project Design: The research project was in the form of a quantitative cross-sectional study, using human subjects.

Setting: The research project occurred during the field hockey season (2008) with players who had acute low back pain. The players were clinically assessed and subdivided into necessary groups at the Chiropractic Day Clinic at the Durban Institute of Technology.

Subjects: Adult, male patients, aged between 18 and 30 years of age, playing premier field hockey. Out of the thirty players, 12 players have played in the National u/21 squad, 7 players have played in a Junior National team and 11 players have played senior provincial field hockey.

Outcome measure: This included three tests. Firstly, the absolute difference of pressure from the reference value of 70mmHg (prone) and 40mmHg (supine) was used as the outcome measure on a Pressure Biofeedback Unit and length of time (in seconds), a correct contraction of the core stability muscles was maintained. Secondly, the length of time (in seconds) for Trunk Extensor Endurance. Thirdly, repeated measures for NRS-101 and Quebec Back Pain Disability Scale for the duration of the research period.

Results: It was found that there was no statistical evidence or convincing trend to show that the training programmes (core stability and trunk extensor endurance) increased the subjects' core strength or trunk extensor endurance in the time allocated, although there seemed to be a placebo effect in the Trunk Extensor Group, which showed improvement in some of the core stability outcomes.

There was statistical evidence that the intervention (training programmes) reduced pain, according to the Quebec Back Pain Disability Scale (Quebec) score over time, and a non-significant trend suggested this according to the Numerical Rating Scale-101 (NRS). Since both groups' NRS and Quebec scores were not significantly different at baseline, the difference can be attributed to the effect of the intervention.

***Conclusions*:**

The results of this study found that the Trunk Extensor Endurance Group, that performed the trunk extensor endurance training programme, yielded better results in core stability and trunk extensor endurance. However, the Core Stability Group, that performed the core stability training programme, showed a quicker reduction in pain levels during the three week intervention period.

Therefore, by combining both training programmes, future rehabilitation of athletes suffering from acute low back pain will be more successful. Sport performance of the athletes (field hockey players), through the proponents of swiss ball training, will also improve.

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Chapter 1

Introduction

1.1 Introduction

Low back pain is one of the most common and costly musculo-skeletal pain syndromes, affecting up to 80% of people at some point during their lifetime. The re-occurrence rate of low back pain is high and these disorders often develop into a chronic fluctuating problem with intermittent flares. It has been stated that caring for chronic low back pain, is one of the most difficult and unrewarding problems in clinical medicine, as no approach to diagnose or any form of treatment, has been shown to be clearly definitive or effective. One possible explanation for the inability to identify effective treatment protocols is the lack of success in defining groups of patients who are most likely to respond to a specific treatment approach (Dankaerts et al, 2005). Estimates of lifetime incidences of low back pain range from 60-80% and although most low back pain episodes (80-90%) subside within 2-3 months, recurrence is common. The major concerns are the 5-10% of people who become disabled with a chronic back pain condition and who account for up to 75-90% of the increased burden on the health budget within the Western industrialized world (O'Sullivian, 2005).

According to Krismer and van Tulder (2007), acute low back pain occurs suddenly after a period of a minimum of six months without low back pain, and lasts for less than six weeks. For most patients with acute low back pain, the etiology is thought to be a mechanical cause involving the spine and surrounding structures. A wide range of terms is used for non-specific mechanical causes, including low back strain/sprain, facet joint syndrome, sacroiliac syndrome, segmental dysfunction, somatic dysfunction, ligamentous strain and myofascial strain. (Atlas and Richard, 2001).

A study by Cholewick and McGills (1992) suggests that biomechanics may be altered due to low back pain or injury to the spine, producing weakness and loss of muscle control, which leads to further injury because the joints are not appropriately supported. Again, this may result in over-compensation by the pelvis or lower extremities, which will increase the predisposition to chronic injuries. According to Hedrick (2000), well developed core stability allows for improved force output, increased neuromuscular efficiency and a decrease in the incidence of overuse injuries.

The normal function of the stabilization system is to provide sufficient stability to the spine to match instantaneous varying stability demands made by changes in spinal posture, static and dynamic load (Panjabi, 1992a). Hicks et al. (2005) suggest that core stability system has a role in ensuring spinal stability and according to van Dillin et al. (2001), a decrease in spinal stability places stress and excessive load on the spinal joints and tissues, which eventually results in low back pain. Richardson and Jull (1995) suggest that control of back pain and prevention of its occurrence can be assisted by enhancing muscle control of the spinal segment through core stability exercises. Therefore, exercise programmes, which are based on active rehabilitation, can reduce low back pain intensity, alleviate functional disability and improve core stability and back extension strength, mobility and endurance.

According to Liebensen (1997), endurance training of back extensor muscles, including the multifidus, has long been recognised as a crucial preventative of recurrent low back pain. The function and coordination of the muscles that stabilize the lumbar spine, especially the lumbar extensor muscles, are often impaired in patients with low back pain (Arokoski et al. 2004). Trunk extensor endurance training will prevent or delay fatigue, which can affect the ability of field hockey players to respond to the demands of an unexpected load: lunge combined with a reverse stick tackle. According to Chok et al. (1999), trunk muscle endurance training will elevate fatigue thresholds and improve performance, thus reducing disability.

Although athletes are in good general physical condition, one cannot assume that athletes have spent much time strengthening their own lower back, core and abdomen muscles. From studies conducted on field hockey players, Murtaugh (2001) reported that 59% of the sample of female field hockey players had low back pain during a season and Korporaal (2002), at the 6th All Africa Games; found that the most frequent injury reported was to the lower back (36.6%). In a study on Descriptive Epidemiology of Collegiate Women's Field Hockey Injuries, over a 15-year period, Dick et al. (2007) concluded that trunk/back was the second most commonly injured area that mainly occurred during practices. Execution of most field hockey ball handling skills requires a combination of spinal flexion and rotation; two movements known to increase the work load of back extensor muscles (Fenety and Kumar, 1992). According to Chok et al. (1999), there is evidence that suggests that muscle endurance is diminished in people with low back pain when compared with individuals without low back pain. Research conducted by Chok et al. (1999), found that endurance exercise is considered to expedite the recovery process for patients with acute low back pain.

The role of trunk stabilizers is to retain the musculature; to control, coordinate and optimize function; especially that of the spine when the field hockey player is hitting the ball, tackling or dribbling. Trunk fatigue, which occurs during intense training or matches, produces a loss in synchrony between upper and lower extremities, which may cause a reduction in muscle strength. This may in turn prevent a proper transfer of force resulting in inappropriate compensation by the body while performing a particular function, for example, incorrect posture while pushing the ball on the run (Cholewick and McGills 1992).

Dynamic trunk stability training, according to Hubley-Kozey and Vezina (2002), includes building muscle strength, endurance and using neuromuscular control to maintain dynamic trunk stability. A swiss ball exercise programme (trunk extensor endurance and core stability) will essentially challenge and encourage stability motor patterns for the primary stabilizing muscles. The stabilizing exercise programme focuses on encouraging repeated sub-maximal efforts to mimic the function of these muscles in the spine (Stanton and Reaburn, 2004). According to Akuthota and Nadler (2004), motor relearning of inhibited muscles may be more important than strengthening in patients with low back pain.

1.2 Aims and objectives

The purpose of this study is to ascertain the effect of core stability versus trunk extensor endurance training in the management of acute low back pain in field hockey players.

1.2.1 Objective 1

To assess the efficacy of core strength stability versus extensor endurance in the management of acute low back pain in field hockey players, in terms of subjective clinical findings (subjective pain perception: NRS 101 scale and Quebec Back Pain Disability Scale).

1.2.2 Objective 2

To assess efficacy of core strength stability versus extensor endurance in the management of acute low back pain in field hockey players, in terms of objective clinical findings (Stabilizer Biofeedback device and Extensor Endurance Test.)

1.3 Rationale for the study

Low back pain is common in field hockey players and athletic movements such as twisting, lunging, running in a bent over position and physical contact all create strenuous forces on the back, which are required during a match or practice sessions, which predispose to low back pain. If the back and trunk has not been trained to function optimally, this can lead to weakness and reduced movement capabilities. Over time, this can lead to impaired athletic performance, injury and pain (Hedrick, 2000). No research has been done to examine the effect of muscle training on symptomatic field hockey players. Trunk strength is critical because all movements either originate in, or are coupled, through the trunk, and a well developed core stability allows for improved force output, increased neuromuscular efficiency and a decrease in the incidence of overuse injuries (Hedrick ,2000).

By strengthening the core stability system and trunk extensor muscles, one enhances the ability to better utilize the musculature of the upper and lower body to perform certain tasks. This results in more efficient, accurate and powerful movements. This research aims to provide a form of management of acute low back pain that is cost effective and easily accessible for field hockey players: core stability and trunk extensor endurance programmes utilising a swiss ball (purchased at any retail store).

In the remaining chapters, the researcher will review the literature on acute LBP (Chapter 2); describe in detail the methodology of this study (Chapter 3) and present the statistics (Chapter 4); the results (Chapter 5) and the subsequent conclusions (Chapter 5). Thereafter, recommendations will be made for suggested improvements in the management of acute LBP.

Chapter 2

Literature Review

2.1 Introduction

This chapter reviews all the recent literature pertinent to this study and includes a description of the anatomy of the core and paraspinal muscles. It also discusses the relationship between core stability, field hockey and acute low back pain.

2.2 To what extent does low back pain impact on us today?

Krismer and van Tuldor, (2007) define lower back pain as pain between the twelfth rib and the inferior gluteal folds with or without leg pain. They also recommend fitness programs and advise to stay active, as this could possibly reduce pain, improve function and prevent low back pain from becoming chronic. Many people may not seek medical care for acute back pain because episodes are typically brief. For patients with acute lower back pain in primary care, 75% to 90% report improvement within one month (Atlas and Richard, 2001). Nonetheless, recent studies indicate that persistence of low-grade symptoms or recurrences are more common than previously recognized, with 25% to 50% of patients having additional episodes over the following year (Atlas and Richard, 2001).

2.3 Core Stability

The core has been described as a 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. Therefore, the core serves as a muscular corset that works as a unit to stabilize the body and spine (Akuthola and Nadler, 2004).

The ligamentous lumbar spine, without the influence of muscles, becomes unstable under very low levels of compressive loads. The intervertebral disc acts as the main load-bearing structure of the lumbar spine, designed to withstand vertical loading forces but it's vulnerable to shear and rotational forces. Therefore, the lumbar facet joints, which limit rotation and anterior shear forces, as well as the muscles that control the spine, protect the intervertebral disc from shear and rotational forces (O'Sullivan, 2005).
According to Panjabi (1992), there is a close relationship between the passive anatomical restraints of the lumbar spine and the muscles that control it.

According to Marshall and Murphy (2005), core stability is a generic description for the training of the abdominal and lumbopelvic region. To define core stability, the combination of a global and local stability system has been used. The global system refers to the larger superficial muscles around the abdominal and lumbar region; such as the rectus abdominus, paraspinal and external obliques. These muscles are the prime movers for trunk or hip flexion, extension or rotation. Unlike the local muscles, the global muscles are important for torque production and general trunk stability because they are not directly attached to the spine (Stevens et al. 2006).

Local stability refers to the deep intrinsic muscles of the abdominal wall, such as transverse abdominus, and mutlifidus. These muscles are associated with segmental stability of the lumbar spine during gross whole body movements (Marshall and Murphy, 2005). According to Stevens et al. (2006), local muscles of the trunk, such as transverse abdominus and multifidus, with their vertebra to vertebra attachments, are supposed to control the fine tuning of the positions of adjacent vertebra (segmental stabilization). Because of their connection through the thoraco-lumbar fascia, the transverse abdominus and the internal oblique, have direct attachment to the lumbar vertebra; thus, are considered to be local muscles. Combining these two concepts of local and global stability, it has been proposed that the alterations in the control of these muscles may lead to dysfunction of the deep/local muscle groups and consequently contribute to segmental spinal instability (Beith et al. 2001). According to O'Sullivan (2005), coordinated patterns of muscle recruitment are essential between the global and local muscle system of the trunk, in order to compensate for the changing demands of daily life, to ensure that the dynamic stability of the spine is preserved.

According to Lee and Vleeming (2003), there are significant neurophysiological differences in timing of contraction of these two muscle systems. When loads are predictable, the local system contracts prior to anticipation of the movement, regardless of the direction, whereas the global system contracts later and is direction dependent. Research is still lacking in classifying all muscles into the two different muscle systems and clinically it appears that parts of some muscles may belong to both systems.

The function of the local muscle system, according to Lee and Vleeming (2003), is to stabilize the joints of the spine and pelvic girdle in preparation or in response to external loads. This can be achieved through several mechanisms; increase in intra-abdominal pressure, increase in tension of the thoracodorsal fascia and increase in the articular stiffness. Research has shown that when the central nervous system can predict the timing of the load, the local system is anticipatory when functioning optimally. Therefore, these muscles work at low levels at all times and increase their action before any further loading or motion occurs. When the local muscle system is functioning optimally, it provides anticipatory intersegmental stiffness of the joints of the lumbar spine and pelvis. The external force, which Lee and Vleeming (2003) termed force closure, augments the form closure (shape of the joints) and helps prevent excessive shearing at the times of loading. This compression occurs prior to the onset of any movement and prepares the low back and pelvis for additional loading from the global system.

Lee and Vleeming (2003) state that a muscle contraction produces a force that spreads beyond the origin and insertion of the active muscle. This force is transmitted to other muscle tendons, fascia, ligaments, capsules and bones that lie both in series and parallel to the active muscle. Therefore, in this manner, forces are produced quite a distance from the origin of the initial muscle contraction.

These integrated muscle systems produce slings of forces that assist in the transfer of the load. The global muscle system is essentially an integrated sling system, composed of several muscles, which provides forces. Their hypothesis is that slings have no beginning or end, but rather connect to assist in the transference of forces. It is possible that the slings are all part of one interconnected myofascial system and a particular sling, which is identified during any motion, is merely due to the activation of a selective part of the whole sling. Three slings have been identified; anterior oblique slings, which contain connections between the external oblique muscle, the anterior abdominal fascia, the contra lateral internal oblique abdominal muscle and the adductor of the thigh; longitudinal sling connects the peroneii muscles, bicep femoris, sacrotuberous ligament, the deep lamina of the thoracodorsal fascia and the erector spinae; and the lateral sling contains the primary stabilizers of the hip joint (gluteas medius/minimus and tensor fascia latae and lateral stabilizers of the thoracopelvic region).

Stability and movement are critically dependent on the coordination of all these muscles surrounding the lumbar spine. Although recent research has advocated the importance of a few muscles, in particular transverse abdominus and multifidus, all core musculature are needed for optimal stabilization and performance (Akuthola and Nadler, 2004).

2.3.1 Anatomy

The attachments, actions and innervations of the three main deep core muscles are as follows:

Transversus Abdominus

The transversus abdominis, as in **figure 2.1**, is the innermost flat muscle of the anterolateral abdominal wall. Its fibres, except for the most inferior ones, run horizontally.

Its origin is the internal surfaces of the seventh to twelfth costal cartilages, thoracolumbar fascia, iliac crest and the lateral third of the inguinal ligament.

The insertion is at the linea alba with the aponeurosis of the internal oblique, pubic crest and pectin pubis via the conjoint tendon.

The function of this muscle is to compress and support the abdominal viscera.

It is innervated by the ventral rami of the inferior six thoracic nerves and the first lumbar nerve (Moore and Agur, 1995: 82, 83).

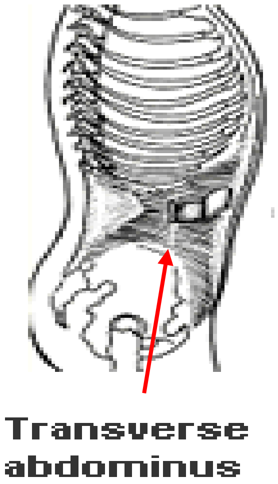

Figure 2.1 Above is a diagram showing the orientation of the transverse abdominus muscle.

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Internal Oblique

The internal oblique, as seen in **Figure 2.2,** is the intermediate flat muscle, the fibres of which run at right angles to the external oblique.

The origin of this muscle is at the thoracolumbar fascia, the anterior two-thirds of the iliac crest and the lateral half of the inguinal ligament.

The insertion of the internal oblique is at the inferior borders of the tenth to twelfth ribs, the linea alba and the pubis via the conjoint tendon.

The action of the internal oblique is to compress and support the abdominal viscera, as well as to flex and rotate the trunk.

The innervation is supplied by the ventral rami of the inferior six thoracic nerves and the first lumbar nerve (Moore and Agur, 1995: 82, 83).

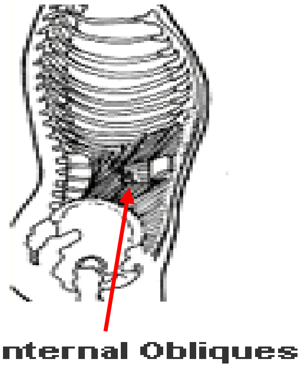

Figure 2.2 Above is a diagram showing the orientation of the internal oblique muscle http://www.performbetter.com/catalog/matriarch/OnePiecePage.asp_Q_PageID_E_56_A_PageName_E_ArticleStabilityBalls2

Lumbar Multifidus

The lumbar multifidus is seen in **Figure 2.3**. It is the most medial of the lumbar muscles and has unique vertebra-to-vertebra attachments between the lumbar and sacral vertebrae. This muscle has five separate bands, each consisting of a series of fascicles that stem from spinous processes and laminae of the lumbar vertebrae. Each lumbar vertebra gives rise to one group of fascicles, which overlap those of the other levels. The fascicles from a given spinous process insert into mamillary processes of the lumbar or sacral vertebrae three, four or five levels inferiorly. The longest fascicles, from

L1, L2 and L3, have some attachments to the posterior superior iliac spine (Richardson et al. 1999: 22).

The multifidus is innervated by the dorsal rami of spinal nerves.

Its functions are to stabilize vertebrae during local movements of the vertebral column (Moore and Agur, 1995: 206).

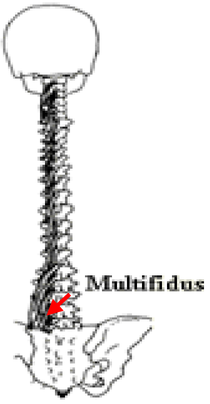

Figure 2.3 Above is a diagram showing the multifidus muscle.
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The attachments, actions and innervations of posterior global core muscles are as follows:

Erector Spinae

The erector spinae lies in a trough on either side of the spinous processes, forming a prominent bulge on either side of the median plane. This muscle arises from a broad tendon from the posterior aspect of the iliac crest, the posterior aspect of the sacrum, the sacral and inferior lumbar spinous processes and the supraspinous ligament.

Iliocostalis lumborum.

The fibres of the iliocostalis lumborum, seen in **Figure 2.4**, run superiorly and attach at the angles of the lower ribs.

Bilateral contraction of this muscle results in extension of the lumbar spine. Unilateral contraction of this muscle results in lateral flexion of the lumbar spine.

Innervation is supplied by the dorsal rami of the spinal nerves (Moore and Agur, 1993: 205, 206).

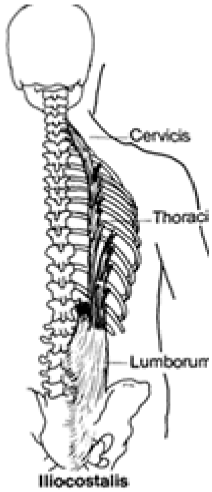

Figure 2.4 Above is a labelled diagram of erector spinae paying special attention to the iliocostalis lumborum muscle.

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The erector spinae in the lumbar region are composed of two major muscles, longissimus and illiocostalis. These are actually primary thoracic muscles that act on the lumbar spine via a long tendon that attaches to the pelvis. This long movement arm is ideal for lumbar spine extension and for creating posterior shear with lumbar flexion (Akuthota and Nadler, 2004)

Longissimus Thoracis

The longissimus thoracis seen in **figure 2.5** originates at the lumbar transverse processes and to the anterior layer of the lumbocostal aponeurosis. Gradually, it blends with the iliocostalis and spinalis muscles.

Insertion is primarily to the transverse processes of the entire thoracic vertebra and to the adjacent first to ninth or tenth ribs.

The principal action of this muscle is lateral flexion and rotation the same side. Together with the iliocostalis and longissimus muscles acting bilaterally, extend the spine.

The innervation of the muscle is supplied by the dorsal primary division of the lateral branch of the spinal nerve. (Moore, 1992: 353)

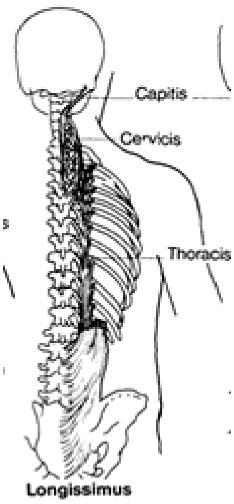

Figure 2.5 Above is a labelled diagram of erector spinae paying special attention to the longissimus thoracis muscle.

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Spinalis

The spinalis thoracis, as in **figure 2.5**, originates at the lumbar spinous processes and to the supraspinous ligament.

Insertion is at the spinous processes in the upper thoracic region as the fibres run superiorly.

The principal action of this muscle is lateral flexion of the same side. Acting bilaterally,it extends the vertebral column. As the back flexes, movement is controlled by gradually lengthening its fibres.

The innervation of the muscle is supplied by the posterior rami of spinal nerves (Moore and Dalley, 2006: 538).

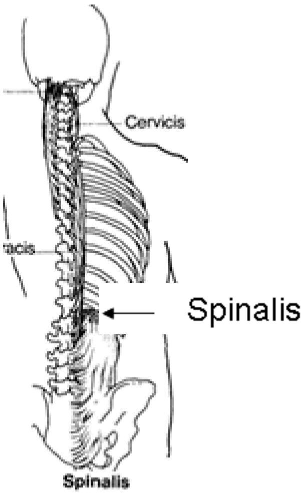

Figure 2.6 The spinalis muscle is displayed in the figure above.
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Muscle forces act to maintain and stabilize the arch-like structure of the lumbar spine. The activation of the erector spinae and psoas major increases the compressive load to the spine when active, which enhances the segmental stiffness and stability of the spine. The segmental stabilizing role of the lumbar multifidus, with separate segmental innervation, ensures control of individual vertebral segments and aids in maintaining lumbar lordosis. Lumbar multifidus also provides spinal proprioception, which is critical for the safe functioning of the lumbar spine. The transverse abdominal wall muscles (transverse abdominis and the transverse fibres of the internal oblique) apply some compressive force to the spine and pelvis and are primarily active in providing rotational and lateral stability to the spine via the thoracolumbar fascia, while maintaining levels of intra-abdominal pressure. The intra-abdominal pressure mechanism is mainly controlled by the diaphragm, transverse abdominis and the pelvic diaphragm, which also provides a stabilizing role to the lumbar spine (O'Sullivian, 2005).

According to O'Sullivian (2005), low levels of spinal loading, as in static postures and dynamic movements - the local muscle system, such as the transverse abdominis and lumbar multifidus - display tonic muscle activation. This occurs throughout all ranges of motion, suggesting the stabilizing function of the muscles. The global muscle system displays activity consistent with torque production and movement initiation; therefore, its function is more direction specific.

2.3.2 The role of core stabilization

The spinal stabilization system is conceptualized as consisting of three subsystems; passive muscular skeletal subsystem, which includes vertebra facet orientation, intervertebra disc, spinal ligament and joint capsules, as well as the passive mechanical properties of the muscles. The active muscular skeletal subsystem consists of muscles and tendons that surround the spinal column. The neural and feedback subsystem consists of various force and motion transducers located in ligaments, tendons, muscles and neural control centres. These passive, active and neural control subsystems - although conceptually separate - are functionally independent (Panjabi, 1992).

The passive subsystem does not provide any significant stability to the spine in the vicinity of the neutral position. It is towards the ends of the ranges of motion that the ligaments develop reactive forces that resist spinal motion.

The active subsystem is the means through which the spinal stabilization system generates forces and provides the required stability to the spine. The magnitude of the force generated in each muscle is measured by the force transducers (signal producing devices) located in the tendons of the muscles.

Therefore, this aspect of the tendons may be part of the neural control subsystem. Within the neutral zone of motion, (that part of the range of physiological intervertebral motion, measured from the normal position, within which the spinal motion is produced with a minimal internal resistance - it is the region of high flexibility around the mid-zone of motion) the restraints and control for bending, rotating and shear force are largely provided by the muscles that surround and act on the spinal segment. The neural subsystem receives information from the various transducers, determines specific requirements for spinal stability and causes the active subsystem to achieve the stability goal (Panjabi, 1992).

Panjabi (1992) states that the normal functioning of the stabilizing system is to provide sufficient stability to the spine to match the instantaneously varying stability demands due to changes in spinal posture, static and dynamic load. Thus, the three subsystems work together to achieve this goal.

Degradation of the spinal system may be due to injury, degeneration and or disease of any one of the subsystems. The neural control subsystem perceives the deficiencies which may develop suddenly or gradually, and attempts to compensate by initiating appropriate changes in the active subsystem, thus, leading to dysfunction and pain over time (Panjabi, 1992a). Panjabi (2003) also proposes that a contributing factor to the high proportion of ill-defined mechanical low back pain may be a degree of segmental instability of the lumbar spine. Clinical instability is defined by Panjabi (1992b) as a significant decrease in the capacity of the stabilizing system of the spine to maintain the intervertebral normal zones within the physiological limits, so that there is no neurological dysfunction, no major deformity and no incapacitating pain. The neutral zone is a small range of displacement around the segment’s normal position where little resistance is affected by passive spinal restraints. The subtle movement in this region may increase with injury, disc degeneration and weakness of the muscles (Panjabi, 1992b). According to Panjabi (1992a), spinal instability may be considered as one of the most important causes of low back pain and spinal instability may result in abnormally large intervertebral motions, which may cause either compression and/or stretching of the inflamed neural elements or abnormal deformations of the ligament, joint capsules, annular fibres, and end plates, which are known to have significant density of nociceptors. In both situations, the abnormally large intervertebral motions may produce pain sensation resulting in low back pain.

However, Lee and Vleeming (2003) presented a model that suggests joint mechanics can be influenced by multiple factors, some intrinsic to the joint(s) itself while others are produced by the muscle action which in turn is influenced by emotional state. Therefore, effective management of low back pain requires attention to all four components, with the main objective to guide the patient towards a healthier way to live, and for athletes, a more efficient way to move.

The Integrated Model of Function was developed by Lee and Vleeming (1998/2003) for managing impaired function. The Integrated Model of Function has four components:

Form closure - describes how the joint's structure, orientation and shape contribute to stability and potential mobility. All joints have a variable amount of form closure and the individual's inherent anatomy will dictate how much additional force is needed to ensure stabilization when loads are increased.

Force closure - describes the force produced by myofascial action (ligaments, muscle and fascia). If the articular surface of the lumbar spine and pelvic girdle were constant and completely compressed, mobility would not be possible. But, compression during loading is variable, therefore, motion is possible and stabilization is required. This is achieved by increased compression across the joint surface at the moment of loading (force closure). The amount of force closure required depends on the individual's form closure and the magnitude of the load.

Motor control - describes specific timing of muscle action or inaction during loading. Efficient movement requires coordinated muscle action, so that stability is ensured while motion is controlled and not restrained. Therefore, the coordinated action between local and global muscle systems ensures stability without rigidity of posture.

Emotions - emotional states can play a significant role in human function, including function of the neuromuscular and skeletal system. Emotional states (flight, fight, or freeze reactions) are physically expressed through muscle action and when sustained for a period, it will influence basic muscle tone and patterning; muscles of the pelvis become hypertonic, which will result in increased compression of the sacroiliac joints.

Stability of the lumbar spine can be described as a fishing rod, placed upright and vertical, with the butt on the ground. If the rod were to have a small load placed on its tip, it would soon bend and buckle. Take the same rod and attach guy wires at different levels along its length and attach their other ends to the ground in a circular pattern. Tighten each guy wire the same tension. Repeat the exercise, loading the tip of the rod and one will observe that the rod can now sustain huge compressive forces successfully. Next, reduce the tension in just one of the wires. The rod will now buckle at a reduced load (McGill et al. 2003). McGill et al (2003) demonstrated that a human lumbar spine, typically an osteoligamentous lumbar spine from a cadaver, will buckle under approximately 90 N (± 20 lbs of compressive load) - this is all that an unbuttressed spine can withstand. The first role of the muscle is to form guy wires to prevent buckling. The analogy demonstrates the critical role of the muscle to first ensure sufficient stability of the spine so that it is prepared to withstand loading, sustain postures and movement. The role of the motor control system is to ensure that the tension in the cables is proportional, so as to not create a focus point where buckling will occur. According to Panjabi (1999a), the large load carrying capacity is achieved by the participation of well-coordinated muscles surrounding the spinal column.

Spinal stability is increased with trunk flexor-extensor muscle co-activation, which increases intra-abdominal pressure and produces abdominal spring force (Arokoski et al.2004). According to Hicks et al. (2005), there is a unanimous agreement that all muscles play a role in ensuring spine stability and that the motor patterns of co-contraction between the full compliment of muscles, are of utmost importance to ensure stability and minimize pain.

According to Lee and Vleeming (2003), a number of studies have provided information that stability is achieved through motion and not rigidity. Small angular displacements of the vertebrae preceded limb movements and occurred contra-laterally (preparatory movement) to the predicted movement of the segment, which resulted in movement. Therefore, optimal stability requires mobility and a finely tuned motor control system. The clinical application supports exercise programmes which encourage mobile stability (movements with control) as opposed to rigidity and bracing.

2.4 Athletes and Low Back Pain

Low back injuries in athletes are among the most challenging and frustrating clinical situations for sports physicians to diagnose and treat. Low back injuries account for 10% to 15% of all athletic injuries and most frequently involve the soft tissue surrounding the spine, according to Green et al. (2001). According to Bukker et al. (2007), acute low back pain is a benign, self limiting disease, with a recovery rate of 80-90% within 6 weeks, irrespective of the treatment or management. Unfortunately, recurrence rates are reported as high as 50% in the following 12 months. Therefore, prevention might be more beneficial in the management of acute low back pain. There is no consensus with regard to a treatment regimen for low back injury in terms of the rest duration, the specific rehabilitation protocol, or the criteria for return of athletes to training and competition. Identification of the risk factors that predispose an athlete to sustain a low back injury would provide valuable assistance to the clinician in the selection of preventive or rehabilitative treatment strategies, given the lack of standard diagnostic tools.

Many of the etiologic factors associated with injury are mechanical in nature and result from sudden movements that impose sudden loading to the spine. A wide range of terms is used for non-specific mechanical causes, including low back pain/strain/sprain, lumbago, facet joint strain syndrome, sacroliliac syndrome, segmental dysfunction, somatic dysfunction, ligamentous strain and myofascial syndrome (Atlas and Deyo, 2001). The neuromuscular control system must respond to the external trunk loading with compensatory muscle forces necessary to mechanically stabilize the lumbar spine. Therefore, muscle control of lumbar spine stability is an important factor in determining trunk kinematic response to sudden loading and the subsequent likelihood of injury. However, because of the spine's multiple degrees of freedom, the motor control for stabilizing it is extremely complex. If the motor control of the lumbar spine is deficient or impaired, it may lead to low back injury, particularly under sudden loading conditions (Greene et al, 2001).

Deficiencies in motor control of the lumbar spine have been proposed as one of the possible mechanisms predisposing people to acute low back injury. Athletes, despite an apparent clinical recovery from an acute low back injury, exhibit prolonged trunk muscle response time when confronted with sudden loading, in comparison with athletes with no history of low back injury. A number of biomechanical, psychosocial, and demographic risk factors for sustaining an acute low back injury have been identified in the general population. Job dissatisfaction and a history of previous or current low back injury are among the best known risk factors. However, to the best of our knowledge, there are no similar prospective studies of athletes. If there are risk factors that predispose athletes to sustain a low back injury, the athlete is at risk of recurrent or chronic problems unless those risk factors are identified and the appropriate rehabilitation and preventive measures are taken (Greene et al. 2001).

A study on university athletes was conducted by Greene et al. (2001), where he used history of low back pain as a risk factor for recurrent back injuries. The results of the study were as follows: Athletes who had low back pain at the time of the survey were six times more likely to sustain a low back injury in the following season/year than athletes without a history of low back injury. A history of low back injury at any time within the last 5 years indicated a three times greater risk for sustaining a future low back injury. There was no difference in relative risks for these two factors between contact and non-contact sports. However, when a family history of low back pain or injury was evaluated independently of present low back pain, or a history of low back injury within the last 5 years; a two times greater risk was found between contact and non-contact sports.

The lower back is also a frequent site of injury in a variety of sports including gymnastics, football, weight lifting, rowing, golf, dance, tennis, baseball and basketball to name a few. The causes of low back pain in active people are diverse and the precise anatomic site of the lumbar injury and pain generation is often difficult. Primary care providers frequently diagnose lumbar strain or sprain and mechanical low back pain in patients, without clear neurological or complicating features. Repetitive movements common in sport can fatigue the supporting structures of the lumbar spine and overwhelm the viscoelastic protective mechanism of the lower back, such as the intervertebral disc and ligaments (Drezner et al. 2001).

If the sport requires jumping, sprinting or kicking; training often focuses on the lower body followed by the upper body - with trunk training performed at the end of the workout. The downside of this is that it does not allow for optimal strength development because without adequate core strength and stability, the athlete will not be able to apply extremity strength. Trunk strength is critical because all movements either originate in, or are coupled through, the trunk. This coupling action, created by a strong core, connects movements of the lower body to those of the upper body and vice versa. A well-developed core allows for improved output, increase in neuromuscular efficiency and a decrease incidence of overuse injuries (Hedrick, 2000).

A strong trunk is critical, because force is transmitted most efficiently through the body in a straight line. When the trunk is poorly developed, the result is poor posture, which can lead to less efficient movements. Such athletes will not be able to maximise their power potentials, often wasting energy through jerky uncoordinated and extraneous movements. Because they lack core strength to maintain proper body alignment, they are prime candidates for injury. Developing the trunk will greatly improve the efficiency and effectiveness of physical performance. Athletic movements such as twisting, jumping, running and physical contact create strenuous forces on the back. If the back has not been trained to function optimally, this can lead to weakness and reduced movement capabilities. Over time, this can lead to impaired athletic performance, cause injury and pain (Hedrick, 2000).

McGill et al. (2003) observed that there are aberrant motor patterns in low back pain patients, which would compromise the ability of the affected person to stabilize efficiently.

Given the high incidence of low back injuries, Vezina and Hubley-Kozey (2000), state that numerous treatment strategies have been proposed. Currently, the most common approaches involve strengthening the trunk and spinal musculature. The theory behind the use of spine stabilization exercises for the patient with spine dysfunction stresses the importance of patient education, trunk muscle strength, muscle control and muscle endurance. Focus has been on exercise to restore dynamic stability of the trunk because spinal instability has been linked to the development of low back dysfunction. Dynamic instability of the spine has been associated with insufficient strength and endurance of the trunk stabilizing muscles and inappropriate recruitment of the trunk and abdominal muscles (Vezina and Hubley-Kozey 2000). According to Chok et al. (1999), poor endurance of the trunk muscles may induce strain on the passive structures of the lumbar spine, eventually leading to low back pain. Evidence suggests that muscle endurance is lower for people with low back pain than for individuals without low back pain. Due to endurance being less in trunk muscles, fatigue can affect the ability of people with low back pain to respond to the demands of an unexpected load. Fatigue, after repetitive loading, also leads to loss of control and precision, which may predispose an individual to developing low back pain. Therefore, trunk muscle endurance training has been recommended to elevate fatigue threshold and improve performance, thus, reducing disability of the lumbar spine.

2.5 Management of acute low back pain

Most new episodes of low back pain are clinically attributed to a mechanical origin. Low back pain of a mechanical nature is due to abnormal short or prolonged stresses that could damage the articular or muscular components of the lumbar and pelvic regions. The high prevalence of low back pain and the functional disability related to it have resulted in the development of a large number of conservative treatment methods. Exercise prescription is one of the most popular approaches in the treatment of patients with non-complicated low back pain (Descarreaux et al. 2002).

Latest research, according to Liebenson (2004), tells us that exercise speeds up recovery and can even minimize the severity of future episodes of back pain. The best exercise for the back focuses on endurance rather than strength. Endurance training; the ability to produce work over time or the ability to sustain effort (Ito et al. (1996)); of the back extensors, including the multifidus, has long been recognized as a crucial prevention method of recurrent low back pain. Now it is also seen as a preventative measure to first time episodes as well (Liebenson, 1997). According to Descarreaux et al. (2002), short term specific exercise programmes seem to be more effective than classical exercises in reducing pain and disability level in a low back pain suffering population.

Several studies have examined the effects of exercise on recurrent rates of acute low back pain, and a number have reported positive results. In a study of 39 patients with acute back pain, there was a significant short and long term decrease in the number of recurrences of back pain in the group of subjects randomized into treatment, consisting of specific spine stabilization exercises, compared with the control group. People with acute, sub-acute or chronic low back pain, there is no evidence that suggests that exercise increases the risks of additional back pain episodes or work disability. To the contrary, current medical literature suggests that exercise has either a neutral effect or has a slightly potential beneficial effect on that risk.

According to Rainville et al. (2004), exercise is safe for individuals with back pain because it does not increase the risk of future back injuries or work absence.

The function and coordination of the muscles that stabilize the lumbar spine, especially the lumbar back extensor muscles, are often impaired in patients with low back pain. According to Arokoski et al. (2004), simple therapeutic exercises were effective in activating lumbar paraspinal and abdominal muscles in healthy volunteers. Therefore, dynamic stability exercises should improve the muscle responsiveness needed to stabilize the spine against perturbations associated with movement and activities of daily living, emphasising proper sequencing of activation, co-activating synergistic muscles, and restoring muscle strength and endurance to key trunk muscles (Vezina and Hubley-Kozey, 2000).

According to MacDonald et al. (2006), some authors advocate exercises, which activate the entire paraspinal muscle group, in order to control spinal motion. They propose the (purpose that the) effectiveness of these exercises is due to the increase in power of the trunk muscles; both segmentally and regionally. Increased tension in the thoracolumbar fascia, through multifidus hypertrophy, increases segmental compression and facilitation of co-contraction of the trunk flexors and extensors, to optimize control of buckling within the lumbar spine. Other authors suggest that rather than increase the strength or hypertrophy of the trunk muscles, the aim of therapeutic exercise in low back pain should be to enhance the function of the trunk muscles, which are thought to be preferentially suited to stabilizing the lumbar spine.

Stability ball exercises allow gentle resisted flexion and extension of the spine, which allows the multisegmental musculature to be fully engaged. Consequently, the development of these spinal muscles allows better postural control and greater efficiency in movement. According to Santana (1999), an individual with a functional spine will move better and be less likely to suffer an injury.

Symmetry of movement has also been identified in the literature as a very important aspect of spinal stabilization. Studies by Grabiner et al. (1992) have indicated that strength alone does not necessarily correlate with normal function. Patients with low back pain have consistently shown lack of symmetry in paraspinal contraction during trunk extension, according to Santana (1999). Many stability ball exercises require symmetrical contraction of the paraspinal for successful exercise execution. Asymmetrical contractions will cause the body to lose balance and roll off the stability ball. Thus, balancing on a stability ball may require asymmetrical contractions but they must be deliberate and controlled in order to maintain balance.

There is also a significant body of work demonstrating the importance of the local system musculature in providing trunk stabilization, particularly the transverse abdominals, multifidus and internal obliques. The works by Hodges, Richardson and others, describe the enormous loads on the spine during daily activities and the role the muscles of the local system play in stabilizing the spine during these activities. They conclude that abdominal training is the cornerstone of any core stabilization programme. This body of research advocates isometric dynamic and unstable training to develop the deep muscles of the local system involved in core stability.

The stability ball allows one to implement a variety of exercises that require isometric stabilization and the unstable nature also provides perturbation stimulus which has been shown to preferentially help recruit the deep local muscular system. Additionally, due to the stability ball's tendency to roll in any direction, it provides training stimuli in all three planes of motion (Santana, 1999).

Stabilization exercises, according to Stevens et al. (2006), are designed to improve function of the muscles that are believed to govern trunk stability and when these muscles are functioning optimally, they will protect the spine from trauma. According to Stanton and Reaburn (2004), the proponents of stability ball training enhances neuromuscular pathways, leading to greater strength, proprioception and balance. Rutherford and Jones (1986) suggest that adaptations from stability ball training will likely result in better coordination of synergistic and stabilizer muscles. Hicks et al. (2005), states that the goals of stabilization exercise are to train muscle motor patterns to increase spinal stability, restrain aberrant micromotion and reduce associated pain.

Within the athletic population, the rehabilitation of spinal injuries presents the clinician with a complex therapeutic challenge. Most of the athletes are not sufficiently injured from their injuries to prevent them from performing daily activities, yet, their athletic performance and enjoyment is significantly restricted. The ultimate goal for the clinician is to return the athlete safely to the repetitive demands of their sports, in a pain free state, as quickly as possible.

Chapter 3

Methodology

3.1 Introduction

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

- Study Design
- Method
- Inclusion Criteria
- Exclusion Criteria
- Assessment Protocol
- Assessment Instruments
- Data Collection
- Statistical Analysis

3.2 Study Design

From a quantitative clinical trial, the aim of the study is to determine the relationship between core strength and trunk extensor endurance relating to the incidence of acute low back pain in a specific population, i.e. field hockey players.

3.3 Method

3.3.1 Sampling Method

A non-probability convenience sampling technique was used. The study was limited to subjects residing in the KwaZulu-Natal province. The researcher spoke to the respective head coaches of the various premier league hockey clubs (University of KwaZulu-Natal Men's 1st Hockey Team , Durban North Men's 1st Hockey Team, DUT/Rovers Men's 1st Hockey Team and Pinetown

Men's 1st Hockey Team) and the players who have low back pain, who had then agreed to participate in the research study. A minimum sample group of thirty competitive hockey players who play in the premier league, provincial or national teams was required.

Recruitment of subjects involved direct personal approach by the researcher. The researcher contacted the head coaches of the respective premier league teams to arrange a meeting with each 1st team of the above mentioned clubs. Each subject was asked the following questions:

Name:	Club:
Age (18-30)	
Duration of play	
Highest achievement	
Playing position	
History of low back pain	
-cause	
-duration	
-area of pain	
-pain referral	
-treatment	

3.3.2 Sample Size

Two sample groups, of 15 participants each, were used (sample size of 30) during the 3 week intervention period. Subjects who met the requirements for the study, according to the inclusion and exclusion criteria, were assigned to a Group 1 or Group 2, using a computer generated randomized numbers table. The two groups continued to perform their normal physical training, which consisted of skill training (field hockey related) and running based conditioning - each performed twice a week. During this time, Group 1 (core stability) and Group 2 (trunk extensor endurance) performed additional physical training twice a week, on a swiss ball, at Queensmead Hockey Stadium.

Participants were evaluated at the initial consultation and diagnosed (as per inclusion criteria), at which point each participant received a letter of information and had to sign an informed consent form (Appendix A) explaining the study and allowing him to withdraw at any time from the study. At this consultation, a diagnosis was made based on a case history (Appendix B), NRS 101 scale (Appendix F), the Quebec Back Pain Disability Scale (Appendix G), physical examination (Appendix C), relevant lumbar spine regional examination (Appendix D) and SOAPE note (Appendix E) in order to establish whether they were eligible for this study and met the following inclusion and exclusion criteria:

3.4 Inclusion Criteria

1. Participants must be between the ages of 18-30 years, so as to avoid the need for parental/guardian consent (Giles, 1997) and these age limitations were used in this study, as this age group represents the majority of professional sports people. Athletes over 19 years of age and below 40 years (an athlete's prime) generally fall somewhat within this range (Hodges, 2002).
2. All participants are currently playing in the Men's KwaZulu-Natal Field Hockey Premier League.
3. All participants must have read the letter of information and signed an informed consent form, which outlines the benefits and potential risks of the testing procedures.
4. Participants will be assessed at the DUT Chiropractic Clinic through a case history, physical examination and lumbar spine regional examination for acute mechanical low back pain, which according to Krismer and van Tulder (2002), lasts for less than 6 weeks (low back strain/sprain, facet joint syndrome, sacroiliac syndrome, somatic dysfunction, ligamentous strain and myofascial strain).

3.5 Exclusion Criteria

1. Field hockey players who don't compete in the KwaZulu-Natal Field Hockey Premier League.

2. Field hockey players with a history of lumbar spinal surgery.

3. Field hockey players with cancer, rheumatoid arthritis, ankylosing spondylitis, disc herniation and neurological disease

4. Any field hockey player failing to sign the informed consent form will be excluded immediately from the study.

5. Females were excluded from this study due to morphological differences and, therefore, to minimize variation.

3.6 Assessment Protocol

1st Consultation	Group 1 (Core Stability)
1	Case history NRS 101 Quebec Back Pain Disability Scale Physical examination Lumbar spine regional examination SOAPE note
2	The patient will be educated on how to contract the transverse abdominal muscle by using the four point kneeling position test (Richardson et al. 1999).
3	The patient will perform an abdominal draw-in test with a biofeedback unit (Stabilizer Manual Chattanooga Group Inc., 4717 Adams Road, Hixson TN 37343, USA), which will be used to test the patient's transverse abdominal muscle strength. This would be the first reading.
4	The patient will partake in an extensor endurance test, a modification from the Biering-Sorensen test, which has been shown to be consistently reliable as a measure of back extensor endurance (Moreau et al. 2001). The patient lies prone with the lower body fixed to the test bed at the ankles, knees, and hips and the upper body extended in a cantilevered fashion over the edge of the test bench. The test bench surface will be approximately 75cm above the surface of the floor. The patient rests his upper body in a flexed position before the exertion. At the beginning of the exertion, the upper limbs are held across the chest with the hands resting on the opposite shoulders, and the upper body will then be lifted from a forward flexed position until the upper torso is horizontal to the floor. The patient is instructed to maintain the horizontal position for as long as possible. The endurance time will be manually recorded in seconds, with a stopwatch, from the time at which the patient assumed the horizontal position until the upper body moved into a forward flexed position. (McGill et al. 1999). The time is recorded.
5	The patient would then be introduced to a 3 week swiss ball exercise programme (Hedrick, 2000. Appendix H). Each patient will be provided with a swiss ball, sized so that when seated on the vertical apex of the ball, the thighs are slightly above horizontal.
6	Each patient will be provided with a training card (Appendix I) outlining the number of sets and repetitions of each exercise to be performed and detailed instruction for each exercise (Appendix H).
7	Training will be performed twice per week at the Queensmead Hockey Stadium, in the gymnasium, before a field hockey training session. Each swiss ball training session will take approximately 25 minutes to complete and will be supervised by the research student to ensure compliance and to maintain optimal exercise technique.

	2nd Consultation (after 3 weeks training programme)
1	Case history NRS 101 Quebec Back Pain Disability Scale Physical examination Lumbar spine regional examination SOAPE note
2	The patient will be re-educated on how to contract the transverse abdominal muscle by using the four point kneeling position test (Richardson et al. 1999).
3	The patient will perform an abdominal draw-in test with a Biofeedback Unit (Stabilizer Manual Chattanooga Group Inc., 4717 Adams Road, Hixson TN 37343, USA), which will be used to test the patient's transverse abdominal muscle strength. This would be the second reading.
4	The patient will partake in an extensor endurance test, a modification from the Biering-Sorensen test, which has been shown to be consistently reliable as a measure of back extensor endurance (Moreau et al. 2001). The patient lies prone with the lower body fixed to the test bed at the ankles, knees, and hips and the upper body extended in a cantilevered fashion over the edge of the test bench. The test bench surface will be approximately 75cm above the surface of the floor. The patient rests his upper body in a flexed position before the exertion. At the beginning of the exertion, the upper limbs are held across the chest with the hands resting on the opposite shoulders, and the upper body will then be lifted from a forward flexed position until the upper torso is horizontal to the floor. The patient is instructed to maintain the horizontal position for as long as possible. The endurance time will be manually recorded in seconds, with a stopwatch, from the time at which the patient assumed the horizontal position until the upper body moved into a forward flexed position. (McGill et al. 1999). The time recorded would be the second reading.

1st Consultation	**Group** 2 (Trunk Extensor Endurance)
1	Case history NRS 101 Quebec Back Pain Disability Scale Physical examination Lumbar spine regional examination SOAPE note
2	The patient will be educated on how to contract the transverse abdominal muscle by using the four point kneeling position test (Richardson et al. 1999).
3	The patient will perform an abdominal draw-in test with a biofeedback unit (Stabilizer Manual Chattanooga Group Inc., 4717 Adams Road, Hixson TN 37343, USA), which will be used to test the patient's transverse abdominal muscle strength. This would be the first reading.
4	The patient will partake in an extensor endurance test, a modification from the Biering-Sorensen test, which has been shown to be consistently reliable as a measure of back extensor endurance (Moreau et al. 2001). The patient lies prone with the lower body fixed to the test bed at the ankles, knees, and hips and the upper body extended in a cantilevered fashion over the edge of the test bench. The test bench surface will be approximately 75cm above the surface of the floor. The patient rests his upper body in a flexed position before the exertion. At the beginning of the exertion, the upper limbs are held across the chest with the hands resting on the opposite shoulders, and the upper body will then be lifted from a forward flexed position until the upper torso is horizontal to the floor. The patient is instructed to maintain the horizontal position for as long as possible. The endurance time will be manually recorded in seconds, with a stopwatch, from the time at which the patient assumed the horizontal position until the upper body moved into a forward flexed position. (McGill et al. 1999). The time would be recorded.
5	The patient will then be introduced to a 3 week trunk extension exercise programme (Chok et al. 1999. Appendix J). Each patient will be provided with a swiss ball, sized so that, when seated on the vertical apex of the ball, the thighs are slightly above horizontal.
6	The exercise has four levels: the first level consists of bilateral shoulder lifts in a prone position. The second level consists of contralateral arm and leg lifts in a prone position. The third level requires the patient to place both hands behind the head and perform bilateral shoulder lifts. The fourth level consists of bilateral shoulder lifts with arms fully elevated. The ease of coping with the exercise will be assessed using a categorical scale. The five grades of the scale are: 1 = "no sweat, could have done one more round", 2 = "just nice", 3 = "slightly strenuous, but coping okay", 4 = "can't continue anymore" and 5 = "just can't do it". The patient progresses to the next exercise if his response is within grades 1, 2 or 3. He is asked to stop if his response was graded 4 or 5 (Chok et al. 1999). A record will be kept by the researcher. The ease with which the

	exercise is performed will be assessed during and at the end of each exercise session. If the patient is able to perform the higher level exercise (grade 3), he will continue at that grade and discontinue the seemingly lower level exercise (grade 2). If the patient is unable to cope with the grade 3 exercise, he will continue the grade 1 exercise and slowly progress to the grade 2 exercise.
7	Each patient will be provided with a training card (Appendix J) outlining the number of sets and repetitions of each exercise to be performed and detailed instruction for each exercise (Appendix K).
8	Training will be performed twice per week at the Queensmead Hockey Stadium, in the gymnasium, before a field hockey training session. Each trunk extension swiss ball training session will take approximately 25 minutes to complete and will be supervised by the research student to ensure compliance and to maintain optimal exercise technique.

	2nd Consultation (after 3 week training programme)
1	Case history NRS 101 Quebec Back Pain Disability Scale Physical examination Lumbar spine regional examination SOAPE note
2	The patient will be educated on how to contract the transverse abdominal muscle by using the four point kneeling position test (Richardson et al. 1999).
3	The patient will perform an abdominal draw-in test with a biofeedback unit (Stabilizer Manual Chattanooga Group Inc., 4717 Adams Road, Hixson TN 37343, USA), which will be used to test the patient's transverse abdominal muscle strength. This would be the second reading.
4	The patient will partake in an extensor endurance test, a modification from the Biering-Sorensen test, which has been shown to be consistently reliable as a measure of back extensor endurance (Moreau et al. 2001). The patient lies prone with the lower body fixed to the test bed at the ankles, knees, and hips and the upper body extended in a cantilevered fashion over the edge of the test bench. The test bench surface will be approximately 75cm above the surface of the floor. The patient rests his upper body in a flexed position before the exertion. At the beginning of the exertion, the upper limbs are held across the chest with the hands resting on the opposite shoulders, and the upper body will then be lifted from a forward flexed position until the upper torso is horizontal to the floor. The patient is instructed to maintain the horizontal position for as long as possible. The endurance time will be manually recorded in seconds, with a stopwatch, from the time at which the patient assumed the horizontal position until the upper body moved into a forward flexed position. (McGill et al. 1999). The time is recorded would be the second reading.

During the 3 week intervention period, both Group 1 (swiss ball core strength training) and Group 2 (trunk extension endurance training) will continue to perform their normal physical training, which will consist of skills training related to field hockey and run based conditioning - each performed twice per week.

After the 3 week intervention period, both groups will undergo a second consultation mirroring the initial consultation. Data will be collected from the two consultations of the two groups and a comparison will be made of the two groups, thus, answering the objectives of the study.

3.7 Assessment Instruments

3.7.1 Subjective data will be obtained from the following:
The Numeric Rating Scale (NRS-101) has been widely used clinically for the assessment of pain (Jensen et al. 1986). According to Jenson et al. (1986), the utility and validity of the 11-point numerical rating scale yielded similar results in terms of the number of subjects who respond correctly to them and their predictive validity when compared to five other methods of measurement of clinical pain intensity. Therefore, the 11-point numerical rating scale can be considered to be a reliable measure of clinical pain intensity.

The Quebec Back Pain Disability Scale (Kopec et al. 1995) is a 20-item self-administered instrument, designed to assess the level of functional disability in individuals with low back pain. It adopts a generally accepted conceptual definition of disability as a restriction of ability to perform daily activities.

The scale contains 20 items and covers six empirically derived sub-domains of disability in back pain. All items contribute to the assessment of global disability and are relevant and acceptable to the patients. The items are scored 0 to 5 and the scale provides an overall disability score, ranging from 0 to 100, by simple summation of the scores for each item. The Quebec Pain Disability Scale can be recommended as an outcome measure in clinical trials, and for monitoring the progress of individual patients participating in treatment or rehabilitation programmes (Kopec et al. 1995).

3.7.2 Objective feedback will be obtained through the use of:
Endurance testing of the transverse abdominal muscle using the Stabilizer Biofeedback device. This would be done using the prone test for transverse abdomimus and internal oblique muscles. The supine position will be used to test the transverse abdominus muscle for endurance (Stabilizer Manual Chattanooga Group Inc.,4717 Adams Road,Hixson TN 37343, USA).

Instruments

An objective measurement was obtained utilizing the Pressure Biofeedback unit (PBU). It is very simple to operate and the visual feedback optimizes muscle control in the patient and understanding of the principles of attaining neutral alignment. The device itself registers changing pressure in an air filled pressure cell. This allows body movement, especially spinal movement, to be detected during exercise. The unit consists of a combined gauge/inflation bulb connected to a pressure cell (Chattanooga Group, A Division of Encore Medical, 2002).
A stopwatch was used to measure the maximal contraction time (s) of Transverse Abdominus muscle (TA).

This research tested the time that TA can maintain a suitable contraction within the correct pressure range, without allowing the patients to compensate or “cheat”. Richardson et al. (1999) developed an abdominal drawing-in test for effective assessment of TA using pressure biofeedback unit (PBU). Their findings are supported by Evans and Oldreive (2000), and Jull et al. (1995), therefore, this test was used to investigate the endurance of TA in this study. This is a simple non-invasive method of assessment and provides an objective clinical measure of TA activity.

In accordance with Richardson et al. (1999), before formal testing began, subjects were taught how to recruit transversus abdominus in a four-point kneeling posiotion. This position provides a facilitated stretch to the deep abdominals resulting from the forward drift of the abdominal contents. This stretch leads to an inhibitory effect on the superficial muscles, particularly rectus abdominis (Richardson and Jull 1995).

When the recruitment of the transversus abdominus muscle was established, the patient was then instructed to lie prone on a chiropractic table with his head turned to one side. The Stabilizer Biofeedback Device was placed under his abdomen, with the centre at the navel and the distal edge at the anterior superior iliac spine (ASIS). The Device was then inflated to the baseline pressure of 70 mmHg.

The patient was then examined as to whether he was able to initiate transversus abdominus activation in this prone position. A drop in pressure of 6-8 mmHg was seen with a correct contraction.
This test was performed at the initial consultation. If the patient could not do this; he was retrained in the four-point kneeling and prone positions to perform this activation satisfactorily, prior to taking the quantitative time-based readings.

The prone test for transverse abdominus and internal oblique muscles:

- Place the three chamber pressure cell under the abdomen and inflate it to a baseline of 70mmHg.
- Draw the abdominal wall to the spine and up towards the chest without moving the spine or pelvis.
- Measure the time in seconds from contraction until the patient can no longer keep the contraction.
- Measure the difference in mmHg over a set period of time and check for fluctuations (Richardson and Jull, 1995).

Supine position for the transverse abdominus muscle:

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- Place the three chamber pressure cell under the lumbar spine and inflate it to a baseline of 40mmHg.
- Draw the abdominal wall to the spine and up towards the chest without moving the spine or pelvis.
- The pressure should remain at 40 mmHg, i.e. no spinal movement.

- Measure the time in seconds from contraction until the patient can no longer keep the contraction.
- Measure the difference in mmHg over a set period of time and check for fluctuations (Richardson and Jull, 1995).

Throughout testing, the same pressure biofeedback unit was used to remove any intra-rater reliability issues as a consequence of using two different units. A drop in pressure of 6-8 mmHg was seen with a correct contraction and a cycling of +/- 2 mmHg was normal during breathing, but a gradual or sudden rise in pressure indicated fatigue (Evans and Oldreive 2000). The researcher monitored the subject's contraction closely for any substitution or compensation mechanisms, including breath holding, rib elevation, movements of the pelvis or spine and abdominal bracing using the oblique muscles.

The extensor endurance test.

This is a modification from the Biering-Sorensen test, which has been shown to be consistently reliable as a measure of back extensor endurance (Moreau, et al. 2001). The patient lies prone with the lower body fixed to the test bed at the ankles, knees, and hips and the upper body extended in a cantilevered fashion over the edge of the test bench. The test bench surface will be approximately 75cm above the surface of the floor. The patient rests his upper body in a flexed position before the exertion. At the beginning of the exertion, the upper limbs are held across the chest with the hands resting on the opposite shoulders, and the upper body is lifted from a forward flexed position until the upper torso is horizontal to the floor. The patient is instructed to maintain the horizontal position as long as possible. The endurance time will be manually recorded in seconds, with a stopwatch, from the point at which the patient assumes the horizontal position until the upper body moves into a forward flexed position. (McGill et al. 1999).

3.8 Data Collection

3.8.1 Frequency

Data collection took place on the day of the assessment. After the 3 week intervention period, both groups had undergone a second consultation mirroring the initial consultation. Data was collected from the two consultations of the two groups and a comparison was made of the two groups, thus, answering the objectives of the study.

3.9 Statistical Analysis

Statistical analysis was completed under the guidance of a statistician from the University of KwaZulu-Natal Medical School. The subjective data was obtained using the Numerical Pain Rating Scale (Appendix F) and the Quebec Back Pain and Disability Scale (Appendix G). The objective data was obtained using the Stabilizer Biofeedback Device.

SPSS version 15.0 (SPSS Inc., Chicago, Illinois, USA) was used for analysis of data. A p value <0.05 was considered as statistically significant.

Demographics and baseline outcome measures were compared between the treatment groups to ensure complete randomization had taken place. This was achieved using the researcher's independent t-tests for normally distributed quantitative variables.

Repeated measures ANOVA testing was used to compare the effect of the intervention on pain and core strength outcomes over time between the groups. A statistically significant time by group interaction effect indicated a significant intervention effect. Profile plots were generated to compare the trends visually by group over time. This was done for each outcome measure separately. In the case of pressure in prone and supine positions, the absolute value of the difference between each participant's pressure value and the reference value (70mmHg for prone and 40mmHg for supine) was used as the outcome measure.

CHAPTER 4

STATISTICAL METHODS AND RESULTS

4.1 Introduction

The statistical findings and results obtained from the data will be discussed in this chapter.

Demographic data consisting of height, weight, age, playing position and the playing duration were analyzed. Objective and subjective findings were also analyzed, and the correlation between findings evaluated.

SPSS version 15.0 (SPSS Inc., Chicago, Illinois, USA) was used for analysis of data. A p value <0.05 was considered as statistically significant.

Demographics and baseline outcome measures were compared between the treatment groups to ensure complete randomization had taken place. This was achieved using the researcher's independent t-tests for normally distributed quantitative variables.

Repeated measures ANOVA testing was used to compare the effect of the intervention on pain and core strength outcomes over time between the groups. A statistically significant time by group interaction effect indicated a significant intervention effect. Profile plots were generated to compare the trends visually by group over time. This was done for each outcome measure separately. In the case of pressure in prone and supine positions, the absolute value of the difference between each participant's pressure value and the reference value (70 for prone and 40 for supine) was used as the outcome measure.

4.2 Demographics

4.2.1 Height, Weight and Age

Thirty male participants partook in the study. Their mean age was 22.5 years (range 18-30 years), mean height 179.2cm and mean weight was 75.6 kg (**Table 4.1**). They were mostly all white, except for one black participant. **Table 4.2** shows that the majority were students (60%).

Table 4.1: Descriptive statistics for age, weight and height in study participants (n=30)

		Age	Height (cm)	Weight (kg)
N	Valid	30	30	30
	Missing	0	0	0
Mean		22.53	179.23	75.76
Std. Deviation		3.104	5.917	7.573
Minimum		18	168	60
Maximum		30	189	93

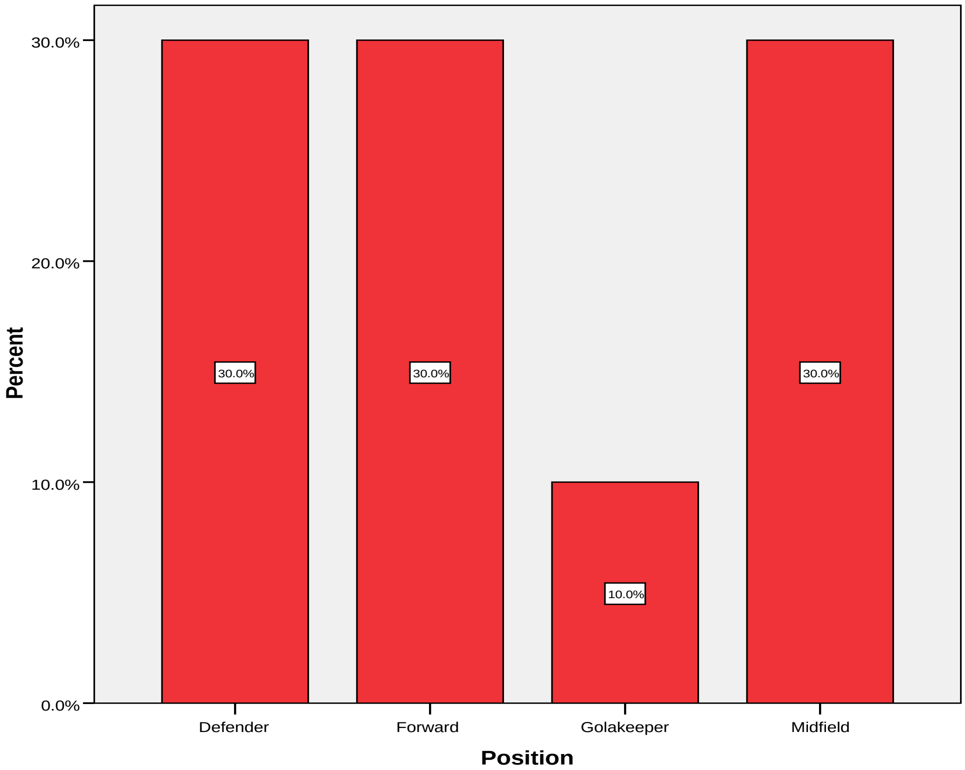
<u>Table 4,2: Occupations of study participants (n=30)</u>

	Frequency	Percent
Architecture Draughtsman	1	3.3
Auditor	1	3.3
Group Training Instructor	1	3.3
Media/PR	1	3.3
Pastor	1	3.3
Property Manager	1	3.3
Sales	1	3.3
Sales Rep	2	6.7
Student	18	60.0
Teacher	3	10.0
Total	30	100.0

From the above information, it is evident that the groups were homogenous, which adds strength to the findings of this study, although the sample size is small. In **Table 4.2**, the majority of the participants were students, allowing them more flexible time to train during the day and not only after hours. The students showed slightly less improvement compared to the other participants, which may possibly be due to better conditioning of the student field hockey players.

4.2.2 Playing Position

Figure 4.1 shows that there were 9 forwards, defenders and mid-field players in the study and 3 goal keepers.



<u>Figure 4.1: Position played by study participants (n=30)</u>

As seen above, a spectrum of playing position was included in this study, which allowed for a cross-sectional evaluation of core muscle endurance and trunk extensor endurance for various playing positions within field hockey.

4.2.3 Clubs

Table 4.3 shows that the majority of participants played for UKZN, followed by Pinetown, Rovers/DUT and Durban North.

Table 4.3: Clubs that the study participants played for

	Frequency	Percent
Dbn North	4	13.3
Pinetown	9	30.0
Rovers/DUT	5	16.7
UKZN	12	40.0
Total	30	100.0

4.3 Low Back Pain

Arokoski et al. (1999), has proposed that paraspinal and abdominal muscles have the greatest capacity for enhancing the stabilization of the spine, as well as having an important role in pain modulation and prevention. A study conducted by Biering-Sorensen (1984) on physical measurements as risk indicators for low back pain over a one year period, found a trend that participants with weaker trunk muscles more often experienced recurrence of low back pain compared with those with stronger trunk muscles. As stated in chapter 2, the dysfunction of the prime core stabilizer -Transverse Abdominus is linked to lower back pain (Hodges et al. 1996), consequently, it is expected that the participants with the back pain would have "weaker" core musculature.

4.3.1 Comparison of demographics and baseline values between the treatment groups.

The participants were randomized into 2 equal groups of 15 each. The completeness of the randomization process was checked by comparing demographics and baseline values between the two groups. Ideally they should be equivalent to ensure that any differences found after the intervention were not due to baseline differences.

Table 4.4: Comparison of age, weight and height between treatment groups

	Treatment group	N	Mean	Std. Deviation	Std. Error Mean	p value
Age	Core Stability	15	22.07	3.195	.825	0.420
	Trunk Extensor Endurance	15	23.00	3.047	.787	
Height (cm)	Core Stability	15	179.67	4.483	1.157	0.696
	Trunk Extensor Endurance	15	178.80	7.213	1.862	
Weight (kg)	Core Stability	15	76.27	7.851	2.027	0.719
	Trunk Extensor Endurance	15	75.25	7.523	1.942	

Table 4.4 shows that there were no significant differences between the two treatment groups in terms of age, weight and height of participants. Neither was there a significant difference in playing duration between the groups (**Table 4.5**).

Table 4.5: Comparison of playing duration between treatment group

	Treatment group	N	Mean	Std. Deviation	Std. Error Mean	p value
Playing Duration (yrs)	Core Stability	15	12.73	3.674	.949	0.165
	Trunk Extensor Endurance	15	14.67	3.754	.969	

Table 4.6 shows that there were no significant differences between the treatment groups in terms of the baseline outcome measurements. This

confirms that the groups were equivalent prior to the intervention. Thus, any changes found after the intervention could be attributed to the effect of the intervention.

Table 4.6: Comparison of baseline outcomes between treatment group

	Treatment group	N	Mean	Std. Deviation	Std. Error Mean	p value
NRS-101 (1)	Core Stability	15	4.27	.961	.248	0.631
	Trunk Extensor Endurance	15	4.00	1.890	.488	
Quebec (1)	Core Stability	15	6.80	6.405	1.654	0.364
	Trunk Extensor Endurance	15	4.60	6.642	1.715	
Difference in prone mmHg	Core Stability	15	6.1333	3.56304	.91997	0.431
	Trunk Extensor Endurance	15	4.9333	4.58984	1.18509	
Time prone	Core Stability	15	36.049	16.1116	4.1600	0.121
	Trunk Extensor Endurance	15	28.449	8.9429	2.3091	
Difference in supine mmHg	Core Stability	15	5.4000	4.01426	1.03648	0.320
	Trunk Extensor Endurance	15	3.9333	3.91821	1.01168	
Time supine	Core Stability	15	61.30	49.437	12.765	0.658
	Trunk Extensor Endurance	15	53.88	41.061	10.602	
Trunk Extensor Endurance 1 (sec)	Core Stability	15	61.11	21.326	5.506	0.406
	Trunk Extensor Endurance	15	55.14	17.151	4.428	

4.4 To assess the impact of core stability program on the measurements of core stability

4.4.1 Difference in pressure (prone)

The absolute difference of the pressure, from the reference value of 70, was used as the outcome measure at both time (assessment) points. Thus, the lower the value (closest to 0), the better the outcome. Both groups showed a slight decrease over time but the time effect was not significant (p=0.459) and neither was the difference in rate of change over time (p=0.934), thus, for this outcome the intervention had no significant effect.

Table 4.7: Between and within-subjects effects for difference in pressure (prone)

Effect	Statistic	p value
Time	Wilk's lambda=0.980	0.459
Time*group	Wilk's lambda=1.00	0.934
Group	F=0.793	0.381

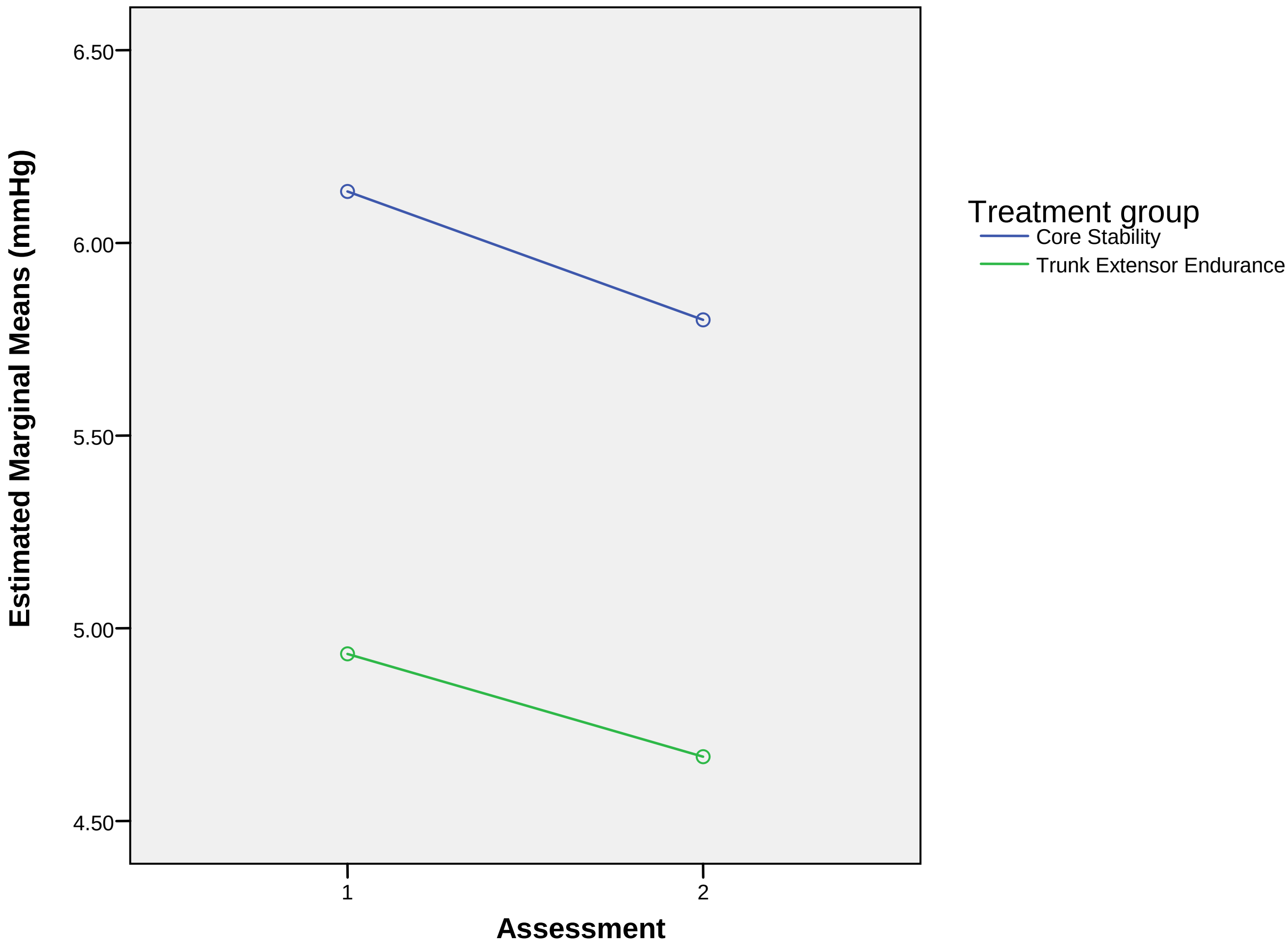


Figure 4.2: Profile plot of mean difference in pressure (prone) over time by group

Remarks:

During the core stability training programme the transversus abdominus and multifidus muscles were "trained", which taught the participants kinaesthetic awareness to maintain a stable spine posture within the functional range during the specified exercise(s) (Rainville et al. 2004). Therefore, the co-contraction phase of the Transversus and Multifidus muscles were more efficient, hence the better mean difference in pressure (prone) for the second assessment. A possibility for the Trunk Extensor Endurance Group having a lower mean difference in pressure (prone) could be due to the trunk extensor endurance training programme, that not only focused on strengthening the trunk extensor muscle endurance, but also created a kinaesthetic awareness to maintain a stable spine during the exercise(s), thereby activating core musculature; mainly transverse abdominus and multifidus muscles.

4.4.2 Time (prone)

Although both groups showed a statistically significant increase in time (p<0.001), there was no difference between the groups in terms of the rate of change over time, thus, no evidence of an intervention effect (p=0.207). **Figure 4.3** suggests that the Trunk Extensor Endurance Group may have increased at a slightly faster rate than the Core Stability Group.

<u>Table 4.8: Between and within-subjects effects for time (prone)</u>

Effect	Statistic	p value
Time	Wilk's lambda=0.428	<0.001
Time*group	Wilk's lambda=0.944	0.207
Group	F=0.087	0.770

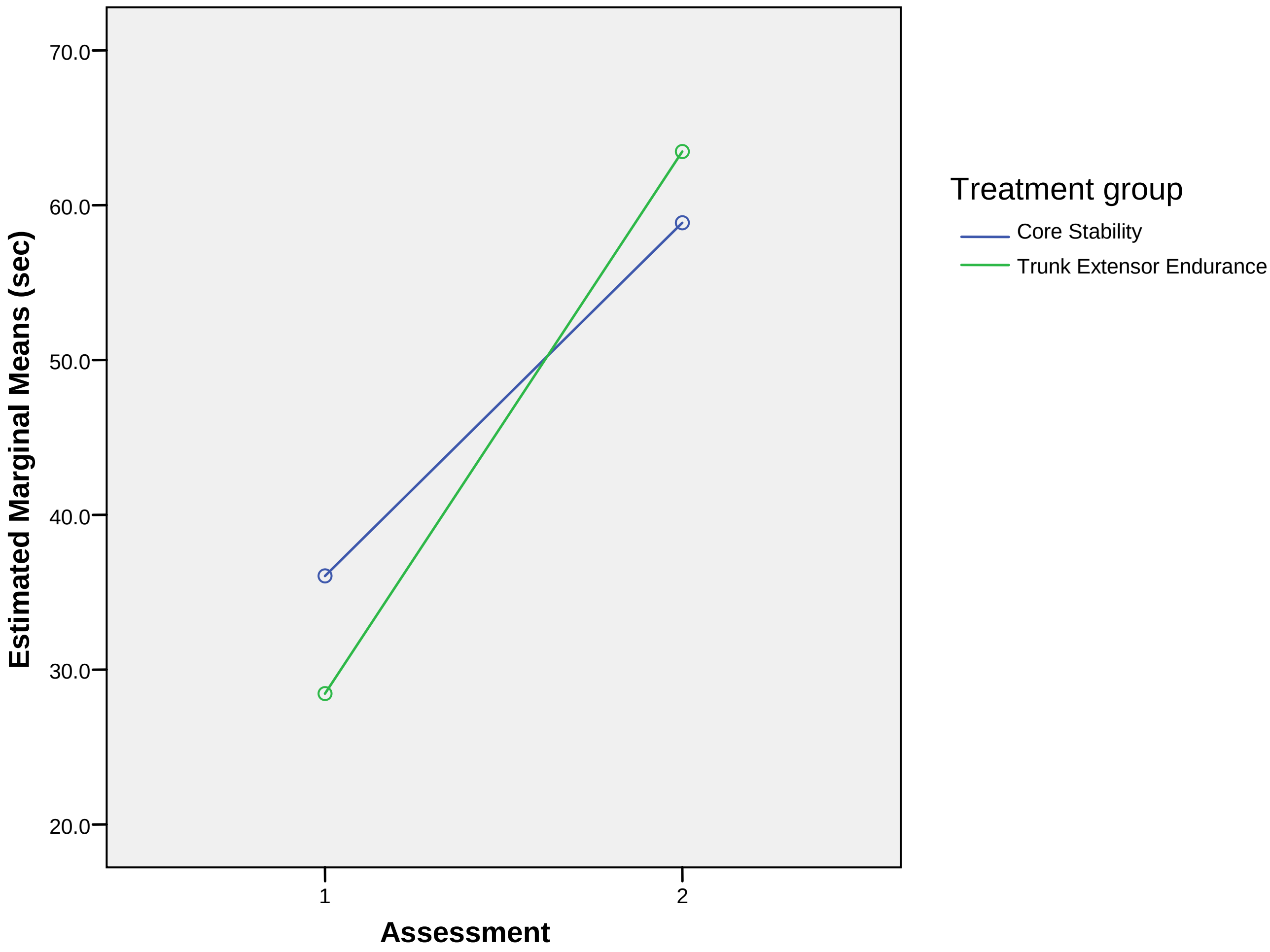


Figure 4.3: Profile plot of mean time (prone) over time by group

Remarks:

The result implies that the field hockey players' global muscles have been trained for endurance purposes by virtue of playing position (forward flexion), and combined with the specific trunk extensor endurance training programme, there could be a greater reflection of endurance of compensating global muscles rather than the local muscle endurance.

4.4.3 Difference in pressure (supine)

There was no evidence of an intervention effect for this outcome (p=0.747), indicating that the rate of change over time was constant in both groups. This is shown in **Figure 4.4** where there was very little change in this outcome in both groups.

Table 4.9: Between and within-subjects effects for difference in pressure (supine)

Effect	Statistic	p value
Time	Wilk's lambda=0.996	0.747
Time*group	Wilk's lambda=0.996	0.747
Group	F=1.739	0.198

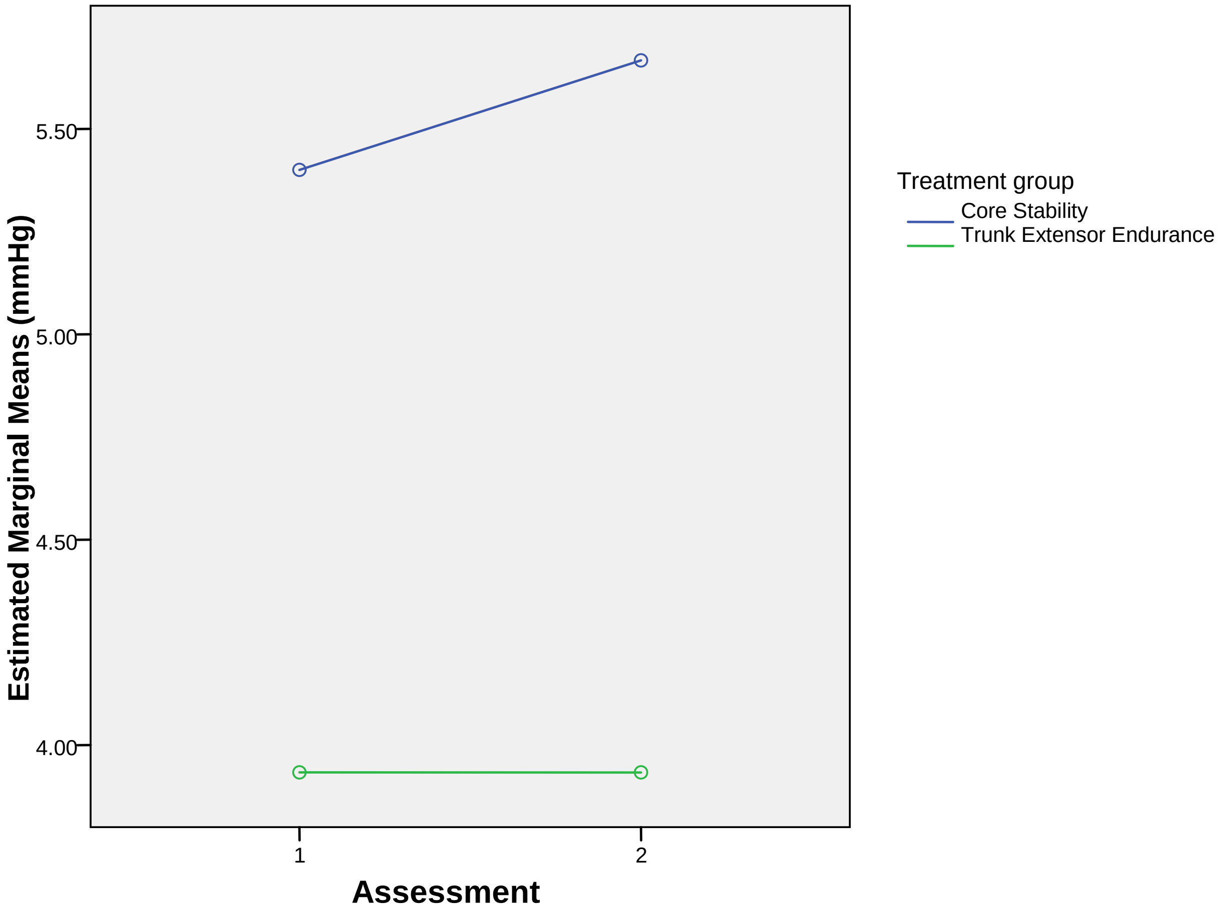


Figure 4.4: Profile plot of difference in pressure (supine) over time by group

4.4.4 Time (supine)

Both groups were able to increase their time in the supine position significantly (p<0.001), but there was no difference between the groups in terms of this increase (p=0.549). Therefore, the intervention had no effect for this outcome (**Figure 4.5**).

Table 4.10: Between and within-subjects effects for time (supine)

Effect	Statistic	p value
Time	Wilk's lambda=0.345	<0.001
Time*group	Wilk's lambda=0.987	0.549
Group	F=0.351	0.558

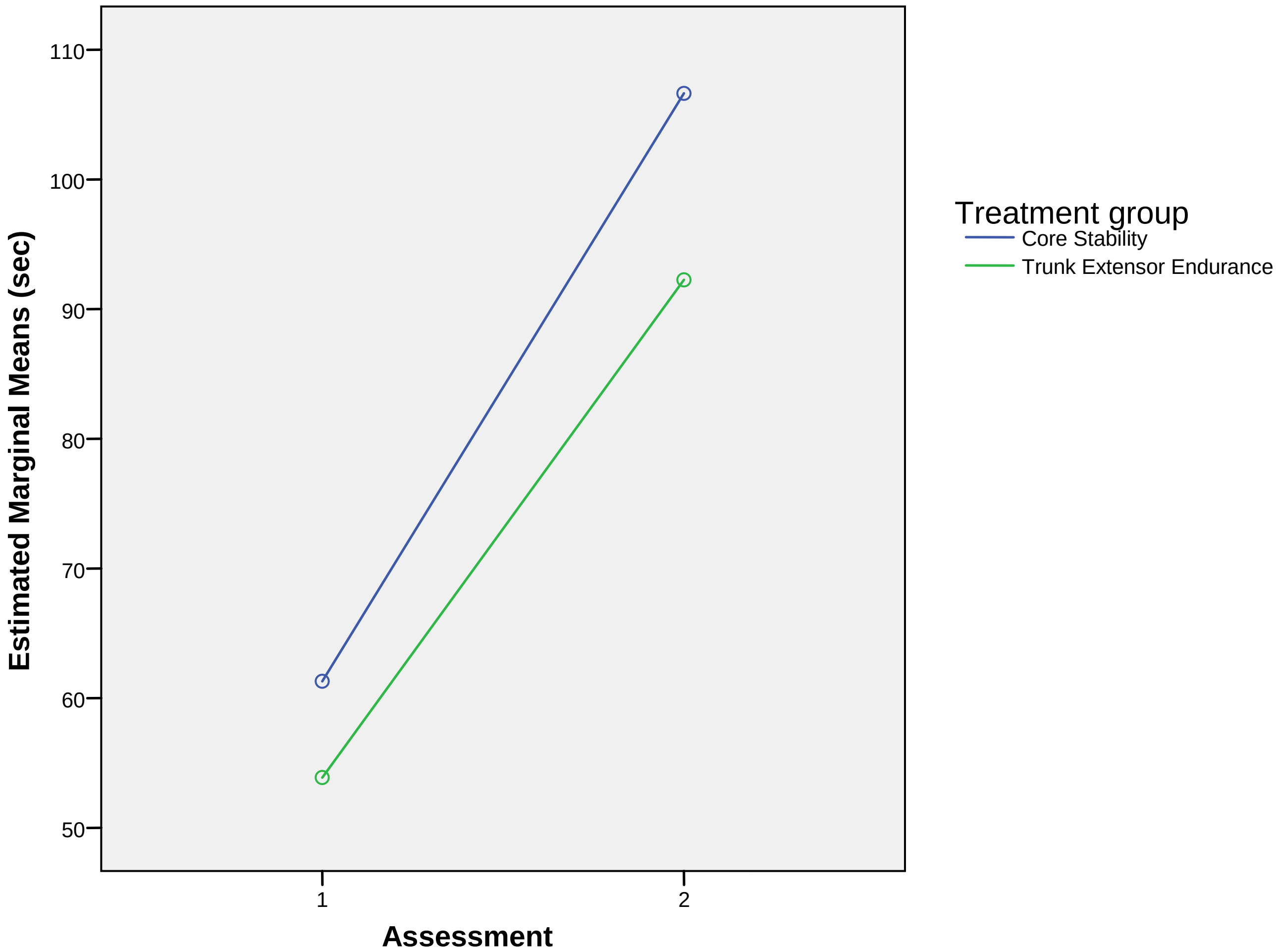


Figure 4.5: Profile plot of time (supine) over time by group

4.5. Trunk extensor endurance

Table 4.11 shows that there was a statistically significant change over time in both groups, and that the rate of change was statistically significantly different between the groups (p=0.021). However, **Figure 4.6** shows that the treatment effect was in the opposite direction to that which was expected. The Trunk Extensor Endurance Group showed a faster rate of increase, with regard to this outcome, than the Core Stability Group.

Table 4.11: Between and within-subjects effects for trunk extensor endurance

Effect	Statistic	p value
Time	Wilk's lambda=0.191	<0.001
Time*group	Wilk's lambda=0.824	0.021
Group	F=0.013	0.911

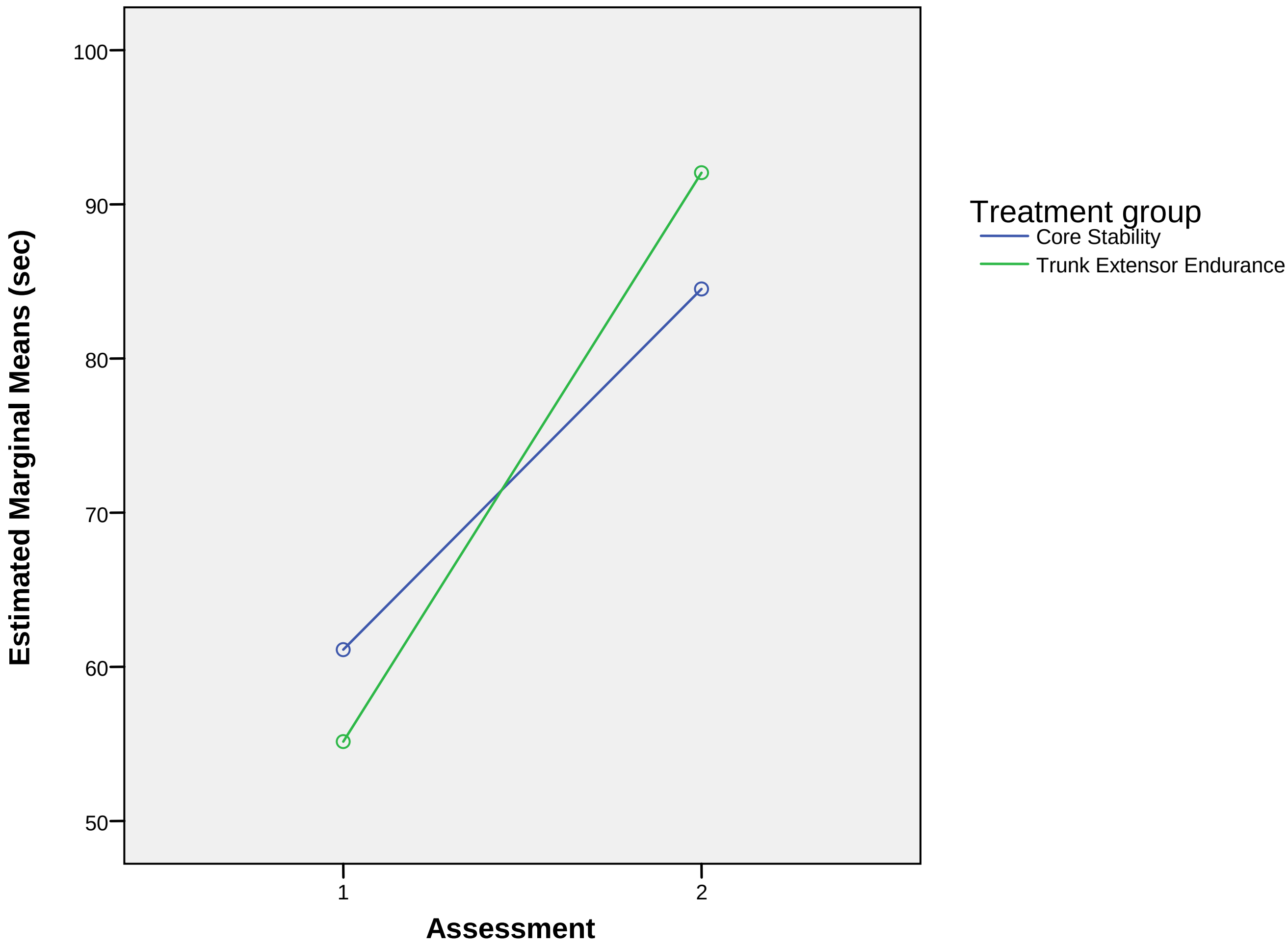


Figure 4.6: Profile plot of trunk extensor endurance over time by group

Remarks:

The result implies that the field hockey players' global muscles have been trained for endurance purposes by virtue of playing position (forward flexion), and combined with the specific trunk extensor endurance training programme, there could be a greater reflection of endurance of trunk extensor muscles.

4.6 To assess the impact of core stability programme on the intensity of lower back pain in terms of objective and subjective measurements.

4.6.1 Numerical Rating Scale- 101 (NRS)

Repeated measures ANOVA analysis for NRS, over time and by group, showed no statistically significant time*group effect (p=0.115), although there was a highly significant time effect (p<0.001). This meant that although both groups' NRS score decreased over time, the rate of decrease was similar in both groups and the effect of the intervention was not significant for this outcome. This is shown in **Figure 4.7** where the slopes of the profiles of both groups were relatively similar. There was a slight trend towards the Core Stability Group's NRS score decreasing slightly faster than that of the Trunk Extensor Endurance Group, but this difference was not statistically significant.

Table 4.12: Between and within-subjects effects for NRS

Effect	Statistic	p value
Time	Wilk's lambda=0.081	<0.001
Time*group	Wilk's lambda=0.914	0.115
Group	F=0.032	0.858

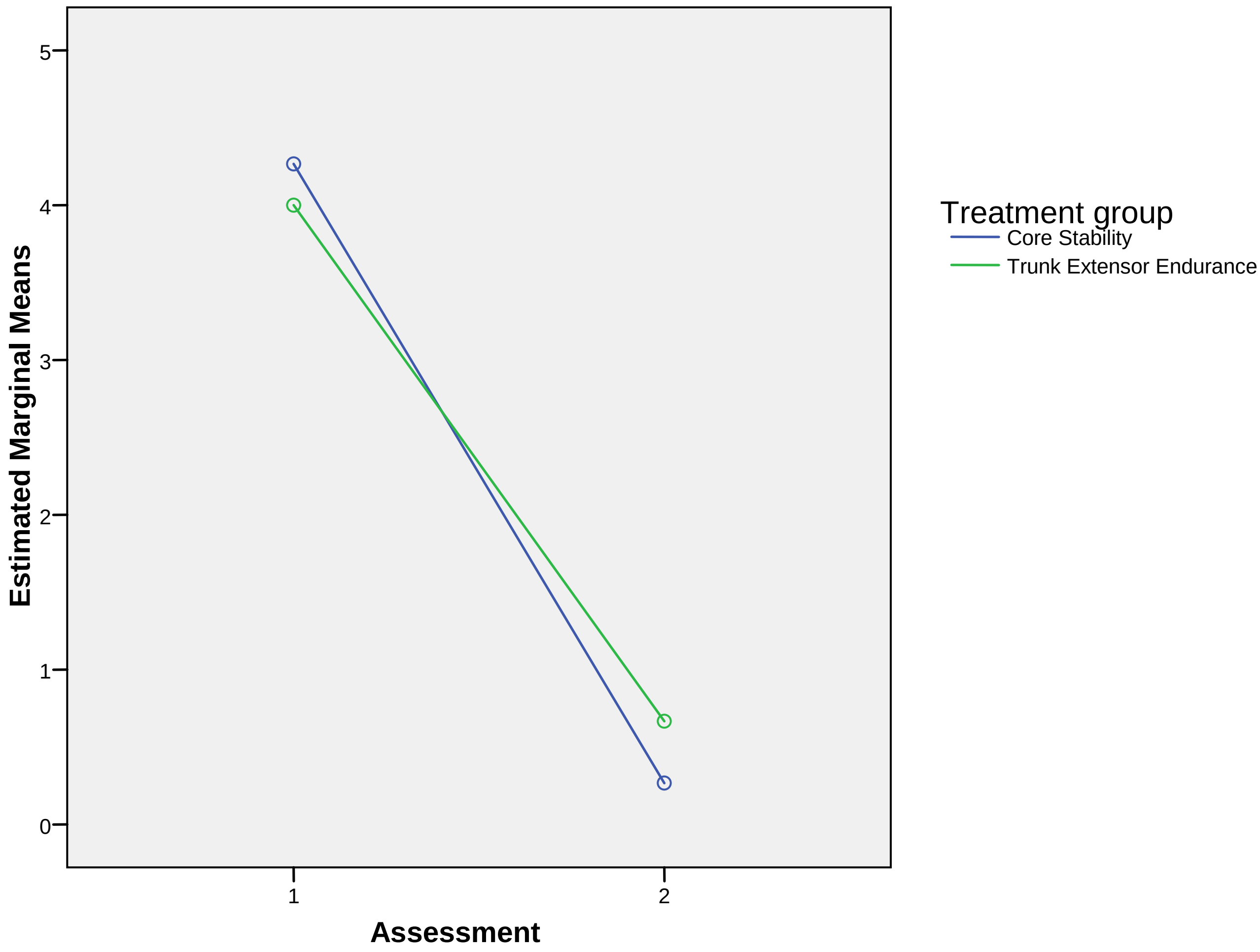


Figure 4.7: Profile plot of mean NRS over time by group

Remarks:

The Core Stability Group performing dynamic core stability exercises may have improved local muscle responsiveness needed to stabilize the spine during specific exercise, causing proper sequencing of muscle activation and co-activation of synergistic muscles. Therefore, restoring muscle strength and endurance to key trunk stabilizers. According to Liebenson (2004), latest research has shown that exercise speeds recovery and can even minimize the severity of future episodes of future back pain.

4.6.2 Quebec Score

There was a statistically significant difference in change in Quebec score between the groups (p=0.020). The Core Stability Group started off at baseline with a higher score than the Trunk Extensor Endurance group, and the rate of decrease in score was significantly faster in the intervention group than in the control group over time. The Trunk Extensor Group did not experience a decrease in score, as shown in **Figure 4.8**. Thus, for this outcome, the intervention had a statistically significantly beneficial effect.

Table 4.13: Between and within-subjects effects for Quebec score

Effect	Statistic	p value
Time	Wilk's lambda=0.820	0.020
Time*group	Wilk's lambda=0.820	0.020
Group	F=0.345	0.562

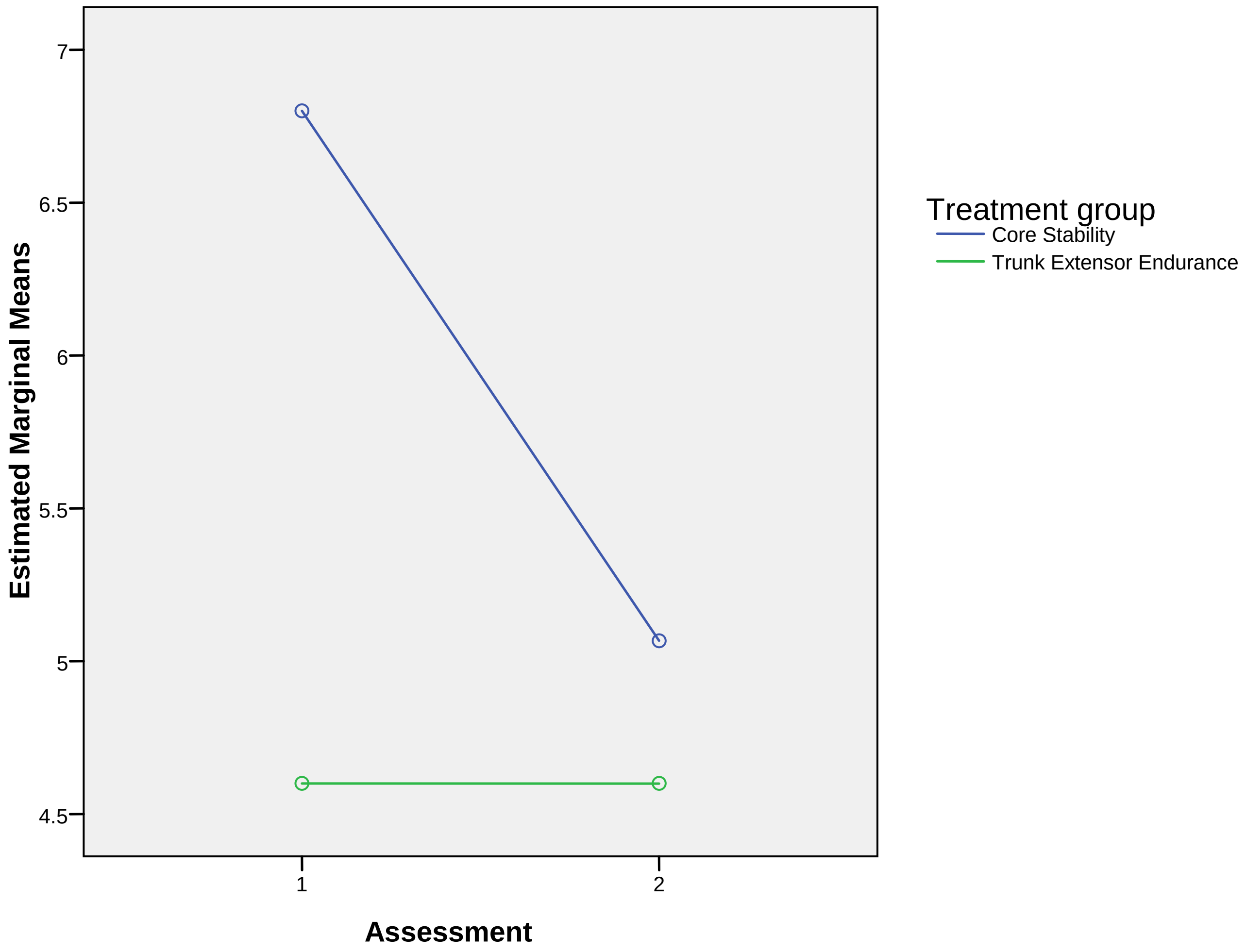


Figure 4.8: Profile plot of mean Quebec score over time by group

Remarks:

This study, therefore, implies that the assumptions in the literature, made with respect to performance of structured exercise, can improve pain levels and functional capacity of individuals with non-specific low back pain (Marshall and Murphy, 2006) and exercise techniques that promote independent contraction of the transverse abdominus muscle (in co-contraction with multifidus muscle) has demonstrated to have effects in relieving pain and disability with chronic low back pain and lowering recurrence rates after acute pain episodes (Richardson et al. 2002). According to Descrarreaux et al. (2002), short-term specific exercise programmes are more effective than classical exercises in reducing pain and disabling level in a low back pain suffering population.

4.7. Summary and conclusion

There was no statistical evidence or convincing trends to show that the intervention (training programmes) increased participants' core strength or trunk extensor strength in the time allocated. However, the Trunk Extensor Endurance Group showed improvement in some of the core stability outcomes over the 3 week period. This may be due to the trunk extensor endurance training programme, which not only focused on strengthening the trunk extensor muscle endurance, but also created a kinaesthetic awareness to maintain a stable spine during the exercise(s), thereby activating core musculature; mainly transverse abdominus and multifidus muscles.

There was statistical evidence that the intervention reduced pain according to the Quebec score over time and only a non-significant trend to suggest this, according to the NRS pain scale. Since both groups' NRS and Quebec scores were non-significantly different at baseline, the difference can be attributed to the effect of the intervention. Thus, even though the intervention may not significantly improve core stability or trunk extensor endurance, it has an effect on pain measured by the Quebec score.

The trunk extension training programme was the most effective in managing acute low back pain in the field hockey player, showing improvement in some of the core stability outcomes, which resulted in activating both the local and global muscle systems creating stability around the spine as well as decreasing pain levels of the athlete during the 3 week period.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter will discuss the outcomes of this research and make recommendations with regards to further research.

5.2 Conclusions

The purpose of this study was to ascertain the effect of core stability versus trunk extensor endurance training in the management of acute low back pain in field hockey players.

It was found that the Trunk Extensor Endurance Group that performed the trunk extensor endurance training programme, yielded better results in core stability and trunk extensor endurance. However, the Core Stability Group that performed the core stability training programme, showed a quicker reduction in pain levels during the three week intervention period.

Therefore, by combining both training programmes, future rehabilitation of athletes suffering from acute low back pain will be more successful, as well as improving sport performance through the proponents of swiss ball training thereby resulting in the improvement of strength, endurance, proprioception and reducing the recurrence of low back pain. All key parameters a field hockey player needs to improve his or her performance.

5.3 Study Limitations

1. The isolation of the deep core muscles during pressure biofeedback measurements was difficult to achieve. The use of superficial or global muscles could not be excluded during core stability testing.

2. It was assumed that the information taken from the subjects in the checklist for past episodes of lower back pain was accurate and reflected reality at that point in time.

5.4 Recommendations

1. This study should be repeated in a larger, more representative sample of a cross-section of the population. This may improve the study's validity and the results would be more statistically significant.

2. Lack of blinding could have resulted in researcher bias. Having a peer intern or clinician, to take objective and subjective measures, may result in more reliable readings.

3. Only one reading for each test at one particular time was taken in this study. It is advised to take multiple readings over a period of time so as to negate factors like fatigue, dehydration and low muscle glycogen stores.

4. In terms of the test for rotary bias, it is the researcher's opinion that for the purpose of future studies, it may be beneficial to focus more on explaining the test procedure to the subjects. Also, it may be of use to evaluate subjects by taking readings from two pressure biofeedback units during the testing process in order to attain more accurate readings.

5. In future studies the compensatory action of global muscles needs to be identified and minimized as much as possible. A suggestion may be the use of a surface electromyelogram (EMG) to track global muscle activation during core stability testing.

6. Future study designs should include a means to assess composition of muscles tested - whether fast twitch or slow twitch, the preparedness of the muscles involved and the degree of neurological stimulation that is afforded to each muscle type.

7. It may also be useful to include another group in a study similar to this one of those patients who have undergone specific core stability training and comparing this with the other patient groups who do not play any sport (general population).

8. Although the researcher attempted to maintain a homogenous sample group, the subjects who participated in this study were varied in terms of the level of play. Some subjects were national players, whilst others were senior provincial players and junior provincial players.

9. A similar study could be conducted by comparing male and female subjects and it might be relevant to investigate muscle recruitment during core and trunk extensor endurance testing, using electromyography or diagnostic ultrasound.

10. A similar study could be conducted using the basic core retraining exercises prescribed by Richardson and Jull (1995); 4 point kneeling, prone lying where body weight is supported and supine crook lying position with and without leg loading.

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http://www.exercise-ball-exercises.com/list-free-exercise-ball-exercises.html

APPENDIX A

LETTER OF INFORMATION

Date__________

Dear Participant, welcome to my research project.

Title of Research:

A comparison study between core stability and trunk extensor endurance training in the management of acute low back pain in field hockey players.

Name of Research Student

Lloyed Clarke Contact number (0826441747 / 373 2205)

Name of Research Supervisor

Dr. Garrick Haswell Contact number (031) 2010341

[MTech-Chiropractic]

Brief Introduction and Purpose of the Study:

When we consider the body position of a field hockey player, the lumbar spine is always in a flexed position, which combined with rotational movements during various hitting and pushing techniques, increases the strain upon the spine and surrounding muscles, thus leading to low back pain. The purpose of the study is the management of acute low back pain by utilizing core stability and/or trunk extensor endurance exercise training on a swiss ball.

Outline of the Procedures

All participants will be split into two equal groups of 15. At DUT Chiropractic Clinic, each subject will receive a standard clinical assessment of acute low back pain and depending in which group the subject is in, either core stability or trunk extensor endurance will be tested. The group tested for core stability will be given a 3 week swiss ball core stability programme and the group tested for trunk extensor endurance will be given a 3 week swiss ball trunk extensor endurance programme. Both training programmes are specifically related to field hockey. These groups will train twice a week in a rehabilitation room at the Queensmead Hockey Stadium under the supervision of the researcher. A second consultation will occur at the DUT Chiropractic Clinic; both groups will receive a standard clinical assessment of acute low back pain. The group that participated in the swiss ball core stability programme will be retested on core stability and the group that participated in the swiss ball trunk extensor endurance programme will be retested on trunk extensor endurance.

The results will be compared to determine which mode of exercise helped in the management of acute low back pain in field hockey players.

Inclusion and Exclusion:

Those taking part in the study must be between the ages of 18 and 30 and compete in the Men's KwaZulu-Natal Field Hockey Premier League.

If you are undergoing any other form of treatment for back pain you may be excluded from the study.

Any participants with a history of spinal surgery, cancer, rheumatoid arthritis, disk herniations, ankylosing spondylitis and neurological disease will be excluded from this study due to it being a contra-indication to swiss ball exercises.

Any participant failing to sign the informed consent form will be excluded immediately from the study.

Participants will be assessed at the DUT Chiropractic Clinic for acute mechanical low back pain.

Assessment:

All core stability and trunk extensor endurance assessment will be performed under the supervision of a qualified chiropractor and by the research student.

Risks and discomfort:

The clinical assessment of core stability, trunk extensor endurance and exercises on the swiss ball are safe and are unlikely to cause any adverse side effects, other than transient tenderness and stiffness that is common to post-exercise soreness.

Remuneration and costs:

Clinical assessment and training programme will be free of charge. Subjects taking part in the study will not be offered any other form of remuneration for taking part in the study.

Implications for withdrawal from the research:

You are free to withdraw at any stage.

Benefits of the study:

Future rehabilitation of athletes suffering from acute low back pain will be more successful as well as improving sport performance through the proponents of swiss ball training, resulting in the improvement of strength, endurance, proprioception and reducing the recurrence of low back pain. All key parameters a field hockey player needs to improve his or her performance. The results of the study will be made available in the Durban University of Technology library in the form of a mini-dissertation.

Confidentiality and ethics:

All patient information will be kept confidential and will be stored in the Chiropractic Day Clinic for 5yrs, after which it will be shredded.

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

Lloyed Clarke 0826441747 or 031 373 2205/2512

Dr Haswell 031 2010341

Statement of Agreement to Participate in the Research Study:

I,……………………………………………(subject's full name),
ID number……………………………………………., have read this document in its entirety and understand its contents. Where I have had any questions or queries, these have been explained to me by……………………………….. . to my satisfaction. Furthermore, I fully understand that I may withdraw from this study at any stage without any adverse consequences and my future health care will not be compromised. I, therefore, voluntarily agree to participate in this study.

Subject's name (print) ……………………………
Subject's signature:………………………….. Date:……………..

Researcher's name (print): ……………………...
Researcher's signature:……………………….. Date:......................

Witness name (print): …………………
Witness signature: ………….......................... Date:………………

Supervisor's name (print):...…………………….
Supervisor's signature: ………………………. Date:……………….

APPENDIX B

Case History

DURBAN UNIERSITY OF TECHNOLOGY
CHIROPRACTIC DAY CLINIC
CASE HISTORY

Patient:____________________________________ Date: __________

File # : __________ Age: __________

Sex : ________ Occupation: __________________________

Intern : _________________________ Signature:____________________

FOR CLINICIANS USE ONLY:

Initial visit
Clinician: Signature :

Case History:

Examination:
Previous:
Current:

X-Ray Studies:
Previous:
Current:

Clinical Path. lab:
Previous:
Current:

CASE STATUS:

PTT:	Signature:	Date:

CONDITIONAL: Reason for Conditional:	
Signature:	Date:

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

Intern’s Case History:

1. Source of History:

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

3. Present Illness:

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

4. Other Complaints:

5. Past Medical History:

< General Health Status

< Childhood Illnesses

< Adult Illnesses

< Psychiatric Illnesses

< Accidents/Injuries

< Surgery

< Hospitalisations

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:

< Tobacco

< Alcohol

< Social Drugs

7. Immediate Family Medical History:

< Age

< Health

< Cause of Death

< DM

< Heart Disease

< TB

< Stroke

< Kidney Disease

< CA

< Arthritis

< Anaemia

< Headaches

< Thyroid Disease

< Epilepsy

< Mental Illness

< Alcoholism

< Drug Addiction

< Other

8. Psychosocial history:

< Home Situation and daily life

< Important experiences

< Religious Beliefs

9. Review of Systems:

< General

< Skin

< Head

< Eyes

< Ears

< Nose/Sinuses

< Mouth/Throat

< Neck

< Breasts

< Respiratory

< Cardiac

< Gastro-intestinal

< Urinary

< Genital

< Vascular

< Musculoskeletal

< Neurologic

< Haematologic

< Endocrine

< Psychiatric

APPENDIX C

Physical

Durban University of Technology ***PHYSICAL EXAMINATION: SENIOR***		
Patient Name :	**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 D

Lumbar Regional

REGIONAL EXAMINATION - LUMBAR SPINE AND PELVIS

*Patient:*______________________*File#:*_______*Date:*_________
Intern\\Resident:_________________________Clinician:___________

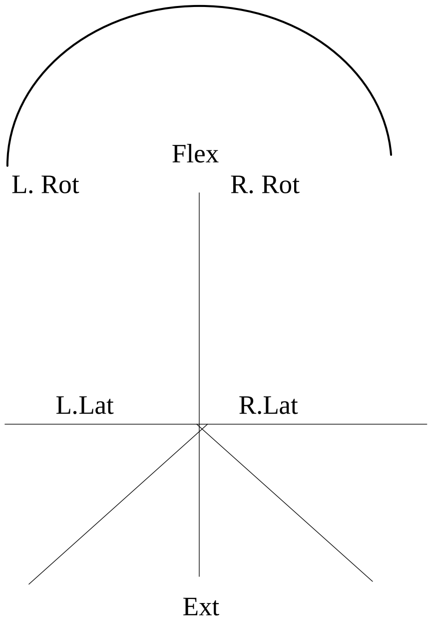
STANDING:

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

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

GAIT:

Normal walking
Toe walking
Heel Walking
Half squat



ROM:

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

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

Which movt. reproduces the pain or is the worst?

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

SUPINE:

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

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

SLR	**L**										
	R										

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

SITTING:

Spinous Percussion
Valsalva
Lhermitte

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

Slump 7 test	**L**										
	R										

LATERAL RECUMBENT:

	L	R
Ober's		
Femoral n. stretch		
SI Compression		

PRONE:

	L	**R**
Gluteal skyline		
Skin rolling		
Iliac crest compression		
Facet joint challenge		
SI tenderness		

SI compression		
Erichson's		
Pheasant's		

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

NON ORGANIC SIGNS:

Pin point pain
Burn's Bench test
Hoover's test
Repeat Pin point test

Axial compressionTrunk rotation
Flip Test
Ankle dorsiflexion test

NEUROLOGICAL EXAMINATION

Fasciculations

Plantar reflex

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

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

BASIC THORACIC EXAM

History
Passive ROM
Orthopedic

BASIC HIP EXAM

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

APPENDIX E

SOAPE Note

DURBAN UNIVERSITY OF TECHNOLOGY

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

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

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

0: ***P:***

E:

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

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

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

O: ***P:***

E:

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

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

APPENDIX F

Numerical Rating Scale –101 Questionnaire

Patient name: ____________________ File No.: __________________

Date: ______________

Please indicate on the line below, the number between 0 and 100 that best describes the pain you experience when it is at its worst. A zero (0) would mean "no pain at all" and one hundred (100) would mean, "pain as bad as it could be." Please record only one number. (Jensen et al. 1986)

0____100

APPENDIX G

The Quebec Back Pain Disability Scale

This questionnaire is about the way your back pain is affecting your daily life. People with back problems may find it difficult to perform some of their daily activities. We would like to know if you find it difficult to perform any of the activities listed below, because of your back. For each activity there is a scale of 0 to 5. Please choose one response option for each activity (do not skip any activities) and circle the corresponding number.

Today, do you find it difficult to perform the following activities because of your back?

		0 Not difficult at all	1 Minimally difficult	2 Somewhat difficult	3 Fairly difficult	4 Very difficult	5 Unable to do
1	Get out of bed	0	1	2	3	4	5
2	Sleep through the night	0	1	2	3	4	5
3	Turn over in bed	0	1	2	3	4	5
4	Ride in a car	0	1	2	3	4	5
5	Stand up for 20-30 minutes	0	1	2	3	4	5
6	Sit in a chair for several hours	0	1	2	3	4	5
7	Climb one flight of stairs	0	1	2	3	4	5
8	Walk a few blocks (300-400 m)	0	1	2	3	4	5
9	Walk several kilometres	0	1	2	3	4	5
10	Reach up to high shelves	0	1	2	3	4	5
11	Throw a ball	0	1	2	3	4	5
12	Run one block (about 100m)	0	1	2	3	4	5
13	Take food out of the refrigerator	0	1	2	3	4	5
14	Make your bed	0	1	2	3	4	5
15	Put on socks (pantyhose)	0	1	2	3	4	5
16	Bend over to clean the bathtub	0	1	2	3	4	5
17	Move a chair	0	1	2	3	4	5
18	Pull or push heavy doors	0	1	2	3	4	5
19	Carry two bags of groceries	0	1	2	3	4	5
20	Lift and carry a heavy suitcase	0	1	2	3	4	5

Add the numbers for a total score: ___________

Minimum detectable change (90% confidence) 15 points

Source: Kopec, JA, Esdaile, JM, Abrahamowicz, M., Abenhaim, L, Wood-Dauphinee, S, Lamping, DL & Williams JI. (1995). The Quebec Back Pain Disability Scale. Spine, 20 (3), 341-352. Reproduced with permission of the publisher. MDC_{90}: Davidson, M. & Keating, J.L. (2002). A comparison of five low back disability questionnaires: Reliability and responsiveness. Physical Therapy, 82 (1), 8- 24.

APPENDIX H
CORE STABILITY SWISS BALL TRAINING PROGRAMME

1. Lunge

http://www.exercise-ball-exercises.com/list-free-exercise-ball-exercises.html

Starting Position

- These ball exercises require you to stand with your back to the ball.
- Raise one foot back and place it on the ball.
- Put your hands on your hips.

Action

- Lower yourself, if you can, until your thigh is horizontal, or you feel a stretch in the rear leg, which ever comes first.
- Raise yourself back up to the starting position.

2. Supine lateral roll

http://www.exercise-ball-exercises.com/list-free-exercise-ball-exercises.html

Starting Position

- Walk yourself out to the supine position (sit on the exercise ball with a neutral lumbar posture, walk your feet forward while leaning back onto the exercise ball; continue forward until your head and upper thoracic spine rests on the ball. Push through your heels to keep your hips up so that you remain straight from your head to your knees).
- Put your arms straight out to the sides so that your shoulders are at 90 degrees to your trunk.
- Keep your feet hip width apart or closer.
- Head, neck and hips should form a straight line from your head to your knees.

Action

- Sway out to one side so that the ball is under one shoulder blade.
- Then sway back to the other shoulder

3. Abdominal crunch

http://www.exercise-ball-exercises.com/list-free-exercise-ball-exercises.html

Starting Position

- Walk yourself out to the supine position (sit on the exercise ball with a neutral lumbar posture, walk your feet forward while leaning back onto the exercise ball; continue forward until your head and upper thoracic spine rests on the ball. Push through your heels to keep your hips up so that you remain straight from your head to your knees).
- Keep your feet hip width apart or closer.
- Head, neck and hips should form a straight line from your head to your knees.

Action

- Slowly and in a controlled manner, use your abdominal muscles to pull your upper body off the ball.
- Visualize the distance between your rib cage and your pelvis as getting shorter.
- Pause for a second and return to the starting position.
- Keep your lower back in contact with the ball at all times.
- The ball should not move during this exercise.

4. Supine Russian twist

http://www.exercise-ball-exercises.com/list-free-exercise-ball-exercises.html

Starting Position

- Walk yourself out into the supine position (sit on the exercise ball with a neutral lumbar posture; walk your feet forward while leaning back onto the exercise ball; continue forward until your head and upper thoracic spine rests on the ball. Push through your heels to keep your hips up so that you remain straight from your head to your knees).
- Put your hands together and point your arms straight up to the ceiling.
- Your feet should be hip width apart or closer.
- Head, neck and hips should form a straight line from your head to your knees.

Action

- Keeping your hips and body parallel to the floor (no sagging of the hips) rotate your shoulders to the right with your arms extended.
- Remember to keep your trunk parallel with the floor.
- Now rotate towards your left and repeat back and forth until the desired number of repetitions is met.
- The ball should preferably stay in one place. Keep your body in a straight line and parallel with the floor, with no sagging of the hips.

APPENDIX I

Swiss Ball training card

Each participant will be provided with a training card outlining the number of sets and repetitions of each exercise to be performed, as well as a detailed instruction for each exercise.

	Week	1		2		3		Sign	
	Date							Subject	Researcher
Exercise	Work out session	1	2	1	2	1	2		
1.Lunge	Sets	2	2	2	2	2	2		
	Reps	8	8	8	8	10	10		
	Rest	1min	1min	1min	1min	1min	1min		
2.Supine lateral roll	Sets	2	2	2	2	2	2		
	Reps	8	8	8	8	10	10		
	Rest	1min	1min	1min	1min	1min	1min		
3.Abdominal crunch	Sets	2	2	2	2	2	2		
	Reps	8	8	8	8	10	10		
	Rest	1min	1min	1min	1min	1min	1min		
4.Supine Russian twist	Sets	2	2	2	2	2	2		
	Reps	8	8	8	8	10	10		
	Rest	1min	1min	1min	1min	1min	1min		

Training will be performed twice per week at the Queensmead Field Hockey Stadium, in the gymnasium, before a hockey training session that occurs twice a week. Each swiss ball session should take approximately 25 minutes to complete and will be supervised by the research student to ensure compliance and to maintain optimal exercise technique.

APPENDIX J
TRUNK EXTENSOR ENDURANCE SWISS BALL TRAINING PROGRAMME

1. Bilateral shoulder lifts

http://www.exercise-ball-exercises.com/list-free-exercise-ball-exercises.html

Starting Position
- These exercise ball exercises require you to start by lying prone over the ball with chest lowered.
- Hands rest on the ball.

Action
- Slowly raise your chest up off the ball.
- Raise your arms up off the ball, keeping your elbows bent at approximately 90 degrees.
- Lower arms and chest slowly.

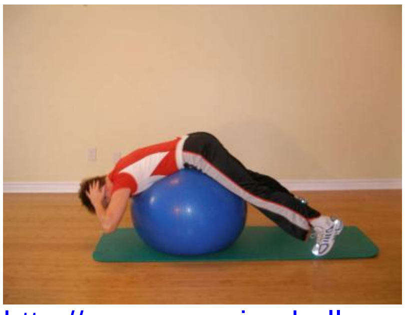
2. Contra-lateral arm and leg lifts

http://www.exercise-ball-exercises.com/list-free-exercise-ball-exercises.html

Staring position
- These exercise ball exercises require you to start by lying prone over the ball with chest slightly raised.
- Hands rest lightly on the floor in front of you.

Action
- Raise one arm in front of you to shoulder height.
- At the same time, raise the opposite leg.
- Hold for 5 seconds.
- Lower your hand and foot to the floor.
- Repeat this on the other side.

3. Bilateral shoulder lifts with hands behind the head




http://www.exercise-ball-exercises.com/list-free-exercise-ball-exercises.html

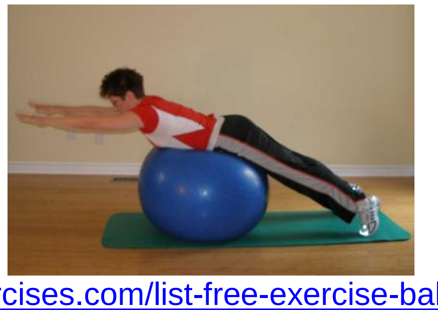
Starting position

- These exercise ball exercises require you to start by lying prone over the ball with chest lowered.
- Feet are resting on the floor about shoulder width apart.
- Place your hands behind your head but don't interlace your fingers.

Action

- Slowly raise your chest up off the ball.
- Keep your chin tucked, as though you were squeezing an orange between your chin and your chest, to stabilize the neck.
- Lower arms and chest slowly.

4. Bilateral shoulder lifts with arms in full elevation

http://www.exercise-ball-exercises.com/list-free-exercise-ball-exercises.html

Starting Position

- These exercise ball exercises require you to start by lying prone over the ball with chest lowered.
- Hands rest lightly on the floor in front of you.

Action

- Slowly raise your chest up off the ball.
- Raise your arms up off the ball, keeping your elbows straight and your arms in front of you.
- Lower arms and chest slowly.

APPENDIX K

Trunk extensor endurance training card

	Week	1		2		3		Sign	
	Date							Subject	Researcher
Exercise	Work out session	1	2	1	2	1	2		
1.level 1	Sets	6	6	6	6	6	6		
Bilateral shoulder lifts	Reps	5	5	5	5	5	5		
	Rest	1min	1min	1min	1min	1min	1min		
	Holding time	20sec	20sec	20sec	20sec	20sec	20sec		
	Ease of the exercise								
2.Level 2	Sets	2	2	2	2	2	2		
Contra-lateral arm and leg lifts	Reps	8	8	8	8	10	10		
	Rest	1min	1min	1min	1min	1min	1min		
	Holding time	20sec	20sec	20sec	20sec	20sec	20sec		
	Ease of the exercise								
3.Level 3	Sets	2	2	2	2	2	2		
Bilateral shoulder lifts with hands behind the head	Reps	8	8	8	8	10	10		
	Rest	1min	1min	1min	1min	1min	1min		
	Holding time	20sec	20sec	20sec	20sec	20sec	20sec		
	Ease of the exercise								
4.level 4	Sets	2	2	2	2	2	2		
Bilateral shoulder lifts with arms in full elevation	Reps	8	8	8	8	10	10		
	Rest	1min	1min	1min	1min	1min	1min		
	Holding time	20secs	20secs	20secs	20secs	20secs	20secs		
	Ease of the exercise								

Training will be performed twice per week at the Queensmead Field Hockey Stadium, in the gymnasium, before a hockey training session that occurs twice a week. Each trunk extensor endurance training session should take approximately 25 minutes to complete and will be supervised by the research student to ensure compliance and to maintain optimal exercise technique.

Precautions and Contra-indications (www.exercises-ball-exercise.com)

- If you are doing exercise ball exercises for the first time, it may be helpful initially to have someone hold the ball or the have the ball propped, in order to learn the movement.

- Use your ball in an open area away from nearby furniture, counters, and sharp objects. Use an appropriate size ball.

- Stop any ball exercises that cause pain or feel awkward. Readjust yourself and reread the instructions. The motto "no pain, no gain" does not apply.

- If you feel any of the exercise ball exercises are too easy, you are probably doing them wrongly. Try to do at least the recommended repetitions.

- People with poor balance should do ball exercises only under close supervision by a physical therapist.

- There is a risk of falling off the ball, particularly during some of the illustrated exercises. Perform exercises slowly and with control, always maintaining correct body position.

- Do not do these ball exercises if you have or have had in the past any neuromusculoskeletal disorder. Seek a healthcare professional capable of diagnosing neuromusculoskeletal pathology prior to attempting any exercises.

- Do not exceed the ability of your spine to stabilize you. Serious injury may result if you place more of a demand on your stabilizing musculature than it is capable of providing. If you feel discomfort, stop the exercise immediately.

- Quality is far more important than quantity. Work with excellent technique (form) and work only until technique fatigue.

- Be sure to follow instructions precisely; stop the exercise if you do not feel comfortable doing the exercise.

- Find the highest capacity burst resistant ball available, and make sure it is properly inflated. Risks include fractures, strains, sprains, concussions, or worse.

APPENDIX L

DATA SHEET

Name:	Club:
Age (18-30)	
Duration of play	
Highest achievement	
Playing position	
History of low back pain	
-cause	
-duration	
-area of pain	
-pain referral	
-treatment	

NAME	CORE STABILITY TEST (Endurance Test)		TRUNK EXTENSOR ENDURANCE TEST
	SUPINE (40mmHg)	PRONE (70mmHg)	
1st Assessment (sec)			
Reading (mmHg)			
2nd Assessment (sec)			
Reading (mmHg)			