A STUDY TO DETERMINE THE RELATIONSHIP BETWEEN CORE MUSCLE STRENGTH AND CHRONIC LOWER BACK PAIN IN AMATEUR FEMALE ROAD RUNNERS AND NON-RUNNERS

By

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I, Susan Leigh Martin, do declare that this dissertation is representative of my own work in both conception and execution.

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DEDICATION

This is dedicated to my parents who have given me incredible support and encouragement throughout my studies. I have an enormous amount of respect for you both and I am exceptionally grateful for all that you have done for me in the past years. Thank you to my brothers, who ensured that I kept my sense of humor during very stressful times of studying and exams. Finally I would like to thank my family – aunts, uncles and grandparents - whose gentle encouragement really helped me to make it through my studies.

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ABSTRACT

It is well known that the lifetime incidence of lower back pain (LBP) is particularly high (Richardson *et al.,* 1999). Most cases of LBP are self-limiting, however certain regional biomechanical deficits may be overlooked, such as core stability. As a result of this, LBP may become a chronic condition in the athletic and general population.

This principle can be applied to road running, as the forces that pass through the muscles of the lower limbs and trunk cannot be properly absorbed if the trunk musculature is not properly trained. This may lead to lower back pain as a result of inadequate functioning and strength of stabilizing structures (Hedrick, 2000).

The purpose of this exploratory cross-sectional study was to determine the relationship between core muscle strength and chronic lower back pain in amateur female road runners and non-runners. The focus was to determine the core stability values in mmHg between amateur female runners with and without chronic LBP, and female non-runners with and without chronic LBP; as well as to compare female runners and non-runners with regard to core muscle strength.

This study was conducted using 4 groups consisting of 10 subjects each, using runners and non-runners with and without chronic lower back pain. Measurements were taken at the Chiropractic Day Clinic and the Comrades Experience.

The numerical pain rating scale (NRS) was utilized to determine the severity of the pain and the subjects' pain score was rated between 2-5. The data collection tool was the pressure biofeedback unit (PBU), which provided numerical readings that were used for the purpose of statistical analysis. The PBU provided objective readings, which represented core stability muscle activation. Subjects were shown how to perform the required core muscle contraction, before commencing the abdominal draw

in test and the test for lumbopelvic posture. The four point kneeling position was used for the purpose of demonstrating to subjects how to recruit the transversus abdominis (TA) and elicit a core muscle contraction.

Data were analysed using SPSS version 13.0 (SPSS Inc., Chicago, Illinois, USA). A p value of <0.05 was considered as statistically significant. Parametric testing was used to compare groups since the quantitative dependant variables were reasonably normally distributed. Independent t-tests were used to compare quantitative outcomes between two independent groups and ANOVA with post hoc Bonferroni tests was used when there were more than 2 groups to compare. Pearson's correlation coefficients and p values were reported to determine relationships between two quantitative variables.

A total of 40 subjects fitted the inclusion criteria for this study – all of which were female. The average age when participating in this study was 35.3 years (SD 5.54) in the runner group and 33.2 years (SD 6.48) in the non-runner group. Weight, height and BMI were not significantly different between the runners and non-runners ($p=0.802$, 0.210 and 0.227 respectively). The average mileage of the 20 runners was 47.8 km (SD 16.9 km) with a range from 35-90km per week.

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 fitness. Some subjects were endurance runners (ultra-marathon and marathon runners) and others were middle distance runners, this may or may not have an effect on their core stability.

This study has demonstrated a link between a deficit in core muscle strength and LBP in female runners and non-runners, as well as a positive correlation between increasing mileage and core muscle strength in runners showing a greater level of endurance with regard to the core muscle contraction as the weekly mileage increased. It was found in this

study that there was no significant difference in core muscle strength between female runners and non-runners. Within the running group those who were symptomatic had poorer endurance than those who were asymptomatic and this finding may indicate that relatively weak core muscles could have an adverse effect on endurance. This may be significant as a similar finding was not present in the non-runner group, and this may indicate that weak core muscles have a more prominent effect on symptomatic runners with regard to core muscle endurance.

Key words:

Core muscle strength (core stability), chronic lower back pain, body mass index (BMI), Pressure Biofeedback Unit (PBU)

GLOSSARY

Core (trunk) muscle strength/ core stability:

For the purpose of this study, core muscles included the abdominal component: rectus abdominis, external oblique, internal oblique and transverses abdominis (TA) and the lumbar component: multifidus, quadratus lumborum, superficial and deep erector spinae, intertransversarii and interspinales (Hedrick, 2000). By activating these muscles, they serve to stabilize the spine and make movement of extremities as efficient as possible, allowing transfer of power with minimal dissipation of energy (Kissane, 2001).

Chronic Lower Back Pain (LBP):

Pain, ache or discomfort experienced in the lumbar region of greater than 12 weeks duration (Guerriero *et al.,* 1999).

Body Mass Index:

Body mass index (BMI) is calculated by measuring a person's weight in kilograms and then dividing by that person's height in metres squared (kg/m^2). The advantage of using this index as opposed to using weight alone, is that it is height-independent, such that tall and short people of similar proportions have a similar BMI. The accepted normal BMI range is 18.5 – 24.9 (Haslett *et al*., 2002).

Pressure Biofeedback Unit:

The pressure biofeedback unit (PBU) consists of an inelastic, three section air-filled bag, which is inflated to fill the space between the target body area, a firm surface, and a pressure dial in the bag for feedback on position. The bag is inflated to a suitable level for the purpose and the pressure is then recorded. The movement of the body off the bag results in a decrease in pressure, while movement of the body onto the bag results in an increase in pressure (Richardson *et al.,* 1999).

Amateur female runners:

Amateur female road runners that have run more than 35 kilometers per week for more than six months and have a BMI between 18.5 – 24.9 kg/m^2 (Haslett *et al*., 2002). These individuals were required to be between the ages of 25 – 45 years. This definition was for the purpose of this study.

Female non-runners:

For the purpose of this study, those individuals included in the study were required to have a BMI between 18.5– 24.9 kg/m^2 and be between the ages of 25 – 45 years (Haslett *et al*., 2002). It was ensured by means of questioning prior to inclusion in this study that these individuals did not participate in any significant running training.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER ONE – INTRODUCTION

1.1. INTRODUCTION: THE PROBLEM

Lower back pain (LBP) has frequently been found to be one of the major causative factors in missed training time in endurance athletes (Bono, 2004). Traditional treatment regimens have primarily focused on pain reduction, which often only provides temporary relief, especially if impairments of the deep muscles of the trunk and back are present. These muscular impairments may possibly persist after pain has dissipated and return to manifest as chronic LBP (Jull and Richardson, 2000).

A region that is frequently associated with the development of LBP due to impairments in muscle strength and motor control are the core stabilisers, which are required to maintain normal posture and stability during periods of activity (Jull and Richardson, 2000). In contrast to post-exercise muscle pain, pain due to overuse in extensive athletic training also occurs, and the source of pain commonly arises from overuse of a group of muscles that have a biomechanical deficit (Bruno, 2004).

There is a high incidence of LBP common to both athletes and non-athletes, the lifetime prevalence of which ranges from 60 percent to 90 percent (Drezner and Herring, 2001). Arokoski *et al.* (2001) state that there is a relationship between poor coordination of paraspinal muscles and LBP. These changes are suggested to be due to a so-called de-conditioning syndrome, as a result of disuse and pain as well as reflex inhibition of the core muscles. Forces that challenge the spine are of interest because a decrease in spinal stability is hypothesised to place stress and excessive load on the spinal joints and tissues, which eventually results in LBP (Van Dillen *et al.,* 2001). Assessment and measurement of the impairment associated with muscular problems linked with LBP must take priority (Richardson *et al., 1999).*

The purpose of this exploratory cross-sectional study was to determine the relationship between core muscle strength and chronic lower back pain in amateur female road runners and non-runners, using the pressure biofeedback unit (PBU) as a measuring tool, during a series of core stability tests, as a means to obtain objective findings. The focus was to determine the core stability values between amateur female runners with and without chronic LBP, and female non-runners with and without chronic LBP; as well as to compare female runners and non-runners with regard to core muscle strength.

1.2. AIMS OF THE STUDY

Sub-problem 1

To determine whether differences in core muscle strength (trunk muscle strength) exist between female runners with chronic LBP and those without LBP.

Hypothesis: *Female runners without LBP should have greater core muscle strength than female runners with LBP.*

Sub-problem 2

To determine whether differences in core muscle strength exist between female non-runners with chronic LBP and those without LBP.

Hypothesis: *Female non-runners without LBP should have greater core muscle strength than female non-runners with LBP.*

Sub-problem 3

To determine whether there is a relationship between LBP and core muscle strength in female runners and non-runners.

Hypothesis: *A relationship between core muscle strength and LBP should be shown to exist in female runners and non-runners.*

1.3. THE NEED FOR RESEARCH INTO CORE MUSCLE STRENGTH IN AMATEUR RUNNERS AND NON-RUNNERS

It is well known that the lifetime incidence of lower back pain (LBP) is particularly high (Richardson *et al.,* 1999). Most cases of LBP are self-limiting; however certain regional muscular impairments may be overlooked, such as core stability. As a result of this, LBP may become a chronic condition in the athletic and general population.

The absence of pain does not necessarily indicate the restoration of function, particularly pertaining to muscle imbalances and impairments in the trunk musculature. There is a high incidence of recurrent and chronic LBP, and this may be due to failure to restore proper function following treatment, and highlights the need for appropriate rehabilitation as an intervention (Drezner and Herring, 2001).

In most sports training routines, emphasis is placed on training and strengthening of extremities involved in a particular activity, and although this is beneficial, without sufficient trunk strength and stability, the strength of the limbs cannot be effectively applied (Hedrick, 2000).

It is widely accepted that the athletic population is highly motivated to return to their particular activity following injury. This poses problems with regard to determining a specific pain initiator, and this often makes diagnosis and treatment challenging (Drezner and Herring, 2001).

Previously, the focus on the treatment of chronic LBP was on pain reduction. However, active rehabilitation has been increasingly advocated as a treatment for chronic LBP (Arokoski *et al*., 2001). By addressing core stability in endurance athletes with chronic LBP, many of the challenges that occur when using traditional treatment regimens for LBP may be eliminated.

Optimal running performance is said to be influenced by core muscle strength, as the development of core muscle strength is said to be the foundation for long term dynamic muscle strength training to maximise the propulsive forces developed by the power-producing legs (Stanton and Reaburn, 2004).

Akuthota and Nadler state that despite its widespread use, research into core strengthening is meagre. Therefore, this study aimed to contribute to the body of knowledge pertaining to core muscle strength and its relationship to LBP in runners and non-runners. This may facilitate a greater understanding of the underlying causes of chronic LBP in active patients – particularly runners – thereby allowing for more focused and effective treatment and prevention of chronic LBP.

The majority of literature and studies conducted, relating to core stability focus on contact sports that involve bursts of activity. This study aimed to fill in a niche in the body of literature relative to endurance athletes, with amateur female runners and non-runners as subjects in the study.

CHAPTER TWO – LITERATURE REVIEW

2.1. INTRODUCTION

This chapter reviews all the available literature and includes a description of the anatomy of the core muscles and biomechanics of the trunk region. It also discusses the relationship between core stability, running and chronic LBP.

2.2. ANATOMY OF THE CORE MUSCLES – LOCAL AND GLOBAL MUSCLE SYSTEMS

The muscles that make up the core region form a supportive “muscular corset”, which serves to support and form the centre of the functional kinetic chain (Akuthota and Nadler, 2004).

For the purpose of this study, core muscles included the abdominal component:

i) rectus abdominis
ii) external oblique
iii) internal oblique
iv) transverses abdominis (TA)

The lumbar component:

i) multifidus
ii) quadratus lumborum
iii) superficial and deep erector spinae
iv) intertransversarii
v) interspinales (Hedrick, 2000).

The core muscles are categorized into local and global muscle systems based on their main mechanical roles in stabilization. The local system includes deep muscles and the deep portions of some muscles that have their origin or insertion on the lumbar vertebrae (Richardson *et al.*, 1999: 14). These muscles are capable of controlling the stiffness and intervertebral relationship of the spinal segments and the posture of the lumbar spine. The lumbar multifidus muscle, with its vertebrae to vertebrae attachments is a prime example of a muscle of the local system. The transversus abdominis, which is the deepest muscle, has direct attachments to the lumbar vertebrae through the thoraco-lumbar fascia and the decussations with its opposite in the midline and can also be considered a local muscle of the abdominal muscle group (Richardson *et al.*, 1999: 14).

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

- i) internal oblique
- ii) external oblique
- iii) rectus abdominis
- iv) lateral fibers of the quadratus lumborum
- v) portions of the erector spinae

These muscles are responsible for moving the spine as well as transferring load directly between the thoracic cage and the pelvis. The primary function of these global muscles is to balance the external loads applied to the trunk so that the residual forces transferred to the lumbar spine can be dealt with by the local muscles (Richardson *et al.*, 1999: 14, 15).

2.2.1. THE ABDOMINAL COMPONENT

The abdominal component of the core muscles consists of:

i) rectus abdominis
ii) external oblique
iii) internal oblique
iv) transversus abdominis (TA) (Hedrick, 2000).

The rectus abdominis is a prominent, strap-like muscle, which is vertically orientated. These muscles are separated by the linea alba and lie close together inferiorly (Moore, 1992: 136). The origin is at the pubic symphysis and pubic crest and inserts at the xiphoid process and the fifth to seventh costal cartilages. The rectus abdominis is three times as wide superiorly as inferiorly; it is narrow and thick inferiorly and broad and thin superiorly. The action of this muscle is to flex the trunk and compress the abdominal viscera. As well as this, the rectus abdominis stabilizes the pelvis during walking and during lower limb lifts from the supine position, it prevents tilting of the pelvis by the weight of the limbs (Moore, 1992: 136). The rectus abdominis is innervated by the ventral rami of the inferior six thoracic nerves (Moore and Agur, 1995: 82, 83).

The transversus abdominis 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).

The external oblique is a superficial flat muscle, which is located in the anterolateral aspect of the abdominal wall (Moore, 1992: 132). Its fleshy part forms the anterolateral portion and its aponeurosis forms the anterior part. The origin of this muscle is at the external surfaces of the fifth to twelfth ribs. The external oblique inserts at the linea alba, pubic tubercle and the anterior half of the iliac crest. The fibres of this muscle pass inferomedially (Moore and Agur, 1995). The action of the external oblique is to compress and support the abdominal viscera as well as to flex and rotate the trunk. The innervation is by the inferior six thoracic nerves and the subcostal nerve (Moore and Agur, 1995: 82, 83).

The internal oblique is the intermediate flat muscle, the fibers of which run at right angles to the external oblique. The origin of this muscle is at the 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).

2.2.2. THE LUMBAR COMPONENT

The lumbar component includes the:

- i) Multifidus
- ii) quadratus lumborum
- iii) superficial and deep erector spinae
- iv) intertransversarii
- v) rotatores
- vi) interspinales (Hedrick, 2000).

The quadratus lumborum is located on the posterior abdominal wall. Superiorly, it attaches at the medial half of the twelfth rib and the tips of the lumbar spinous processes. The inferior attachments are at the iliolumbar ligament and internal lip of the iliac crest (Moore and Agur, 1995: 134). The actions of the quadratus lumborum are to control lateral flexion in the erect position. The stabilizing function of this muscle of the lumbar spine on the pelvis is so important that with bilateral paralysis of this muscle, walking is impossible (Travell and Simons (b), 1993: 35 vol. 2) When acting unilaterally, with the pelvis fixed, the quadratus lumborum acts mainly as a lateral flexor of the spine to the ipsilateral side. With the spine in the fixed position, unilateral contraction of the quadratus lumborum results in elevation of the ipsiliteral hip. When acting bilaterally, the quadratus lumborum extends the spine (Travell and Simons (b), 1993: 35 vol. 2).

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

The origin of the rotatores muscles is from the transverse processes. The fibres of the rotatores pass superomedially and attach to the junction of the lamina and transverse process of the vertebra of origin, or they attach to the spinous process above the vertebra of origin, spanning one to two segments. The function of these muscles is to stabilize vertebrae and

assist with local extension and rotary movements of the vertebral column. Innervation is supplied by the dorsal rami of the spinal nerves (Moore and Agur, 1993: 205)
The erector spinae muscle consists of three components that span the cervical, thoracic and lumbar regions:

i) iliocostalis (lumborum, thoracis and cervicis)
ii) longissimus (thoracis, cervicis and capitis)
iii) spinalis (thoracis, cervicis and capitis)

The segment of the erector spinae that is described for the purpose of this study, is the iliocostalis lumborum. 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. The fibers of the iliocostalis lumborum 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).

The intertransversarii originate at the transverse processes of the cervical and lumbar vertebrae, and insert at the transverse processes of adjacent vertebrae. The principal actions of these muscles are to assist in lateral flexion of the spine, and when they act bilaterally, they serve to stabilise the spine. The innervation of these muscles is supplied by the dorsal and ventral rami of the spinal nerves (Moore and Agur, 1993: 207).

2.3. BIOMECHANICS OF RUNNING

It is important to take the biomechanics of the lumbar spine into account when dealing with endurance athletes. Akuthota and Nadler (2004), suggest that the lumbar spine is the link between the lower extremities and the trunk, and plays a significant role in the transfer of forces through the body in most sports via the kinetic chain. The muscular “corset” formed by the trunk musculature is said to be the foundation of all limb movements, and is the centre of the functional kinetic chain (Akuthota and Nadler, 2004). A high degree of lumbopelvic stability may contribute to athletic performance by aiding in the efficient transmission of force generated by the lower body through the trunk to the upper body. An inability to stabilize the lumbopelvic region, during running, is suggested to lead to poor technique and inefficient application of force (Mills *et al*., 2005).

Literature suggests, that all movements of the body either originate in or are coupled through the trunk, and this coupling action is created by a strong trunk region. Impact loading of the lumbar spine is of primary concern when dealing with runners and sports that involve running. The forces that occur on impact of heel strike are transferred up the kinetic chain to the lumbar spine, and to the related supporting structures of the trunk (Hedrick, 2000).

Spinal instability is considered to be one of the most important causes of lower back pain, but is poorly defined and not well understood (Panjabi, 1992). A widely promulgated theory is that of the spinal stabilizing system, which consists of three subsystems, namely the passive musculoskeletal subsystem, active musculoskeletal subsystem, and neural feedback subsystem. The spinal stabilizing system is said to have three fundamental functions, these being:

i) to permit movements between body parts
ii) to carry loads
iii) for protection of the spinal cord and nerve roots

These functions may not be performed properly, unless mechanical stability exists (Panjabi, 1992). These subsystems may be applied to the core stabilisers – the strength of which is essential to athletic performance.

A general increase in muscle tone by training has been shown to decrease the risk for developing low back problems. The explanation for this is that this causes enhanced stability of the spinal system in the form of increased capacity to generate muscle tension. The strengthening of selective muscle groups may make up for specific passive stability loss due to an injury (Panjabi, 1992).

The biomechanics of running involves the study of forces (kinetics) and the study of motion (kinematics). Two important concepts to take into consideration when dealing with running biomechanics are that of the kinetic chain and that of the ground reaction force (Shamus and Shamus, 2001: 243, 244).

The kinetic chain is essential to the understanding of athletic activities, which involve coordinated movements of the joints and limbs to perform a task. Individual body segments and joints are collectively called links, and these segments and joints must be moved in specific sequences in order to allow for efficient accomplishment of the required task (Brukner and Khan, 2002: 28). The sequencing of the links of an athletic activity is referred to as the kinetic chain. The activation of the sequencing of the kinetic chain results in the generation of force and energy in each link of the kinetic chain; the summation of these forces and energy results in efficient transfer of the force and energy to the terminal link (Brukner and Khan, 2002: 28).

The ground reaction force (GRF) is the force reaction generated in response to the force that is transmitted to the ground by the foot or shoe. This principle is based on Newton's third law: For every action, there is an equal and opposite reaction (Shamus and Shamus, 2001: 243, 244). The reaction against the body may be transferred to other parts of the body in accordance with the objective to be accomplished in the sport concerned (Watkins, 1996: 13). The GRF is the representation of the acceleration of the body's total center of gravity (Shamus and Shamus, 2001: 243, 244). Watkins (1996), states that in sports that involve the feet, the ground furnishes the action, which is transmitted by the lower extremities to the pelvis. The back transmits the action to the shoulders and upper extremities. From there it is transmitted back along the spine to the pelvis and lower extremities, resulting in greater speed. In all sports, the spine plays a central role in accomplishing the objective of the sport (Watkins, 1996: 13).

There are two phases of the running gait cycle, these being the stance phase and the swing phase. The stance phase may be divided into three components: contact, mid-stance and propulsion. The swing phase is divided into follow through, forward swing and foot descent. The actions of walking gait and running gait cycles can be differentiated by the fact that with the walking gait cycle, there is placement of one foot in front of another and is separated by periods when both feet are in contact with the ground, referred to as double limb support (Brukner and Khan, 2002: 51). Double limb support does not occur in running, but rather a phase that is referred to as float or nonsupport whereby, neither limb contacts the ground (Shamus and Shamus, 2001: 242, 243).

There is an increased range of pelvic, hip and knee rotation as a result of increases in joint movements during running, this increase in joint movement must be absorbed by increasing muscle forces that are acting over these joints. During slow running over longer distances, the stance phase has a longer duration than the flight phase. As the running speed increases, the stance phase and flight phase times approach each other until the stance phase becomes shorter than the swing phase, which occurs during sprinting (Brukner and Khan, 2002: 51).

2.4. LOWER BACK PAIN IN RUNNERS AND NON-RUNNERS

2.4.1. LOWER BACK PAIN IN RUNNERS

Athletic activities which involve running place strenuous forces on the lower back, and if the lower back has not been trained to function optimally, it can lead to weakness and reduced movement capabilities. Over time this can lead to impaired athletic performance, injury and pain (Hedrick, 2000). It is well documented that patients suffering from LBP have diminished lumbar proprioception, poor postural control and longer trunk muscle reaction latencies (McGill, 2003).

During running, the lumbopelvic girdle is held in constant flexion and this posture, when sustained for prolonged periods of time can lead to chronic biomechanical faults, which in turn increase the risk of developing chronic LBP in the running population (Brier and Nyfield, 1995).

Watkins (1996), states that lower back pain is commonly reported in runners. In achieving the aerobic conditioning that running provides the runner often must experience stiffness, contractures and selected areas of muscle weakness. Runners have a natural tendency to develop isolated abdominal weakness, frequently producing a significant imbalance between flexor and extensor muscles, both in the legs and in the trunk.

2.4.2. LOWER BACK PAIN IN NON-RUNNERS

Epidemiological studies have provided information on factors, which predict the onset of back pain. These studies have demonstrated that demographic factors such as female gender, older age and lower social class are associated with a higher risk of future onset as well as aspects of lifestyle such as lack of physical activity and obesity (Macfarlane *et al.*, 2006). Studies that have been conducted principally in the workplace have identified that mechanical load, posture and whole body vibration, play a role in the development of LBP. Other studies have identified predictors of outcome of an episode of LBP: in particular, the role of demographic factors, clinical factors (including severity, extent of pain and disability) which are important to consider (Macfarlane *et al.*, 2006).

The above points account for the inclusion criteria relevant to this study, particularly pertaining to the selection of only female subjects, within a narrow Body Mass Index (BMI) range. Due to the fact that obesity is a risk factor for developing LBP, a narrow BMI range was utilized as an inclusion criterion for this study (Macfarlane *et al.*, 2006).

A narrow numerical pain rating scale (NRS) rating of 2-5 was selected as in inclusion criterion to ensure that clinical factors such as severity, extent of pain and disability were taken into account, and thus the sample group would remain homogenous in terms of pain rating (Macfarlane *et al.*, 2006).

Runners versus non-runners were chosen for this study, and as a result of this, the lifestyle factors may differ between the two groups. In terms of activity levels, it was assumed for the purposes of this study that the runners were more active than the non-runners. This challenges the statement that a lack of physical activity is a risk factor for the development of LBP (Macfarlane *et al.*, 2006). This study intends to demonstrate that it is not only inactivity that increases risk of developing but rather that LBP is found in active and inactive populations, although the precipitating factors may differ between groups.

2.5. THE IMPORTANCE OF CORE STABILITY IN RUNNERS AND NON- RUNNERS

Literature suggests that strengthening and reconditioning of lower back and abdominal musculature may result in the enhancement of spinal segmental support and control (Jull and Richardson, 2000). It has been shown that there is a link between motor control deficits in muscles of the local stabilizing system, particularly the transverses abdominis and lumbar multifidus and the development of low back pain. These muscles appear to lose their normal anticipatory function in some subjects, exhibiting delays in activation, and thus a loss of their normal pre-programmed function for support, which will be restored by improving strength and control of stabilizing trunk musculature (Jull and Richardson, 2000).

Richardson *et al.* (1999) state that a fundamental discovery was that the muscle dysfunction related to low back pain was a problem in motor control in the deep muscles related to segmental joint stabilization. Normally, the transversus abdominis – in its spinal supporting role-appears to be controlled independently of the other abdominal muscles. Its action is closely linked to that of the diaphragm and pelvic floor muscles, and appears to affect spinal support through its attachments to the thoracolumbar fascia and its close links to the development of intra-abdominal pressure. Its contraction with the deep fibers of the lumbar multifidus during normal function forms a deep abdominal corset controlling lumbo-pelvic joints during dynamic and static functional tasks. This pattern of motor control is lost in low back pain patients (Richardson *et al.*, 1999: 6).

It has been said that core stability is, in essence a description of the muscular control required around the lumbar spine to maintain functional stability. Core strengthening has been used as a preventative regimen, as a form of rehabilitation and as a performance-enhancing program for various lumbar spine and musculoskeletal injuries (Akuthota and Nadler, 2004).

2.5.1. CORE STABILITY IN RUNNERS

It has been said that core stability is not just a matter of activating a few of the targeted core muscles, but rather that the core muscles be viewed as a so-called moving target. The core muscles should be approached as a three-dimensional system, which is concerned with support; anticipation of unexpected loads; and to ensure sufficient stiffness in any degree of freedom of the joint which may be compromised due to injury. Motor control fitness is essential to achieving the stability target under all possible conditions for performance and injury avoidance (McGill *et al*., 2003).

Coordinated muscle activity produces the athletic activity necessary for a sport, and the role of muscle co-ordination in athletic function cannot be underestimated. Trunk strength is an important treatment method for back pain and can prevent back injuries (Watkins, 1996: 142).

Training programs of many athletes are including lumbopelvic stability training, as a high degree of lumbopelvic stability may contribute to athletic performance by aiding in more efficient transmission of forces which are generated by the lower body through the trunk to the upper body (Mills *et al*., 2005). Mills *et al.* (2005) state that expert opinion from observation suggests that an inability to stabilize the lumbopelvic region during running leads to poor technique and inefficient application of force.

2.5.2. CORE STABILITY IN NON-RUNNERS

There are many exercise programs that are prescribed for patients with spinal pain however, these exercise programs focus primarily on strength, endurance, fitness and functional capacity training. These general programs are appropriate in the late stages of rehabilitation, and are of value in the de-conditioned patient, as they provide greater general muscular support for the spine (Jull and Richardson, 2000). Jull and Richardson (2000) suggest that these exercise programs may not directly address the physical impairments in the neuromuscular system associated with the onset of low back pain, and that a key impairment in the muscle system is one of motor control, rather than one of only strength.

Jull and Richardson (2000), state that links are emerging between low back pain and motor control deficits in muscles of the local system, notably the transversus abdominis and lumbar multifidus. These muscles seem to lose their normal anticipatory function in patients with low back pain, exhibiting delays in activation and thus a loss of their normal pre-programmed function for support. In contrast to patients without low back pain, the tranversus abdominis appears to be unable to function independently of the other abdominal muscles in patients with low back pain.

2.6. TREATMENT OF LOWER BACK PAIN IN RUNNERS AND NON-RUNNERS

2.6.1. MANIPULATION

Manipulation is a high velocity, low amplitude thrust, which is performed at the end range of motion of a joint (Norris, 1998:355). Potential hypotheses for the working mechanism of spinal manipulation are: (i) release for the entrapped synovial folds; (ii) relaxation of hypertonic muscle; (iii) disruption of articular or peri-articular adhesions; (iv) reduction of disc bulge; (v) mechanical stimulation of nociceptive joint fibres; (vi) change in neurophysiological function; and (vii) reduction of muscle spasm (Van Tulder *et al.*, 2005).

2.6.2. MOBILIZATION

This technique is employed when pain and protective spasm limit physiological movement. By mobilizing a restricted joint(s), normal physiological range of motion and pain reduction may be achieved. Mobilization aims to improve joint mobility and reduce pain by using accessory movements of the involved joint(s) to reach normal joint range of motion (Norris, 1998: 354, 355).

2.6.3. MASSAGE

Massage is the manipulation of soft tissues namely muscles and fascia by using the hands or a mechanical device. Massage is utilized to promote circulation and relaxation of muscle spasm or tension. Massage is thought to offer symptomatic relief of pain through physiological and mental relaxation as well as by increasing pain threshold (Van Tulder *et al.*, 2005).

2.6.4. TRIGGER POINT PRESSURE RELEASE

Trigger point pressure release is the application of slowly increasing, non-painful pressure over a trigger point until a barrier of tissue resistance is encountered. Thereafter, contact is maintained until the tissue barrier releases and pressure may then be increased in order to reach a new barrier to eliminate the trigger point tension and tenderness (Travell and Simons (a), 1993: 8 vol. 1).

2.6.5. DRY NEEDLING

Trigger points are identified by spot tenderness in a palpable taught band, and then an acupuncture needle is inserted into the trigger point. Dry needling frequently causes post-injection soreness. However, dry needling is an effective technique for inactivating trigger points and relieving pain caused by trigger points (Travell and Simons (a), 1993: 163 vol. 1).

2.6.6. CORE STABILITY EXERCISES (LUMBOPELVIC STABILIZATION EXERCISES)

Core stability exercises aim to ensure that contraction of the transversus abdominis and multifidus are sufficient to control lumbar spine position with increasing loads. These exercises consist of formal exercise training programs and functional exercise programs related to the patient’s daily living activities (Richardson *et al.,* 1999: 150). Core stability exercises utilize the principle of minimizing forces applied to the lumbar spine during functional activities and to ensure that the deep local muscle system is operating to stabilize the individual spinal segments (Richardson *et al.,* 1999: 17).

The performance of any core stability exercise must be preceded by a conscious activation of the deep muscles by gently drawing in the abdomen. Load is gradually added through a variety of exercises. Load can be applied through body positioning, challenging the muscle system by decreasing the stability of the body position, use of equipment or the direct application of increasing load (Richardson *et al.*, 1999: 150).

2.6.7. MEDICATION

"Acetaminophen (paracetamol), mild opioids and non-steroidal anti-inflammatory drugs are the first line drugs for low back pain, but there is no evidence to suggest the one is more effective than the others" (Mens, 2005). The indications for analgesics and NSAIDs are very similar and both are prescribed primarily for pain relief (Mens, 2005). When using medication for chronic low back pain lasting benefits occur if the medication is used to control pain while activity levels are increased and function is improved (Mens, 2005).

3. SUMMARY

An increasing body of literature suggests that athletes cannot rely only on sport specific activities, but instead must train this unique group of muscles in order to allow for optimum functioning of these muscles during sporting activities. The majority of studies conducted in relation to core stability, and its relevance to sporting activities, seem to focus predominantly on contact sports, which involve bursts of activity. It is therefore not known the extent to which core stability contributes to LBP in the endurance athlete, and to what extent it differs from non-runners. Despite its widespread use, research in core strengthening is meagre (Akuthota and Nadler, 2004) therefore this study is aimed at filling in a niche in the body of literature.

CHAPTER THREE – MATERIALS AND METHODS

3.1. INTRODUCTION

This chapter will include a detailed description of the study design, patients selected to participate in this study and the methods of evaluation of core stability utilised in this study. The measurements obtained and the statistical procedures used in the analysis of the data will be discussed.

This research intended to focus on the subset of patients who have activity related LBP (namely running) and non-runners with chronic LBP without clear neurologic, spondylitic, or complicating symptoms (Drezner and Herring, 2001). Asymptomatic runners and non-runners were evaluated as control groups.

3.2. THE STUDY DESIGN

This study was designed as an exploratory cross-sectional study conducted in order to determine whether a relationship between core muscle strength and chronic lower back pain in amateur female road - runners and non-runners exists. The unit of analysis was female runners.

3.3. SAMPLE SIZE

The sample group for this study consisted of forty patients. The study consisted of 4 groups with 10 subjects in each group – N=40. For statistical purposes, groups were named Group A to D.

Group sizes of 10 each allowed a statistically significant difference to be detected at the 95% level of confidence and 80% power if mean differences were at least as large as 8 mmHg and SD's of the groups are no larger than 6 mmHg.

Group A: Runners with chronic LBP n=10

Group B: Runners without chronic LBP n=10

Group C: Non-runners with chronic LBP n=10

Group D: Non-runners without chronic LBP n= 10

3.4. THE SUBJECTS

3.4.1. PARTICIPANT SELECTION

Participants were recruited through advertising posters and flyers (Appendix 12) at local running clubs, physiotherapists, biokineticists, general practitioners and local newspapers. Flyers were distributed at various running races in the greater Durban area and at the Comrades Experience at the Durban Exhibition Centre.

The participant evaluation and selection process began with all possible participants undergoing a cursory interview (Appendix 1) with the researcher in order to exclude subjects that did not fit the criteria for the study. Participants successfully complying with this interview were evaluated at a single consultation, during which each of them received: a letter of information (Appendix 7); signed an informed consent (Appendix 8) form explaining the study, allowing them to withdraw at any time from the study with no repercussions. To determine whether subjects could participate in the study: a brief medical history and specific lower back history (Appendix 3), physical examination (Appendix 4) and lower back regional examination (Appendix 5) were performed. Core muscle strength and endurance measurements were then taken, and were recorded on a data collection sheet (Appendix 6).

The required number of participants in this study was forty. This total of forty was divided into four groups consisting of ten each: Group A to D as described in 3.3.

3.4.2. SAMPLING PROCEDURE

A systematic sampling technique was used in this study, whereby subjects were placed into the relevant group following a telephonic screen. A telephonic screen or interview (at the Comrades Experience) (Appendix 1) was utilized to determine whether subjects met all inclusion criteria. This consisted of determining the severity of pain by using the numerical pain rating scale (Appendix 2) and a series of questions pertaining to the relevant inclusion and exclusion criteria. Subjects were required to have pain of more than 12 weeks duration – either persistent or intermittent - with a numerical rating score of 2-5 and were required to run >35 kilometers per week for more than 6 months (only pertained to Group A and Group B).

Points (a) and (b) below indicate the screening questions which were asked prior to subjects being included or excluded from this study, according to whether potential subjects are runners or non-runners:

a) <u>Runners</u>

Prospective subjects were asked questions the following questions, in order to determine that running was the cause of LBP:

i) Age
ii) Mileage per week
iii) Period of time that LBP was present.
iv) The severity of the LBP by means of the numerical pain rating scale (NRS).

The nature of the study was explained at this point. Subjects were provided with a letter of information, and were required to sign an informed consent form at the start of the consultation.

b) <u>Non-runners</u>

Prospective subjects were asked the following questions to determine the severity and duration of LBP:

i) Age
ii) Period of time that LBP was present.
iii) The severity of the LBP by means of the numerical pain rating scale (NRS).

The nature of the study was explained at this point. Subjects were provided with a letter of information, and were required to sign an informed consent form at the start of the consultation.

The level of activity of the non-runners was not recoreded.

The letter of information, informed consent form and NRS were in English, as subjects were required to converse in English as a first or second language in order for subjects to understand instructions form the researcher regarding performance of measurement tests.

Subjects underwent a medical case history, physical examination and lumbar spine regional examination, before commencing measurements.

3.5. INCLUSION AND EXCLUSION CRITERIA

Inclusion criteria

1) Female road runners and non-runners between 25-40 years of age were considered for the study in order to maintain a homogenous sample group. Female subjects were included in this study, as demographics have shown that female gender is related to a higher risk of developing LBP (Macfarlane *et al*., 2006). Differences

between male and female anatomy and physiology were taken into account, and it was therefore found to be favorable to focus exclusively on a specific gender.

2) Participants were required to run >35 km per week for more than 6 months (this only pertains to runners). A mileage of 35 km per week was selected, as it has been said that there is a clear, positive association between weekly mileage and running injury rate (Wang *et al.,* 1993).

3) The body mass index (BMI) of all subjects (runners and non-runners) was calculated. The BMI was calculated by dividing the weight of the subject by the height of the subject squared:

$$\text{Weight (kg)}/\text{Height}^2\text{ (m)} = \text{BMI}$$

The normal BMI range, which was utilized for the purpose of this study, was a BMI of 18.5 to 24.9 kg/m^2 (Haslett *et al.,* 2002). This eliminated patients who were overweight or underweight according to the BMI, as this may have influenced the results if the section of the population was evaluated was too broad. Macfarlane *et al.* (2006) suggest that obesity may cause a greater risk for developing LBP therefore for the purposes of this study a narrow BMI was selected as an inclusion criterion so as to ensure that sample groups remained homogenous, and this also reduced the number of causative factors for LBP.

4) Criteria for LBP:
   i) Numerical pain rating between 2-5, as this is a range that is considered to be mild to moderate pain. This eliminated patients with severe pain from the study, as severe LBP may result in reflex pain inhibition of the affected segmental muscles (Richardson *et al.*,1999: 6).

ii) Pain present for 12 weeks or more (Guerriero *et al.,* 1999), and may be persistent or intermittent in nature. This time frame was put in place to ensure that subjects were no longer in the sub-acute phase of LBP. Intermittent pain was also included, as it allowed for subjects who did not experience constant pain over a 12 week period to be included in the study.

iii) Presence of quadratus lumborum, gluteus medius or erector spinae myofascial trigger points, found on lumbar spine regional examination.

iv) A positive result for any of the following orthopedic tests on lumbar spine regional examination: facet joint challenge of any joint from L1-L5; Patrick Faber test; Erichson's test; Sacro-iliac compression.

5) Subjects in Group A were symptomatic female runners who have run >35 km per week for more than 6 months.

6) Subjects in Group B were asymptomatic female runners who have run >35 km per week for more than 6 months.

7) Subjects in Group C were symptomatic female non-runners with chronic LBP.

8) Subjects in Group D were asymptomatic female non-runners.

Exclusion Criteria

1) Lumbar spine surgery (Van Dillen *et al.,* 2001)
2) Pregnancy (Van Dillen *et al.,* 2001)
3) Severe kyphosis or scoliosis (Van Dillen *et al.,* 2001)
4) Spinal stenosis (Van Dillen *et al.,* 2001)
5) Neurological disease (Van Dillen *et al.,* 2001)
6) Cancer (Van Dillen *et al.,* 2001)
7) Pain cannot be present for less than 12 weeks (Guerriero *et al.,* 1999)
8) Recent significant trauma to the lumbar spine – within the past year.
9) Nerve root entrapment (Descarreaux, 2002)
10) Inflammatory arthritides (Descarreaux, 2002)

Those subjects that were rejected i.e.: subjects who did not meet the inclusion criteria were referred to other interns in the Chiropractic Day Clinic for treatment of their condition.

3.6. DATA COLLECTION

3.6.1 LOCATION

Data were collected at the Chiropractic Day Clinic at the Durban Institute of Technology, at the Comrades Experience and at a chiropractor's practice in Durban.

The Comrades Experience is for the purpose of registration for the Comrades Marathon. The Comrades Experience took place from the 12 June 2006 to 15 June 2006. By conducting assessments at the Comrades Experience, it allowed for direct access to the population of female runners who corresponded with the criteria for this study. Permission for utilizing the Pressure Biofeedback Unit off-campus at the Comrades Experience and at the chiropractor's practice was obtained by means of a letter addressed to the Head of the Department of Chiropractic.

3.6.2. SUBJECTIVE MEASUREMENT

The numerical pain rating scale (NRS) was utilized to determine the severity of the pain and the subjects' pain score was rated between 2-5. The NRS was in English, as it has not been validated in Zulu. This scale may have been interpreted differently in a language other than English, and this could have influenced the results.

3.6.3. DATA COLLECTION TOOLS: THE PRESSURE BIOFEEDBACK UNIT

The data collection tool was the pressure biofeedback unit (PBU). The PBU provided numerical readings, which were used for the purpose of statistical analysis. The PBU provided objective readings, which represented core stability muscle activation.

The PBU consists of an inelastic, three section air-filled bag which is inflated in order to fill the space between the target body area and a firm surface, as well as a pressure dial for monitoring the pressure in the bag for feedback on position (Richardson *et al*., 1999). The bag was inflated to an appropriate level for the purpose and the pressure was recorded. The movement of the body part off the bag resulted in an increase in pressure (Richardson *et al*., 1999).

The device has come into general use for all parts of the body. However, its use in assessing the abdominal drawing in action has become its most important use in relation to the treatment of problems of the local muscle system in LBP patients. The pressure biofeedback unit was found to meet the need for quantification of the abdominal draw in action (Richardson *et al*., 1999).

Mills *et al.* (2005) state that lumbopelvic instability is defined as a deviation of the lumbar spine and pelvis from an arbitrarily defined neutral position, and is demonstrated by a change in cuff pressure, which is indicated on the PBU.

As the transversus abdominis produces narrowing of the abdominal wall, measurement of the amount of movement of the abdomen that is produced provides a method of identifying a patient's ability to perform the contraction (Richardson *et al*., 1999).

The principle of using the PBU was that when the unit was placed under the abdomen, initially it conformed to the patient's shape. As the patient drew in the stomach off the pad, the pressure in the pad was indicated as reduced on the pressure dial (Richardson *et al*., 1999). The pressure reduction was proportional to the degree to which the subjects could elevate the abdominal wall.

The specific construction of this device has considerable advantages: First, since the material is inelastic it can accurately reflect abdominal wall motion without distortion. This is assisted by the partitioning of the device into three sections, which assists with the distribution of the air within the pad. When the device is positioned appropriately, the shape of the pad permits an evaluation to be made of the movement of the abdomen (Richardson *et al*., 1999). The same PBU was utilized throughout the testing process in order to prevent any intra-rater reliability issues as a result of using two different units.

3.6.4. OBJECTIVE MEASUREMENTS

Subjects were shown how to perform the required core muscle contraction, before commencing the abdominal draw in test and the test for lumbopelvic posture. The four point kneeling position was used for the purpose of demonstrating to subjects how to recruit the transversus abdominis (TA) and elicit a core muscle contraction.

The four point kneeling position (Appendix 9) allowed subjects to be shown how to activate and isolate the TA, such that assessment could be performed accurately. The position the subject assumed in the four point kneeling position was such that they were relaxed with the hips over the knees and the shoulders over the elbows. Subjects were instructed to breathe in and out, then without breathing in, slowly draw the lower part of the abdomen up and in towards the spine without movement of the trunk or pelvis. Normal breathing was resumed once the contraction had been performed and was to be sustained for a period of 10 seconds (Richardson *et al*., 1999: 111).

Subjects were also instructed to maintain a steady position of the spine, and to avoid deep inspiration in order to prevent abdominal wall movement (Richardson *et al.,* 1999: 110). By issuing these instructions, it allowed for subjects to perform an isolated TA contraction while performing the abdominal draw in test, and the test for lumbopelvic posture.

The abdominal draw in test (Appendix 10) was performed with the subject in a prone lying position, and the PBU was utilized at this point in order to evaluate the ability of the subject to perform this abdominal isolation test (Richardson *et al*., 1999: 111). The prone position made the isolated abdominal contraction more challenging and therefore eliminated some of the stimuli present in the four point kneeling position.

The PBU was placed under the abdomen with the navel in the center and the distal edge of the pad in line with the right and left anterior superior iliac spines. The PBU was then inflated to 70 mmHg and was allowed to stabilize, allowing for detection of fluctuations in pressure due to normal breathing, which may be approximately 2 mmHg for each inhalation and exhalation. Subjects were instructed to perform an abdominal contraction identical to that of the four point kneeling position (Richardson *et al*., 1999: 113).

A normal reading was a reduction of 6-10 mmHg as the subject performed a core contraction this indicated that subjects were able to contract the TA successfully. A sudden rise in pressure indicated fatigue (Richardson *et al.,* 1999: 114).

Once the subject performed this test successfully, there was a two-minute rest period. Following the two-minute rest period an endurance test was performed, whereby the above procedure was repeated, but the subject was required to maintain the core contraction for as long as possible. This was measured with a stopwatch and was measured in seconds (s). During this test, the researcher closely monitored the pressure gauge of the PBU and monitored the subject to detect whether any compensatory mechanisms were being employed, this included movements of the pelvis and spine, breath holding and rib elevation.

The test for lumbopelvic posture (Appendix 11) was also performed. This test examined the ability of the trunk muscles to hold the lumbopelvic region in a steady position during progressive levels of leg loading (Richardson *et al.,* 1999). Subjects were in "the supine crook lying position, as this permits monitoring of a stable or unstable lumbopelvic position with the applied leg load, without extraneous movement variables arising from the body sway and balance" (Richardson *et al.,* 1999: 118). The PBU was placed under the lumbar spine in order to identify movement of the lumbopelvic region. The PBU provided a measure of movement away from the neutral position. Measurements were taken bilaterally for assessment in the saggital, plane as well as bilaterally for assessment of rotary bias.

If leg loading was directed in the saggital plane, the PBU was placed across the lumbar spine with its base at the S2 level. If the leg load emphasized a rotary bias, the PBU was placed longitudinally along the lateral aspect lumbar spine on the side that was to be evaluated. The PBU was inflated to 40 mmHg. A core muscle contraction and posterior pelvic tilt was performed and maintained before any leg loading occurred. The abdominal draw in contraction was maintained throughout the test. Subjects were required to maintain 40 mmHg on the pressure gauge while performing a series of leg loading movements. As the core muscle contraction was performed, the pressure increased slightly and the subject was instructed to maintain this pressure throughout the testing procedure. The leg loading movements were graded according to the point at which the patient could no longer maintain the posterior pelvic tilt.

The test was demonstrated to the subjects. Thereafter, subjects were required to perform a "practice test" to ensure that subjects understood the requirements of the test. Following a two-minute rest period after the practice test, the actual test commenced.

The legs were placed in the adducted position to measure saggital control and with the legs abducted when assessing for rotary control.

Leg slide procedure for the purpose of this study:

The subjects were required to slide the "test leg" into extension along the examination surface either with the heel in contact with the examination surface or 5 centimetres above it, depending on which stage of the testing was being conducted. The subject was then required to bring the leg back along the examination surface to the starting position.

Grade 1:

a) Single leg slide was performed with contralateral leg support, the test leg slides the heel down the surface of the examination surface.
b) Unsupported leg slide was performed with the heel of the test leg held approximately 5 cm from the examination surface.

Grade 2:

a) Single leg slide with the contralateral leg unsupported. The test leg slides the heel down the surface of the examination surface.
b) Unsupported leg slide with the contralateral leg unsupported, and the test leg was held approximately 5cm from the examination surface.

At the point when the leg load exceeded the muscle capacity, there were changes in the reading on the pressure gauge, either up or down, depending on whether the leg load was emphasizing saggital or rotatory bias (Richardson *et al.*, 1999).

Subjects were allocated a grading at the point at which they could not maintain the core muscle contraction. Subjects with poor control showed significant pressure changes on leg loading at grade 1 a (poor control) and 1 b (below average control) and were not able to complete grade 1 procedure. Subjects with good control showed minimal pressure changes with leg loading and were able complete the procedure up to grade 2 a (good control) and 2 b (excellent control).

3.7. STATISTICAL ANALYSIS

A p value of < 0.05 was considered as statistically significant. SPSS version 13.0 (SPSS Inc., Chicago, Illinois, USA) software was used for analysis.

Independent 2 sample t-tests were used to compare mean values in 2 groups: LBP and non-LBP separately for runners and non-runners (intra-group analysis). Inter-group analysis compared values between runners and non-runners, accounting for LBP. This was done using a generalized linear model (GLM).

CHAPTER 4 – RESULTS AND DISCUSSION

4.1. STATISTICAL ANALYSIS

Data were analyzed using SPSS version 13.0 (SPSS Inc., Chicago, Illinois, USA). A p value of <0.05 was considered as statistically significant. Parametric testing was used to compare groups since the quantitative dependant variables were reasonably normally distributed. Independent t-tests were used to compare quantitative outcomes between two independent groups and ANOVA, with post hoc Bonferroni tests was used when there were more than 2 groups to compare. Pearson's correlation coefficients and p values were reported to determine relationships between two quantitative variables.

4.2. RESULTS

4.2.1. DEMOGRAPHICS

Demographic data are shown and compared between the two groups: runners and non-runners. There were 20 participants per group (n=40 in total). The mean age of the runners was 35.5 years (SD 5.54) and the mean age of the non-runners was 33.2 (SD 6.48). There was no significant difference between the mean ages of the two groups (p=0.225). Weight, height and BMI were also not significantly different between the runners and the non-runners (p=0.802, 0.210 and 0.227 respectively). Table 1 shows the summary statistics and comparison of the two groups with respect to these variables.

Table 1: Summary statistics and comparison of demographics between runners and non-runners

	Group	N	Mean	Std. Deviation	Std. Error Mean	p value
Age	Runner	20	35.5	5.539	1.239	0.225
	Non runner	20	33.1	6.475	1.448	
Weight (kg)	Runner	20	58.7	5.025	1.124	0.802
	Non runner	20	59.2	6.187	1.383	
Height (cm)	Runner	20	166.6	6.046	1.352	0.210
	Non runner	20	163.6	8.598	1.923	
BMI	Runner	20	21.1	1.3108	.2931	0.227
	Non runner	20	21.7	1.7679	.3953	

The average mileage done by the 20 runners was 47.7 km (SD 16.9 km) with a range from 35 to 90 km per week. The average baseline NRS of the participants with back pain was 3.25 (SD 0.79) with a range from 2 to 5.

REMARKS:

The comparison of demographics shows two homogenous groups (runners and non-runners), which adds strength to the findings of this study, although the sample size is small.

4.3. PRIMARY RESEARCH OBJECTIVES

4.3.1. OBJECTIVE 1

To determine whether differences in core muscle strength (trunk muscle strength) exist between female runners with chronic LBP and those without LBP.

Table 2 shows the comparison in mean measures of core muscle strength between the runners with LBP and runners without LBP. It can be seen that there was no significant difference between the runners with LBP and the runners without LBP in terms of the abdominal draw in test (test 1 measure 2), the difference between the set value of 70 mmHg and the fluctuation from this value during core contraction (p=0.596). However, with regard to the time of sustained core contraction (test 1 measure 3) there was a statistically significant difference (p=0.009), with the runners without LBP having much higher mean contraction time than the runners with LBP. Also the test for saggital bias (test 2 measures 3 and 4) values were significantly higher in runners without LBP (p=0.016 and 0.002 respectively). The test for rotary bias (test 3 measures 3 and 4) showed borderline non-significant differences between those with and without LBP, with those runners with LBP having higher values than those without LBP (p = 0.062 and 0.058 respectively).

Table 2: Summary statistics for Runners: Comparison of core muscle strength between those with and without LBP

	LBP	N	Mean	Std. Deviation	Std. Error Mean	p value
Test 1 - measure 2 (mmHg)	no	10	11.8	2.201	.696	0.596
	yes	10	11.0	4.137	1.308	
Test 1 - measure 3 (seconds)	no	10	379.5	289.036	91.401	0.009*
	yes	10	73.6	72.676	22.982	
Test 2. Measure 3	no	10	34.4	2.633	.833	0.016*
	yes	10	30.6	3.658	1.157	
Test 2. Measure 4	no	10	33.8	3.938	1.245	0.002*
	yes	10	28.6	1.350	.427	
Test 3. Measure 3	no	10	34.0	2.667	.843	0.062
	yes	10	31.2	3.553	1.123	
Test 3. Measure 4	no	10	33.8	3.824	1.209	0.058
	yes	10	30.8	2.700	.854	

- Statistically significant at the 0.05 level (2-tailed).

REMARKS:

Muscle spasm and reflex inhibition of the trunk muscles that contribute to the development of de-conditioning syndrome may account for the fatigue that the symptomatic patients experience while performing the abdominal draw in test and the test for saggital bias. However, this does not account for the lack of significant findings when evaluating readings from the test for rotary bias (Arokoski *et al*., 2001).

Richardson *et al.* (1999) acknowledge that the measurement of motor control problems – such as core muscle weakness – will always present difficulties in both the clinic and in research, in comparison to only measuring endurance of these muscle groups. This may account for the lack of clinically significant findings when assessing rotary bias. It is the opinion of the researcher that the test for rotary bias may be more difficult to perform when compared to the test for saggital bias and this may have had an effect on the readings obtained for the purpose of statistical analysis.

4.3.2. OBJECTIVE 2

Determine whether differences in core muscle strength exist between female non-runners with chronic LBP and those without LBP.

Table 3 shows the comparison in mean measures of core muscle strength between the non-runners with LBP and non-runners without LBP. It can be seen that there was a significant difference between the non-runners with LBP and the non-runners without LBP in terms of the abdominal draw in test (test 1 measure 2), the difference between the set value of 70 mmHg and the fluctuation from this value during core contraction ($p=0.016$). However, with regard to the time of sustained core contraction (test 1 measure 3) there was no significant difference ($p=0.735$). Also the test for saggital bias (test 2 measure 3) values were borderline non-significantly higher in non-runners without LBP ($p=0.094$), while test 2 measure 4 values were significantly higher in non-runners without LBP. The test for rotary bias (test 3 measures 3 and 4) showed non-significant differences between those with and without LBP, with those non-runners with LBP having slightly higher values than those without LBP ($p = 0.145$ and 0.404 respectively).

Table 3: Summary statistics for Non-runners: Comparison of core muscle strength between those with and without LBP

	LBP	N	Mean	Std. Deviation	Std. Error Mean	p value
Test 1 - measure 2 (mmHg)	no	10	12.4	2.633	.833	0.016*
	yes	10	9.6	2.066	.653	
Test 1 - measure 3 (seconds)	no	10	252.6	133.526	42.225	0.735
	yes	10	212.6	343.158	108.516	
Test 2. Measure 3	no	10	33.2	2.530	.800	0.094
	yes	10	30.6	3.893	1.231	
Test 2. Measure 4	no	10	33.8	2.573	.814	0.001*
	yes	10	29.8	1.989	.629	
Test 3. Measure 3	no	10	34.0	3.127	.989	0.145
	yes	10	31.8	3.327	1.052	
Test 3. Measure 4	no	10	32.0	3.399	1.075	0.404
	yes	10	30.8	2.860	.904	

- Statistically significant at the 0.05 level (2-tailed).

REMARKS:

The differences in measurements between the non-runners with LBP and the non-runners without LBP shows that the symptomatic non-runners were performing relatively weaker core contractions according to the readings taken from the PBU. This is supported by the suggestion that tests to assess lumbar multifidus and transversus abdominis muscle function, indicate that patients with LBP had difficulties in performance, in terms of lack of endurance of core muscle strength, that are not evident in those who did not suffer from back pain previously (Richardson *et al.,* 1999).

4.3.3. OBJECTIVE 3

To determine whether there is a relationship between LBP and core muscle strength in female runners and non-runners.

The presence of LBP significantly affected all measures of core muscle strength in both runners and non-runners combined, except for the abdominal draw in test measure 2, which showed a borderline non-significant difference with non-affected participants showing higher values than affected participants ($p = 0.053$). In all the other measures mean values were significantly higher in those without LBP. This is shown in Table 4.

Table 4: Summary statistics for runners and non-runners combined: Comparison of core muscle strength between those with and without LBP

	LBP	N	Mean	Std. Deviation	Std. Error Mean	p value
Test 1 - measure 2 (mmHg)	no	20	12.1	2.382	.533	0.053
	yes	20	10.3	3.262	.729	
Test 1 - measure 3(seconds)	no	20	316.0	228.595	51.115	0.029*
	yes	20	143.1	251.727	56.288	
Test 2. Measure 3	no	20	33.8	2.587	.579	0.003*
	yes	20	30.6	3.676	.822	
Test 2. Measure 4	no	20	33.8	3.238	.724	<0.001*
	yes	20	29.2	1.765	.395	
Test 3. Measure 3	no	20	34.0	2.828	.632	0.015*
	yes	20	31.5	3.364	.752	
Test 3. Measure 4	no	20	32.9	3.640	.814	0.045*
	yes	20	30.8	2.707	.605	

- Statistically significant at the 0.05 level (2-tailed).

REMARKS:

Referring to abdominal draw in measure 2, it is the opinion of the researcher that with respect to this study it appears that the ability to perform the core contraction is not lost, but rather that it is the endurance of the core muscles that is affected. This accounts for the ability to perform the core contraction effectively in both groups, but with a significant discrepancy in the time of sustained core contraction between the symptomatic and asymptomatic groups. The asymptomatic subjects were able to sustain a contraction significantly more effectively than the symptomatic group when being measured for the length of time which they could sustain the core contraction.

The results show that asymptomatic individuals have significantly greater core muscle strength overall in comparison to the symptomatic group. The literature confirms these findings: Jull and Richardson (2000) suggest that links are emerging between LBP and motor control deficits in muscles of the local muscle system, notably the transversus abdominis and lumbar multifidus – these muscles exhibit delays in activation and lose their normal pre-programmed function for support.

4.3.4. OBJECTIVE 4:

To compare runners and non-runners with regard to core muscle strength

Table 5 shows that there was no difference in any measure of core stability between runners and non-runners.

Table 5: Summary statistics for participants with and without LBP combined: Comparison of core muscle strength between runners and non-runners

	Runner (1)/Non-runner (2)	N	Mean	Std. Deviation	Std. Error Mean	p value
Test 1 - measure 2 (mmHg)	Runner	20	11.4	3.251	.727	0.675
	Non runner	20	11.0	2.714	.607	
Test 1 - measure 3 (seconds)	Runner	20	226.5	258.262	57.749	0.941
	Non runner	20	232.6	254.256	56.853	

Test 2. Measure 3	Runner	20	32.5	3.663	.819	0.598
	Non runner	20	31.9	3.463	.774	
Test 2. Measure 4	Runner	20	31.2	3.915	.875	0.591
	Non runner	20	31.8	3.037	.679	
Test 3. Measure 3	Runner	20	32.6	3.378	.755	0.779
	Non runner	20	32.9	3.339	.747	
Test 3. Measure 4	Runner	20	32.3	3.570	.798	0.401
	Non runner	20	31.4	3.119	.697	

Therefore it is evident from the results of this study that the presence of LBP significantly affected some measurements of core stability in both runners and non-runners, and that there was no difference in core stability between runners and non-runners.

4.4. SECONDARY RESEARCH OBJECTIVES

4.4.1. OBJECTIVE 5

To determine whether there is an association between BMI and poor core stability

Table 6 shows that there is no correlation between BMI and any of the measures of core stability. This could be due to the relatively narrow range of BMI's of study participants due to eligibility requirements of the study (range 19.1 to 24.2 kg/m^2, all within normal ranges). Perhaps a relationship would have been evident if there were underweight and overweight participants in this study.

Table 6: Pearson's correlation between BMI and measures of core stability

		BMI
Test 1 - measure 2 (mmHg)	Pearson Correlation	-.200
	Sig. (2-tailed)	.216
	N	40
Test 1 - measure 3(seconds)	Pearson Correlation	.116
	Sig. (2-tailed)	.474
	N	40
Test 2. Measure 3	Pearson Correlation	-.026
	Sig. (2-tailed)	.871
	N	40
Test 2. Measure 4	Pearson Correlation	-.119
	Sig. (2-tailed)	.466
	N	40
Test 3. Measure 3	Pearson Correlation	-.043
	Sig. (2-tailed)	.793
	N	40
Test 3. Measure 4	Pearson Correlation	-.254
	Sig. (2-tailed)	.114
	N	40

4.4.2. OBJECTIVE 6

To determine whether there is an association between mileage, LBP and poor core stability in runners

Table 7 shows that there was no association between mileage and LBP in runners (p=0.949). The mean mileage was similar in runners with and without LBP, which makes this a very comparable group.

Table 7: Comparison of mean mileage in runners with and without LBP

	LBP	N	Mean	Std. Deviation	Std. Error Mean	p value
Mileage (km)	yes	10	48.0	15.846	5.011	0.949
	no	10	47.5	18.745	5.928	

Table 7 shows that mileage was only correlated with time of core contraction (test 1 measure 3). The correlation coefficient was 0.580, indicating a weak positive correlation, which was nonetheless statistically significant (p=0.007). Thus the time of sustained core contraction was higher as the runner's mileage increased. Mileage was not correlated with any other measure of core stability.

Table 8: Pearson's correlation between mileage and measures of core stability

		Mileage (km)
Test 1 - measure 2 (mmHg)	Pearson Correlation	-.074
	Sig. (2-tailed)	.757
	N	20
Test 1 - measure 3 (seconds)	Pearson Correlation	.580(*)
	Sig. (2-tailed)	.007
	N	20
Test 2. Measure 3	Pearson Correlation	-.219
	Sig. (2-tailed)	.354
	N	20
Test 2. Measure 4	Pearson Correlation	-.053
	Sig. (2-tailed)	.826
	N	20

Test 3. Measure 3	Pearson Correlation	-.086
	Sig. (2-tailed)	.719
	N	20
Test 3. Measure 4	Pearson Correlation	.256
	Sig. (2-tailed)	.276
	N	20

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

REMARKS:

The results therefore show a positive correlation between mileage and core stability in terms of endurance. It appears that there is a relationship between higher mileage and a strong core region.

4.4.3. OBJECTIVE 7

To determine the average normal fluctuation of pressure readings from the abdominal draw in test

For this objective, only runners and non-runners without back pain were used, since it was previously determined that back pain affected their measurements. Table 9 shows the statistics for the 20 asymptomatic participants. Their mean pressure decrease was 12.10 with a range of 8 to 18. The standard error of the mean was 0.533, giving a 95% confidence interval of 10.9 to 13.1 mmHg. This means that we are 95% confident that the true population mean pressure decrease is between 10.9 and 13.1 mmHg.

Table 9 : Descriptive statistics for pressure reading fluctuation in asymptomatic participants

Test 1 - measure 2 (mmHg)

N	20
Mean	12.10
Std. Error of Mean	.533
Std. Deviation	2.382
Minimum	8
Maximum	18

REMARKS:

The mean values of the pressure readings taken during the abdominal draw in test reflected are not in keeping with the literature. A successful performance of the abdominal draw in test is indicated by a pressure reduction of 6mmHg – 10 mmHg, which conflicts with the mean pressure readings noted during this research of 10.96 - 13.15mmHg (Richardson *et al.,* 1999).

4.4.4. OBJECTIVE 8

To compare the average time which participants were able to sustain a core contraction between the 4 groups

The time which participants were able to sustain a core contraction was compared between the 4 groups with an ANOVA test in Table 10. It can be seen that there was a borderline non-significant difference between the 4 groups overall (p=0.052). Further Bonferroni post hoc tests were done to determine if there were any significant differences between any of the groups individually. The results are shown in Table 11. There was only a significant difference between symptomatic and asymptomatic runners (p=0.039). No other group differences existed with regards to this outcome. Figure 1 shows that the symptomatic runners had the lowest mean time of core contraction.

Table 10: ANOVA test to compare mean time of core contraction between the groups

Test 1 - measure 3(seconds)

	Sum of Squares	df	Mean Square	F	p value
Between Groups	476240.075	3	158746.692	2.830	0.052
Within Groups	2019693.700	36	56102.603		
Total	2495933.775	39			

Table 11: Bonferroni post hoc tests to compare differences in mean time of core contraction between individual groups

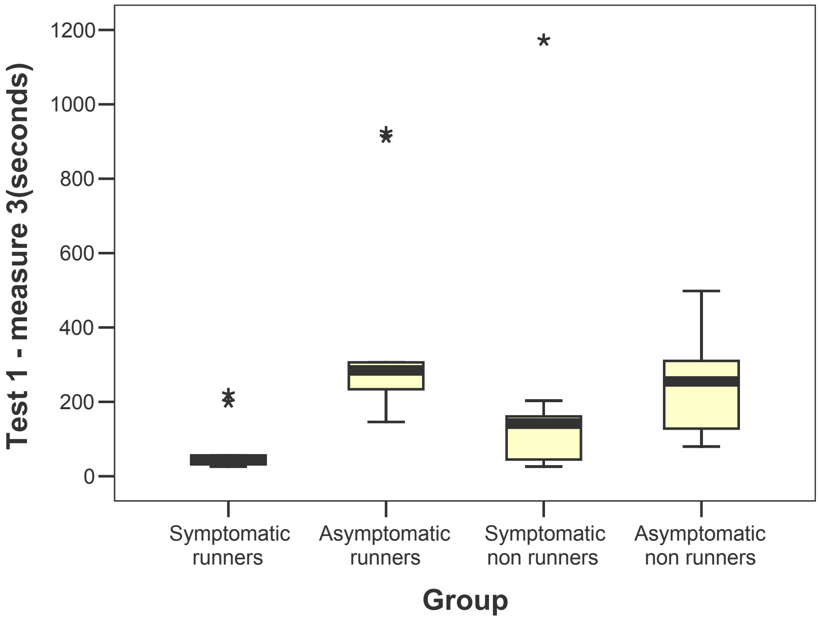
Dependent Variable: Test 1 - measure 3(seconds)

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	p value	95% Confidence Interval	
Symptomatic runners	Asymptomatic runners	-305.900(*)	105.927	0.039	-601.65	-10.15
	Symptomatic non-runners	-139.000	105.927	1.000	-434.75	156.75
	Asymptomatic non-runners	-179.000	105.927	0.598	-474.75	116.75
Asymptomatic runners	Symptomatic runners	305.900(*)	105.927	0.039	10.15	601.65
	Symptomatic non-runners	166.900	105.927	0.743	-128.85	462.65
	Asymptomatic non-runners	126.900	105.927	1.000	-168.85	422.65

Symptomatic non-runners	Symptomatic runners	139.000	105.927	1.000	-156.75	434.75
	Asymptomatic runners	-166.900	105.927	0.743	-462.65	128.85
	Asymptomatic non-runners	-40.000	105.927	1.000	-335.75	255.75
Asymptomatic non-runners	Symptomatic runners	179.000	105.927	0.598	-116.75	474.75
	Asymptomatic runners	-126.900	105.927	1.000	-422.65	168.85
	Symptomatic non-runners	40.000	105.927	1.000	-255.75	335.75

- The mean difference is significant at the 0.05 level.

Figure 1: Boxplot of the distribution of time of core contraction by group



5. SUMMARY

Hypothesis 1:

Female runners without LBP should have greater core muscle strength than female runners with LBP. This hypothesis is accepted.

Hypothesis 2:

Female non-runners without LBP should have greater core muscle strength than female non-runners with LBP. This hypothesis is accepted in terms of the measurements for the abdominal draw in test (test 1 measure 2): The fluctuation from the difference between the set value of 70 mmHg and the fluctuation from this value during core contraction was greater in non-runners without LBP. This also applies to the test for saggital bias. This hypothesis cannot be accepted in terms of time results for the abdominal draw in test and the non-significant differences when assessing for rotary bias.

Hypothesis 3:

A relationship between core muscle strength and LBP should be shown to exist in female runners and non-runners. This hypothesis is accepted for all measures of core muscle strength, as all the core measures were higher in asymptomatic subjects. However, it cannot be accepted for the abdominal draw in test, measure 2, which showed a borderline non-significant difference and the mean values were significantly higher in those without LBP.

Therefore within runners and non-runners and in the entire sample group, core muscle strength was significantly affected by low back pain. In this study it was demonstrated that no difference existed between the core strength of the two groups, which the researcher did not anticipate.

Runners and non-runners did not have significantly different core muscle strength. BMI did not affect core muscle strength either.

Although the two groups were similar in most respects, when applying intra-group comparison to the runners, for most measures of core stability, those who were symptomatic for LBP had significantly weaker core muscle strength when compared to the asymptomatic group. The time of sustained core contraction was only significantly different between symptomatic and asymptomatic runners, and not symptomatic and asymptomatic non-runners. Mileage was positively correlated to the time of sustained core contraction in runners. The 95% confidence interval of the true population mean pressure decrease for the abdominal draw-in test in asymptomatic runners and non-runners was between 10.9 and 13.1 mmHg.

Therefore with regards to the title of this study there is a relationship that exists between core muscle strength and chronic lower back pain in amateur female runners and in non-runners.

CHAPTER 5 – CONCLUSION & RECOMENDATIONS

CONCLUSION

This study intended to determine the relationship in core muscle strength and chronic lower back pain in amateur female road runners and non-runners, using the pressure biofeedback unit (PBU) as a measuring tool during a series of core stability tests in order to obtain objective findings. The focus was to determine the core stability values between amateur female runners with and without chronic LBP and female non-runners with and without chronic LBP; as well as to compare female runners and non-runners with regard to core muscle strength.

The literature suggests that the high incidence of running injuries is of great concern to researchers, as epidemiological studies associate running injuries with weekly running distance. Results of past studies have demonstrated that there is a linear, positive relationship between mileage and injury rate (Wang *et al*., 1993).

The findings of the study suggest that mileage plays an important role in core stability as the results show a positive correlation between increasing mileage and core muscle strength. This may indicate that those who have a higher weekly mileage may have greater core muscle strength in comparison to those running a lower mileage per week, however this should be viewed with reservation because of the possibility of a type 1 error. There was no significant difference in core stability between female runners and non-runners.

When specifically looking at runners, LBP has a substantial effect on endurance as shown by the clinically significant difference in core stability measures when applying intra-group comparisons of symptomatic and asymptomatic runners. It was found that symptomatic runners had significantly weaker core muscle strength overall. This could be explained by the nature of running, as repetitive movements, which may fatigue the supporting structures of the lumbar spine and thus cause reflex muscle spasm and pain (Drezner *et al.,* 2001). The eventual result of this process is that there may be reflex inhibition of the segmental muscles, which could perpetuate the pain cycle and have an adverse effect on posture, which is indelibly linked with core stability (Richardson *et al*., 1999).

This study has demonstrated a link between a deficit in core muscle strength and LBP in female runners and non-runners, as well as a positive correlation between increasing mileage and core muscle strength in runners. With the runners showing a greater level of endurance with regard to the core muscle contraction as the weekly mileage increased. It can also be concluded that there was no significant difference in core muscle strength between female runners and non-runners.

RECOMMENDATIONS

DURING THE RESEARCH PROCESS THE FOLLOWING POINTS WERE NOTED:

- 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 the level of fitness. Some subjects were endurance runners (ultra marathon and marathon runners) and others were middle distance runners, this may or may not have an effect on their core stability.
- The inclusion criteria for Group C and Group D could have been more specific in terms of how much activity these subjects were involved in. For example, subjects may have been non-runners, but may have been fit as a result of some other activity. It is therefore suggested that for the purposes of future studies, the inclusion criteria be more limiting for the level of activity of subjects.
- A similar study could be conducted by comparing male and female subjects and it might be relevant to investigate muscle recruitment during core testing, using electromyography or diagnostic ultrasound.
- 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.

CHAPTER SIX – REFERENCES AND APPENDICES

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LIST OF APPENDICES

APPENDIX 1

Questions to be asked during cursory interview:

Inclusion Criteria:

Runners:

- Are you between the ages of 25 and 45?
- Are you a runner?
- How many kilometers on average do you run per week?
- Do you suffer from lower back pain? (this allows for inclusion into symptomatic and asymptomatic groups)
- How long have you suffered from lower back pain?
- Please could you rate your back pain on a scale of 0 to 10 – 0 being no pain and 10 being excruciating pain.
- What is your weight and height?

Non-runners:

- Are you between the ages of 25 and 45?
- Do you suffer from lower back pain? (this allows for inclusion into symptomatic and asymptomatic groups)
- How long have you suffered from lower back pain?
- Please could you rate your back pain on a scale of 0 to 10 – 0 being no pain and 10 being excruciating pain.
- What is your weight and height?

Exclusion Criteria:

- Have you had any accidents that injured your lower back?
- Do you have a history of surgery, fracture or major injury to your lower back?
- Is here a possibility that you may be pregnant?
- Have you had a history of any of the following:

Inflammatory arthritides

Neurological disease

Cancer

Nerve root entrapment

Spinal stenosis

APPENDIX 2

Numerical Pain Rating Scale:

0 1 2 3 4 5 6 7 8 9 10

- Subjects will be required to circle the score which best indicates the severity of their pain.
- A pain score of zero indicates the absence of pain.
- A pain score of ten indicates severe pain.
- A pain score of five indicates moderate pain.

APPENDIX 3 - CASE HISTORY

APPENDIX 4 – PHYSICAL EXAMINATION

APPENDIX 5 – LUMBAR REGIONAL EXAMINATION

APPENDIX 6

DATA COLLECTION SHEET

Patient Name: ____________________ Date: ___________

Clinician: ________________________ Signature:__________________

NUMERICAL PAIN RATING SCALE

0 1 2 3 4 5 6 7 8 9 10

DEMOGRAPHIC INFORMATION:

Weight: _________________ Height: ___________________

Body Mass Index: $\frac{\text{Weight}}{\text{Height}^2}$ = _________________

Patient Age: ________ Mileage per week: __________

ABDOMINAL DRAW IN TEST

	Fluctuation of stabilizer from the set value of 70mmHg during core contraction (mmHg)	Difference between the set value of 70mmHg and fluctuation from this value during core contraction (mmHg)	Time of sustained core contraction (seconds)
Actual Endurance test			

TEST FOR LUMBOPELVIC POSTURE

	Grading		Fluctuation from set value of 40 mmHg at the point at which the subject cannot maintain core contraction (mmHg)		Difference between the set value of 40mmHg and fluctuation from this value at the point at which the subject cannot maintain core contraction (mmHg)	
	Right	Left	Right	Left	Right	Left
Test Saggital Bias						
Test Rotary Bias						

APPENDIX 7

Letter of Information

Dear Patient

Welcome to my study. My study is being conducted in order to determine whether a relationship exists between core muscle strength and the development of LBP.

Title of Study:

To Determine the Relationship Between Core Muscle Strength and Chronic Lower Back Pain in Amateur Female Road Runners and Non-runners.

Supervisors:	Dr. N.L. de Busser	(031) 204 2244
Research student:	Susan Leigh Martin	(031) 2042205
Institution:	Durban University of Technology	

Purpose of the study:

The purpose of this study is to determine whether a relationship exists between core muscle strength and the development of lower back pain. The participants will be placed into the following groups: 10 female runners with chronic LBP; 10 female runners without LBP; 10 female non-runners with LBP and 10 female non-runners without LBP.

Procedures

The consultation for this appointment will take place at the Comrades experience or at the Durban University of Technology. At this consultation, you will be required to have a case history taken, physical examination and lower back regional examination done. You will then be required to perform certain tests in order to assess core stability. This consultation will be approximately one hour long.

Risks/Discomfort

The testing of your core stability is relatively harmless, and the tests which evaluate core stability are painless and non-invasive.

Benefits:

Your contribution to this study, by volunteering to partake will help us Chiropractors to build on our knowledge. This will benefit you as a patient, as we will be able to provide you with more effective health care in the future. On completion of your participation of this study, you will be eligible for 1 free treatment at the Durban University of Technology Chiropractic Day Clinic.

New Findings:

You will be made aware of any new findings during the course of this study.

AS A VOLUNTARY PARTICIPANT IN THIS RESEARCH STUDY, YOU ARE FREE TO WITHDRAW FROM THE STUDY AT ANY TIME, WITHOUT GIVING A REASON.

Cost of the study

The testing procedure will be free of charge and your participation in this study is voluntary.

Confidentiality

All patient information is confidential. The results of this study will be used for research purposes only. Only individuals that are directly involved in this study (Dr. N.L. de Busser and myself) will be allowed access to these records.

Persons to contact should you have any problems or questions:

Should you have any questions that you would prefer being answered by an independent individual, feel free to contact my supervisors on the above numbers. If you are not satisfied with a particular area of this study, please feel free to forward any concerns to the Durban University of Technology Research and Ethics Committee.

Thank you for participating in my research study.

__________________ Date:__________________

Susan Leigh Martin
(Research Student)

APPENDIX 8

INFORMED CONSENT FORM

(To be completed by patient / subject)

Date :
Title of research project :

To Determine the Relationship Between Core Muscle Strength and Chronic Lower Back Pain in Amateur Female Road Runners and Non-Runners.

Name of supervisor: Dr. N.L. de Busser

Tel : (031) 204 2244

Name of research student: Ms. S.L. Martin

Tel : (031) 204 2205

Please circle the appropriate answer YES /NO

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

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

Please Print in block letters:

Patient /Subject Name:__________________________Signature: ________ ____

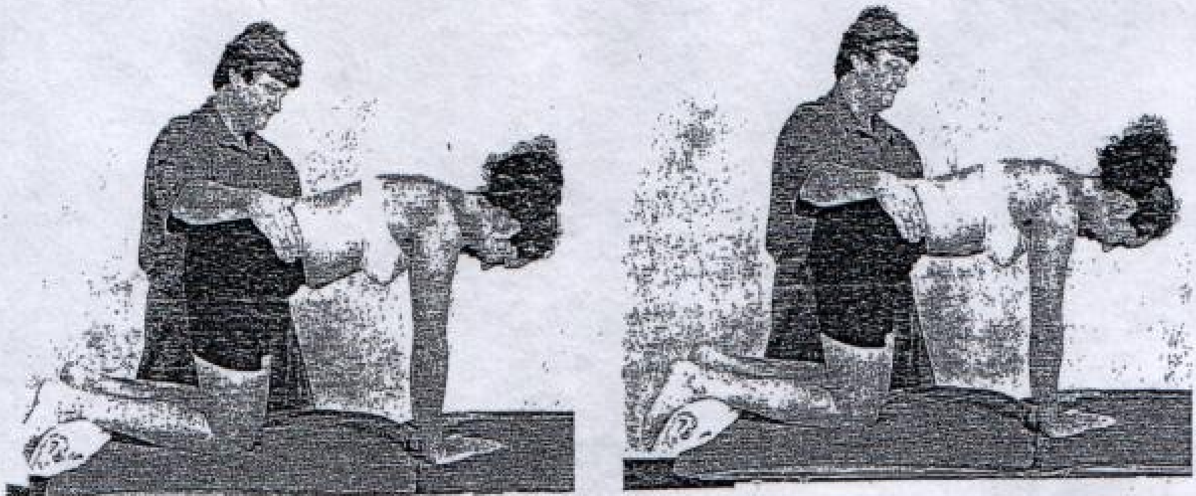
Witness
Name:___ __________________________Signature:______________

Research Student

Name:_____________________ Signature:_______________

APPENDIX 9: FOUR POINT KNEELING POSITION AND PROCEDURE

(Richardson *et al.*, 1999. pp. 110)



(a) (b)

Figure 8.4 Teaching the test action in the four-point kneeling position: (a) with the abdomen relaxed; (b) following the abdominal drawing-in action. Note the elevation of the lower abdominal wall.

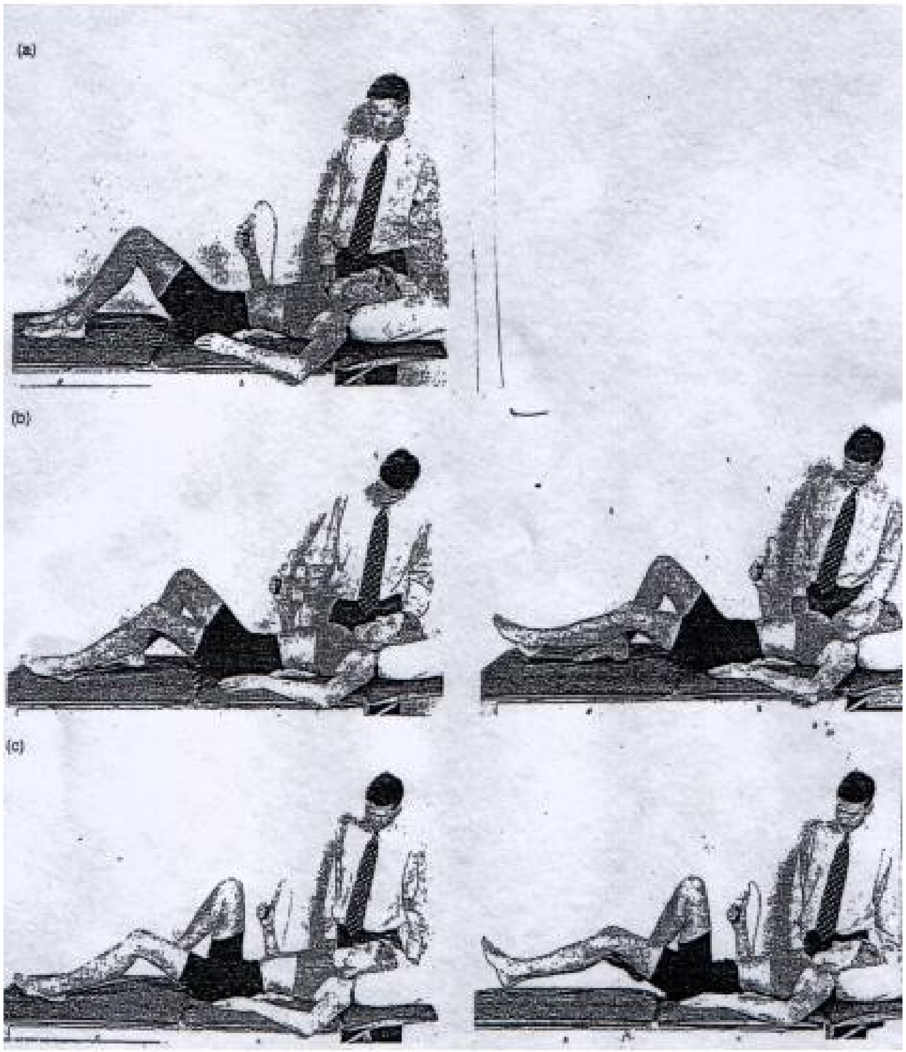
APPENDIX 10: ABDOMINAL DRAW IN TEST

(Richardson *et al.*, 1999. pp. 111)

Figure 8.5 The abdominal drawing-in test in the prone position. (Note: The arm is flexed so that the position of the biofeedback unit can be seen.)

APPENDIX 11: TEST FOR LUMBOPELVIC POSTURE

(Richardson *et al.*, 1999. pp. 120)



APPENDIX 12

Are you a Female Runner or Non-Runner between the ages of 25-45?

Female subjects are required to participate in research which is being conducted at the Chiropractic Day Clinic at **Durban University of Technology** to assess **core stability** in female runners and non-runners with and without **LOWER BACK PAIN.** For a **FREE** Assessment call

Sue Martin (031) 204 2205