A CROSS-SECTIONAL COHORT STUDY OF CORE STABILITY MUSCLE ACTIVATION AND ENDURANCE IN ELITE MALE ATHLETES AND ITS LINK WITH MECHANICAL LOWER BACK PAIN

by

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A dissertation submitted to the Faculty of Health Sciences, in partial compliance with the requirements for a
Master's Degree in Technology: Chiropractic at the
Durban Institute of Technology.

I, Natalie Robertson
do hereby declare that this dissertation represents my own work in both conception and execution, except where specific assistance is sought and duly acknowledged

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DEDICATION

It is with immense pleasure that I dedicate this dissertation to:

My parents: thank you for your continued sacrifice, support and encouragement. You have given me the greatest gifts of a wonderful upbringing and an excellent education. I am eternally grateful.

Thanks to Raydon for being my 'pillar of strength' and believing in me even when I lost hope. Your constant motivation during the project and throughout the course kept me going.

In memory of my late friend and colleague Donna Weyer-Henderson.

ACKNOWLEDGEMENTS

My special thanks to: -

Supervisor, Dr. C. Myburgh: I am eternally grateful to you for your supervision. Your assistance and input in this dissertation are highly appreciated.

Dr. C. Korporaal: I am forever indebted to you for taking time out of your extremely busy schedule to assist me at all times and make invaluable inputs. I consider myself truly blessed to have had the honour and pleasure of working with you.

In addition, I record my appreciation to the following people for their assistance with this dissertation: -

1. To all the patients who participated in this study, and who, through their contribution, made this study possible.
2. Mrs. T.M. Esterhuizen, Biostatistician, of Nelson R. Mandela School of Medicine for statistical support.
3. Mrs I. Ireland, Pat and Linda their assistance during my clinic years, and the period of this study.
4. My very, special friends; the class of 2000 for their love, support and providing humour during the project.

ABSTRACT

Objectives:

To compare the relative activation and endurance of core stability muscles in 2 different populations i.e. elite athletes and non-athletes, and establish whether these findings correspond to episodes of mechanical lower back pain.

Project Design:

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

Setting:

Patients presenting with no current lower back pain to the Chiropractic Day Clinic at the Durban Institute of Technology.

Subjects:

Adult, male patients, aged between 18 and 35 years of age, fitting into either the elite athlete category or the non-athlete category.

Outcome measure:

Decrease in pressure (in mm Hg) on a Pressure Biofeedback Unit and length of time (in seconds) a correct contraction of the core stability muscles was maintained.

Results:

It was found that there was no significant difference in the core stability strength between elite athletes and the general population, although the athletes did show a relatively increased endurance. In addition it was found that mechanical lower back pain had little if any effect on core stability performance.

***Conclusions*:**

The results of this study did not support the assumption that elite athletes have an increased core stability activation relative to the general population however athletes showed a significantly greater endurance than non-athletes. The elite athletes also tended to have more mechanical lower back pain than non-athletes.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Modern life for most individuals has meant a steady reduction in physical activity and an increasingly sedentary lifestyle (Back Care 2000). This is most probably due to the steady decrease in manual labour, an increase in labour- saving devices and the rise of more passive entertainments such as computer games and television. Unfortunately, the implication is that once strong muscle systems that helped us maintain ‘good’ posture and movement and prevented injuries, have grown weak through inactivity. In short, we have reduced our core stability.

The literature currently suggests that an increasing number of the population suffer from lower back pain, which can be linked to dysfunction of the core stabilizers (i.e.Transversus Abdominis (TA), Multifidus and the deep fibres of the Quadratus Lumborum) (Hodges et al. 1996b). Abdominal muscles, particularly those creating the deep abdominal wall, are considered essential in preventing back injury and ensuring optimal performance in physical activity (Davis, C., Laskowski E. 1998-2004.Mayo Foundation for Medical Education and Research). Similarly another author stated that core stability training was essential to sports performance and overall injury prevention (Quinn 2002).

The traditional assumption in the literature is that sportsmen/women are protected from back pain due to their higher level of abdominal muscle strength (Biering-Sorensen 1984). According to Biering-Sorensen (1984), people with an increased level of physical fitness from sports participation have a lower risk of low back pain. Most people know regular exercise will improve their appearance and general health, but few realize the positive effects that good physical conditioning can have on their lower back pain. It has been stated that a person in good physical shape is much less likely than the average person to injure their back during work or daily activities and various studies have shown dramatic reductions of lower back pain in individuals who are physically fit (Kolettis 2000). However, this “common sense” assumption may not necessarily have merit, therefore the common assumption that athletes are stronger than the general population in terms of core stability muscle strength would thus automatically mean that their incidence of lower back pain would be lower. This research was aimed at testing this assumption.

Should it be shown that this premise in fact does not hold true, we would be able to inform athletes of a correct and necessary training program for their core stabilizers, thus reducing possibility of injury and increasing the duration of their sports career.

However, should the premise that sportsmen have stronger core stabilizers hold true, then we would be able to encourage a greater number of people from the general population to partake in sports or more physical activity and possibly include core stability muscle training in their daily routines.

This study was aimed at investigating whether elite athletes have higher levels of core stability activation and endurance, than the sedentary population due to their intensity and frequency of training.

Ninety male subjects between the ages of 18-35 years were systematically sampled. Group A consisted of 60 athletes and will be selected and assessed first. Group B will be made up of 30 non-athletes, subdivided equally into a strictly sedentary population (Group Bs) and a moderately active population (Group Bm, not exercising or attending gym more than 2 times a week). Data collection will include a reading of a decrease in pressure in mm Hg on the Pressure Biofeedback Unit (PBU) for measuring activation ability and a time reading in seconds of the length of time the patients could sustain a correct static contraction of TA or their endurance ability. Relevant lower back data was gleaned through a systematic demographic data checklist.

1.2 Aims and objectives

The aims and objectives were to compare the relative activation and endurance of core stability muscles in 2 different populations and establish whether these findings correspond to past episodes of mechanical lower back pain.

Objective 1- To compare core stability activation and endurance between elite sportsmen and a matched cohort in the general population.

Hypothesis

It is hypothesized that elite sportsmen would have an increased core stability activation and endurance relative to the general population.

Objective 2- To establish whether core stability activation and endurance is associated with mechanical lower back pain.

Hypothesis

Subjects from either elite athletes or general population groups would have a decreased core stability activation and endurance if they had experienced mechanical lower back pain in the past.

In the remaining chapters the researcher will outline pertinent literature around the topic, describe the methodology of the study in detail and present the statistics, results and subsequent conclusions drawn from them.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter I will discuss recent literature pertinent to this study in order to present the status quo of literature on the topic. To begin with, I shall present pertinent epidemiological data on lower back pain itself in order to highlight its importance. This will be followed by a brief discussion of the relevant anatomy in order to orientate the reader. The main body of this chapter will be devoted to concepts related to core stability and its association with lower back injury. This will include views on both the sedentary as well as the elite athletic populace. I shall conclude this chapter with a discussion on the approach to treating and rehabilitating low back pain patients taking onto account all the literature reviewed here.

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

Studies on the prevalence and incidence of lower back pain (LBP) suggest that it is ubiquitous, probably the leading cause of disability and morbidity in middle-aged persons, and by far the most expensive source of workers' compensation costs in Ontario - as indeed in most other jurisdictions (Manga, 1993).

Other recently published papers have shown that an increasing number of the population suffer from lower back pain (LBP). Consider these statistics from the National Institute of Health:

- Seventy to 85 percent of all people have back pain at some time in their life.

- Back pain is the most frequent cause of activity limitation in people younger than 45 years old. (www.holyname.org/health_information_resources/health_manuals/Men/lowback.htm)

Another study revealed that most recent-onset lower back pain episodes settle but only one in three resolves completely over a 12-month period. About three in five will recur in an on-going relapsing pattern and about one in ten do not resolve at all (Kent et al. 2005).

From the above statistics one can see that LBP is indeed impacting greatly on our everyday lives and productivity.

2.3 The concept of core stability

The core muscles lie deep within the trunk of the body and act like a corset, taking pressure off the back. The key muscles involved function to stabilize the trunk and maintain the so-called neutral zone of the spine (Davis, C., Laskowski E. 1998-2004.Mayo Foundation for Medical Education and Research). According to Janda (1984):

> "The only available 'rational' treatment of chronic back pain syndromes and prevention of recurrences of acute pain is the patient's development of a perfect muscular corset."

Interestingly, as early as the 1920's, Joseph Pilates talked about developing a 'girdle of strength', by learning to recruit the deep- trunk muscles (Menezes, 2000). Even without a complete knowledge of anatomy and the benefits of the latest muscle activity research, he was very aware of the importance of these deep muscles and the supportive effect they produce.

2.3.1 Anatomy

In discussing the relevant anatomy it is important to remember that from a neuromuscular point of view the muscles of the trunk can be divided into an outer or global system, and a deep or local system. The global system consists of the large, torque producing muscles that are superficial and important for controlling spinal orientation and external loads, (rectus abdominus, internal oblique, external oblique, quadratus lumborum, erector spinae etc). The muscles of the local system are deep, lie close to the vertebrae and are capable of increasing stiffness between the spinal segments, and within the bony components of the pelvis (Jull et al. 2000). The major muscles involved are the transverses abdominis (TA), Multifidus, pelvic floor muscles, diaphragm and deep fibres of the quadratus lumborum (QL). There is substantial evidence indicating that in health the muscles of the local system possess defining motor control characteristics. Specifically they are anticipatory and non-direction specific in their activation (Richardson et al.1999). This means that they anticipate spinal and/or pelvic loading (regardless of its direction) and increase their activity slightly to augment the passive stability of the vertebral column and pelvis in preparation. Further evidence shows these characteristics are lost in LBP patients, and they do not spontaneously recover with the resolution of pain (Richardson et al.1999, Hides et al. 2001).

The attachments, actions and innervations of the three main core muscles are demonstrated in the figures below:

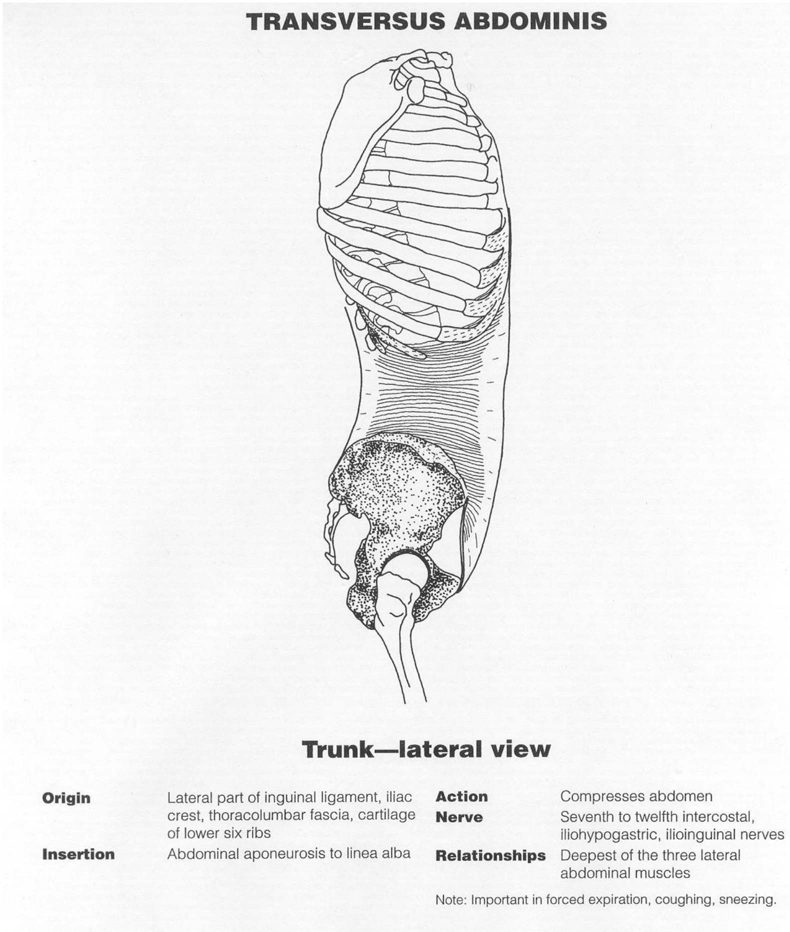


Figure 1- The left transversus abdominis muscle and its attachments, innervation and action (The University of Auckland, Bioengineering Institute, www.auckland.ac.nz).

In descriptions of abdominal morphology the regional anatomy of these muscles is conflicting and has not yet been comprehensively examined. In a recent study, Urquhart 2005, the orientation, thickness and length of the upper, middle and lower fascicles of TA and obliquus internus abdominis, and the upper and middle fascicles of obliquus externus abdominis were measured. The quantitative data of morphological differences collected between regions of these abdominal muscles, suggested a variation in function between muscle regions. And so proves that the TA does not function like other abdominal muscles.

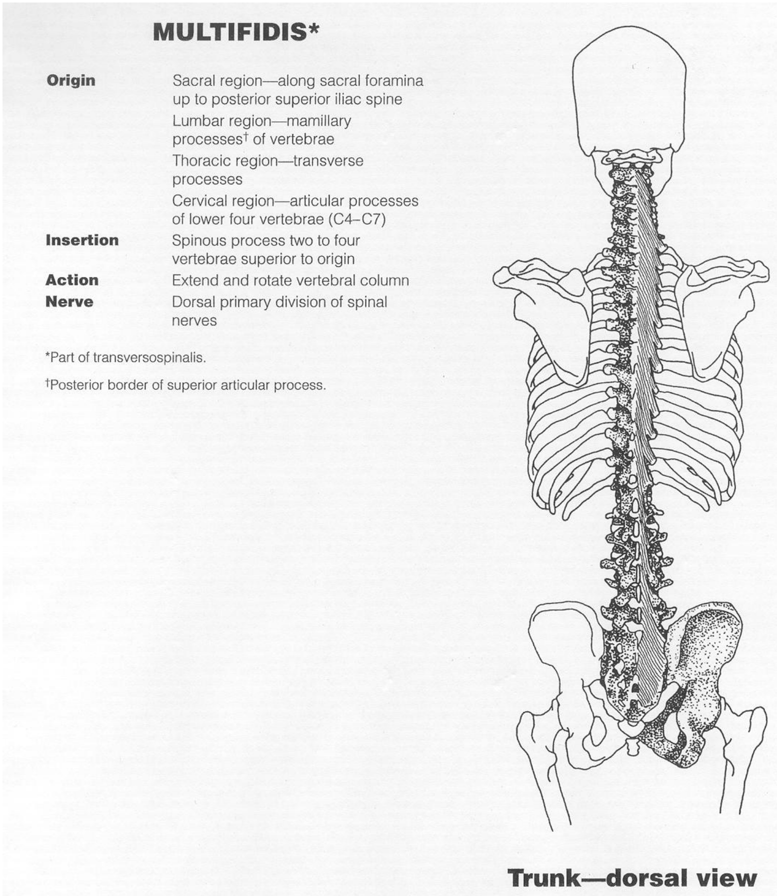


Figure 2- Multifidus muscle and its attachments, innervation and action (The University of Auckland, Bioengineering Institute, www.auckland.ac.nz).

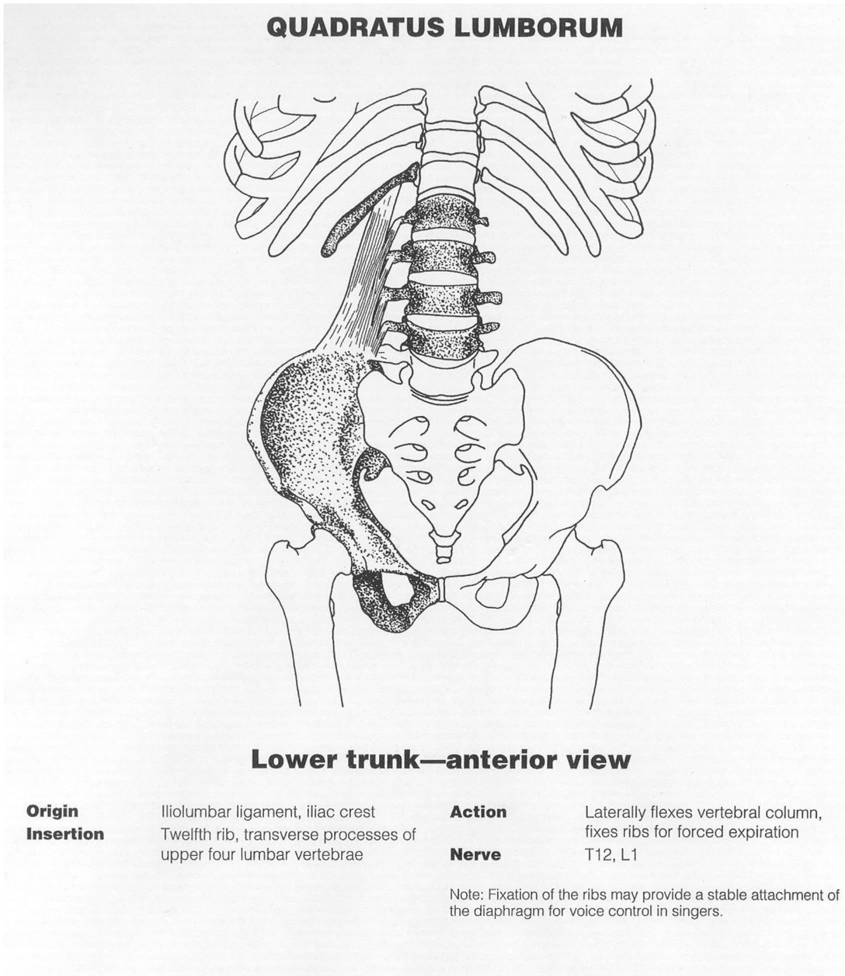


Figure 3- The left Quadratus Lumborum and its attachments,innervation and action (The University of Auckland, Bioengineering Institute, www.auckland.ac.nz).

2.3.2 The role of core stability musculature

The importance of core stabilizers in the biomechanics of the lumbar spine has been documented in recent studies by Hodges et al. 2003, on trunk muscle recruitment in humans it is suggested that diaphragm and TA activity, and the associated intra-abdominal pressure contribute to the control of intervertebral motion. Relative intervertebral motion of the L3 and L4 vertebrae and the stiffness at L4 were measured in response to displacements of the L4 vertebra imposed via a device fixed to the L4 vertebral body. In separate trials, diaphragm and TA activity was evoked by stimulation of the phrenic nerves and via electrodes threaded through the abdominal wall. The results of these studies indicate that elevated intra-abdominal pressure and contraction of diaphragm and TA provide a mechanical contribution to the control of spinal intervertebral stiffness or stabilization.

How much stiffness is necessary to stabilize the spine? When there is too little stiffness, the joint will buckle under load. Too much stiffness will cause massive loads and limit joint motion. Interestingly the literature shows that in most situations only a modest amount of stability is required to stabilize a joint. Cholewicki and McGill 1996 and Cholewicki et al. 1997 have demonstrated that sufficient stability of the lumbar spine (neutral spine) is achieved with modest levels of co-activation.

In work done by Richardson et al. 2002, two abdominal muscle patterns were tested in the same group of individuals, and their effects were compared in relation to sacroiliac joint laxity. One pattern was contraction of the TA, independently of the other abdominals; the other was a bracing action that used all the lateral abdominal muscles.

Drawing in the abdominal wall is a specific exercise for the TA muscle (in co-contraction with the multifidus), which is used in the treatment of back pain. It has been shown that with the incorporation of TA or core stability exercises in a lower back pain treatment protocol, the recurrence of lower back pain within a 3-year period was reduced from 75% to 35%. This study of a biomechanical model on the mechanics of the sacroiliac joint, however, predicted a significant effect of TA muscle force. Thirteen healthy individuals who could perform the test patterns were included. Sacroiliac joint laxity values were recorded with study participants in the prone position during the two abdominal muscle patterns. The values were recorded by means of Doppler imaging of vibrations. Simultaneous electromyographic recordings and ultrasound imaging were used to verify the two muscle patterns.

The results showed the range of sacroiliac joint laxity values observed in this study was comparable with levels found in earlier studies of healthy individuals. These values decreased significantly in all individuals during both muscle patterns ($P < 0.001$). The independent TA contraction decreased sacroiliac joint laxity (or rather increased sacroiliac joint stiffness) to a significantly greater degree than the general abdominal exercise pattern ($P < 0.0260$).

They concluded that contraction of the TA significantly decreases the laxity of the sacroiliac joint. This decrease in laxity is larger than that caused by a bracing action using all the lateral abdominal muscles. These findings are in line with the biomechanical model predictions and support the use of independent TA contractions for the treatment of low back pain.

The factors that affect lumbar stability have been an area of extensive research. The clinical application of this research in the form of lumbar stabilization exercise programs has become a common treatment of low back pain and is also increasingly used by athletes to improve performance and by the general public for health and the prevention of injury (Barr et al. 2005).

2.3.3 The relationship between lower back pain and the core stability musculature

Lower back pain has been linked with dysfunction of the prime core stabilizer - Transversus Abdominis (TA) (Hodges et al. 1996b). Conversely strong core muscles are considered essential in preventing back injury and ensuring optimal performance in physical activity (Davis, C., Laskowski E. 1998-2004.Mayo Foundation for Medical Education and Research).

A potential theory, (Richardson, 1997), is that when a person has a back injury the multifidus muscle reduces in size at the level of the injury in the spine, in as short a time as 14 days. When the injury has settled and the pain gone the multifidus does not recover its size and strength automatically. This means there is an area at the injured level, which is more vulnerable to re-injury. This may be a reason why people have repeated episodes of back pain after the initial one.

Danneels et al. 2001 performed a study to determine the potential for different exercise models to reverse the pathology related atrophy of the lumbar multifidus muscle in people with low back pain. As described by various researchers, the lumbar multifidus experiences a number of morphological and neurophysiological changes following low back injury (Zhao et al. 2000, Hides et al. 1994, Rantanen et al.1993). One of these changes is a segmental atrophy, which develops at the level of pathology, on the symptomatic side and, in conflict to the Richardson 1997 theory, as quickly as 24 hours after the injury (Hides et al. 1994). Further, these changes have been shown to persist beyond the resolution of symptoms (Hides et al.1996) and for at least five years after surgical intervention for intervertebral disc herniation (Rantanen et al.1993). There is evidence that such findings are indicative of a neurologically mediated process rather than a simple disuse or weakness phenomenon (Solomonow et al.1999).

In their study, Danneels and colleagues compared the motor re-education model, originally developed by Richardson et al. 1999 and as studied by O'Sullivan and colleagues 1997 against two variations of a traditional strengthening model. The first of these strength-training variations utilized typical concentric and eccentric lumbar extensor loading motions. The other added a static or isometric component, which was to be maintained between the concentric and eccentric phases of the exercise.

The authors concluded that, in order to correct the atrophy observed in the lumbar multifidus, patients should perform strengthening exercises targeting the lumbar extensors, ideally incorporating an isometric "pause" into these exercises. Danneels et al. 2001 reported that this was the only exercise model tested that developed sufficient hypertrophy to correct the multifidus atrophy seen in their experimental population.

These findings conflict with those of Hides et al. 1996, Hides et al. 2001, who have published data showing correction of the pathology-induced lumbar multifidus atrophy using a considerably more specific and subtle activation of the multifidus muscle (Richardson et al.1999).

The low load multifidus activation exercise, developed by Richardson et al. (1999) and used by O'Sullivan et al. (1997) is to be performed as a co-contraction with the transversus abdominis muscle, and is intended to correct a neurologically mediated loss of normal multifidus muscle volume. In studies in which the cross sectional area (CSA) of a pathological multifidus muscle has been compared with its contralateral and "healthy" segmental partner, this form of motor re-education exercise has been shown to normalise the CSA of the pathological multifidus in as little as four weeks (Hides et al. 1996).

With repetitive strain or movement (as in sports related injuries), sustained end range loading or trauma, the body learns compensatory movement patterns to protect injured muscles. If compensatory patterns are repeated often enough, and long enough, they become habitual (Leach, 1994 with reference to Patterson – Steinmetz theory model 1965). In this case, the Central Nervous System may bypass the deep stabilizing muscles, and may send movement messages directly to the superficial muscles. The movement pattern may look much the same, but it is missing the element of core stability. Lack of core stability leads to more muscle imbalance, which in turn can be a precursor to more injury (Janda et al. 1984). An unstable spine will lead to more pain and might potentially cause other joint problems along with bringing misalignment, (Dagenais 2001-2002).

In theory, the stabilizers should always be engaged prior to initiating any movement to make sure the spine is stable therefore the endurance (ability to remain contracted at a certain level for a prolonged period of time) of the core stabilizers is vital and so is being researched in this study. It appears that for most tasks rather low levels of activation are necessary for long periods of time. This suggests that endurance and not necessarily strength is most important for the muscles that are involved in stabilizing the spine (McGill 1999) and thus this study utilizes an assessment which evaluates endurance as apposed to strength of the core stability musculature.

Evans & Oldreive (2000) carried out a study on golfers using pressure biofeedback, with the intention of examining TA endurance in individuals with and without LBP. They concluded that golfers with a history of LBP had a statistically significant reduction ($p<0.025$) in the endurance of a TA static contraction compared with golfers with no history of low back pain. The researcher tested the endurance of TA via a series of 10 second contractions interspersed with 20-second rests. This methodology is based on research by Richardson and Jull (1995). The role of TA has been shown to be a continuous stabilizer during spinal movements (Hodges & Richardson 1997); therefore a continuous contraction would be more appropriate for assessing endurance and consequently was used in this study.

In work by Hodges & Richardson (1996a), the sequence of activation of trunk muscles during upper limb movements was investigated in addition to the effect that LBP had on this sequence. While movements in all directions resulted in contraction of the trunk muscles, TA was invariably the first muscle to activate and was not influenced by the direction of movement. This supported the research done by Cresswell et al. (1992, 1994). Contraction of TA was significantly delayed in patients with low back pain in all movements, indicating a deficit in the motor control of TA. Hodges & Richardson (1996a) hypothesizes that this may result in ineffective muscular stabilization of the lumbar spine. The study proposed a method for assessing the muscular stability of the lumbar spine using fine wire electromyography (EMG) and highly trained researchers. This makes replication of this method difficult outside a laboratory.

In keeping these “potential theories” in mind and the impact of lower back pain on core stability performance one can see the importance of seeking lower back treatment and an individualized specific exercise program in the event of lower back injury.

2.4 The Athlete and core stability

In most sports good balance and overall muscular strength are involved and therefore core stability is helpful. However there are some sports where good core stability is especially important, these include contact or collision sports, such as hockey, football or rugby. It is a common observation that many rugby players have strong peripheral muscles but have poor central muscles i.e. spinal muscle strength and control, and would benefit from basic core stability muscle exercises, (www.fitness4rugby.com 2004). Although the world's top golfers rely on an indefinable combination of concentration, physical endurance, skill and consistency to remain at the top of their game, the application of strength and conditioning know-how in the area of core stability is beginning to make an impact in the sport (English Institute of Sport 2004).

In a recent article on speed in young athletes by Brian J. Grazzo (DevelopingAthletics.com 2004) it was said that speed camps and speed-based training programs are currently among the most popular and trendy activities within the youth sport industry. He said,

> "The core musculature is comprised of all muscles (major and minor) from just below the pelvis to right around the scapula. All of these muscles need to be conditioned in order to maximize the potential speed of the young athlete. Speed requires core stability."

The functional result of good core stability is that when an athlete is performing a sporting movement or technique, they are able to maintain the correct posture and alignment, particularly in the lumbar spine and pelvic area, (Keene et al. 1985). Biering-Sorensen (1984) found that people with an increased level of physical fitness from sports participation are associated with a lower risk of low back pain, i.e. this is due to their stronger core muscles- does this provide athletes with increased protection to injury? That is what this study is attempting to determine.

2.5 Our understanding of the clinical management of LBP

Treatment for patients with undiagnosed lower back pain includes a progression from single plane to multi-plane exercises, and emphasis on dynamic stabilization (Barnes 1995). And it has been shown that exercises under the supervision of physical therapists, emphasizing abdominal and peri-pelvic strengthening are essential (Micheli 1995). The muscle targeted in core strengthening is specifically your TA to engage this muscle you must visualize pulling your belly button in toward your spine. These are small moves, but by learning the proper way to contract your TA - and keep it contracted- you will gain the most benefit, (Charles Davis, physical therapist 2003).

From the rehabilitative point of view traditional exercise approaches have focused on strength, endurance and functional capacity training. Although these programs are appropriate in the late stages of rehabilitation, (for increasing muscular support of the spine, and hold value for the deconditioned patient), recent research suggests that they do not address the physical impairments in the neuromuscular system associated with the onset, persistence and re occurrence of LBP (Richardson et al.1999, Jull et al. 2000).

A specific type of exercise termed “segmental stabilisation training” has been developed that directly addresses the motor control impairments of the neuromuscular system (Jull et al. 2000). Segmental stabilization is aimed at protecting and supporting the spinal segments from re-injury by re-establishing an enhancing muscle control to compensate for any loss of segmental stiffness caused by injury or degenerative change (Richardson et al.1999). Segmental stabilization is a specific therapeutic exercise program aimed at reversing the loss of motor control in the local muscle system, and restoring the normal synergy between the local and global systems. The initial and pivotal focus is on retraining a coordinated co-contraction of the local muscles. During this retraining process, the motor control of the local muscles is restored by activating them cognitively and as independently as possible from the global muscles (Richardson et al.1999, Jull et al. 2000).

It is believed that the most effective lower back programmes need to take into consideration all the muscles of the spine, how they move and function and in which positions these movements occur. Front, back or side and large or small - all the muscles involved in lower back movements and postural control should be trained. This comprehensive approach also takes into consideration that back injury can be caused by various factors, including poor posture, lifting strain, poor stability, muscle strength imbalances, small repetitive stresses and poor flexibility. The more comprehensive and varied the lower back programme, the more likely all these factors will be accounted for (Richardson et al.1999).

2.6 Conclusion

From the above information one can see that even if you have muscular arms and legs, if your core muscles are weak, you won't be able to move as efficiently- your muscles won't respond readily to the task at hand.

From the literature above one can see the key issues highlighted in this section, mainly:

- The core muscles are believed to function to maintain a "neutral spine"
- This is achieved by causing an intervertebral stiffness or stabilization through co-contraction of the TA and Multifidi muscles.
- In the event of lower back injury, deep multifidi muscles atrophy very rapidly and so can leave a symptom-free lower back susceptible to recurring episodes of back pain.

- Good core strength is particularly important in collision sports and speed work, providing balance to the athlete and correct posture and alignment of the pelvis during the discipline.
- “Segmental stabilization exercises” have been introduced to retrain neuromuscular pathways and address any motor control impairments.

The motor control dysfunction model as developed over the past decade by a variety of researchers- (Panjabi 1992, Rantanen et al. 1993, Solomonow et al.1999, Richardson et al.1999, Hides et al. 2001) holds great promise, both as a basis for understanding the causes of back pain and in developing more effective treatment strategies for lower back patients.

CHAPTER 3

METHODOLOGY

3.1 Introduction

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

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

3.2 Study Design

A quantitative, cross-sectional cohort design was employed. A Cohort Study type was considered appropriate for the non-intervention data that was required in this study (Sunny Downstate Medical center, Medical research library of Brooklyn, 2005, Babbie and Mouton 2001: 94).

3.3 Method

3.3.1 Sampling- method

The method was that of convenience sampling. This occurred on a “first-come, first served” basis where, as the patient presented to the Chiropractic Day Clinic, they were treated as soon as was convenient for the patient and the researcher.

Advertisements informing the public about the study were placed in newspapers, at the Durban Institute of Technology campus and at various sporting clubs and sporting events (Appendix 4). Word of mouth was also used to inform the general public. The subjects all reside in the Greater Durban Metropolitan area. The benefit of this form of sampling is that it allowed the researcher to reach people of all ethnic backgrounds and the people who partook in the sports relevant to this study. This in turn allowed the study to be as closely representative to the general population as possible.

3.3.2 Sampling-size

This study included 90 male subjects. 60 patients were elite sportsmen; 30 patients were non-elite sportsmen and fell into either a sedentary subgroup or a moderately active subgroup. The researcher chose this for statistical reasons in order to have a large enough sample to assume normal distribution and to use parametric statistics.

3.3.3 Patient screening and evaluation

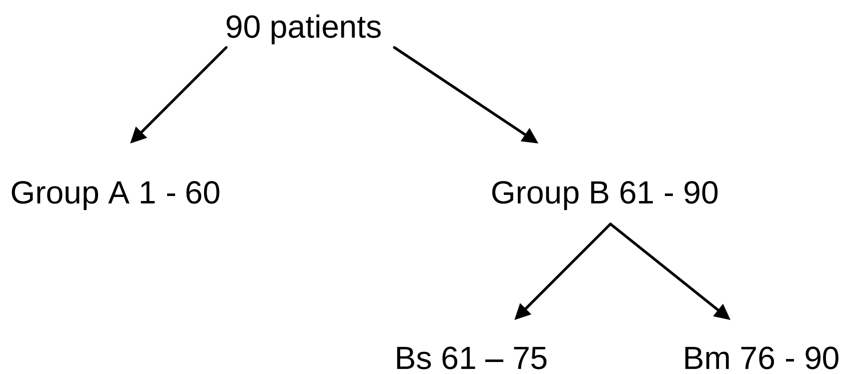
The participant evaluation and selection process began with all possible subjects undergoing a cursory telephonic discussion with the researcher to exclude subjects that obviously did not fit the criteria for the study.

In this telephonic discussion the subjects were asked four standard questions to determine if the patient would be eligible for the study. These questions were:

- How old are you?
- Do you play any sport at a club A or provincial level?
- Do you have lower back pain at the moment?
- Have you undergone any specific core stability training in the last year?

Participants were allocated into 2 prospective groups:

Group 1 was represented by A 1-60 (elite athletes) and group 2 was represented by B 61-90 (non-athletes) of which was subdivided equally into groups Bs and Bm (sedentary and moderately active respectively). As seen in figure 1 below:



Participants successfully accepted from the telephonic screening were evaluated at an initial consultation. At this initial consultation, the patient received a letter of information (Appendix 2) and signed an informed consent (Appendix 3) form. They then underwent a patient case history (Appendix 5), relevant physical examination (Appendix 6) and lumbar regional examination (Appendix 7) in order to establish whether they were eligible for this study and met the following inclusion and exclusion criteria:

3.4 Inclusion criteria

1. Patients were male between 18 to 35 years of age. These age limitations were used in this study as this age group represents the majority of professional sports people. Athletes over 19 years of age and below 40, an athlete's prime, generally falls somewhere within this age range. These are the years after an athlete's body has finished its developmental growth stages and before the aging process starts to slow it down (Hodges 2002).

2. Patients were asymptomatic with regards to lower back pain. This is because contraction of TA was significantly delayed in patients with current low back pain in all movements, indicating a deficit in the motor control of TA (Cresswell et al. 1992, 1994).
3. With regards to the elite sports group, the rugby, soccer and hockey players were of a 1st team club level or provincial level or higher. Golfers were a 5 handicap or less to enter the study. Cyclists were at a provincial level or higher. The sports included were disciplines where good core stability is especially important.

   With regards to the non- elite sports group, the sedentary population subgroup did not exercise or attend gym at all, while the moderately active subgroup did exercise or attended gym no more than twice a week.

3.5 Exclusion criteria

1. Patients currently receiving treatment for mechanical lower back pain as patients should be asymptomatic at the time of the study.
2. Contraindication to abdominal muscle strengthening: Glaucoma, pregnancy, hypertension, osteoporosis, spinal tumours, inflammatory diseases and impaired circulation (Harms-Ringhdal, 1993.)
3. Patients with extreme discomfort on contracting the abdominal muscles.
4. History of lumbar surgery. Richardson (1997), suggested the stabilizing function of the core musculature can be reduced when an injury to spinal structures occur.
5. Patients suffering form known neurological disorders or muscular degenerative conditions.

6. Patients had not undergone any specific core stability muscle training within the last year. Treatment for patients with undiagnosed lower back pain includes a progression from single plane to multi-plane exercises, and emphasis on dynamic stabilization (Barnes 1995).
7. Females were excluded from this study due to morphological differences and therefore to minimize variation.
8. Patients who did not sign the informed consent form.

Those subjects that were rejected from the study i.e. those who did not meet the inclusion criteria were referred to other interns in the chiropractic day clinic for treatment of their condition.

3.6 Instruments

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

A stopwatch measuring maximal contraction time (s) of TA.

3.7 Assessment protocol

The procedure involved the measurement of core stability activation and endurance in both groups during a once off consultation.

This research tested the time that TA can maintain a suitable contraction within the correct pressure range, without allowing the patients to compensate or "cheat". Richardson et al. (1990) developed an abdominal drawing-in test for effective assessment of TA using pressure biofeedback unit (PBU). Their findings are supported by Cairns et al. (2000), Evans & Oldreive (2000), and Jull et al. (1995) therefore this test will be used to investigate the endurance of TA in this study. This is a simple non-invasive method of assessment and provides an objective clinical measure of TA activity. The PBU consists of an inflation bulb and pressure gauge connected to a three-section inelastic inflatable pressure cell. The principle underlying the development of the PBU is that when the unit is placed under the abdomen it initially conforms to the patients shape and as the patient draws in their stomach off the pad the pressure in the pad reduces. This pressure reduction is proportional to the degree the patient can elevate their abdominal wall, and therefore the extent of contraction of TA.

In accordance with Richardson et al. (1999), before formal testing begins participants are taught to recruit TA in four-point kneeling. This position provides a facilitated stretch to the deep abdominals resulting from the forward drift of the abdominal contents. This stretch leads to an inhibitory effect on the superficial muscles, particularly rectus abdominis (Richardson & Jull 1995).

When this ability was recognized to be present, participants were then instructed to lie prone on a chiropractic table with their head turned to one side. The PBU was placed under their abdomen, with the centre at the navel and the distal edge at the ASIS (anterior superior iliac spine). It was then inflated to the baseline pressure of 70 mmHg.

Throughout testing, the same pressure biofeedback unit was used to remove any intra-rater reliability issues as a consequence of using two different units. Participants were then examined as to whether they can initiate TA in this prone position. A drop in pressure of 6-8 mmHg was seen with a correct contraction and a cycling of +/- 2 mmHg is normal during breathing, but a gradual or sudden rise in pressure indicated fatigue (Evans & Oldreive 2000). The patient then had a 2-minute rest. A second test (the endurance test) was then carried out to measure the time that TA can maintain a suitable contraction within the correct pressure range over a period in seconds (s). The researcher monitored the participant's contraction closely for any substitution or compensation mechanisms, including breath holding, rib elevation, movements of the pelvis or spine and abdominal bracing using the oblique muscles. Breath holding and rib elevation would result in a drop in pressure of only 1-2 mmHg, while abdominal bracing cause a rise in pressure of 1-2 mmHg. Contraction of rectus abdominis will result in a pressure increase.

Each participant was asked questions from a checklist on what sport they are involved in and whether they have suffered any past episodes in lower back pain as well as some relating relevant factors to establish an incidence of lower back pain thus allowing a comparison between the 2 groups to be made.

The data will be collected in a Data sheet as seen in Appendix 1.

3.8 Data collection

3.8.1 Frequency

Data collection took place on the day of the assessment. As this was a single consultation research study and all measurements were taken during this consult.

3.9 Statistical analysis

Data were captured in MS Excel and exported to SPSS version 11.5 (SPSS Inc.,Chicago,III, USA) for data analysis. Hypothesis testing methodology was employed to test all hypotheses by means of parametric statistical tests. Independent t-tests were used to compare means between two unrelated groups, and Pearson’s correlation was done to assess correlation between two quantitative variables. Generalized linear models (GLM) were generated to assess the independent determinants of core stability and endurance. Data will be analyzed at a 95% level of confidence.

CHAPTER 4

STATISTICAL METHODS AND RESULTS

4.1 Introduction

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

Demographic data consisting of height, weight and sport were analyzed. Objective and subjective findings were also analyzed, and the correlation between findings evaluated.

4.2 Demographics

4.2.1 Height and Weight

Sixty male athletes and thirty male non-athletes (15 sedentary and 15 moderately active) were enrolled as participants in the study. Mean heights and weights were compared between the two groups, and showed no significant differences (p =0.350 and 0.255 respectively). Summary statistics and p values of the comparison of height and weight between the two groups are shown in Table 1.

Table 1: Comparison of mean height and weight between the two groups of participants (n=90)

	GROUP	N	Mean	Std. Deviation	Std. Error Mean	P value
HEIGHT	Athletes	60	1.7868	.07710	.00995	0.350
	Non-athletes	30	1.7697	.09027	.01648	
WEIGHT	Athletes	60	79.83	14.328	1.850	0.255
	Non-athletes	30	76.17	14.295	2.610	

From the above information, it is evident that the groups are homogeneous, in terms of height and weight, so the results are more meaningful and comparisons between these subgroups can be made (Mouton 1996).

4.2.2 Sport

The sports played by the athlete group are shown in Figure 1. The most common sport played was soccer (n=27, 45% of the athletes), followed by hockey (n=16, 27%) and rugby (n=14, 23%). There were 2 cyclists and one golfer.

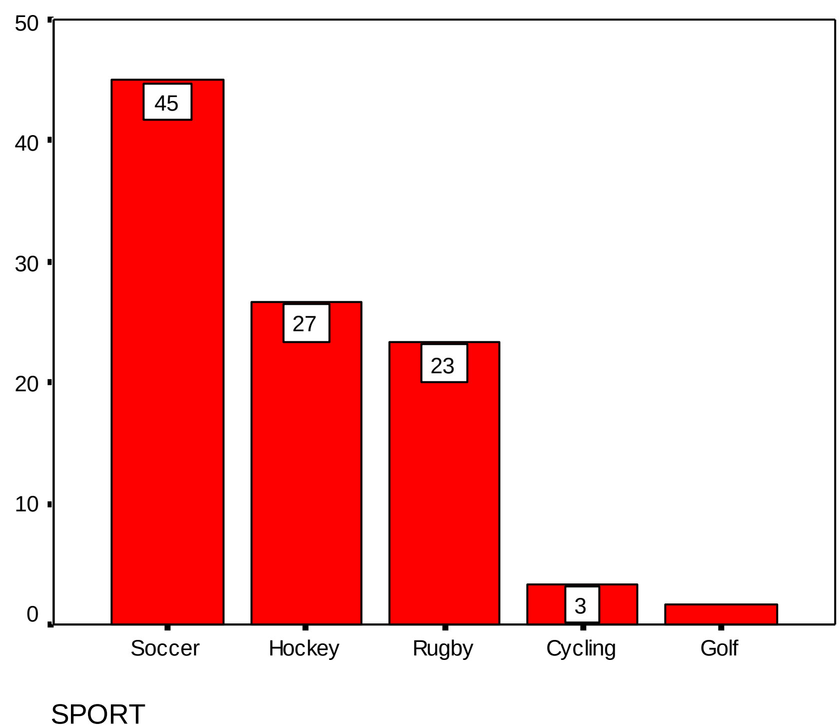


Figure 4: Percentage of athlete participants by type of sport (n=60)

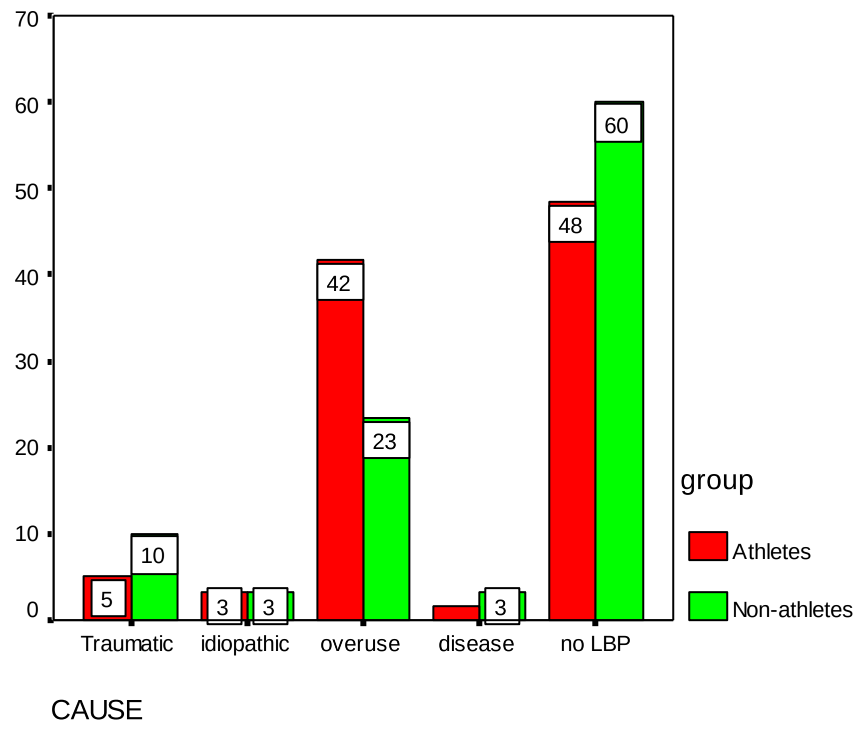
As seen above a spectrum of sports was included in this study, which allowed for a cross sectional evaluation of core muscle endurance and strength for the sporting codes included. It should however be noted that during data collection the cycling group recorded the largest measurements of core stability activation and endurance and so may affect the overall average calculated and skew the results obtained (Mouton 1996).

4.3 Low back pain

As stated earlier in chapter 2, the dysfunction of the prime core stabilizer- Transversus Abdominis (TA) is linked to lower back pain (Hodges et al. 1996b), consequently it is expected that those participants with low back pain will have “weaker” core musculature.

In total 43 participants reported experiencing low back pain (47.8%). Of these participants with LBP, the majority reported that their LBP was experienced less than 1 year ago (n=31, 72.1%), while 28% had experienced it 1-5 years ago (n=12). Figure 2 broadly indicates the cause of their LBP. 42% of the athletes had mechanical LBP and 23% of the non-athletes had mechanical LBP. 23 participants reported that running was an aggravating factor in their LBP. All 43 participants with LBP reported pain as the only symptom. Treatment for LBP was by a chiropractor (63.3%) or physiotherapist (36.7%) only.

Chiropractic may have been the more popular treatment undergone as in the event of LBP there is a consequent decrease in core stability, which leads to muscle imbalance, which in turn can be a precursor to more injury (Janda et al. 1984). This “unstable spine” will lead to more pain and might potentially cause other joint problems along with bringing misalignment (Dagenais 2001-2002), resulting in the chiropractor being consulted.



<u>Figure 5: Cause of LBP in athletes and non-athletes (n=90)</u>

According to the literature in chapter 2, it was found that people with an increased level of physical fitness from sports participation are associated with a lower risk of LBP due to their stronger core muscles (Biering-Sorensen 1984). The results of this study have shown otherwise. Various explanations for this can be put forward including - the fatigue factor, incorrect training techniques and repetitive injury theory (Janda <u>et al.</u> 1984).

It is also important to note that the high representation of athletes in the overuse category of LBP and the high representation of non-athletes in the no LBP category may skew the final results one way or another. This is as a result of the baseline entry into the study being affected by inherent differences between the groups (Mouton 1996).

4.4 Hypothesis tests

4.4.1 Hypothesis 1

The first objective of the study was to compare core stability activation between athletes and non-athletes.

Null hypothesis: there is no difference between populations of athletes and non-athletes in the mean decrease in pressure ($\mu 1 = \mu 2$).

Alternative hypothesis: there is a difference between the populations of athletes and non-athletes in the mean decrease in pressure ($\mu 1 \neq \mu 2$).

Table 2 shows the results of the independent samples t-test comparing mean decrease in pressure between athletes and non-athletes. There was no significant difference ($p=0.954$) between the means, and one can see from the table that the two means were almost identical.

Table 2: Comparison of mean decrease in pressure between athletes and non –athletes (n=90)

	GROUP	N	Mean	Std. Deviation	Std. Error Mean	P value
DECREASE	Athletes	60	-13.08	5.927	.765	0.954
	Non-athletes	30	-13.00	7.516	1.372	

Thus the null hypothesis could not be rejected. It was concluded that there was no significant difference between the mean pressure decrease in athletes and non-athletes.

It was expected that athletes would have a significantly higher mean decrease in pressure than the non-athletes because of their peak physical condition (Biering-Sorensen, 1984) however this was shown not to be true.

With repetitive strains and lower back injuries being more common in the athletic population than the non-athletes (from the above bar graph on LBP – figure 2), it is possible that the athlete's body learns compensatory movement patterns to protect injured regions (Sahrmann 2002). If compensatory patterns are repeated often enough, and long enough, they become habitual (Leach 1994 with reference to Patterson – Steinmetz theory model 1965).

In the case of this study, the central nervous system may therefore bypass the deep stabilizing muscles, and may send stabilization and movement messages directly to the superficial or global muscles (Janda et al. 1984). In turn, the core muscles become weaker and atrophy (Richardson, 1997 and Daneels et al. 2001), such that their core strength is similar to the average non-athletic person.

This study therefore implies that the assumptions in the literature made with respect to athletes having greater activation ability than non-athletes is a premise that is based on an incorrect foundation where activation is a direct measure of the core stabilizers. This is especially true if athletes are able to compensate sufficiently utilizing the global muscles to achieve the functions of the core stabilizers.

4.4.2 Hypothesis 2

The second objective was to compare mean endurance in seconds between the two groups (athletes and non-athletes).

Null hypothesis: there is no difference between the population means of athletes and non–athletes in terms of endurance ($\mu1= \mu2$).

Alternative hypothesis: there is a significant difference between the population means of athletes and non–athletes in terms of endurance ($\mu1\neq \mu2$).

Table 3 shows that there was a statistically significant difference in mean endurance between the two groups ($p = 0.024$). The mean endurance of the athletes was higher than that of the non-athletes (42.4 seconds versus 28.2 seconds).

Table 3: Comparison of mean endurance (time in seconds) between athletes and non–athletes (n=90)

	group	N	Mean	Std. Deviation	Std. Error Mean	P value
ENDURANCE	Athletes	60	42.4367	43.85189	5.66126	0.024
	Non-athletes	30	28.2007	13.57950	2.47927	

Thus, the null hypothesis was rejected. It was concluded that athletes had a higher mean endurance time than non-athletes in the population.

This outcome was expected, as it is a common assumption that elite athletes have a stronger core stability musculature than the general population. This is based on the fact that athletes are supposed to be more able to activate and control movements relative to the general population because of their intensive training schedules. Therefore it is assumed that they also have a greater endurance of the local stabilizers, so in theory they should have increased core stability endurance and this is practically supported by the results in table 3.

However, an elite athlete also has larger, stronger and more finely tuned global muscles relative to a non-athlete and can recruit them to a greater degree. This is from strenuous training programs endured by elite sportsmen (Guyton and Hall, 1996). It should be noted that although this study involved the testing of the core stabilizers, it was very difficult to prevent any global muscle input.

This is supported by Janda et al. (1984) who found that muscle movement patterns could be much the same in both global and local activation. The net result implies that if the athlete has global muscles that are trained for endurance purposes by virtue of the sporting code in which they participate, that the results of endurance obtained in this study could be a greater reflection of the endurance of compensating global muscles rather than the local muscle endurance.

This would support the suggestion made for core stabilizer activation (seen above in table 2), where the athletes and the non-athletes recorded the same activation levels as measured by the decrease in pressure (i.e. athletes having the same activation levels as the non-athlete population indicates that there is no difference in activation, however with endurance the use of global muscles make the athlete out perform the non-athlete).

4.4.3 Hypothesis 3

There is an association between mechanical low back pain and core stability activation (decrease in pressure).

Null hypothesis: the mean decrease in pressure is the same in the population with mechanical low back pain as in the population without mechanical low back pain ($\mu1= \mu2$).

Alternative hypothesis: the mean decrease in pressure is not the same in the population with mechanical low back pain as in the population without mechanical low back pain ($\mu1\neq \mu2$).

Table 4: Comparison of mean decrease in pressure between participants with mechanical low back pain and those without (n=90)

	Mechanical LBP	N	Mean	Std. Deviation	Std. Error Mean	P value
DECREASE	yes	32	-14.19	6.822	1.206	0.219
	no	58	-12.43	6.219	.817	

It must be noted that the above table does not reflect athletes or non-athletes only; it reflects only those participants in the study that had low back pain versus those without low back pain. This implies that the groups are not necessarily comparable at baseline (Mouton, 1996), with the non-low back pain group having a majority of non-athletes whereas the low back pain group having the majority of athletes, as can be seen in Figure 2.

Nonetheless Table 4 shows that there were 32 participants (35.6%) who had mechanical low back pain. Their mean decrease in pressure was -14.2, whilst that in the participants without low back pain was lower (-12.43). This difference was not statistically significant (p = 0.219).

Therefore we could not reject the null hypothesis. There was no difference in pressure decrease between the group with mechanical low back pain and the group without. Thus mechanical low back pain was not associated with core stability activation.

This concurs with the previous discussion, whereby there is an association between previous exposure to low back pain and the recruitment of global muscles in those with low back pain (in this study predominantly athletes). The recruitment of these global muscles could have masked any significant difference that was present. It is therefore suggested that future research stratify the population groups in the study as follows:

	Athlete	Non-athlete – moderate	Non-athlete – no exercise
Low back pain	15	15	15
No low back pain	15	15	15

This would allow for a more accurate and baseline comparable differences between the groups with respect to low back pain being absent or present. This would be similar to the table found under hypothesis 5 (table 6), with the exception that the numbers should be equal in all groups and that it not be restricted to mechanical low back pain.

4.4.4 Hypothesis 4

This hypothesis states that there is an association between mechanical low back pain and endurance (time in seconds).

Null hypothesis: there is no difference in mean endurance time between the population with mechanical low back pain and the population without ($\mu1= \mu2$).

Alternative hypothesis: there is a difference in mean endurance time between the population with mechanical low back pain and the population without ($\mu1\neq \mu2$).

Table 5: Comparison of mean endurance time between participants with mechanical low back pain and those without (n=90)

	Mechanical LBP	N	Mean	Std. Deviation	Std. Error Mean	P value
ENDURANCE	yes	32	34.5463	23.43373	4.14254	0.554
	no	58	39.4266	42.98976	5.64483	

Table 5 shows that the mean endurance time in seconds was slightly higher in those without mechanical low back pain (39.4 seconds versus 34.5 seconds). However, this difference was not statistically significant ($p = 0.554$).

Thus, we could not reject the null hypothesis. In the population as there was no difference between the endurance times of people with mechanical low back pain and those without. Thus there was no association between mechanical low back pain and endurance time.

Again the need for stratification of the athletes and non-athletes make these results unclear and it is suggested that they are interpreted with caution.

Nonetheless these results do indicate that with a history of LBP, core stability endurance is reduced and holds true to work done by Hodges et al. (1996) who found that with lower back pain this predisposed to dysfunction of the TA.

It must also be noted that the input by the global muscles cannot be ruled out, which would have resulted in the results being less statistically significant than found in the above table (table 5).

4.4.5 Hypothesis 5

Being an athlete is associated with lower prevalence of mechanical low back pain than non-athletes.

Null hypothesis: there is a similar prevalence of mechanical low back pain in the population of athletes and non-athletes ($\pi 1= \pi 2$).

Alternative hypothesis: there is a different prevalence of mechanical low back pain in the populations of athletes and non-athletes ($\pi 1= \pi 2$).

Table 6: Cross-tabulation of group by mechanical low back pain (n=90)

			Mechanical LBP		Total
			yes	no	
group	Athletes	Count	25	35	60
		Row %	41.7%	58.3%	100.0%
	Non-athletes	Count	7	23	30
		Row %	23.3%	76.7%	100.0%
Total		Count	32	58	90
		Row %	35.6%	64.4%	100.0%

Pearson's chi square 2.93, p = 0.087

There was a non-significant association between group and mechanical low back pain (p = 0.087). There was a slightly higher prevalence of mechanical LBP in athletes (41.7%) compared with non- athletes (23.3%). Thus being an athlete was not associated with a lower prevalence of LBP in the population than non-athletes. The null hypothesis was not rejected.

This is in conflict with Biering-Sorensen (1984) who found that those involved in sports participation had a lower risk of LBP.

In contrast to this, the outcomes of these results is in keeping with Hodges and Richardson (1996), where they stated that:

> "Contraction of transversus abdominis was significantly delayed in patients with low back pain with all movements" and that "the delayed onset of contraction of transversus abdominis indicates a deficit of motor control and is hypothesized to result in inefficient muscular stabilization of the spine."

This is supported by the more recent work of Hungerford, Gilleard, and Hodges (2003), who state as a result of their cross-sectional study of electromyographic onsets that "the delayed onset of obliquus internus abdominis, multifidus, and gluteus maximus electromyographic activity of the supporting leg during hip flexion, in subjects with sacroiliac joint pain, suggests an alteration in the strategy for lumbopelvic stabilization that may disrupt load transference through the pelvis".

These strategies could possibly be explained by over training and resultant fatigue of the global muscles in athletes, which increases an elite athlete's susceptibility to developing LBP, due to excessive spinal loading, which would affect the function of the local stabilizers.

This discussion further supports the assertions made earlier in this research whereby the activation would be similar on the athlete and non-athlete, whereby the athlete recruits the global musculature to achieve the same outcome as the non-athlete in this respect. In addition with respect to endurance, the athlete has a greater ability to use the global muscles to maintain the endurance time as compared to the non-athlete making this a distinct difference between the two.

4.4.6 Hypothesis 6

There is a correlation between core stability activation and endurance.

Null hypothesis: there is no correlation between decrease in pressure and endurance in time (r=0).

Alternative hypothesis: there is a correlation between decrease in pressure and endurance in time (r≠0).

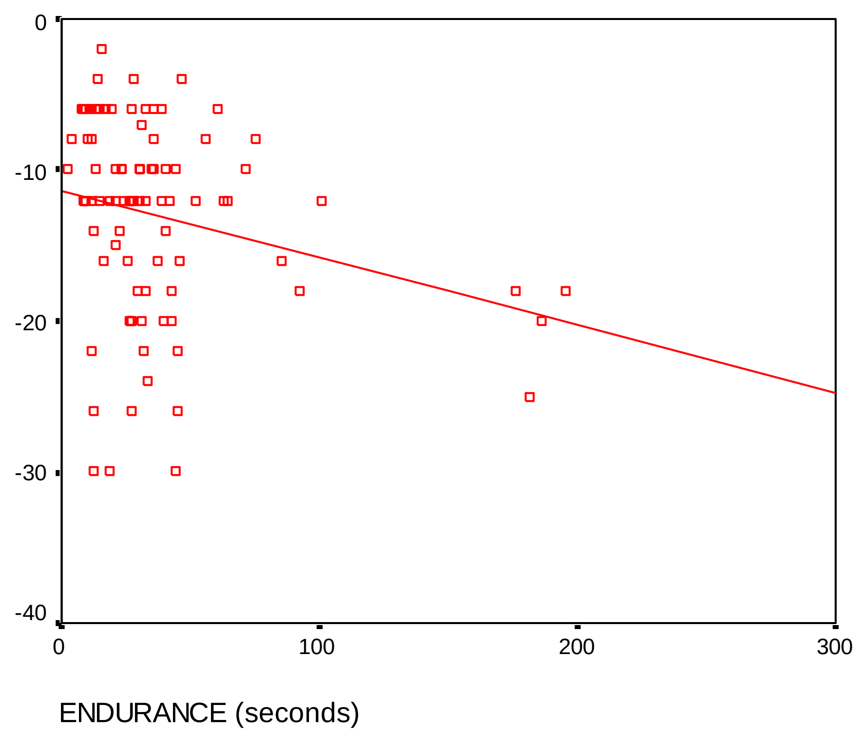
Table 7: Pearson's correlation between decrease in pressure and endurance in seconds

		DECREASE	ENDURAN

DECREASE	Pearson Correlation	1	-.257(*)
	Sig. (2-tailed)	.	.015
	N	90	90
	Sig. (2-tailed)	.015	.

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

There was a statistically significant, although weak negative correlation between endurance and core stability (r = -0.257, p = 0.015). The greater the decrease in pressure (or the more negative the value) the higher the endurance time. This correlation coefficient indicated a weak relationship, and Figure 3 shows that there was a large scatter of points around the best-fit line. Some participants who had a large decrease in pressure could only hold it a short time.



<u>Figure 6: Scatterplot of endurance versus decrease in pressure in study participants (n=90)</u>

Thus the null hypothesis was rejected. We conclude that there is a relationship between endurance and decrease in pressure in the population; however, this relationship is relatively weak.

It must be noted that the population in total included athletes and non-athletes, therefore there is a wide variance in the noted decrease in pressure and the time (endurance) noted in the scatterplot.

In this respect athletes could have achieved:

- A decrease in pressure with an increased endurance utilizing the global muscles or
- A decrease in pressure with the local muscles and increased endurance with the global muscles

And the non-athletes (dependant on degree of sports participation)

- A decrease in pressure with local muscles, yet a decreased endurance utilizing the global muscles or
- A decrease in pressure with the local muscles and increased endurance with the global muscles

Thus with respect to the results obtained where it indicated that the greater the decrease in pressure (or the more negative the value) the higher the endurance time, it would seem that the following combinations are plausible

- A decrease in pressure with an increased endurance utilizing the global muscles or
- A decrease in pressure with the local muscles and increased endurance with the global muscles.

A caution must however be noted as this result does not take into account whether the athlete has a history of low back pain or not and therefore no further suggestion can be made with respect to which of the above options are more plausible and in keeping with the literature or not.

4.5 Determinants of core stability activation

Table 8 shows that only endurance (time in seconds) was a significant predictor for the dependant variable of core stability activation (pressure decrease) (p = 0.011). Group and mechanical low back pain did not influence the mean core stability activation. The low ‘r’ squared value of 0.053 means that the overall fit of the model was poor, only 5.3% of the variability in pressure decrease was explained by the predictors in the model. This implies that there are other factors not measured in the study, which may have influenced the variability in core stability activation.

Table 8: GLM model of factors affecting core stability activation

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	353.638(a)	4	88.409	2.238	.072
Intercept	5272.165	1	5272.165	133.489	.000
ENDURANCE	266.609	1	266.609	6.750	.011
GROUP (athletes vs. non athletes)	27.493	1	27.493	.696	.406
MECHANICAL LBP	100.227	1	100.227	2.538	.115
GROUP * MECH_LBP	9.587	1	9.587	.243	.623
Error	3357.084	85	39.495		
Total	19051.000	90			
Corrected Total	3710.722	89			

a R Squared = .095 (Adjusted R Squared = .053)

4.6 Determinants of endurance

Table 9 shows that only core stability activation (decrease in pressure) was a significant predictor for the dependant variable of endurance (p = 0.011). Group and mechanical low back pain did not influence the mean endurance. The low r squared value of 0.080 means that the overall fit of the model was poor, only 8% of the variability in endurance was explained by the predictors in the model. This implies that there are other factors not measured in the study, which may have influenced the variability in endurance.

Table 9: GLM model of factors affecting endurance

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	14919.816(a)	4	3729.954	2.937	.025
Intercept	3187.054	1	3187.054	2.510	.117
DECREASE IN PRESSURE	8572.037	1	8572.037	6.750	.011
GROUP	2701.509	1	2701.509	2.127	.148
MECHANICAL LBP	831.681	1	831.681	.655	.421
GROUP * MECH_LBP	685.805	1	685.805	.540	.464
Error	107937.469	85	1269.853		
Total	250714.579	90			
Corrected Total	122857.285	89			

a R Squared = .121 (Adjusted R Squared = .080)

From the above tables 8 and 9 it is evident that neither the groupings (athletes versus non-athletes) or sub-groupings (mechanical low back pain absence or presence) in this study are predictors of core stability activation but endurance is (at 5.3%) and vice versa (at 8%). This indicates that although the measures are related and possibly negatively (as per table 7 and figure 3), they are not the only factors that are responsible for the changes / influences on core stability activation and endurance.

These other factors may be related to:

- Type of muscle fibers found in the local and global stabilizers e.g. fast twitch versus slow twitch fibers. Fast twitch fibers (global muscles) can deliver extreme amounts of power for a few seconds to a minute or so. On the other hand, slow twitch fibers (local muscles) provide endurance, delivering prolonged strength of contraction over many minutes to hours (Guyton and Hall, 1996).
- The degree of physiological preparedness with respect to glycogen stores and fuel supply for any given activity. The performance of a muscle, to a great extent, depends on the nutritive support to the muscle- more than anything else on the amount of glycogen that has been stored in the muscle before the period of exercise. This is also related to the type and the amount of training muscles undergo (Guyton and Hall, 1996).
- The degree of neurological stimulation that is afforded to the respective muscle types as well as the neurological pathways that exist, either normal or compensatory – with respect for e.g. to the presence or absence of changes if the person has had low back pain (Leach 1994 with reference to the Patterson and Steinmetz model 1965).
- According to Panjabi (1992), the spinal stabilizing system consists of three interrelating sub-systems-

    1. Control sub-system (neural)
    2. Passive sub-system (spinal column, joints, ligaments)
    3. Active sub-system (muscular)

  A dysfunction of any component of any of the sub-systems can result in an immediate response from the other sub-systems to successfully compensate, which would result in normal function of the system as a whole. If there were however, a long-term adaptive response of one or more sub-systems, this would result in normal function but with altered spinal stabilization. Finally, an injury to one or more component of any sub-system would result in overall system dysfunction leading to painful conditions (Panjabi 1992).

These factors however, remain hypotheses as this study did not employ the means to assess these factors and thus suggestions for further study include the incorporation of these factors into the study design through appropriate measurement tools.

4.7 Intra-group comparisons

4.7.1 Athletes

Hypothesis : Within the athletes there is an association between core stability activation and endurance with low back pain.

Table 10 shows that there was no association between presence or absence of mechanical LBP and core stability activation or endurance (p = 0.460 and 0.291). We thus fail to reject our null hypothesis.

Table 10: Comparison of mean core stability and activation in athletes with mechanical LBP and without (n=60)

	Mechanical LBP	N	Mean	Std. Deviation	Std. Error Mean	P value
DECREASE IN PRESSURE	yes	25	-13.76	6.173	1.235	0.460
	no	35	-12.60	5.786	.978	
ENDURANCE	yes	25	35.3120	25.85937	5.17187	0.291
	no	35	47.5257	52.92389	8.94577	

4.7.2 Non-athletes – moderately active

Hypothesis: Within the moderately active non-athletes there is an association between core stability activation and endurance with low back pain.

There was no significant difference in mean decrease in pressure or endurance between the group with LBP and without LBP, thus we cannot reject the null hypothesis.

Table 11: Comparison of mean core stability and activation in moderately active non-athletes with mechanical LBP and without (n=15)

	Mechanical LBP	N	Mean	Std. Deviation	Std. Error Mean	P value
DECREASE IN PRESSURE	yes	5	-18.80	9.121	4.079	0.403
	no	10	-14.80	8.121	2.568	
ENDURANCE	yes	5	37.2320	9.27032	4.14581	0.486
	no	10	31.9300	14.99456	4.74169	

It must be noted that the intra-group sample size is very small for LBP and therefore any conclusions drawn will have to be considered with caution.

4.7.3 Non-athletes – Sedentary

Hypothesis: Within the sedentary non-athletes there is no association between core stability activation and endurance with low back pain.

Table 12 shows that there were no significant differences in mean pressure decrease or endurance in the sedentary group between those with LBP and without (p = 0.597 and p = 0.589). Thus the null hypothesis was not rejected.

Table 12: Comparison of mean core stability and activation in sedentary non-athletes with mechanical LBP and without (n=15)

	Mech LBP	N	Mean	Std. Deviation	Std. Error Mean	P value
DECREASE IN PRESSURE	yes	2	-8.00	2.828	2.000	0.597
	no	13	-10.15	5.383	1.493	
ENDURANCE	yes	2	18.2600	7.02864	4.97000	0.589
	no	13	23.3877	12.53434	3.47640	

4.8 Discussion of the intra-group analysis:

4.8.1 With respect to endurance

The results present as expected with the athletes having the highest endurance for one of a number of reasons including:

1. Their ability to recruit global muscles
2. Their ability to have physiological and other mechanisms that support their ability to sustain a contraction within the muscles recruited.

It is however also recognized that the non-athlete (2) and moderate athlete (5) populations do not have sufficient numbers in their respective groups to draw firm conclusions on their performance in the endurance measure. Therefore at best, these results need to be read with caution and thus trends in each group are looked at rather than specifics because of the small sample size (Mouton 1996).

4.8.2 With respect to activation / decrease in pressure

This seems to be best in the moderate exercise / athlete group, where the activation is highest as indicated by the largest decrease in pressure in both the low back pain and the no low back pain groups indicated as (-18.80 and -14.80 respectively).

This should be expected as the:

- Athlete group has a higher incidence of low back pain (as found in table 10) and therefore a greater chance of local muscle atrophy due to pain inhibition or altered compensatory recruitment patterns for muscle activation, as compared to the moderate athlete group. This is especially true when one considers the causes of repetitive strain, fatigue and overload. The sheer volume or quantity of an activity has been blamed for the abundance of the overuse injuries (Booher et al. 1989 and Garrick et al. 1990). Although this is true to a certain extent, there is evidence to suggest that the quality of motion may play a significant role in the production of overuse injuries (Klafs et al. 1981, Hay et al.1982, Brancazio 1984). This generally states that it is the manner in which an athlete chooses and applies his sports techniques that will determine his rate of overuse injuries. The quantity and intensity by which he executes his "poor quality" sports techniques only serves to magnify the problem of overuse injuries.

- The non-athlete group makes little use of activity to activate the local muscles and they are therefore unable to recruit the muscles when required for a specific task, even in view of the fact that they have little or no low back pain (as per table 12).

Therefore these two groups do not attain the same levels of activation as the moderate exercisers, whether it is with respect to the presence or absence of low back pain.

Again this discussion is based on the proviso that the results are taken with caution as they are based on small numbers in certain instances.

One anomaly that does however become apparent is that there are higher activation values seen in those with a history of LBP in the athletic and moderately active groups, which indicates that global muscles may play a role especially in terms of representing an altered recruitment pattern related to previous injury in the low back. This could be as a result of the deep core muscles having been negatively affected by the low back injury and so the global muscles now take on the role of stabilization as well as movement.

4.9 Summary and conclusions

Athletes were similar to non-athletes in terms of height and weight and hence a reasonably matched cohort was achieved and the results could be compared.

The main hypothesis of this study was to confirm the view that athletes had increased core stability activation and endurance, and thus lower prevalence of mechanical low back pain relative to the general population. This was not shown to be the case in this study, since in this study athletes relative to non-athletes (moderately active and sedentary groups) showed no significant difference in terms of core stability activation; however athletes showed significantly greater endurance than non-athletes.

However athletes also tended to have more mechanical low back pain then non-athletes, with the prevalence of LBP among athletes being unnaturally high (42%) as seen in Figure 2 and is in conflict to Biering-Sorensen (1984) who stated that people with an increased level of physical fitness from sports participation have a lower risk of low back pain (Biering-Sorensen 1984). But concurs with theory that the fatigue factor, incorrect training techniques and repetitive injury theory may contribute to this especially in this day and age where demands on professional athletes are high (Janda et al. 1984) as well as with the findings of Hodges and Richardson (1996) and Hungerford, Gilleard and Hodges (2003).

It could therefore be hypothesized that the greater endurance of the athletic group can possibly be attributed to their greater recruitment and development of their global muscles. As stated earlier in the chapter, the global and local muscle patterns are difficult to differentiate from one another and the researcher found it difficult to ensure complete isolation of the core stabilizers (Janda et al. 1984).

One method to better control for this would be the sampling method, as a result of the sampling procedure being non random in this study, it provided an environment that supported the possibility that the athletes who volunteered may have done so because of their history of LBP, and thus they would not have been a random selection of the population of athletes. Thus it is suggested that future studies employ a stratification method of sample allocation to groups.

Another hypothesis was that with a history of lower back pain a reduction in core stability activation and endurance would be evident in either the elite athletes or the moderately active and sedentary patient groups, as was found in the study on golfers (Evans and Oldrieve 2000). There was however found to be no association between mechanical LBP and core activation and endurance in any of the 3 groups in this study but there was a slight trend towards those participants with mechanical LBP showing a higher mean decrease in pressure and a lower endurance than those without low back pain.

A slight trend was seen towards those participants with mechanical LBP showing a higher mean decrease in pressure and a lower endurance than those without low back pain. This is very interesting as it raises the following questions:

- Are those patients with a history of low back pain activating their core muscles?
- Are they using their superficial or the larger global muscles to decrease the pressure on the PBU?

The discussion stems around whether they can / cannot hold this contraction for as long as those without low back pain. This may be because after an episode of low back pain the anticipatory and non-direction specific activation of the core muscles is lost and they do not spontaneously recover with the resolution of pain (Richardson et al.1999, Hides et al. 2001).

There was a slight negative correlation between core stability activation and endurance, thus subjects who had high decrease in pressure also had high endurance times. The GLM models showed that it was only endurance which influenced core stability activation and vice versa, and that whether the participant was an athlete or not, and whether they had LBP or not did not make a significant impact on core stability activation or endurance. This was further verified by intra-group (stratified by athlete, moderately active and sedentary) comparisons of decrease in pressure and endurance with LBP, which were not significant. Here the question of whether core stability performance is indeed related to the level of activity or the history of LBP or does some independent neurological reflex determine this independent of these factors?

The activation test measured the neurological nature or “firing ability” of the core stability musculature while the endurance test measured more the physiological function of these muscles and so it would be better to group the activation testing with another neurological test- like nerve conduction ability. The endurance testing would be more meaningful grouped with muscle function tests or possibly blood tests. This would most definitely help with the global/local muscle debate, as the local muscles were so difficult to isolate in this study.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

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

5.2 Conclusions

The purpose of this study was to compare core stability strength between elite sportsmen and the general population and to establish the effect of core stability strength on the incidence of mechanical lower back pain.

It was found that there was no significant difference in the core stability strength between elite athletes and the general population, although the athletes did show a relatively increased endurance. In addition, it was found that mechanical lower back pain had little if any effect on core stability performance.

5.3 Study limitations

1. The isolation of the deep core muscles during pressure biofeedback measurements was difficult to achieve. The use of superficial or global muscles could not be excluded.
2. It was assumed that the subjects were truthful about the absence of lower back pain at the time of the study.
3. It was assumed that the information taken from the subjects in the checklist for past episodes of lower back pain was accurate and reflected reality at that point in time.

5.4 Recommendations

1. This study should be repeated in a larger more representative sample of a cross-section of the population. This may improve the study's validity and the results would be more statistically significant.
2. A stratified grouping of those with and without LBP and those of athletes and non-athletes is recommended for subsequent studies.
3. Lack of blinding could have resulted in researcher bias. Having a peer intern or clinician to take objective and subjective measures may result in more reliable readings.
4. In future studies, one sporting code should be used rather than many so as to reduce any skewing of results from other sporting disciplines.
5. Only one reading for each test at one particular time was taken in this study. It is advised to take multiple readings over a period of time so as to negate factors like fatigue, dehydration and low muscle glycogen stores.
6. In future studies the compensatory action of global muscles needs to be identified and minimized as much as possible. A suggestion may be the use of a surface electromyelogram (EMG) to track global muscle activation.
7. Future study designs should include a means to assess composition of muscles tested- whether fast twitch or slow twitch, the preparedness of the muscles involved and the degree of neurological stimulation that is afforded to each muscle type.
8. As this study paired an activation test with an endurance test, it would be advisable for future studies to pair off an activation test with another test that is closely related to this e.g. nerve conduction ability and an endurance test with muscle function tests or muscle composition analysis.
9. It may also be useful to include another group in a study similar to this one of those patients who have undergone specific core stability training and comparing this with the other patient groups who have not.

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LETTER OF INFORMATION

Dear patient, welcome to this study.

Title of research project:

"A cross-sectional cohort study of core stability muscle activation and endurance in elite athletes and its link with mechanical lower back pain."

Name of supervisor: Dr C. Myburgh (031-2042923)

Name of research student: Natalie Robertson (031-2042205)
Name of institution: Durban Institute of Technology

Introduction and Purpose of the study:

This study hopes to show that there is a difference in core stability muscle activation and endurance between athletes and non-athletes and whether a weaker core muscles are related to a higher incidence of mechanical lower back pain.

This study involves research on 90 participants. There will be 2 groups in my study. Group A and Group B. Group A will be made up of athletes and group B of non-athletes. Both groups will have their core stability muscle strength assessed and compared. A question after the measurement is taken, is then answered by the participants with regards to any previous episodes of lower back pain. All of you have the option of having a free treatment once the study is completed.

Procedures:

You will be required to undergo an initial examination at the Chiropractic Day Clinic at the Durban Institute of Technology.

This consultation will include a case history taking, relevant physical examination and a lower back regional examination.

Once you have been accepted into the study, your core strength will be assessed and you will answer the questions on data checklist on any previous occurrences of lower back pain. The procedure should take approximately 45 minutes.

Risks/ Discomfort:

No risks are at stake in this study.

Benefits:

There will be no charge for any of these consultations. You will be given a free assessment of core stability muscle strength and advice on strengthening these muscles if need be in the optional free consultation once the study is completed.

New Findings:

You have the right to be informed of any new findings that are made.

Reasons why you may be withdrawn from the study without your consent:

1. You experience extreme pain whilst core stability muscle strength is assessed.
2. You are free to withdraw from the study at any time, without giving a reason.

Remuneration/ Cost of the study:

Please note there will be no remuneration at all. Your participation in this study is voluntary and all procedures are free of charge.

Confidentiality:

All patient information remains confidential and the results will be used for research purposes only although, supervisors and senior clinic staff may be required to inspect records. You will be contacted at the end of the study and your individual results will be provided.

Persons to contact for problems or questions:

You may ask questions of an independent source (if you wish to contact my supervisor, he is available on the above number). If you are not satisfied with any area of the study please feel free to forward any concerns to the Durban Institute of Technology Research and Ethics Committee.

Thank you for your participation in this study.

Natalie Robertson
(Chiropractic intern)

Dr. C. Myburgh
(Supervisor)

INFORMED CONSENT FORM

(To be completed by patient/ subject)

Date: ____

Title of research project:

"A cross-sectional cohort study of core stability muscle activation and endurance in elite athletes and its link with mechanical lower back pain."

Name of supervisor: Dr. C. Myburgh (031-2042923)

Name of research student: Natalie Robertson (031-2042205)

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

9. Who have you spoken to?____

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

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

Patient/ Subject Name:_____________________________ Signature:______________

Witness Name:___________________________________ Signature:______________

Research Student Name:___________________________ Signature:______________

DATA SHEET

Patient Name:	**File:**		
	Sport:		
Height: (m)	**Group:**		
Weight: (kg)			
Biofeedback unit reading:		**mmHg**	
	-70	**mmHg**	**(Baseline value)**
Decrease/Increase in pressure:		**mmHg**	
Endurance test (seconds):			

Data checklist for lower back pain

History of lower back pain:		**Yes**		**No**	
When?	**>5 years ago**	**1-5 years ago**			**Within 1 year**
Duration?					
Cause:	**Traumatic**	**Idiopathic**			**Overuse**
Aggravating factors:					
Relieving factors:					
Associated signs and symptoms: (pain, tingling or numbness down the leg/s)			**Pain**	**Tingiling**	**Numbness**
Previous treatment?	**Chiropractic**		**Physio**	**Rehab**	**Medical doctor**