A CROSS SECTIONAL COHORT PILOT STUDY OF THE ACTIVATION AND ENDURANCE OF THE TRANSVERSUS ABDOMINIS MUSCLE IN THREE POPULATIONS

By

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I, Sarah Kim Ferguson do hereby declare that this dissertation represents my own work in both conception and execution, except where specific assistance was sought and duly acknowledged

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DEDICATION

For my Tribe

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ABSTRACT

Objectives:
To compare the activation and endurance of the Transversus Abdominis muscle in three different populations. These consisted of a sedentary, moderately active and Pilates trained group.

Project Design:
A cross-sectional, pilot study on 45 healthy female subjects.

Setting:
Eligible subjects reported to the Chiropractic Day Clinic on the Steve Biko Campus at the Durban University of Technology as well as at the Pilates House studio, Silvervause Centre, Durban.

Subjects:
Female subjects aged between 25 and 45 years who were part of the one of the three populations.

Outcome Measure:
A pressure biofeedback unit was used to gain feedback, through a decrease in pressure (mmHg), about the activation and the endurance (time scale categories) of the transversus abdominis muscle. Lumbopelvic posture categorisation assisted in assessing the lumbopelvic postural response of the candidates.

Results:
Transversus abdominis activation was significantly greater in the Pilates population as demonstrated by the abdominal draw-in ($p = 0.001$) and lumbopelvic posture tests ($p < 0.01$). The median of both the Pilates groups and the moderately active groups was the same "60 to 90 seconds" and was greater than the sedentary group median (30 to 60 seconds). The seventy-fifth percentile of the moderately active population fell in the "120 to150 second" category. However, no statistically significant differences were found in comparing the Pilates group to the sedentary group ($p = 0.345$) or to the moderately active group ($p = 0.653$).

Conclusions:
It was found that Pilates as a core training regimen may have benefits that aid in Transversus abdominis activation and enhancing lumbopelvic stability. This study demonstrated that Pilates was significantly associated with greater core strength when compared to a sedentary lifestyle, in terms of most of the outcome strength measures. The moderately active group compared with the Pilates group showed borderline statistical significant results for the abdominal draw-in test. Yet the Pilates group showed significantly better performance of the lumbopelvic posture test in comparison to other two groups. No significant findings were noted for endurance for all three populations.

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CHAPTER ONE

Introduction

1.1 Introduction

Lumbopelvic stability has become recognised as an integral contributing factor towards a healthy spine. Increased usage of labour reducing devices and longer time spent commuting, coupled with the popularity of sedentary entertainment such as computer games and television, are having an impact on our posture (Scholle and Hannine, 2005). The Transversus Abdominis (TrA) has a fundamental function in promoting healthy trunk function (Hodges *et al*., 1996b; Richardson *et al*., 1999). The Pilates method purports to train the core muscles effectively and improve overall core functioning.

Core stability implies that muscular strength and motor control around the lumbar spine is activated and functioning adequately to ensure lumbar stabilization (Akuthota and Nadler, 2004). Richardson *et al*. (1999) provided a segmental stabilization model for the function and dysfunction of the deep lumbopelvic muscles. These important deep muscles serve to protect each segment of the spine individually as well as aid in more efficient load distribution of forces from the trunk through the lumbopelvic region to the limbs. The deep musculofascial corset formed by the primary core stabilizer the Transversus Abdominis as well as the Multifidus and fascial system is of great importance in providing joint stiffness in the lumbar spine and pelvis during weightbearing and hence is protective in function. Healthy function and movement of the spine may only be realised if the local and global muscles of the lumbopelvic region are functioning at optimum (Richardson and Hides, 2004).

Core strengthening exercises are a developing trend in the health and fitness industry and are being promoted as the focus point of any training programme for athletes at all levels (Bliss and Teeple, 2005). The main aim being to strengthen the core musculature and in so doing promote lumbar functional stability. The Pilates method has been accepted into the trend of core stability training and is seen as a viable exercise routine. Through this, Pilates method has developed a significant following. Pilates is purported to promote body performance and core strengthening whilst maintaining overall efficiency in movement (Anderson and Spector, 2000).

According to Muscolino and Cipriani (2004a), Pilates method traditionally follows core strengthening principles, as well as focusing on the correct posture and alignment of the body. The primary objective is to target the core musculature of the person performing the exercises and centre the body's movements around these muscles so that a mindful focus of doing the exercise in the correct posture is maintained (Winsor, 2001). Thus they would essentially strengthen the local and global abdominal muscles in providing spinal stability whilst simultaneously lengthening and strengthening the back muscles.

A study performed on thirty-six female individuals by Herrington and Davies (2003) that were asymptomatic of low back pain suggested that the Transversus Abdominis is activated effectively through Pilates training in comparison to the groups who performed regular abdominal exercises such as abdominal curls and the non-training control group.

1.2 The Scope of this study

A variety of training methods exist that purport to improve core functionality. Since Pilates method follows the principles of core strengthening, this study aimed to gain insight into Pilates methods effect upon the core. Although, it is popular to train the core in gym with the use of a variety of apparatus such as the Swiss ball this research hoped to ascertain information as to whether Pilates method is a more effective and efficient way of training the core. Additional information on previous episodes of back pain and data on number of children, pregnancies and birthing techniques was collected in order to gain insight into outside factors that could have influenced this female population group. This study aimed to discover whether there are any benefits from the performance of Pilates method as opposed to gym exercises. Previous research lends weight to the fact that Pilates method may be effective in training the core stabilizers and hence, this research aimed to verify this.

1.3 Aims and Objectives

Therefore the aim of this study was to examine and compare the core functioning and the endurance of the Transversus Abdominis (TrA) in three different populations. Each of the three groups consisted of fifteen female subjects between the ages of 25- 45 years. Group A subjects comprised a strictly sedentary population. The second group, Group B was required to be moderately active. Group C attended regular Pilates classes at Pilates House studio.

Minimal research has been done in the field of Pilates and it is for this reason that null hypotheses were set.

Objective one: To determine the activation of the Transversus Abdominus muscle in three groups: sedentary, physically active and those that practice Pilates method.

> *Hypothesis one: The activation of the Transversus Abdominis muscle of the three groups will not display any difference.*

Objective two: To determine the endurance of the Tranversus Abdominus muscle in three groups: sedentary, physically active and those that practice Pilates method.

> *Hypothesis two: The endurance of the Transversus Abdominis muscle of the three groups will not display any difference.*

CHAPTER TWO

Literature Review

2.1 Introduction

It is well agreed upon in the literature that the Transversus Abdominis has a vital role to play in maintaining a strong and healthy core (Cresswell *et al*., 1994; Hodges and Richardson 1996, 1997, 1999; Hodges *et al*., 1996; Richardson *et al*., 1999). Pilates method follows the concepts of core stability and purports to strengthen the core and contribute towards postural awareness. A review of the literature performed by Akuthota and Nadler (2004) revealed that relatively little research has been performed with regards to core stability although the concept is promoted and widely used in recreational gym settings, as well as clinically in rehabilitation scenarios.

2.2 Relevant Anatomy

2.2.1 Muscle function in Trunk Stability

Bergmark (1989) categorised the anatomy of the trunk into two aspects from a neuromuscular standpoint, with the superficial muscles being the outer global system and the deeper muscles constituting the deep, local system. Both these systems have vital roles to play, as no one muscle is of more worth. All muscles have integral roles to play depending on varying movements and postural demands. The integration of the two systems ensures that stability is maintained if the coordinated action of both the systems is present. It has been noted that exercise which aims to activate these muscles in sequential order is required to retain and ensure motor control and future stability (Richardson *et al*., 1999).

2.2.1.1 The Global System

The global system consists of the larger muscles of rectus abdominis, the external and internal obliques, quadratus lumborum and erector spinae. Although, they do provide some trunk support and are involved in postural control of the 'core', these muscles are limited in providing individual support to vertebrae and hence in providing intersegmental stiffness. Thus, it supports the argument for the importance of these muscles within a rehabilitation setting (Richardson *et al*., 1999). With the muscles in this system being larger, the functional role is to produce and control movement of the trunk whilst generating larger torques and to also respond to external loading of the vertebrae.

Rectus Abdominis

A long muscle that arises from the pubic crest and attaches caudally into the 5th and 7th costal cartilages of the ribs as well as to the xyphoid process. It is separated by three horizontal bands that traverse the muscle and allow for attachment of the external obliques (Lee, 2004).

Internal Obliques

This bilateral muscle arises from the lateral iliac crest and the thoracodorsal fascia. Running between the external obliques and the TrA, it attaches to the 10th, 11th and 12th ribs. The anterior fibres blend with the TrA aponeurosis and eventually attach to the pubic crest. The intermediate fibres assist to form an aponeurosis of the external obliques and the TrA (Lee, 2004).

External Obliques

The biggest abdominal muscle, which arises from the outer surfaces of the lower eight ribs, the posterior fibres run inferiorly to the anterior half of the iliac crest. Bilaterally the upper and middle fibres unite with the abdominal aponeurosis centrally, whilst the deeper layers of the fibres blend with the aponeurosis of the contralateral internal obliques (Lee, 2004).

Quadratus Lumborum

These rectangular like muscles, which connects from the anterior surfaces of L1 to L4 transverse processes on either aspect of the spine. The fibres are arranged in oblique and longitudinal arrangements and connect to the iliums and the 12^{th} ribs (Bogduk, 2005).

Each muscle comprises of different layers: anterior, middle and posterior. Within each layer, exist fascicles that are interwoven and present in an irregular composition. There still exists uncertainty as to the actual function of the Quadratus lumborum muscle, yet it is thought to play a role in both lumbar lateral flexion as well as lumbar extension as the muscle attaches behind the centre of saggittal rotation (Bogduk, 2005).

Lumbar Erector Spinae

The erector spinae comprises of two muscles: the longissimus thoracis and the iliocostalis lumborum. Each of these muscles is made up of two components as each of these muscles arises either from a lumbar or a thoracic site. Hence, they are named appropriately to the site from which they arise: longissimus thoracis *pars lumborum*, iliocostalis lumborum *pars lumborum,* longissimus thoracis *pars thoracis* and iliocostalis lumborum *pars thoracis* (Bogduk, 2005).

2.2.1.2 Local Muscle System

Panjabi (1992a,b) emphasised the importance of the local muscles in intersegmental stabilisation. Although there is no agreement in the literature over the constituents of the local system, Bergmark (1989) noted the following muscles as important: Multifidus, Transversus Abdominis, the deep fibres of the

Quadratus Lumborum and the posterior fibres of the internal oblique which insert into the thoracolumbar fibres. These muscles are smaller and lie closer to the spine and help to increase intersegmental muscle stiffness and hence control lumbar functional stability. Not only do they balance loading at a segmental level, a certain proprioceptive function is apparent (Richardson *et al*., 1999)

Multifidus

The most medial and biggest of the lumbar muscles, the multifidus, is an important segmentally arranged muscle. It attaches from the spinous processes or laminae of the lumbar spine caudally to the mammillary processes of the vertebrae. The most important feature of the multifidus arrangement is that the fascicles are organised segmentally and are therefore designed, in morphology and innervation, to act on a single vertebral spinous process in a synchronized fashion. The prime function of the multifidus appears to be as a 'stabiliser' and as of yet, no research indicates specifically the planes of movement that are involved (Bogduk, 2005).

Transversus Abdominis

The deepest abdominal muscle and also the primary core stabiliser the Transversus Abdominis (TrA) originates from the lateral third of the inguinal ligament and the anterior two thirds of the iliac crest, the lateral aspect of the thoracodorsal fascia and the inner aspect of the lower six costal cartilages of the ribs. Distal attachments are mainly to the aponeurotic fibres of the contralateral TrA and internal oblique muscle (Lee, 2004). Urquart *et al.,* (2005a) noted that there is differentiation in fibre orientation of the TrA namely in the upper, middle and lower regions. The upper region was orientated superomedially, the middle fibres ran inferomedially and the lower region appeared inferomedially more so than the middle. A subsequent study by Urquart *et al.* (2005b), compared and noted the difference in the morphology of the TrA, internal oblique and external oblique. They noted the difference of fibre orientation between the TrA and the internal oblique muscle and the importance this finding could have on the approach to training the abdominal muscles in therapeautic exercise.

2.2.2 The Deep Muscular Corset

The relationship between the TrA, multifidus and the fascial system is of utmost importance in understanding local muscle function. The TrA appears to play its role in spinal stability through its pull exerted upon the fascia when the muscle is contracted. The TrA inserts anteriorly into the abdominal fascia and posteriorly into the thoracolumbar fascia. Hides *et al.* (2006), conducted a study with thirteen male subjects using real time ultrasound and MRI to view the TrA thickness during varying degrees of contraction. They concluded that when the TrA contracts bilaterally or is “drawn-in”, it has the ability to provide a corset like action and actively provide lumbopelvic stability (Richardson and Hides, 2004).

2.3 Biomechanics of the Lumbar Spine in relation to Core Stability

Panjabi (1992a) developed and introduced an effective model of spinal stabilisation. This model assisted in linking the concepts of instability and spinal stabilisation, which aids in our understanding of low back dysfunction in a clinical setting. The basic fundamentals of the model link together three subsystems, which are interdependent and together, must work efficiently to maintain adequate stability of the task at hand. The substructures according to Panjabi’s model are as follows:

- Passive subsystem: consists of osseous and ligamentous structures.
- Active subsystem: refers to the spinal muscles and their own force generating capacity.
- Neural subsystem: recognized to control the above-mentioned muscles in relation to sensory feedback.

Hence any discrepancies in either of the subsystems, and the other two remaining substructures will compensate accordingly. This concept of a dynamic and interchangeable model has enabled a greater understanding of the versatility of trunk control.

It is agreed upon in the literature, that neuromuscular control is required to maintain equilibrium of the spine and must be functioning efficiently in order to cope with variable dynamic circumstances, so that a level of stability can be achieved or maintained (Granata *et al*., 2005). The lumbar spine is expected to support a load from the upper torso that is four to five times greater than its own buckling load threshold. Added to this is a variety of outer forces that act on the spine on a daily basis. The dampening of external forces acting in the segments of the spine and those forces arising from interaction between these and the muscular forces generated in response is the single most important mechanical function of the spine (Cholewicki and Silfies, 2004). Lumbar spine stability increases with trunk loading and if the magnitude is great enough this can bring about trunk muscle activation (Cholewicki *et al*., 2000).

Since the spine is recognized to be "inherently unstable", it is generally accepted that it relies on the superficial and deep intrinsic trunk muscles to form a corset type structure that helps maintain what has been called the theoretical neutral zone of the spine (Panjabi, 1992b). Panjabi also noted the neutral zone has low muscle stiffness and relies on trunk muscles for increased stability. Not only must the muscles be adequate in tone and endurance in order to satisfy the dynamic demands of spinal control, but that the contributions would be only as effective as the controller: the central nervous system (CNS) (Panjabi, 1992a). The CNS must interpret the varied stability status from internal and external forces and initiate an appropriate co-coordinated response (Hodges, 2004). Hodges and Richardson (1996) hypothesised that the ineffective functioning or activation of the TrA might result in inadequate muscular stabilization of the lumbar spine.

Analyses of biomechanical models have suggested that the abdominal co-activation through antagonistic contraction may be recruited in order to provide trunk stiffness and in doing so perform the stabilising role for the lumbar spine (Gardner-Morse and Stokes, 1998). The spinal column is also responsible for absorbing and transferring forces from the torso to the lower limbs. Wagner *et al.* (2005) used a biomechanical model and Ljapunov's theory to examine certain loading patterns on the spine and the effect of motion on the spine. The study evaluated antagonistic trunk muscles of the spine and their stabilising behaviour. The constitution of the model relied on the maximum contraction velocity of the muscle, which was based on the Hill-type model. The Hill-type model aids in describing the relationship of the force-contraction velocity of the muscle. Utilising a pair of Hill-type, antagonistic muscles to constitute the model, sudden loads and quick-release of an external force were applied to the 10 male subjects. It was found that it could be advantageous to use simultaneous contraction (co-contraction) of the abdominal and lumbar muscles whilst training.

2.4 The Concepts of Core Stability and Strengthening

Core training is being increasingly recognised as an essential part of any training programme, regardless of the person's level of activity. The main understanding being that the 'powerhouse' links the trunk and the limbs and provides support around the neutral spine as well as during more complex and interactive movements (Bliss and Teeple, 2005).

The umbrella term 'core strengthening' is used to describe a number of different interpretations of the concept of training the broad and loosely defined area called the core (Akuthota and Nadler, 2004). A variety of definitions abound as to what exactly constitutes the core, physically as well as physiologically. According to Kibler *et al.* (2006) the definition of core stability is " *the ability to control the position and motion of the trunk over the pelvis to allow optimum production, transfer and control of force and motion to the terminal segment in integrated* *athletic activities*". The core is seen as playing a pivotal role in the biomechanics of the body by providing an important linking system.

Akuthota and Nadler (2004) described core strengthening as a "*description of the muscular control required around the lumbar spine to maintain functional stability*". Their review recognised that core strengthening has also been promoted in various arenas including recreational as well as medical settings.

2.5 Clinical Relevance of Trunk Stability and Motor Control

Current research indicates that in asymptomatic subjects, there are a variety of co-activation, activation patterns of the trunk muscles and timing of activation. Cholewicki and Silfies (2004) stated that this may be due to the complexity of the motor control system and suggest that different and varying co-contractions, timing patterns or activations may provide the appropriate stability for that specific activity. Traditionally, individual muscle training was incorporated with an emphasis on the traditional training protocols of high repetitions and high loads.

Programmes that place emphasis on one specific motor control pattern are also being questioned (McGill *et al.,* 2003). Muscle activity required for daily, low-load tasks requires co-contraction of the trunk muscles for long periods of time with low force. Hence, programmes should be based on dynamic movements that incorporate postural control with low load and high repetitions. A learning process should exist whereby the individuals are encouraged to develop their own stabilization strategies. Therefore, a gross contraction of the trunk musculature would progressively acquire a more skilled specific pattern of co-activation contraction that will maintain the expected or desired stability (Cholewicki and Silfie, 2004).

2.6 The Specific role of the Transversus Abdominis in Core Stability

The TrA appears to function independently of the other trunk muscles. Many studies have lead to the conclusion that TrA functions separately from the remainder of the abdominal muscles including the rectus abdominis, external obliques and the internal obliques (Cresswell *et al.,* 1994; Hodges and Richardson 1996, 1997,1999). Ultimately, it is believed that the TrA plays a primary role as a stabilising muscle for the lumbar spine. There exist differences, in the schools of thought, as to how the TrA achieves this mechanism. Cresswell *et al.* (1994) believes that the TrA acts through increasing the intra-abdominal pressure whilst Hodges and Richardson (1996) believe that the action of the muscle on the motion segment is responsible for resisting different forces acting on the joints, namely rotatory and translatory.

There is debate within the literature regarding the role of intra-abdominal pressure (IAP) in the control of the trunk (Hodges, 2004). A subsequent study by Hodges et al. (2005), aimed to evaluate the relationship between spinal stiffness and IAP. The extensor and flexor muscles were made redundant for the study and IAP was increased by stimulation of the phrenic nerves to the diaphragm. They concluded that although the IAP contributed to increased spinal stiffness with selective diaphragm stimulation, it must be noted that the diaphragm is not selectively and exclusively activated during functional activities and therefore, spinal stability is the net effect of combined elements including the appropriate muscles. The TrA has been implicated as an abdominal muscle that is able to create IAP (Cresswell et al., 1994). However, Gardner-Morse and Stokes (1998) believe that the muscle co-activation required for intersegmental stiffness can lead to an increase on compressive forces on the spine. Yet, Cresswell et al. (1994) concluded that the increase of pressure noted within the abdominal cavity prior to limb movement would appear to add to spinal stability and be protective in function.

The reaction of the TrA in regards to changing stimulus and environment appears to be different in comparison to the superficial postural muscles, which rely on directional information from the brain before effectively engaging in activity. It is increasingly recognized that the TrA is separately influenced by the CNS and appears to react in a more basic manner than the global muscles of the trunk (Hodges and Richardson, 1997; Hodges and Richardson, 1999). Urquart *et al*., (2005a) noted that the TrA also responds to a variety of postural situations and responds regionally according to the demands made upon the trunk muscles. The TrA is recognized as having a significant role to play in providing and contributing towards intersegmental stiffness and spinal stability (Hodges and Richardson, 1999).

A study performed by Richardson *et al*. (2002), demonstrated the effect of the abdominal pull-in on the sacroiliac joint. Subjects were instructed to pull in their abdominal musculature and keep the spine straight, hence only engaging the transverses abdominis and the multifidus, in place of the higher level of activity through abdominal 'bracing'. The effect noted was a decrease in sacroiliac joint laxity and therefore an increase in the joint stiffness measured by Doppler imaging of vibrations. Hence, the results indicate the TrA provides joint stiffness during weight bearing. As noted above, the local system tends to be isolated upon the action of drawing-in or hollowing of the abdomen.

The activation of the TrA occurs during static trunk movements as well as with trunk loading (Cresswell *et al*.,1994). The TrA is an anticipatory muscle of the low back and is recruited prior to any upper or lower extremity movement (Hodges and Richardson 1997, 1999). According to Hodges and Richardson (1997), the TrA activation occurred prior to the prime mover of the hip joint when they evaluated the reaction of the TrA in 15 young adults whose trunk muscle activity with simultaneous lower limb movement was evaluated. With preprogrammed limb movement, the TrA is seen to be active prior to the activity of the prime mover, and then throughout the limb's movement. With leg loading it is noted that the TrA is one of the first muscles active regardless of the direction of movement of the limb or the direction of loading on the spine (Richardson *et al.*, 1999).

A study by Hodges and Richardson (1999), on 15 asymptomatic young adults evaluated and compared the response of the abdominal muscles and the deltoid muscle. The subjects were stimulated with different flashing green-coloured lights that indicated a direction that they would be required to move in. Electromyographic recordings from the left abdominal musculature and right deltoid were taken using ultrasound guided, fine wire electrodes to measure level of muscle activity. The time it took for the EMG to react to the stimulus (reaction time) and latent period between the onset of the EMG of the deltoid and each of the abdominal muscles was recorded and analyzed. Results indicated that the TrA maintained a constant state of activity to the stimulus, which contrasted, with the findings of the other abdominal musculature (internal and external oblique) and the deltoid where there was a longer latent period before onset of activity of the muscle. Amongst their conclusions is that the TrA appears to respond separately from the other abdominal muscles pertaining to the motor control command for limb movement. This is in contrast to the other abdominal musculature, which may indicate that, the TrA is influenced by the CNS separately (Hodges and Richardson, 1999).

According to Hodges (2003a) study the key concept was revealed as follows:

"When the upper limbs were moved rapidly in response to a light, the anticipatory postural adjustment did not stiffen the trunk, but rather there was a consistent pattern of trunk motion that was specific to the direction of limb movement."

The above statement explains that the most advantageous stability may be achieved though mobility, movement and a well-functioning efficient control system and not through rigidity or inflexibility. The TrA may have a dampening function that is used to dispel forces acting on it. Clinically, this information would then support the use of exercise programmes that aim to perform the movements with control or 'mobile stability' and not the use of bracing or rigidity (Lee, 2004).

The TrA is widely acknowledged not to activate or to have a variable time-delay in response to leg loading in subjects that have chronic back pain (Hodges and Richardson 1997, 1999). The TrA is hypothesized to be inefficient in muscular stabilization of the lumbar spine due to a deficit in motor control function in patients with low back pain (Hodges and Richardson, 1996). Furthermore, Soderberg and Barr (1983) concluded that the TrA is often difficult to activate and train, and may be weaker in both sedentary individuals and persons with chronic low back pain.

2.7 Moderate activity and its relationship to core stability

Kinematic data gathered by Saunders *et al*. (2005) identified, through EMG activity that the TrA and other abdominal muscles are active throughout running and walking. Therefore, an increase of locomotor activity placed demands on the core and in turn the muscles responded. The TrA is contracted tonically throughout all phases of gait motion with speeds of up to 3 m/s, walking and running, unlike the other more superficial abdominal muscles (Saunders *et al.,* 2004). This in turn further verifies the TrA's function as a stabilizing muscle that contributes to intersegmental stiffness of lumbar spine and pelvis (Richardson *et al*., 2002 and Hodges *et al*., 1999, 2003b).

It has been indicated that abdominal curls may be inadequate in training the core effectively and in aiding or building lumbopelvic control (Herrington and Davies, 2003). It was found that only 33% passed the abdominal pull in test (or TrA isolation test) as opposed to the 83% of the Pilates-trained group that passed the test. However, both groups faired better than the sedentary control, which only had a 25% success rate. When lumbopelvic stability (LPS) was tested, the

Pilates group had only a 42% pass rate, whilst both the gym and sedentary groups had 0% pass rate.

However, there are people undertaking regular cardiovascular exercise such as running and walking without performing any core stability exercises. A pilot study by Robertson (2005) suggests that regular moderate exercise without any core strengthening exercises performed, does not serve to enhance core stability performance.

A study by Mills *et al*., (2005) performed on thirty-three female basketball and volleyball athletes, revealed that after a 10-week training regimen, which included specific core training exercises, lumbopelvic stability was increased. Measurements were taken before training started and once the subject had completed the full 10-week programme. Results indicated that the athletes responded with increased lumbopelvic stability and were able to achieve higher scores on the lumbopelvic grading post training programme, even when subjected to an imposed higher torque.

2.8 Pilates and its relationship to core training

With the current focus on core strengthening, Pilates has developed a significant following. With the growing awareness in core strengthening strategies, mounting interest in Pilates is leading to increased popularity within the medical fraternity and the fitness industry. Von Sperling de Souza *et al*., (2006) performed a descriptive study to provide foundational literature on the subject and concluded that additional studies, which are experimental in design, are required to determine Pilates method's effectiveness as a therapeautic tool or intervention. The study also stated that available research studies appear to have poor controls and there are few published controlled or randomised controlled Pilates studies available.

A fitness programme that follows the fundamentals of core training principles, Pilates method, was originally developed by Joseph Pilates, and aims to incorporate and combine principles from gymnastics, martial arts and dance to provide a body conditioning system that has a strong focus on mind- body inter-functioning (Von Sperling de Souza *et al*., 2006). The main aims of Pilates method are purported to promote body performance and core strengthening whilst maintaining overall efficiency in movement (Anderson and Spector, 2000).

Pilates method has existed in dancing and gymnastic circles for many years, yet it has only recently became widely available to the general public. However, it has surpassed its fad status and is punted widely as a beneficial tool in the promotion of core strength and is being prescribed by health professionals.

According to Siler (2000), the six key principles of the Pilates method are centering, concentration, control, precision, breath and fluidity.

- Concentration is important in that it is the mind that guides the body.
- Control refers the performance of an exercise without unnecessary exertion during the movement. Therefore, momentum is not used to aid motion.
- The concept of centering encompasses the ‘powerhouse’ or core and the how our energy is focused in the powerhouse and how this energy flows outward to the limbs.
- Precision is emphasized in that every motion in a Pilates movement has a purpose. Therefore, quality of the movement is paramount.
- Breath is regulated in order to maintain optimum nutrition to body tissues.
- Fluidity of the movements ensures the grace and the smooth interchange between exercises.

Siler (2000) in addition has three other principles, which help to encourage a holistic approach to the exercise. Imagination, intuition and integration are considered key ingredients to the enablement of further coordination of the mind body connection.

A major tenet of Pilates method is the principle of “centering”, whereby it is believed that all the body’s movements originate from the core. The core is also commonly referred to as the “powerhouse” and hence Pilates method aims to strengthen this “powerhouse” and ensure that it is functioning at optimum (Muscolino and Cipriani, 2004a). The concept of the ‘powerhouse’ forms the foundation of all Pilates movements (Alpers *et al*., 2002). It is believed in Pilates method that the ‘powerhouse’ is responsible for storing all the energy necessary for the movement. It is projected that this ‘powerhouse’ is the centrepoint of the body and if anatomically described it is the point where the TrA, multifidus and erector spinae interact. The aim is to keep the ‘powerhouse’ initiated and in use throughout all the movements. Hence, if limbs are required to move, the mindful thought involves moving the limb from the center or ‘powerhouse’ (Winsor, 2001).

The primary aims of the exercises are alignment of the spine or body and core strength with an emphasis on postural awareness. Progressive by design the method of Pilates can be safe for the beginner yet effective and challenging for even the most advanced candidate. Essentially, Pilates exercises aim to challenge the neuromuscular system (Anderson and Spector, 2000).

Joseph Pilates developed a system of exercises that varied from floor mat work to the use of devices such as barrels, stability chairs and reformers. Exercises range from the simple, which are completed in one plane on a stable, broad surface (mat), to those more intricate moves. Complexity of the exercise can be altered by decreasing the size or stability of the surface or by loading of the trunk through movement of the limbs. The apparatus helps to create different load patterns which could alter and diversify load patterns applied to the body, hence creating a dynamic environment which would stimulate the neuromuscular system constantly, creating and encouraging adaptation and strengthening or retraining of the motor system (Anderson and Spector, 2000). Whilst keeping the spine in a neutral position, limb movements as well as training apparatus can be added to produce different loading patterns to the trunk muscles or 'powerhouse'. It aims to strengthen these core muscles, with specific mindful focus on the 'powerhouse', whilst performing other limb movements that may be distant to the core (Musculino and Cipriani, 2004b).

For the period during which the exercises are performed, the aim is to engage the core muscles and keep them contracted throughout all the movements performed. At first small movements are used in a singular plane but gradually these are built up to more dynamic movements in multiple planes of movement once the participant has the endurance to keep the correct posture during the movements. As strength and form develops, the base of support may be minimized to enhance retraining of proprioceptive mechanisms whilst promoting more efficient and economical movement patterns (Anderson and Spector, 2000).

Herrington and Davies (2003) evaluated thirty-six females in a study that considered the effect of Pilates method upon the TrA. The study consisted of two training groups, one group consisted of a Pilates trained group and the other group had been trained in doing abdominal curls over a period of six months. A non-training group served as a control. A PBU was used to assess their TrA activation and lumbopelvic stability (LPS). The Pilates group achieved a better rate of activation and LPS than both the group doing abdominal curls and the group doing no abdominal exercises. This study serves to suggest that the TrA could be more efficiently trained and contracted voluntarily along with subsequent improvement of the lumbopelvic posture in subjects that regularly practice Pilates method.

Hence, this research aims to determine whether the TrA is activated and whether endurance of this muscle is developed through Pilates training in comparison to regular moderate exercise. This would assist in providing an indication as to whether Pilates method may be a beneficial tool in training core musculature and to enhance lumbopelvic posture.

2.9 Conclusions

The literature available suggests that more studies are needed in the Pilates arena to aid and develop the body of literature. According to Von Sperling de Souza *et al.,* (2006), studies are needed that are experimental in design and that explore the idea of Pilates method as a therapeautic tool or intervention. Herrington and Davies's (2003) study suggested that Pilates encouraged improved ability to contract the TrA and maintain LPS in comparison to a non-training control group and those performing abdominal curl exercises.

According to Cholewicki and Silfie (2004), in an article reviewing the literature of the biomechanics of the lumbar spine, it was noted that most research regarding the motor control assessments and treatment thereof, is in its early stages. They noted that more controlled studies regarding the assessment and treatment of the trunk are required to formulate protocol in regards to motor control diagnostic assessment and treatment.

Currently, it is suggested that although the local muscles of the trunk contribute towards control of the lumbar spine, they can be compromised by influences from the presence of pain and other homeostatic functions such as respiration. Hence, healthy functioning of these deep trunk muscles are required to promote good spinal movement with the adequate amount of control at the intervertebral segment. This lends support to the development and use of programmes to promote inter-functioning motor control and coordination with other homeostatic mechanisms of the deep muscles (Hodges, 2004).

According to Akuthota and Nadler's (2004) review of the literature, it has been noted that inadequate research as to the clinical outcomes of core strengthening programmes has been done. This statement was expanded upon and it appears that there is no consensus as to what the constituents of a core-strengthening programme are. They concluded that much research on the core is related to low back pain, yet despite this fact, due to new discoveries in motor control theories, the body of research is poised for a new direction.

The aim of this study was to determine and compare the activation and endurance of the TrA in three different fitness populations. This will provide information as to the core stability status of individuals who are regular exercisers in the average gym setting as opposed to those that perform Pilates method exercises, which actively engage their 'powerhouse' muscles throughout all body movements performed. Both of the above mentioned groups were assessed in comparison with a control group comprising of sedentary individuals.

CHAPTER THREE
Methodology

3.1 Introduction

In this chapter the main methodological criteria and design factors shall be discussed in order to substantiate the data collection process. They shall be further discussed under the following appropriate headings:

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

3.2 Study Design

The design of the study was that of a cross-sectional, quantitative study conducted on 45 subjects. As little published research exists in the field of Pilates a pilot study was performed.

3.3 Method

3.3.1 Sampling method

Opportunity sampling was used and the subjects were accepted into the research on a first come, first served basis. Advertising at gyms and the Durban University of Technology was used. The researcher also approached persons within and related to the health and fitness industry including chiropractors, physiotherapists and personal trainers to aid the advertising process. The Pilates group was drawn solely from the Pilates House studio. All subjects were drawn from the greater Durban Metropolitan area.

Each of the subjects underwent a physical and lumbar regional examination before data collection commenced. The abdominal draw-in test, lumbopelvic posture grading and endurance measurement of the Transversus Abdominis (TrA) muscle were used to collect relevant data. Data collection was achieved using a pressure biofeedback unit (PBU) called the Stabilizer using mmHg as the measurement unit. This device enabled the researcher to measure the activation ability and strength of maximal contraction of the subject to engage their TrA. This device coupled with a stopwatch was used to measure the static contraction of the TrA over a length of time. A surface electromyography machine measured feedback from the TrA muscle

Statistical analysis was completed on SPSS version 13. A *p* value of less than 0.05 was considered statistically significant.

3.3.2 Sampling Size

This study included 45 female subjects. Three groups consisting of fifteen subjects each were utilised and subjects were distributed appropriate to their fitness levels and type of training or lack thereof. The sedentary group provided a non-training control. However, the moderately active fitness group was a similar control as it enabled a comparison between the Pilates group.

3.3.3 Subject screening and evaluation

The participant evaluation and selection process began with a brief telephonic interview with the researcher to determine if participants were eligible for the study and into which subgroup they would fall.

The following five standard questions were used to determine eligibility of the prospective subject for the research project.

- Age
- Lack of symptoms in the lower back region.
- Training habits.
- Training period per week
- Regularity of training

If the candidate was successful at the telephonic interview, the candidate was then evaluated at an initial screening in order to determine whether they fulfilled all inclusion criteria. At this stage that the subject was presented with a Letter of Information (Appendix 2) and signed an informed consent form (Appendix 3). A case history (Appendix 5) was taken and then the subject underwent a full physical examination (Appendix 6) and a lower back regional examination (Appendix 7). The information obtained was vital for establishing whether the subject met the inclusion and exclusion criteria and hence their suitability for the study.

3.4 General Inclusion Criteria

1. Subjects were female.
2. Between the ages of 25 to 45 years.
3. Subjects were asymptomatic with regards to low back pain.

4. The BMI as calculated by dividing the weight of the subject by the Height of the subject squared: Weight (kg)/ Height^2 (m^2). The BMI had to be within normal range of 18.5 to 24.9 kg/m^2 (Haslett *et al*., 1995).

3.5 General Exclusion Criteria

1. Subjects who currently had low back pain or who were currently receiving treatment for low back pain.
2. Contraindications for abdominal muscle strengthening: Glaucoma, pregnancy, hypertension, osteoporosis, spinal tumours, inflammatory diseases and impaired circulation (Harms-Ringhdal, 1993).
3. Subjects who had extreme discomfort upon contracting abdominal muscles.
4. History of lumbar / abdominal surgery or trauma within the last six months (see footnote at bottom of page).
5. Subjects who had any known neuromuscular disorders.
6. A significant scoliosis.
7. Any subjects that were pregnant or that were breastfeeding or that had given birth within the previous six months.
8. Males were excluded from this study to minimise variation and morphological differences.
9. Subjects who did not sign the informed consent form.
10. Persons who did not understand or comprehend the assessment instructions were excluded from the study.

Note: Due to the popularity of Caesarian sections and other abdominal surgery that involve female reproductive organs, it was decided to allow participants who had had abdominal surgery more than six months prior to the study to take part in the research. A study by Becker et al. (2005), noted that reinnervation and 80% of muscle function was restored in a rat skeletal muscle within three months. Scant research on human reinnervation was available. Refer to page 35 for a detailed table regarding history of abdominal surgery.

3.6 Specific Group Criteria

<u>Group A</u>

1. Subjects were not to participate in any exercise routine.
2. The occupation of the individual was to require minimum activity.

<u>Group B</u>

1. Participants were expected to engage in moderate resistance training for a minimum of 2.5 hours per week (ACSM, 2001).
2. Moderate resistance exercise was included in the individuals training routine for at least three months duration (ACSM, 2002).
3. Exercise may include cardiovascular and weight training.
4. Participants were recruited from a gym setting.
5. Attendance of core target or Pilates classes was prohibited.
6. Casual use of Swiss balls or core exercises in a gym setting was permitted.

<u>Group C</u>

1. Participants were included who performed Pilates at least twice a week.
2. At least three months of Pilates training on a regular basis was required.
3. Attendance of a minimum of 24 classes within the last three months was required.
4. Subjects were drawn from one Pilates studio to minimise the interference from different training techniques.
5. Subjects were allowed to participate in cardiovascular exercise.

3.7 Instruments

The Stabilizer also known as a Pressure Biofeedback Unit (PBU) (Chattanooga Group, Tennessee, USA) was employed to measure quantitively the activation and endurance of the Transversus Abdominus muscle.

The Stabilizer pressure biofeedback unit (PBU) was used to evaluate and indirectly measure the subjects' ability to contract the TrA and to evaluate lumbopelvic stability. Cairns *et al*., 2000 demonstrated the effectiveness and reliability of this tool in measuring deep abdominal muscle function as well as rotatory and sagittal bias of the lumbar stabilisation (Jull *et al*., 1993). The same unit was used on all subjects to remove any intra-rater reliability factors that may have resulted from using two different units.

A stopwatch was used to measure the maximum time of contraction of the TrA in seconds and then data was allocated into the appropriate time scale category. As the endurance time could have been indefinite with some candidates, time categories were introduced along with the cut-off time of three minutes, in order to limit the possibility of lengthy endurance times by subjects. A surface electromyography (sEMG) device (Chattanooga Group, Tennessee, USA) was used as a guidance tool to read muscle activity from the TrA. Pads were placed over the TrA bilaterally and then the reading was noted when subject exhibited their maximum contraction.

3.8 Assessment protocol

Each participant was asked relevant questions pertaining to their age, race, history of low back pain, history of pregnancies, number of children, birthing techniques used, in order to collect data. This was to aid in preventing variables influencing and confounding data analysis.

The aim was to measure the endurance of the core muscles and their activation during a once-off consultation.

The role of the TrA has been demonstrated to be of great importance in continuous spinal stabilisation during movement. In order to effectively assess the participant's TrA endurance effectively, Richardson *et al*. (1999) developed a test designed to target the TrA called the abdominal draw-in test. A pressure biofeedback unit (PBU) was employed to measure the contraction of the TrA over a period of time with the subject aiming to keep the TrA activated in order to keep the pressure reading of the PBU within the required range. Findings from Cairns *et al.* (2000), and Jull *et al.* (1993) support the claims of Richardson.

The participant was taught to recruit the TrA and in so doing so, they hollowed out their abdomen. This in turn provided an inhibitory effect on the superficial rectus abdominis, as well as allowed the identification of any substitution strategies and a chance for them to be rectified (Richardson et al., 1999).

Each test was explained verbally to the subject and then the participant was given the opportunity to practice the test. Once the subject was recognised to be competent in recruiting the TrA in isolation, formal testing commenced.

Abdominal Draw-In Test

The abdominal draw in test was performed in the prone position on a gym mat. The PBU was placed across the subject's lower abdomen in line with the ASIS (anterior superior iliac spine) bilaterally and centred using the naval as reference. The three-section bag was then inflated to a baseline pressure of 70 mmHg.

From this position the subject was then requested to draw in their abdomen and hence contract the TrA. The examiner then noted whether there was any drop in pressure. When a contraction was correctly performed, a drop in pressure of 6-

10 mmHg was seen. With normal breathing, fluctuations in pressure of approximately 2 mmHg were noted. However if there was a sudden rise or fall in pressure, this was most likely due to fatigue or recruitment of other muscles. The examiner noted whether there was any deep inspiration or movement of the trunk or pelvis, as this would have falsely influenced readings.

Next, the duration of the contraction of the TrA was timed with a stopwatch. The examiner was alert to any compensatory movements by the participant such as arching the back, elevation of the rib cage that would have artificially influenced the readings on the PBU. Subject's endurance was measured according to a time scale category (0 – 30, >30 – 60, >60 – 90, >90 – 120, >120 – 150, >150 - 180 seconds) (see Appendix 1).

Lumbopelvic Posture

The PBU was once gain employed to measure lumbopelvic posture.
This test allowed the use of progressive leg loading whilst the subject was supine, to examine the strength of the trunk muscles as they provided lumbopelvic stability.

The participant was shown the procedure and then was required to practise the movements to ensure that the subject understood what was required. The subject would assume a supine crook position in order to allow the examiner to observe any changes in pelvic tilt from the neutral plane. The PBU was placed under the lumbar spine, depending on whether a sagittal or rotatory bias was emphasized*. "When the leg-load test emphasized a rotatory bias, the bag was positioned longitudinally just lateral to the lumbar spine; if leg-loading was directed more along the sagittal plane, the bag was placed along the lumbar spine, with it's base at S2 level*" (Richardson *et al.*, 1999) The legs were in the adducted position to measure saggital control and were abducted when assessing for rotary control.

The PBU was inflated to 40 mmHg. The subject was then requested to draw in their abdomen whilst maintaining the neutral position of the pelvis (i.e. no posterior pelvic tilt). The abdominal wall was to be kept tight throughout the leg load procedure. The subject had to maintain the flatness of the abdomen and hence the pressure reading for the entire leg load procedure.

Leg slide procedure:

The subject's position began in the supine crook position. They were then asked 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 then brought the heel back along the examination surface to the starting position.

Grade 1:

A: Single leg slide performed with contralateral leg support. The heel on the test leg slid 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 slid the heel down the surface of the examination surface.

B: Unsupported leg slide with the contralateral leg unsupported. The test leg was held approximately 5 cm from the examination surface and extended before being brought back to the starting position.

At the point where the leg load exceeded muscle capacity, a bulge in the abdominal musculature was noted and simultaneous fluctuations in the reading on the pressure gauge were apparent. At this point the subject would be graded to the appropriate level.

As soon as the pressure changed, the subjects were allocated their relevant grading, at the point at which they could not maintain the abdominal draw in contraction. Poor control of the abdominal muscles was revealed by significant pressure changes on leg loading at grade 1 *a* (poor control) and 1 *b* (below average control) hence the subjects were not able to complete grade 1 procedure. Subjects with good control showed minimal pressure changes with leg loading and were able to complete the procedure up to grade 2 *a* (good control) and 2 *b* (excellent control).

3.9 Data Collection

3.9.1 Frequency

Data collection took place during a once off consultation on the day of the initial assessment. All measurements required for the study were taken that day. Data collection took place at the Chiropractic Day Clinic at the Durban University of Technology, Steve Biko Campus and Pilates House studio at Silvervause Centre, corner of Silverton and Vause roads.

3.10 Statistical Analysis

Data was entered and analysed in SPSS version 13 (SPSS Inc, Chicago, Ill, USA). A p value of < 0.05 was considered as statistically significant. The outcomes of interest were: Lumbar posture categories (4 categories – ordinal data), Muscle contraction (decrease in pressure) and endurance (on a time scale of 1 to 6 – ordinal data). The exposure of interest was the population group (3 nominal groups: sedentary, moderately active and Pilates). However, there were additional factors that could influence the outcome (e.g. age) and these were listed and measured using a questionnaire. Associations between the exposures of interest and the outcomes were assessed bivariately:

1. Population group and lumbar posture: Mann-Whitney test
2. Population group and muscle contraction: ANOVA with Bonferroni multiple comparison tests.
3. Population group and endurance: Mann-Whitney test

In order to account for any confounding by other factors, bivariate models were used.

CHAPTER FOUR

Statistical Methods and Results

4.1 Introduction to Statistical Methodology

SPSS version 13 (SPSS Inc., Chicago, Illinois, USA) was used to analyse the data. A *p* value of <0.05 was considered as statistically significant.

Bivariate associations between demographics or risk factors and population groups were tested using Pearson's chi square tests in the case of categorical variables, or ANOVA tests in the case of quantitative normally distributed variables, and Kruskal-Wallis tests in the case of ordinal variables.

Bivariate associations to assess the differences between population groups and the outcome variables were achieved using Pearson's chi square tests in the case of categorical variables, or ANOVA tests in the case of quantitative normally distributed variables (with Bonferroni post hoc tests), and Mann – Whitney tests in the case of ordinal variables. Box plots were used to graphically display and compare the summary statistics for ordinal variables by exercise group.

Spearman's rho correlation coefficients were calculated to assess the strength of relationship between decrease in pressure (mmHg) and endurance.

4.2 Results

4.2.1 Demographics

The study sample consisted of 45 female participants, 15 in each population group. Their mean age was 32.5 years (SD ±6.5 years, range 25 to 45 years). Racially, the vast majority of the sample was White (80 %), while 5 (11.1%) were Black and 4 (8.9%) were Indian. The median number of pregnancies was 0 (range 0 to >5) and the median number of children was 0 (range 0 to 3). The occupational categories of the participants are shown in Table 4.1. The majority of the sample consisted of professionals.

Table 4.1: Occupational categories of sample (n=45)

	Frequency	Percent
Social work professionals	1	2.2
Directors and chief executives	2	4.4
Production and operations managers	2	4.4
General managers	2	4.4
Health professionals	2	4.4
Home executives	2	4.4
Higher teaching professionals	3	6.7
Business professionals	3	6.7
Natural and engineering science professionals	3	6.7
Self employed	3	6.7
Clerks	4	8.9
Student	4	8.9
Modern health associate professionals	6	13.3
Artistic, entertainment and sport professionals	8	17.8
Total	45	100.0

A variation of childbirth techniques was demonstrated by the sample, which is presented in Figure 4.2. The majority had not given birth. Of those who had given birth, the most frequent method utilised was the C-section (24.4%; n = 11).

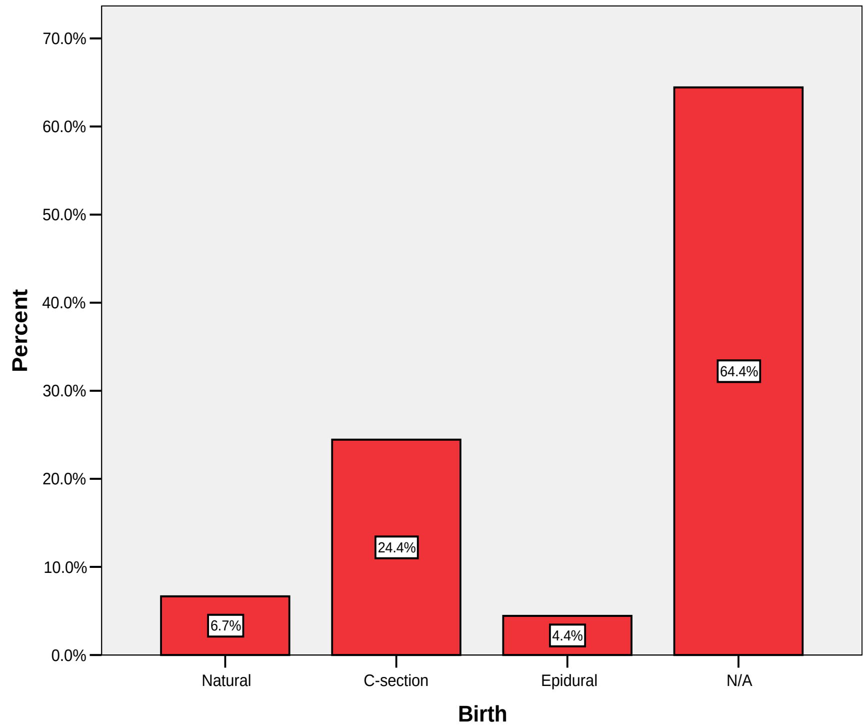


Figure 4.1: Childbirth types experienced by sample (n=45)

Table 4.2: History of abdominal surgery across a time spectrum for the three populations (*n* = 17)

Population groups	Abdominal surgery > 6 months -1 year ago	Abdominal surgery 1 – 2 years ago	Abdominal surgery 2 – 5 years ago	Abdominal surgery > 5 years ago
Pilates		2	3	3
Moderately active			1	3
Sedentary	1	2	1	1

Categories of surgeries: Caesarian section 11

Appendectomy 4

Laproscopy 1

Sterilisation 1

4.2.2 Comparison of demographics between population groups.

Since this was not a randomised trial and participants were allocated to a population group based on exercise training habits, there may have existed differences in demographics between the different groups, which may have influenced the outcome measures of this study. Therefore, the demographics were compared between the individual population groups.

There was no significant difference in age between the three groups (ANOVA $f = 2.177$; $p = 0.126$). Mean ages were similar between the groups, as demonstrated by Table 4.3. However, the Pilates group tended to be slightly older than the other two groups, though this difference was not statistically significant.

Table 4.3: Descriptive statistics for age by group

Group	Mean	N	Std. Deviation
Pilates	35.2	15	6.6
Moderately active	30.5	15	6.1
Sedentary	31.9	15	6.3
Total	32.5	45	6.5

In the cross-tabulation between race and populations the chi square assumptions were violated, as a result the statistical evaluation of the data could not be performed because of the absence of subjects in some subgroups. 66.7% of cells had expected counts <5, thus the *p* value is not valid. Nevertheless, the trend shown in Table 4.4 was that the white participants tended to be in the Pilates group, while all the black participants were in the sedentary group and all the Indian participants were in the moderately active group.

Table 4.4: Cross tabulation of race by population group

			Race			Total
			White	Black	Indian	
Group	Pilates	Count	15	0	0	15
		% within group	100%	0%	0%	100%
	Moderately active	Count	11	0	4	15
		% within group	73.3%	0%	26.7%	100%
	Sedentary	Count	10	5	0	15
		% within group	66.7%	33.3%	0%	100%
Total		Count	36	5	4	45
		% within group	80%	11.1%	8.9%	100%

$\chi^2 = 19.16$, $p = 0.001$

No difference between the groups in terms of low back pain ($p = 0.310$). The proportion, with a previous history of LBP, was similar in all groups, although slightly higher in the moderately active group as seen in Table 4.5.

Table 4.5: Cross tabulation of low back pain by population group

			Low back pain		Total
			Yes	No	
Group	Pilates	Count	6	9	15
		% within group	40%	60%	100%
	Moderately active	Count	9	6	15
		% within group	60%	40%	100%
	Sedentary	Count	5	10	15
		% within group	33.3%	66.7%	100%
Total		Count	20	25	45
		% within group	44.4%	55.6%	100%

$X^2 = 2.34$, $p = 0.310$

No significant difference between the groups in terms of birth type ($p = 0.471$), however, again the chi square assumptions were violated by a high number of zero values in the cells. Nevertheless, the trend demonstrates that the moderately active group had a below average number of children in comparison to the other two groups, while natural birth was more common in the sedentary group (Table 4.6).

Table 4.6: Cross tabulation of birth type and group

			Birth				Total
			Natural	C-section	Epidural	N/A	
Group	Pilates	Count	1	4	0	10	15
		% within group	6.7%	26.7%	0%	66.7%	100%
	Moderately active	Count	0	2	1	12	15
		% within group	0%	13.3%	6.7%	80%	100%
	Sedentary	Count	2	5	1	7	15
		% within group	13.3%	33.3%	6.7%	46.7%	100%
Total		Count	3	11	2	29	45
		% within group	6.7%	24.4%	4.4%	64.4%	100%

$X^2 = 5.58$, $p = 0.471$

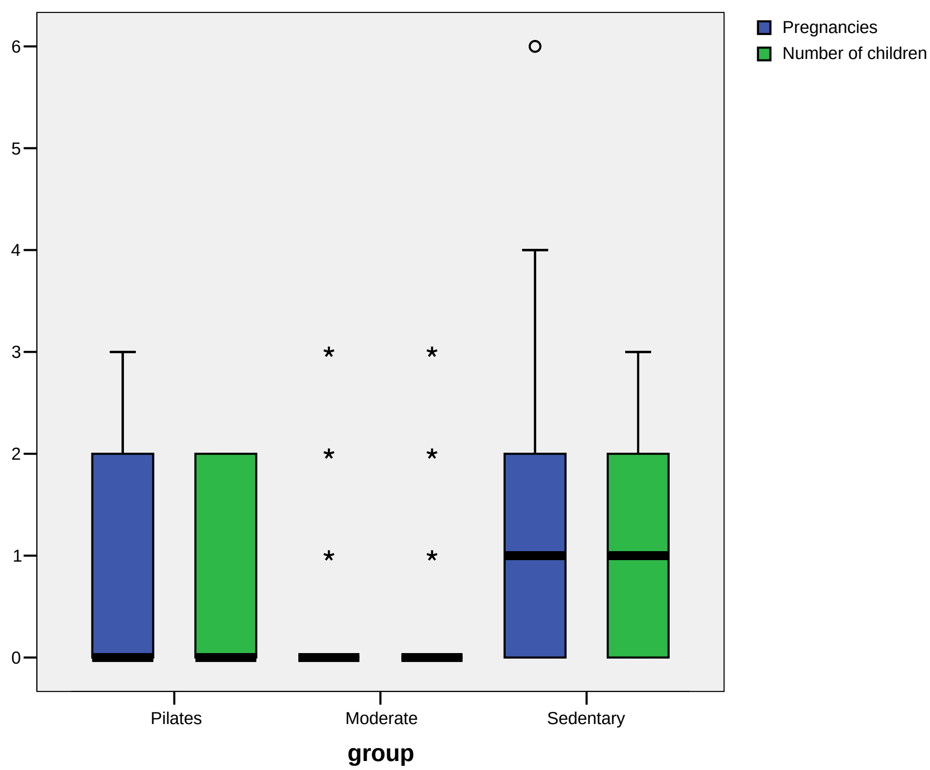


Figure 4.2: Boxplot of number of pregnancies and children by population group

The median number of pregnancies and children were 0 in both the Pilates and moderately active groups, while it was 1 in the sedentary group as seen in Figure 4.2. One person in the sedentary group had >5 pregnancies. The difference was not statistically significant ($p = 0.161$ and $p = 0.179$ for pregnancies and children respectively).

4.3 Primary Research Objectives

4.3.1 Comparison of outcomes between population groups.

Since there were no significant differences between the population groups with respect to demographics and risk factors (except for race, the effects of which can not be commented on), bivariate analysis and comparisons between exercise groups was done. The quantitative normal variables were tested with one way ANOVA. Bonferroni post hoc tests were performed in the event of a significant ANOVA result, to determine between which groups the significance lay.

4.3.1.1 Transversus abdominis activation between the population groups.

The level of activation of the TrA muscle was demonstrated through a maximal contraction of the TrA. The Abdominal draw-in test was used as described in Chapter Three to evaluate activation. The strength of the contraction led to a relative decrease in pressure, as measured with the PBU, from 70 mmHg and the resulted in a new lower pressure. This pressure was noted as well as the total decrease in pressure.

ANOVA tests for sEMG and abdominal draw-in test showed that there was a significant difference between groups in mean sEMG ($p = 0.045$), new pressure ($p = 0.001$) and difference in pressure ($p = 0.001$)

Table 4.7: Mean, standard deviation and range for sEMG and abdominal draw-in measures: decrease in pressure and new pressure.

Group		EMG	New pressure	Difference in pressure
Pilates	Mean	59.5	59.1	10.9
	Std. Deviation	21.8	3.5	3.5
	Minimum	24	50	6
	Maximum	91	64	20
	Upper 95% CI	71.6	61.0	12.9
	Lower 95% CI	47.4	57.1	9
Moderately active	Mean	51.2	62.0	8
	Std. Deviation	21.7	3.2	3.2
	Minimum	21	56	4
	Maximum	86	66	14
	Upper 95% CI	63.2	63.8	9.8
	Lower 95% CI	39.2	60.2	6.2
Sedentary	Mean	40.8	63.9	6.1
	Std. Deviation	15.4	3	3
	Minimum	20	60	2
	Maximum	86	68	10
	Upper 95% CI	49.3	65.5	7.8
	Lower 95% CI	32.4	62.2	4.5
Total	Mean	50.5	61.6	8.4
	Std. Deviation	20.9	3.8	3.8
	Minimum	20	50	2
	Maximum	91	68	20

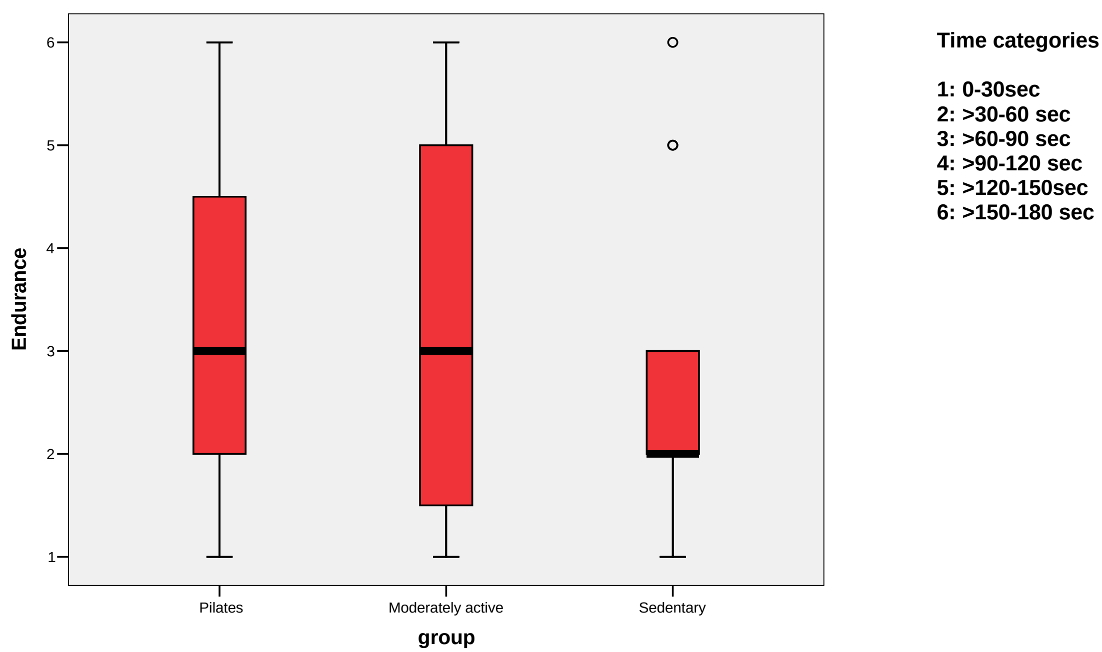
ANOVA with Bonferroni multiple comparison testing showed that significant differences were found between the sedentary group and the Pilates group (p = 0.040) but not between the moderately active group and Pilates group. For new pressure measurement, the significance was between the Pilates and moderately active groups (p = 0.043) and between the sedentary and Pilates groups (p < 0.001). For difference in pressure only the sedentary and Pilates groups differed significantly (p = 0.001)(ANOVA and Bonferroni multiple comparison tests for sEMG, new pressure and difference in pressure results are presented in Appendix 9).

4.3.1.2 Transversus Abdominis endurance between the population groups.

Measurements of endurance were treated as ordinal variables and analysed non-parametrically with Mann Whitney tests to compare the Pilates group to both the sedentary group and the moderately active group. The boxplot of Figure 4.3 demonstrates these variables by group.

<u>Table 4.8 Median (IQR) for endurance in all population groups.</u>

		Endurance		
		Median	25th Percentile	75th Percentile
Group	Pilates	3.0	2.0	4.5
	Moderately active	3.0	1.0	5.0
	Sedentary	2.0	2.0	3.0



<u>Figure 4.3: Boxplot of endurance in mmHg by population group</u>

4.3.1.3 Comparison of lumbopelvic posture between the three populations

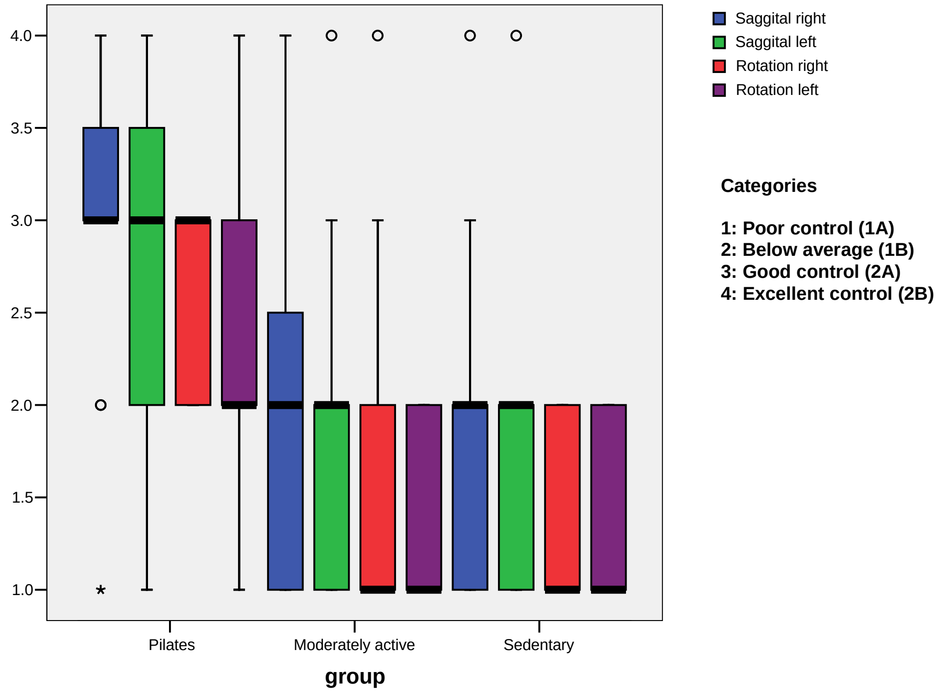


Figure 4.4:Boxplot of lumbopelvic posture values by group

Lumbopelvic posture was measured using the PBU to gain information of the TrA response to applied leg loading and the resultant lumbopelvic control. Each test was divided into 4 categories of lumbopelvic control as seen in the Chapter Three.

Measurements of lumbopelvic posture were treated as ordinal variables and analysed non-parametrically with Mann Whitney tests to compare the Pilates group to both the sedentary group and the moderately active group. Boxplots of these variables by group are shown by Figure 4.4. In terms of the median IQR the Pilates group demonstrated better lumbopelvic control compared to the either the moderately active or sedentary groups.

4.3.1.4 Comparison of the sedentary and Pilates samples

Endurance was significantly different between the sedentary and Pilates groups. The Pilates group scored significantly higher medians on the lumbopelvic posture saggital and rotation variables than the sedentary group as seen by Table 4.9.

Table 4.9: Mann- Whitney tests for the comparison of median endurance and lumbopelvic posture between sedentary group and Pilates group.

OUTCOME	GROUP	N	MEAN RANK	SUM OF RANKS	P VALUE
Endurance	Pilates	15	17.07	256.00	0.345
	Sedentary	15	13.93	209.00	
	Total	30			
Lumbopelvic posture: Saggital right	Pilates	15	20.53	308.00	0.001*
	Sedentary	15	10.47	157.00	
	Total	30			
Saggital left	Pilates	15	20.33	305.00	0.002*
	Sedentary	15	10.67	160.00	
	Total	30			
Lumbopelvic posture: Rotation right	Pilates	15	21.60	324.00	<0.001*
	Sedentary	15	9.40	141.00	
	Total	30			
Rotation left	Pilates	15	20.40	306.00	0.002*
	Sedentary	15	10.60	159.00	
	Total	30			

* significant at $p = 0.05$

4.3.1.5 Comparison of moderately active and Pilates samples

Significant differences between the moderately active group and the Pilates group is noted in terms of all these parameters except for endurance as seen by Table 4.10. These were higher in the Pilates group than in the moderately active groups.

<u>Table 4.10: Mann- Whitney tests for the comparison of median endurance, lumbopelvic posture between moderately active group and Pilates group</u>

OUTCOME	GROUP	N	MEAN RANK	SUM OF RANKS	P VALUE
Endurance	Pilates	15	16.23	243.50	0.653
	Moderately active	15	14.77	221.50	
	Total	30			
Lumbopelvic posture: Saggital right	Pilates	15	18.97	284.50	0.029*
	Moderately active	15	12.03	180.50	
	Total	30			
Saggital left	Pilates	15	20.00	300.00	0.004*
	Moderately active	15	11.00	165.00	
	Total	30			
Lumbopelvic posture: Rotation right	Pilates	15	20.10	301.50	0.003*
	Moderately active	15	10.90	163.50	
	Total	30			
Rotation left	Pilates	15	20.70	310.50	0.001*
	Moderately active	15	10.30	154.50	
	Total	30			

* significant at $p = 0.05$

4.3.1.6 Comparison of moderately active and sedentary samples

No significant difference is noted on in terms of all these parameters between the moderately active group and the sedentary group as seen by Table 4.11.

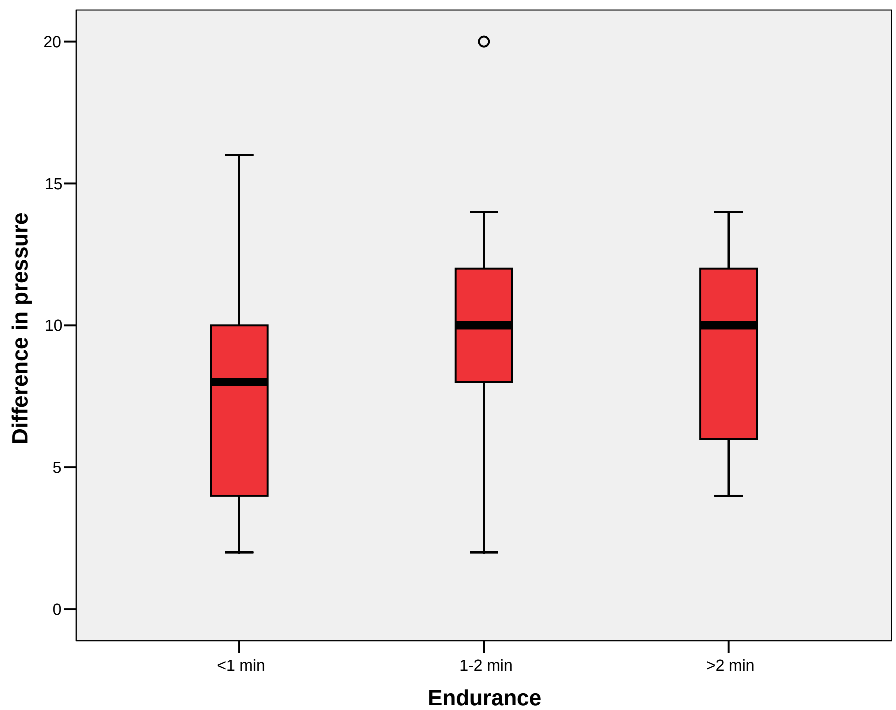
Table 4.11: Mann- Whitney tests for the comparison of median endurance, lumbopelvic posture between moderately active group and sedentary group

	GROUP	N	MEAN RANK	SUM OF RANKS	P VALUE
Endurance	Moderately active	15	16.00	240.00	0.775
	Sedentary	15	15.00	225.00	
	Total	30			
Saggital right	Moderately active	15	16.60	249.00	0.512
	Sedentary	15	14.40	216.00	
	Total	30			
Saggital left	Moderately active	15	15.77	236.50	0.870
	Sedentary	15	15.23	228.50	
	Total	30			
Rotation right	Moderately active	15	16.40	246.00	0.595
	Sedentary	15	14.60	219.00	
	Total	30			
Rotation left	Moderately active	15	15.00	225.00	0.775
	Sedentary	15	16.00	240.00	
	Total	30			

4.4 Secondary Research Objectives

4.4.1 Correlation between pressure decrease and endurance

There was a slight trend towards a positive correlation between pressure decrease and endurance (Spearman's rho=0.254, p=0.090), although the correlation was not statistically significant, and the strength of the correlation was weak. When endurance was further categorised into three categories: < 1 minute, 1-2 minutes and > 2 minutes, the trend became more visible, and statistical significance was reached (rho = 0.308, p = 0.039), although the strength of the correlation was still weak. A developing trend of improvement between the less than one minute group and the 1-2 minute group may be noted, however, the trend was noted to decline when including the greater than two minute group. A box and whisker plot of the trend is shown in Figure 4.5.



<u>Figure 4.5: Boxplot of activation of the TrA by endurance of the TrA in the sample (n=45)</u>

4.5 Conclusion

Therefore this study demonstrated that Pilates method is significantly associated with greater core strength (p = 0.001) when compared to a sedentary lifestyle, in terms of all the outcome strength measures, except for endurance (p = 0.345). Again, the Pilates sample performed significantly better than the moderately active sample in terms of some of the outcome measures: level of activation of the TrA including lumbopelvic posture (p = 0.03) and decrease in pressure, although the latter showed borderline statistical significance (p = 0.043). Overall, in the case of endurance, no significant difference between the three populations was noted.

CHAPTER FIVE

Discussion and Conclusions

5.1 Introduction

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

5.2 Discussion of Outcomes

5.2.1 Demographics

The demographics have shown that all three population groups were similar and comparable except for the uneven racial distribution. The majority of the participants in the study were white (80%) and the trend showed that the Pilates group tended to be white. Indians (8.9%) were most likely to be in the moderately active category and blacks (11.1%) were most likely to fall into the sedentary category. There existed no statistically significant differences between the population groups in relation to profession, history of low back pain, pregnancies, children and method of childbirth. Hence, although sample size was small, the three groups were fairly homogenous which adds value to the statistical findings.

5.2.2 Research Tests

5.2.2.1 Transversus Abdominis activation

Comparison of the core strength and activation in all three populations, revealed a significant difference between the Pilates and sedentary groups. Activation of the Transversus abdominis was significantly greater in the Pilates group ($p < 0.001$) compared to the sedentary group. The Pilates group demonstrated a greater ability to engage the core muscles and this further facilitates the argument that Pilates trained individuals, engage the deeper abdominal muscles effectively (Anderson and Spector, 2000). According to Musculino and Cipriani (2004a), Pilates aims to strengthen the 'powerhouse' and "*the Pilates method of body conditioning affects the powerhouse in three major ways: posterior tilt of the pelvis, lengthening of the spine, and increasing the tone or structural integrity of the abdominopelvic cavity*". They further believe that isometrically strengthened abdominal muscles are vital to achieve all three of the above concepts and that the correct working of the powerhouse shall ensure a flexible and strong centre. Hence, due to the fact that the Pilates group is constantly focused on the 'powerhouse' during training, the results obtained for the *abdominal draw-in test* were greater than those obtained from the two other population groups, which gives credence to the purported claims of the Pilates method.

The level of activation of the TrA measured with the abdominal draw-in test was found to be greater in subjects in the Pilates group, with a mean pressure decrease of 10.9 mmHg (SD ±3.5 mmHg) and a range of 6 to 20 mmHg. According to Richardson *et al*. (1999), normal activation is between 6 and 10 mmHg and therefore the findings of this study are slightly higher than expected. This is in keeping with the findings of both Martin (2006) and Robertson (2005) who also had higher readings for the abdominal draw-in test. Robertson's (2005) study on core muscle activation in elite male athletes showed a mean reading of 13.1 mmHg in the athlete group. A subsequent study by Martin (2006) on core activation in amateur female runners showed that mean pressure decrease was 11.8 mmHg (SD ±2.2 mmHg).

However, both other groups' mean readings fell into the predicted category of appropriate activation of the TrA. The maximum of the moderately active group was 14 mmHg. It is acknowledged in the literature, that current non-invasive methods of assessing the deeper musculature is limited and is subject to clinical practice and the perception of the subject as to what is required for measurements to be as precise as can be expected (Richardson *et al.,* 1999).

The sedentary group may not have engaged the local muscle system appropriately during the test and also did not perform regular daily exercise, which may have recruited the local muscle system and hence had an impact on test results. Therefore, the degree of activation (mean = 6.1 mmHg) was expected.

The overall mean readings for the Pilates group fell into the “good postural control” category. The Pilates method encourages abdominal setting or contraction prior to commencement of limb movement in correct execution of Pilates exercises. Physiologically, efficient muscle activation in kinetic chain function begins with pre-programmed sequences of activation that are then solidified through repetition of the task appropriate to the movement required (Kibler *et al*., 2006).

With respect to the above, Pilates method advocates the use of the deep stabilizing muscles, including the Transversus abdominis at an early stage in order to promote stabilization of the pelvis in conjunction with leg movement. Postural muscles are predominately Type I fibres and used in daily movements and activities. During limb movement, if there exists unsatisfactory compensatory patterns, unwanted tightening of other larger muscles may occur. Encouragement of the muscles to lengthen eccentrically may be beneficial in order to promote forces to be transferred appropriately and distribute potentially destructive forces. Pilates method is being recognized as a neuromuscular intervention and ultimately encourages the participant to become autonomous with the movements. Pilates aims to intervene in the current motor patterns and encourage the correct sequence of the postural muscles so that the spine remains adequately protected in various static and dynamic postures (Anderson and Spector, 2000). According to Norris (2001), this may encourage the pre-setting of the TrA in expectation of leg loading. The researcher found that the Pilates group had significantly greater ($p < 0.01$) lumbopelvic control in comparison to the moderately active and sedentary groups, which gives further credence to the claims of Pilates method.

The mean measurement for the static contraction of TrA was 6.1 mmHg (sedentary group) and 8 mmHg (moderately group). These readings fell into the normal range (6 – 10 mmHg) as accepted by Richardson *et. al*. (1999). Therefore the groups readings were within the normal range. The Pilates readings were greater than the expected normal range, which further lends weight to Pilates purported claims. When the muscle was tested under dynamic circumstances, with the *lumbopelvic posture test* the subjects of both these groups did not perform as well as the Pilates group. Both the sedentary group and the moderately active group's median readings fell into the "below average" and "poor control" categories of lumbopelvic control respectively. Variability of readings in the groups was noted and this may suggest that the subjects may have had difficulty in grasping the concept of the desired core contraction.

The sEMG readings also showed a trend towards greater muscle activity of the TrA in the Pilates group than in both of the other groups; however, the information gathered from this device may be imprecise and was not necessarily appropriate for the study.

5.2.2.2 Transversus Abdominis endurance

The median of both the Pilates groups and the moderately active groups was the same "60 to 90 seconds" and was greater than the sedentary group median (30 to 60 seconds). The seventy-fifth percentile of the moderately active population fell in the "120 to 150 second" category. However, no statistically significant differences were found in comparing the Pilates group to the sedentary group (p = 0.345) or to the moderately active group (p = 0.653). Further comparison between the moderately active group and the sedentary group revealed no statistical significant difference (p = 0.775). As scant literature exists on endurance of the TrA it is difficult to comment on the lack of differences noted between the three population groups.

5.3 Hypotheses

5.3.1 Hypothesis test 1

The first objective of the study was to compare the activation (decrease in pressure) of the transversus abdominis between three populations: sedentary, moderately active and Pilates.

Null hypothesis:
There will be no difference in decrease of pressure (activation) of the transversus abdominis between the three populations.

The null hypothesis cannot be accepted.

5.3.2 Hypothesis test 2

The second hypothesis was to compare the endurance of the transversus abdominis in seconds between the three populations: sedentary, moderately active and Pilates.

Null hypothesis:
There will be no difference in endurance of the transversus abdominis between the three populations.

Therefore the null hypothesis is accepted.

5.4 Study Limitations

1. Isolation of the deep abdominal musculature was difficult to achieve. The superficial or global muscles could not be excluded as playing a role in the performance of the exercises that involved the use of the pressure biofeedback device as a measurement tool.
2. The sEMG was an imprecise tool to use, since it is possible that it measured feedback from the more superficial abdominal muscles such as the internal and external oblique muscles. The researcher also found the model of machine to be inappropriate as a research tool to gather quantitative data.
3. Additional exercise undertaken by the Pilates group was not taken into account in this particular study. This could have influenced readings.
4. Specific details of the training habits or mode of training of the participants were not taken into account for this study.
5. Subjects that had undergone abdominal surgery in the last six months were included.
6. Distribution of race across the groups was uneven.
7. In future studies, further attention could be given to stricter somatotype regulation.

5.5 Recommendations

1. Although this study was a pilot study, the statistical analysis would be enhanced with a larger sample size.
2. Stratified sampling could be utilized to ensure an even spread across the sample range.
3. Due to morphological differences between the sexes, it may be of benefit to use the same study of design on males.

4. Stricter, more specific group criteria with regards to the moderately active group and the Pilates group are recommended. Homogeny would be improved if subjects had to specify type and amount of exercise training.
5. Future research could compare another specific type of core training method to Pilates.
6. It would be useful to use another type of activation measurement device or method. EMG using fine wire needles would also provide more accurate data about the specifics of the TrA contraction. Perhaps ultrasound scans could ensure accuracy of contraction as well as provide visual data of the TrA.
7. It is recommended that for future studies multiple readings of the abdominal contractions should be taken at the same consultation to ensure consistency.
8. sEMG could be used to track the global muscle activity and input during core contractions.

5.6 Conclusion

The purpose of this study was to establish if Pilates exercise was, as it purports, effective as a core stability exercise programme.

It was found that the Pilates group had stronger core activation than the gym counterparts. Both the moderately active and Pilates group performed better than the sedentary control group in all components of testing except for endurance. Lumbopelvic posture performance was significantly greater in the Pilates group and hence, Pilates may be beneficial as a training regime to enhance lumbopelvic stability and core activation.

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APPENDIX 1
Data Sheet

Full Name: ______________________
Age: ______________________
Race: ______________________
Occupation: ______________________

History of low back pain: Yes No

Number of pregnancies: 0 1 2 3 4 5 <

Birthing techniques: Natural C-section Epidural

Number of children: 0 1 2 3 4 5 <

<u>Surface EMG reading:</u>

__________________%

<u>Abdominal Draw In (mmHg)</u>

Abdominal contraction obtained (yes/no)	
Yes	**No**

Stable Pressure reading: **70 mmHg**
Abdominal contraction

New Pressure reading: ________

Difference in pressure: ________

Contraction obtained	**Timed contraction (in seconds)**
	Less than 30 seconds
	30 seconds to one minute
	One minute to one minute and thirty seconds
	One minute thirty seconds to two minutes
	Two minutes to two minutes and thirty seconds
	Two minutes and thirty seconds to three minutes

<u>MAXIMAL ENDURANCE TEST</u>

Grading	**Grading achieved** (mark appropriate box)			
	SAGGITAL		**ROTATORY**	
Grade 1A (poor control)				
Grade 1B (below average control)				
Grade 2A (good control)				
Grade 2B (excellent control)				
	R	L	R	L

<u>LUMBOPELVIC POSTURE</u>

APPENDIX 2
LETTER OF INFORMATION

Date:…………………200..

Dear Participant

Welcome to my research project. Thank you for your interest.
Title of Research:
A cross sectional pilot study on the activation and endurance of the Transversus Abdominis in three populations.

NAME OF RESEARCH STUDENT
Sarah Kim Ferguson Contact number (031) 204 2205

NAME OF RESEARCH SUPERVISOR
Dr. Nikki De Busser Contact number (031) 208 7333

You have been selected to take part in a study to evaluate core stability in three different populations: a Pilates group, a moderately active population and a non activity group. 45 patients will be required to complete the study. All participants, including you, will be allocated to a group according to whose criteria you best fulfill.

Inclusion and exclusion:
If you suffer from any low back pain or previous episodes of back pain, you may be excluded from the study.

Research process:
This will be a once off consultation. During the case history and physical examination, you will be screened for suitability for entry into the project. You will be required to perform various exercises in varying degrees of difficulty and measurements will be taken during this process.

Treatments:
No treatments will take place during the consult. However, you will be able to claim one free treatment (valid for one month after initial examination) at the Chiropractic Day Clinic to be used at your convenience.

Risks and Discomfort:
The evaluation is safe and unlikely to cause any adverse side effects.

Remuneration and costs:
All patient information is confidential and the results of the study will be made available in the Durban University of Technology library in the form of a mini-dissertation.

Implications for withdrawal from the research:
You are free to withdraw at any stage.

Benefits of the study:
Your full co-operation will assist the Chiropractic profession in expanding its knowledge in regards to Pilates and thus gaining further insight into its effects on core stability and hence allowing for more effective rehabilitation of patients.

Confidentiality and Ethics:
All patient information will be kept confidential and will be stored in the Chiropractic Day Clinic for 5 years after which it will be shredded.
Please don't hesitate to ask questions on any aspect of the study. Should you wish you can contact my research supervisor at the above details or alternatively you could contact the Faculty of Health Sciences Research and Ethics Committee as per Mr. Vikesh Singh (031) 204 2701

Thank you
Yours sincerely,

…………………………..	………………………….
Sarah Kim Ferguson	Dr Nikki De Busser
	(M.Tech Chiropractic)
(Research student)	(Supervisor)

APPENDIX 3

INFORMED CONSENT FORM

(To be completed by the patient / subject)

Date: ___

Title of Research Project:

A cross-sectional pilot study to determine and compare the activation and endurance of the Transversus Abdominis muscle in three populations.

Name of Supervisor: Dr. N. De Busser M.Tech Chiropractic (031-2087333)

Name of Research student: Sarah Kim Ferguson (031- 2042205)

Please circle the appropriate answer	YES	NO
1. Have you read the research information sheet?	Yes	No
2. Have you had the opportunity to ask questions regarding this study?	Yes	No
3. Have you had satisfactory answers to your questions?	Yes	No
4. Have you had the 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 from 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 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: ___

APPENDIX 4

Are you female and between the ages of 25 and 45

Do you attend regular classes at

Pilates House

Research is currently being carried out by the

Chiropractic Department
Durban University of Technology

FREE

core stability muscle assessment

is available to those who qualify to take part in the study.

For more information contact Sarah on

2042205 or 072 2411 072

Are you female
and
between 25 and 45 years?

and train regularly
at your local

GYM

Research is currently being carried out
by the
Chiropractic Department
Durban University of Technology

<u>FREE</u>

core muscle stability
assessment

is available to those who qualify
to take part in the study.

For more information contact Sarah on
2042205 or 072 2411 072

APPENDIX 5

DURBAN UNIVERSITY OF TECHNOLOGY CHIROPRACTIC DAY CLINIC
CASE HISTORY

Patient: ______________________ Date: ________

File # : __________ Age: ________

Sex : ________ Occupation: ______________________

Intern : ______________________ Signature ______________________

FOR CLINICIANS USE ONLY:
Initial visit
Clinician: Signature :

Case History:

Examination:
Previous: Current:

X-Ray Studies:
Previous: Current:

Clinical Path. lab:
Previous: Current:

CASE STATUS:

PTT:	Signature:	Date:

CONDITIONAL:
Reason for Conditional:

Signature: Date:

Conditions met in Visit No:	Signed into PTT:	Date:

Case Summary signed off:	Date:

<u>Intern's Case History:</u>

1. **Source of History:**

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

3. **Present Illness:**

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

4. **Other Complaints:**

5. **Past Medical History:**

- General Health Status
- Childhood Illnesses
- Adult Illnesses
- Psychiatric Illnesses
- Accidents/Injuries
- Surgery
- Hospitalizations

6. Current health status and life-style:

- Allergies
- Immunizations
- Screening Tests incl. x-rays
- Environmental Hazards (Home, School, Work)
- Exercise and Leisure
- Sleep Patterns
- Diet
- Current Medication
  Analgesics/week:
- Tobacco
- Alcohol
- Social Drugs

7. Immediate Family Medical History:

- Age
- Health
- Cause of Death
- DM
- Heart Disease
- TB
- Stroke
- Kidney Disease
- CA
- Arthritis
- Anaemia
- Headaches
- Thyroid Disease
- Epilepsy
- Mental Illness
- Alcoholism
- Drug Addiction
- Other

8. Psychosocial history:

- Home Situation and daily life
- Important experiences
- Religious Beliefs

9. Review of Systems:

- General
- Skin
- Head
- Eyes
- Ears
- Nose/Sinuses
- Mouth/Throat
- Neck
- Breasts
- Respiratory
- Cardiac
- Gastro-intestinal
- Urinary
- Genital
- Vascular
- Musculoskeletal
- Neurologic
- Haematologic
- Endocrine
- Psychiatric

APPENDIX 6

Durban University of Technology

PHYSICAL EXAMINATION: SENIOR

Patient Name : ________________________ **File no :**__________ **Date :**_________

Student : **Signature :**

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

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

SYSTEM SPECIFIC EXAMINATION:	
CARDIOVASCULAR EXAMINATION	
RESPIRATORY EXAMINATION	
ABDOMINAL EXAMINATION	
NEUROLOGICAL EXAMINATION	
COMMENTS	
NEUROLOGICAL EXAMINATION:	See Regionals

Clinician: **Signature :**

APPENDIX 7

REGIONAL EXAMINATION - LUMBAR SPINE AND PELVIS

Patient:________________________________ File#:______Date:_________
Intern\Resident:__________________________ Clinician:__________________

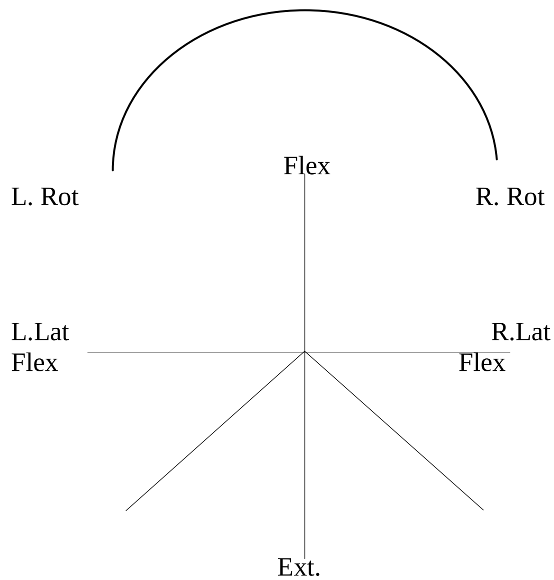
STANDING:

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

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

GAIT:

Normal walking
Toe walking
Heel Walking
Half squat



ROM:

Forward Flexion = 40-60° (15 cm from floor)
Extension = 20-35°
L/R Rotation = 3-18°
L/R Lateral Flexion = 15-20°

Which movt. reproduces the pain or is the worst?

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

SUPINE:

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

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

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

SITTING:

Spinous Percussion
Valsalva
Lhermitte

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

Slump 7 test	L										
	R										

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

PRONE:	L	R
Gluteal skyline		
Skin rolling		
Iliac crest compression		
Facet joint challenge		
SI tenderness		
SI compression		
Erichson's		
Pheasant's		

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

NON ORGANIC SIGNS:

Pin point pain
Axial compression
Trunk rotation
Burn's Bench test
Flip Test
Hoover's test
Ankle dorsiflexion test
Repeat Pin point test

NEUROLOGICAL EXAMINATION

Fasciculations

Plantar reflex

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

MYOTOMES

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

BASIC THORACIC EXAM

History
Passive ROM
Orthopedic

BASIC HIP EXAM

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

MOTION PALPATION AND JOINT PLAY

	R	L
Upper Thoracics		
Lumbar Spine		
Sacroiliac Joint		

FEB 2007

APPENDIX 8

DURBAN UNIVERSITY OF TECHNOLOGY

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

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

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

0: ***P:***

E:

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

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

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

O: ***P:***

E:

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

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

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

O: ***P:***

E:

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

DURBAN UNIVERSITY OF TECHNOLOGY

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

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

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

A:

0:

P:

E:

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

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

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

A:

O:

P:

E:

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

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

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

A:

O:

P:

E:

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

APPENDIX 9

TABLES

Table 1: ANOVA comparison of mean age between groups

	Sum of Squares	df	Mean Square	F	P value
Between Groups	176.133	2	88.067	2.177	0.126
Within Groups	1699.067	42	40.454		
Total	1875.200	44			

Table 2: ANOVA tests for EMG, new pressure and difference in pressure between exercise groups.

		Sum of Squares	df	Mean Square	F	p value
EMG	Between Groups	2639.383	2	1319.692	3.342	0.045
	Within Groups	16584.536	42	394.870		
	Total	19223.919	44			
New pressure	Between Groups	180.844	2	90.422	8.756	0.001
	Within Groups	433.733	42	10.327		
	Total	614.578	44			
Difference in pressure	Between Groups	175.644	2	87.822	8.333	0.001
	Within Groups	442.667	42	10.540		
	Total	618.311	44			

Table 3: Bonferroni multiple comparison tests for EMG, new pressure and difference in pressure between the exercise groups

Dependent Variable	(I) group	(J) group	Mean Difference (I-J)	Std. Error	P value	95% Confidence Interval	
EMG	Pilates	Moderately active	8.307	7.256	0.776	-9.79	26.40
		Sedentary	18.720(*)	7.256	0.040	.63	36.81
	Moderately active	Pilates	-8.307	7.256	0.776	-26.40	9.79
		Sedentary	10.413	7.256	0.476	-7.68	28.51
	Sedentary	Pilates	-18.720(*)	7.256	0.040	-36.81	-.63
		Moderately active	-10.413	7.256	0.476	-28.51	7.68
New pressure	Pilates	Moderately active	-3.000(*)	1.173	0.043	-5.93	-.07
		Sedentary	-4.867(*)	1.173	<0.001	-7.79	-1.94
	Moderately active	Pilates	3.000(*)	1.173	0.043	.07	5.93
		Sedentary	-1.867	1.173	0.357	-4.79	1.06
	Sedentary	Pilates	4.867(*)	1.173	<0.001	1.94	7.79
		Moderately active	1.867	1.173	0.357	-1.06	4.79
Difference in pressure	Pilates	Moderately active	2.933	1.185	0.052	-.02	5.89
		Sedentary	4.800(*)	1.185	0.001	1.84	7.76
	Moderately active	Pilates	-2.933	1.185	0.052	-5.89	.02
		Sedentary	1.867	1.185	0.369	-1.09	4.82
	Sedentary	Pilates	-4.800(*)	1.185	0.001	-7.76	-1.84
		Moderately active	-1.867	1.185	0.369	-4.82	1.09

* The mean difference is significant at the .05 level.

FIGURES

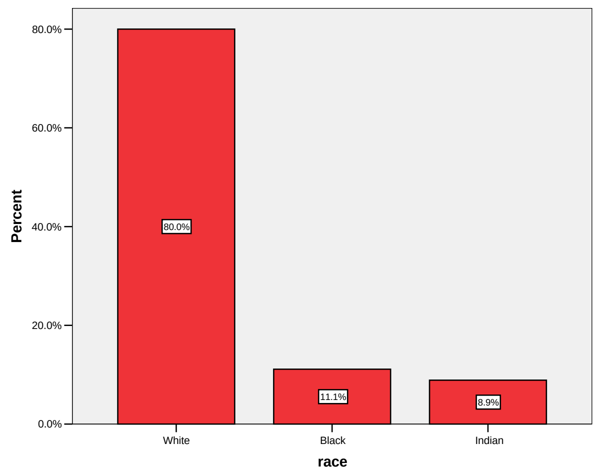


Figure 1: Racial distribution of study sample (n=45)

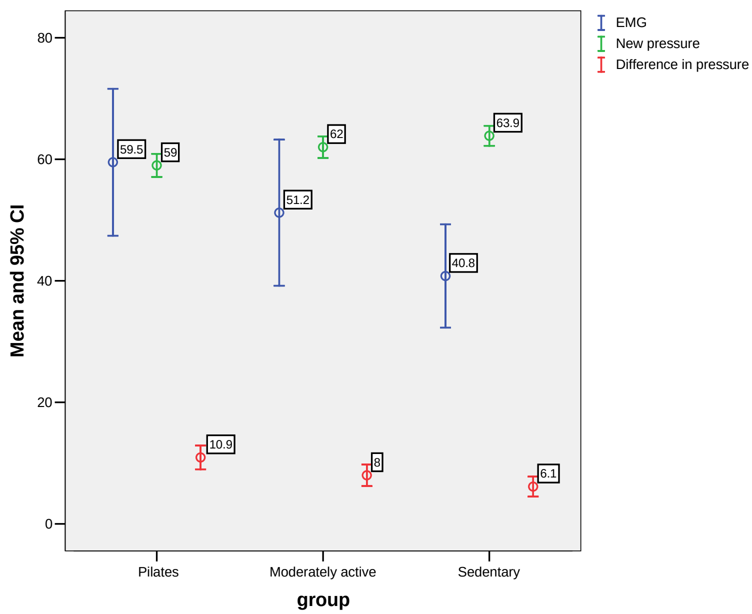


Figure 2: Error bar plot of EMG, new pressure and difference in pressure by exercise group, showing mean and 95% confidence interval.

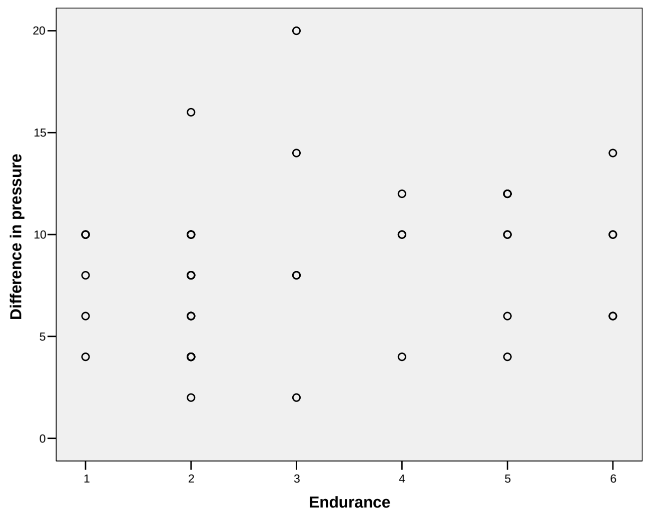


Figure 3: Scatterplot of activation of the TrA by endurance of the TrA in the sample (n=45)