THE PREVALENCE AND FACTORS ASSOCIATED WITH LOW BACK PAIN IN PHYSIOTHERAPY STUDENTS AT THE UNIVERSITY OF THE WITWATERSRAND

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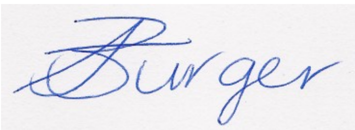
DECLARATION

I, Salmina Magdalena Burger, declare that this dissertation is my own work. It is being submitted for the degree of Master of Science in Physiotherapy in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other University.



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ABSTRACT

The research reported in this dissertation centered around the prevalence and factors associated with low back pain (LBP) among the undergraduate physiotherapy students at the University of the Witwatersrand. Physiotherapy students are prone to LBP due to a flexion posture while studying, lifting patients and working. After pathology, muscle activity is influenced, affecting optimal function of the spine. Preventative strategies can minimise recurrences of LBP. Physiotherapy students enrolled for 2010 at the University of the Witwatersrand participated in a cross-sectional prevalence study. A questionnaire, multi-stage fitness test and physical assessment were completed. Statistical analysis was done with univariate analysis for associations with LBP. The study revealed that the lifetime LBP prevalence was 35.6% among all four physiotherapy year groups. The prevalence increased from first year to third year but unexpectedly decreased in the fourth year group. Significant associations with LBP were posterior-anterior mobilisations on L4 ($p=0.003$) and L5 ($p\leq0.001$) centrally, left lumbar multifidus (LM) cross-sectional area ($p=0.02$), right obliquus internus abdominis ($p=0.02$) and transversus abdominis (TrA) thickness at rest ($p=0.03$), both TrA during contraction, left ($p=0.02$) and right ($p=0.01$), as well as the pull of the TrA during contraction on the left ($p=0.03$).

The present work is the first study to show measurements with ultrasound imaging of LM and TrA on physiotherapy students. The prevalence of LBP might be reduced if students are more aware of LBP and consequential muscle imbalances that might perpetuate the problem. The dissertation concludes with a discussion of future research avenues. It is suggested that an intervention to make students aware of LBP and risk assessments in South Africa will help to identify and address hazards in the workplace.

DEDICATION

I dedicate this study

in memory of my brother Francois Swart

1982-2004

and

all the undergraduate physiotherapy students

who want to help people and in the process might injure themselves

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LIST OF ABBREVIATIONS

ADIM	-	Abdominal Drawing-In Manoeuvre
ASIS	-	Anterior Superior Iliac Spine
ASLR	-	Active Straight Leg Raise
BMI	-	Body Mass Index
CI	-	Confidence Interval
CSA	-	Cross-Sectional Area
CT	-	Computerized Tomography
ES	-	Erector Spinae
HSAWA 74	-	The Health and Safety at Work Act 1974
IASP	-	The International Association for the Study of Pain
L	-	Left Side
LM	-	Lumbar Multifidus
MRI	-	Magnetic Resonance Imaging
OE	-	Obliquus Externus Abdominis
OI	-	Obliquus Internus Abdominis
OMT	-	Orthopaedic-Manual Therapy
OR	-	Odds Ratio
PA	-	Posterior-Anterior
PAIVM	-	Passive Accessory Intervertebral Movement
PF	-	Pelvic Floor
R	-	Right Side
RA	-	Rectus Abdominis
RUSI	-	Real-Time Ultrasound Imaging
SLR	-	Straight Leg Raise
TrA	-	Transversus Abdominis
USI	-	Ultrasound Imaging
WMSD’s	-	Work-Related Musculoskeletal Disorders

DEFINITIONS

ALTERED MUSCLE TIMING or recruitment imbalance occurs between synergistic muscle groups in functional movement. A consistent ideal sequence of recruitment occurs in asymptomatic subjects while abnormal patterns of recruitment are present in symptomatic subjects. A link is identified between abnormal patterns of recruitment in both peripheral and trunk local stability muscles and pain or pathology. This may result in abnormal development of uncontrolled movement and a loss of functional or dynamic stability. (Comerford and Mottram, 2001b).

BODY MASS INDEX (BMI) is calculated by taking an individual's weight in kilograms and dividing it by his or her height in metres squared. The standard BMI ranges for adults are given on page 32 in Table 2.2 (Mei et al, 2002).

DYSFUNCTION refers to abnormal functioning. Stability dysfunction of the local stability muscles develops after the onset of pain and pathology (Comerford and Mottram, 2001a). Although pain and dysfunction are related, pain might resolve, but dysfunction can persist (Hides et al, 1996; Hodges and Richardson, 1996).

INSTABILITY is defined by Panjabi (1992) as "a significant decrease in the capacity of the stabilizing system of the spine to maintain the intervertebral neural zones within the physiological limits so that there is no neurological dysfunction, no major deformity, and no incapacitating pain".

PREVALENCE OF LOW BACK PAIN is the proportion of people in a known population who have symptoms regarding low back pain over a particular period of time (Waddell, 1999).

The following operational definitions can be distinguished:

More than one year LBP: Also described as lifetime low back pain (Waddell, 1999). It is a general measure of low back pain and is defined as at least one episode of low back pain experienced in the past by the subjects (Nyland and Grimmer, 2003; Jordaan, 2005).

12-month LBP: At least one episode of low back pain experienced in the last year (Waddell, 1999).

One-month LBP: At least one episode of low back pain experienced in the last month (Nyland and Grimmer, 2003).

One-week LBP: At least one episode of low back pain experienced in the last week (Nyland and Grimmer, 2003).

Present LBP: Also described as point prevalence (Waddell, 1999) and is low back pain at the time of testing or of the interview (Jordaan, 2005).

LOW BACK PAIN is described by the Nordic back pain questionnaire as an "ache, pain or discomfort in the lower back whether or not it extends from there to one or both legs (sciatica)" (Nyland and Grimmer, 2003).The symptoms include pain, a tingling feeling, numbness or a feeling of heaviness. For data collection by the questionnaire it was assumed that low back injuries or low back disorders will result in low back pain and therefore considered synonymous.

MUSCLE IMBALANCE is the lack of balance or proportion between muscles (Collins, 1988). Comerford and Mottram (2001b) quoted authors like Janda, O'Sullivan et al and Lee et al, who identified muscle imbalance between the agonist and antagonist, for example the abdominal and back extensor muscles. The conclusion was drawn that an imbalance in the lower back muscles and weakening strength are damaging factors for athletes and non-athletes (Lee et al, 2011).

NEUTRAL POSITION is the position of the spine in which the overall internal stresses in the spinal column and the muscular effort to hold the posture are minimal (Panjabi, 1992).

NEUTRAL ZONE is the part of range of physiological intervertebral motion, measured from the neutral position, within which the spinal motion is produced with minimal internal resistance. It is the zone of high flexibility or laxity (Panjabi, 1992).

OCCUPATIONAL INJURY or work-related injury is an injury from exposure in the work environment that can lead to death, lost work time, work restriction or transfer to another job (Holder et al, 1999).

PHYSIOTHERAPIST plays a major role in primary health care in terms of examination, evaluation, diagnosis, prognosis, intervention and outcomes. Procedural interventions in practise by physiotherapists include the following: therapeutic exercise; functional training in self-care and home management (activities of daily living); manual therapy techniques; prescription, application, fabrication of devices and equipment; airway clearance techniques; electrotherapeutic and mechanical modalities (Pereira, 2009).

POSTURE may be defined as a situation when the centre of gravity of each body segment is placed vertically above the segment below. It is the state of musculoskeletal balance that involves a minimal amount of stress and strain on the body (Jordaan, 2005).

RISK FACTORS are characteristics statistically associated with, although not necessarily causally related to, an increased risk of morbidity or mortality (Stedman's Medical Dictionary, 2000).

CHAPTER 1

1. INTRODUCTION AND RESEARCH QUESTION

1.1 BACKGROUND

Low back pain (LBP) is one of the most prevalent and one of the most commonly treated musculoskeletal conditions (Rundell et al, 2009). Eighty percent of the adult population experience LBP in their lifetime (Ekstrom et al, 2008). This means that most individuals will experience LBP regardless of their age, gender or career. Therefore LBP may not only impact work efficiency but also have an effect outside the work environment during activities of daily living (West and Gardner, 2001; Cromie et al, 2000; Holder et al, 1999). A study on physiotherapy students conducted at an Australian tertiary institution found a 69% prevalence of LBP experienced during their lifetime (lifetime LBP prevalence) (Nyland and Grimmer, 2003). Of the students, 65% experienced LBP in the preceding 12-months (one-year LBP prevalence) compared to 44% in the preceding month (one-month prevalence) and 28% in the preceding week (one-week prevalence). Final year students, and students between 20 and 21 years old, were significantly associated with the prevalence of LBP (Nyland and Grimmer, 2003).

The strongest predictor of LBP in adults is a history of related symptoms like pain, tingling, numbness or a feeling of heaviness when younger (Watson et al, 2002). Thus, taking a thorough history of the patient's pain during a physiotherapy evaluation and noting the behaviour of symptoms from adolescence is fundamental. Jordaan (2005) reported that 50% or more of the adolescents in a prevalence study presented with lifetime and one-year prevalence of LBP, where Korovessis et al (2010) reported that 41% experienced LBP. Work-related injuries are of concern, especially among physiotherapists where a previous history of symptoms might be influenced by the occupation (Cromie et al, 2000).

Most physiotherapists experience work-related musculoskeletal disorders (WMSD's), especially LBP during their career (Rozenfeld et al, 2010). It follows that physiotherapists are at risk of experiencing back pain in the process of helping and treating patients (Rozenfeld et al, 2010; Campo et al, 2008; West and Gardner, 2001). The onset of LBP amongst younger physiotherapists occurs between the ages of 21 and 30 years and within the first four years of qualification and starting to practice physiotherapy (Molumphy et al, 1985). Other authors report a prevalence of 30-40% with up to 60% LBP in the first five years of employment (Karachi et al, 2007; West and Gardner 2001; Cromie et al, 2000; Mierzejewski and Kumar, 1997; Scholey and Hair, 1989). In Karachi's study the physiotherapists were below 30 years of age and the prevalence of LBP increased significantly from first year to fourth year (Karachi et al, 2007). To prevent recurrence of LBP preventative measures must be taken. For standardisation, a clear definition is needed for recurrent LBP as demonstrated in a systematic review done by Stanton et al (2010) to minimise different findings for prevalence and treatment outcomes for recurrent LBP.

After an injury or occurrence of LBP the pain usually subsides without any intervention (Lau et al, 2008). Thus improvement in disability occurs resulting in a return to work within one month or less. Therapists are able to predict which patients with acute LBP are more likely to recover with a clinical prediction rule (Hancock et al, 2009). The concern is that most people, who experience LBP, including physiotherapists, will experience 66% to 84% recurrence of LBP within 12 months if no intervention is undertaken (Pengel et al, 2003). With no intervention poor movement habits contribute to imbalances between muscle groups. Imbalances produce stress and strain on various structures, which if overloaded develop into pain and pathology (Comerford and Mottram, 2001b).

Pain and pathology to the lower back cause dysfunction and lesions within the muscle bulk, causing muscle weakness and a dysfunction of the local stabilizer recruitment (Comerford and Mottram, 2001b). Muscle weakness and dysfunction result in predisposition for recurrence and a progression of muscle imbalances. In addition to these muscle imbalances, lifestyle habits or behaviours like administrative work (sitting in front of a computer) or driving long distances in a motor vehicle, also result in altered muscle recruitment and timing of muscle activation (Comerford and Mottram, 2001b). When muscle recruitment is compromised, muscle weakness and dysfunction are caused, resulting in pain and atrophy of the muscles. Atrophy of the muscle as in lumbar multifidus (LM), is localised to the site or segmental level of pathology (Hides et al, 1996; Hides et al, 1994). As a result of pain, atrophy, weakness and dysfunction, recurrences of LBP can affect functional stability (Comerford and Mottram, 2001a). These mechanically induced pain disorders present with either an excess or deficit in spinal stability for which evidence exists but further research is required to validate it (O'Sullivan, 2005). Dysfunction of the spinal stabilizing system following an injury decreases the passive (e.g. ligaments) and active (muscles and tendons) stability (Panjabi, 1992). The neural control system compensates for the decrease in passive and active stability by increasing the stabilizing function of the remaining passive and active spinal components (muscle spasm, injury or fatigue). The increase in the stabilizing function causes accelerated degeneration, abnormal muscle loading or muscle fatigue, resulting in chronic dysfunction and pain over time (Panjabi, 1992). Low back pain needs to be addressed among physiotherapists and physiotherapy students to prevent recurrence irrespective of the cause. Studying and treating patients can be associated with LBP or, as a result of the pain, cause dysfunction and muscle weakness resulting in more pain.

Young physiotherapists who work in hospitals have a high prevalence of LBP (Cromie et al, 2000; Bork et al, 1996). Physiotherapy students are prone to LBP due to their practical training in hospitals and the time spent studying or “sitting looking down” (Nyland and Grimmer, 2003). The most common risk factors for students and qualified physiotherapists are transferring and lifting patients, performing repetitive tasks and working in awkward positions for long periods (e.g. standing, bending over, sitting or kneeling). Bending, twisting movements and static postures into flexion or rotation of the spine greater than 20 degrees from neutral were also noted as risk factors of LBP among physiotherapists (Shum et al, 2010; Salik and Özcan, 2004; West and Gardner, 2001; Cromie et al, 2000; Holder et al, 1999).

Factors that are associated with LBP for physiotherapy students include students’ exposure to educational activities such as sitting looking down while studying, and treating patients (Nyland and Grimmer, 2003). The combination of sitting while studying, an intensive curriculum, performing clinical work in strenuous postures and reduced movement into extension, make students more vulnerable to musculoskeletal injuries in their lower back area (Dankaerts et al, 2009). An increase in vulnerability of the lower back in subjects who present with altered motor control may cause more strain on the spine, resulting in more LBP (O'Sullivan, 2004, 2000). More research is needed to determine the factors associated with greater risk of occupational injuries among physiotherapists and to develop preventative strategies (West and Gardner, 2001).

Low back pain experienced by the students in the last month was associated with sitting looking down and studying more than 20 hours per week (OR 2.4; 95%CI 1.4-4.1) (Nyland and Grimmer, 2003). Time spent treating patients for more than 20 hours was associated with one-month LBP (OR 1.9 (95%CI 1.1-3.6)) and one-week LBP (OR 2.1 (95%CI 1.1-4.1)) (Nyland and Grimmer, 2003). The length of study years (exposure related to specific year) of physiotherapy students (years two to four) was also a significant risk factor for LBP. Therefore students need to take preventative measures to protect themselves from developing LBP while studying and treating patients.

By maintaining a neutral position of the spine of the lower back when treating patients the lumbar area is protected (Panjabi, 1992). A neutral spine in its neutral zone decreases the dysfunction of muscles in the lower spine, therefore protecting the physiotherapist from developing LBP (Panjabi, 1992). Pain or pathology from LBP presents in areas of the spine where there is abnormal segmental control, motor recruitment deficit and decreased neural mobility (Fanucchi et al, 2009). When muscle weakening and dysfunction in the spine occurs, more pain develops (Comerford and Mottram, 2001b). It therefore follows that muscles need to control segmental movement of the spine (Mottram and Comerford, 1998). Muscles that contribute to lumbar segmental stability are the muscle cylinder. The cylinder consists of transversus abdominis (TrA), posterior fibres of psoas, lumbar multifidus (LM), the diaphragm and pelvic floor (PF) muscles. Contraction of the cylinder raises intra-abdominal pressure that stabilises the spine and maintains the lumbar spine in neutral giving segmental stabilisation (Mottram and Comerford, 1998). The cylinder is needed to function optimally to prevent injuries or muscle imbalances.

In response to LBP, segmental reflex inhibition of the LM and TrA occurs. A decrease of the cross-sectional area (CSA) of the specific muscle, altered recruitment patterns and timing occurs on the level affected (Kiesel et al, 2007b). Panjabi et al (1989) also proposed that the deep fibres of LM control spinal stability at each motion segment, thus assisting in the neuromuscular system. Lumbar multifidus is the only muscle of the cylinder that assists in extension of the lumbar spine. Recovery of LM and TrA are not spontaneous on resolution of pain and disability, thus specific training is needed to restore symmetry in size (Hides et al, 1996).

1.2 SIGNIFICANCE OF THE STUDY

Physiotherapy students may be more prone to LBP due to factors such as low level of activity and their flexion posture while studying and working (Nyland and Grimmer, 2003). After an episode of LBP the muscle activity of muscles such as LM and TrA is influenced, affecting optimal function (Kiesel et al, 2007a). The prevalence of LBP in physiotherapy students at the University of the Witwatersrand is unknown. This dissertation reports on lifetime, 12-month, six-month, one-month, one-week and at present LBP prevalences because of the differential nature of exposure across all four year levels and to the range of variables tested. Analysis across the four year levels gives a clearer picture of the prevalence of lifetime LBP and the factors associated with LBP. In relation to all the LBP prevalences the different practical and theoretical exposures are summarized in Table 4.3 – Table 4.5. In another study, differences were noted between year levels of physiotherapy students (Nyland et al, 2003). Furthermore, by understanding the factors associated with LBP in physiotherapy students at the University of the Witwatersrand, preventative strategies and interventions may be developed to minimise recurrences.

1.3 RESEARCH QUESTION

What is the prevalence and what are the factors associated with LBP among undergraduate physiotherapy students at the University of the Witwatersrand?

1.4 STUDY OBJECTIVES

1.4.1 Aim of the Study

- To establish the prevalence of LBP among undergraduate physiotherapy students at the University of the Witwatersrand.
- To investigate a range of factors associated with LBP among undergraduate physiotherapy students at the University of the Witwatersrand.
- To explore neuromuscular associations with LBP.

1.4.2 Objectives

1.4.2.1 To assess LBP (recent and remote) in physiotherapy students across the four years of study.

1.4.2.2 To compare a range of factors in students with and without LBP.

1.4.2.3 To identify neuromuscular associations with LBP by:

a) Establishing neural mobility using the passive straight leg raise (PSLR) test.
b) Establishing level of pain objectively with central and unilateral posterior-anterior (PA) vertebral pressures on L4 and L5.
c) Determining the degree of lumbar multifidus (LM) muscle recruitment at L4.
d) Determining the voluntary low threshold recruitment of transversus abdominis (TrA).
e) Assessing the cross-sectional area (CSA) of lumbar multifidus (LM) on the left and right side at L4 with ultrasound imaging (USI).
f) Determining the degree of an isolated transversus abdominis (TrA) contraction with ultrasound imaging (USI).

1.4.2.4 To explore relationships between LBP and neuromuscular findings.

1.5 OUTLINE OF THE DISSERTATION

1.5.1 Chapter 1 (Introduction and Research Question)

In this chapter background information and relevance of the study are given regarding the prevalence of LBP in physiotherapy students, and the question arises whether physiotherapy students at the University of the Witwatersrand suffer from LBP even before they are qualified? Factors associated with LBP in physiotherapy students are also investigated.

1.5.2 **Chapter 2 (Literature Review)**

In this chapter a review of the literature concerning back pain with a particular focus on the prevalence of LBP in physiotherapy students locally and globally is given. Musculo-skeletal injuries among physiotherapists are explored as well as the factors associated with LBP in physiotherapists. Literature explaining the factors influencing LBP is explored. Information on stability of the spine regarding muscle activation is given, especially on local stabilisers like lumbar multifidus and transversus abdominis and the measurement thereof with diagnostic ultrasound. In 2.3 the literature is discussed regarding the justification of the measuring instruments used in the methodology.

1.5.3 **Chapter 3 (Methodology)**

The methodology and different measuring instruments are discussed in chapter 3. A self-administered questionnaire was used and a multi-stage fitness test followed by a physical assessment. The physical assessment of height, weight, neurodynamic test, vertebral accessory movements, muscle activation and measurements by diagnostic ultrasound was done by the researcher.

1.5.4 **Chapter 4 (Results)**

Using the research objectives, the results from the statistical analysis are discussed and interpreted in this chapter.

1.5.5 **Chapter 5 (Discussion)**

The discussion is based on the results of the study and includes the prevalence of LBP among all the physiotherapy students. The factors associated with LBP regarding the year groups are discussed and compared with other studies. The strengths and limitations are discussed and recommendations are made.

1.5.6 **Chapter 6 (Conclusion)**

This chapter provides a summary of findings and conclusions.

CHAPTER 2

2. LITERATURE REVIEW

2.1 INTRODUCTION

In this chapter the literature is examined in two sections. In 2.2 an overall view on low back pain (LBP) among physiotherapists and especially physiotherapy students is given. Socio-demographic and clinical factors associated with LBP are included in the literature reviews. Educational factors impacting on the students while studying and occupational factors before and after graduating as physiotherapists are discussed. The most suitable measuring instruments and the reasons why they are used are discussed in 2.3.

2.2 LOW BACK PAIN

A literature search was conducted using the databases: Cinahl, Cochrane, Medline and Pedro. English articles relevant to this study up to February 2011 were identified and analysed for quality and reliability. For randomized controlled trials the Pedro score was used. For observational studies the sample size and how it was related to the population and the representativeness of the population was considered. The reliability of an article and which tool was used and how it was developed was analyzed within the methodology of the articles. A manual search was also done at the University of the Witwatersrand's Library on all the physiotherapy journals and relevant textbooks on all related topics. Keywords used were: body mass index, diagnostic ultrasound, fitness, health policies, lifting, low back pain, lumbar multifidus, muscle activation, muscle imbalances, muscle strength, neural dynamic tests, occupational injuries, physiotherapy, physiotherapy students, prevalence of low back pain, rehabilitative ultrasound imaging, risk factors, smoking, stabilisation, transversus abdominis and transfers.

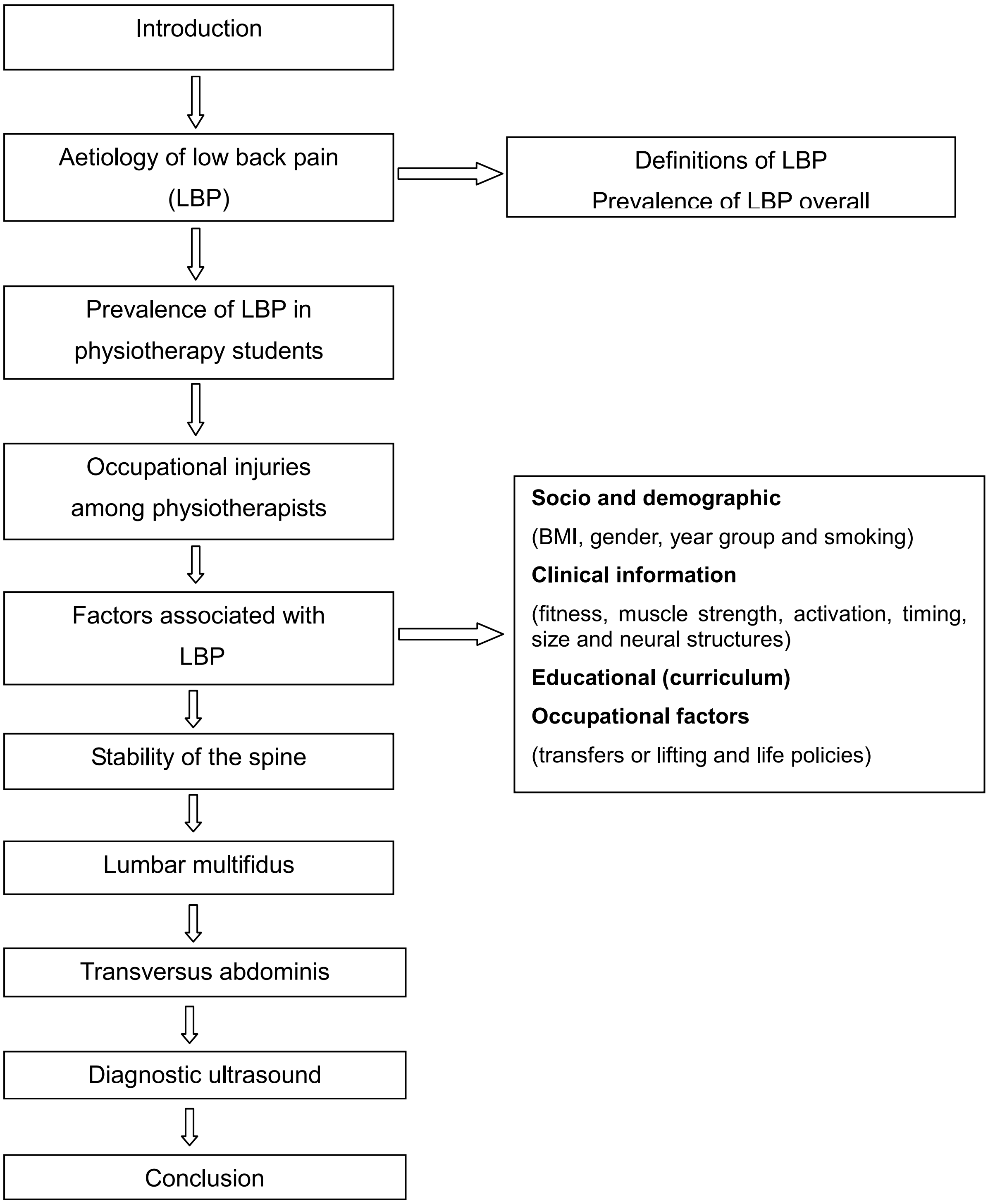

Figure 2.1: Outline of the Literature Review in Section 1

Systematic reviews and randomised controlled trials (RCT's) were found with the literature search regarding motor control exercise for LBP, procedures in physical examination of LBP and determinants of occupational disability following a low back injury. Two cohort studies on what was relevant for LBP prevalence and several non-experimental and descriptive studies on ultrasound imaging, lumbar strengthening exercises and factors associated with LBP were found. Five articles were considered specifically relevant to physiotherapy students and the prevalence of LBP. The risk factors involved with LBP were reviewed. Figure 2.1 outlines the structure of the literature review.

2.3 AETIOLOGY OF LOW BACK PAIN

When the different definitions, phases and stages of LBP were compared, many discrepancies were found (May et al, 2006). The definition of LBP is mainly based on either the anatomical regions where the pain is located or on the duration of symptoms. The International Association for the Study of Pain (IASP) concluded that lumbar, sacral, or lumbosacral spinal pain or any combinations thereof, are described as LBP according to anatomical tomography (Bogduk, 1999). Non-specific LBP is used when the aetiology is unknown, while the terms acute, sub-acute and chronic are used for persistent LBP (May et al, 2006).

Acute LBP is defined as pain for less than three weeks. It usually subsides and disability improves without any intervention (Pengel et al, 2003). In a systematic review of the prognosis of acute LBP, Pengel et al (2003) concluded that 82% of people off work returned back to work and that pain and disability improved within one month. If the LBP persists or the cause of LBP is not established, smaller improvements might occur up to three months but the pain persists for up to 12 months. Symptoms that last for five to seven weeks are classified as sub-acute LBP (Malliou et al, 2006). The IASP has defined chronic pain as pain that has persisted for longer than three months. For research purposes six months is preferred when referring to chronic LBP (Bogduk, 1999). Back pain is one of the commonest musculoskeletal conditions treated by physiotherapists (Rundell et al, 2009). Ironically, physiotherapists themselves suffer from musculoskeletal occupational injuries.

2.4 PREVALENCE OF LOW BACK PAIN IN PHYSIOTHERAPY STUDENTS

Four cross-sectional prevalence studies that relate to whether undergraduate physiotherapy study is a risk factor for LBP were found (Falavigna et al, 2011; Steyl et al, 2010; Karachi et al, 2007; Nyland and Grimmer, 2003). All the students enrolled for the four year Bachelor of Physiotherapy programme at one Australian university and also at three South African universities were included in the studies with no exclusion criteria, making the sample representative. The prevalence of LBP ranged from 18% as musculoskeletal dysfunction

(Steyl et al, 2010) to 60% after one year of clinical practice (Karachi et al, 2007), to 66.8% in the last year (Falavigna et al, 2011) and 69% for lifetime LBP (Nyland and Grimmer, 2003). This is higher compared to findings of the Chartered Society of Physiotherapy where 12% of physiotherapy students were reported to have sustained a LBP injury during training (Glover et al, 2005). In a study by Nyland and Grimmer (2003) the prevalence of LBP was reported at 69% for lifetime LBP, 63% for 12-months LBP, 44% for one-month LBP and 28% for one-week LBP. Karachi et al (2007) on the other hand found 60% LBP prevalence after one-year, 43% after one-month and 32% after one-week. Falavigna et al (2011) found 77.9% for lifetime prevalence of LBP, 66.8% prevalence in the last year and 14.4% prevalence at the time of testing. An increased prevalence of LBP was noted among physiotherapy students compared to medical students. The prevalence of LBP among physiotherapy students ranged from 12% - 77.9% (Falavigna et al, 2011). These four studies were the only prevalence studies referring to different prevalences of LBP among physiotherapy students (Falavigna et al, 2011; Steyl et al, 2010; Karachi et al, 2007; Nyland and Grimmer, 2003).

Eight studies were reviewed to determine the prevalence of LBP among qualified physiotherapists and physical therapists. The prevalence ranged from 26% - 80% (Campo and Darragh, 2010; Glover et al, 2005; Salik and Özcan, 2004; Ruzelj, 2003; West and Gardner, 2001; Cromie et al, 2000; Holder et al, 1999; Bork et al, 1996). Two of the studies (Cromie et al, 2000; Holder et al, 1999) could be considered representative with populations of 536 and 667. Although including equal numbers of physiotherapists and physiotherapy assistants, they fail to reflect the true ratio of physiotherapists and assistants in all 50 states (Holder et al, 1999). The subjects were randomly selected. A high response rate of 67.9% and 67% respectively were noted (Cromie et al, 2000; Holder et al, 1999). The other two studies had a population of 120 and 217 respectively. Although all the physiotherapists were included in the total population, moderate response rates of 59% and 53% were noted (Salik and Özcan, 2004; West and Gardner, 2001).

In the studies by Salik and Özcan (2004); West and Gardner (2001); Cromie et al (2000) and Holder et al (1999) the questionnaires were mailed to relevant subjects. The prevalence of LBP was seen to be high in the mentioned studies (Salik and Özcan, 2004; West and Gardner, 2001; Cromie et al, 2000; Holder et al, 1999), possibly because physiotherapists with LBP are more likely to respond to such a questionnaire, and in so doing would bias the results. The average age when injury was first experienced ranged from 17-30 years for the four studies. Sixteen percent had the injury while they were still physiotherapy students and 56% in the first five years after qualification (West and Gardner, 2001). A thorough history was taken of all injuries prior to, during and after studying as physiotherapists (West and Gardner, 2001; Cromie et al, 2000). Comparatively Salik and Özcan (2004) and Holder et al (1999) took no LBP history before the subjects began working as a physiotherapist, thus influencing the results for lifetime prevalence of LBP.

The transferring of patients, performance of repetitive tasks, the lifting of heavy equipment and working when physically fatigued are risk factors related to LBP (Salik and Özcan, 2004). In addition, unanticipated sudden movements or falls by patients and working with confused or agitated patients aggravated LBP injuries in physiotherapists. In response to their injury, 20,5% physiotherapists worked to improve their body mechanics, 16,4% avoided lifting, 13,7% changed their working position frequently and 10,5% increased the use of other personnel (Salik and Özcan, 2004). As preventative strategies the physiotherapists incorporated aids like height-adjustable beds to reduce postural strains on the spine and the use of a helper (Cromie et al, 2000). Half of the physiotherapists improved their body mechanics to prevent the recurrence of LBP. Forty-three percent increased the use of other personnel, 24% changed their working position frequently and 34% consulted a doctor for treatment of their LBP. Twenty-five percent reported losing half a day or more as a result of their injury (Holder et al, 1999).

The Chartered Society of Physiotherapy released statistics in 2005 concerning 3661 physiotherapists, physiotherapy assistants and students. Sixty-eight percent had suffered work-related injuries during their career. Thirty percent of the 3661 sample stated that their injury started with a sudden accident through manual handling or by lifting a patient (Graham and Grey, 2005). Interestingly, 32% were injured within their first five years of graduating and 12% were students on clinical placement. Similar results were reported in another study where 16% of those injured, were undergraduate physiotherapy students and 56% were injured in the first five years post qualification (West and Gardner, 2001). Only a minority of those reported their injury to their employers (Graham and Grey, 2005). Other studies conducted in Canada and the United Kingdom (UK), specifically on physiotherapists suffering from LBP, have shown a higher prevalence in younger physiotherapists (Cromie et al, 2000; Bork et al, 1996; Scholey and Hair, 1989; Molumphy et al, 1985). Although the studies were not representative of the total physiotherapy population, broad spectra of physiotherapists from all fields of physiotherapy were assessed.

2.5 OCCUPATIONAL INJURIES AMONG PHYSIOTHERAPISTS

Physiotherapy is an occupation that involves manual, hard labour with many occupational musculoskeletal injuries (West and Gardner, 2001). Common musculoskeletal injuries among qualified physiotherapists include injuries to the neck, hands, wrists and back, with the lower back being most prevalent (Rozenfeld et al, 2010; Darragh et al, 2009; Campo et al, 2008; Caragianis, 2002; Cromie et al, 2001; West and Gardner, 2001; Cromie et al, 2000; Bork et al, 1966). The effect of occupational injuries on physiotherapists is a key concern as income is directly related to the physiotherapist's health. After an injury, 17.7% of physiotherapists in the state of Victoria, Australia (Cromie et al, 2000) and 33% physiotherapists in Turkey (Salik and Özcan, 2004) changed their field of practice. The physiotherapists in Turkey changed their field of practice due to their musculoskeletal injuries 1.9 times more than the rate in the study by Cromie et al (2000).

2.6 FACTORS ASSOCIATED WITH LBP AMONG PHYSIOTHERAPISTS

In the LBP studies reviewed, specific factors were identified and these will be reviewed in this section (Falavigna et al, 2011; Bakker et al, 2009; Darragh et al, 2009; Campo et al, 2008; Salik and Özcan, 2004; Nyland and Grimmer, 2003; Caragianis, 2002; West and Gardner, 2001; Cromie et al, 2000; Holder et al, 1999; Mierzejewski and Kumar, 1997; Scholey and Hair, 1989).

2.6.1 Socio- and Demographic Information

2.6.1.1 Height, weight and body mass index

In a study done on adolescent LBP, an association was noted between hyperlordotic postures, an increase in body mass index (BMI) and LBP (Perry et al, 2009). A significant association was also noted between a high BMI and LBP in boys (Jordaan, 2005). However many studies report no association between LBP and BMI, and this finding was supported by Karachi et al (2007) in their study using undergraduate physiotherapy students in the Western Cape (p=0.6).

2.6.1.2 Gender and age

Increasing age has been found to be a risk factor (ages 20 and 21 years when compared with the younger students), in particular among males (Nyland and Grimmer, 2003). This adds to the results by Karachi et al (2007), where LBP increases significantly with an increase in age (p=0.03). Nyland and Grimmer (2003) also found the mean age of all the students without LBP in all four year groups was 19.8 years (95%CI; 19.3-20.3). The mean age of students with LBP was 20.2 years (95%CI; 19.5-23.6). No significant difference could be detected between gender groups as an associated factor of LBP versus no LBP. There was a significant association between LBP prevalence at one-month (p=0.01) and LBP prevalence at one-week (p=0.01) among female subjects. Another factor, that was associated with LBP, was the length of university study undertaken by the subjects.(Nyland and Grimmer, 2003).

2.6.1.3 Physiotherapy year of training

Low back pain and injury become more common as the students progress from first year to final year (Karachi et al, 2007; Nyland and Grimmer, 2003). As shown previously, being a final year physiotherapy student (mean age 20 or 21 years) was associated with LBP compared with the other year groups (Nyland and Grimmer, 2003). The prevalence of LBP increased significantly for all students with each year of study from 49% - 76% (p=0.001). One university showed a significant increase in LBP from first to fourth year (44.23% - 87.5%; p=0.03) (Karachi et al, 2007). Being exposed to undergraduate physiotherapy study for more than four semesters was significantly associated with LBP (OR=2.55; CI=1.43-4.55; p=0.001) (Falavigna et al, 2011).

2.6.1.4 Smoking

Another socio- and demographic factor discussed in the literature is smoking. Feldman et al (1999) and Goldberg et al (2000) reported that smoking and the quality of cigarettes smoked are associated with LBP. This is supported by Vogt et al (2002) who found differences between smokers and non-smokers. Smokers had longer episodes of LBP and lower mental and physical health status scores than non-smokers. Eriksen, as quoted by Bakker et al (2009) noted that subjects who were smokers were at risk for developing LBP after lifting and standing. Adolescents who smoked had a lower mental health score than non-smokers; thus smoking may have a negative effect on growing tissue (Feldman et al, 1999). This might also have an effect on fitness and level of activity (Perry et al, 2009).

2.6.2 Clinical Information

2.6.2.1 Fitness and level of activity

The differences between height and body mass may exert different torques on the spine in different activities. In a study done by Perry et al (2009) a higher aerobic capacity in adolescent boys was a significant risk factor for LBP. The boys were heavier and taller compared to the girls (all fourteen years of age). This means that fitter boys (being heavier and taller compared to girls), may increase spinal load during longer, more intense activity, loading the tissues beyond their threshold or tolerance (Perry et al, 2009).

To the contrary, adults undertaking exercise and fitness, showed a reduction in LBP prevalence in most studies, and changes in fitness and exercise affected pain prevalence and intensity for up to three years (Hayden et al, 2005; Koumantakis et al, 2005). Staal et al (2005) found no association between the development of LBP, disc degeneration and being active as adults.

Active students at university level had a lower risk of LBP at one year (Cahmak et al, 2004). Similar studies done on children (Harreby et al, 1997) and adults (Suni et al, 1998) have shown a similar trend. The contrary has also been found. Kirstensen et al (2001) found that high levels of activity and being physically active more than two or three times per week generates LBP. According to the research, it appears that being active in moderation lowers the risk of developing LBP whereas being active at a high level or for more than two to three times per week increases the prevalence of LBP. Bakker et al (2009) found strong evidence that leisure time sport and exercises are not associated with LBP, and that activities during leisure time (e.g. gardening and hobbies) have conflicting evidence regarding risk of LBP. More research is required to determine specific levels of activity and fitness and the effect they have on LBP (Hayden et al, 2005; Koumantis et al, 2005).

2.6.2.2 Muscle strength, activation and timing

Stability and control of the spine are major factors in non-specific LBP. Non-specific LBP is the term used when the source of the pain cannot be isolated (Panjabi, 2003). For stability and segmental control of the neutral spine, the local stabilising muscles need to be recruited (Comerford and Mottram, 2001b). Transversus abdominis (TrA) (Hodges and Richardson, 1996) and lumbar multifidus (LM) (MacDonald et al, 2004) activity are delayed during arm movements in individuals with LBP. In any movement of the body, TrA and LM need to contract to maintain a stable spine. If they fail to contract, or are delayed, this is known as altered timing and recruitment (Comerford and Mottram, 2001b). Hodges and Richardson (1996) noted altered motor control of TrA in subjects with LBP whereas Hides et al (1996) state that LM muscle recovery is not automatic after resolution of LBP. For optimal control and coordination of the spine an intervention was developed aiming at the training of pre-activation of the local stabilisers (TrA and LM). Training of TrA and LM takes place by slowly progressing from static and dynamic to functional movements where both the local and global trunk muscles are integrated maintaining a stable spine (Ferreira et al, 2007).

A systematic review on motor control exercises for persistent, non-specific LBP included fourteen trials and revealed that motor control exercises were significantly more effective in reducing LBP compared to minimal intervention (Macedo et al, 2009). This was true for short term follow-up whereas long term results were achieved when motor control exercise was combined with pain therapy (Macedo et al, 2009). The review concluded that minimal motor control exercise is not more effective than applying manual therapy or other forms of exercise (Macedo et al, 2009). Based on the information in this review it appears that a combination of treatments (pain therapy, manual therapy and motor control exercise) is necessary to achieve optimal beneficial results in subjects with chronic LBP. Stokes et al (2007) concluded that factors other than activation and timing of muscles are important e.g. muscle size and thickness.

2.6.2.3 Change in muscle composition (size or thickness)

Muscle composition can change after an incident of LBP. A decrease in the cross-sectional area (CSA) of the paraspinal muscles was noted among young cricketers with LBP (Hides et al, 2008b). The muscles atrophied due to pain and did not return to their original width unless the muscle was specifically recruited and strengthened (Stokes et al, 2007). Individuals with LBP showed an increase in fatigability (Roy et al, 1989) and also show an increase in intramuscular fat in the paraspinal muscles (Alaranta et al, 1993). Fatty deposits or fibrous tissue infiltration and atrophy are radiological findings in young cricketers with LBP (Hides et al, 2008a). In the last few years researchers have used real-time ultrasound imaging (RUSI) via a parasagittal view to identify segmental changes in muscle thickness. A decrease in the CSA of LM ipsilateral to painful symptoms in patients with acute LBP was noted (Hides et al, 1996) which agrees with Henry and Teyhen's (2007) findings. However, in elite weight lifters with LBP, no changes were noted in the resting CSA of LM (Sitilertpisan et al, 2012). As muscle composition changes, neural structures within muscles are affected and need to be addressed for optimal functionality (Butler, 2000).

2.6.2.4 Neurodynamic structures

Neurological structures are very sensitive. After an injury neural mobility is compromised affecting one side of the body (Butler, 2000). In 12-13 year old children with LBP, a difference in neural mobility was already noted between left and right sides. (Fanucchi et al, 2009). Neural mobility is measured by the passive straight leg raise (PSLR) test as described by Butler (2000, 1991). From Jordaan's (2005) study, limited range in the PSLR test was linked to rapid skeletal growth in children. This will affect development and structures surrounding neural tissue, involving muscle activation, timing or composition and causing pain or dysfunction (Jordaan, 2005). No studies were found regarding neurological structures and physiotherapy students.

2.6.3 Educational Activity Factors

Nyland and Grimmer (2003) found that one-month LBP was associated with sitting looking down and studying for more than 20 hours per week. In the systematic review done by Bakker et al (2009), sitting at work was not associated with LBP. Twenty hours time spent treating patients was associated with LBP prevalence at one-month for males but not for females (Nyland and Grimmer, 2003). Karachi et al (2007) propose that further studies are needed to test for the prevalence of LBP in undergraduate physiotherapy groups as more aspects of university life need to be measured, specifically poor sitting, stress, frequency and intensity of injury, sports and recreational habits.

2.6.4 **Occupational Factors**

2.6.4.1 **Transfers and lifting of patients**

Transfers and lifting contribute to LBP (Campo et al, 2008; Molumphy et al, 1985). In the UK two out of five people suffer from LBP (The Chartered Society of Physiotherapy, 2006). A third of nurses have to leave their profession each year due to a back injury from lifting patients (Griffith and Stevens, 2004). The load carried by nurses is high; for example in a 28-bedded elderly care ward, 2500kg would be lifted or moved by two nurses in just one hour (Griffith and Stevens, 2004). The recommended maximum weight lifted by one person at a time is 30kg and for two people is 40kg (20kg each) (The Chartered Society of Physiotherapy, 2006). These limits are applicable to physiotherapists during rehabilitation and treating patients (Griffith and Stevens, 2004).

Fifty percent of moving and handling injuries among physiotherapists occur within the first four years after qualification (Molumphy et al, 1985). One out of six physiotherapists needs to leave the profession within six years due to back injuries in the UK, and over 80% of physiotherapists have lower back injuries. The age group at risk is less than 30 years of age (The Chartered Society of Physiotherapy, 2008). Manual handling includes the transporting, supporting, carrying, lifting, lowering and pulling or pushing of a load by hand (Griffith and Stevens, 2004).

In a systematic review of spinal mechanical load as a risk factor for LBP, 12 studies reported on 34 exposures of load (Bakker et al, 2009). Seven studies reported no association between heavy physical load and LBP, whereas five studies found associations between being female and lifting more than 11.3kg, the combination of smoking and standing or lifting, climbing stairs while lifting, and carrying heavy loads as part as their daily activity. The study concluded that conflicting evidence exists for heavy physical load as risk factor for LBP (Bakker et al, 2009).

The most common risk factors for physiotherapists are transferring and lifting patients, performing repetitive tasks, working in awkward positions and working in the same position for long periods (e.g. standing, bending over, sitting or kneeling) (Nyland and Grimmer, 2003). During forward bending the loading increases significantly on the spine during their early and middle ranges in subjects with LBP and a positive SLR sign (Shum et al, 2010). According to national and local guidelines, unsafe handling practices are the underarm ‘drag’, the orthodox lift including the cradle lift, bear hug, through arm, cross arm, pivot transfer, hammock (top and tail lift) and the flip turn (The Chartered Society of Physiotherapy, 2008).

Bending, twisting movements and static postures into flexion or rotation of the spine greater than 20 degrees from neutral were noted as risk factors of LBP among physiotherapists

(Salik and Özcan, 2004; West and Gardner, 2000; Cromie et al, 2000; Holder et al, 1999). An increase risk for LBP was noted when working in a bent or twisted position for more than two hours (Bakker et al, 2009; Van Nieuwenhuyse et al, 2006). Conflicting evidence also exists were no associations were noted with LBP and 13 different bending or twisting exposures (Bakker et al, 2009). Other supposedly dangerous practises include the patients holding onto the carer and lifting with poles and canvas (Vieira et al, 2006). Equipment like hoists can be used for safety and to help the carer (Griffith and Stevens, 2004). Safer handling includes the use of equipment, to get closer to the load, maintaining a neutral spine, bending at the hips and knees to transfer weight within the base of support. As a result of the high incidence of LBP injuries, policies and legislation are needed to protect employers for health and safety (The Chartered Society of Physiotherapy, 2006).

2.6.4.2 Life policies and legislation

The Health and Safety at Work Act (HSAWA 74) was established in 1974 in the UK giving clear guidelines to employers and their employees (The Chartered Society of Physiotherapy, 2006). In South Africa, Health and Safety legislation was established in 1993 and updated in 2004. Employees are expected to be responsible for their own health and safety and report an unsafe condition (Occupational Health and Safety Act South Africa 1993, amended 2004). In the UK, the duty of the employer is to ensure the health, safety and welfare of all employees. The duty of the employee is to fully utilise the equipment or systems of work provided by the employer, and to inform the employer of any physical conditions which may affect ability to perform manual handling safely (The Chartered Society of Physiotherapy, 2006). In Australia, the legislation states that employers must provide a safe workplace for their employees (Cromie et al, 2001). Employees are expected to take care of themselves and others, accept any training to carry out their work safely and to co-operate with the employer enabling him to comply with health and safety (Griffith and Stevens, 2004).

In the UK the Manual Handling Operations Regulations became a legal requirement on January 1st 1993. Manual handling is defined as “any transporting or supporting of a load including the lifting, putting down, pushing, pulling, moving or carrying by hand or by bodily force.” A load can include people, animals and inanimate objects. In comparison it is not the case in South Africa (Occupational Health and Safety Act South Africa 1993, amended 2004). The Occupational Health and Safety Act in South Africa does not address the rights and protections of employees to the same extent as in the UK and does not have the necessary legal precedents in place.

The Chartered Society of Physiotherapy states that, although newly qualified physiotherapists might feel that they had better manual handling training than physiotherapists trained earlier, new graduates might not be able to manage their time and case load properly. This perception might increase the risk for developing musculo-skeletal dysfunction such as LBP (Graham and Grey, 2005). As a preventative strategy for work-related musculoskeletal disorders (WMSD) related to posture, ergonomics need to be considered (Obembe et al, 2008). Unexpected events and staff shortages when dealing with patients also affect preventative strategies (Graham and Grey, 2005). Much work has been done to investigate the development of back pain and all the factors associated with LBP.

2.6.5 Conclusion: Factors Associated with Low Back Pain

Students are exposed to factors predisposing them to LBP such as flexion activities, sitting posture while studying and performing clinical work. There is little published as to how LBP might influence their profession later on once they are qualified. The combination of sitting postures while studying, an intensive curriculum, performing clinical work in straining postures and less movement into extension make students more vulnerable to musculoskeletal injuries in their lower back, and increase the risk of LBP when working (Dankaerts et al, 2009). This might correlate with O'Sullivan's hypothesis that subjects who present with altered motor control of their lower back experience more strain on the spine, resulting in more LBP (O'Sullivan, 2004, 2000). What was also interesting was that the risk increased for students once they completed first year (Nyland and Grimmer, 2003). Clearly one of the factors that is important is the stability of the spine.

2.7 STABILITY OF SPINE

Two interrelated parameters of spinal stability need to be considered due to the multisegmental nature of the lumbar spine (Gardner-Morse et al, 1995). The first parameter is control of spinal orientation, which relates to maintaining a corrected posture of the spine against imposed forces and compressive loading. The second is control of the intersegmental relationship at the local level, that is lumbar segmental control. Efficient stability of the spine is dependent on the integrity of both levels of support (Gardner-Morse et al, 1995).

Muscles that contribute to lumbar segmental stability consist of transversus abdominis (TrA), posterior fibres of psoas, lumbar multifidus (LM), the diaphragm and pelvic floor (PF) muscles (Mottram and Comerford, 1998). These muscles all form the integrated local muscle cylinder. The integrated local muscle cylinder is the deepest layer of muscles that originate and insert segmentally on lumbar vertebrae, and their contraction creates intra-abdominal pressure that stabilises the spine. In doing this the lumbar spine is maintained in neutral, therefore controlling inter-segmental motion or translation, maintaining the corrected posture. The muscles respond to changes in posture. In practice, low extrinsic loads give a physiotherapist the ability to maintain a correct posture whilst performing various physical activities such as lifting (Mottram and Comerford, 1998).

A physiotherapist needs to maintain a neutral position of the lower back when treating patients, thus protecting the lumbar area. A neutral spine decreases the dysfunction of muscles in the lower spine, thus protecting the physiotherapist from developing LBP. When muscles weaken and dysfunction in the spine occurs, pain develops. Pain or pathology present as abnormal segmental control of the spine, motor recruitment deficit and decreased neural mobility (Fanucchi et al, 2009). Muscles become fibrotic and shortened, losing extensibility due to injury, pain and fear of movement, causing instability of the spine (Panjabi et al, 1989).

The maintenance of spinal stability encompasses three main elements: the passive support of the osseo-ligamentous structures, the support of the muscle system and control of the muscle system by the central nervous system (Mottram and Comerford, 1998). O'Sullivan hypothesized that where the integrity of the passive stabilising structures of the lumbar spine has been compromised, as in LBP patients, the neuromuscular system may play an important role in providing dynamic stability to the segment (O'Sullivan, 2004). This supports the hypothesis that interplay between the passive, active and neural control systems are essential for spinal stability (Panjabi et al, 1989).
Given the importance of the deep muscle system for the production of movement and the control of high physiological load (Mottram and Comerford, 1998), the global muscle system's primary responsibility is reviewed. It is proposed that the global muscles have a role in stability and mobility. Both these roles are important for control of low loads or normal functional activities. Although both muscle systems work together, the local system contributes to spinal stability, being closer to the centre of rotation of the spinal segments and with shorter muscle lengths which are ideal for controlling intersegmental motion or translation (Comerford and Mottram, 2001b). Specific exercises, concentrating on the deep abdominal and LM muscles as opposed to focussing on global stability muscles, are effective in decreasing pain and functional disability in patients (O'Sullivan, 2000). Therefore, both the local and global stability muscles need to be retrained to increase spinal stability, decrease pain, maintain the spine in neutral and to move functionally (Mottram and Comerford, 1998).

2.8 LUMBAR MULTIFIDUS

To understand the function and morphology of lumbar multifidus (LM), many studies have been done on LM in healthy and injured subjects with LBP (Sitilertpisan et al, 2012; Kiesel et al, 2007b; Hides et al, 2006, 1998, 1996, 1994; Panjabi et al, 1989). Lumbar multifidus is the most medial of all the paraspinal muscles. Its size increases caudally (consisting of five layers) and looks like a large multifascicular muscle (Macintosh et al, 1986). All lumbar muscles contribute to spinal stability, especially lumbar erector spinae (ES) (Mottram and Comerford, 1998).

The deep fibres of LM control spinal stability at each motion segment thus assisting in the neuromuscular system (Panjabi et al, 1989). Lumbar multifidus is the only muscle of the cylinder that assists in extension of the lumbar spine. In response to LBP, segmental reflex inhibition of the LM and TrA occurs resulting in a decrease of the cross-sectional area (CSA), altered recruitment patterns and timing (Kiesel et al, 2007a). Static and dynamic imaging can be used to measure the paraspinal muscles (Hides et al, 2008a, 1996, 1994). Atrophy of LM has been observed when magnetic resonance imaging (MRI) and computerized tomography (CT) scanning have been used.

Specific training of the LM is required because it does not recover spontaneously even after pain and disability have resolved (Hides et al, 1996). There is evidence that exercise therapy is effective for chronic LBP and that individuals who suffer from acute and sub-acute LBP might benefit from exercise therapy (Ekstrom et al, 2008). This is supported in the reasoning to include voluntary contraction of the deep fibres of LM in rehabilitative exercise programs (Hides et al, 1998). The other muscle that contributes to lumbar segmental stability is transversus abdominis (TrA) (Mottram and Comerford, 1998).

2.9 TRANSVERSUS ABDOMINIS

Transversus abdominis (TrA) activates prior to movement in anticipation of an increased load on the spine in order to maintain stability of the spine. The activity can be independent of the direction of trunk movement or the load (Hodges and Richardson, 1996). In a more recent study (Allison et al, 2008), contradictory results were stated on the feedforward responses of TrA. Transversus abdominis is identified as being directionally specific and acts asymmetrically. This means that during unilateral arm flexion the contralateral TrA contracts prior to movement in order to increase stability of the spine during movement. The ipsilateral TrA shows an unexpected delayed activation. When the arm is changed the side to side difference switches. Therefore, the authors concluded that TrA is directionally specific and that during a unilateral movement, bilateral preactivation of TrA is not normal (Allison et al, 2008).

During a TrA abdominal drawing-in manoeuvre (ADIM) the TrA shortens and pulls on the anterior abdominal fascia and thoracolumbar fascia. As seen with ultrasound imaging (USI) the muscle thickens and forms an arc laterally like a "corset". For a good contraction without substitution, the obliquus externus (OE) abdominis and obliquus internus (OI) abdominis remain unchanged or only minimal changes are noted. The change in muscle thickness of TrA needs to be symmetrical. (Teyhen et al, 2008). Teyhen et al (2009) measured the deep abdominal muscles during the active straight leg raise test (ASLR). A symmetrical change in TrA and OI muscle thickness during the ASLR test were noted in subjects with and without LBP, regardless of whether the USI measurements were done ipsilateral or contralateral to the side of symptoms.

In USI of the abdominal muscles in subjects without LBP, the rectus abdominis (RA), OI, OE and TrA respectively represent 35%, 28.4%, 22.8% and 13.8% of the cumulative anterior and lateral abdominal wall thickness (Teyhen, 2007). During functional controlled activities the mean increase in TrA thickness was 20% in subjects without LBP, where the mean increase in thickness for subjects with LBP was significantly smaller (4%). There was no difference in muscle thickness for the OI and OE respectively between the LBP and no-LBP groups. According to Teyhen et al (2008) it means that LBP affects the functional contraction of TrA and the stabilising action needed for the spine. Ultrasound imaging provides a thorough measurement of the abdominal muscles (Teyhen, 2007).

Twenty-one studies (ranging from 1997 to 2008) were included in a systematic review on the reproducibility of Rehabilitative Ultrasound Imaging (RUSI) in the measurement of TrA activity (Costa et al, 2009). The studies included subjects with and without LBP. Only four of the included studies provided thorough descriptions on the assessment methodology. The review highlighted limitations to the current reproducibility for the measurement of thickness change in TrA, especially over time. This means that further studies are needed to establish reproducibility of RUSI for the abdominal wall muscles. What was interesting is that most of these studies only calculated the reproducibility of measurements of the abdominal muscles. The measurement of thickness changes, comparing one image in resting state with an image during a contraction. This was only done in six studies. Other measurements such as differences in thickness changes over time were not found in any studies (comparing two different thickness changes of the same muscle over time to identify improvement or deterioration) (Costa et al, 2009).

Changes were observed in lateral abdominal muscle thickness measured with RUSI after spinal manipulation in patients with LBP (Ranay et al, 2007). Lateral abdominal thickness was assessed with the patient at rest and during an ADIM prior and just after a spinal manipulation. A small sample size of nine patients was taken. Another concern is that manipulation techniques are not always specific to the spinal level targeted lacking segmental specificity (Ross et al, 2004). In spite of this small sample size, six out of the nine patients with acute LBP had an increase in TrA thickness during an ADIM immediately following spinal manipulation. Limitations to the case report were that no cause-and-effect conclusions can be drawn, but that these muscle changes may suggest that spinal manipulation influences muscle behaviour (Ranay et al, 2007).

2.10 DIAGNOSTIC ULTRASOUND

To identify neuromuscular associations with LBP among physiotherapy students, the activation of LM and TrA was measured. These muscles can be measured by electromyographic (EMG) analysis and ultrasound imaging (USI) (Ekstrom et al, 2008; Whittaker et al, 2007a). Surface EMG analysis has been used for measurement of adults' low back muscles, especially the LM, however many limitations arise. The EMG is subject to 'crosstalk' between muscles (signal recorded from adjacent muscles), and movement of electrodes on the skin occurs during analysis. Optimal positions for producing maximum voluntary isometric contraction (MVIC) are not clearly established for each muscle group (Ekstrom et al, 2008).

Ultrasound imaging has been used since the 1950's for medical purposes such as diagnostic imaging. The main use of USI is still radiological examination of soft tissue, organs and ligaments. Rehabilitation and USI was first used by Ikai and Fukunaga in 1968 and used by physiotherapists in the 1980's by Dr. Archie Young and colleagues at the University of Oxford. Young et al (1985) showed that muscle wasting is underestimated when a tape measure is used. Several other studies about the quadriceps muscles, strength training, ageing on muscle size and the relationship between muscle size and strength followed (Whittaker, 2007). All these studies used compound B-scanning which was replaced in the 1990's by real-time USI (Whittaker, 2007).

Hides et al (2001, 1996, 1994) used USI in studies detecting atrophy of LM at the level where symptoms were present and ipsilateral to the painful side. Recovery of the muscle was not spontaneous after pain subsided. Specific training is needed to decrease the risk of recurrences of LBP. Since 1994 more muscles of the trunk and limbs have been investigated with USI (Stokes et al, 1997). The current use of USI can be divided into Rehabilitative USI (RUSI) and diagnostic imaging. Table 2.1 shows the different features of RUSI versus diagnostic imaging.

Rehabilitative ultrasound imaging is used for the measurement of morphological features (morphometry), such as muscle length, depth, diameter, the CSA of the muscle, volume, changes and impact on associated structures (Whittaker, et al 2007a). On the other hand, diagnostic USI is used to examine the effects of injury or disease on ligaments, tendons and muscle tissues that require different training and skills that can be addressed after being identified.

Table 2.1: The Differences between RUSI and Diagnostic Imaging

	RUSI	**Diagnostic Imaging**
Use	Evaluation of muscle structure (morphology) by repeated assessments	Examining effects of injury/disease on ligaments, tendon and muscle tissues. A single diagnostic investigation.
	Biofeedback mechanism	

The practice guidelines for the use of USI for the abdominal, pelvic and paraspinal muscles were developed at the first International Meeting on RUSI (May et al, 2006). The representatives approved the following statement: “Rehabilitative ultrasound is a procedure used by physical therapists to evaluate muscle and related soft tissue morphology and function during exercise and physical tasks. Rehabilitative ultrasound is used to assist in the application of therapeutic interventions aimed at improving neuromuscular function. This includes providing feedback of the muscle to the patient and physical therapist to improve clinical outcomes” (Whittaker, 2007). To summarize, RUSI can be used in clinical and research settings to study muscles difficult to assess like the abdominal wall (Teyhen et al, 2007), posterior spine (Stokes et al, 2007) and pelvic floor (Whittaker et al, 2007b) as well as to use RUSI as a biofeedback tool to help with rehabilitation (Henry et al, 2007). With the statement, a visual representation was created to illustrate where RUSI fits into the wider spectrum of medical USI (see Figure 2.2).

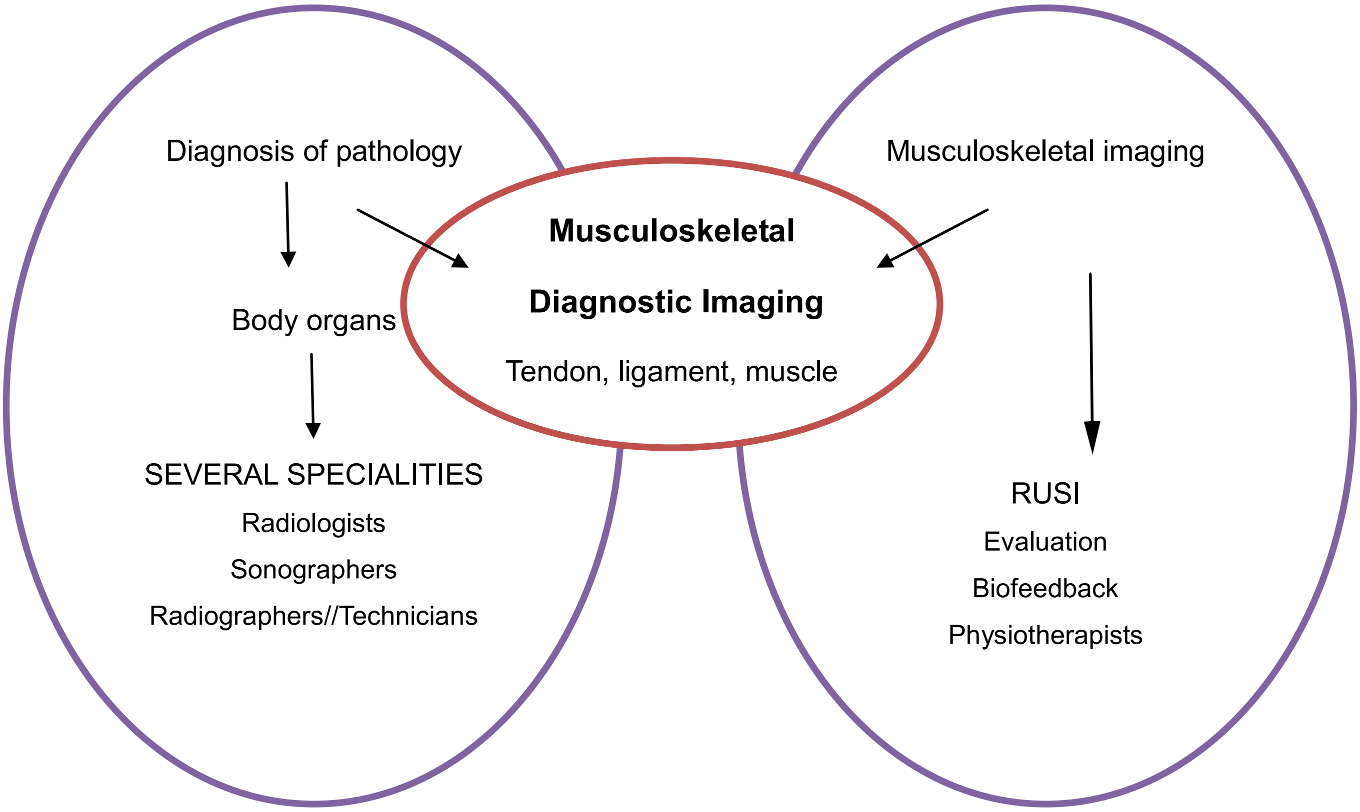

Figure 2.2: Fields of Medical Ultrasound Imaging (Whittaker, 2007)

Five indications for RUSI were identified in an editorial by Teyhen (2007). These are:

- The first is the assessment and analysis of altered motor behaviour in individuals with neuromuscular dysfunction. Examples of its use are in the abdominal muscles during the abdominal drawing-in manoeuvre (ADIM), the pelvic floor muscles in patients with LBP and urinary stress incontinence.
- The second is the identification of a subgroup of patients who might benefit from a specific exercise strengthening program.
- Thirdly, RUSI is used as a visual feedback to assist in lumbar stabilising exercises. Physiotherapists are using RUSI more as an objective training tool and to enhance motor learning.
- Fourthly the influence of treatments on muscular behaviour can be determined. In a case report, muscle changes were seen after manipulation of the spine (Ross et al, 2004).
- Finally, emerging applications with growth of the field. Muscles in the cervical spine, foot and other extremity muscles have been assessed with RUSI.

In another systematic review by Koppenhaver et al (2009) RUSI is described. From the results, RUSI was discussed as a valid measure of trunk muscle size and activation during isometric sub-maximal contractions. Sixty papers were included in the review. It was concluded that clinicians can be confident in muscle thickness and CSA measurements when RUSI is used but more care needs to be taken when using changes in muscle size to reflect muscle activation (especially during high levels of contraction and tasks that have not been validated). Koppenhaver et al (2009) reported reliable results when using USI during low levels of isometric contraction of TrA, OI, OE and LM. Costa et al (2009) however reported that further studies are needed to establish reproducibility of RUSI for the abdominal wall muscles. His results were specifically related to only TrA contraction. When measuring muscle activation during high levels of contraction, especially concentric and eccentric contractions, clinicians need to take note of where these measurements fluctuate and thus make it difficult to compare (Koppenhaver et al, 2009).

2.11 CONCLUSION

The literature reviewed in this chapter, gives a concise description of the prevalence of LBP among physiotherapy students. The prevalence ranged from 18% as musculoskeletal dysfunction to 60% after one year of clinical practise and 69% for lifetime LBP. Factors associated with LBP are smoking and the quality of cigarettes, an increase in BMI, being male and aged 20 and 21 years. Low back pain progressed from first year to final year in physiotherapy students. Transversus abdominis (TrA) and LM's muscle activity and timing are delayed in individuals with LBP and a decrease in the CSA of the muscles is noted in patients with LBP. As muscle composition changes, neural structures are also affected and need to be addressed with the muscles for optimal functionality. Recent literature was found regarding diagnostic ultrasound and the measurements of LM and TrA specifically as these muscles protect the spine. In 2.12 the measuring instruments chosen for the study will be discussed and justified.

2.12 JUSTIFICATION OF STUDY INSTRUMENTS USED

The aim of this section is to justify the measuring instruments according to the literature.

2.12.1 Questionnaire

The data collection process in this study started with a questionnaire. Most of the previous statistics on LBP among physiotherapists and physiotherapy students were done on the data analysis of questionnaires. The questionnaire was developed by the researcher for South African physiotherapy students taking into consideration the students' curriculum, hours spent clinically; theory; as well as literature. See Appendix 1 for the questionnaire.

2.12.2 Multi-Stage Fitness Test

Secondly, the fitness of all the students was measured using the multi-stage fitness test. A disadvantage to the test is that environmental conditions can affect the results, as the test is often conducted outdoors. The scoring can also be subjective and levels of motivation can influence the score attained (Tomkinson et al, 2003). This fitness test is usually used for sports teams, school groups and active individuals. Large groups can participate at the same time with minimal costs and in a limited area (Léger and Lambert, 1982). It was therefore decided that the test would be applicable to this study. See Appendix 2 for the recording sheet.

2.12.3 Physical Assessment

2.12.3.1 Body mass index

It is also important to remember that although the body mass index (BMI) is fairly accurate, there are still variations on the basis of gender, race and age. By way of example, women tend to have more body fat than men, but may have the same BMI, and athletes may have a high BMI due to muscle mass rather than body fat. In Table 2.2 the standard BMI ranges are given for adults.

Table 2.2: The Standard Body Mass Index Ranges for Adults (Mei et al, 2002)

BMI weight	Status
Underweight	Below 18.5
Normal	18.5-24.9
Overweight	25.0-29.9
Obese	30.0+

2.12.3.2 Neurodynamic test

The passive straight leg raise (PSLR) test is a neurodynamic test used to determine neural mobility. The test, as described by Butler (2000, 1991), is one of the most reliable and important tests used by physiotherapists as part of their neural objective assessments. Neural mobility was also tested with the PSLR test by Fanucchi et al (2009) in a study done on the prevalence of LBP in 12-13 year old children.

If the posterior thigh symptoms are increased or decreased with ankle dorsiflexion or eversion (sensitising test) this would be a positive test suggesting there is a neurodynamic component and decreased neural mobility (Fanucchi et al, 2009). The test is also positive if there is a difference between the left and right range of hip flexion limited by pain (Butler, 2000).

2.12.3.3 **Posterior-anterior central and unilateral vertebral pressure**

Passive accessory intervertebral movements (PAIVM's) of L4 and L5 as described by Petty (2006) and Maitland et al (2001) were done centrally and unilaterally on the abovementioned levels. The L4/5 and L5/S1 intervertebral discs are frequently a source of symptoms. More movement occurs in this lumbar area and the muscles TrA and LM protect and stabilise these levels (Maitland et al, 2001).

2.12.3.4 **Lumbar multifidus recruitment assessment**

The LM originates from the dorsal surface of the sacrum, the sacrotuberous ligament, the aponeurosis of the erector spinae (ES), the posterior superior iliac spine and the posterior sacroiliac ligaments (Sahrman, 2002). By contracting eccentrically, the LM controls flexion and shearing of vertebrae anteriorly when doing forward bending. The LM muscle has a longer lever and is able to produce a greater extension than the ES, because of its attachment to the spinous processes. This muscle also assists in the stability of the spine by way of the compression force that the LM exerts on the vertebrae (Sahrmann, 2002).

The LM muscle should be able to be recruited in different positions and with any load. When prone, the muscle has minimal afferent feedback and this is the most used position to test LM recruitment (Kiesel et al, 2007). It is unloaded and no weight-bearing facilitation is present. With minimal feedback and facilitation, the prone position could be a motor control challenge. If the activation of the LM in prone can be achieved, it will be easy to recruit the muscle in any other position. Thus, for students, the upright postures (sitting, standing and treating patients) are the positions where it is easiest to facilitate, and teach the correct activation of LM.

2.12.3.5 **Transversus abdominis recruitment assessment**

Transversus abdominis (TrA) activates prior to movement of the trunk or the rest of the body. Its function is to increase the stability of the spine and produce the stiffness required to protect the spine in anticipation of load. In LBP subjects, the anticipatory activation of TrA is delayed and thus the motor control (functional contraction) of TrA is affected. (Teyhen et al, 2008). For this study the focus will be on LM and TrA as these two muscles are of extreme importance in stabilising the lumbar vertebrae during the transfer of energy from the upper body to the lower extremities (Vleeming et al, 1997).

2.12.3.6 **Ultrasound imaging of segmental lumbar multifidus**

Ultrasound imaging (USI) has been used since the 1950's for medical purposes. Recently, more interest has developed for USI and rehabilitation among clinical physiotherapists. Hides et al (2001, 1996, 1994) used USI in studies detecting the atrophy of LM, on the

level of symptoms and on the side of acute LBP. They also noted that the muscles did not recover spontaneously when the pain subsided and that specific training is needed to decrease the risk of recurrences of LBP.
Many studies have been done on LM, on healthy and injured patients who suffer from spinal pain (Hides et al, 2008a, 1996, 1994; Sitilertpisan et al, 2012). Static and dynamic imaging can be used to measure the paraspinal muscles. Quantitative measurements of LM have been used to determine the level of contraction (change in thickness of the muscle), the change in size over time compared to surrounding tissue, and in rehabilitation as a biofeedback tool for the patient and therapist (Stokes et al, 2007).

According to the anatomy, the LM lies most medially of all the paraspinal muscles. Its size increases caudally, (consisting of five layers) and looks like a large multifascicular muscle (Macintosh et al, 1986). A transverse or parasagittal image can be used with the USI to see the LM's morphometry. In the transverse section, the cross-sectional area (CSA) can be measured, whereas in a parasagittal (longitudinal) image, muscle fascicles can be easily identified as connective tissue. They are easier to interpret with USI for muscle thickness (Kiesel et al, 2007b) and with biofeedback when the muscle changes during contraction (Hides et al, 1994; Van et al, 2006). In a study done by Hides et al (2008b) on cricketers with and without LBP before attending a cricket training camp, the mean and standard deviation (SD) of the CSA of L4 and L5 were as follows:

Table 2.3: The Pretraining Cross-Sectional Area of the Lumbar Multifidus (mean ± SD) at L4 and L5 for Cricketers with and without Low Back Pain (Hides et al, 2008b)

	Cricketers with no-LBP		**Cricketers with LBP**	
Level	Large side	Small side	Large side	Small side
L4 (cm^2)	6.53 ± 2.15	6.45 ± 2.21	7.06 ± 2.65	6.93 ± 2.73
L5 (cm^2)	8.04 ± 1.70	7.98 ± 1.79	7.43 ± 2.09	6.81 ± 2.20

Key: cm^2=square centimetre, CSA=cross-sectional area, L4=4th lumbar vertebrae, L5=5th lumbar vertebrae, LBP=low back pain, SD=standard deviation.

The difference between the large and small sides (including SD measurements) in LM CSA, seen in cricketers with LBP, is larger than that seen in cricketers with no-LBP (Hides et al, 2008b). In contrast, in elite weightlifters with no LBP, the resting CSA of LM suggested symmetry between sides. Larger LM were noted at the L4 level (females: 7.09 ± 0.38; males: 8.75 ± 0.37cm^2) than the measurements reported by Stokes et al (2007), and no difference was noted in the CSA of LM between subjects with unilateral or bilateral LBP (Sitilertpisan et al, 2012).

2.12.3.7 **Ultrasound imaging of transversus abdominis**

Transversus abdominis (TrA) should contract prior to all other muscles and remain tonically contracted throughout a task. Delayed timing and absent activity has been reported in individuals with LBP (Whittaker, 2007). With load or limb movement, contraction of OI and TrA should be observed. There will be an increase in depth, decrease in length and lateral corseting of both muscles. The contractions need to be present for the full loading task until the limb is lowered. Absence of contraction, delayed timing and excessive response followed by inability to fully relax after the task, are abnormal reactions (Whitaker, 2007). If the subject can isolate and contract TrA, the subject will be asked to repeat the contraction while breathing normally. If the subject fails to contract the TrA in isolation, an abnormal response will be noted. Both sides of the abdomen need to be evaluated to note asymmetry (Kiesel et al, 2007b).

When performing USI, the left side of the rib area is exposed inferior to the rib cage and superior to the iliac crest. The muscles of the lateral abdominal wall are the OI and OE (both generally thicker than TrA, with OI being thicker than OE) (Whittaker, 2007) with inspiration and expiration the muscle thickness changes. For the resting measurement of the abdominal wall, the measurement is taken at the end of expiration. Gel is placed on the area (mid-axillary line inferior to the ribs) and the indicator on the probe is positioned to the left side when the image is examined.

During an ideal response of an isolated TrA contraction, there is a slow and controlled increase in depth, and decrease in length of the TrA, with minimal change of the OI. The TrA forms a corset laterally on the image as its slides under OI horizontally, increasing the tension in the anterior TrA fascia. An abnormal response would be the inability to contract the TrA in isolation from the other abdominal wall muscles, showing that it is either absent, or there is insufficient recruitment of the TrA. The response is often asymmetrical; therefore both sides need to be examined. If there is an increase in OE this is incorrect, due to the angle of penetration. In this case, the ultrasound probe will need to be repositioned. In chapter 3 the methodology of the study will be discussed.

CHAPTER 3

3. METHODOLOGY

3.1 INTRODUCTION

In this chapter the research design, instruments, the procedure and statistical analysis of the study will be discussed. Discussed are the most suitable measuring instruments, and the reason why they are used. The validity and reliability of all the measuring instruments were assessed according to literature.

3.2 STUDY DESIGN

All undergraduate physiotherapy students enrolled for 2010 at the University of the Witwatersrand, were asked to participate in a cross-sectional study. No intervention was done. The results of this study will help to establish a baseline for the existing LBP prevalence situation in physiotherapy students at one tertiary institution in South Africa and possibly provide evidence for an intervention to mitigate the risks of LBP in the student body.

3.2.1 Study Population

The sample consisted of all the physiotherapy students enrolled for 2010 across all years of study at the University of the Witwatersrand.

3.2.2 Sample Selection and Size

To determine the effect size for prevalence in physiotherapy students, the LBP prevalence found in published studies was used to calculate an average prevalence (Falavigna et al, 2011; Steyl et al, 2010; Karachi et al, 2007; Glover et al, 2005; Nyland and Grimmer, 2003). The resultant 45.2% average was used to establish a significant difference of at least 38% (83% from the pilot study results obtained and shown in Table 4.1, minus 45% average calculated based on literature found). For the prevalence of LBP in our sample, compared to the population, we calculated a minimum sample size of 74 at a power of 90% and $p<0.05$ using STATA 10 software. The sample used in our study targeted all 208 physiotherapy students registered from first to fourth year in 2010 in order to ensure that a threshold of 74 would be achieved.

Table 3.1: Sample of the Available Subjects for 2010

Year of Study	1	2	3	4	Total
Potential subjects	73	47	42	43	205

3.2.3 **Inclusion Criteria**

The subjects consisted of all physiotherapy students for the year 2010.

Definition of a case: The case definition was developed based on LBP experience by Nyland and Grimmer (2003). The case was defined as an “ache, pain or discomfort in the lower back that lasted for more than 24 hours when present”. The definition needed to be broad enough to capture LBP prevalences, identifying LBP as a problem and not just stiffness in the lower back area. Subjects that were excluded from the study are discussed in 3.2.4.

3.2.4 **Exclusion Criteria**

With regards to the first part of the study, and upon completion of the questionnaire, exclusion criteria were listed for the objective measurements.

- Scoliosis, or any structural asymmetry.
- If the subject found it difficult to stand without support.
- Any operations undertaken in the past six months that included skeletal, muscular or ligamentous elements.
- Any operation involving the back.
- If the subjects were using supports or braces for their back, legs or neck.
- If the subjects suffered from any diseases (cancer, TB, lung diseases or AIDS) at the time of testing.
- If female, whether they were pregnant.
- With regards to the ultrasonic imaging, lower limb deep tendon reflex loss or gross myotomal strength loss, fractures, infection, tumour or recent ingestion of a contrast medium (which is a contra-indication to USI). (Kiesel et al, 2007a).

3.3 **STUDY INSTRUMENTS USED**

Previous studies done on physiotherapy students and LBP used questionnaires to collect data. For this study the data-collection process consisted of three phases: a questionnaire, a fitness test and physical assessment. This was done to determine the prevalence of LBP, if factors could be associated with LBP and to test for reliability and validity. In Table 3.2 the study objectives, instruments used and procedures done are discussed.

Table 3.2: Study Objectives, Instruments and Procedures Used

Study Objective	Study Instrument	Variables Tested	Tool/Procedures
Objective 1: To assess LBP (recent and remote) for physiotherapy students across the four years of study. **Objective 2:** To compare a range of factors in students with and without LBP	Questionnaire Fitness assessment	Demographic information, clinical information, presence or absence of LBP, LBP history, activity level, educational exposure and occupational exposure Fitness level between LBP and no-LBP subjects	Administer Questionnaire to all students, Appendix 1 Multi-stage fitness test, after questionnaire completion, Appendix 2
Objective 3: To identify neuromuscular associations with LBP by:	Questionnaire	Potential risk factors	Statistical analysis
a. Establishing neural mobility	PSLR test	Neural mobility between LBP and no-LBP subjects	Neurodynamic PSLR test in supine, Appendix 3
b. Establishing level of pain objectively	Central and unilateral PA's on L4 and L5	Presence or absence of pain	Researcher assesses pain with central and unilateral PA's in prone, Appendix 4
c. Determining the level of lumbar multifidus muscle recruitment	LM recruitment test at L4	Recruitment of LM on left and right side of LBP and no-LBP subjects	Subject tested in prone by researcher, Appendix 5
d. Determining the level of voluntary low threshold recruitment of transversus abdominus	TrA recruitment test	Recruitment of TrA of LBP and no-LBP subjects	Subject tested in lying by researcher, see Appendix 6
e. Assessing the cross-sectional area of lumbar multifidus on the left and right side	CSA of LM at L4 with USI	The percent thickness change of LM measured with LBP and no-LBP subjects	Subject tested in prone by DP-2200 Digital ultrasonic imaging system, Appendix 7
f. Determining the level of an isolated transversus abdominis contraction	Measurement of TrA with USI	The percent thickness change of TrA between rest and ADIM with LBP and no-LBP subjects	Subject in supine by DP-2200 Digital ultrasonic imaging system, Appendix 8
Objective 4: To explore relationships between LBP and neuromuscular findings	Results of Objective 1, 2 and 3	Neuromuscular findings in subjects with and without LBP	Statistical analysis

Key: ADIM = abdominal drawing–in manoeuvre, CSA = cross-sectional area, L4 = 4th lumbar vertebrae, L5 = 5th lumbar vertebrae, LBP = low back pain, LM = lumbar multifidus, PSLR = passive straight leg raise test, PA = posterior-anterior mobilisation, TrA = transversus abdominis, USI = ultrasound imaging.

3.3.1 Questionnaire

The questionnaire was developed from the literature (Pereira, 2009; Karachi et al, 2007; Steyl, 2007; Fyfe, 2006; Glover et al, 2005; Jordaan, 2005; West and Gardner, 2001; Cromie et al, 2000; Holder et al, 1999; Bork et al, 1996). Validity refers to the accuracy and trustworthiness of instruments and data ensuring that research to follow using that particular tool is accurate (Pereira, 2009; Bernard, 2000).

Validity of Questionnaire: A panel of experts or focus group was asked to discuss the questionnaire, focussing on conciseness and appropriate content with regard to the subject area. The focus group should consist of between seven to ten participants with common characteristics (Greenbaum, 2000). In this study the panel or focus group consisted of nine participants; five orthopaedic manual therapy (OMT) physiotherapists, a lecturer and researcher at the University of the Witwatersrand, two physiotherapy lecturers at a postgraduate level and one sports physiotherapist. A pilot study followed with 45 students of the 2009 fourth year physiotherapy group. They were asked to comment on the questionnaire. Small changes were made, but overall the content was satisfactory and acceptable. A separate set of experts (consisting of various graduated and qualified OMT physiotherapists), was also asked to complete the questionnaire.

Reliability of the Questionnaire: The reliability was conducted on the variables of the questionnaire to determine test-retest reliability. Twelve third year occupational therapy students volunteered to complete the questionnaire on two separate occasions, one week apart. Each outcome variable was scored and compared with the first questionnaire completed for each student (Wojtys et al, 2000). Test-retest reliability ranged from 75% to 91.7% for the LBP prevalences with Kappa-statistics. For activity level the agreement was 100% determined with Kappa-statistics and p-values for McNemar’s test, where a score of 1.000 indicates symmetry. These results indicate excellent agreement and high repeatability or consistency. Repeatability and agreement are used in the context of reliability (Weir, 2005). These terms describe the same concept, however in practice agreement and reliability are not synonymous (Weir, 2005). When the correlation coefficient is higher than 0.8 (80%) the effect of measurement error and correlation attenuation is minimal (Weir, 2005). On educational and occupational questions, the respondents had the same answers to all the questions as they were all in their theory block, and not doing any transfers or lifts of patients.

3.3.2 **Pilot Study**

The purpose of the pilot study was to familiarise the researcher with the equipment, to estimate the time needed to complete the tests and to identify unanticipated problems and bias. The time taken to assess individuals was determined in order to make a schedule for each year group's assessments. The characteristics of the pilot study are shown in the results section (chapter 4; Table 4.).

3.3.3 **Multi-Stage Fitness Test**

The second data-collection phase was the multi-stage fitness test. This test is also known as the 20 meter shuttle run test or the beep or bleep test and was used to determine aerobic fitness. The researcher and assistants were blinded to the LBP status of the subjects. The description of the test is in Appendix 2.

3.3.4 **Physical Assessment**

The physical assessment consisted of the following variables tested: passive straight leg raise test, posterior-anterior central and unilateral vertebral pressure on L4 and L5, recruitment of LM and TrA and ultrasound measures of LM during rest and TrA during rest and contraction. The physical assessment was done on a separate occasion to the fitness test and the completion of the questionnaire. The assessment was done by the researcher and an assistant wrote up all results to speed up the process of data collection. The researcher and the assistant were blinded to LBP status of the subjects. Intra-rater reliability was determined for the measurement of muscle recruitment, mobility of neural structures, vertebral pressure and USI. The researcher did all the tests and therefore it was necessary to determine intra-rater reliability. This term refers to the same results obtained when the instrument is administered to the same sample twice by the same rater (Leedy, 1997). The reliability assessments were done on two consecutive days prior to the start of the study just after the pilot study was done on the questionnaires. All the listed physical tests are dependent on the expertise of the assessor. In order to determine intra-rater reliability the assessor used 13 experts in orthopaedic-manual therapy and neuromuscular system fields as subjects. They were tested and retested two days later (Jordaan, 2005). Assessments were done at the same time of day to eliminate biological bias. The rater was blinded during the second assessment to any findings of the first assessment. In Table 3.3 the intra-class coefficient (ICC) and the 95% confidence interval (95% CI) of the differences for the physical assessments are given. Intra-class correlation was determined using R Software (R: a language and environment for statistical computing, 2011).

Table 3.3: Repeatability of the Physical Tests (n=13)

Physical tests	ICC	95% CI
Passive straight leg raise test:		
Left	0.94	0.80-0.98
Right	0.88	0.66-0.96
Recruitment of lumbar multifidus:	-0.01	-0.52-0.52
Recruitment of transversus abdominis:	0.65	0.20-0.88
Lumbar multifidus cross-sectional area by USI:		
Left	0.75	0.38-0.92
Right	0.72	0.32-0.90
TrA, OI and TrA slide by USI:		
Right OI at rest	0.99	0.99-1.0
Right OI contracted	0.99	0.98-1.0
Right TrA at rest	0.99	0.99-1.0
Right TrA contracted	0.99	0.98-1.0
Right TrA slide	0.95	0.85-0.99

Key: CI = 95% confidence interval, ICC = intra-class coefficient, OI = obliquus internus abdominis, TrA = transversus abdominis, USI = ultrasound imaging.

The results of the measurement method comparison indicate an acceptable repeatability of all the measures (Weir, 2005) except recruitment of lumbar multifidus which showed low repeatability. The implication for recruitment of LM in prone (as explained in Appendix 5), shows a motor control challenge for the subject and assessment difficulty which might be easier in upright postures. The same results were obtained for central and unilateral PA's on L4 and L5 indicating good reliability.

3.3.4.1 Height

A stadiometer in meters was used to measure standing height. The height was recorded to the nearest 0.5cm.

3.3.4.2 Weight

Weight was measured with a calibrated digital electronic scale in kilograms and to the nearest 0.5kg.

3.3.4.3 Body mass index

Body mass index (BMI) was calculated by: body weight in kilogram divided by height in meters squared.

3.3.4.4 **Neurodynamic test - Passive straight leg raise test**

Subject Position and Test: The subject lay supine. The researcher passively adducted and medially rotated the leg with knee extended, flexing the hip until the subject felt an onset of thigh symptoms. During the PSLR test, the nervous system was under tension. The normal response was a strong stretching feeling or tingling in the posterior thigh, behind the knee, calf and foot (Petty, 2006). The range of hip flexion was measured by the researcher or research assistant with a measuring tape, from the heel of the foot to the end of the plinth. Two measurements for left and right were done and the average calculated.

Table 3.4: Presentation of Straight Leg Raise Measurements

PSLR (cm from heel to plinth)	**Left leg 1**	**Right leg 1**	**Left leg 2**	**Right leg 2**

Key: cm = centimetre, PSLR = passive straight leg raise

3.3.4.5 **Passive accessory intervertebral movements**

Posterior-anterior central vertebral pressure

Central pressure was put on L4 and L5. Pain was assessed using the four grades of movement. If pain was experienced on mobilisation it was recorded as 'yes', if no pain was experienced on mobilisation, it was recorded as 'no'. The grade of mobilisation was recorded when pain occurred. A description of the technique is given in Appendix 4.

Posterior-anterior unilateral vertebral pressure

The four grades of movement were also applied unilaterally to each side on L4 and L5. The same method was applied as with the central PA mobilisation.

3.3.4.6 **Lumbar multifidus recruitment assessment**

Subject Position and Test: The subject lay prone with the spine in neutral (pillows under stomach if needed) so that the muscles of the lower back were relaxed. The researcher placed fingers/thumbs next to the spinous processes (between the erector spinae muscle and spine) on the deeper muscles and pressed the fingers/thumbs firmly into the muscles. With the muscles relaxed the researcher asked the subject to locally contract (or swell) the muscles into the fingers of the researcher.

With ideal recruitment the researcher should have felt the muscles harden as tension was generated. The contraction should have been symmetrical between the left and right sides of the vertebral level that the researcher was assessing, maintained twice for 15 seconds.

The contraction should have been similar between adjacent segmental levels. For the purposes of this study, the level L4 was assessed. The TrA and obliquus should have co-activated automatically. If the muscle was not activated, or the subject was unable to segmentally recruit, it indicated a loss of control of the deep segmental fibres of lumbar multifidus (Hides et al, 1994, 1995, 1996; Hodges and Richardson, 1996).

Table 3.5: Recording Sheet of Lumbar Multifidus Recruitment

Muscle action	**Specific Activation**		**Recruitment**	
Side	Right side	Left side	Right side	Left side
L4 LM				

Key: L4 = 4th lumbar vertebrae, LM = lumbar multifidus

3.3.4.7 **Transversus abdominis recruitment assessment**

Subject Position and Test: The subject was positioned in ‘crook’ lying. The researcher palpated inferiorly and medially from the anterior superior iliac spine (ASIS) along the inguinal ligament and was feeling for a tensioning of the muscle. The lower antero-lateral abdominal wall should have led the contraction without expansion of the OI. The movement was also described as the ADIM. The patient was instructed to hollow, or draw in the lower abdominal wall without OE rib cage depression, posterior pelvic tilt or OI bulge. Normal breathing while maintaining a consistent contraction was considered normal. The contraction needed to be minimal (20-30%) and sustained for 15 seconds, repeated twice and should ‘feel easy’.

Two ratings were also given, one for specific activation of muscle, the other for the recruitment of the muscle. Ideal recruitment was to hollow or draw in the lower abdominal wall without the depression of the OE rib cage, posterior pelvic tilt or OI bulge. A normal breathing pattern while maintaining a consistent contraction was correct. The same recording for specific activation and recruitment as in LM was used. TrA needed to be 20-30% recruited, and must have felt and looked easy. A dysfunction would occur if the subject tried too hard to contract the muscle and a substitution occurred with surrounding muscles. During the dysfunction the muscle could be activated easily with load, but maximum effort was required to recruit if unloaded.

Table 3.6: Recording Sheet of Transversus Abdominis Recruitment

Muscle action	Specific Activation		Recruitment	
Side	Right side	Left side	Right side	Left side
TrA				

Key: TrA=transversus abdominis

3.3.4.8 Ultrasound imaging of segmental lumbar multifidus

For the transverse application of USI and the best image clarity of LM, a 5MHz curved array probe was used with the ultrasound machine in B mode (Stokes et al, 2005; Whittaker et al, 2007a). A digital ultrasound diagnostic imaging system, (Mindray DP-2200) was used in this study.

Subject Position and Test: The subject lay in prone, with one to two pillows under the hips, to ensure that the lumbar spine was 10˚ from horizontal as recommended by Hides et al (1995) and Kiesel et al (2007a). For standardisation the researcher had to be on the left side of the prone subject. The lumbar spinous processes were marked at L4 with a water-soluble marker (Whittaker, 2007).

The procedure involved placing the probe longitudinally (sagittal plane) to determine L5 and L4. When L4 was identified, the probe was rotated 90˚ for a transverse application. The marker on the probe had to face the left side of the subject. The probe could be moved laterally from the spinous process of the vertebrae being examined, so that the side of interest was highlighted. The angle was manipulated anterolaterally until a clear transverse view of the medial compartment of LM was seen and the lamina and spinous process were visualised (Whittaker, 2007).

The total gain (signal sensitivity of the image resulting in a clearer image (Costa et al, 2009)) of the ultrasound unit was lowered and the subject was asked to lift the ipsilateral leg to clarify the lateral border of LM from longissimus (Stokes et al, 2005). When the borders were identified, the depth control could be adjusted so that the image filled the screen. The subject needed to be fully relaxed before capturing the CSA (Whittaker, 2007). Measurements of the left and right sides were made. The average CSA for each side was taken for data analysis. The shape of LM was also recorded: symmetrical, round, oval or triangular.

Table 3.7: Recording Sheet of Cross-Sectional Area of Lumbar Multifidus

Muscle Action	**Resting CSA Measurement 1**		**Resting CSA Measurement 2**		**Average CSA**	
Side	Left side	Right side	Left side	Right side	Left side	Right side
L4 (cm^2)						

Key: cm^2 = square centimetre, CSA = cross-sectional area, L4 = 4th lumbar vertebrae

Figure 3.1 shows an example of the imaging of the CSA of LM (transverse image) of one of the subjects at level L4 during rest.

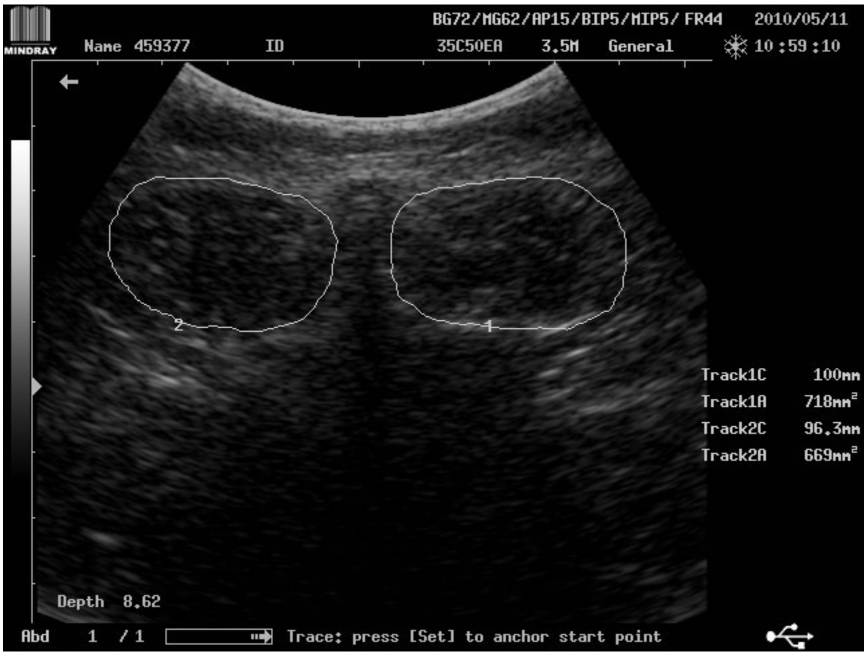

Figure 3.1: Image of Lumbar Multifidus at L4 with Ultrasound Imaging

In the above image the internal caliper of the ultrasound unit was used to trace the circumference. This was 100mm (10cm) for the right side of the LM, from which a CSA of 718mm^2 (7.18cm^2) is estimated. On the left side the circumference was 96.3mm (9.63cm) and the CSA 669mm^2 (6.69cm^2). During the recording of LM, the resting shape (oval) was also noted for qualitative analysis.

In Figure 3.2 for example the CSA of the left and right side of LM were different. The left side was smaller, possibly indicating atrophy and pathology on the specific level.

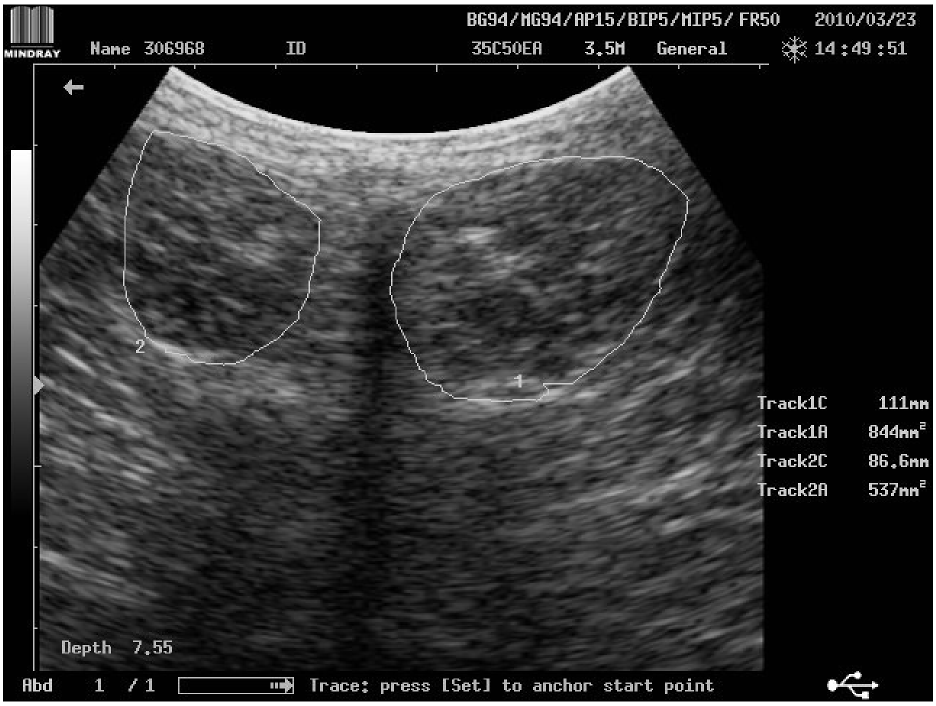

Figure 3.2: Left and Right Side of Lumbar Multifidus Asymmetrical with Ultrasound Imaging

A CSA of 537mm² (5.37cm²) on the left side and 844mm² (8.44cm²) on the right side were noted. The asymmetry might indicate atrophy or pathology in the LM muscle.

3.3.4.9 **Ultrasound imaging of transversus abdominis**

A 2-5 MHz curvilinear transducer set at 5MHz was the best instrumentation to use. The same machine was used as for LM.

Subject Position and Test: For this study the subject was positioned in supine with the transducer placed along the lateral abdominal wall, superior to the iliac crest, along the midaxillary line (Kiesel et al, 2007a). Prior to the test the subject was instructed on breath holding, external oblique activity and posterior pelvic tilt.

The first measurement was taken at the end of respiration, as done by Kiesel et al (2007a). The next TrA activation was taken while the subject performed the ADIM. The subject was instructed by the researcher to “exhale and gently draw his or her lower stomach in towards his/her spine”. With the activation of the TrA, the pull on the fascia should show a bend on the opposite side. The TrA should pull the anterior fascia 1-1.5cm without any substitution by the OI muscles. Less than a 1cm pull on the fascia was considered inefficient recruitment (Whittaker et al, 2007a).

Table 3.8: Abdominal Wall Measurements with Ultrasound Imaging

Muscle action	RESTING		CONTRACTED		% CHANGE	
Side	Right side	Left side	Right side	Left side	Right side	Left side
TrA depth						
IO depth						
TrA pull/length						

Key: OI=oblique internal, %=percentage, TrA=transversus abdominis

In Figure 3.3 the resting image of the left abdominal wall is shown. For preferential activation of the TrA, an isolated contraction of the TrA was expected.

Figure 3.3: Resting Image of the Left Lateral Abdominal Wall

In Figure 3.3 the measurement at rest of OI was 7.6mm and for TrA was 4.11mm. In Figure 3.4 the increase in depth and lateral corseting were noted as the TrA slides under the OI and increases tension in the anterior TrA fascia.

Figure 3.4: Contraction of the Abdominal Wall

In Figure 3.4 an increase was noted during contraction. The measurement of OI was 8.21mm, for TrA was 5.75mm and the TrA pull 1.67cm. Similar images were obtained from the abdominal draw in manoeuvre.

3.4 PROCEDURE

The procedure of how the data were collected, recorded and analysed will be discussed in the following section.

3.4.1 Data Collection and Recording

Data collection took place firstly by completing the questionnaire. Then the multi-stage fitness test was done. The fitness test was followed by an evaluation, done by the researcher, on a separate day. All the information was documented and subjected to analysis. The following was done before the data collection started:

Suitable times were arranged with the class representatives and co-ordinators of each year group to explain the study to the students and to distribute the information sheet, assent, informed consent forms and questionnaires. A contact number and email address of the researcher was given if there were any questions. The signed assent and informed consent forms as well as questionnaires were collected.

3.4.2 Ethical Considerations

The ethical considerations of confidentiality and anonymity were maintained throughout the data collection and analysis of the questionnaire, fitness test and physical assessment tests.

3.4.2.1 Questionnaire

Questionnaires were completed after the subjects had signed the informed consent form. The subject's student number was used in all data analysis so that results could be given back to the appropriate student. Only student numbers were used so that the results of the questionnaire, fitness test and assessment would remain anonymous. The questionnaires were explained by the researcher and completed in the presence of the researcher, should any of the students have had any questions. The completed questionnaires were collected at the end of the session. Extra questionnaires were available at the physical assessment if the students still needed to complete one or if they were absent on the day that the questionnaires were completed.

3.4.2.2 Fitness

Four separate days were allocated for each year group for the multi-stage fitness test. A 20 metre long area on an even surface was allocated for the fitness test. The area was measured with a measuring tape and marked with cones. All available students were tested. Confidentiality was ensured by using a research assistant and the use of student numbers as opposed to names.

3.4.2.3 Physical assessment

The evaluation was done in a separate room, set up with all the equipment to ensure the privacy of the subjects. The research assistant noted all the measurements and assisted with height and weight measurements. The evaluation included the measurement of height, weight, PSLR, PA's on L4 and L5, LM and TrA recruitment, and USI of LM and the abdominal wall muscles. All information was coded for data analysis, ensuring confidentiality of participants.

3.4.3 Data Analysis

Objective 1 and 2:

Descriptive statistics included frequency tabulations, charts for categorical variables and summary statistics (mean, standard deviation and range) for quantitative variables. The prevalence of LBP between the different year groups was compared using Pearson's chi square test.

Objective 3:

Neuromuscular associations with LBP were identified using Pearson's chi square tests or Fisher's exact tests for categorical data and Student's t-test for continuous data where appropriate. Testing was done at the 0.05 level of significance.

Objective 4:

Further analysis was done to explore relationships between LBP and neuromuscular findings. Univariate and multivariate analysis employed logistic regression, and adjustments were made to determine the relationship between the factors associated with LBP.

3.5 CONCLUSION

In this chapter the study design, sample selection criteria and instruments used were described. Thereafter the procedure of the study was described in detail, including the data collection, data recording and statistical analysis. The ethical considerations were also discussed. The results of the statistical analysis of this study will be discussed in chapter 4.

CHAPTER 4

4. RESULTS

4.1 INTRODUCTION

The aim of this study was to assess the effect of the cumulative exposure to physical and educational demands of the physiotherapy course among physiotherapy students at the University of the Witwatersrand. The exposure and factors associated with low back pain are discussed. As described in chapter 3, data were collected by means of a questionnaire, fitness test and physical assessment. In chapter 4, the results are discussed in an introduction and three separate parts according to the objectives of the study. The introduction contains results regarding reliability, the pilot study, and the study sample and how the subjects responded. In Section 4.2 the prevalence of LBP and effects of the cumulative exposure to physical and educational demands of the physiotherapy course are given (objective one). Section 4.3 contains a description of the characteristics of the study sample. The description includes demographic and anthropometric factors, pain behaviour and physical measurements, comparing students with LBP and no-LBP (objective two). In Section 4.4, the neuromuscular associations with LBP are explored (objective three) and in Section 4.5 the relationships between LBP and neuromuscular findings (objective four) are presented. Data analysis was performed using Stata Statistical Software, release 10, Stata Press, Stata Corporation, 2007, College Station, Texas. Figure 4.1 outlines the presentation of the results of this study according to the objectives.

4.1.1 Results on Reliability

The reliability was discussed in chapter 3 in methodology. Repeatability results of the physical assessments are explained in chapter 3 and shown in Table 3.3.

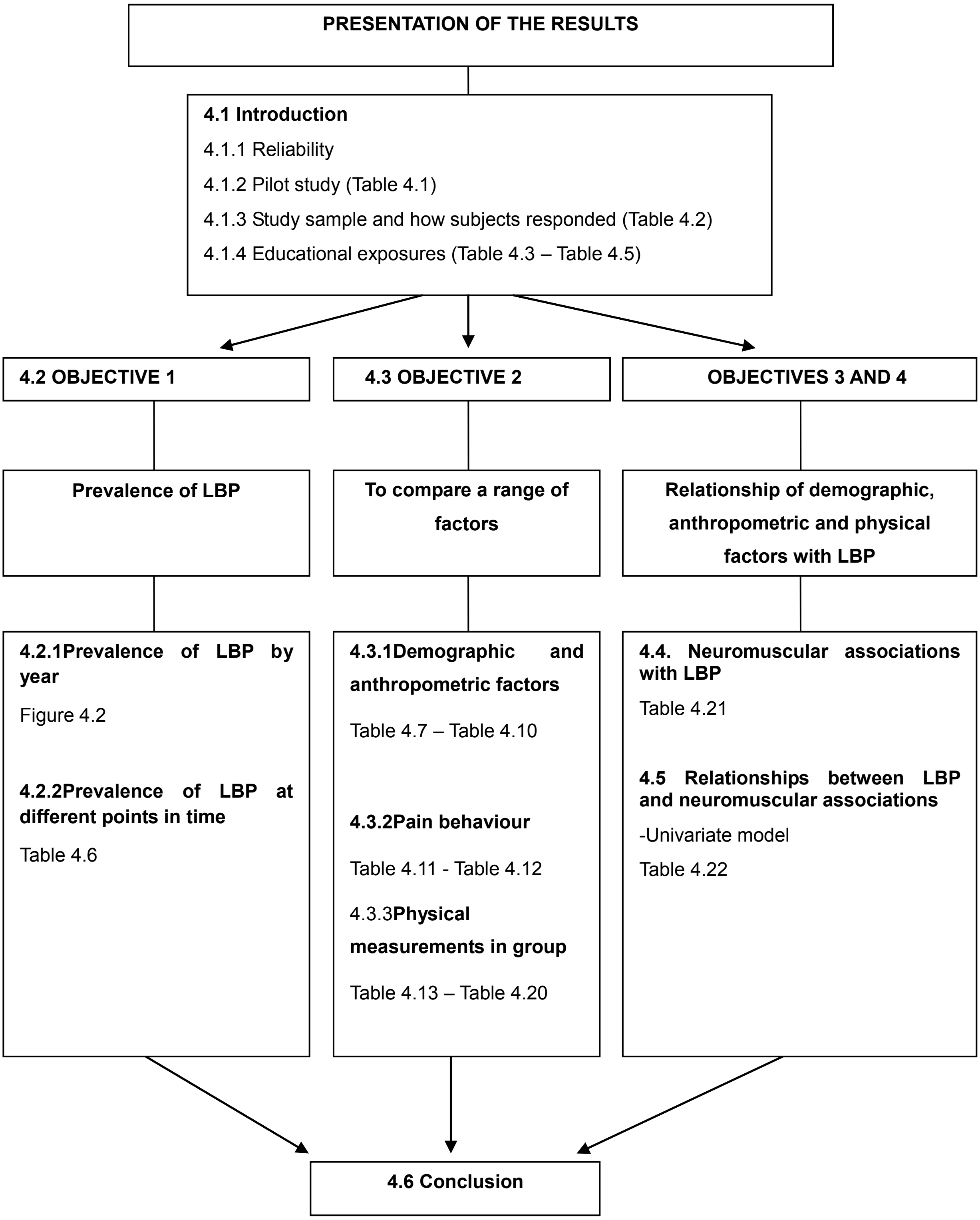

Figure 4.1: Outline of the Results of the Study

Key: BMI = body mass index, CSA = cross-sectional area, PA = posterior-anterior mobilisation, PT = physiotherapy, LM = lumbar multifidus, LBP = low back pain, TrA = transversus abdominis, USI = ultrasound imaging.

4.1.2 Results of the Pilot Study

Pilot study results are shown in Table 4. and were obtained from the 48 2009 fourth year physiotherapy students in preparation of the data collection in 2010.

Table 4.1: Characteristics of Pilot Study Sample (n=48)

	Female	**Male**	**Total**
Available Students	40	8	48
Response rate (%)	90	87.5	89.6
Rejected questionnaires*	4	1	5
Mean age in years (SD)	23.03 (±2.73)	22.25 (±0.09)	22.89 (±2.51)
Prevalence of LBP% (95%CI)	88 (77-98)	63 (29-96)	83 (73-94)

*Rejected due to incomplete questionnaires.

Key: CI = 95% confidence interval, LBP = low back pain, % = percentage, SD = standard deviation.

A high response rate of 89.6% was noted with an overall LBP prevalence of 83%. The high prevalence of LBP was possibly because the students were tested at the end of the year. Only five questionnaires were rejected due to incomplete information regarding LBP.

4.1.3 Study Sample and how the Subjects Responded

In Table 4.2 the study sample and how participants responded are displayed.

Table 4.2: Main Study Sample and Response Rate (n=208)

	Year Level				**Overall**
	1 n=73	**2** n=47	**3** n=45	**4** n=43	n=208
Response Rate (total sample)					
Completed questionnaires n(%)	65 (89.0)	46 (97.9)	45 (100)	38 (88.4)	194 (93.3)
Fitness test n(%)	20 (27.4)	40 (85.1)	14 (33.1)	25 (58.1)	99 (47.6)
Physical examination n(%)	57 (87.6)	45 (95.7)	41 (91.1)	36 (83.7)	179 (86.1)
Gender (for students who completed questionnaires)					
Male n(%)	9 (13.9)	8 (17.4)	7 (15.6)	13 (34.2)	37 (19.1)
Female n(%)	56 (86.2)	38 (82.6)	38 (84.4)	25 (65.8)	157 (80.9)
Mean age in Years (SD)	19.2(±2.5)	19.7(±1.5)	20.9(±1.3)	21.9(±1.5)	20.2 (±2.1)

Key: % = percentage, SD = standard deviation

From the total group of 208 physiotherapy students, eight subjects did not consent to participate in the study, 200 questionnaires were completed, of which six were incomplete, hence 194 questionnaires were included in the analysis. The overall response for the four years was 93.3%. Of all the students included, 47.6% (n=99) completed the multistage-fitness test and 86.1% (n=179) the physical assessment. Effort was made to encourage students to fully complete the questionnaires and not leave blank spaces in the instructions. Several repeat appointments were set over a period of six months to give each student the opportunity to be assessed physically to. Reminders were also sent by email and by asking class lecturers to inform students of appointments. Therefore, the sample may be lower than n=194 for the demographic and anthropometric data analysis and lower than n=179 for the physical measurements because of missing data.

The ages ranged from 17 to 34 years for the four groups, with a mean age of 20.2. Race was excluded because of the small number of non-Caucasian students. In terms of gender, 19.1% of respondents were male (n=37) and 80.9% (n=157) female.

4.1.4 Curriculum and Educational Exposures

The scheduled curriculum and educational 'exposures' of the first to fourth year physiotherapy students during 2010 are shown in Table 4.3: The physiotherapy curriculum exposes students to theory and practical hours.

Table 4.3: Educational Exposure of First to Fourth Year Students

Year of study	Practical/Theory
First year	Mainly theory
Second year	Mainly theory with some hospital visits and practicals
Third year	4 weeks theory; 6 blocks of 20hrs per week practical
Fourth year	6 weeks of theory; 6 blocks of 40hrs per week practical

In second year the students have mainly theory, with eight to eleven hours of hospital visits and practicals per week. From third year the amount of practical hours and clinical work increases substantially from six blocks of 20 hours per week to six blocks of 40 hours per week in fourth year. The third years have four weeks of theory compared to the six weeks of theory in fourth year, both at the beginning of the year. The scheduled versus actual exposure for each year group will be discussed in Table 4.4 and Table 4.5.

Table 4.4: Scheduled Hours from First to Fourth Year as per Curriculum

	Hours Exposure		
	Theory	**Practical***	**Total**
First year	581	0	581
Second year	851	152	1003
Third year	408	750	1158
Fourth year	150	764	914
Total hours over years 1 - 4	1990	1666	3656

*Practical hours include clinical experience and practicals in class.

The group in the pilot study (fourth years in 2009) were exposed to 1990 hours of theory and 1666 hours of practical at the time of completing the questionnaire. The students' actual exposure in cumulative hours at the time of testing per year are shown in Table 4.5.

Table 4.5: Cumulative Hours Exposure at Time of Testing

Students	**Actual hours exposure at time of testing in 2010**			**Cumulative exposure at time of test (actual in 2010 plus total from prior years)**		
	Theory	**Practical**	**Total**	**Theory**	**Practical**	**Total**
First year (n=57)	436	0	436	436	0	436
Second year (n=45)	426	76	502	1007	76	1083
Third year (n=41)	306	563	869	1738	715	2453
Fourth year (n=36)	150	57	207	1990	959	2949

To explain the above calculations, for example at the time of testing in 2010, the third years had 563 hours of practical exposure for the year. This was then added to the scheduled exposure/s in prior years, giving a cumulative exposure of 2453 hours. Although the fourth year students had the most hours exposure cumulatively for theory and practical, they were assessed near the beginning of the year. They were therefore only exposed to 57 hours of practical and 150 hours of theory for the year, giving a cumulative figure of 2949 up to that point.

4.2 OBJECTIVE ONE: TO ASSESS LBP (RECENT AND REMOTE) FOR PHYSIOTHERAPY STUDENTS ACROSS THE FOUR YEARS OF STUDY

Operational definitions of low back pain (LBP) are clarified under definition of terms on page xiv.

4.2.1 Prevalence of Low Back Pain

The lifetime prevalence of LBP among the first to fourth year physiotherapy students was 35.6% (69/194; n=194). Figure 4.2 shows the prevalence of LBP at the time of testing of first to fourth years.

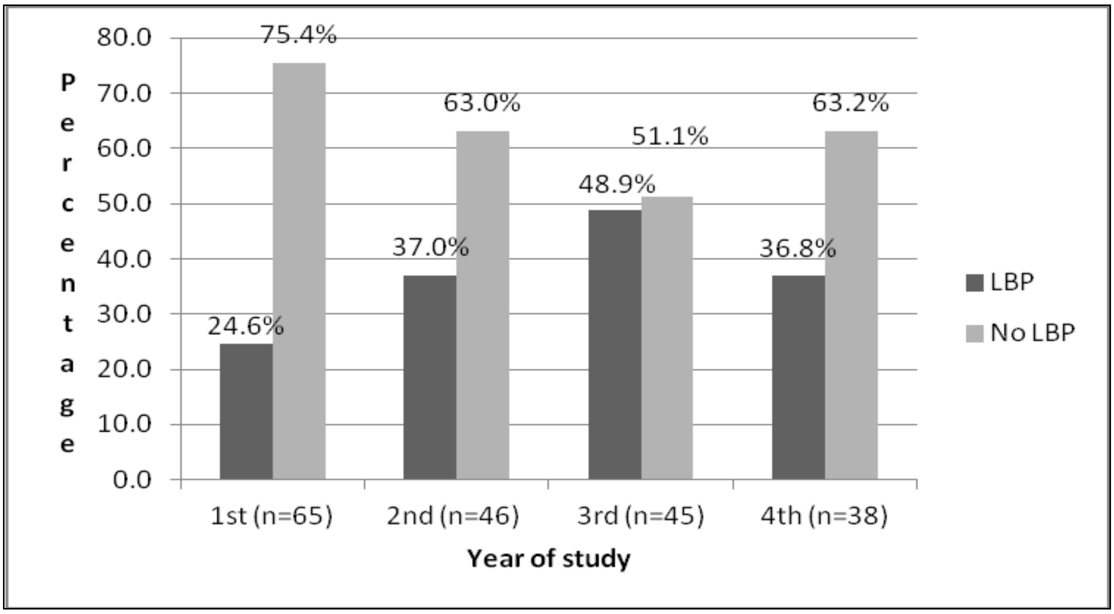

Figure 4.2: Prevalence of Low Back Pain by Year of Study (n=194)

4.2.2 Prevalence of Low Back Pain at Different Points in Time

Prevalence of LBP at different points in time was reported in the questionnaire as present LBP, LBP in the last week, last month, past 12-months or at >1year. For further analysis, the prevalences of LBP at different points in time were categorised into no-LBP, recent LBP (present, last week and last month) and “remote” LBP (months 1-12 and more than 12 months). Mazanec (2004) categorised acute LBP as pain experienced less than one month, subacute LBP for less than three months and chronic for more than three months. In this study acute LBP is displayed as recent LBP, and subacute and chronic LBP as remote LBP.

Table 4.6: Prevalence of No-LBP, Recent LBP and Remote LBP among the Physiotherapy Students

LBP categories	First year n (%)	Second year n (%)	Third year n (%)	Fourth year n (%)	Total n (%)
No-LBP	49 (39.2)	29 (23.2)	23 (18.4)	24 (19.2)	125 (100)
Recent*	7 (15.2)	11 (23.9)	18 (39.1)	10 (21.7)	46 (100)
Remote**	9 (39.1)	6 (26.1)	4 (17.4)	4 (17.4)	23 (100)

*Recent - acute LBP

**Remote – subacute and chronic LBP

Across the study years the increase in recent LBP was significant (p=0.045; Pearson chi² test). This agrees with findings from Table 4.4 and Table 4.5. Notably the relationships between LBP and the cumulative practical and practical hours were also significant (p=0.02 and p=0.04 respectively see Table 4.15. Notably there is no relationship between theory exposure alone and LBP. Total exposure at the time of testing increased by ± 150% per year up to third year, but was less for the fourth years because they were tested early in the year. The 35.6% prevalence of LBP across the years of study is significantly different from the 83% found in the pilot study (69/194 versus 40/48; p<0.0001), but is similar to the average as published in the literature.

4.3 OBJECTIVE TWO: TO COMPARE A RANGE OF FACTORS IN STUDENTS WITH AND WITHOUT LBP

As per previous studies, the demographic and anthropometric factors investigated included gender, age, BMI, activity level, smoking and fitness.

4.3.1 Demographic and Anthropometric Factors

Table 4.7: Description of Demographic Factors (Gender and Age) of Study Sample with LBP and No-LBP (n=194)

Factor	Category	Number of Respondents		p-values
		LBP n (%)	No-LBP n (%)	
Gender	Male Female	15 (21.7) 54 (78.3)	22 (17.6) 103 (82.4)	0.48
Age	n mean (SD)	69 20.0 (±1.9)	125 20.6 (±2.5)	0.14

No differences were noted in gender or age for LBP and no-LBP groups.

Table 4.8: Description of Anthropometric Factors of Study Sample (n=182 for body mass index and n=193 for activity level)

Factor	Category	Number of respondents		p-values
		LBP	No-LBP	
BMI	N Mean (SD) Under 18.5 n(%) Between 18.5-24.9 n(%) Over 25.0 n(%)	65 23.4 (±4.0) 1(1.5) 51 (78.5) 13 (20.0)	117 22.6 (±3.5) 12 (10.2) 82 (70.1) 23 (19.7)	0.22
Activity level	Active Not active	18 50	41 84	0.36

For BMI, the mean (SD) for the overall group is within the normal BMI values, being 22.9 (±3.8), and no significant relationship was found between BMI and LBP. There was also no relationship between LBP and whether students were or were not categorised as active. One student did not complete the question regarding activity in the questionnaire, hence a sample of 193 and only 182 student's length and weight were taken for calculation of BMI.

Table 4.9: A Comparison of Activity Level and Low Back Pain Prevalence for the First, Second, Third and Fourth Year Students (n=193)

Year	LBP		p-value
	No n (%)	Yes n (%)	
First			
Activity No	25 (51.0)	11 (68.8)	
Activity Yes	24 (49.0)	5 (31.2)	0.22
Second			
Activity No	21 (72.4)	12 (75.0)	
Activity Yes	8 (27.6)	4 (25.0)	0.85
Third			
Activity No	15 (65.2)	15 (68.2)	
Activity Yes	8 (34.8)	7 (31.8)	0.83
Fourth			
Activity No	23 (95.8)	12 (85.7)	
Activity Yes	1 (4.2)	2 (14.3)	0.26

An insignificant increase in the level of inactivity was noticed as the students progress. In first year only 44% of students are active compared to only 8% in fourth year. However, no relationship was noted between activity level and LBP. In Table 4.10 a summary for fitness is shown for all years.

Table 4.10: Fitness (n=99) in Physiotherapy Students with or without LBP

Factor	Category	Number of Respondents		p-value
		LBP n(%)	No-LBP n(%)	
Fitness	Average to excellent Poor	22 (64.7) 12 (35.3)	30 (46.2) 35 (53.8)	0.51

No significant effect of fitness on LBP was noted, however a relatively high percentage of students with average to excellent fitness had LBP.

For smoking, the summary of students who smoke by study year is shown in Figure 1, Appendix 14. The second years smoked more than other years (11%), however smoking had no effect on the prevalence of LBP (p=0.51; Fisher's exact test).

4.3.2 Pain Behaviour Characteristics in Physiotherapy Students Experiencing Low Back Pain

The characteristics of the LBP experienced by students are shown in Table 4.11.

Table 4.11: Pain in Participants Reporting Low Back Pain (n=69)

	Respondents N	%
Mode of onset of LBP		
▪ Spontaneously	15	21.7
▪ Motor vehicle accident	2	2.9
▪ Sports injury	23	33.3
▪ Physiotherapy, treatment of patient	13	18.8
▪ Other trauma (fall, lifting object)	6	8.7
▪ Don't know	10	14.5
▪ Other	9	13.0
Frequency of LBP episodes		
▪ Every day	6	8.7
▪ 1 to 3 times per week	17	24.6
▪ Once every 2 weeks	12	17.4
▪ Once per month	9	13.0
▪ Once every 3 to 6 months	15	21.7
▪ Less than once in 6 months	7	10.1
Duration of LBP episode		
▪ A few hours to one day	44	63.8
▪ 2 to 3 days	16	23.2
▪ 4 to 5 days	2	2.9
▪ One week	1	1.4
▪ Longer than one week	2	2.9

The mode of onset of the LBP was mostly a sports injury (n=23; 33.3%), followed by a spontaneous incident (n=15; 21.7%) and during physiotherapy treatment given to a patient (n=13; 18.8%). The frequency of one to three times per week of LBP episodes was reported by 24.6% (n=17) of participants. Pain episodes once every three to six months were reported by 21.7% (n=15) of students compared to 17.4% (n=12) who reported episodes once every two weeks. For 63.8% (n=44), the duration of the LBP episode lasted from a few hours to one day, followed by 23.2% (n=16) who experienced their symptoms for two to three days. Table 4.12 shows how students manage their LBP when symptoms are present.

Table 4.12: Management of the Low Back Pain by Respondents with Low Back Pain and the Effectiveness of the Treatment Given (n=69)

	Respondents N	%
Management of low back pain		
▪ Rest in bed	23	33.3
▪ Medical doctor	1	1.4
▪ Medication	18	26.1
▪ Physiotherapy	13	18.8
▪ Unsupervised exercises, e.g. gym	24	34.8
▪ Other	23	33.3
Effectiveness of the treatment?		
▪ Not at all	7	10.1
▪ Only for short while	6	8.7
▪ Pain relief, but still get pain regularly	19	27.5
▪ Pain relief, still get pain seldom	24	34.8
▪ Total pain relief, never had pain again	9	13.0

Most students managed the pain on their own with exercises 34.8% (n=24), followed by rest in bed (n=23; 33.3%) and other treatments (n=23; 33.3%) like heat, stretches, massage and Transact ®(anti-inflammatory) plasters. The minority seek professional help. Of those who received physiotherapy, some received more than one modality to manage their pain. Irrespective of treatment modalities received, only 9 (13%) had complete relief.

A univariate analysis was done to test for associations between demographic and anthropometric factors and the prevalence of LBP. In contrast to the literature none of the parameters assessed were associated with or appeared to be risk factors for LBP.

4.3.3 Physical Measurements in Group

The physical factors assessed were neural mobility by the PSLR test, the level of pain with PA's on L4 and L5, LM and TrA recruitment, and USI measurements of the CSA of LM and activation of TrA. The results are shown in Table 4.13 to Table 4.20. In Table 4.13 the measurements for neural mobility are shown.

Table 4.13: Neural Mobility in Physiotherapy Students with or without LBP (n=192)

Factor	Category	Number of respondents		p-value
		LBP	No-LBP	
Neural mobility Mean (SD) in cm	N L PSLR R PSLR	69 84.1 (±19.9) 84.6 (±20.0)	123 81.6 (±25.7) 81.6 (±25.6)	 0.62 0.16

Key: PSLR=passive straight leg raise

No significant differences in neural mobility were noted.

Table 4.14: Posterior-Anterior Mobilisations on L4 and L5 in Subjects with and without History of LBP (n=176)

Factor	Category	Number of Respondents		p-value
		LBP	No-LBP	
PA's on L4 (grades 1-4)	N	65	111	
	Central			
	No pain with PA	45 (69.2)	98 (88.3)	**p=0.003**
	Pain	20 (30.8)	13 (11.7)	
	Left	65	111	
	No pain with PA	38 (58.5)	83 (74.8)	p=0.07
	Pain	27 (41.5)	28 (25.2)	
	Right	65	111	
	No pain with PA	34 (52.3)	84 (75.7)	**p=0.003**
	Pain	31 (47.7)	27 (24.3)	
PA's on L5	**Central**	65	111	
	No pain with PA	37 (56.9)	95 (85.6)	**p<0.001**
	Pain	28 (43.1)	16 (14.4)	
	Left	65	111	
	No pain with PA	34 (52.3)	81 (73.0)	**p=0.02**
	Pain	31 (47.7)	30 (27.0)	
	Right	65	111	
	No pain with PA	33 (50.8)	79 (71.2)	**p=0.004**
	Pain	32 (49.2)	32 (28.8)	

Key: L4 = 4th lumbar vertebrae, L5 = 5th lumbar vertebrae, L = left, PA = posterior-anterior mobilisation.

While there was a consistent relationship between the mobilisation eliciting pain on L5, this was not quite the case with L4.However it is worth noting that the p value of 0.07 is not far of from the required 0.05.

4.3.4 Consolidation of Results from Demographic, Anthropometric and Physical Analysis

In Table 4.15 the range of factors are tested for association with LBP. Students' t-test was used for continuous variables and Pearson's chi-square test for categorical variables. Testing was done at the 0.05 level of significance.

Table 4.15: Association of Low Back Pain with Demographic, Anthropometric and Physical Factors

FACTORS	LBP	No-LBP	p-value
Year of study (n=194)	2.5 (±1.1)	2.2 (±1.2)	0.06
Practical exposure hours	209.8 (±244.9)	132.2 (±207.8)	**0.02***
Theory exposure hours	334.1 (±108.6)	354.8 (±111.1)	0.2
Total exposure hours	1748.4 (±986.6)	1439.7 (±1029.2)	**0.04***
Gender (female)	78.3% (54/69)	82.4% (103/125)	0.48
Age (years)	20.0 (±1.9)	20.6 (±2.5)	0.14
BMI	23.4 (±4.0)	22.6 (±3.5)	0.22
Active/inactive	26.5% (18/68)	32.8% (41/125)	0.36
Smoking	8.7% (6/69)	4.8% (6/125)	0.28
Fitness	64.7% (22/34)	46.2% (30/65)	0.18
PA's on L4 (n=176)	**30.8% (20/65)**	**11.7% (13/111)**	**0.003***
PA's on L4 L	**41.5% (27/65)**	**25.2% (28/111)**	**0.07**
PA's on L4 R	**47.7% (31/65)**	**24.3% (27/111)**	**0.003***
PA's on L5	**43.1% (28/65)**	**14.4% (16/111)**	**<0.001***
PA's on L5 L	**47.7% (31/65)**	**27.0% (30/111)**	**0.02***
PA's on L5 R	**49.2% (32/65)**	**28.8% (32/111)**	**0.004***

Key: (*) Factors associated with LBP, BMI = body mass index, L4 = 4th lumbar vertebrae, L5 = 5th lumbar vertebrae, LBP = low back pain, PA = posterior-anterior mobilisation, Total exposure = practical and theory combined.

Significant relationships were found between LBP and students hours of practical exposure (p=0.02) as well as to total cumulative physical exposure during the physiotherapy course (p=0.04). These (and no doubt other factors) were associated with the expression of pain on posterior-anterior mobilisation of L4 and L5.

Table 4.16: Physical Measurements for Lumbar Multifidus Activation and Recruitment for Left and Right Side in Subjects with and without LBP (n=175)

Factor	Category	Number of respondents		p-value
		LBP	No-LBP	
LM recruitment	**Left**	64	111	
	Activation and recruitment	58 (90.6)	99 (89.2)	p=0.95
	No recruitment	6 (9.4)	12 (10.8)	NS
	Right	64	111	
	Activation and recruitment	59 (92.2)	105 (94.6)	p=0.39
	No recruitment	5 (7.8)	6 (5.4)	NS

Key: L = left, LBP = low back pain, LM = lumbar multifidus, NS = not significant, R = right

No difference was observed for lumbar multifidus recruitment on the left or right side in subjects with or without LBP. Specific activation of LM requires correct activation for two to three seconds while maintaining a neutral spine without substitution or holding breath. The subject can recruit LM if a consistent activation can be maintained for 15 seconds twice while breathing normally with no tactile or visual feedback. (Assessment explained in Appendix 5). Most of the subjects could recruit LM regardless of whether they had LBP or not.

Table 4.17: Physical Measurements for Activation and Recruitment of Transversus Abdominis in Subjects with or without LBP (n=176)

Factor	Category	Number of respondents		p-value
		LBP	No-LBP	
TrA recruitment	**Left**	65	111	
	Activation and recruitment	65 (100)	109 (98.2)	p=0.51
	No recruitment	0 (0)	2 (1.8)	NS
	Right	65	111	
	Activation and recruitment	64 (98.5)	111 (100)	p=0.31
	No recruitment	1 (1.5)	0 (0)	NS

Key: L = left, LBP = low back pain, NS = not significant, R = right, TrA = transversus abdominis

Most of the students could recruit or activate TrA effectively, regardless of whether they had LBP or not. Specific activation and recruitment were evaluated as for LM (Assessment of TrA explained in Appendix 6).

Table 4.18: Cross-Sectional Area of the Lumbar Multifidus, Mean (SD) at L4 Vertebral Level for Students with Low Back Pain and No-Low Back Pain

	No-LBP			**LBP**		
	Left side	**Right side**	**% Diff in CSA**	**Left side**	**Right side**	**% Diff in CSA**
n cm² mean (SD)	108 6.60 (±1.50)	107 6.40 (±1.50)	2.40	62 6.00 (±1.70)	62 6.10 (±1.70)	-2.87

Key: *Percentage difference in CSA calculated by ([left side CSA – right side CSA]/left side CSA) x 100. L4 = 4th lumbar vertebrae, LM = lumbar multifidus, CSA = cross sectional area.

While the mean CSA measurements are generally smaller in subjects with LBP, only the left LM CSA is significantly associated with LBP (p=0.02).

Table 4.19: Thickness Measures (Mean) Using Ultrasound Imaging During Rest and Contraction of (a) Obliquus Internus Abdominis, (b) Transversus Abdominis and (c) Slide of the Anterior Abdominal Fascia with No-Low Back Pain per Study Year

		Thickness During Rest		**Thickness during contraction (ADIM)**	
		L side Mean (SD)	R side Mean(SD)	L side Mean (SD)	R side Mean(SD)
Total n=108	**(a)OI**(mm) **(b)TrA**(mm) **(c)TrA slide**(mm)	6.56(±2.0) 4.34(±1.3) -	6.71(±1.9) 4.20(±1.0) -	7.15(±2.3) 6.16(±1.7) 18.11(±2.1)	7.43(±2.4) 6.21(±1.4) 18.43(±2.1)

Key: LBP = low back pain, SD = standard deviation, R = right, L = left, OI = obliquus internus abdominis, TrA = transversus abdominis, USI = ultrasound imaging, ADIM = abdominal drawing-in manoeuvre.

Table 4.20: Thickness Measures (mean) Using Ultrasound Imaging During Rest and Contraction of (a) Obliquus Internus Abdominis, (b) Transversus Abdominis and (c) Slide of the Anterior Abdominal Fascia with Low Back Pain

		Thickness during rest		**Thickness during contraction (ADIM)**	
		L side Mean (SD)	R side Mean(SD)	L side Mean (SD)	R side Mean(SD)
Total n=62	**(a)OI**(mm) **(b)TrA**(mm) **(c)TrA slide**(mm)	7.2(±2.4) 4.43(±0.9) -	7.43(±2.1) 4.60(±1.2) -	7.78(±2.7) 6.79(±1.6) 17.22(±3.2)	7.92(±2.6) 6.88(±1.6) 18.47(±2.3)

Key: LBP = low back pain, SD = standard deviation, R = right, L = left, OI = obliquus internus abdominis, TrA = transversus abdominis, USI = ultrasound imaging, ADIM = abdominal drawing-in manoeuvre.

When thickness of the various muscles at rest and during contraction were compared for subjects with and without LBP it was found that for OI and TrA at rest the muscles were significantly thicker on the right in students with LBP (both p=0.02). During contraction only TrA showed greater thickness in LBP subjects but on both sides (left p=0.02; right p=0.01), although the difference was greater on the right. There was also a significant correlation between TrA slide on the left and LBP (p=0.03).

4.4 OBJECTIVE THREE: TO IDENTIFY POSSIBLE NEUROMUSCULAR ASSOCIATIONS WITH LBP

Table 4.21 outlines data for neuromuscular associations with LBP.

Table 4.21: Association of Low Back Pain with Neuromuscular Results

FACTORS	LBP Mean (SD)	No-LBP Mean (SD)	p-value
PSLR - L in cm (n=192)	84.09 (±19.9)	81.56 (±25.7)	0.62
PSLR - R in cm (n=192)	84.64 (±20.0)	81.64 (±25.6)	0.16
LM recruitment – L (n=175)	90.6% (58/64)	89.2% (99/111)	0.95
LM recruitment – R (n=175)	92.2% (59/64)	94.6% (105/111)	0.39
TrA recruitment – L (n=176)	100% (65/65)	98.2% (109/111)	0.51
TrA recruitment – R (n=176)	98.5% (64/65)	100% (111/111)	0.31
LM CSA – L in cm² (n=170)	**6.0 (±1.7)**	**6.6 (±1.5)**	**0.02***
LM CSA – R in cm² (n=170)	6.1 (±1.7)	6.4 (±1.5)	0.25
USI in mm:			
OI rest – L (n=170)			
OI rest – R (n=170)	7.2 (±2.4)	6.6 (±2.0)	0.06
OI contraction – L (n=170)	**7.4 (±2.1)**	**6.7 (±1.9)**	**0.02***
OI contraction – R (n=170)	7.8 (±2.7)	7.2 (±2.3)	0.10
TrA rest – L (n=170)	7.9 (±2.6)	7.4 (±2.4)	0.18
TrA rest – R (n=170)	4.4 (±0.9)	4.3 (±1.3)	0.62
TrA contraction – L	**4.6 (±1.2)**	**4.2 (±1.0)**	**0.02***
(n=170)	**6.8 (±1.6)**	**6.2 (±1.7)**	**0.02***
TrA contraction – R	**6.9 (±1.6)**	**6.2 (±1.4)**	**0.01***
(n=170)	**17.2 (±3.2)**	**18.1 (±2.1)**	**0.03***
TrA slide – L (n=170)	18.5 (±2.3)	18.4 (±2.1)	0.92
TrA slide – R (n=169)			

Key: (*) Factors associated with LBP, CSA=cross-sectional area, LM=lumbar multifidus, IO=internal oblique, PSLR=passive straight leg raise, TrA=transversus abdominis.

For the neuromuscular variables six were significant, the L LM CSA (p=0.02), the OI and TrA during rest on the R side (p=0.02; p=0.02), the TrA during a contraction on the R side (p=0.01) and left side (p=0.02) and the L TrA slide (p=0.03). Further analysis was done to test and measure the relationships of the variables with LBP and express as an odds or relative risk ratio.

4.5 OBJECTIVE FOUR: TO DETERMINE THE RELATIONSHIPS BETWEEN LBP AND NEUROMUSCULAR FINDINGS

The results of the univariate model are shown in Table 4.22.

Table 4.22: Univariate Analysis to Determine the Neuromuscular Relationships with LBP

Factors	**Odds ratio**	**95% CI**	**p-value**
PA L4	2.51	1.10-5.72	0.03
PA L5	4.22	1.96-9.07	<0.001
L LM CSA	0.79	0.64-0.97	0.02
R TrA during rest	1.40	1.04-1.89	0.03
R OI during rest	1.19	1.02-1.40	0.03
L TrA during contraction	1.26	1.03-1.53	0.02
R TrA during contraction	1.35	1.08-1.68	0.01
L TrA slide	0.88	0.77-0.99	0.04

Key: CI = 95% confidence interval, CSA = cross-sectional area, L4 = 4^{th} lumbar vertebrae, L = left, LM = lumbar multifidus, PA = posterior-anterior mobilisation, R = right, TrA = transversus abdominis

From the results in Table 4.22 atrophy of the left LM CSA is likely (OR=0.79; 95% CI=0.64-0.97) because of the relationship of LBP to a smaller LM CSA. The increase in thickness of the right TrA and OI during rest and contraction indicate that the likelihood of LBP is increased. However, sensitivity to pain with mobilisations of central PA's on L4 and L5 are 2.51 times and 4.22 times more likely to be associated with LBP. A weaker pull of the L TrA slide was significantly associated with LBP.

4.6 CONCLUSION

Ninety-three percent of students responded to the questionnaire, 47.6% participated in the multi-stage fitness test and 86.1% presented for the physical examination. The LBP prevalence for the four years studied was 35.6% (lifetime), which was lower than in the pilot study but is in accordance with published literature on the subject. The significant relationships with LBP were the increase in physical exposure over the four years of the physiotherapy course. Pain was identified with PA's on L4 and L5. Reduction of the left LM CSA was noted. Thickness of the right OI, the right TrA at rest as well as the right TrA during contraction was significantly increased.

CHAPTER 5

5. DISCUSSION

5.1 INTRODUCTION

The main findings of the study are discussed in this chapter and are organised in accordance with the flow diagram in Figure 5.1 which illustrates the relationship between predisposing factors and the resultant cycle of back pain. The findings regarding the prevalence of low back pain (LBP), the range of factors associated with LBP and neuromuscular associations with LBP will be compared with literature and discussed accordingly. The sequence of events leading to LBP and the factors that influence LBP are shown in Figure 5.1.

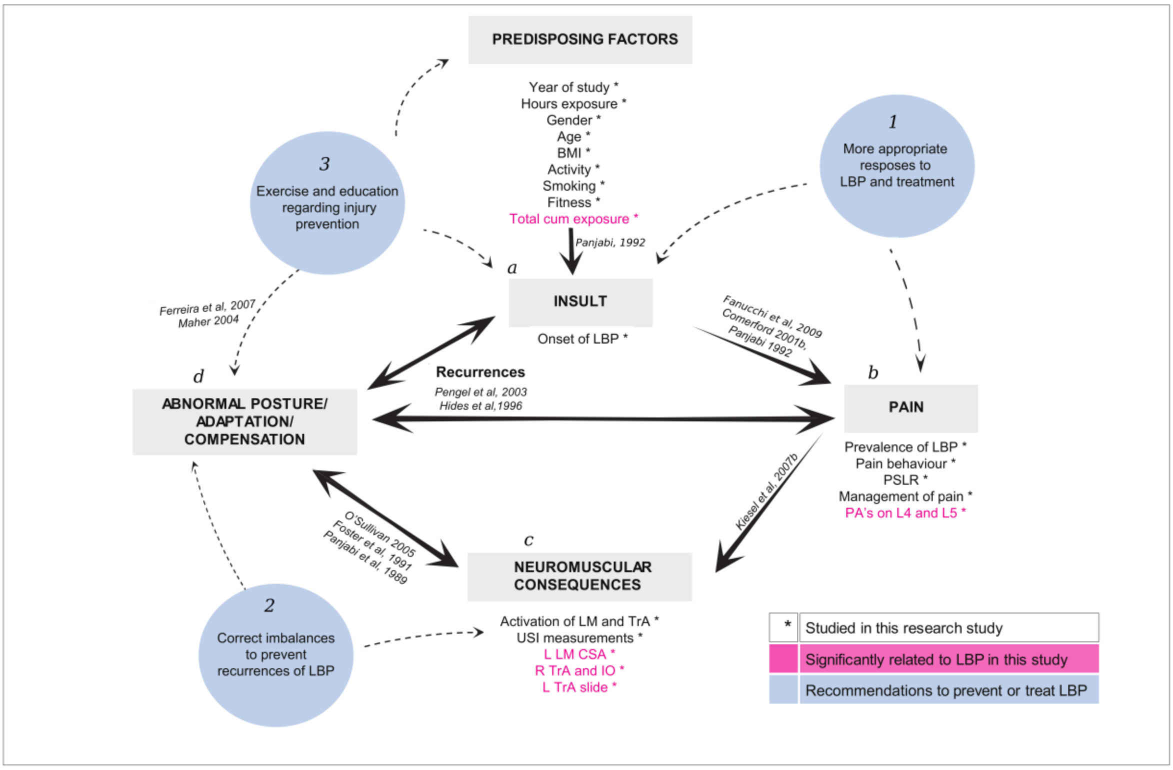

Figure 5.1: Flow Diagram Showing Main Findings of this Study, Significant Results and Recommendations for Future Research

Key: BMI = body mass index, CSA = cross-sectional area, L = left, LBP = low back pain, LM = lumbar multifidus, L4 = 4th lumbar vertebrae, L5 = 5th lumbar vertebrae, OI = obliquus internus abdominis, PA = posterior-anterior mobilisation, PSLR = passive straight leg raise test, R = right, Total cum exposure = practical and theory combined, TrA = transversus abdominis, USI = ultrasound imaging.

Figure 5.1 outlines a schema of events developed as part of this research and includes references to supporting literature that was reviewed as part of the project. The cycle starts with the predisposing factors leading to susceptibility to an insult (a) and LBP (b). This is followed by neuromuscular consequences (c), adapted postures (d) and a susceptibility to aggravated or recurrent LBP, particularly if the cycle is not broken by the introduction of primary, secondary or tertiary preventive measures (circles 1-3). This process is discussed in the context of the four year physiotherapy course and the students involved in education and training for the degree. Each stage of the cycle is discussed in sequence form a to d as labelled in Figure 5.1.

a) **Predisposing factors and development of LBP**

Whereas others have found that age, gender, BMI, smoking, fitness and level of activity predispose to LBP (Bakker et al, 2009; Karachi et al, 2007; Nyland and Grimmer, 2003; Kirstensen et al, 2001), and have postulated that individuals' passive (ligaments and bone) and active (muscles and tendons) systems play a role (Panjabi, 1992), in the present study the major determinant of LBP appeared to be the students' exposure to cumulative hours of practical work, particularly over the first three years. In contrast to some of the findings of Nyland and Grimmer (2003), in the present study it did not appear that hours spent "sitting looking down" engaged in theoretical learning played a role. The unexpected and counter-intuitive finding of a reduced incidence of LBP in the fourth year students could perhaps be explained by the timing of assessments in that group (i.e. they were assessed after the end-of-year holidays, after a few weeks of theoretical work and before starting clinical work).

b) **Prevalence and Pain associated with LBP**

Prevalence of lifetime LBP in the study group of first- to fourth year students was found to be 35.6%. This was significantly lower than the 83% observed in a pilot study of fourth year students, but was similar to the average rate of 45% calculated from studies cited in the literature review in chapter 2 (Falavigna et al, 2011; Steyl et al, 2010; Karachi et al, 2007; Glover et al, 2005; Nyland and Grimmer, 2003). The literature was examined for studies relating to LBP prevalence among physiotherapy students. Four cross-sectional prevalence studies that relate to whether undergraduate physiotherapy study is a risk factor for LBP were found (Falavigna et al, 2011; Steyl et al, 2010; Karachi et al, 2007; Nyland and Grimmer, 2003). Other studies focussed on qualified physiotherapists and the prevalence of LBP (Campo and Darragh, 2010; Glover et al, 2005; Salik and Özcan, 2004; Ruzelj, 2003; West and Gardner, 2001; Cromie et al, 2000; Holder et al, 1999; Bork et al, 1996), and their results were therefore not compared. The results of this study are lower in comparison with the significant 72.9%

(p=0.03) prevalence of LBP at one university followed by 60.6% and 56.8% at another two universities among physiotherapy students in South Africa (Karachi et al, 2007). Nyland and Grimmer (2003) and Karachi et al (2007) had methodological differences to the current study that could have influenced their results and possibly explain the difference in these results. The reason for a high prevalence among their respondents despite a low response rate could be that the questionnaires in these studies were mailed to the subjects whereas in this study the questionnaire was completed in the presence of the researcher. The method of mailing the questionnaires could have created bias in the response to LBP absence or presence because those respondents without LBP were less likely to return their questionnaires. Of all the physiotherapy students at the University of the Witwatersrand in 2010, 93.3% completed questionnaires (n=194). This percentage is higher in comparison with the 72% (n=250) by Karachi et al (2007) and 58.1% (n=333) by Nyland and Grimmer, (2003). As shown in Figure 5.1 the predisposing factors found in literature and in other studies (Falavigna et al, 2011; Steyl et al, 2010; Karachi et al, 2007; Nyland and Grimmer, 2003) were assessed and tested for association with LBP in this group.

The total cumulative hours exposure to practical and theory were significantly associated with LBP. Nyland and Grimmer (2003) identified educational exposures like ‘sitting looking down’ and ‘treating patients’ for more than 20 hours per week increasing the risk of LBP. Other factors related and associated with LBP in physiotherapists were the transferring of patients, performance of repetitive tasks, lifting of heavy equipment and working when physically fatigued (Salik and Özcan, 2004). The hours of work were associated with injury amongst physiotherapists and identified as a risk exposure (Darragh et al, 2009). In the study by Karachi et al (2007) 81% of students reported that they were taught kinetic handling techniques, and 68.6% rarely used kinetic handling and suffered most from LBP. Although there is a high percentage of students who claim to have LBP due to incorrect handling of patients, 95% state that they are taught back care techniques (Karachi et al, 2007). While the prevalence of LBP is lower in this study than in others overall, the data confirm the incremental effect of exposure to practical work during the physiotherapy course. In this study, 24.6% of the students with LBP experienced the pain one to three times per week. For most of the students (63.8%) the duration of an episode of LBP lasts from a few hours to one day. Pain was managed by the students doing exercise by themselves or to rest in bed and to use modalities like heat, doing stretches or massage. In other studies physiotherapists manage their LBP by taking sick leave, modifying their physiotherapy techniques and decreasing their patient contact hours (Glover et al, 2005; West and Gardner, 2001; Holder et al, 1999). More drastic approaches were retiring, changing the work setting or leaving the profession (Campo et al, 2008; Cromie et al, 2000).

Responses to the questionnaires indicated that the onset of LBP among students in this study was mostly related to sports injuries (33.3%). This is in accordance with findings of other authors (Perry et al, 2009; Kirstensen et al, 2001). In 18.8% of cases of LBP, patient management was identified as the cause of the pain. This accords with the research of Bakker et al (2009); Griffith and Stevens (2004); Salik and Özcan (2004); and Nyland and Grimmer (2003) in which transferring of patients, performance of repetitive tasks, lifting of heavy equipment and working when physically fatigued contributed to LBP. Slightly more than one-third of students with LBP in the present study (36.2%) were unable to link the LBP to a specific causative or precipitating action or event.

Fifty-five percent of those with LBP had pain from once per week to once per month, and for almost two-thirds of the students (63.8%) the duration of an episode ranged from a few hours to one day. Pain was largely self-managed by means of bed rest, self-directed exercise, and/or modalities such as heat, stretching or massage. Other studies involving qualified therapists cite actions that are not possible among students e.g. taking sick leave or decreasing patient contact hours (Glover et al, 2005; West and Gardner, 2001; Holder et al, 1999). More-drastic actions taken by qualified therapists include leaving the profession or retirement (Campo et al, 2008; Cromie et al, 2000).

In terms of objective measurement of pain, whereas no differences were found when measuring neural mobility by means of the PSLR test in students with or without LBP, there were highly significant differences with posterior-anterior mobilisations on L4 and L5. These differences in subjects with pain were most marked centrally and on the right ($p<0.001$-0.004), whereas responses on the left either reached lower levels of significance ($p=0.02$) or just missed it ($p=0.07$).

c) **and d) Neuromuscular consequences, abnormal posture, adaptation and compensation**

One of the most striking findings of this study was the apparent atrophy of LM on the left side (significance of difference between left and right sides $p=0.02$, and odds ratio of 0.79; 95% CI 0.64-0.97 for cross-sectional area of LM in students with LBP). These results are similar to previous studies that found localised LM atrophy in subjects with LBP (Hides et al, 2008a; Barker et al, 2004; Danneels et al, 2001). A recent study by Hodges et al (2006) investigated pigs for disc and nerve root injuries by measuring the

CSA with USI before and after lesions on level L4. The CSA was reduced ipsilateral to the disc lesion and extended to other levels not affected by the nerve lesion. Hodges et al's (2006) findings are supported in studies involving human subjects where LM does not recover spontaneously (Hides et al, 1996). The CSA of LM is reduced ipsilateral to side of symptoms (Hides et al, 2001, 1996, 1994), indicating that the left side was where most of the subjects had an injury. Another related change following LBP and affected muscles is the increase in intramuscular fat. Subjects with LBP showed an increase in fatigability (Roy et al, 1989) and an increase in intramuscular fat (Alantra et al, 1993). Hides et al (2008a) noted that fatty deposits or fibrous tissue infiltration and atrophy are common radiological findings. These morphological and physiological changes occur even when the individual has resumed work, sport and activity (Hides et al 2008b; 1996).

In this study no significant differences were found for LM and TrA recruitment or activation in students with or without LBP. This is in contrast to other work, for example that of McDonald et al (2004) and Hodges and Richardson (1996) who observed delayed and inefficient activity of muscles in individuals with LBP. However in this research into physiotherapy students with LBP there were indeed differences in the thickness of various muscles when assessed by means of USI. Specifically, OI and TrA on the right were significantly thicker at rest in LBP subjects than in those without LBP and both TrA's were thicker bilaterally under contraction with LBP. TrA slide was found to be **less** on the left side with LBP (all the latter p values between 0.01 and 0.03). All these findings were found to confer an increased risk/association with LBP.

The development of LBP, possibly superimposed on prior injury to the lower back likely contributes to poor movement habits, causing muscle imbalances. These muscle imbalances may increase the strain on nerve tissue, muscle and the bones which, if overloaded, cause either an additional insult or pain (Comerford and Mottram, 2001b). In response to LBP, motor control deficit has been found to cause abnormal control of the spine, decreasing neural mobility (Fanucchi et al, 2009). Neuromuscular responses may follow, including segmental reflex inhibition, altered recruitment patterns and timing of the LM and TrA (Kiesel et al, 2007b). O'Sullivan (2005) noted that either an excess or deficit in spinal stability affects functional stability, causing an abnormal posture. Muscles may become fibrotic and shorten, losing extensibility and increasing instability of the spine (Panjabi et al, 1989). Muscle weakening and imbalances in the lower back may influence sporting activities and activities of daily living due to limited range caused by LBP (Foster et al, 1991). Furthermore LBP can influence factors like muscle activity, altering recruitment and timing of muscle activation, affecting the stability of the spine and neural structures and therefore resulting in additional LBP (O'Sullivan, 2005; Panjabi, 1992). Recovery of the LM and TrA are not spontaneous on resolution of pain and disability, possibly causing injury of the spine and recurrences of LBP (Pengel et al, 2003; Hides et al, 1996). The cycle of LBP and recurrences will continue unless these factors are addressed.

The hours of work were associated with injury amongst physiotherapists and identified as a risk exposure (Darragh et al, 2009). In the study by Karachi et al (2007) 81% of students reported that they were taught kinetic handling techniques, and 68.6% rarely used kinetic handling and suffered most from LBP. Although there is a high percentage of students who claim to have LBP due to incorrect handling of patients, 95% state that they are taught back care techniques (Karachi et al, 2007).

The way to restore muscle function and size is when specific training of the LM occurs at that specific level (Hides et al, 2008b). This highlights the need to consider L4 LM training as both a preventative and treatment measure for LBP in physiotherapy students. The R IO and TrA at rest were increased in size. While contracting, the right TrA were significantly thicker than the left side. A significantly weaker pull of the TrA was noted on the L side with LBP.

5.1.1 Unifying Theory Based on Findings in this Study and Reviewed Literature

The following illustrations are presented: Figure 5.2 and Figure 5.3 represent anterior and posterior views of the human body. From the associations tested, factors that were significantly associated with LBP are presented in these figures and provide a framework from which to integrate all the significant results found.

The 'lower-crossed syndrome' theory, also referred to as distal or pelvic crossed syndrome, was identified by Janda in 1987 and discussed by Page et al (2010). Janda states that continued muscle imbalance will extend throughout the muscular stystem over time. In the upper cross syndrome inhibition of the deep neck flexors has been evident. Using this same thinking the results of this study in the lower back may be interpreted in this same manner. While the Janda model is essentially a theory and not scientifically proven, in clinical practice it is used to explain the crossover effect when muscles are affected on one side of the body in relation to the other. Deep stabilising muscles (LM and TrA) are inhibited due to pain, and substituted by activation of global muscles. This pattern of imbalance creates joint dysfunction, especially at L4-L5 and L5-S1 segments. Muscle imbalances shown in Figure 5.2 and Figure 5.3 may lead to changes in movement patterns. Altered recruitment patterns start with delayed activation of stabilising muscles and early facilitation of a synergist (compensatory mechanism). Muscle tightness develops, leading to compensatory mechanisms and inhibition for example if the TrA is inhibited the LM is also inhibited which could explain why these muscles were significantly associated where LBP was present (Comerford and Mottram, 2001b; O'Sullivan, 2000). Due to inhibition of the local stabilisers muscle recruitment sequence is altered and hence leads to compensatory postural adjustment. Janda, as cited by Page et al (2010), noted altered peripheral input due to pain, therefore changing muscle activation which impacts on movement patterns. In light of Janda's explanation of the lower-crossed syndrome one could interpret the results obtained from an anterior view on the one side as crossing over on the posterior view to the other side as shown in Figure 5.2 and 5.3.

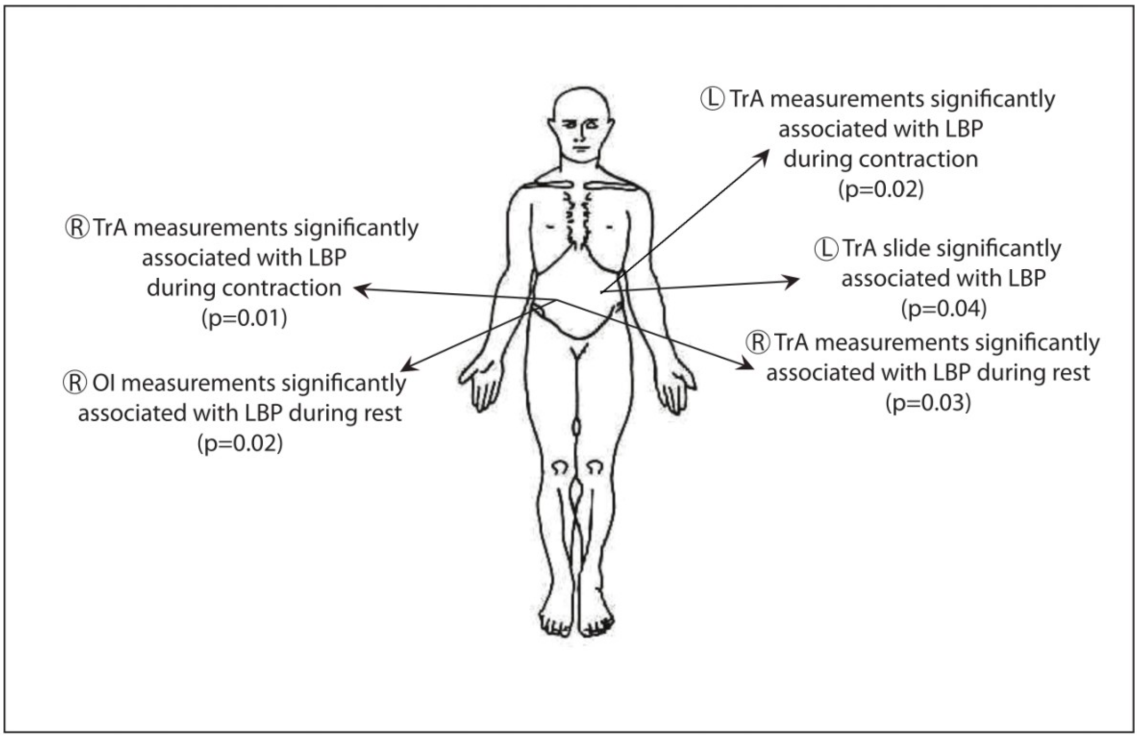

Figure 5.2: Anterior View Representing Significant Results of the Factors Associated with LBP in the Total Study Sample

Key: LBP = low back pain, OI = obliquus internus abdominis, LM = lumbar multifidus, R = right, TrA = transversus abdominis

Inhibition of the local stabilisers leads to fatty infiltration in these muscles and this may contribute to increased muscle thickness (Hides et al, 2008a; Alaranta et al, 1993). During contraction the increase in thickness in the right and left TrA's (p=0.01; p=0.02) as well as the left TrA slide (p=0.04) were significantly associated with LBP. Transversus abdominis and OI thickness measurements on the right during rest (p=0.03; p=0.02) were significantly associated with LBP. It therefore follows that on the right side anteriorly, students are affected by pain shown by the larger measurements during rest and contraction of TrA and

OI. No studies have been found to corroborate the results of changes in muscle thickness and slide of TrA , OI, and LM in physiotherapy students with LBP. The posterior illustration is seen in Figure 5.3.

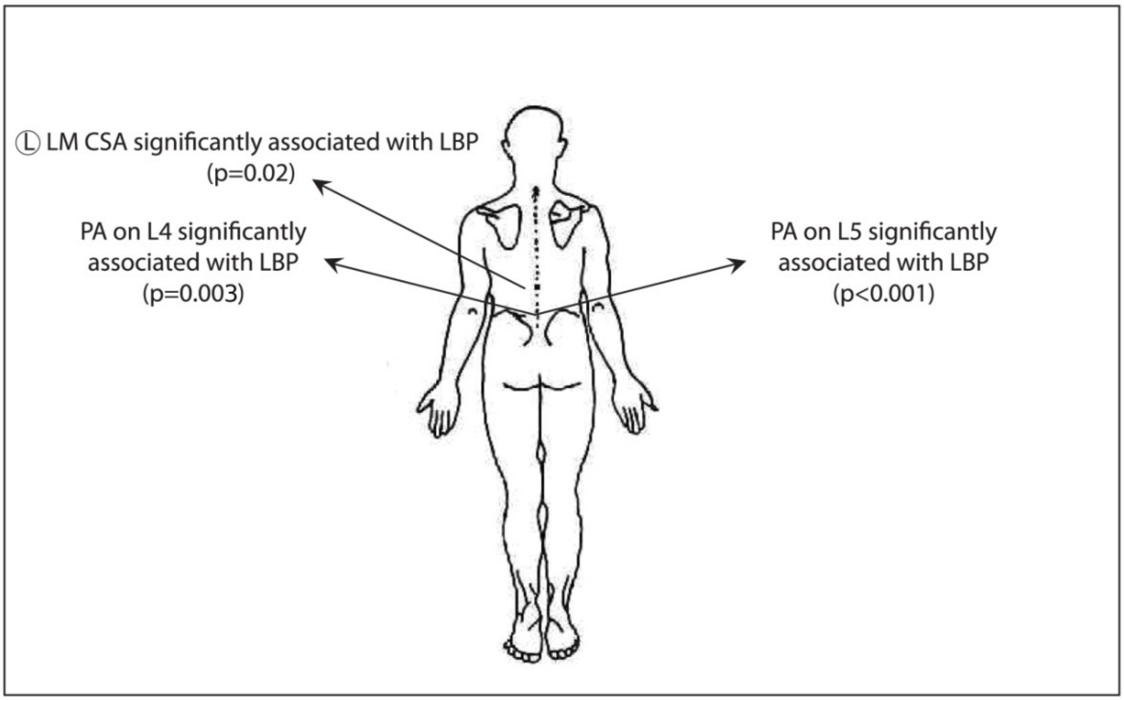

Figure 5.3: Posterior View Representing Significant Results of the Factors Associated with LBP in the Total Study Sample

Key: CSA = cross-sectional area, L = left, LBP = low back pain, LM = lumbar multifidus, PA = posterior-anterior mobilisation.

PA's on L4 and L5 (p=0.003; p≤0.001) and the left CSA of LM (p=0.02) were significantly associated with LBP. On the left side pain affects CSA ipsilateral to symptoms, therefore one can conclude that the left side was affected posteriorly (Hides et al, 1994, 1996, 2001). There were predominantly more problems in the abdominals on the right side with some problems during contraction in the TrA on the left anteriorly. The results are not distinctly of a clear cross over effect however according to Figure 5.2 the right abdominal muscles have more problems. Therefore the cross over to the left LM seen in Figure 5.3 may apply using Janda's theory.

5.1.2 Interventions to Prevent, Treat and/or Avoid Complications of LBP

As shown in Figure 5.1, circles 1-3 outline important interventions that could be employed at each stage of the LBP cycle. In this regard, students with LBP In the present study showed evidence of inadequate self-management rather than an awareness of options to mitigate risk of recurrence of prior LBP or to optimally manage existing LBP. Exercise and education regarding injury prevention has been shown to be cost effective in preventing LBP in trainee physiotherapists (Ferreira et al, 2007; Maher, 2004). With more appropriate responses to LBP and more effective treatment, recurrences of LBP can be prevented (Pengel et al, 2003; Hides et al, 1996).

Of concern is the fact that there is a correlation between year of study, exposure to practical training and LBP. In other words, despite proper training, information and incremental knowledge of the discipline of physiotherapy, students nevertheless injure themselves. This highlights the lack of application of theory to practice. Most undergraduate training takes place in government hospitals. Unfortunately most government hospitals are overburdened and understaffed, resulting in a heavy caseload and lack of time to implement safer handling for students (Von Holdt and Murphy, 2007). It could also be that at workplace students are assigned a large number of patients, making it difficult for the young physiotherapy student to set boundaries (Griffith and Stevens, 2004). This can add to repetitive lifting and transferring of patients, resulting in LBP.

Finally, in terms of secondary and tertiary prevention, once LBP is present greater efforts should be made to act on the consequences by correcting muscle imbalances to restore function and size after pain and pathology (O'Sullivan, 2005; Foster et al, 1991; Panjabi et al, 1989). A physiotherapy student who has experienced LBP can mitigate further damage and predisposition to LBP by addressing these specific muscles during training before qualifying and starting work as a physiotherapist.

5.2 LIMITATIONS OF THIS STUDY

As in other studies, the lack of a thorough history regarding LBP injury prior to studying and graduating as a physiotherapist might have influenced results and underestimated prevalence (Karachi et al, 2007; Nyland and Grimmer, 2003). Along these lines, a low reliability of the history of LBP in the questionnaire was noted and this is an aspect that would require attention in future studies. In retrospect and in the light of lateralisation of findings in students with LBP such as probable LM atrophy on the left side and preponderance of muscle thickness differences on the right, it would have been useful to document handedness and any lateralisation of LBP. Information regarding hand dominance was not included in the questionnaire and could explain the presence or side of LBP symptoms, especially when delayed back muscle response time to the nondominant side was noted by Sung et al (2004). In the physical assessment, posture was also not evaluated to confirm the muscle imbalances.

In terms of study design it would be preferable to conduct this type of study on a cohort of students progressing from first to fourth year rather than carry out a cross-sectional prevalence study in which it is more difficult to establish causal relationships or to get reliable perspectives on the natural history of LBP (Abramson and Abramson, 2000).

5.3 RECOMMENDATIONS

The abovementioned limitations aside, LBP appears to be a real issue for physiotherapy students during their four years of training. As such it is important to implement an early intervention programme to identify prior LBP and undertake appropriate steps to mitigate the risks of further insults. There should also be more emphasis on prevention of LBP in students without prior history, and the development of risk assessment tools that will help to identify and address specific educational and clinical exposure hazards for the students (Graham and Grey, 2005). As shown in a study carried out in the UK, while students believed they were not at risk and that they were adequately prepared and trained, they nevertheless presented with LBP injuries (The Chartered Society of Physiotherapy, 2006). Programs on manual handling, ergonomics and kinetic handling can be implemented, in order to make students more aware and to better equip them to protect themselves.

The results of this study confirm some of the clinical protocols that are practised in the management of LBP, for example the importance of preventative training and development of core stability. However, what is important and should be emphasised is the focus on specific muscles such at LM, OI and TrA, and the use and application of the lower-crossed effect.

CHAPTER 6

6. CONCLUSION

The dissertation reported on the prevalence of low back pain among physiotherapy students at the University of the Witwatersrand and explored factors associated with LBP. The study design was a cross-sectional prevalence study and the data were collected by having the subjects complete a questionnaire and do a fitness test, followed by a physical assessment, by the researcher.

The following factors were significantly associated with LBP:

- The hours of practical exposure (p=0.02), cumulative hours exposure (p=0.04) and PA's on L4 and L5 were associated with LBP (p=0.003; p<0.001).

- The significant neuromuscular responses to LBP were the L LM CSA (p=0.02), the OI and TrA during rest on the R side (p=0.2; p=0.02), the TrA during a contraction on the L and R sides (p=0.02; p=0.03) as well as the (L) TrA slide (p=0.03).

- In the univariate analysis, the PA's on L5 and L4 were significantly associated with LBP. The L LM revealed atrophy, and the TrA and IO an increase in thickness. A less effective slide of the left TrA on the abdominal wall was noted with LBP.

The results revealed specific associations with and possible consequences of LBP, the factors associated with LBP and how they might predispose the students to further LBP.

It is important to adequately train and make the students aware of LBP injuries in their first year of the physiotherapy programme, therefore empowering them to reduce the prevalence of LBP. A newly qualified physiotherapist might not be able to manage time as efficiently as other more experienced staff. Physiotherapists would likely be at lower risk of developing LBP as a product of musculoskeletal dysfunction if they were able to enter the profession with an awareness of the factors associated with the condition obtained while studying at an undergraduate level.

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APPENDIX 1

- QUESTIONNAIRE

QUESTIONNAIRE

Please answer all the questions accordingly. Fill in the answers on the lines, or tick the boxes with the suitable answers.

Reference number: ______________

Exclusion criteria:

1. Do you have any structural asymmetry like scoliosis? Yes □ No □
2. Do you find it difficult to stand without support? Yes □ No □
3. Did you have any operations in the past six months done on your bones, muscles or ligaments? Yes □ No □
4. Have you ever had any back operations? Yes □ No □
5. Do you use any supports or braces for your back, legs or neck? Yes □ No □
6. Do you suffer from any diseases (cancer, TB, lung diseases or AIDS) at the moment, or have you had any diseases recently? Yes □ No □

If you are female:

7. Are you pregnant at the moment? Yes □ No □

If you answered **YES** to any of the eight above questions, then you can't participate in this study and do not have to answer any of the following questions.

If you answered NO to all eight questions above, please answer all of the following questions on the next pages.

1. Socio- and Demographic information

1.1 Age : __________

1.2 Gender : Male □ Female □

1.3 Current year of study in Physiotherapy?

First □ Second □ Third □ Fourth □

1.4 How many cigarettes do you smoke per day, if any?

0 - I don't smoke □ 1-5 □ 5-10 □ 10-20 □ 20-40 □ 40+□

2. Clinical information

Please answer the following on your experience on low back pain. Low back pain is described as an "ache, pain or discomfort in the lower back whether or not it extends from there to one or both legs (sciatica)" (Nyland and Grimmer, 2003). The symptoms that you could experience is pain, tingling feeling, numbness or a feeling of heaviness.

2.1 Have you ever suffered from low back pain or discomfort that lasted more than 24 hours?

Yes □ No □

*If **NO**, answer from number **4** onwards.*

---

*If **YES**, please answer the following questions.*

2.2 When did your last incident of low back pain occur?

I have low back pain at the moment	
During the last week	
During the last month	
During the past 6 months	
During the past 12 months	
More than 12 months ago	

2.3 Where you ever diagnosed with a back condition by Dr or Physiotherapist? Yes □ No □

If **YES**, please specify when and what:

____

2.4 Mark on the line below the worst intensity low back pain you've ever experienced?

No Pain |————————————————| Worst pain ever

2.5 When you have low back pain, the pain is: Constant □ Intermittent □

3. Low back pain history

3.1 Can you identify what initiated your low back pain?

Started spontaneously	
Motor vehicle accident	
Sports injury	
Physiotherapy activity during treatment of patient	
Other trauma (fall, lifting object)	
Don't know	
Other, name:	

3.2 How often do you have back pain?

Every day	
One to 3 times per week	
Once every 2 weeks	
Once per month	
Once every 3 to 6 months	
Less than once in 6 months	

3.3 How long does the pain last when it is present?

A few hours to one day	
2 to 3 days	
4 to 5 days	
One week	
Longer than one week	

3.4 Do you have low back pain at the moment? Yes □ No □

3.5 How do you manage your low back pain when you have it?

Rest in bed	
Medical Doctor	
Medication	
Physiotherapy	
Exercises	
Other, name:	

3.6 Did the treatment help?

Not at all	
Only for short while	
Pain relief, but still gets pain regularly	
Pain relief, still gets pain seldom	
Total pain relief, never had pain again	

4. Activity level

4.1 Do you exercise at the moment? Yes □ No □

If **YES**, complete which/what kind of sports you participate in on the next page.

(Use the grey table as a guide to encircle the suitable numbers in the other three columns)

Tick what you do:		**How often?**	**How long?**	**How hard?**
Aerobics		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Athletics		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Cricket		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Cycling/spinning		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Dance		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Gymnastics		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Gym		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Hockey		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Jogging		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Netball		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Play musical instrument		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Rugby		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Soccer		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Swimming		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Tennis		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Other and name:		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

How often do you do it?				
1	**2**	**3**	**4**	**5**
1x every two weeks/less	1-2x per week	3x per week	4x to 5x per week	6x or more per week

For how long do you do it?				
1	**2**	**3**	**4**	**5**
Less than 30minutes	30 minutes	45 minutes	60 minutes	90 minutes or more

How hard do you exercise?				
1	**2**	**3**	**4**	**5**
Do not sweat at all	Sweat minimally, not out of breath	Sweat moderately, slightly breathless	Sweat a lot, breathless	Sweat severely, breathless, tired

4.2 Mark on what level you participate in the sport mentioned above.

Level	Sport 1	Sport 2	Sport 3
Social level only			
Compete on university level			
Compete on club level			
Compete on provincial level			
Compete on national level			

4.3 How long have you been participating in the above-mentioned sport?

How long?	Sport 1	Sport 2	Sport 3
1 to 3 months			
4 to 6 months			
7 to 12 months			
13 months to 2 years			
More than 2 years			

5. Educational exposure

Tick all the activities you do while sitting/lying down in the table below.

(Use the grey table as a guide)

	Tick what you do:	How often?	For how long?
In class (sitting)		1 2 3 4 5	1 2 3 4 5
Studying		1 2 3 4 5	1 2 3 4 5
Work on computer		1 2 3 4 5	1 2 3 4 5
Watch television/movies		1 2 3 4 5	1 2 3 4 5
Lying down		1 2 3 4 5	1 2 3 4 5
Reading		1 2 3 4 5	1 2 3 4 5
Sitting		1 2 3 4 5	1 2 3 4 5
Sleeping during day		1 2 3 4 5	1 2 3 4 5
Other – name:		1 2 3 4 5	1 2 3 4 5

How often do you do it?				
1	**2**	**3**	**4**	**5**
1x every two weeks/ less	1-2x per week	3x per week	4x to 5x per week	6x or more per week

For how long do you do it?				
1	**2**	**3**	**4**	**5**
Less than 30minutes	30 minutes	45 minutes	60 minutes	90 minutes or more

Tick all the activities you do while standing up in the table below. *(Use the grey table as a guide)*

	Tick what you do:	**How often?**	**For how long?**
Treating patients/working		1 2 3 4 5	1 2 3 4 5
Practising techniques on someone else		1 2 3 4 5	1 2 3 4 5
Having techniques practised on you		1 2 3 4 5	1 2 3 4 5
Other – name:		1 2 3 4 5	1 2 3 4 5

6. Occupational exposure

What is your exposures per day?

6.1 How many transfers do you do per day? ______________

6.2 How many patients do you need to lift per day? ______________

If you are female, please answer nr. 7.

If you are male, thank you for your participation.

This information will be handled with the strictest confidentiality.

---

7. If you are female, answer the following questions

7.1 When experiencing low back pain, do you get the low back pain only during menstruation? Yes □ No □

7.2 Do you get low back pain during other times **and** during menstruation? Yes □ No □

7.3 Have you had any children? Yes □ No □

If **YES**, how many? 1 child □ 2 children □ 3 or more □

7.4 When was the last pregnancy? ________________________

Thank you for taking the time to complete the questionnaire.

To be completed by the researcher/research assistant:

Other measurements

1. Height ____________

2. Weight ____________

3. BMI (calculated by the researcher) ___________

4. **Fitness test results**

	Men	Women
Excellent	> Level 13	> Level 12
Very good	Level 11 – level 13	Level 10 – level 12
Good	Level 9 – level 11	Level 8 – level 10
Average	Level 7 – level 9	Level 6 – level 8
Poor	Level 5 – level 7	Level 4 – level 6
Very poor	< Level 5	< Level 4

5. **Neuro-dynamic test**

	Right leg			**Left leg**		
	1st SLR	2nd SLR	Average	1st SLR	2nd SLR	Average
Cm from heel						

6. **Assessment of low threshold voluntary recruitment efficiency of TrA**

	Specific Activation		***Recruitment***	
	Right side	Left side	Right side	Left side
TrA				

7. **USI TrA measurement**

Patient file

Student no □

M/F □

okay □

TrA L

Gel, below ribs □

Button to left side of subject □

Relaxed, freeze □

Shift + F □

_______check frame no □

TrA R

Gel, below ribs □

Button to left side of subject □

Relaxed, freeze □

Shift + F □

_______check frame no □

Split screen

Contract TrA □

Freeze □

Shift + F □

________check frame no □

Split screen

Contract TrA □

Freeze □

Shift + F □

________check frame no □

	Resting		**Contracted**		**% Change**	
	(R)	(L)	(R)	(L)	(R)	(L)
TrA depth						
IO depth						
TrA length/pull						

8. PA's

	Central PA	**Unilateral PA**	**Unilateral PA**
		Right	**Left**
L4	No Yes Grade:	No Yes Grade:	No Yes Grade:
L5	No Yes Grade:	No Yes Grade:	No Yes Grade:

9. LM recruitment test

	Specific Activation		***Recruitment***	
	(R)	(L)	(R)	(L)
L4 LM				

10. USI of LM

Patient in prone, pillow under stomach. Level L4/L5, decrease total gain (borders more evident).

CSA at rest: ipsilateral leg lift to differentiate lateral border of LM from Longissimus, depth control adjusted. Full relaxation before capturing CSA.

LM

L4 – freeze

shift + F □

____check frame no □

	Resting CSA, measurement 1		**Measurement 2**		**Average CSA**	
Level	Large side	Small side	Large side	Small side	Large	Small
L4(cm²)						

Qualitative analysis: symmetrical, round, oval, triangular

Resting shape	**Large side**	**Small side**
L4		

APPENDIX 2

- MULTI-STAGE FITNESS TEST

MULTI-STAGE FITNESS TEST

The test involves continuous running between two lines 20 meters apart. The subject starts running when instructed by the compact disc (CD) or tape (recorded beep). The speed starts slow and the subject continues running between the lines, turning when signalled by the recorded beeps. After a minute, the sound indicates an increase in speed and the beeps will be closer together. This will be the next level. If the subject fails to reach the line in time, the subject must run to the line and try to catch up with the speed of the level within two more beeps. And, if the subject reach the line before the beep, the subject must wait until the beep before continuing. The test is stopped if the subject fails to reach the line within two meters for two consecutive ends.

Scoring of the multistage fitness test:

The subject´s score is the last level and number of shuttles completed before they were unable to keep up with the recording (see Beep test recording sheet). In the table below, the levels are categorized into six different categories: excellent, very good, good, average, poor and very poor for men and women respectively.

Scoring for beep test.

	Men	**Women**
Excellent (Level 0)	>level 13	> level 12
Very good (Level 1)	Level 11 – level 13	Level 10 – level 12
Good (Level 2)	Level 9 – level 11	Level 8 – level 10
Average (Level 3)	Level 7 – level 9	Level 6 – level 8
Poor (Level 4)	Level 5 – level 7	Level 4 – level 6
Very poor (Level 5)	< Level 5	< Level 4

By entering the level and number of shuttles for that level the predicted VO^2max can be calculated. The calculator appears to be accurate to within 0.1ml/kg/min of published values (Ramsbottom et al, 1988). Another calculation by Ahmaidi (1992) is used to determine VO^2max where velocity is determined using the distance covered in 30 seconds during the last stage of the test:

VO2 max = 31.025 + (3.238 × velocity) - (3.248 × age) + (0.1536 × age × velocity)

The correlation to the actual VO^2max scores is high.

Beep test recording sheet

Subject number (same as questionnaire number):..................................

Level 1	1 2 3 4 5 6 7
Level 2	1 2 3 4 5 6 7 8
Level 3	1 2 3 4 5 6 7 8
Level 4	1 2 3 4 5 6 7 8 9
Level 5	1 2 3 4 5 6 7 8 9
Level 6	1 2 3 4 5 6 7 8 9 10
Level 7	1 2 3 4 5 6 7 8 9 10
Level 8	1 2 3 4 5 6 7 8 9 10 11
Level 9	1 2 3 4 5 6 7 8 9 10 11
Level 10	1 2 3 4 5 6 7 8 9 10 11
Level 11	1 2 3 4 5 6 7 8 9 10 11 12
Level 12	1 2 3 4 5 6 7 8 9 10 11 12
Level 13	1 2 3 4 5 6 7 8 9 10 11 12 13
Level 14	1 2 3 4 5 6 7 8 9 10 11 12 13
Level 15	1 2 3 4 5 6 7 8 9 10 11 12 13
Level 16	1 2 3 4 5 6 7 8 9 10 11 12 13 14
Level 17	1 2 3 4 5 6 7 8 9 10 11 12 13 14
Level 18	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Level 19	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Level 20	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Level 21	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

Total:

Level ………………. and number of shuttles for that level.......................

Predicted VO^2max: ……..............

APPENDIX 3

- NEURODYNAMIC TEST

NEURODYNAMIC TEST

Passive straight leg raise test (Butler 2000 and Petty 2006)

Testing

Neural mobility is tested with the passive straight leg raise test (SLR) as described by Fanucchi et al (2009) in a study done on prevalence of low back pain in 12-13 year old children.

Starting Position

The subject lies supine. The researcher or research assistant passively adducts, medially rotates, knee in extension and then flexes the hip to the onset of the subject's posterior thigh symptoms.

Method

The SLR moves and tensions the nervous system. The normal response is a strong stretching feeling or tingling in the posterior thigh, behind the knee, calf and foot (Petty, 2006).

Positive Result

If the posterior thigh symptoms are increased or decreased with ankle dorsiflexion or eversion (sensitising test), this would be a positive test suggesting there is a neurodynamic component and decreased neural mobility (Fanucchi et al, 2009). The test is also positive if there is a difference between the left and right range of hip flexion limited by pain (Butler, 2000). The range of hip flexion measured with a goniometer by the researcher or research assistant.

	Left leg	**Right leg**
Degrees of hip flexion with the passive SLR test		

APPENDIX 4

- MOBILISATION OF L4 AND L5

MOBILISATION OF L4 AND L5

Passive accessory intervertebral movements (PAIVM's) of L4 and L5 as described by Petty (2006) and Maitland et al (2001).

- **Posterior-Anterior Central Vertebral Pressure**

  Starting position

  The subject lies prone with arms next to side or hanging down plinth face turned to one side. The researcher stands at the left side of the subject and places her left hand on the subject's back. The part between the pisiform and the hook of the hamatum (of the ulnar border of the hand) is in contact with the spinous process of L4. The researcher's shoulders are directly over the vertebrae mobilized and the wrist of the left hand in full extension, forearm neutral (between supination and pronation) for optimal contact. The left hand is reinforced by the right.

  Method

  The researcher moves her body weight forwards and over the vertebrae in a oscillating movement. The pressure is transmitted through the shoulders and arms. Pain assessed by the four grades of movement (Maitland et al, 2001):

  - *Grade I* A small-amplitude movement near the starting position of the range
  - *Grade II* A large-amplitude movement that starts at the beginning of range. It is part of the range that is stiffness or muscle spasm free.
  - *Grade III* A large-amplitude movement, moving into stiffness or muscle spasm at end range.
  - *Grade IV* A small-amplitude movement into stiffness or muscle spasm at end of range.

  Uses

  Best used in patients with evenly distributed pain to both sides of the spine especially chronic lumbar nerve root pain and buttock pain.

- **Posterior-anterior unilateral vertebral pressure**

  Starting position

  The subject lies prone with arms next to side face turned to painful side. If assessing left side, researcher stands on left side of subject, placing thumbs on back adjacent to spinous process on the left. The thumbs are pointing towards each other, fingers spread around for stability.

  Method

  The researcher positions her shoulders over the area being palpated as pressure is applied.

  Uses

  When muscle spasm in the deep intrasegmental muscles is felt. The technique is carried out on the side of the pain or muscle spasm.

PASSIVE ACCESSORY INTERVERTEBRAL MOVEMENTS (PAIVM'S)
RECORDING OF L4 AND L5

Subject number:..............

Recording done by documenting pain or no pain with accessory movement on L4 and L5.

Behaviour of pain:
If pain on mobilization, record as : "Yes".
If no pain on mobilization, record as : "No".

	Central PA	**Unilateral PA**	**Unilateral PA**
		Left	**Right**
L4	Yes / No	Yes / No	Yes / No
L5	Yes / No	Yes / No	Yes / No

APPENDIX 5

- LUMBAR MULTIFIDUS RECRUITMENT ASSESSMENT

LUMBAR MULTIFIDUS RECRUITMENT ASSESSMENT

Anatomy: The multifidus originate from the dorsal surface of the sacrum, the sacrotuberous ligament, the aponeurosis of the erector spinae, the posterior superior iliac spine and the posterior sacroiliac ligaments (Mathers et al, 1996, taken out of Sahrman, 2002).

Functions: By contracting eccentrically, the multifidus control flexion and shearing of vertebrae anteriorly when doing forward bending. The multifidus muscle has a longer lever arm that produces extension than the erector spinae, because of it's attachment to the spinous processes. The other function is to assist in stability of the spine due to the compression force that multifidus exerts on the vertebrae (Sahrmann, 2002).

Position of subject: Subject lie in prone, with spine in neutral (pillows under stomach if needed). Muscles of lower back relaxed.

Test by the researcher: The researcher places his/her fingers/thumbs next to the spinous processes (between the erector spinae muscle and spine), on the deeper muscles. The researcher sink his/her fingers firmly into the muscle.

Command by the researcher: With the muscles relaxed, the researcher asks the subject to locally contract (or swell) the muscles into the fingers of the researcher.

Ideally recruitment: The researcher should feel the muscle harden, as tension is generated. The should be a symmetrical contraction between the left and right sides of the vertebral level the researcher is assessing. The contraction should also be similar between adjacent segmental levels. The transversus abdominis and obliques should co-activate automatically.

Positive/Negative recruitment: The contraction should be maintained consistently for 15 seconds, repeated two times. If the muscle cannot be activated, or the subject is unable to segmentally recruit, it indicates a loss of control of the deep segmental fibers of lumbar multifidus (Hides et al, 1996; 1995; 1994; Hoges and Richardson,1996).

Reason for prone position: Lumbar multifidus should be able to be recruited in different positions and with any load. With prone, the muscle has minimal afferent feedback. It is unloaded and no weight-bearing facilitation present. With minimal feedback and facilitation the prone position could be a motor control challenge. If activation of lumbar multifidus in prone can be achieved, it will be easy to recruit the muscle in any other position. Thus, for students, the upright postures (sitting and studying or standing and treat patients), are the positions where it is easiest to facilitate and teach the correct activation of multifidus.

Assessment of low threshold voluntary recruitment efficiency of LM		
Mark each requirement with a tick or cross for both left and right		
Specific Activation		
Requirements	***Left***	***Right***
Correct activation pattern in unloaded posture		
Sustained contraction (2-3seconds)		
Maintain control of the neutral position		
Without substitution or co-contraction rigidity		
Without holding breath		
Activation rating		
Recruitment		
Requirements	***Left***	***Right***
Looks easy and feels easy		
Consistent activation		
Benchmark standard (15 seconds x 2 repetitions)		
Normal relaxed breathing		
No fatigue		
No extra feedback (tactile or visual)		
Recruitment rating		
Overall Rating		

APPENDIX 6

TRANSVERSUS ABDOMINIS RECRUITMENT ASSESSMENT

TRANSVERSUS ABDOMINIS RECRUITMENT ASSESSMENT

Functions: Activates prior movement of the trunk or rest of the body. TrA increases the stability of the spine and stiffness protecting the spine in anticipation to load. In low back pain subjects the anticipatory activation of TrA is delayed and the motor control affected.

Position of subject: Patient in crook lying, palpate inferior and medially from the ASIS along the inguinal ligament. Palpate for tensioning.

Test by researcher: The lower antero-lateral abdominal wall should lead the contraction without expansion of the internal obliques.

Command by the researcher: Instruct patient to hollow or draw in the lower abdominal wall without external oblique rib cage depression, posterior pelvic tilt or internal oblique bulge. Normal breathing while maintaining a consistent contraction is normal.

Ideally recruitment: Sustain contraction for 15 seconds and repeat 2 times. Needs to be 20-30% and feels easy.

Positive/negative recruitment: A dysfunction occurs when the subject tries too much and substitution occurs with other muscles, can activate muscle easily with load but maximum effort required to recruit if unloaded.

Assessment of low threshold voluntary recruitment efficiency of TrA		
Mark each requirement with a tick or cross for both left and right		
Specific Activation		
Requirements	***Left***	***Right***
Correct activation pattern in unloaded posture		
Sustained contraction (2-3seconds)		
Maintain control of the neutral position		
Without substitution or co-contraction rigidity		
Without holding breath		
Activation rating		
Recruitment		
Requirements	***Left***	***Right***
Looks easy and feels easy		
Consistent activation		
Benchmark standard (15 seconds x 2 repetitions)		
Normal relaxed breathing		
No fatigue		
No extra feedback (tactile or visual)		
Recruitment rating		
Overall Rating		

APPENDIX 7

- ULTRASOUND IMAGING OF SEGMENTAL LUMBAR MULTIFIDUS

ULTRASOUND IMAGING OF SEGMENTAL LUMBAR MULTIFIDUS

Transverse application

Ultrasound imaging (USI) has been used since the 1950's for medical purposes. Recently, more interest developed about USI and rehabilitation among clinical physiotherapists. Hides et al, (2001, 1996, 1994) used USI in studies detecting atrophy of LM on the level of symptoms and on the side of acute LBP. They also noted that the muscle do not recover spontaneously when pain subsided and that specific training is needed to decrease the risk of recurrences of low back pain.

Many studies have been done on LM in healthy and injured patients with spinal pain (Hides et al, 2006, 1996, 1994). Static and dynamic imaging can be used to measure the paraspinal muscles. Quantitative measurements of LM have been used to determine the level of contraction (change in thickness of the muscle), the change in size over time compared to surrounding tissue and in rehabilitation as a biofeedback tool for the patient and therapist (Stokes et al, 2007).

The anatomy shows that the LM lies most medially of all the paraspinal muscles. Its size increases caudally, (consisting out of 5 layers) and looks like a large multifascicular muscle as described by Macintosh et al, (1986). A transverse or parasagital image can be used with the USI to see the LM's morphometry. In the transverse section the CSA can be measured, where in a parasagital (longitudinal) image muscle fascicles can easily be identified from connective tissue. They are easier to interpret especially for muscle thickness (Kiesel et al, 2007b) and with biofeedback when the muscle changes during contraction (Hides et al, 1994; Van et al, 2006).

Instrumentation:

For the best image clarity of LM, a 5MHz curved array probe, not higher (7-10MHz) or lower (3MHz) is suited with the ultrasound machine in B mode (Stokes et al, 2005; Whittaker et al, 2007).

Subject position:

The subject is in a prone lying position, with one to two pillows under the hips to ensure that the lumbar spine is 10degrees from horizontal as measured by Hides et al, (1995) and Kiesel et al, (2007b). For standardization the researcher must be on the left side of the prone subject. Mark the lumbar spinous processes with a water-insoluble marker that can be removed with a alcohol swab from L5 (cranially palpated from the sacrum) towards the other lumbar vertebrae. (Whittaker, 2007).

Probe placement:

Start by placing the probe longitudinally (sagittal plane), to determine L5 and L4. When level of interest is identified, rotate the probe 90º for a transverse application. The marker on the probe must face the right side of the subject. The probe can be translated laterally from the spinous process of the vertebrae being examined so that the side of interest is highlighted. Manipulate the angle, anterolateral until a clear transverse view of the medial compartment of LM, the lamina and spinous process is achieved. (Whittaker, 2007).

Lower the total gain of the ultrasound unit and ask the subject to lift the ipsilateral leg (Stokes et al, 2005) to clarify the lateral border of LM from longissimus. When the borders are identified, the depth control can be adjusted so that the image is the full screen. Measure the cross-sectional area (Whittaker, 2007). In a study done by Hides et al, (2008b) on cricketers with and without LBP before and after attending a cricket training camp, the mean ± SD of the CSA of L4 and L5 were as follow:

Table 1: CSA of the LM (Mean ± SD) at L4 and L5 for cricketers with and without LBP

	Cricketers without LBP		**Cricketers with LBP**	
Level	**Large side**	**Small side**	**Large side**	**Small side**
L4 (cm^2)	6.53 ± 2.15	6.45 ± 2.21	7.06 ± 2.65	6.93 ± 2.73
L5 (cm^2)	8.04 ± 1.70	7.98 ± 1.79	7.43 ± 2.09	6.81 ± 2.20

Reproduced from Hides et al, (2008b).

Recording of ultrasound imaging of segmental lumbar multifidus

Subject number: ________________________

	Subjects without LBP		**Subjects with LBP**	
Level	**Left side**	**Right side**	**Left side**	**Right side**
L4 (cm^2)				
L5 (cm^2)				

APPENDIX 8

- ULTRASOUND IMAGING OF TRANSVERSUS ABDOMINIS

ULTRASOUND IMAGING OF TRANSVERSUS ABDOMINIS

Instrumentation:

2-5 MHz curvilinear transducer set at 5MHz.

Subject position:

The subject is in hook lying supine with the transducer placed along the lateral abdominal wall, superior to the iliac crest, along the midaxillary line (Kiesel et al, 2007b). Teach subject prior test to avoid common errors, like breath holding, external oblique activity and posterior pelvic tilt.

Probe placement:

First measurement taken at the end of respiration as done in Kiesel et al, (2007b). The next TrA activation will be taken while the subject performs the abdominal drawing-in maneuver (ADIM). The subject will be instructed by the researcher to "exhale and gently draw his or her lower stomach in towards his/her spine".

TrA activation:

The "pull on the fascia" have to make bent on opposite side. The TrA will pull the anterior fascia 1-1,5cm without any substitution by the obliques internus (OI) muscles. Less than 1cm pull on fascia is considered inefficient recruitment. TrA should contract prior to all other muscles and remain tonically throughout a task. Delayed timing and absent activity has been reported in individuals with LBP (Whittaker, 2007).

With load or limb movement, contraction of OI and TrA should be observed. There will be an increase in depth, decrease in length and lateral corseting of both muscles. The contractions need to be present for the full loading task until the limb is lowered. Absence of contraction, delayed timing and excessive response followed by inability to fully relax after the task are abnormal reactions. (Whittaker, 2007).

If the subject can isolate and contract TrA, the researcher will ask him/her to repeat the contraction and breath normally while contracting. If the subject fails to contract the TrA in isolation, an abnormal response will be noted. Both sides of the abdomen need to be evaluated to note asymmetry (Kiesel et al, 2007b).

APPENDIX 9

- INFORMATION DOCUMENT

INFORMATION DOCUMENT

Dear Physiotherapy student,

Hallo, I am Elaine Burger, a post graduate physiotherapist doing my masters dissertation on the prevalence of low back pain in physiotherapy students at the University of the Witwatersrand.

My study title is the prevalence and factors associated with low back pain in physiotherapy students at the University of the Witwatersrand.

Many people suffer from low back pain. Low back pain is pain from the buttocks up to the lower part of your spine and sometimes the pain can refer to your legs as well.

With this study, we want to know how many physiotherapy students suffer from low back pain. We also want to find out what the factors are associated with low back pain. These factors will be determined by looking at the fitness level of each student, to establish neural mobility using the passive straight leg raise test and to establish your level of pain if you have low back pain at L4 and L5 with central and unilateral PA's (posterior-anterior passive accessory intervertebral movements or PAIVM's).

Then we want to determine the level of lumbar multifidus muscle recruitment and low threshold recruitment of transversus abdominis. By measuring these two muscles with ultrasound imaging, which is a non-invasive, painless procedure (Whittaker, 2007), the cross sectional area of lumbar multifidus and an isolated transversus abdominis contraction can be assessed.

We ask you to please complete the questionnaire. The questionnaire is anonymous and should take you between 8 and 10 minutes to complete. Then we want to invite you to take part in a multistage fitness test. The test involves continuous running between two lines 20 meters apart. The speed starts slow, increasing with each level. The level is signalled by recorded beeps on CD or tape. A qualified physiotherapist with CPR certification will be present.

We then ask you to please take part in objective measurements. These include a neurodynamic straight leg raise test and central and unilateral posterior-anterior passive accessory intervertebral movements on L4 and L5 to locate pain. With the straight leg raise the researcher will do hip flexion, medial rotation of the hip with the knee in extension to determine if neural mobility is decreased. A slight pull posterior the knee, calf or upper leg might be experienced. Discomfort or pain may be felt if pathology is present. The researcher will do central and unilateral posterior-anterior passive accessory intervertebral movements on L4 and L5 to locate pain.

We then ask you to please participate in lumbar multifidus recruitment assessment. You will be asked to lie in prone and contract or swell the muscles of multifidus into the fingers of the researcher after a clear explanation on how to recruit the muscle. The test will take 5 minutes to complete. Thereafter, the TrA muscle recruitment test will take place. Subject tested in crook lying by researcher and will also take 5 minutes to complete.

We also invite you to take part in a voluntarily lumbar multifidus muscle thickness analysis with ultrasound imaging at L4, L5 and L4/L5, which is a painless, non-invasive procedure and performed by the researcher. You will receive your results and it will stay anonymous. And lastly we want to invite you to take part in a voluntarily transversus abdominis muscle timing and recruitment with ultrasound imaging.

With all the information you give me, I want to put all the data together, analyze it and the results presented in my dissertation masters. The results might be published in a research paper written for the scientific community. The individual results will not be made available to anyone without your express and written permission. I have obtained approval for my study from the Committee for Research on Human Subjects of the University of the Witwatersrand.

Participation in this study is voluntary and you are allowed to withdraw at any time. If after reading this information sheet you decide against participating in the study please be assured that this will not affect your position as a student in the department. If you have any questions please ask me.
I would like you to please take part in this study and confirm your willingness to do so by signing the consent form.

For further information contact The Chairman, Health Research Ethics Committee, Prof P. Cleaton-Jones at 011-717-1234.

Sincerely,

…..

Mrs Elaine (S.M.) Burger
MSc Dissertation

…......…...

Supervisor: Dr Hellen Myezwa (PhD)
Lecturer
Physiotherapy Department
School of Therapeutic Sciences
University of the Witwatersrand

APPENDIX 10

- CONSENT FORM FOR SUBJECTS

CONSENT FORM FOR SUBJECTS

UNIVERSITY OF THE WITWATERSRAND, PHYSIOTHERAPY

CONSENT TO ACT AS A SUBJECT IN RESEARCH

I,_________________________________ being 18 years or older, consent to participating in a research project entitled: '**THE PREVALENCE AND RISK FACTORS OF LOW BACK PAIN IN PHYSIOTHERAPY STUDENTS AT THE UNIVERSITY OF THE WITWATERSRAND**'.

The questionnaire and procedure have been explained to me and I understand and appreciate their purpose, any risks involved, and the extent of my involvement. I have read and understand the attached information leaflet.

I understand that the procedures form part of a research project, and may not provide any direct benefit to me.

I understand that all experimental procedures have been sanctioned by the Committee for Research on Human Subjects, University of the Witwatersrand, Johannesburg.

I understand that my participation is voluntary, and that I am free to withdraw from the project at any time without prejudice.

___________________________ ______________

Subject name and signature Date

___________________________ ______________

Investigator name and signature Date

APPENDIX 11

- CONSENT FORM FOR GUARDIAN/PARENT

CONSENT FORM FOR GUARDIAN/PARENT

UNIVERSITY OF THE WITWATERSRAND, PHYSIOTHERAPY

I,________________________________(guardian/parent)of____________________________ being 17 years or younger, consent to participating in a research project entitled: '**THE PREVALENCE AND RISK FACTORS OF LOW BACK PAIN IN PHYSIOTHERAPY STUDENTS AT THE UNIVERSITY OF THE WITWATERSRAND**'.

The questionnaire and procedure have been explained to me and I understand and appreciate their purpose, any risks involved, and the extent of my minor's involvement. I have read and understand the attached information leaflet.

I understand that the procedures form part of a research project, and may not provide any direct benefit to him/her.

I understand that all experimental procedures have been sanctioned by the Committee for Research on Human Subjects, University of the Witwatersrand, Johannesburg.

I understand that his/her participation is voluntary, and that he/she is free to withdraw from the project at any time without prejudice.

____________________________ ______________

Guardian/parent name and signature of subject Date

_____________________________ ______________

Investigator name and signature Date

APPENDIX 12

- ASSENT FORM

ASSENT FORM

UNIVERSITY OF THE WITWATERSRAND, PHYSIOTHERAPY

I,____ being 17 years or younger, consent to participating in a research project entitled: '**THE PREVALENCE AND RISK FACTORS OF LOW BACK PAIN IN PHYSIOTHERAPY STUDENTS AT THE UNIVERSITY OF THE WITWATERSRAND**'.

The questionnaire and procedure have been explained to me and I understand and appreciate their purpose, any risks involved, and the extent of my minor's involvement. I have read and understand the attached information leaflet.

I understand that the procedures form part of a research project, and may not provide any direct benefit to him/her.

I understand that all experimental procedures have been sanctioned by the Committee for Research on Human Subjects, University of the Witwatersrand, Johannesburg.

I understand that his/her participation is voluntary, and that he/she is free to withdraw from the project at any time without prejudice.

______________________ ________________

Signature of subject Date

______________________________ ________________

Investigator name and signature Date

APPENDIX 13

- LETTER OF PERMISSION FROM PHYSIOTHERAPY DEPARTMENT

Physiotherapy

School of Therapeutic Sciences • Faculty of Health Sciences • 7 York Road, Parktown 2193, South Africa
Tel: +27 11 717-3702 • Fax: +27 11 717-3719 • E-mail: maryanne.cannon@wits.ac.za

The Chairman

Health Research Ethics Committee

University of the Witwatersrand

1st September 2009

Dear Prof Cleaton-Jones

Elaine Burger can conduct her research in this department. The title of her study is "The prevalence and risk factors of low back pain in physiotherapy students at the University of the Witwatersrand". She will be required to follow the appropriate procedures of gaining informed consent from all participants in her study.

Thank you

Sincerely yours

Aimee Stewart

Associate Professor

Post graduate Coordinator

Department of Physiotherapy

APPENDIX 14

- SUPPLEMENTARY RESULTS

SUPPLEMENTARY RESULTS

The following results were achieved and were not significant. Results regarding demographic and anthropometric data are given below.

Association between year of study and smoking

Smoking by year is shown in Figure 1.

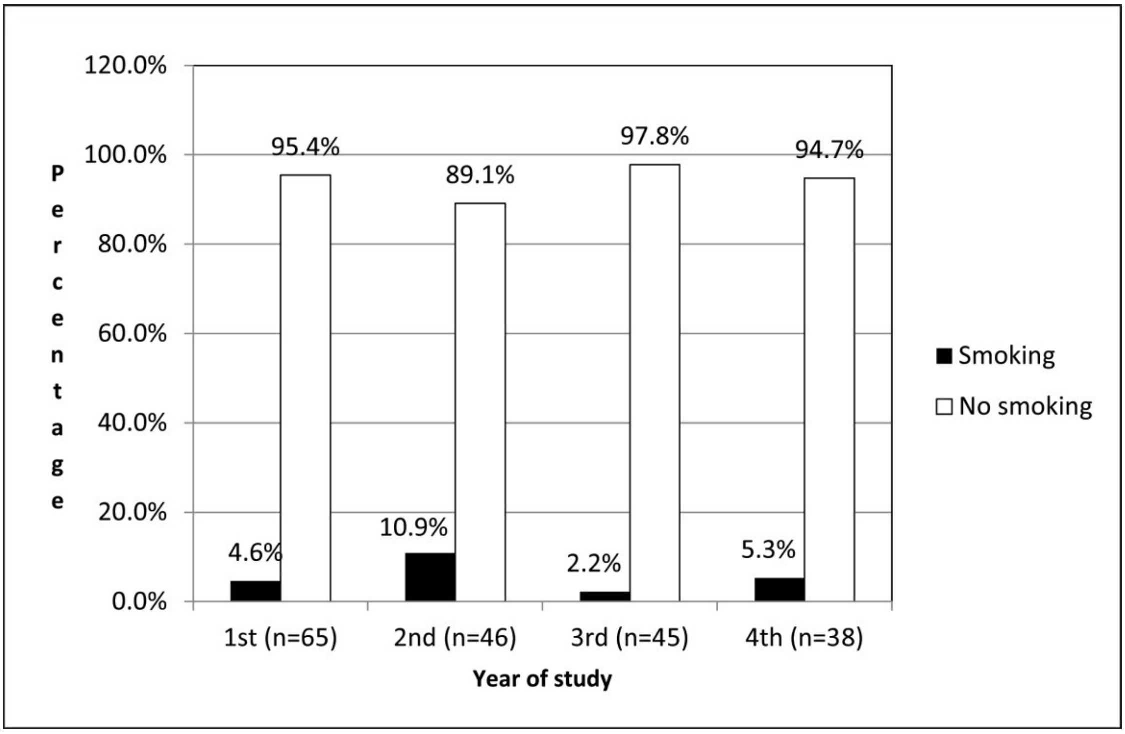

Figure 1 Association between year of study and smoking (n=194).

The second years smoked the most being 11%. The Fisher's exact test was done to compare the prevalence of LBP, year of study and if the subjects smoke or not. In all four year groups, the results were not significant (p=0.28).

OBJECTIVE ONE: TO ASSESS LBP (RECENT AND REMOTE) FOR PHYSIOTHERAPY STUDENTS ACROSS THE FOUR YEARS OF STUDY

The results regarding objective one and the prevalence of LBP are shown in chapter 4.

OBJECTIVE 2: TO COMPARE A RANGE OF FACTORS IN STUDENTS WITH AND WITHOUT LBP

The results regarding objective two and gender are shown in chapter 4.

A comparison of age by year and low back pain

A comparison of age between the different year groups among the physiotherapy students and LBP are shown in Table 1.

Table 1 A comparison of age by year and low back pain prevalence (n=194).

Year of study	LBP No Mean age (SD)	LBP Yes Mean age (SD)	Total
First (n=65)	n=49	n=16	19.2 (±2.5)
	19.0 (±1.8)	19.9 (±4.1)	
Second (n=46)	n=29	n=17	19.7 (±1.5)
	19.6 (±1.2)	19.8 (±1.9)	
Third (n=45)	n=22	n=23	20.9 (±1.3)
	20.7 (±1.4)	21.0 (±1.2)	
Fourth (n=38)	n=24	n=14	21.9 (±1.5)
	22 (±1.5)	21.9 (±1.5)	
First-fourth (n=194)	n=124	n=70	20.2 (±2.1)
	20.0 (±1.9)	20.6 (±2.5)	

A slight increase in the mean age from first year to fourth year was noted. The subjects with LBP in each year were older compared to the subjects in the no-LBP group, except for the fourth years. The total mean (SD) age from first to fourth year was 20.2 (±2.1), those with LBP 20.6 (±2.5) and those with no-LBP 20.0 (±1.9). In Table 2, a comparison of body mass index (BMI) and LBP prevalence is given in each year group.

A comparison of body mass index by year and low back pain

In Table 2 a comparison of body mass index (BMI) and LBP prevalence are given.

Table 2 A comparison of body mass index by year and low back pain prevalence (n=182).

Year	LBP		Total
	No Mean BMI (SD)	Yes Mean BMI (SD)	
First (n=61)	n=46	n=15	22.9 (±3.9)
	22.5 (±3.8)	23.9 (±4.2)	
Second (n=46)	n=29	n=17	22.8 (±4.6)
	22.7 (±4.4)	22.9 (±5.1)	
Third (n=37)	n=18	n=19	22.5 (±2.9)
	22.4 (±3.5)	22.6 (±2.5)	
Fourth (n=38)	n=24	n=14	23.4 (±3.1)
	22.8 (±2.4)	24.5 (±3.9)	
Total (n=182)	n=117	n=65	22.9 (±3.8)
	22.6 (±3.6)	23.4 (±3.9)	

The mean (SD) BMI for all the subjects with LBP was 23.4 (±3.9) and is higher in comparison with the subjects with no-LBP, 22.6 (±3.6). Activity level and the students' fitness level are discussed in chapter 4. One of the physical measurements assessed was neural mobility and is summarised next.

Neural mobility, right versus left leg by using the passive straight leg raise (PSLR) test

Neural mobility was tested with the PSLR test in cm. In Table 3 the mean and SD of the right and left PSLR test are given for the subjects with LBP and no-LBP according to their year of study.

Table 3 Mean (SD) of neural mobility by LBP prevalence and year with PSLR test (n=192).

Year	**LBP**	
	No Mean (SD)	**Yes Mean (SD)**
First	n=48	n=16
L-PSLR in cm	83.0 (±26.0)	83.2 (±22.8)
R-PSLR in cm	83.2 (±26.3)	83.1 (±22.9)
Second	n=29	n=17
L-PSLR in cm	88.5 (±17.9)	89.2 (±6.5)
R-PSLR in cm	88.5 (±17.9)	89.0 (±5.9)
Third	n=22	n=22
L-PSLR in cm	67.2 (±37.5)	83.7 (±27.0)
R-PSLR in cm	67.2 (±37.6)	84.5 (±28.1)
Fourth	n=24	n=14
L-PSLR in cm	83.0 (±11.7)	79.6 (±9.4)
R-PSLR in cm	84.0 (±12.1)	81.3 (±10.9)
Total	n=123	n=69
L-PSLR in cm	81.6 (±25.7)	84.1 (±19.9)
R-PSLR in cm	81.6 (±25.6)	84.6 (±20.0)

Key: cm = centimetre, LBP = low back pain, L = left, PSLR = passive straight leg raise, R = right, SD = standard deviation.

In subjects with LBP, the PSLR measurement in cm was less if compared to the subjects with no-LBP for all year groups except the third years. The largest difference between the left and right PSLR test within a year group between the subjects with LBP and no-LBP was the third years. A larger difference was noted between the left and right PSLR in the fourth year subjects with LBP and no-LBP if compared to the other year groups. The results of sensitivity to pain with posterior-anterior (PA) mobilisations, the recruitment of lumbar multifidus (LM) and transversus abdominis (TrA) are shown in chapter 4. The cross-sectional area (CSA) of LM are discussed next.

Lumbar multifidus cross-sectional area large side versus small side on level L4 with ultrasound imaging

In Table 4.18: Cross-Sectional Area of the Lumbar Multifidus Mean (SD) at L4 Vertebral Level for Students with Low Back Pain and No-Low Back Pain in the main document the CSA of LM at L4 are given for the students with and with no-LBP. The measurements were arranged according to the large and small side instead of left versus right side. In Table 4 the ratio (R/L) between the left and right side of CSA of LM of students with and without LBP are shown.

Table 4 Mean (SD) of R/L cross-sectional area in cm² of lumbar multifidus at L4 by low back pain prevalence and study year (n=168).

Year level	R/L LM CSA		*Difference	Total
	No-LBP (n)	LBP (n)		
1st year				
n (%)	41(24.4)	14(8.3)		55(32.7)
Mean(SD)	99.94 (±9.99)	101.21 (±12.24)	-1.27(±-2.25)	100.27 (±10.51)
2nd year				
n (%)	28(16.7)	17(10.1)		45(26.8)
Mean(SD)	96.29 (±12.03)	102.84 (±11.89)	-6.55 (±0.14)	98.76 (±12.27)
3rd year				
n (%)	15(8.9)	17(10.1)		32(19.0)
Mean(SD)	93.24 (±11.27)	104.32 (±16.99)	-11.08(±-5.72)	99.13 (±15.43)
4th year				
n (%)	23(13.7)	13(7.7)		36(21.4)
Mean(SD)	97.36 (±8.64)	103.92 (±17.94)	-6.56(±-9.3)	99.73 (±12.94)
Total				
n (%)	107(63.7)	61(36.3)		168(100)
Mean(SD)	97.49 (±10.59)	103.11 (±14.59)	-5.62(±-4)	99.53 (±12.45)

Key: *Difference calculated by R/L no-LBP side minus the LBP side, LBP = low back pain, SD = standard deviation, R = right, L = left, L4 = 4th lumbar vertebrae, LM = lumbar multifidus, cm²= cubic centimetre, CSA = cross sectional area.

In students without LBP, the differences between the left and right side of LM is small with the left side being larger than the right side. The third years have a larger difference between left and right, followed by the second years. In the students with LBP, the right side was larger compared to the left side. In the third year group, the largest difference was noted between left and right.

The left and right side of transversus abdominis measurements during rest and contraction with ultrasound imaging

The abdominal wall consists of obliquus internus abdominis (OI), transversus abdominis (TrA) and the slide of the anterior abdominal fascia. The measurements are obtained by diagnostic ultrasound (USI). The width and length of pull of the muscles during rest and a contraction in students with LBP and no-LBP is summarised in Table 4.18.

The results of Objective three and four are shown in the main document from Table 4.20 to Table 4.22.

APPENDIX 15

- ETHICAL CLEARANCE CERTIFICATE

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Division of the Deputy Registrar (Research)

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
R14/49 Ms SM Burger

CLEARANCE CERTIFICATE	**M090929**
PROJECT	The Prevalence and Risk Factors of Low Back Pain in Physiotherapy Students at the University of the Witwatersrand
INVESTIGATORS	Ms SM Burger.
DEPARTMENT	Physiotherapy Department
DATE CONSIDERED	2009/10/02
DECISION OF THE COMMITTEE*	Approved unconditionally

Unless otherwise specified this ethical clearance is valid for 5 years and may be renewed upon application.

DATE 2009/10/02 **CHAIRPERSON** ....
(Professor PE Cleaton-Jones)

*Guidelines for written 'informed consent' attached where applicable

cc: Supervisor : H Myezwa

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University.
I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to a completion of a yearly progress report.**

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES...

....