The Association between Trunk Muscle Endurance and Lumbar-Pelvic Instability in Adolescent Low Back Pain

Françoise Lewis

Supervisors:
Wendy-Ann Wood
Benita Naude

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DECLARATION

I, Françoise Louise Lewis, declare that this research report is my own work. It is being submitted in partial fulfilment for the degree of Masters of Science in Physiotherapy at the University of the Witwatersrand, Gauteng. It has not been submitted before, for any degree or examination, at this or any other University.

Assistance with the statistical design and data analysis was given by a statistician.

Françoise Louise Lewis **Date**

ABSTRACT

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Low back pain (LBP) is a common cause of discomfort in modern society, and the prevalence of LBP in the adolescent population is high and has a predictive value for the occurrence of LBP as an adult.

The aim of the study was to investigate the association between adolescent LBP and trunk muscle endurance and lumbar-pelvic instability, as well as the association between trunk muscle endurance and lumbar-pelvic instability. Sports and physical activity participation, sedentary activity participation and a family history were also investigated as they have been identified in previous studies as potential risk factors.

The study was a cross sectional study of 80 adolescents in grade 8 to grade 11, aged 12 to 17 years, at three high schools in Gauteng, who agreed to participate in the study. Data was collected by means of a validated questionnaire and a physical examination. The level of significance for associated factors was set at 0.05.

The results revealed a lifetime prevalence of 82.50%, one year prevalence of 78.80% and point prevalence of 23.80%. Adolescents with LBP have decreased endurance of the trunk extensor muscles but increased endurance of the trunk flexor muscles, which is statistically significant ($p=0.044$). Lumbar-pelvic instability is not associated with adolescent LBP. Extensor trunk muscle endurance and poor lumbar pelvic stability show an association ($p=0.031$), with those adolescents with decreased trunk extensor muscle endurance presenting with poor lumbar-pelvic stability.

A family history of LBP is significant for point prevalence of LBP ($p=0.012$), and one-year prevalence of LBP is marginally significant ($p=0.086$). Low activity level participation was reported by a large percentage of all subjects. Sedentary activity participation is moderate in the LBP group, but the results are not statistically significant.

There is a need for preventative strategies to decrease the prevalence of adolescent LBP. Increased awareness of LBP and potential risk factors needs to be addressed.

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LIST OF ABBREVIATIONS

ASLR	active straight leg raise
BMI	body mass index
cm	centimetre
End	endurance
Ext	extension
Flex	flexion
kg	kilograms
L	left
LBP	low back pain
Prev	Prevalence
PSIS	posterior superior iliac spine
R	right

CHAPTER 1 - INTRODUCTION

1.1 INTRODUCTION AND PROBLEM STATEMENT

Low Back Pain (LBP) is an extremely common cause of discomfort in modern society (Limon et al, 2004). LBP in school aged children is more frequent than previously thought (Burton et al, 2006). It has been suggested that the study of adolescent LBP may give insight into the common occurrence of adult LBP (Fairbank et al, 1984), and that adolescent LBP has important consequences for the occurrence of adult LBP (Watson et al, 2002).

In the adult population recurrent and chronic back pain is one of the highest causes responsible for absenteeism from work (Andersen et al, 2006; Burton et al, 2006), with the lifetime prevalence of non-specific LBP in industrialised countries estimated between 60% to 70% (Burton et al, 2006; Burton, 2005).

LBP causes a major economic and medical problem (Taimela et al, 1997). A previous history of LBP and early onset of LBP show an association with adult LBP, therefore preventing LBP in adolescents may have a positive impact in adulthood (Feldman et al, 2001). It is important to understand the link between adolescent and adult LBP if preventative programmes are to be effective (Hestbaek et al, 2006). Research must focus on the young population (Hestbaek et al, 2006; Leboeuf-Yde and Kyvik K, 1998) as it has been shown that more than half the population will have LBP before the age of 20 (Hestbaek et al, 2006).

Numerous possible risk factors for the occurrence of adolescent LBP have been identified (Bernard et al, 2008; Arab et al, 2007; Andersen et al 2006; Evans et al, 2006; Mikkelson et al, 2006; Demoulin et al, 2004; Sjolie and Ljunggren, 2001; Ito et al, 1996; Salminen et al, 1992). Subjects with LBP present with trunk muscle impairment (Ito et al, 1996), with muscle imbalances and movement dysfunction in either the local or the global muscle system (Comerford and Mottram, 2001).

A multidisciplinary approach and perspective studies are necessary when dealing with adolescent LBP as the experience and expression of pain is influenced by maturation of the musculoskeletal, emotional and cognitive systems, and is influenced by the social and psychosocial surroundings (Taimela et al, 1997).

An extensive literature review revealed that lumbar-pelvic stability and trunk muscle endurance in adolescents have not been investigated in the same study. Decreased trunk muscle endurance is significantly associated with adolescent LBP

(Bernard et al, 2008; Arab et al, 2007; Salminen et al, 1992), but no association has been recorded between lumbar-pelvic instability and adolescent LBP (Jordaan, 2005). This study will investigate both trunk muscle endurance and lumbar-pelvic instability. The contribution of physical risk factors remains uncertain, with the evidence of the association between adolescent LBP and risk factors conflicting and limited (Perry et al, 2009).

Identification of possible risk factors that can be modified in adolescent LBP is important for effective management and prevention of future LBP as an adult (Perry et al, 2009).

1.2 RELEVANCE OF THE STUDY

The reported prevalence of adolescent LBP is high and represents a public health issue. The South African Department of Health (Health Protocol 1999) highlight the need to provide for appropriate child and adolescent health services essential for the foundation for growth and development. There is limited research available on the adolescent population in South Africa in regards to LBP. This research report will be a primary step in an important public health issue. By determining the aetiological factors of adolescent LBP it will be possible to put into place cost-effective preventative strategies or rehabilitation programmes that will benefit the adolescent.

1.3 RESEARCH QUESTION

The research question is:

Is decreased lumbar muscle endurance and lumbar-pelvic instability associated with adolescent low back pain?

1.4 STUDY OBJECTIVES

1.4.1 Aim of the study

The aim of the study is to establish the association between decreased trunk muscle endurance and lumbar-pelvic instability in adolescent low back pain.

1.4.2 Objectives

1. To establish the association between decreased trunk muscle endurance and LBP in adolescents.
2. To establish the association between lumbar-pelvic instability and LBP in adolescents. .

3. To establish the association between trunk muscle endurance and lumbar-pelvic instability in adolescents

1.5 ORGANISATION OF THE RESEARCH REPORT

Chapter 1

An introduction to the research topic is given in this chapter. The problem of adolescent and adult LBP is presented. The research question and aims and objectives of the research report are laid out.

Chapter 2

A review of the literature is presented in this chapter. Aspects included in the literature review include: adolescent LBP, adult LBP, the link between adolescent and adult LBP, Lumbar spine function and stability, muscle function, lumbar-pelvic stability and lumbar dysfunction.

Chapter 3

The methodology of the study is presented in this chapter. It will include the sample population and size as well as the inclusion and exclusion criteria. The measuring instruments and the physical assessment used for data collection will be discussed. Ethical consideration and statistical analysis will also be covered in this chapter.

Chapter 4

The results of the statistical analysis are presented, interpreted and discussed in this chapter

Chapter 5

The main findings of the study are discussed in this chapter.

Chapter 6

The conclusion of the study is discussed in this chapter, as well as clinical recommendations and recommendations for future research.

CHAPTER 2 – LITERATURE REVIEW

2.1 INTRODUCTION

This chapter will review the current literature covering adolescent LBP, adult LBP and the possible link between adolescent and adult LBP. Spinal function and dysfunction will be reviewed. The literature revealed no studies covering the development or occurrence of lumbar dysfunction in adolescents. Lumbar spine mechanics and dysfunction in adults will therefore be discussed. Risk factors for the development of adolescent LBP will be presented and discussed.

A literature search was conducted on the following databases: Pub Med and Pedro and included English Articles published between 1992 and June 2009. Keywords used were adolescent, adult, anthropometric, dysfunction, endurance, epidemiology, growth, instability, low back pain, motor control, prevalence, and risk factors.

2.2 LOW BACK PAIN

"Pain is a complex symptom that can be affected by a variety of physical and psychological factors" (Barr et al, 2007).

2.2.1 Introduction

LBP is defined as pain and discomfort, localised below the costal margin and above the inferior gluteal folds, with or without leg pain, not attributed to recognisable, known specific pathology (Masiero et al, 2008; Burton et al, 2006). Non-specific LBP is defined as LBP not attributed to recognisable, known specific pathology (Burton et al, 2006). In 85% of people, pain cannot be attributed to pathology (Burton, 2005). LBP is rarely a self-limiting disorder but is characterised by unpredictable variations in pain status with temporary remissions (Hestbaek et al, 2006). LBP is an issue for all ages and in all sectors of society (Burton, 2005).

This section will give an overview of the prevalence of LBP in adolescent and adults, and the possible link between adolescent and adult LBP.

2.2.2 Low back pain in Adolescents

The knowledge of the natural course of adolescent LBP is limited (Hestbaek et al, 2006). The prevalence of adolescent LBP is relatively high (Burton et al, 1996), but the understanding regarding the aetiology of such pain is poor (Watson et al, 2003).

Adolescent LBP was previously thought to be rare and indicate serious pathology (Andersen et al, 2006; Balague et al, 1999). Later studies reveal that LBP in school children is much more frequent than previously thought (Burton et al, 2006), and is a common complaint in adolescents (Andersen et al, 2006; Kovacs et al, 2003; Feldman et al, 2001; Burton et al, 1996; Taimela et al, 1997; Fairbank et al, 1984), with the prevalence of LBP during school age approaching that seen in adults (Burton et al, 2006; Burton, 2005). Adolescent LBP becomes increasingly recurrent with time (Taimela et al, 1997; Burton et al, 1996).

Studies of low back pain in children indicate that LBP during school years has a relatively high prevalence. Statistics vary from country to country: Finland 20%, England 26%, Canada 33%, United States 36% and Switzerland 51% (Burton et al, 1996). In a study of 7542 adolescents in a study by Masiero et al. (2008), the reported prevalence of LBP was 20.5%. Balague et al. (1999) reported the lifetime prevalence of LBP among children and adolescents between 31% and 51%. The results of a prevalence study conducted in North Gauteng, South Africa, indicate a lifetime prevalence of adolescent LBP of 52.6%, one- year prevalence of 50% and point prevalence of 14.7% (Jordaan, 2005).

The understanding regarding the aetiology of adolescent LBP with no apparent clinical cause is poor (Watson et al, 2003), but serious pathology is uncommon (Watson et al, 2002). LBP in school children is a health problem that requires more attention and resources (Masiero et al, 2008), with the possibility that the study of adolescent LBP may give insight into the common occurrence of adult LBP (Fairbank et al, 1984), as a previous history and early onset of LBP are associated with adult LBP (Feldman et al, 2001). The symptom of LBP in adolescents may have important consequences for the occurrence of adulthood LBP, particularly as it is so common (Watson et al, 2002).

2.2.3 Low back pain in Adults

LBP is an issue for all ages and all sectors of society (Burton et al, 2006; Burton, 2005). Non-specific LBP in industrialised countries remains a major public health burden (Demoulin et al, 2004). The lifetime prevalence of non-specific adult LBP in industrialized countries is estimated between 60-90% (Burton et al, 2006; Burton, 2005; Pool-Goudzwaard et al, 1998; Salminen et al, 1995), with the incidence increasing with age (Harreby, 1995), making LBP one of the most common and costly complaints in today’s society (Arab et al, 2007). At least 10% of adult LBP becomes chronic. This represents a significant economic and medical problem (Taimela et al, 1997). The cause in 70% to 80% of individuals is unclear (Pool-Goudzwaard et al, 1998). Many adults forget their earlier episodes of adolescent LBP, none the less, some adolescent experience of LBP may subsequently relate to symptoms as an adult (Burton et al, 1996). LBP in adulthood has a high prevalence and a large impact on individuals and society, requiring studies on the early stages of the problem (Salminen et al, 1995; Salminen et al, 1992).

2.2.4 Adolescence to Adulthood

Recent surveys report a high prevalence of LBP in children and adolescents that increases with age, with a positive correlation between low back pain in adolescence and that experienced in adulthood (Limon et al, 2004; Balague et al, 1999). It has been suggested that the investigations into adolescent LBP may give insight into the frequent presentation of adult LBP (Fairbank et al, 1984), as adolescent LBP may have a predictive value for the occurrence of adult LBP (Hestbaek et al, 2006; Limon et al, 2004; Feldman et al, 2001; Balague et al, 1999). A cohort study by Hestbaek et al. (2006) covered the transition from childhood into adulthood and showed a significant increase in the probability of getting LBP as an adult, if the subject had adolescent LBP. LBP in adolescence is a significant risk factor for adult LBP (Andersen et al, 2006; Hestbaek et al, 2006; Burton, 2005; Feldman et al, 2001; Harreby, 1995) and the risk increases with increasing duration of LBP in adolescence, and is independent of age and gender (Hestbaek et al, 2006). In a study by Brattberg as cited by Balague et al. (1999), it was reported that adult subjects who reported adolescent LBP, demonstrated higher cumulated and point prevalence of LBP, a higher number of hospital admissions for LBP as well as reduced work capacity.

In a review of current literature Burton et al. (2006) concluded that there is no evidence that attempts to prevent LBP in schoolchildren will have any impact on adult LBP, but states that the most powerful risk factor for LBP is a previous history of LBP. A need exists to establish the nature of the association between adolescent LBP and adult LBP (Hestbaek et al, 2006). Implementing preventative measures in schools might serve an important function (Harreby, 1995), and have a positive impact in adulthood (Feldman et al, 2001).

Understanding the aetiology of adolescent LBP may help to understand the aetiology of adult LBP and may assist in designing appropriate interventions to relieve the burden of chronic adult LBP on society (Watson et al, 2002).

2.3 RISK FACTORS FOR ADOLESCENT LOW BACK PAIN

2.3.1 Age

Prevalence and incidence of adolescent LBP increases with age (Watson et al, 2002; Feldman et al, 2001; Balague et al, 1999; Taimela et al, 1997; Burton et al, 1996; Harreby, 1995; Salminen et al, 1992), particularly evident among children thirteen years of age or older (Balague et al, 1994; Balague et al, 1993). In a longitudinal study by Burton et al. (1996) lifetime prevalence of LBP rose from 11.6% at age 11+ to 50.4% at age 15+, on average a 10% annual increase. In a study by Andersen et al. (2006) the mean age of reported first time LBP was 13.3 years.

Lebouef-Yde and Kyvik. (1998) documented the reporting of LBP in girls slightly earlier than boys, possibly at the time of puberty, but Fairbank et al. (1984) reports the age of onset to peak at age 14 in girls and age 13 in boys. Grimmer and Williams (2000), reported an elevated prevalence in boys a year later than in girls, which may reflect a relationship between LBP and rapidly growing musculoskeletal structures. Korovessis et al. (2004) reports girls show the highest prevalence of LBP at age 11 years, and boys at 15 years, with a progressive increase in LBP with the onset of puberty till 15 years of age.

The difference seen between the genders with regards to age at which LBP is first experienced may be due to gender differences in peak growth rates, with girls' growth rates peaking at 13 years and boys' growth rates peaking at 15 years of age (Grimmer and Williams, 2000).

2.3.2 Gender

The prevalence of back pain appears to be higher among girls than among boys (Masiero et al, 2008; Korovessis et al, 2004; Kovacs et al, 2003; van Gent et al, 2003; Watson et al, 2002; Grimmer and Williams, 2000; Balague et al, 1999; Balague et al, 1994), with female gender a significant risk factor for adolescent LBP (Balague et al, 1999).

Burton et al. (1996) reported a similar prevalence in boys and girls up to the age of 11+ but thereafter boys reported a higher prevalence, with 60% prevalence in boys 15+ and 40% prevalence in girls 15+. Taimela et al. (1997) report no difference in the prevalence of LBP in girls and boys.

2.3.3 Family History

There is significant association between adolescent LBP and a positive family history of LBP (Masiero et al, 2008; Balague et al, 1999; Balague et al, 1994). Children with a parent who has been treated for LBP are more likely to report LBP themselves (Balague et al, 1994), Sjolie, (2004), Sjolie, (2002) and Harreby et al. (1995), report no association between adolescent LBP and a familial history of LBP.

2.3.4 Anthropometric Parameters

Balague et al. (1999) state that the association between LBP and anthropometric factors remains unproved. A number of studies report no association between any anthropometric characteristics and LBP (Masiero et al, 2008; Korovessis et al, 2004; Kovacs et al, 2003; Watson et al, 2003; Grimmer and Williams, 2000; Salminen et al, 1995). In a study by Fairbank et al. (1984) an association between increased weight and the occurrence of LBP has been reported, and in a study by Salminen et al. (1992) they noted that symptomatic boys of 15 years of age were taller than asymptomatic boys.

2.3.5 Physical Activity

There are conflicting findings reported with regards to the association between LBP and physical activity. Some studies report an association between LBP and no physical activity or low frequency of physical activity participation, with sports avoiders reporting a higher prevalence of LBP (Masiero et al, 2008; Sjolie, 2004; van Gent et al, 2003; Salminen et al, 1995; Fairbank et al, 1984), while other studies report that high sports participation, particularly partaking in competitive sports activities, is significantly associated with LBP (Burton et al, 2006; Jordaan, 2005; Watson et al,2003; Balague et al, 1999; Balague et al, 1994), with the risk dependent on the type of activity or sport, the level of competition and the intensity of training (Balague et al, 1999). Sjolie (2004) state that time spent participating in physical activity is proportionally associated with decreasing levels of LBP (Sjolie, 2004).

It has been suggested that low activity subjects demonstrate muscle atrophy (Salminen et al, 1995) and decreased muscle endurance (Andersen et al, 2006), and could be the cause of LBP, or the consequence of recurrent or continuous LBP (Salminen et al, 1995), while regular participation in sports appears to be protective of LBP in adolescents (Grimmer and Williams, 2000), with regular performance of non-strenuous physical activity important for trunk muscle strength and endurance (Limon et al, 2004). Participating in regular physical activity could prevent LBP, due to correctly performed motor activity which results in improved muscle strength and flexibility (Masiero et al, 2008). Physical activity during adolescence and growth builds trunk strength and endurance and may improve the development of the low back musculature structures which may facilitate optimal low back function (Mikkelson et al, 2006).

Sports activity of between 0-8 hours a week seems to be safe according to Balague et al. (1994). The risk of injuries increases when the frequency of training is more than 10 hours a week (Balague et al, 1994), while Kovacs et al. (2003) report that participation of any sports activity more than twice a week is significantly associated with LBP.

The benefits of participating in physical activity during adolescence as a predictor of reduced adult LBP needs further investigation (Mikkelson et al, 2006). Burton (2005) summarised the European guidelines for prevention in LBP in which it was concluded that there is no evidence that sports participation or being physically active has a preventative effect on adolescent LBP, and that there is insufficient evidence to recommend a limitation of involvement in competitive sports participation as a preventative measure for adolescent LBP.

2.3.6 Sedentary Activity

Prevalence of adolescent LBP increases as sedentary activity levels increase (Jordaan, 2005; Grimmer and Williams, 2000; Balague et al, 1999; Balague et al, 1994). Sjolie, (2004) reports a positive correlation between adolescent LBP and more than 15 hours per week spent watching television or computer work. It is suggested that this could be due to the prolonged sitting position, bad posture and the lack of physical activity (Balague et al, 1999; Balague et al, 1994).

Other studies report no association between LBP and hours of partaking in sedentary activities, including, watching television and using computers (Kovacs et al, 2003; van Gent et al, 2003; Watson et al, 2003).

Burton (2005) summarised the European guidelines for prevention in LBP in which it was concluded that there is no evidence that decreasing sedentary activities will have a preventative effect on adolescent LBP.

2.3.7 Muscle Endurance

Muscle endurance is defined as the ability to produce work over time or the ability to sustain effort (Ito et al, 1996). Muscle endurance has been shown to be protective against LBP (McGill, 2001). Decreased trunk muscle endurance, with a modified back flexor to extensor ratio, has been recorded in adolescents with LBP and identified as a potential risk factor for LBP as loss of muscle control follows trunk muscle fatigue (Bernard et al, 2008; Arab et al, 2007; Andersen et al, 2006; Evans et al, 2006;

Mikkelson et al, 2006; Demoulin et al, 2004; Sjolie and Ljunggren, 2001; Ito et al, 1996; Salminen et al, 1992). Conversely high back muscle endurance strength is associated with low risk of back pain. Adolescents with high isometric back extensor endurance have a lower risk of back pain (Andersen et al, 2006).
It is possible a causal relationship exists between LBP and decreased stability (Sjolie and Ljunggren, 2001). Andersen et al. (2006) state that it is not possible to tell which came first, LBP or low muscle endurance, but the association that exists between LBP and muscle endurance may indicate that isometric muscle endurance may protect against back pain. To protect the passive structures of the lumbar spine from injury the ability of the trunk muscles to maintain appropriate levels of activation over long periods of time may be more important than maximum strength (Evans et al, 2006).

Testing trunk muscle endurance is important in the prediction, prevention and rehabilitation of low back pain. Imbalance in trunk muscle strength between agonists and antagonists muscles may be a risk factor for low back pain (Arab et al, 2007).

Muscle endurance can be increased by means of muscle stabilisation programmes in both healthy subjects and LBP patients, therefore if low muscle endurance is the, or partly the cause of LBP, it may be possible to treat or prevent LBP (Andersen et al, 2006). Burton, (2005) summarised the European guidelines for prevention in LBP in which it was concluded that there is insufficient evidence for or against muscle strengthening as a preventative measure for adolescent LBP.

2.3.8 Lumbar-Pelvic Stability

In a study by Jordaan (2005), no association was found between adolescent LBP and lumbar-pelvic instability. No other studies in the literature were found investigating lumbar-pelvic instability in adolescents. Poor lumbar-pelvic instability has been found to be associated with LBP in the adult population. Subjects with SIJ pain demonstrate altered motor control strategies during ASLR in an attempt to compensate for the deficit neuromuscular system to enhance form and/or force closure of the pelvis during load transfer (O'Sullivan et al, 2002).

Subjects presenting with pain present with an altered ASLR demonstrating altered breathing patterns and kinematics of the diaphragm and pelvic floor. There is decreased diaphragmatic motion in an attempt to brace or splint in conjunction with increased intra-abdominal pressure. This may be an attempt to control load transfer through the lumbo-pelvic region (O'Sullivan et al, 2002).

2.3.9 Emotional Status

An association appears to exist between adolescent LBP, psychosomatic factors and emotional problems (van Gent et al, 2003; Watson et al, 2003; Balague et al, 1999), with an association reported between poor mental health and the development of LBP (Feldman et al, 2001). Poor well being and in particular the perception of poor fitness is associated with adolescent LBP. It is possible that poor wellbeing may exaggerate the perception of LBP (Sjolie, 2002).

2.3.10 Schoolbag

The load that most adolescents or children carry daily is their school bag (Negrini et al, 1999). It has been suggested that daily carrying of heavy school bags by students increases the stresses applied on the spinal structures which are undergoing rapid growth, with the possibility of structural damage (Korovessis et al, 2004). School bag weight has been presumed to be a risk factor for LBP but without clear scientific evidence (van Gent et al, 2003). A review of current literature by Burton, (2005) and Burton et al. (2006) concluded that there is no consistent evidence for or against recommending a limit to school bag weight as a preventative measure for adolescent low back pain.

No association exists between LBP and method of carrying school books (Korovessis et al, 2004; Kovacs et al, 2003). While in a study by Jordaan (2005) it was found that asymmetrical mode of carrying school bags over one shoulder or in one hand increases the prevalence of LBP however this result was not statistically significant for lifetime prevalence or one-year prevalence. Grimmer and Williams (2000) report that longer periods of time carrying heavy pack backs is strongly associated with adolescent LBP.

In a study by Limon et al. (2004) they report a large proportion of the adolescents involved in the study carried more than 15% of their body weight, which they state is above the recommendation by experts of 10 to 15% of body weight, although these limits are scientifically unproven. No correlation exists between the weight of the back pack carried and adolescent LBP (Korovessis et al, 2004; Watson et al, 2003), but an association exists between the perceived weight of the schoolbag and the complaint of LBP (van Gent et al, 2003).

Burton (2005) summarised the European guidelines for prevention in LBP in which it was concluded that there is no consistent evidence for or against recommending a limit to schoolbag weight as a preventative measure for adolescent LBP.

2.4 LUMBAR SPINE STABILITY

2.4.1 Introduction

Stability is a dynamic process involving static positions and controlled movement. The biomechanical system of the spine and the efficiency of the system and the longevity of the components are dependent on the precise function of the individual segments (Barr et al, 2005).

Altered lumbar spine biomechanics play a role in spinal pathology and pain (Barr et al, 2005). Dysfunctional movement patterns caused by changes in strength, poor endurance, changes in flexibility, or abnormal neural control will result in tissue damage, which would result in decreased stability of the spinal structures. This decreased stability would result in increased demand placed on the already inefficient muscles, resulting in a dysfunctional degeneration cascade (Barr et al, 2005).

This section will give an overview of lumbar spine stability, classification, muscle function, lumbar-pelvic stability, and dysfunction.

2.4.2 Classification

2.4.2.1 Introduction

Panjabi has described a model for spinal stability that consists of three components: the passive system (oseoligamentous structures), the active system (the spinal muscles), and the neural control system (Barr et al, 2005). The interdependent function of the passive, active and neural subsystems, are responsible for spinal stability. A link exists between the passive subsystem and the neuromuscular systems (Jull and Richardson, 2000). These systems are interdependent with one system compensating for deficits in another. Dysfunction of the active system such as poor muscle endurance or decreased muscle strength and/or tissue damage affecting the passive system may make the segment more difficult to stabilise and result in instability (Barr et al, 2005).

Panjabi's classification system focuses on the creation of spinal stability and stiffness, but movement is also important. Movement of the spine assists with dissipating forces and reducing energy expenditure. Excessive spinal stiffness results in increased energy expenditure and increased load on the spinal segments (Barr et al, 2005).

2.4.2.2 Passive System

The bone and ligamentous structures make up the passive component contributing to spinal stability. They provide passive restraint towards the end of the range of movement, but offer less support to the spine in the neutral position (Barr et al, 2005; McGill, 2001). Panjabi has described the 'neutral zone' as the range of intervertebral motion within which the spinal motion is produced with minimal internal resistance. If there is laxity of the passive joint restraints the neutral zone may be abnormally increased. Instability can be due to an abnormal increase in the size of the neutral zone or due to a lack of dynamic muscle control of the neutral zone (Comerford and Mottram, 2001).

2.4.2.3 Active System

The second component contributing to spinal stability is made up of the muscles that surround the spine and provide support and stiffness at the intervertebral level (Barr et al, 2005). Stable joints can be created by moderate levels of muscle activity, with only a moderate degree of muscular coactivation of only 10% of maximal contraction needed to provide segment stability (Barr et al, 2005; McGill, 2001). The motor control system is able to control stability through co-ordinated muscle co-activation, and by placing the joints in positions that enhance the contribution by the passive restraints (McGill, 2001). Increased muscle coactivation is needed to stabilise a segmental level that has been damaged or compromised by ligamentous laxity or disc disease. Therefore endurance is more important than absolute muscle strength (Barr et al, 2005). Sudden loading of the spine or unpredictable activities require a strength reserve. The demands on both strength and endurance are increased in sports (Barr et al, 2005).

2.4.2.4 Neuromuscular System

The neural control system is the third component of spinal stability. It coordinates muscle activity in response to predicted and unpredicted forces. The correct muscles must be activated at the right time and in the right amount to perform the desired movement and protect the spine from injury (Barr et al, 2005; Comerford and Mottram, 2001; Brumagne et al, 2000), requiring sensory, biomechanical and motor-processing strategies together with learned responses (Comerford and Mottram, 2001). The neural control sub-system modulates the balance of movement and stiffness (Barr et al, 2005).

2.5 MUSCLE FUNCTION

2.5.1 Introduction

Throughout the last two decades there has been an increase in awareness of the importance and relevance of the specialised and integrated action of the muscle system in maintaining stability and optimal function of the musculoskeletal system (Comerford and

Mottram, 2001). The muscle system provides support to the articular structures through its function to aid stability (Richardson and Jull, 1995).

A number of muscles cross the spine and contribute to lumbar mobility and stability. The muscular system is a complicated system composed of the deep muscles and the superficial muscles. The deep muscles are responsible for the control of stiffness and intervertebral relationships, and have their origin or insertion on the lumbar vertebrae. The superficial muscle system consists of the large global muscles that produce torque for spinal movement and handle external loads applied to the spine (Barr et al, 2005).

Muscles can be classified in relation to function as stabiliser and mobiliser muscles. Three different functional muscle roles have been classified: the local stability muscles, the global stability muscles and the global mobility muscles (Comerford and Mottram, 2001). A cylinder of muscles, including multifidi, transversus abdominis, quadratus lumborum, the pelvic floor, and the diaphragm surrounds the spine to provide stability (Barr et al, 2005).

In spinal segments with structural damage, if the muscles are functioning correctly, they can compensate for structural deficits (Barr et al, 2005).

2.5.2 Local Stability Muscles

The local stability muscles maintain mechanical stiffness of the spine and control inter-segmental motion and the neutral joint position by increasing muscle stiffness. They are continuously active throughout the movement, activity is independent of the direction of movement and contraction produces no length change therefore no movement (Comerford and Mottram, 2001).

The local muscles, of which multifidus and transversus abdominis are components, attach directly to the lumbar vertebrae and are responsible for segmental stability and controlling the lumbar segment positions, and have the greatest ability to control the neutral zone (Barr et al, 2005; Richardson and Jull, 1995), and are capable of increasing spinal segmental stiffness (Jull and Richardson, 2000). Transversus abdominis and multifidi muscles function as both lumbar and pelvic stabilisers (Pool-Goudzwaard et al, 1998).

The lumbar multifidi control spinal motion, the motion of a lumbar segment and vertebral movement during posture and spinal movements, due to their short intervertebral attachments (Mac Donald et al, 2006). They serve to protect the articular structures, discs and ligaments from excessive strain and injury (Barr et al, 2005). The multifidus muscle has the capacity to restore control of segmental motion post injury (Mac Donald et al, 2006). The deep fibres of the multifidus muscle have a greater percentage of type I slow twitch muscle fibres which are vulnerable to the adverse effects of pain and immobilisation (MacDonald et al, 2006).

Transversus abdominis is attached to the vertebrae through the thoracolumbar fascia and stiffens the spine by increasing intra-abdominal pressure (Barr et al, 2005). Transversus abdominis is important in lumbar stabilisation and contracts with all trunk movements and is recruited prior to the other abdominal muscles (Richardson and Jull, 1995).

In healthy subjects, the deep fibres of multifidi and transversus abdominis contract prior to other muscles in anticipation of limb movement and fire independent of the direction of limb movement, to control intervertebral movement, to stabilise the spine and prevent unwanted spinal movement with limb movement (Barr et al, 2007; Barr et al, 2005; Richardson and Jull, 1995).
A cylinder of deep muscles surround the spine and provide stability, therefore spinal stability is not only dependent on multifidi and transversus abdominis (Barr et al, 2005).

The pelvic floor has an important function in lumbar stability. The pelvic floor muscles form the base of the abdominal cavity and contract during activities that increase intraabdominal pressure. In painfree subjects, strong voluntary contraction of the abdominal muscles causes pelvic floor muscle activity at the same intensity as maximal effort of the pelvic floor muscles. The pelvic floor muscles contract before the abdominal muscles and not simply as a response to increased intraabdominal pressure (Barr et al, 2005).

The diaphragm forms the roof of the cylinder and contributes to lumbar stability by increasing intraabdominal pressure. For transversus abdominis to increase tension in the thoracolumbar fascia, diaphragmatic activity is needed to prevent displacement of the abdominal viscera. In healthy subjects, lumbar stabilisation is assisted by diaphragmatic activation prior to large limb movement and is independent of the respiratory phase (Barr et al, 2005).

2.5.3 Global Stability Muscles

The global stabiliser muscles, of which quadratus lumborum and internal oblique muscles are components, generate force to control range of motion. They control movement throughout range by eccentric length change and low-load deceleration of momentum, and activity is direction dependent (Richardson and Jull, 1995). The global muscles are the large torque producing muscles which link the pelvis to the thoracic cage and provide general trunk stabilisation. These muscles minimise the forces on the spine by balancing the external loads (Richardson and Jull, 1995), and play a role in controlling spinal orientation (Jull and Richardson, 2000), The global muscles control trunk movement and provide co-contraction during tasks or activities such as lifting or walking, and include quadratus lumborum, lattisimus dorsi and the superficial spine flexors and extensors (Barr et al, 2007). Quadratus lumborum is a spine stabiliser (McGill, 2001), and a lateral stabiliser of the spine. It increases lumbar stiffness by its attachment through the thoracolumbar fascia to the transverse processes of the lumbar spine (Barr et al, 2005).

2.5.4 Global Mobility Muscles

The global mobiliser muscles, of which rectus abdominis and the erector spinae muscles are components, demonstrate non-continuous activity and generate torque to produce range of movement and concentric length change, therefore concentric production of movement and concentric acceleration of movement. The global mobilisers are important for shock absorption of load (Comerford and Mottram, 2001) and for balancing loads (Richardson and Jull, 1995).

Other trunk muscles assist in spinal stability, including external oblique, internal oblique, rectus abdominis, psoas major and the other paraspinal muscles. These muscles assist with maintaining stabilisation by load and direction-specific activity, and prevent unwanted trunk movement during limb movement and acceptance of loads to the trunk (Barr et al, 2005). Erector spinae muscles produce torque to create extension on the lumbar spine as well as intervertebral compression (MacDonald et al, 2006).

The superficial global muscles control spinal orientation by activation in a direction-specific response (Barr et al, 2005). Co-contraction of the lumbar superficial flexors and extensors is required to control spinal buckling (MacDonald et al, 2006).

2.5.6 Summary

To protect the passive structures of the lumbar spine from injury the ability of the trunk muscles to maintain appropriate levels of activation over long periods of time may be more important than maximum strength (Evans et al, 2006).

Muscle activation results in joint stiffness in a nonlinear fashion, with stiffness resulting in stability. Small levels of muscle activity create stiff and stable joints. Joints also possess inherent joint stiffness due to the passive restraints, particularly contributing to stiffness at the end of range of motion. Co-ordinated muscle coactivation controls stability of the joints, and to a lesser degree places joints in positions that allows passive stiffness contribution (McGill, 2001).

During sudden loading of the spine, stability is crucial in order to prevent the development of low back injuries. In situations where loading occurs, low levels of activity in the back muscles and the abdominal muscles are present, which increases spine stiffness and decreases the movement caused by sudden loading and assist in stabilising the spine (Essendrop, 2002).

It is hypothesised that for correct lumbar stabilisation, muscle endurance is more important than absolute muscle strength, as only a small percentage of maximal muscle contraction is needed to stabilise the spine (Barr et al, 2007).

2.6 MUSCLE ENDURANCE

Muscle endurance is defined as the ability of a muscle group to perform repeated contractions over a specific period that is sufficient to cause fatigue (Wilder et al, 2006). The endurance time in a contraction is the duration the required force can be maintained by the skeletal muscle, when the muscle fatigues it fails to maintain the force (Hagberg, 1981). The muscular load influence on the time of sustained contraction is a function of the percentage of the maximum voluntary contraction (MVC) (Hagberg, 1981). Sustained use results in muscle fatigue and an inability of the muscles to produce force or power. Fatigability may not de detected initially because the activity-induced weakness lessens quickly when the exertion stops; the degree of weakness is not profound; it is not tested for. The sustained muscle activity that induces fatigue is a physiological process that depends on changing states induced by activation of spared peripheral and central axons and neurons and compromised muscle (Dobkin, 2008).

Variables that may influence the onset of fatigue include: the subjects motivation; the pattern of motor unit activation; and intensity and duration of activity (Dobkin, 2008). At sustained contraction levels above 15-20% of MVC the rapid decrease in endurance times is due to impairment in blood flow resulting in ischemia due to increased intramuscular pressure. There is an accumulation of metabolites and a depletion of energy compounds resulting in an impaired contraction process causing localised muscle fatigue (Hagberg, 1981).

Interventions to increase motor reserve include endurance and strengthening exercises, varying the biomechanical requirements of repetitive muscle contraction, pharmacological intervention to enhance synaptic efficacy, and training-induced neural plasticity (Dobkin, 2008).

Muscle strength and endurance can be improved in childhood and adolescents by means of higher repetition-moderate load resistance training programmes during the initial adaptation period (Faigenbaum et al, 1999).

2.7 LUMBAR-PELVIC STABILITY

Intervertebral control, control of spinal orientation, and control of whole body equilibrium are required for lumbar-pelvic stability (Barr et al, 2005). Effective stabilisation of the sacroiliac joints (SIJ's) is required as load transfer from the spine to the pelvis passes through these joints. Stabilisation of the SIJ can be increased by form closure or force closure. Form closure is the interlocking of the ridges and grooves on the joint surfaces, and force closure is the compressive forces of the muscles, the ligaments and the fascia (Pool-Goudzwaard et al, 1998).

Load transfer can be altered negatively by muscle weakness or insufficient ligament tension. Lumbar-pelvic stability depends on the ligaments around the SIJ, the thoracolumbar fascia as well as several muscles including transversus abdominis and multifidus muscles. The thoracolumbar fascia plays an important role in force transfer, especially in stabilisation of the lower lumbar spine and the sacro-iliac joints. Contraction of the muscles that attach to the thoracolumbar fascia including the multifidi muscles can increase the tension in the fascia. Due to its connection with the upper and lower limbs, the fascia is capable of transmitting forces from the lower to the upper limbs and vice versa. Several muscles contribute to force closure. Three muscle slings have been described: a longitudinal sling; a posterior oblique sling; and an anterior oblique sling. The longitudinal sling consists of the multifidus muscle attached to the sacrum, the deep layer of the thoracolumbar fascia, and the sacrotuberous ligament. The posterior oblique sling consists of the coupled function of the lattisimus dorsi muscle and the gluteus maximus muscle. The anterior oblique sling consists of the transversus abdominis muscle and the external and internal oblique muscles. Contraction of the muscles making up the slings can ensure stabilisation of the SIJ's (Pool-Goudzwaard et al, 1998).

The active straight leg raise test (ASLR test) is an indicator of lumbar-pelvic stability (Mens et al, 2001) and measures the functional integrity of the transverses abdominis and multifidus muscles, which are classified as local stabiliser muscles. ASLR is a low level physical load in painfree subjects, with the predominant motor control pattern of ipsilateral tonic activation of the abdominal wall and chest wall (Beales et al, 2008). ASLR in

painfree individuals shows a predominant local motor control strategy with minimal intra-abdominal pressure change (Beales et al, 2008). The mono-articular stabiliser muscles (multifidus and transversus abdominis) should activate early. Dysfunction of the local stability muscles is due to alteration of normal motor recruitment resulting in loss of segmental control and loss of control of joint neutral (Comerford and Mottram, 2001).

2.8 DYSFUNCTION

2.8.1 Introduction

The biomechanics of individuals with non-specific LBP differs from healthy individuals (Barr et al, 2007), with trunk muscle impairment related to LBP pathology (Ito et al, 1996). Muscle imbalances and movement dysfunction predominate in the presence of pathology (Comerford and Mottram, 2001).

Pain and pathology show an association with dysfunctional motor recruitment of the local and global stabiliser systems (Comerford and Mottram, 2001). Subjects with LBP present with muscle dysfunction and poor motor control of the deep muscles of the trunk and back (Jull and Richardson, 2000) and the stabilisation function of the anti-gravity muscles is affected (Richardson and Jull, 1995). Subjects with LBP present with diminished muscle strength and endurance (Barr et al, 2005).

A dysfunctional motor control system can result in inappropriate levels of muscle force and stiffness resulting in joint buckling or shear translation (McGill, 2001) resulting in increased risk of injury (Brumagne et al, 2000).

2.8.2 Muscle Dysfunction

2.8.2.1 Local Stability Muscles

Dysfunction in the local stability system presents as abnormal segmental control and recruitment deficits resulting in poor control of the neutral zone. Abnormal segmental control can present as excessive or uncontrolled segmental translation or segmental loss of muscle cross- sectional area at the site of dysfunction. Motor recruitment deficits may present as altered timing or altered patterns of recruitment (Comerford and Mottram, 2001). In subjects with LBP, lumbar stabilisation deficits appear with a dysfunctional deep stability system (Barr et al, 2005; Richardson and Jull, 1995). Poor spinal stability and pain may be caused by changes in a spinal segment that allows excessive segmental movement. Instability may be caused by disc disease, decreased muscle strength, poor endurance, inefficient neural control, or motor control errors, resulting in increased load on the passive structures (Barr et al, 2005; Barr et al, 2007).

A motor control error in which there is reduced activation of the intersegmental muscles can result in rotation at an intervertebral level and may result in spinal buckling resulting in injury (McGill, 2001). A muscle which has an inappropriate force or a damaged passive tissue can cause instability in one or more dimensions, as the spinal joints rotate in three planes and translate along three axes (McGill, 2001).). The anticipatory recruitment and increase in protective intra-abdominal pressure and stiffening of the spine is no longer effective in subjects with LBP, resulting in altered recruitment and the development of uncontrolled movement and a loss of dynamic stability (Comerford and Mottram, 2001).

Changes specific to the lumbar multifidus occurs in subjects with LBP (MacDonald et al, 2006; Pool-Goudzwaard et al, 1998), with muscle atrophy demonstrated (Barr et al, 2007; Barr et al, 2005; Pool-Goudzwaard et al, 1998), which does not resolve spontaneously without specific treatment, even when the pain has resolved (Barr et al, 2007; Barr et al, 2005). A specific exercise training programme has shown to be effective to reverse the multifidi muscle atrophy (Barr et al, 2005).

The transversus abdominis muscle demonstrates dysfunctional activity in subjects with LBP (Barr et al, 2005; Pool-Goudzwaard et al, 1998), with the prime movers activating before the delayed transversus abdominis, resulting in poor lumbar spine and pelvic stabilisation (Barr et al, 2007; Barr et al, 2005; Comerford and Mottram, 2001; Pool-Goudzwaard et al, 1998).

Through this motor control change in both the multifidus muscles and transversus abdominis muscle, co-ordination between the multifidi and transversus abdominis muscle, which are thought to possibly be the initiators of force closure, will be disturbed (Pool-Goudzwaard et al, 1998).

2.8.2.2 Global Stability Muscles

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Dysfunction in the global system presents as an imbalance between the mono-articular stability muscles and the bi-articular mobility muscles. This imbalance is due to three causes: length associated changes related to muscle function; imbalance in synergistic or antagonistic muscle recruitment; and direction dependent relative stiffness and compensation (Comerford and Mottram, 2001). Weaker isometric and isotonic back extensor muscle strength and decreased muscle endurance have been identified in subjects presenting with LBP (Barr et al, 2005). Weak back extensor muscles play a role in the pathogenesis of back problems (Andersen et al, 2006). Decreased isometric strength is one of several factors associated with back pain (Barr et al, 2007). A significant risk factor for the development of LBP appears to be decreased muscle endurance (Ito et al, 1996). Individuals with LBP demonstrate abnormal trunk flexor-to-

extensor strength ratios (Barr et al, 2005). Trunk flexor to extensor ratio may be more important than endurance or absolute strength (Barr et al, 2007).

2.8.3 Compensation Mechanisms

A damaged passive tissue that has lost stiffness or a single muscle with an inappropriate force can result in instability (McGill, 2001). Dysfunction in the passive stabilising system may be compensated for by coactivation of the global muscles resulting in dysfunctional activity of the superficial muscles. This compensation will result in increased spine stability and stiffness but leads to increased compressive load on lumbar segments. The global muscles cannot provide control over individual spinal segments and therefore have a limited ability to control shear forces. The end result is compromised spinal function and restricted spinal motion. The global muscles will be unable to perform their intended function and motion, if they are used to achieve spinal stability, and may perform additional, unwanted actions (Barr et al, 2005).

2.8.4 Postural Control

Subjects with LBP have altered postural control and perform poorly on balance tasks, due to impaired neuromuscular feedback and delayed muscle reaction times (Barr et al, 2007; Barr et al, 2005). If lumbar spine proprioceptive is diminished, local muscle control and segmental stability is at risk, making the spine vulnerable to injury (Brumagne et al, 2000).

2.8.5 Rehabilitation Programmes

Lumbar-stabilisation exercise programmes can be used to regain spinal stability. The components that need to be addressed include: the deep musculature (multifidi) which provides intersegmental lumbar vertebral control; muscles which increase intra-abdominal pressure (transversus abdominis, pelvic floor, and the diaphragm) to increase lumbar stability; global muscles (lattisimus dorsi and quadratus lumborum) that provide co-contraction during activities and control trunk movement; and the correct neural control of these muscles (Barr et al, 2007). It has been suggested that by enhancing muscle control of the spinal segments, and improving active segmental stabilisation, back pain can be controlled and recurrence prevented (Richardson and Jull, 1995).

2.9 GROWTH AND DEVELOPMENT OF THE ADOLESCENT

"Growth is an important force for change in childhood" (Hensinger and Arbor, 1989).

Growth is extraordinarily complex. It is influenced by injury, health, disease, gender, genetics and environment. It is uncertain, asymmetrical and at times disproportionate. Growth is a dynamic continuum, only predictable within narrow limits (Hensinger and Arbor, 1998). The adolescent spine is in varying stages of growth making it different from the adult spine. Until the age of 18 years, the spine of an adolescent has periods of sporadic and extreme growth, and during these periods of growth it is less able to withstand stresses (Grimmer and Williams, 2000), with a steep incline in LBP in children observed around puberty (Andersen et al, 2006). A direct relationship appears to exist between LBP and the rapidly growing musculoskeletal structures (Grimmer and Williams, 2000).

Mechanical forces, genetics, nutrition, drugs and hormones affect the growth, development and maintenance of the body (Hensinger and Arbor, 1998; LeVeau and Bernhardt 1984). Forces act on the body and can affect the size and shape of the body parts, especially the musculoskeletal system. The shaping of a growing bone can be seen in abnormal and normal growth. Mechanical influences on the human body are very important as many aspects of growth, development and maintenance are in fact mechanical. The clinician by understanding the reactions of tissues and growth processes to loads can assist to direct the normal growth and development of the musculoskeletal system (LeVeau and Bernhardt 1984).

There are different tempos of growth of the axial and appendicular skeleton. The growth of the legs before puberty is more rapid while the growth of the trunk increases at puberty. Therefore depending on the age of exposure to pathology, deficits may appear in the spine dimensions at the time of early puberty or in limb dimensions prepuberty (Bass et al, 1999). The adolescent growth spurt is very different between girls and boys (Hensinger and Arbor, 1989).

A small constant force or load applied to tissues has a greater effect than heavy brief force or load. During the period of growth a persistent gentle load may lead to deformity, or alternatively it may be used to correct a deformation (LeVeau and Bernhardt 1984). The dynamic nature of growth can be used to a child's advantage to ensure good growth and development as in the treatment of the spine and scoliosis. The dynamic nature of growth can also be the force for increasing deformities, such as muscle imbalance or an injury to a growth plate (Hensinger and Arbor, 1989).

The forces of deformation affect those structures more susceptible to creep, the viscoelastic structures. In an idiopathic scoliosis the ligaments and muscles shorten and thicken on the concave side and stretch and relax on the convex side. Similar changes may be seen with a kyphosis but in an anteroposterior direction (LeVeau and Bernhardt 1984).

2.10 CONCLUSION OF LITERATURE REVIEW

A number of modifiable risk factors or risk indicators for adolescent LBP have been identified. These include lifestyle factors (sports participation, physical activity participation and sedentary activities), school related factors (school bags), physical factors (muscular strength, flexibility, physical fitness) and psychosocial factors (Burton, 2005). The role of most risk factors remains controversial (Cardon and Balagué, 2004). By establishing which risk factors are important, it is possible to design an appropriate intervention programme. A discussion of the risk factors for adolescent LBP identified in numerous studies are discussed in the literature review in detail due to the fact that it has been indicated that a number of factors may play an aetiological role in the development of adolescent LBP due to the adolescent spine being in different stages of maturity (Grimmer and Williams, 2000).

This study aims to investigate both trunk muscle endurance and lumbar-pelvic stability and establish the association with adolescent low back pain. Pain and pathology show an association with dysfunctional motor recruitment of the local and global stabiliser systems (Comerford and Mottram, 2001). Jordaan, (2005) found no association between decreased local stabiliser muscle function in adolescents with LBP, while other studies (Bernard et al, 2008; Salminen et al, 1992) report a significant association between global stabiliser and global mobiliser dysfunction and low back pain.

This study will also investigate family history, sporting and physical activity participation, and sedentary activity participation. A number of factors have been identified as aetiological contributors towards adolescent LBP. Muscle dysfunction is just one component that could play an aetiological role and cannot be looked at in isolation. These other factors will be looked at to ensure the sample represented a normal study sample and to put the sample into context. Sedentary and physical activity participation may influence the result. By looking at these factors it is ensured that the sample was not biased, with a study sample that does not participate in physical activity or participates to an extreme and the same with sedentary activity participation.

Evaluating modifiable risk factors for the possible development of low back pain in adolescents is relevant if preventative intervention can be implemented. Modifying certain risk factors and implementing preventative measures in schools may serve to prevent the development of adolescent LBP. Risk factor modification will not necessarily result in the prevention of LBP because the primary causative mechanisms for first time LBP remain largely undetermined (Burton, 2005; Cardon and Balagué2004). .

CHAPTER 3 – METHODOLOGY

3.1 STUDY DESIGN

The study is a cross sectional study

3.2 SAMPLE SELECTION

3.2.1 Sample population

The population chosen were adolescents in grade 8-11 of both genders attending one of the Independent Schools Association of South Africa (ISASA) member schools identified in the Central Gauteng region who agreed to participate in the study.

At the time of the study there were 67 schools registered as ISASA member schools in the Central Gauteng region. Schools identified to participate in the study were narrowed down to 24 schools based on schools with both males and female students and similar sports offered. From these 24 schools that were approached three agreed to participate in the study.

3.2.2 Sample selection

3.2.2.1 Inclusion criteria

- Male and female adolescents in grades 8-11, aged 12 to 17 years.
- Adolescents from which consent and assent was obtained.

3.2.2.2 Exclusion criteria

- Adolescents with a history of spinal surgery.
- Use of orthotic devices such as braces or lumbar support.
- Surgery, fractures or other orthopaedic procedure to pelvis or lower limbs within the last six months.
- Adolescents with known spinal pathology (Scheurmann's disease, spondlyosis, spondylolithsesis, rheumatic problems).
- Adolescents with visible spinal pathologies (scoliosis, kyphosis).
- Neurological conditions which alter motor tone.
- Any other serious co-morbidities.

3.2.3 Sample size

The questionnaire investigated the following four main factors:

- Family history
- Sports participation
- Physical activity participation

- Sedentary participation

The physical assessment investigated the following four factors:

- Functional integrity of lumbar stabilising muscles
- Abdominal muscle endurance strength
- Back extensor muscle endurance strength
- Side flexor endurance strength

The questionnaire was validated previously and was therefore used in its entirety although not all the information captured was relevant for the current study and did not form part of the statistical analyses. Other physical factors measured to establish the anthropometric characteristics of the sample and were not part of the objectives of this study and were not included in the statistical analyses. The study therefore investigated eight factors in total and were analysed statistically. For statistical purposes for each factor to be investigated n=10, therefore minimum sample size n=80.

3.2.4 Ethical consideration

The Research protocol was submitted to the Research Ethics Committee of the University of the Witwatersrand and approval to conduct the research was granted (Appendix J).

Only subjects from whom written informed assent was granted as well as written informed consent from a parent/guardian were included in the study. All information remained strictly confidential. Anonymity of the subjects was maintained by allocating each subject a reference number which was used on all documentation, data collection sheets and any related data for the study. The personal details of the subjects were only available to the researcher and were kept in a secure place. The list of names and numbers will be kept in a secure place only know to the researcher. Names and personal information will not be divulged. The names of the schools included in the study shall remain confidential. The physical assessment was conducted in a secluded area to ensure privacy. The rights of all participants was protected.

3.3 MEASURING INSTRUMENTS

3.3.1 Questionnaire

A questionnaire was used to obtain information on LBP and the characteristics and behaviour of pain, physical and sedentary activities, emotional status and family history.

The questionnaire used was validated and used in a previous study investigating the prevalence of and risk factors for adolescent LBP. It was developed for the South African adolescent (Jordaan, 2005). Permission was granted to use the questionnaire. The questionnaire captured data that was not used in the current study and should have been modified for the main objectives of the study. This is identified as a limitation of the study.

3.4 PHYSICAL MEASURMENTS

3.4.1 Trunk muscle endurance

Trunk muscle endurance evaluation has greater discriminative validity than maximal voluntary contractile force (Demoulin et al, 2004). Trunk muscle endurance may be a better predictor of LBP than muscle strength, and important in the prevention and rehabilitation of LBP (Arab et al, 2007). Isometric endurance muscle testing requires no special equipment, is quick and easy as well as being cost effective (Arab et al, 2007).

Intra-rater and inter-rater reliability is high for all endurance tests (Evans et al, 2006). For all endurance tests, the subject was encouraged to hold the test for as long as possible. Tests were terminated if the position could not be maintained or if there was obvious signs of fatigue or pain (Evans et al, 2006).

3.4.1.1 Trunk extension muscle endurance

Back extensor endurance was recorded using the Sorensen test (Bernard et al, 2008; Arab et al, 2007; Evans et al, 2006; Andersen et al, 2006; Sjolie and Ljunggren, 2001; Salminen et al, 1992).

The participant was positioned in prone with the upper edge of the iliac crests aligned with the edge of the table. The lower body was fixed to the table by two straps, located around the pelvis and ankles. The upper body was supported on a small stool slightly lower than the plinth. With the arms folded across the chest, the patient was instructed to maintain the upper body in a horizontal position for as long as possible, or until the position could no longer be maintained, the test was stopped after 240 seconds (Arab et al, 2007; Evans et al, 2006; Demoulin et al, 2004; Salminen et al, 1992).

The measurement was recorded once.

3.4.1.2 Trunk flexion muscle endurance

Abdominal endurance was recorded using the Shirado test (Bernard et al, 2008; Evans et al, 2006; Ito et al, 1996; Salminen et al, 1992).

The participant was positioned in supine, arms crossed over their chests and hips and knees flexed to 90°. The test began when the subject performed a small sit-up lifting the shoulders off the plinth. The position was held for as long as possible, or until the position could no longer be maintained, the test was stopped after 240 seconds (Evans et al, 2006).

The measurement was recorded once.

3.4.1.3 Trunk lateral flexion muscle endurance

The trunk lateral flexor endurance was recorded using the side bridge endurance test (Evans et al, 2006; McGill S et al, 1999).

The participant was positioned lying on their sides with their legs extended resting on their forearm with the elbow flexed to 90°. The top foot is placed in front of the lower foot for support. The participant was instructed to lift the hip off the bed, support themselves on their one elbow and their feet, and maintain a straight line with the whole body throughout the test. The uninvolved arm was held across the chest with the hand placed on the opposite shoulder. The position was held for as long as possible (Evans et al, 2006; McGill et al, 1999). The test was repeated on the opposite side.

The measurement was recorded once.

3.4.2 Lumbar-pelvic stability

The ASLR test was used to measure the functional integrity of the lumbar stabilising muscles (Mens et al, 2001). The reliability of the test has been established (Mens et al, 2001). The test-retest reliability of the ASLR measured with Pearson's correlation coefficient was 0.87 (Mens et al, 2001). The ASLR test is easy to perform, reliable, with high reliability, sensitivity and specificity (Mens et al, 2001). The ASLR test is a validated and reliable test to assess load transfer through the pelvis (Beales et al, 2008).

The participant is positioned in supine, and asked to alternatively raise the legs 20cm. The subject reports the ease or difficulty or performing the test, rating it as not difficult at all; minimally difficult; somewhat difficult; fairly difficult; very difficult; or unable to do (Mens et al, 2001; Mens et al, 2002). To quantify the measurement three pressure biofeedback units were used to measure the rotatory component of the spine (Jull et al, cited by Jordaan, 2005). Two pressure biofeedback units were positioned beneath the posterior superior iliac spines on each side just lateral to the midline. One pressure biofeedback unit was placed beneath the leg at the ankle of the resting leg. Each was inflated to a baseline pressure of 40mmHg (Jordaan, 2005).

The participant was instructed to lift one leg 20cm above the bed, keeping the leg straight, and hold for 5 seconds to allow recording of the pressure change at the three pressure biofeedback units. This was repeated on the opposite leg. The test was repeated twice and the mean value used.

The subject then stood and was fitted with a sacroiliac belt. The mobility of the SIJ is reduced when a SIJ belt is fitted around the pelvic girdle (Mens et al, 1999). The test was therefore repeated with the SIJ belt to assess if by improved form closure the local stability muscle function improved. The test was then repeated as above and the subject's perception and the pressure changes recorded.

3.5 PROCEDURE

3.5.1 Pilot study

Five adolescents within the same age range as the study were recruited from one of the schools who had given permission to participate in the study. Information sheets were given to the parents and the learners and consent and assent obtained. The physical examination techniques were conducted and the questionnaire completed. The physical examination was repeated on the same five subjects one week later. The pilot study allowed the researcher to familiarise herself with all examination techniques and the data collection form, to establish intra-rater reliability of the physical assessment measurements, and to establish a time frame for completion of the physical assessment and the questionnaire. The results from the pilot study showed good intra-rater reliability and are presented in Appendix K (Table 4.8 and Table 4.9).

3.5.2 Main study

The following was done prior to commencement of the data collection.

- A letter was written to the Independent Schools Association of South Africa, requesting permission to conduct the study at the secondary schools who are members of ISASA (Appendix A). The researcher was informed that permission was not necessary from the main body and to contact the individual schools for permission.

- A letter was written to the individual schools belonging to the ISASA, requesting their permission to participate in the study (Appendix B).

- Three schools indicated interest in the study. Appointments were set up with the principals and staff to explain the purpose of the study and obtain their permission for the learners of their school to participate in the study.

- The parent (Appendix C) and learners (Appendix D) information letter, the parent/guardian's informed consent forms (Appendix E), the learners assent form (Appendix E), and medical history questionnaires (Appendix F) were distributed to every learner in grade 8 to grade 11 at the three schools.

- The consent/assent forms were returned and a list of learners compiled from each school of those learners willing to participate in the study.

3.5.2.1 Data Collection

3.5.2.1.1 Questionnaire

- Each learner who gave permission to participate in the study was allocated a reference number which appeared on all data collection forms. The reference number was recorded on a completed list of the learners' names, to ensure the same reference number was used on the data collection sheet of the physical assessment.

- The questionnaire (Appendix G) was explained to those learners who agreed to participate in the study. The questionnaire was then distributed to each learner for completion. The learners kept the questionnaire until the physical assessment. After the physical assessment, the learner returned the questionnaire and asked any questions. The researcher checked the questionnaire to ensure all aspect were completed and understood.

3.5.2.1.2 Physical assessment

- A suitable time was arranged with the individual schools for completion of the physical assessment.
  The physical assessment was conducted in a private facility. The researcher conducted all the physical tests and the results were captured on a data capture form (Appendix I) for each subject.

- The physical assessment was conducted in the following order:
  - ASLR test
  - ASLR test with belt
  - Abdominal muscle endurance test

- Back extensor muscle endurance test
- Trunk side flexor endurance test on right
- Trunk side flexor endurance test on left
- A one minute rest period was given between the endurance tests

3.5.2.2 Data Capture

The data from the questionnaire and from the physical assessment data capture sheet were captured into a Microsoft Excel spreadsheet with the subject’s reference number. Each set of data was double checked.

3.6 STATISTICAL ANALYSIS

Prevalence of LBP within the study was expressed as a percentage.

The analyses were design based and conducted at a level of significance of p=0.05. Statistically significant results were considered with a p-value equal to or smaller than 0.05. A p-value between 0.05 and 0.1 was considered as marginally significant, and a p-value of more than 0.1 was not statistically significant.

Confidence limits (CI 95%) were determined for those data with a p-value that was statistically significant

For the categorical data, Pearson Chi-squared test of independence was used. This is based on the expected values of the frequency distribution. The null hypothesis is that the outcomes are statistically independent. The null hypothesis can be rejected and it can be concluded that there is a relationship between the variables at the 5% level of significance if the p-value is less than 0.05.

ANOVA (Analysis of Variance) is done to compare means between three or more independent samples. This was used to establish the relationship between trunk muscle endurance and lumbar-pelvic stability. The null hypothesis is that the means are equal. If the p-value is less than 0.05, the null hypothesis can be rejected and it can be concluded that there is a statistically significant difference between the samples at the 5% level.

The Student’s two-sample t-test is used to compare means between two independent samples. The null hypothesis is that the means are equal. The normal student’s t-test assumes that the variances are equal. But for the endurance tests the variances are not equal according to a Folded F test, so, Sattherwaites t-test was used for this variable. This is a variation of the student’s t-test designed for samples were the variances are not equal. If the p-value is less than 0.05, the null hypothesis can be rejected and it can be concluded that there is a statistically significant difference between the samples at the 5% level.

3.7 CONCLUSION

The study design, aims, sample selection number and inclusion and exclusion criteria have been presented in this chapter. The procedure and method of the study has been described as well as the data collection, data recording and statistical analysis. The results of the statistical analysis will be presented in chapter 4.

CHAPTER 4 – RESULTS

4.1 INTRODUCTION

The aim of the study was to investigate the association between trunk muscle endurance and lumbar-pelvic instability in adolescents. If an association exists a risk factor may be identified. Other previously identified risk factors were also investigated, although not part of the primary objectives of the study. These included family history, sports activity participation, physical activity participation and sedentary activity participation. Data was collected by means of a questionnaire and a physical assessment, as described in Chapter 3. The findings are presented in this chapter.

4.2 QUESTIONNAIRE

4.2.1 Demographic Distribution

The questionnaire was completed by a total of 80 learners in grades 8 to 11, aged 12 to 17 years, at three high schools in the Gauteng region. There was a fairly even representation of male (42.50%, n=46) and female participants (57.50%, n=35) (Appendix L, Table 4.10).

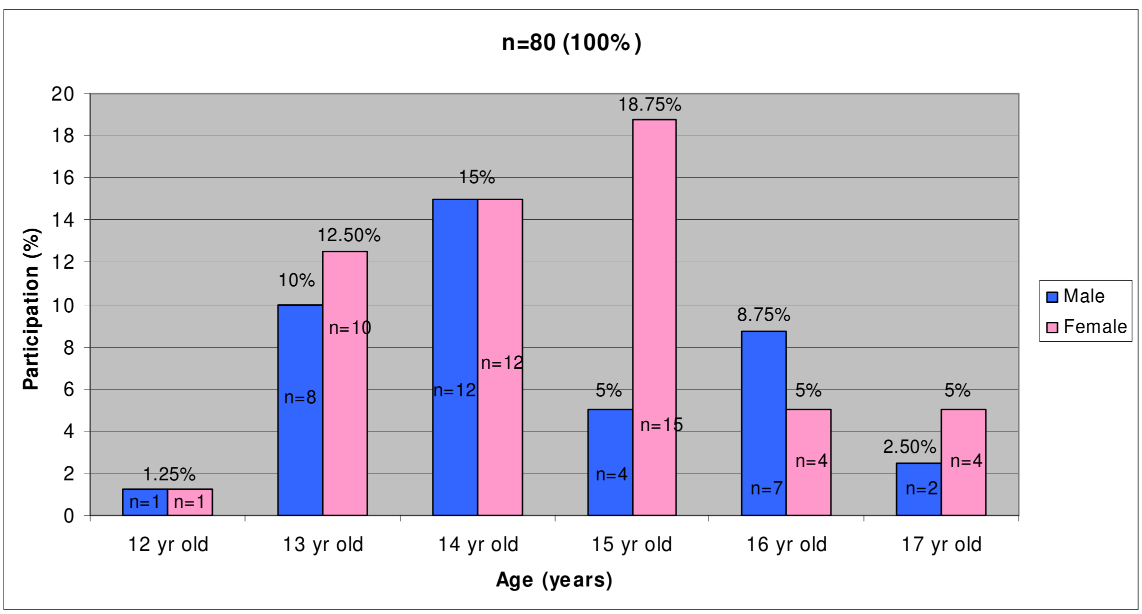

Figure 4.1 Representation of male and female participation in each age group

The age group representation is illustrated in Figure 4.1. The 12 year old age group was small in comparison to the other groups (n=2), the 16 and 17 year old age groups were moderately represented (n=11 and n=6 respectively), the 13, 14 and 15 year old groups were well represented (n=18, n=24 and n=19 respectively) (Appendix L, Table 4.11)

The representation of males and females within each age group is represented in Figure 4.1. The age groups were represented by an almost equal number of males and females, except the 15 year old age group which was represented by more females than males.

4.2.2 Prevalence of LBP

The lifetime prevalence of adolescent LBP in this study was 82.50% (n=66), one-year prevalence was 78.80% (n=63), and point prevalence was 23.80% (n=19).

Prevalence of LBP within the study was established to ascertain if the sample is representative of a normal sample and to correlate this study sample to other studies.

4.2.2.1 Prevalence of LBP by gender

The prevalence of LBP between genders is represented in Table 4.1

Table 4.1 Prevalence of LBP by gender

Prevalence of LBP (%)	Female (n=46)		Male (n=35)	
	%	N	%	N
Lifetime	80.43	37	85.29	29
1-Year	80.43	37	76.47	26
Point	28.26	13	17.65	6

The lifetime prevalence was slightly higher in males than females. The one-year prevalence and point prevalence were higher in females than males.

4.2.2.2 Prevalence of LBP by age group

The prevalence of LBP within each age group is represented in Table 4.2

Table 4.2 Prevalence of LBP by age group

Age Group	Lifetime Prevalence		1-Year Prevalence		Point Prevalence	
	%	n	%	n	%	n
12 year (n=2)	100	2	100	2	0	0
13 year (n=18)	88.89	16	88.89	16	33.33	6
14 year (n=24)	79.16	19	79.17	19	8.33	2
15 year (n=19)	73.68	14	73.68	14	26.32	5
16 year (n=11)	90.91	10	63.64	7	27.27	3
17 year (n=6)	83.33	5	83.33	5	50.00	3

The results indicate a high life time, one year and point prevalence in the 13 year old age group. The life time prevalence shows an increase again at the 16 year old age group. Point prevalence in the 13 year old and the 17 year old age group was higher than in the 14 year old, 15 year old, and 16 year old age group.

The characteristics of LBP are presented in Appendix M.

4.2.3 The association between LBP and family history

Those adolescents with a history of LBP and a family history of LBP are presented in Table 4.3.

Table 4.3 Prevalence of LBP and family history

Prevalence of LBP	Family History				p-value	Confidence Limits (CI 95%)
	Yes		No			
	%	n	%	n		
Lifetime (n=66)	56.06	37	43.94	29	0.368	44.09 – 67.37
1 Year (n=63)	58.73	37	41.27	26	0.086	46.57 - 70.89
Point (n=19)	78.95	15	21.05	4	0.012	60.62 – 97.28
No LBP (n=14)	42.86	6	57.14	8	0.368	21.38 – 67.41

There was an association between point prevalence of LBP and family history (p=0.012). Of those subjects with a point prevalence of LBP, 78.95% (n=15) reported a family history of LBP. There was a marginally significant association between one year prevalence of LBP and family history (p=0.086). There was no association between life prevalence of LBP and family history of LBP (p=0.368).

4.2.4 The association between LBP and activity level

Sports participation and other physical activity participation were determined by multiplying the frequency of sports participation per week, by the duration of a practice session and by the intensity of a session. This gave a sub total score which was multiplied by the number of weeks in a month (4.33). This gave a total score for monthly participation. For each subject the sports in which they participated where added together. Tertiles were determined from the total scores and expressed the sporting and other physical activity levels into low (0-500), moderate (501-1000) and high tertiles (>1001).

The association between LBP and sports participation is represented in Figure 4.2 (Appendix L, Table 4.9).

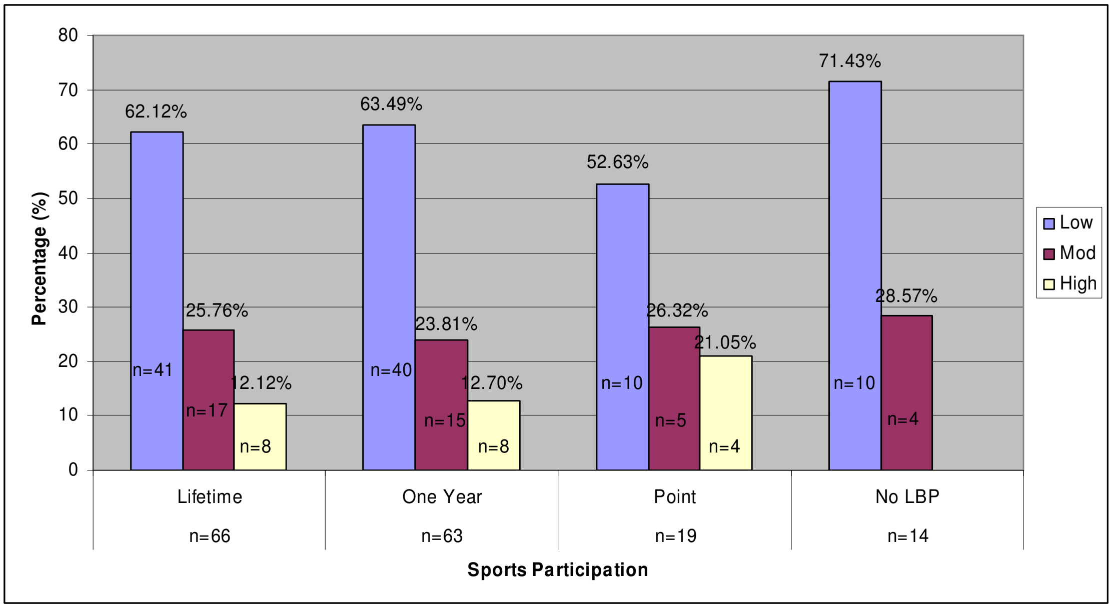

Figure 4.2 Association between sports participation and LBP

No association was found between LBP and sports participation. Low sports participation was reported by the majority of adolescents in the study whether they experienced LBP or not. Only those adolescents who reported high sports participation reported LBP. The results are not statistically significant (p=0.389 for lifetime prevalence, p= 0.242 for one year prevalence and p=0.171 for point prevalence).

The association between LBP and physical activity participation is presented in Figure 4.3 (Appendix L, Table 4.10).

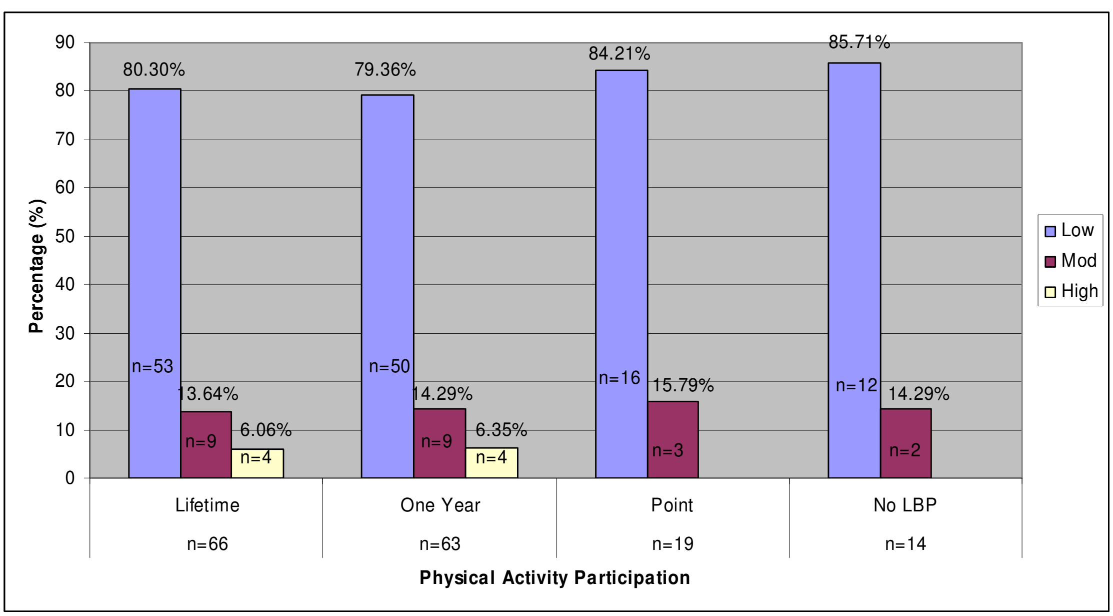

Figure 4.3 Association between physical activity and LBP

No association was found between LBP and physical activity participation. Low physical activity participation was reported by the majority of adolescents in the study whether they experienced LBP or not. A small percentage of subjects reported high physical activity participation and they reported lifetime or one year prevalence of LBP. The results are not statistically significant. (p=0.640 for lifetime prevalence, p=0.530 for one year prevalence and 0.510 for point prevalence).

4.2.5 The association between LBP and sedentary activity

Sedentary activity participation was calculated by multiplying the frequency of sedentary activity per week, by the duration of the session. This gave a sub total score which was multiplied by the number of weeks in a month (4.33). This gave a total score for monthly sedentary activity participation. For each subject the sedentary activities in which they participated where added together. Tertiles were determined from the total scores and expressed the sedentary activity levels into low (0-300), moderate (301-600) and high tertiles (>601).

The association between LBP and sedentary activity participation is presented Figure 4.4 (Appendix L, Table 4.12)

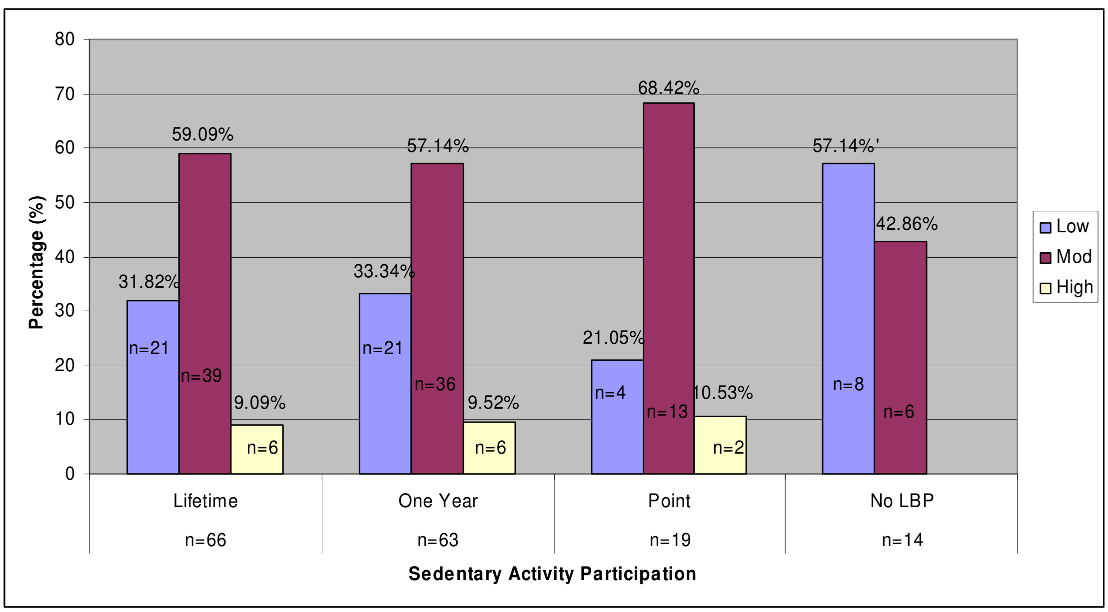

Figure 4.4 Association between sedentary activity and LBP

No association was found between LBP and sedentary activity participation. There is an increase in lifetime, one year prevalence and point prevalence as sedentary activity participation increases from low to moderate. The number of learners with a history of LBP partaking in high levels of sedentary activity is low relative to those in the moderate tertiles.

The number of learners with no history of LBP partaking in low levels of sedentary activity is higher than those partaking in moderate levels of sedentary activities. No learners with no history of LBP partake in high levels of sedentary activity. The results for sedentary activity participation and LBP are not statistically significant. (p=0.145 for lifetime prevalence, p=0.308 for one year prevalence and p=0.280 for point prevalence).

4.3 PHYSICAL ASSESSMENT

4.3.1 The association between LBP and lumbar-pelvic instability

The results of the subject's perception of performing the ASLR are presented in Figure 4.5 (Appendix L, Table 4.12 and Table 4.13)

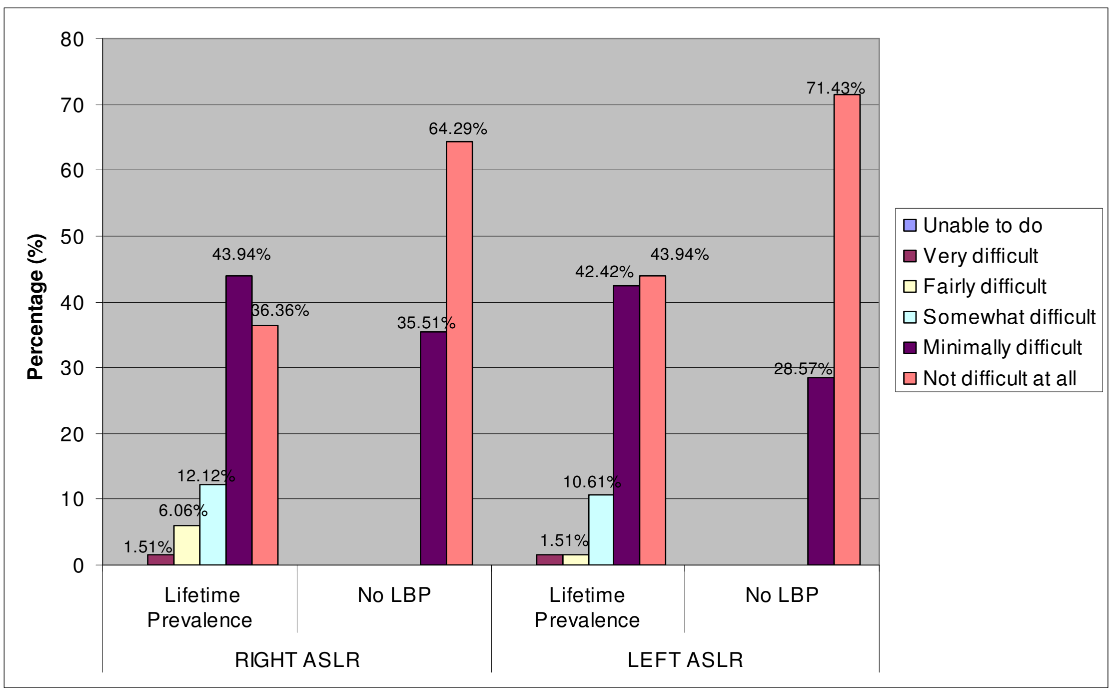

Figure 4.5 Subjects perception of ASLR

No association was found between lifetime prevalence of LBP and subjects perception of the right and left ASLR (p=0.275 and p= 0.373 respectively). Of the participants who reported no LBP, all reported the ASLR as either minimally difficult or not difficult at all to perform. Only those adolescents with a lifetime prevalence of LBP expressed a degree of difficulty in performing the ASLR.

The results of the pressure change recorded at the PSIS on the side of the ASLR are presented in Figure 4.6 (Appendix L, Table 4.14 and Table 4.15).

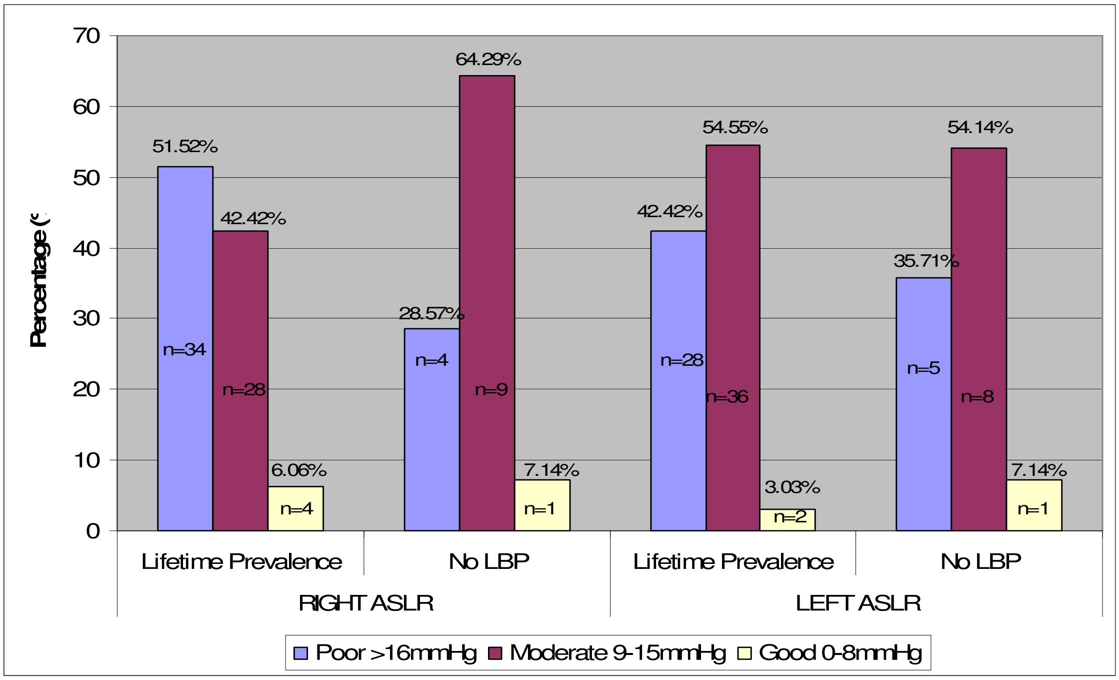

Figure 4.6 Pressure change at PSIS on side of ASLR test

No association was found between lifetime prevalence of LBP and the ASLR test for either the right or the left ($p=0.287$ and $p=0.719$ respectively). Of the total study population only a small number of subjects presented with a good ASLR whether they reported LBP or not. The majority of subjects presented with a moderate or poor ASLR.

The results of the pressure change recorded at the opposite foot while performing the ASLR are presented in Figure 4.7 (Appendix L, Table 4.16 and Table 4.17).

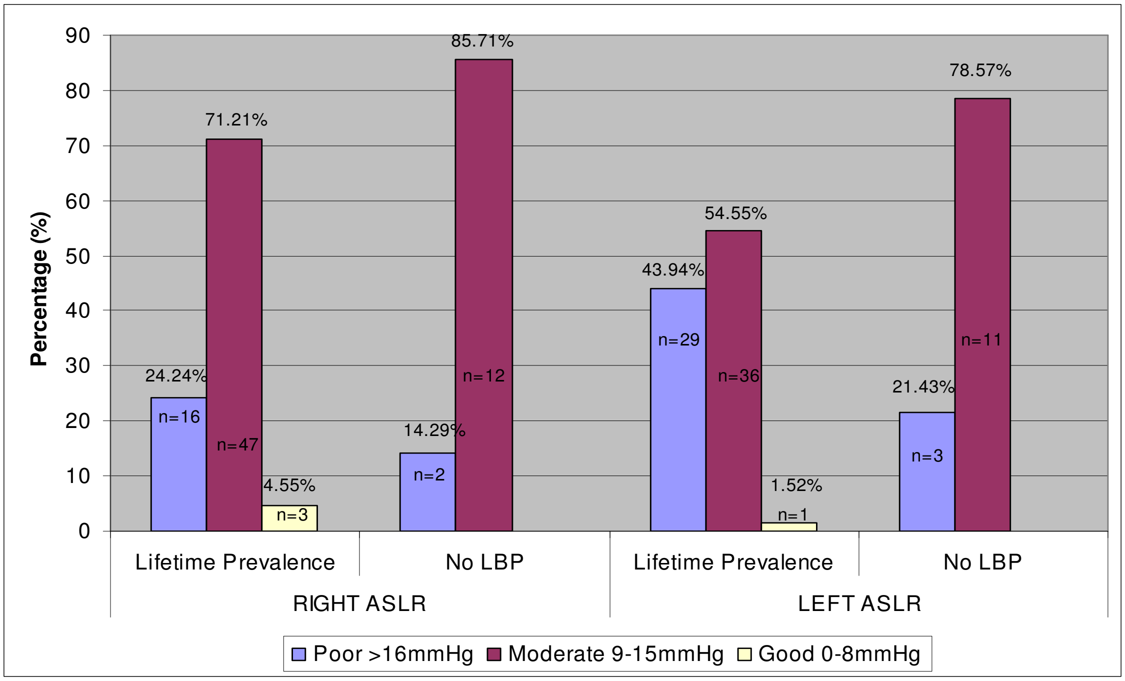

Figure 4.7 Pressure change at the opposite foot of ASLR test

No association was found between lifetime prevalence and the pressure change at the opposite foot while performing the ASLR for either the right or the left (p=0.478 and p= 0.245 respectively). The majority of subjects with a lifetime prevalence of LBP presented with a moderate right and left ASLR, and only a small percentage presented with a good ASLR as recorded by the pressure change at the opposite foot. The majority of those adolescents with no history of LBP presented with a moderate ASLR, with no subjects presenting with a good ASLR on either the right or left as recorded at the opposite foot.

4.3.2 The effect of a SIJ belt on lumbar-pelvic instability

The results of the subject's perception of performing the ASLR with and without a SIJ belt for those adolescents with a life prevalence of LBP are presented in Figure 4.8 (Appendix L, Table 4.18 and Table 4.19).

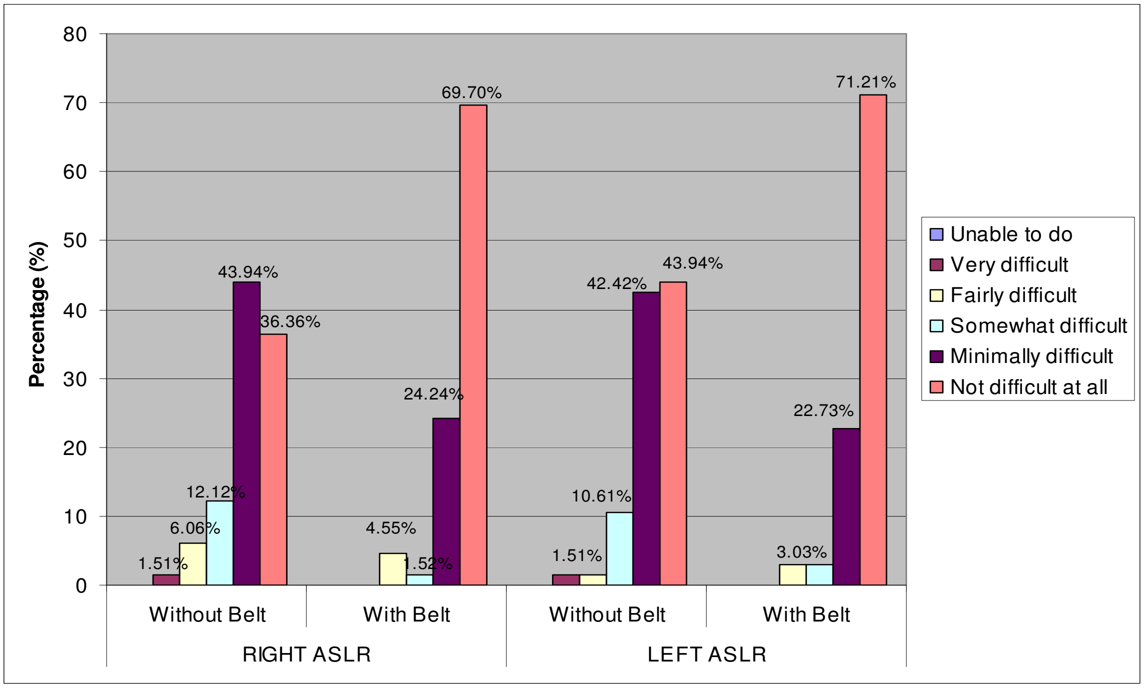

Figure 4.8 Subjects reporting lifetime prevalence of LBP perception ASLR with and without SIJ belt

No association was found between the subjects perception of ASLR with and without the SIJ belt on the right or the left ($p=0.251$ and $p= 0.444$ respectively). Once fitted with a SIJ belt the number of adolescents who reported no difficulty with performing the ASLR test increased. Once fitted with the belt no adolescent reported the test being very difficult on either the right or left.

The results of the pressure change recorded at the PSIS on the side of the ASLR with and without the SIJ belt for those adolescents with a life prevalence of LBP are presented in Figure 4.9 (Appendix L, Table 4.20 and Table 4.21).

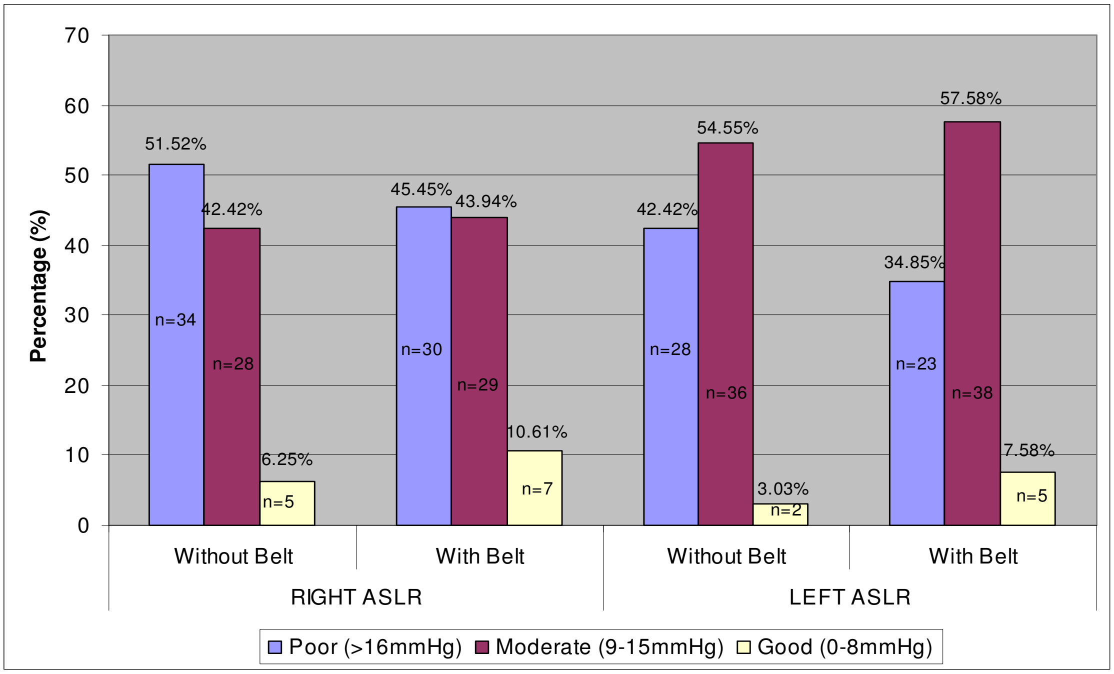

Figure 4.9 Subjects reporting lifetime prevalence of LBP pressure change at PSIS on side of ASLR test with and without SIJ belt

No association was found between the performance of the ASLR as measured at the PSIS, with and without the SIJ belt for either the right or the left (p=0.509 and p= 0.694 respectively). Once fitted with a SIJ belt the number of adolescents who presented with a good ASLR increased.

The results of the pressure change recorded at the opposite foot while performing the ASLR with and without the SIJ belt for those adolescents with a life prevalence of LBP are presented in Figure 4.10 (Appendix L, Table 4.22 and Table 4.23).

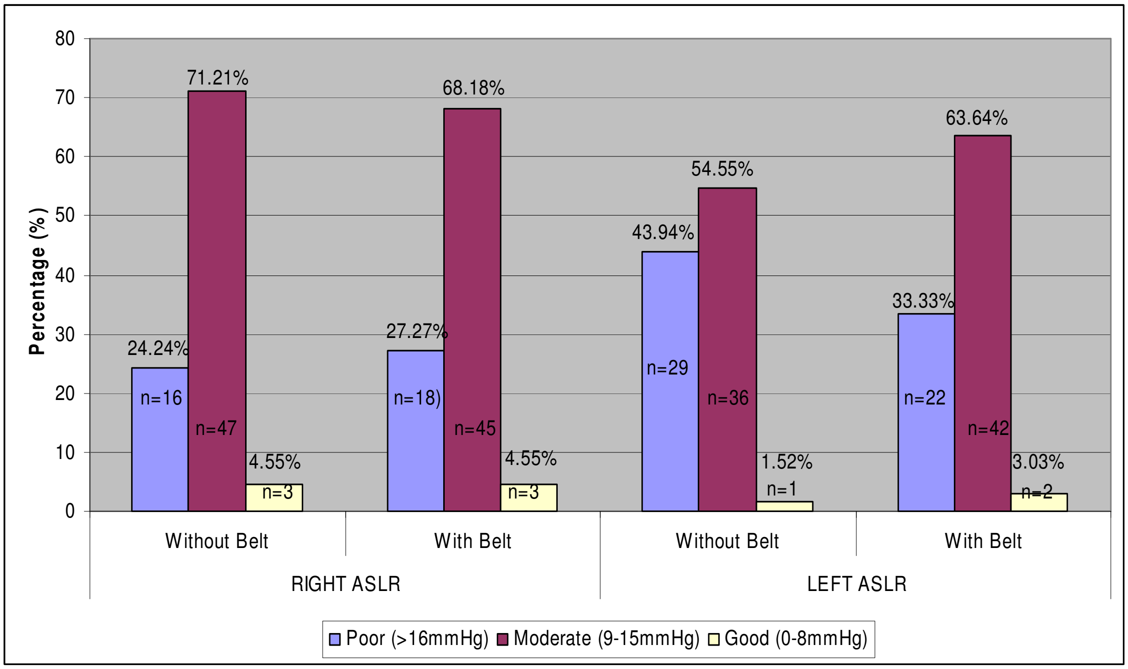

Figure 4.10 Subjects reporting lifetime prevalence of LBP pressure change at opposite foot of ASLR test with and without SIJ belt

No association was found between the performance of the ASLR as measured at the opposite foot, with and without the SIJ belt for either the right or the left (p=0.269 and p= 0.251 respectively). Once fitted with a SIJ belt the number of moderate right ASLR test decreased, while the number of moderate left ASLR tests increased. The number of good tests on the right remained the same and the number of good tests on the left increased slightly.

The SIJ belt had a greater impact on the subject's perception while performing the ASLR than on the pressure changes recorded at the PSIS and the opposite foot.

4.3.3 The association between LBP and muscle endurance

The mean values for trunk flexor muscle endurance are presented in Figure 4.11 (Appendix L, Table 4.24).

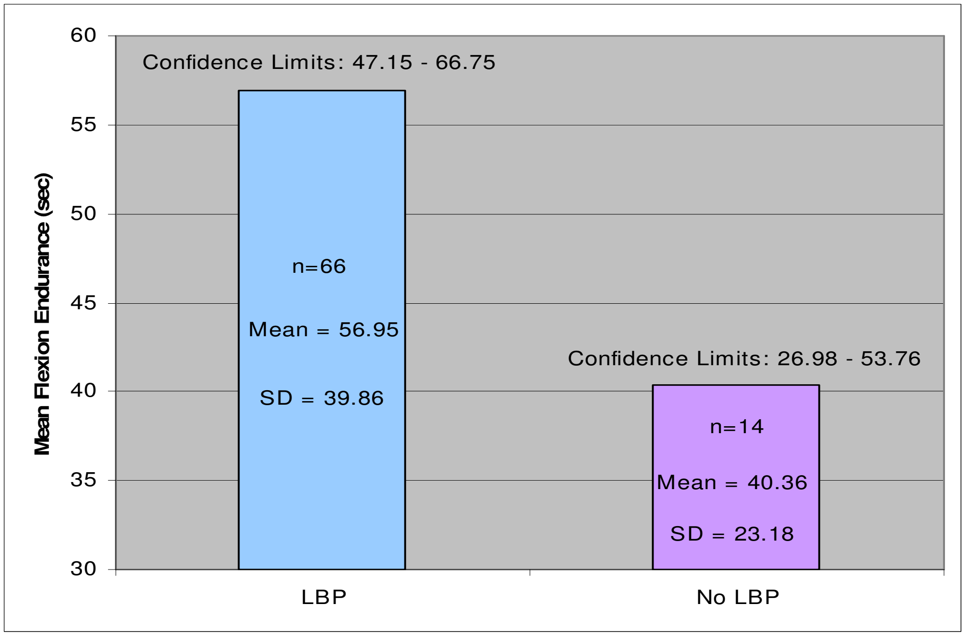

Figure 4.11 Mean values for trunk flexor muscle endurance

There was an association between LBP and increased flexor muscle endurance (p=0.044). Those participants reporting LBP recorded higher endurance times for flexor muscle endurance (mean=56.95 SD 39.86) as opposed to those participants who reported no LBP (mean = 40.36 SD 23.18).

The mean values for trunk extensor endurance are presented in Figure 4.12 (Appendix L, Table 4.25)

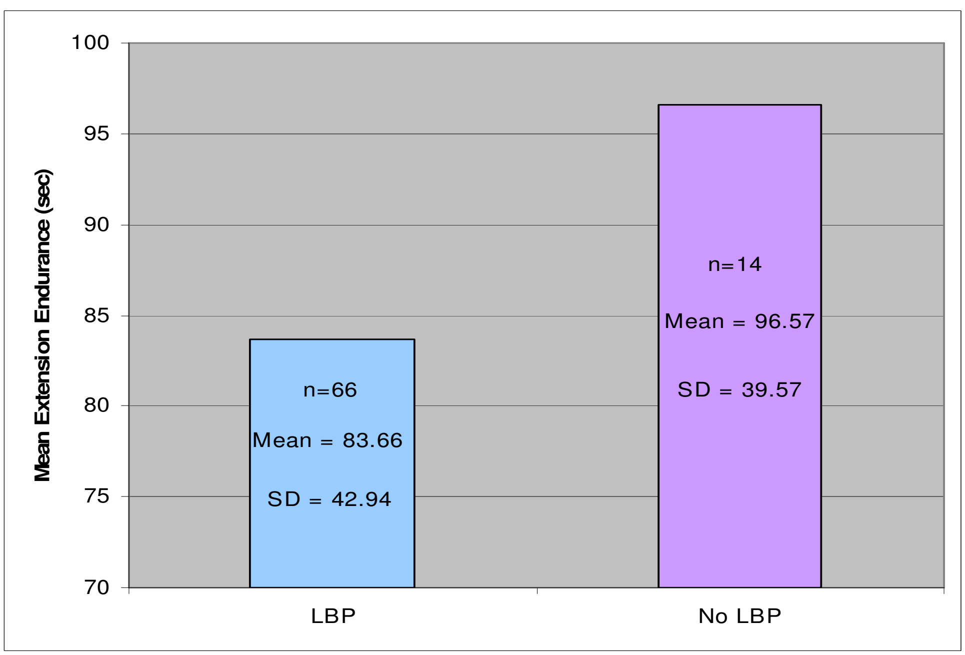

Figure 4.12 Mean values for trunk extensor muscle endurance

No association was found between LBP and extensor trunk muscle endurance (p=0.304) however those participants reporting LBP recorded lower endurance time for extensor muscle endurance (mean = 83.66 SD 42.94) as opposed to those participants who reported no LBP (mean = 39.57 SD 39.57).

The mean values for trunk right side flexor endurance are presented in Figure 4.13 (Appendix L, Table 4.26).

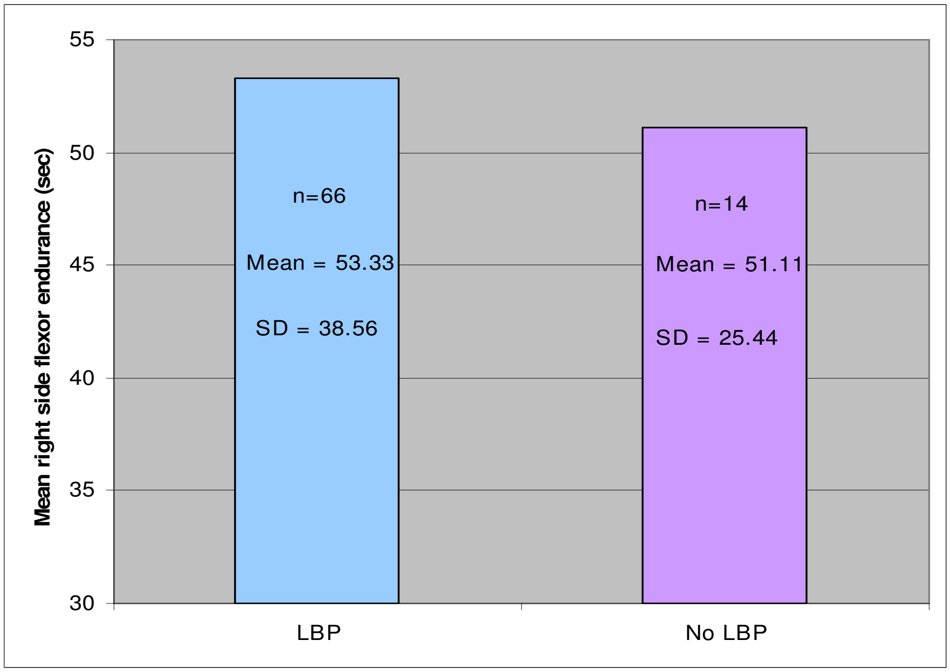

Figure 4.13 Mean values for right side trunk flexion muscle endurance

No association was found between LBP and right side flexor muscle endurance (p=0.838). Those participants reporting LBP recorded higher endurance time for right side flexor muscle endurance (mean = 53.33 SD 38.56) as opposed to those participants who reported no LBP (mean = 51.11 SD 25.44).

The mean values for trunk left side flexor endurance are presented in Figure 4.14 (Appendix L, Table 4.27).

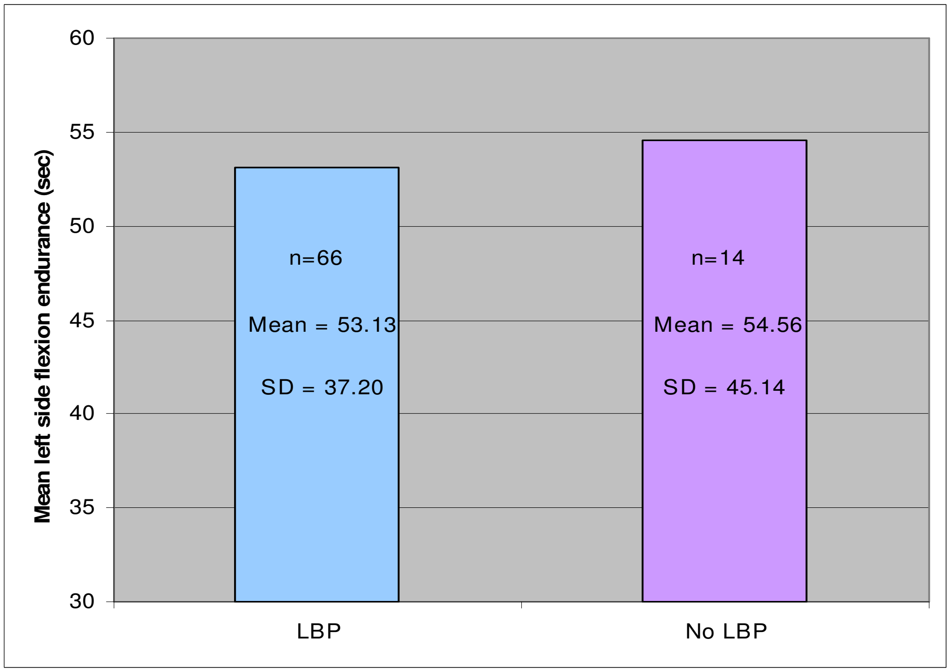

Figure 4.14 Mean values for left side trunk flexion muscle endurance

No association was found between LBP and left side flexor muscle endurance (p=0.900).Those participants reporting LBP recorded lower endurance time for left side flexor muscle endurance (mean = 53.13 SD 37.20) as opposed to those participants who reported no LBP (mean = 54.56 SD 45.14).

The ratio of trunk muscle extensor endurance to flexion and to right and left sided flexor muscle endurance is presented in Table 4.4.

Table 4.4 Ratio of flexion to extension trunk muscle endurance

Ratio	LBP		No LBP	
	Mean	SD	Mean	SD
Flex: Ext	0.822	0.730	0.510	0.348

Adolescents with a history of LBP presented with a modified flexor to extensor ratio, but it must be remembered those with a history of LBP presented with increased trunk flexor muscle endurance and decreased trunk extensor endurance.

4.3.4 The association between lumbar-pelvic instability and muscle endurance

The participants lowest score for the left and right ASLR test measured at the left and right PSIS respectively was recorded and used as that subjects average ASLR score. The endurance test results were then associated with that score.

The results of the mean muscle endurance and the average ASLR are presented in Figure 4.14 (Appendix L, Table 4.28).

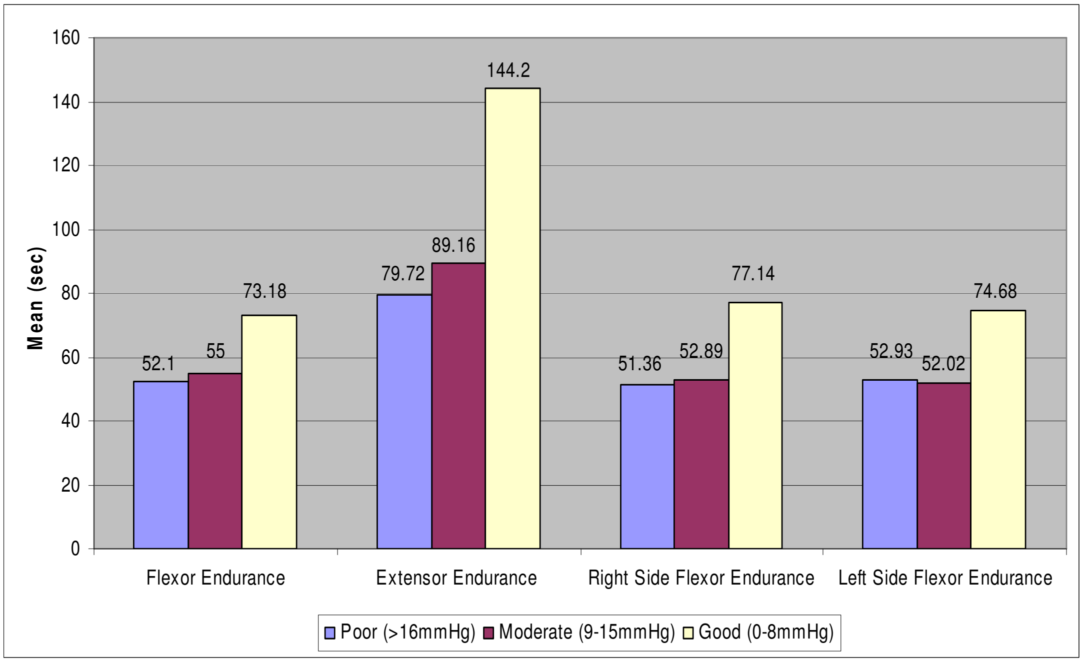

Figure 4.15 Mean muscle endurance and ASLR

Those subjects with a good ASLR had better endurance scores for all four endurance tests. Those with moderate ASLR results had better flexor and endurance results than those subjects with poor ASLR results. Left and right side flexor endurance results were fairly similar for those subjects with a moderate and poor ASLR.

There was an association between the ASLR test and trunk extensor muscle endurance (p=0.031).Those adolescents with better performance of the ASLR test measuring the integrity of the deep stabilising muscles, had better endurance of the trunk extensor muscles.

Confidence limits for extension endurance and averaged ASLR are as follows: those subjects presenting with a poor ASLR, confidence limits are 68.03 – 91.41, and for those subjects presenting with a moderate ASLR the confidence limits are 74.40 – 100. Confidence limits cannot be established for subjects with a good ASLR as there were only three subjects.

The results of the flexor muscle endurance test and the averaged ASLR are presented in a scatter plot in Figure 4.16

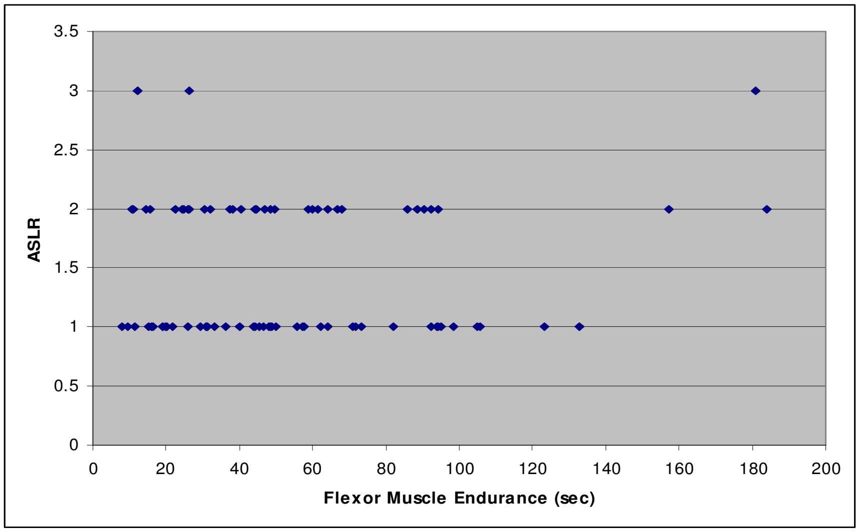

Figure 4.16 Flexor muscle endurance and ASLR

The highest flexor muscle endurance times were recorded by those subjects with a moderate and good ASLR result.

The results of the extensor muscle endurance test and the averaged ASLR are presented in a scatter plot in Figure 4.17

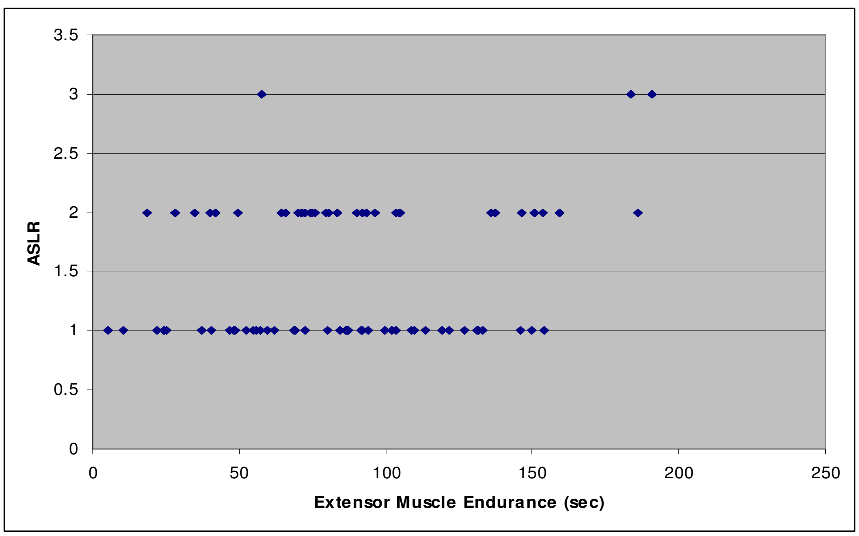

Figure 4.17 Extensor muscle endurance and ASLR

The highest extensor muscle endurance times were recorded by those subjects with a moderate and good ASLR result.

The results of the right side flexor muscle endurance test and the averaged ASLR are presented in a scatter plot in Figure 4.25.

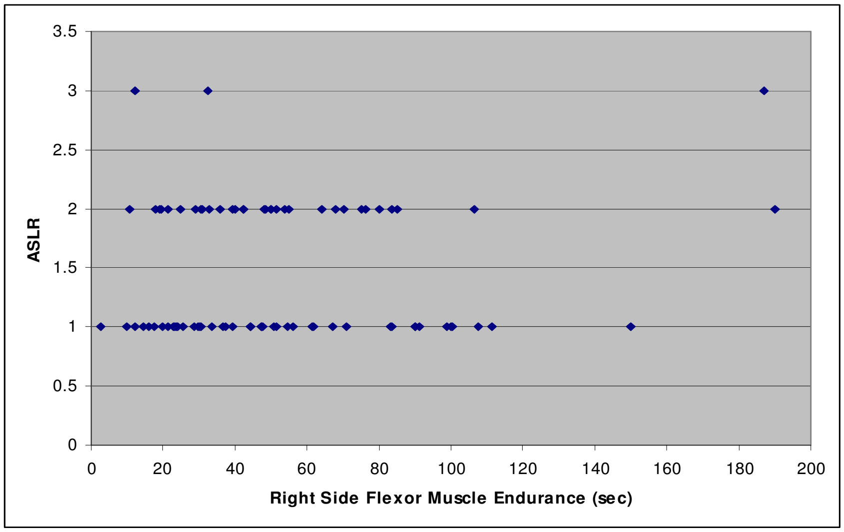

Figure 4.18 Right side flexor muscle endurance and ASLR

The highest right side flexor muscle endurance times were recorded by those subjects with a moderate and good ASLR result.

The results of the right side flexor muscle endurance test and the averaged ASLR are presented in a scatter plot in Figure 4.26

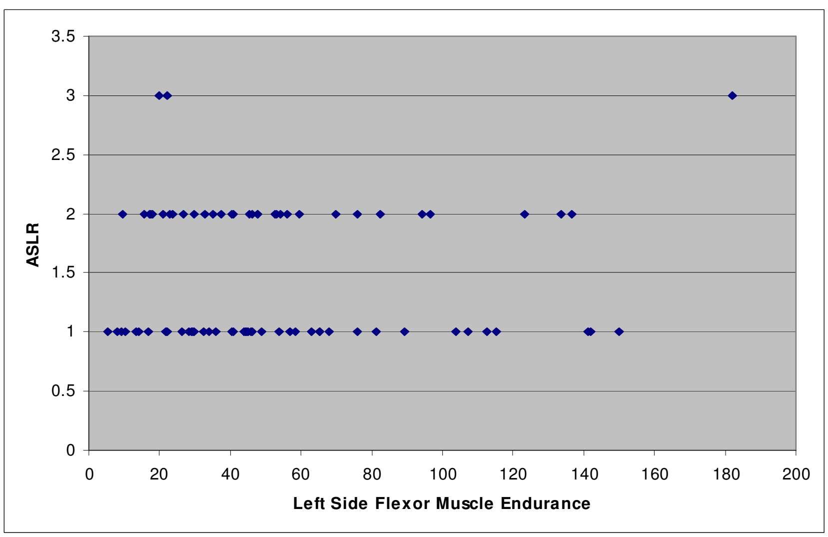

Figure 4.19 Left side flexor muscle endurance and ASLR

The highest right side flexor muscle endurance times were recorded by those subjects with a good ASLR result.

4.5 Conclusion

The results of the univariate analyses are presented in chapter 4. The prevalence of adolescent LBP within the study was high for both lifetime and one-year prevalence. The lifetime prevalence was higher in males but the one-year and point prevalence was higher in females. An association was found between point prevalence of adolescent LBP and a family history of LBP, and a marginally significance result was found between one-year prevalence of adolescent LBP and a family history. There was an increasing trend in lifetime, one-year prevalence and point prevalence of LBP in those adolescents reporting a low level of sports and physical activity participation. The results were not statistically significant. Those adolescents reporting lifetime, one-year and point prevalence reported a moderate level of sedentary activity, the results however were not statistically significant.

No association was found between adolescent LBP and lumbar-pelvic instability. A great percentage of adolescents with and without LBP presented with decreased lumbar-pelvic stability.

Those adolescents with LBP presented with increased trunk flexor muscle endurance and these findings were statistically significant ($p=0.044$). Those adolescents with LBP presented with decreased trunk extensor muscle endurance, however the results were not statistically significant ($p=0.031$). Side flexor muscle endurance was similar in adolescents with and without LBP.

Those adolescents with good lumbar-pelvic stability had greater trunk muscle endurance times as opposed to those adolescents with poor lumbar-pelvic stability. A significant association was found between trunk extensor muscle endurance and lumbar-pelvic instability.

CHAPTER 5 – DISCUSSION

5.1 INTRODUCTION

The main findings of the research will be discussed in this chapter. The discussion will cover the prevalence of adolescent LBP and the association between LBP and trunk muscle endurance and lumbar-pelvic instability. The aim of the study was to establish if an associated exists between decreased trunk muscle endurance and lumbar-pelvic instability and adolescent LBP, as well as to investigate the association between trunk muscle endurance and lumbar-pelvic instability.

5.2 PREVALENCE OF LBP

The results of this study indicate a high lifetime and one-year prevalence of LBP. The results are higher than those recorded in other studies in which the prevalence of adolescent LBP was investigated. In these studies lifetime prevalence has been recorded between 26% to 69.30% (Jordaan, 2005; Kovacs et al, 2003; Balague et al, 1994; Balagué et al, 1993; Fairbank et al, 1984), and one-year prevalence has been recorded between 50% and 57% (Jordaan, 2005; Sjolie, 2004). Point prevalence of adolescent LBP in this study is similar to that reported in other studies which have documented point prevalence between 13% and 23.90% (Masiero et al, 2008; Watson et al, 2002; Lebouef-Yde and Kyvik, 1998; Balagué et al, 1993). It is possible that more adolescents with LBP wanted to participate in the study as opposed to their painfree peers accounting for the high lifetime and one-year prevalence.

The results of this study indicate a higher prevalence than has been reported in other studies however comparison of results from studies is difficult due to different research methods, different data collection processes, different age groups, different countries, and different definitions of LBP.

The results of this study and other studies reveal that adolescent LBP is a common complaint. The concern is that a clear link has been shown to exist between adolescent and adult LBP with adolescent LBP a significant risk factor for adult LBP (Andersen et al, 2006; Hestbaek et al, 2006; Burton, 2005; Limon et al, 2004; Feldman et al, 2001; Balague et al, 1999; Harreby, 1995).

Intervention programmes may prove to be effective in preventing the pain experienced becoming increasingly recurrent or chronic in nature. A definite need exists to try to understand the nature of back pain in schoolchildren and to implement intervention programmes.

5.3 LUMBAR-PELVIC INSTABILITY

The results of the current study indicate that lumbar-pelvic instability is not associated with adolescent LBP. The majority of adolescents within the study whether they presented with LBP or not demonstrated poor lumbar-pelvic stability when assessed with the ASLR test. These results are similar to those reported by Jordaan (2005).

A strong association has been reported between adult LBP and lumbar-pelvic instability (O'Sullivan et al, 2002). The results of the current study indicate that a similar association between adolescent LBP and lumbar-pelvic instability does not exist. The ASLR test is a measure of lumbar-pelvic stability and measures the integrity of the deep stabilising muscles including transversus abdominis and multifidi, a poor result indicates decreased stabilisation due to weakness of the local stability muscles which control intersegmental motion. This may result in increased or uncontrolled segmental motion and poor dynamic stability. This does not appear to be the mechanism of dysfunction in the adolescent spine. The results of this finding may indicate that other control systems are at play in achieving stability of the adolescent spine. The three subsystems identified are the active, passive and neural control subsystems. It could be possible that the passive restraints play a more important role than the active restraints in maintaining stability of the adolescent spine. This requires further investigation.

Although a high percentage of adolescents with and without LBP had poor or moderate ASLR results. The motor control pattern in those subjects with and without LBP appears different and requires further investigation. Adolescents with no history of LBP appear to exert more pressure though the opposite leg when performing the ASLR. Three slings have been identified in producing force closure around the SIJ. It would be interesting to investigate and compare the muscle activity in the three slings in adolescents with and without LBP.

Once fitted with a SIJ belt the subject's perception of performing the ASLR improved. In a study by Mens et al. (1999) the ability to perform the ASLR was improved in 20 out of 21 patients when fitted with a SIJ belt. In the current study the number of good test results increased once subjects were fitted with the SIJ belt, although this was not a statistically significant finding. Lumbar-pelvic instability does not appear to be a mechanism of pain generation or dysfunction in the adolescent spine, therefore fitting them with a belt aimed at improving lumbar-pelvic stability may be of no benefit.

The adolescent spine is in varying stages of growth with a rapidly growing musculoskeletal system. During the growth spurt it is less able to withstand stresses applied to it (Grimmer and Williams, 2000). Various forces act on the body during growth and these forces can affect the musculoskeletal system (LeVeau and Bernhardt, 1984). The natural growth process could be a factor contributing to stability or instability of the adolescent spine.

5.4 TRUNK MUSCLE ENDURANCE

The mean value for trunk flexor muscle endurance in subjects with LBP was increased as opposed to painfree individuals. This was a statistically significant finding (p=0.04). These results are similar to those reported by Perry et al. (2009) and Bernard et al. (2008). Perry et al. (2009) suggest that the possible mechanism for this is due to the significant flexion or compressive loading forces the trunk flexor muscles can exert on the lumbar spine. The results of this study are contrary to those reported by Salminen et al. (1992) in which decreased flexor muscle endurance was associated with LBP. It cannot be determined from this study if the changes seen in trunk muscle flexor endurance are the cause or effect of LBP. It could be that the flexor muscle endurance is increased due to compensatory mechanisms of the global muscles in an effort to improve spinal stability or it could be the cause of LBP as suggested by Perry et al. (2009).

Trunk extensor muscle endurance was decreased in those adolescents with a history of LBP. These results are similar to other studies in which decreased trunk extensor muscle endurance was recorded in adolescents with LBP (Bernard et al, 2008; Andersen et al, 2006; Sjolie and Ljunggren, 2001; Salminen et al, 1995). It cannot be determined from the study whether weak trunk extensor muscles are the cause or effect of LBP and requires further investigation.

The endurance times recorded for trunk side flexor muscle endurance were similar in those adolescents with and without a history of LBP. No studies have been found investigating side flexor trunk muscle endurance in adolescents.

Studies show both deficits and excesses of back muscle performance are related to LBP (Perry et al, 2009). Whether the weakening is the result or the cause of LBP needs to be investigated prospectively (Andersen et al, 2006). In a three year follow up study by Salminen et al. (2005) it was found that the measure of muscle strength and atrophy of the paraspinal muscles did not appear to be predictors of the appearance of LBP. LBP cannot be attributed to muscle weakness in a simplistic way (Balagué et al. 1999).

The ratio of flexor to extensor endurance was different in those subjects with and without LBP. Adolescents with a history of LBP had a ratio of 0.822 while painfree adolescents had a ratio of

0.510. The ratio of trunk flexors to extensors may be as or more important than trunk muscle endurance or absolute muscle strength. In a study by Bernard et al. (2008) a modified ratio of trunk flexors to extensors was noted. Muscle balance is necessary to contribute to normal biomechanics during growth (Bernard et al, 2008). The results of the study indicate the need to address trunk muscle endurance in adolescents presenting with LBP. The differences in muscle endurance observed may be the consequence of pain rather than the cause of pain and requires further investigation. The results of this study indicate that in adolescents with LBP the rehabilitation programme needs to address trunk muscle endurance and ensure a balance exists between the trunk muscle flexors and extensors. The trunk side flexor muscles do not appear to play a role in adolescent LBP. Further research in the form of a prospective study is needed to further investigate this finding.

5.5 LUMBAR-PELVIC INSTABILITY AND TRUNK MUSCLE ENDURANCE

No previous studies, in adults or adolescents, have been found to compare the results of this study in which lumbar-pelvic instability and trunk muscle endurance have been investigated.

By investigating lumbar-pelvic stability the integrity of the local stabilising muscles is assessed, while investigating trunk muscle endurance the integrity of the global muscles is assessed.

One might expect that if there is a dysfunction in one muscular system another muscular system might compensate to achieve spinal stability. If a subject presented with poor lumbar-pelvic stability or decreased local stability muscle function, they would have increased strength or endurance of the global muscles in an effort to increase spinal stability and visa versa. The results of this study do not reflect this.

The results of this study indicate that those adolescents with a good ASLR had better muscle endurance for all the trunk muscles and those adolescents with poor ASLR had decreased muscle endurance with lower mean scores. This was only statistically significant for extensor muscle endurance.

The dysfunction of the muscular system in adolescent LBP appears to be with muscle endurance as opposed to the local muscle stabilisers.

5.6 FAMILY HISTORY

The results of this study show a statistically significant association ($p=0.012$) between a family history of LBP and point prevalence of adolescent LBP. A one year history of adolescent LBP was marginally significant (p=0.086) in regard to a family history of LBP. The results indicate no association between lifetime prevalence of adolescent LBP and a family history of LBP (p=0.386). Previous studies have shown an association between adolescent LBP and a family history (Masiero et al, 2008; Balagué al, 1999; Balague et al, 1994), while other studies report no association exists (Kovacs et al, 2003; Harreby et al, 1995).

The family may play an important role in terms of their perception of the problem, and in terms of their attitude and perception of pain (Masiero et al, 2008). It is still to be determined if the finding of a link between a family history and adolescent LBP is due to genetics or a psychosocial environmental factor (Balagué et al, 1994).

5.7 SPORTS PARTICIPATION

The results of this study indicate that the majority of the adolescents in the study, whether they reported LBP or not, fell into the low tertiles of sports participation. Only those adolescents who reported high sports participation reported lifetime, one year or point prevalence of LBP. No association was found between sports participation and LBP in this study with no statistically significant results. Previous studies have reported high sports participation especially in competitive sports to be associated with LBP (Jordaan, 2005; Feldman et al, 2001; Kovacs et al, 2000; Balagué et al, 1999). Korovessis et al. (2004) report that sports exposure increased LBP in girls, while Burton et al, (1996) reported a positive correlation between sports exposure and back pain only in boys. It is interesting to note that 25.4% of participants reported the mode of onset of LBP as due to a sports injury, yet the majority of individuals fell within the low tertiles of sports participation. Other studies have reported LBP to be more common in those adolescents who avoided sports (Masiero et al, 2008; Fairbank et al, 1984), and participating in physical activity less than three times a week (Sjolie, 2004).

The conflicting results seen in studies could be due to the difficulty experienced in comparing results as sports participation has been determined in different ways. Some authors have looked at the frequency per week, others the intensity, and others the duration of sports participation. The value of the categories into which adolescents fell is also different with authors not giving the actual values of the categories. In this study sports participation has been divided into low, moderate and high but the actual values of these tertiles may be different from other studies.

It cannot be determined from this study if low levels of sports participation are the cause or effect of LBP. It could be suggested that the low sports participation seen in this study could be the effect of LBP. It would be interesting to determine the subject's perception of this issue and if their sports participation has changed since they developed LBP. Low levels of sports participation could also be the cause of LBP, as it has been suggested that that those adolescents who are more active may be protected from mechanical LBP (Feldman et al, 2001; Grimmer and Watson, 2000), by improving muscle strength and flexibility (Masiero et al, 2008). This requires further investigation.

It was beyond the scope of this research report to investigate the association between trunk muscle endurance, lumbar-pelvic instability and sports participation but it would be interesting to see if those adolescents with low levels of sports participation also presented with altered muscle function.

5.8 PHYSICAL ACTIVITY PARTICIPATION

The majority of adolescents within the study, whether they presented with LBP or not, reported low levels of physical activity participation. A small percentage of participants reported high physical activity participation and they presented with lifetime and one year prevalence of LBP. No association was found between sports participation and LBP in this study with no statistically significant results. Conflicting findings have been reported in previous studies, with some studies reporting adolescent LBP associated with high physical activity participation (Jordaan, 2005; Balague et al, 1999; Taimela et al, 1997; Balague et al, 1994), while Salminen et al. (1995) reported adolescent LBP prevalence to increase with a low frequency of physical activity.

It cannot be determined from this study if low levels of physical activity participation are the cause or effect of LBP. Low levels of physical activity participation could be the cause or the effect of adolescent LBP. It has been suggested that non strenuous physical activity is important to preserve and build trunk muscle strength and endurance (Limon et al, 2004). This needs further investigation.

The conflicting results between studies could be due to the fact that between studies there are many different definitions of physical activity participation and determining the categories into which the adolescents fell varied from study to study. In this study physical activity participation has been divided into low, moderate and high but the actual values of these tertiles may be different from other studies.

It was beyond the scope of this research report to investigate the association between trunk muscle endurance, lumbar-pelvic instability and physical activity participation but it would be interesting to see if those adolescents with low levels of physical activity participation also presented with altered muscle function.

5.9 SEDENTARY ACTIVITY PARTICIPATION

The results of the current study indicate that lifetime, one year and point prevalence of adolescent LBP increased as increased levels of sedentary activity participation were reported from the low to the moderate tertiles. Although the results were not statistically significant a definite trend was apparent. Similar results have been reported in other studies in which higher sedentary activity participation was associated with adolescent LBP (Masiero et al, 2008; Jordaan, 2005).

Although it cannot be determined from this study if higher levels of sedentary activity are the cause or effect of LBP. Jordaan, (2005) suggests that increased sedentary activity participation and low levels of physical activity participation may result in poor development of the musculoskeletal system which is therefore unable to tolerate mechanical loading or stress resulting in dysfunction which may lead to pain (Jordaan, 2005).

Difficulty is experienced in comparing results due to different definitions of sedentary activity participation.
In the current study sedentary activity included time and frequency spent watching television, working on a computer, studying, reading, watching movies, sleeping and lying down. These were all added together to give a total amount of sedentary activity a month. Other studies looked at individual activities such as time spent watching television (Balagué et al, 1999; Balagué et al, 1994), sitting time (Grimmer and Watson, 2001) or a combination of activities such as time spent working on a computer and time spent watching television (Sjolie, 2004).

It was beyond the scope of this research report to investigate the association between trunk muscle endurance, lumbar-pelvic instability and sedentary activity participation but it would be interesting to see if those adolescents with low to moderate levels of sedentary activity participation also presented with altered muscle function

It has been indicated that the treatment of adolescent LBP is multimodal. Family history, sports participation, physical activity participation and sedentary activity participation have been identified in previous studies as potential risk factors. These factors were therefore included in this study as a number of contributing factors may be involved in the cause of adolescent LBP and may need to be addressed together. It was also important to ensure the sample was not biased.

5.10 CRITICAL REVIEW OF THE STUDY

The strengths and limitations of the study will be reviewed.

Strengths of the study are as follows:

- The three schools were in very different socio-economic geographical areas.

- The researcher was blinded to the results of the questionnaire until completion of the physical assessment.

- This was the first study to investigate the association between lumbar-pelvic instability and trunk muscle endurance, and provides a baseline for future research.

- Eight factors were investigated in the study; a sample size of 80 was an adequate sample size.

Limitations of the study are as follows:

- Difficulties were encountered in finding schools which were willing to participate in the study. Two of the schools had a smaller number of students than the third school; this resulted in an uneven participation between the three schools.

- Some outcome measures were based on self reports. No attempts were made to validate the complaint of LBP reporting with parents/guardians.

- The questionnaire used should have been modified to include only those questions relevant to the current study.

- Each school year may have a different set of environmental risks, the data for the entire sample was analysed together and not per grade.

- Due to the high prevalence of reported LBP, it was an uneven match when investigating possible risk factors for LBP. Possible associations may have been missed. A matched case-control study would give more definite associations.

- Only adolescents in grade 8 to grade 11 were included in the study. It would be beneficial to include learners in lower grades as in the current study adolescents already presented with a high prevalence of LBP in grade 8 and grade 9. This was not possible in the current study as those grades fall into the primary school system.

- As this is a cross sectional study, it is not possible to demonstrate causality but only possible to show an association.

- Unmeasured variables could bias the result (e.g. psychosocial factors).

5.11 CONCLUSION

In this chapter the results of the study in terms of the research report have been discussed.

The lack of association between the factors investigated in this study of adolescents with LBP could be due to other physical characteristics not investigated in this study. The prevalence of LBP within the study was very high which makes true association between the potential risk factors and LBP difficult.

The interaction of multiple risk factors requires more attention. LBP is multidimensional therefore no single intervention is likely to be effective at preventing the overall problem of LBP.

CHAPTER 6 – CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The aim of the study was to investigate the association between adolescent LBP and lumbar-pelvic instability and trunk muscle endurance as well as investigate the association between lumbar-pelvic instability and trunk muscle endurance.

Lifetime, one-year and point prevalence of adolescent LBP were high in the current study.

Lumbar-pelvic instability showed no association with adolescent LBP. Trunk muscle endurance showed a stronger association. Adolescents with LBP presented with increased trunk flexor muscle endurance and decreased trunk extensor muscle endurance. The times recorded for trunk side flexor muscle endurance was similar in those adolescents with and without LBP.

Those adolescents with better lumbar-pelvic stability had better trunk muscle endurance results. This was only statistically significant for extensor trunk muscle endurance.

Point prevalence showed a statistically significant association with family history one-year prevalence a marginally significant result, while lifetime prevalence of LBP showed no association with family history.

The majority of adolescents in the study reported low activity level participation. Those adolescents in the moderate tertiles of sedentary activity participation reported a higher prevalence of LBP.

6.2 CLINICAL RECOMMENDATIONS

The implications of the findings can only be generalised to the specific population.

The high prevalence of adolescent LBP indicates the need for preventative strategies. Preventative strategies should include the following:

- Adolescents need to be educated on back care.
- Back care awareness needs to be addressed with learners of all ages as well as with parents and teachers.

- Adolescents need to be educated on correct lifestyle modifications in an effort to prevent or reduce the occurrence of LBP.

- Exercise needs to be encouraged to promote better physical fitness, endurance and strength. Exercise appears to have a protective function on LBP.

- Adolescents must be educated on the negative effects of prolonged sedentary activities and the effects of poor posture during this time.

- Adolescents need to be educated on correct spine function and on spinal stability.

- A multidisciplinary approach is necessary as the risk factors are multi-factorial.

6.3 RECOMMENDATIONS FOR FURTURE RESEARCH

Recommendations for future research include the following:

- Longitudinal studies are needed in order to establish the cause and effect relationship of LBP and risk factors in the adolescent population.

- School furniture and ergonomics were not addressed in this study. The effects of sitting position on causality of adolescent LBP needs to be investigated.

- The study should be repeated as a matched case-control study to better define the association between the factors investigated and adolescent LBP.

- Further research is needed to describe the motor control pattern in adolescents when performing the ASLR.

- Further research is needed to investigate the association between lumbar-pelvic instability and trunk muscle endurance as this is the only study to date and therefore only sets a starting point for research in this field.

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APPENDIX A

LETTER TO INDEPENDENT SCHOOLS ASSOCIATION OF SOUTH AFRICA

ISASA Central Office 27 July 2008

Request to conduct a research study in ISASA member schools in Central Gauteng

I am a post-graduate student at the University of the Witwatersrand, and am planning a research study for a MSc Degree. My study will focus on the adolescent, and investigate possible risk factors that could cause low back pain in the adolescent.
From a review of the literature it is evident that there is an increase in low back pain in adolescents. Possible reasons include too little exercise, too much sedentary activities and too little sport, and decreased muscle strength and endurance. It has also been indicated that low back pain as an adolescent could be a predictor for low back pain as an adult.

The aim of this study is too further investigate decreased muscle endurance and stability as possible risk factors for adolescent low back pain. The study entails a short questionnaire that must be completed on sporting activities, time spent working on a computer or watching television, and on the nature of low back pain if present. Thereafter height and weight will be measured, and four standard physiotherapy tests will be used to record muscle strength and stability.
The information gained will help the researcher identify possible risk factors that could cause back pain in the adolescent. The adolescent is in a phase of rapid growth therefore it is important to plan a preventative programme to ensure the adolescent grows into a healthy pain-free adult.

I am writing to you to request your permission to conduct this study at certain schools that are ISASA members. The principals of the selected schools will be informed on the nature of the study, and their permission will be obtained in writing before the school is included in the study. The protocol will be submitted to the Research Ethics Committee, University of the Witwatersrand on 7th August 2008.

I would appreciate it sincerely if you would consider this request favourably.
Yours Sincerely

Françoise Lewis
Tel: 011 794 5044
Mobile: 082 699 0495
Email: franlewis@live.co.za

APPENDIX B

LETTER TO SCHOOL PRINCIPAL

To the Principal of __________________ High School

Hello, my name is Francoise Lewis. I am a registered physiotherapist, and am currently completing a Masters degree in physiotherapy at the University of the Witwatersrand. As part of my degree, I am studying low back pain in adolescents. I would like to invite your school to participate in the study, and request your permission to allow the Grade 8 – 11 learners at your school to participate in the study.

Permission for the study will be applied for with the University of the Witwatersrand, Human Research Ethics Committee (HREC).

I have included a description of the purpose of the study that will be involved:

South African and international studies on adolescent low back pain report the prevalence of low back pain to be between 20% - 50%. This is a very high percentage. Research indicates that adolescent low back pain is predictive of adult low back pain. A need has been identified to establish risk factors and associated factors for adolescent low back pain, and perhaps identify screening tools that can be used to identify adolescents at risk for low back pain.

This study aims to establish the prevalence of adolescent low back pain and identify possible risk factors that are present in adolescents that could be associated with low back pain.

All adolescents who agree to take part in the study will be allocated a number. This number will be on all documents and information collected relating to the adolescent for the entire study. The list of numbers and corresponding names will be kept in a locked safe. Names and public information will not be publicly divulged, and any results published from the study will remain anonymous.

The adolescent's participation in this study is entirely voluntary, and each adolescent is free to withdraw from the study at any time. No reason is required and no adverse consequences will follow his/her withdrawal. No cost will be incurred by any participating schools, learners or parents.

I will provide the parents and learners with an information sheet, explaining what the study will involve and inviting them to participate in the study. Parents will be required to sign informed consent and the adolescents sign assent before they will be included in the study.

All adolescents who have signed the assent form and whose parents have given consent will be eligible to participate in the study. From those learner's 5-10 boys and 5-10 girls in grades 8, 9, 10 and 11 will be randomly selected to be included in the study.

The learners who have been selected to participate in the study will need to complete a questionnaire at school. I will be there to help them fill it in. The questionnaire will take about 20 minutes to complete. The questionnaire contains information that must be completed on sporting activity, time spent working on a computer or watching television, the presence of back pain or other muscle and joint problems. I will also measure the adolescents muscle endurance and strength using four simple, standard physiotherapy assessments. The adolescent's height, weight and school bag weight will be measured. The measurements will take about 25 minutes for each child, and will be done in an enclosed, private area. I will arrange to take the measurements at a time which is convenient for your school and your learners. It is a once off measurement and physical assessment. As mentioned above, the learners name will not appear on the questionnaire, and all results will remain anonymous and be handed with strictest confidentiality.

Once the study is complete, I will inform your school, parents and pupils of the outcome of the entire study. Your learner's participation in this study will help contribute to the development of an effective assessment and screening programme to identify risk factors associated with adolescent low back pain. As the adolescent is in a phase of rapid growth, a preventative programme can be implemented, to ensure the adolescent develops into a healthy adult.

I would greatly appreciate your help in allowing your school to participate in the study.

Please feel free to contact me if there is any information, regarding this study, that you do not clearly understand, or if you require any further information.

Yours Sincerely
Françoise Lewis
Tel: 011 794 5044; Mobile: 082 699 0495
Email: franlewis@live.co.za

APPENDIX C

PARENTS – INFORMATION SHEET

Dear Parents of Grade 8 – 11 Pupils

Hello, my name is Fran Lewis. I am a physiotherapist currently completing my Masters degree in physiotherapy at the University of the Witwatersrand. As part of my degree, I am investigating low back pain in adolescents. Your child's school has kindly agreed to allow all grade 8-11 learners who are willing to take part, to participate in the study. I would like to invite your child to participate, and would be very grateful if you would consider letting him/her join in the study.

The following information will explain the purpose of the study and what will be involved.

South African and international studies on adolescent low back pain report the prevalence of low back pain to be between 20% - 50%. This is a very high percentage. Research indicates that adolescent low back pain is predictive of adult low back pain. A need has been identified to establish potential risk factors for adolescent low back pain.

This study aims to establish the prevalence of adolescent low back pain and establish the association between muscle weakness and instability on adolescent low back pain.

All adolescents who agree to take part in the study will be allocated a number. This number will be on all documents and information collected relating to the adolescent for the entire study. The list of numbers and corresponding names will be kept in a locked safe. Names and public information will not be publicly divulged, and any results published from the study will remain anonymous.

Your child's participation in this study is entirely voluntary, and is free to withdraw from the study at any time. No reason is required and no adverse consequences will follow his/her withdrawal. No cost will be incurred.
This study will include all children – whether they have previously complained of low back pain or not.

All learners who agree to take part in the study will need to complete a questionnaire relating to low back pain. The questionnaire will be completed at school, it will take about 20 minutes to complete. I will be there to explain it to them and help them fill it in.

I will measure your child's weight, height and school bag weight. I will also measure their muscle endurance and strength with four simple, standard physiotherapy assessments. This will be done in an enclosed, private area. The physical tests will take about 25 minutes to complete. No names will appear on the questionnaire, and all results will remain anonymous and will be handled with the strictest confidence.

From those learners and parents who have agreed to participate in the study, 5-10 girls and 5-10 boys will be randomly selected from each grade. It will be a once off assessment and completion of the questionnaire.

Your child's participation in this study will help contribute to the development of an effective assessment and screening programme to identify risk factors associated with adolescent low back pain. As the adolescent is in a phase of rapid growth, a preventative programme can be implemented, to ensure the adolescent develops into a healthy adult.

The school is not directly involved in this study, and they will not have access to your child's personal results. Once the study is complete, I will inform the school of the results of the study.

I would greatly appreciate you discussing this with your child and allowing your child to participate in the study. If you give your consent will you please fill in the consent form attached as well as the medical history form. If your child has any serious back problems or illness he/she is not required to take part in the study.
Your child needs to agree to participate in the study and needs to sign his/her name on the assent form attached.

Please return the consent form to the school by
____

Please feel free to contact me if you require any further information or if there is something you are unclear of regarding the study.

Thank you very much for your assistance.

Françoise Lewis
Tel: 011 794 5044
Mobile: 082 699 0495
E-mail: franlewis@live.co.za

APPENDIX D

LEARNERS – INFORMATION SHEET

Hello, my name is Fran Lewis. I am a physiotherapist and I am studying low back pain in children. Your school has agreed to allow all grade 8-11 learners who are willing to take part to join in my study. I would like to invite you to take part in my study. Before you agree to take part, it is important you read this letter and understand what the study involves.

In this study I would like to investigate what effect your muscles might have on low back pain. If you are part of the study, you will need to fill in a questionnaire. The questionnaire will ask you about what sport you do, how much time you spend at the computer, and about if you get back pain or not. It is not a test, and I will be there to explain it to you and help you fill it out if needed. I will also measure your trunk muscle endurance strength with four simple tests. This will be done in a private area and you will be in shorts and a t-shirt.

If at any time, you no longer want to be part of the study, you are allowed to say so and you do not have to give any reason.

I would be very grateful if you would give it some thought and would agree to participate in the study. If you want to take part, you and your parents need to complete the attached form and return it to school as soon as possible.

Thank you for your help

Françoise Lewis
Tel: 011 794 5044
Mobile: 082 699 0495
E-mail: franlewis@live.co.za

APPENDIX E

INFORMED CONSENT FORM

I hereby confirm that I have been informed by the researcher, Francoise Lewis, about the nature and purpose of this research study. I have received, read and understood the attached information sheet regarding the study. I was provided with a telephone number to contact the researcher should I require.

I am aware that the results of the study, including all personal details of my child, will be strictly confidential and will remain anonymous in all reports relating to the study. I understand that my child may withdraw from the study at any stage and there will be no adverse consequences should he/she choose to do so.

I consent to my child participating in the study.

Printed Name **Signature** **Date**

INFORMED ASSENT FORM

I hereby confirm that I have been informed by the researcher, Francoise Lewis, about the nature and purpose of this research study. I have received, read and understood the attached information sheet regarding the study.

I am aware that the results of the study, including all my personal details will remain strictly confidential. I may, at any stage, without any adverse consequence, withdraw from the study.

I assent to participate in the study.

Printed Name **Signature** **Date**

APPENDIX F

PARTICIPANTS MEDICAL HISTORY QUESTIONNAIRE

Dear Parent

Thank you for agreeing to let your child participate in this study. Please complete the questions below carefully. Due to the nature of this study, some children will have to be excluded. The questions below will help us decide if it is necessary to exclude your child from this study. **This information will be strictly confidential.**

Please feel free to contact the researcher if you require further information or if you would like to discuss any of the questions below.

---

1. Does your child have a severe scoliosis which requires him/her to wear a brace or which requires surgery?

YES	NO

2. Does your child find it difficult or impossible to stand up on his/her own without using an orthotic device or brace?

YES	NO

3. Is your child currently being treated for a fracture (broken bone)
in the back, pelvis, legs or arms?

YES	NO

4. Is your child currently being treated for any previous injury by a doctor/physiotherapist/biokineticist?

YES	NO

If **yes** specify: ____

5. Has your child been diagnosed with a neurological condition which affects the tone in his/her muscles?

YES	NO

6. Does your child have a chronic or serious illness, which requires him/her to take daily medication or receive regular treatment?

If **yes**, please list:
____

7. Has your child been diagnosed with a serious spinal pathology (e.g. tumour)?

YES	NO

If **yes**, please list:
____

THANK YOU

APPENDIX G

QUESTIONNAIRE

General Information

Reference Number: _______ Date of Birth: ___________

Age: _________

Male	Female

1. Sports participation

1. Do you participate in sport?

YES	NO

2. In the table below tick the sport/s in which you participate.
   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?
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
Jogging	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Cycling	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
Athletics	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
Netball	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
Hockey	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Aerobics	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Other – name:	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 or less	1x to 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 30 min	30 min	45 min	60 min	90 min or more

How hard do you practice?				
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

3. On what level do you participate in the sport mentioned above?

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

4. How long have you been participating in the abovementioned 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			

2. Other Physical Activities

1. Do you participate in any other activities other than sport?

YES	NO

2. In the table below tick the physical activities that you take part in. Use the grey table as a guide to encircle the suitable numbers in the other three columns.

Physical activity	Tick what you do:	How often?	How long?	How hard?
Dancing				
Walking for fun				
Walk/cycle to school				
Gardening				
Washing the car				
Cleaning the house				
Disco				
Play musical instrument				
Other – name:				

How often do you do it?				
1	2	3	4	5
1x every two weeks or less	1x to 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 30 min	30 min	45 min	60 min	90 min or more

How hard do you practice?				
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

3. Sedentary Activities: (activities done when you are sitting/lying down)

Tick all the activities you do while sitting/lying down in the table below
Use the grey table as a guide to encircle the suitable numbers in the other two columns

Physical activity	Tick what you do:	How often?	How long?	How hard?
Watching television				
Working on a computer				
Studying				
Reading				
Washing movies				
Sitting				
Sleeping during the day				
Lying down				
Other – name:				

How often do you do it?				
1	2	3	4	5
1x every two weeks or less	1x to 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 30 min	30 min	45 min	60 min	90 min or more

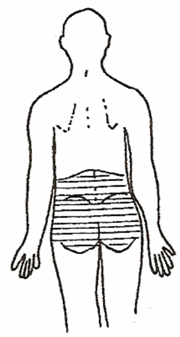
4. Back Pain

1. Have you ever had pain or discomfort in the lower part of your back that lasted more than 21 hours (1 day)?

YES	NO

2. Have you ever had pain or discomfort in the area indicated in the figure below?

YES	NO



3. Have you had pain or discomfort in the lower part of your back in the last 12 month's (1 year)?

YES	NO

4. If you had pain in the lower part of your back in the past 12 months (1 year), answer the following questions:

a. When did it start?

1 to 3 months ago	
4 to 6 months ago	
7 to 12 months ago	
13 months to 2 years ago	
more than 2 years ago	

b. How did it start?

Spontaneously	
motor vehicle accident	
sports injury	
other trauma (fall, lifting)	
other – name:	

c. 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	

d. How long does the low back pain last when it is present?

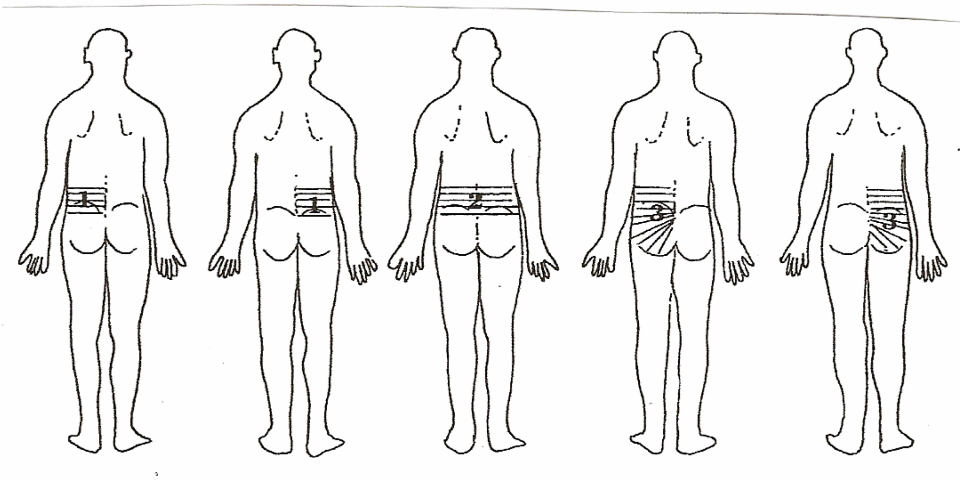
a few hours to one day	
2 to 3 days	
4 to 5 days	
one week	
longer than one week	

5. Do you have pain in the lower part of your back at the moment?

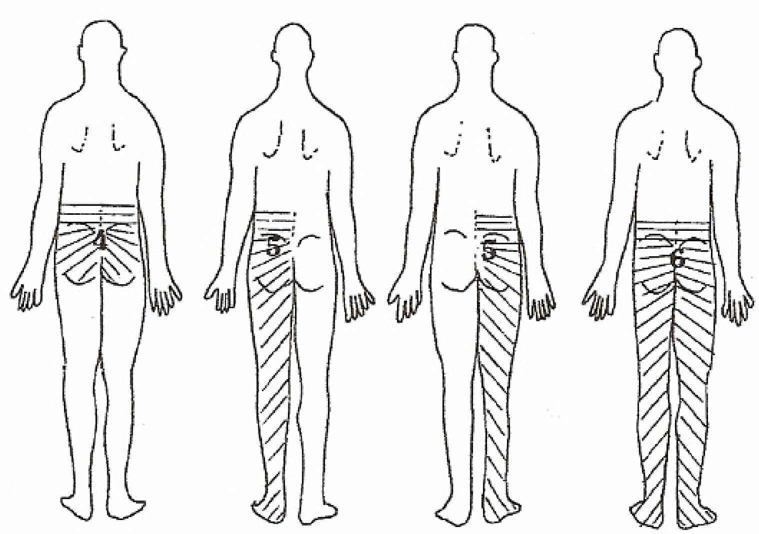
YES	NO

6. Look at the figures and indicate the area in which you experience your back pain. **Please note:**

The back pain can only be in the lower part of your back, (both sides or only on one side), or sometimes the symptoms can spread to the buttock(s), the thigh(s) or the lower part of the leg(s). The symptoms that you could experience is pain, tingling feeling, numbness or a feeling of heaviness.



Area 1 **Area 1** **Area2** **Area 3** **Area 3**



Area 4 **Area 5** **Area 5** **Area 6**

Area 1: only one side (left or right side) of the low back	
Area 2: both sides of the low back	
Area 3: one side of the low back and spreading into the buttocks (left or right side)	
Area 4: both sides of the low back and spreading into both buttocks	
Area 5: one side of the low back and spreading into the buttocks and leg on that side	
Area 6: both sides of the low back, spreading into both buttocks and legs	

7. Does the pain in your back make any of the following activities difficult?

	YES	**NO**
Reaching up, e.g.: to get a book from a shelf		
Carrying your school bag		
Sitting on a chair for a 45 min lesson		
Stand for 10 minutes, e.g.: in a queue		
Sitting up from a lying position		
Bending down e.g.: to put your socks on		
Stand up from a chair		
Running fast, e.g.: to catch a bus		
Sports activities		

8. Have you ever had to stop or change your sport activities due to pain in your lower back?

YES	**NO**

9. Have you had any treatment for the back pain?

YES	**NO**

a. If **yes**, what treatment did you have?

Rest in bed	
Medication	
Physiotherapy	
Exercises	
Other, name:	

b. Did the treatment help?

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

5. School bag information

1. How do you usually carry your school bag?

Backpack carried on both shoulders	
Backpack carried on one shoulder	
Suitcase carried in one hand	
Trolley type on wheels pulled with one hand	

2. If you carry your school bag on one side, which side is it?

Right	Left

3. Are you left or right handed?

Right	Left

3.Do you get tired carrying your school bag?

Never	
Sometimes	
Often	
Always	

4.Do you think your school bag is too heavy for you?

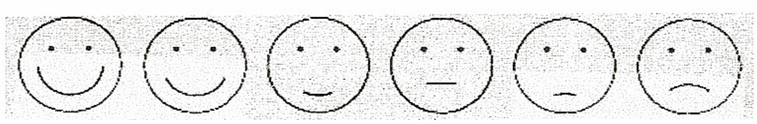
YES	**NO**

5. If you reported that you get low back pain, do you think picking up or carrying your schoolbag makes it worse?

YES	**NO**

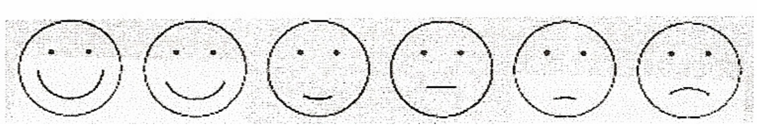
6. Emotions

1.How do you feel about your school work?
Mark the face that indicates your feeling, by circling the letter underneath?



A B C D E F

2. How do you feel about your life in general?
Mark the face that indicates your feelings, by circling the letter underneath it?



A B C D E F

7. Family History

Do you ever hear your mom or dad complaining about back pain?

YES	NO

8. If you are a girl, please answer the following questions

1. If you reported that you experience low back pain, do you get the low back pain only during menstruation (during your monthly period)?

YES	NO

2. Do you get back pain at other times as well as during menstruation (monthly period)?

YES	NO

Thank you for your participation

APPENDIX H

PHYSICAL TESTS

Active Straight Leg Raise Test

The active straight leg raise test will be used to measure the functional integrity of the lumbar stabilising muscles (Mens et al, 2001).

The participant is positioned in supine, and asked to alternatively raise the legs 20 cm. The ease with which they do it is reported by the participant and observed by the tester.

To quantify the measurement, three pressure biofeedback units will be used. Two pressure biofeedback units will be positioned beneath the posterior superior iliac spines on each side just lateral to the midline. One pressure biofeedback unit will be placed beneath the leg at the ankle of the resting leg. Each shall be inflated to a baseline pressure of 40mmHg (Jordaan, 2005)

The participant is instructed to lift one leg 20cm above the bed, keeping the leg straight, and hold for 10 seconds to allow recording of the pressure change at the three pressure biofeedback units. This shall be repeated on the opposite leg. The test shall be repeated twice and the mean value used.

The subject will then stand and be fitted with a sacroiliac belt. The influence of the belt on the ability to actively raise the leg will be assessed by the participant (Mens et al, 1999).

The test will then be repeated as above and the pressure changes recorded.

Trunk Flexion Muscle Endurance

Abdominal muscle endurance will be recorded using the Shirado Test (Bernard et al, 2008; Evans et al, 2006; Ito T et al, 1996).

Participant is positioned in a supine position and raises the lower extremities with 90’ flexion of the hip and knee joints. Participant’s arms are crossed in front of their chest. A small sit up is performed lifting the shoulders off the plinth.

The position is held for as long as possible and time recorded in seconds with a stop watch.

In participant's who experience no difficulty in holding the position, the test is stopped after 240 seconds.

The measurement will be recorded once.

Trunk Extension Muscle Endurance

Back extensor endurance will be recorded using the Sorensen Test (Bernard et al, 2008; Evans et al, 2006; Demoulin C et al, 2004).

The participant is positioned in prone with the upper edge of the iliac crests aligned with the edge the table. The lower body is fixed to the table by two straps, located around the pelvis and knees. The upper body is supported on a small stool slightly lower than the plinth. With the arms folded across the chest, the subject is asked to isometrically maintain the upper body in a horizontal position. The position is held for as long as possible and time recorded in seconds with a stop watch.

In subjects who experience no difficulty in holding the position, the test is stopped after 240 seconds.

The measurement will be recorded once.

Trunk Lateral Flexion Muscle Endurance

Trunk lateral flexor endurance will be recorded using the side bridge test (Evans et al, 2007; McGill et al, 1999).

The participant is positioned lying on their sides with legs extended. The top foot is places in front of the lower foot. Participant is instructed to support themselves lifting their hips off the mat to maintain a straight line over their full body length, and support themselves on one elbow and their feet. The uninvolved arm was held across the chest with hand placed on the opposite shoulder. The positioned is held for as long as possible and time recorded in seconds with a stop watch.

In subjects who experience no difficulty in holding the position, the test is stopped after 240 seconds.

The measurement will be recorded once.

APPENDIX I

Physical Assessment Data Collection Sheet Form

Reference Number: _________ **Date: _______**

Consent Form Signed: ______

Assent Form Signed: ______ **Questionnaire Completed: ______**

---

1. Height: ___________ cm

2. Weight: ___________ kg

3. Body mass index: ___________ m²

4. School bag weight: ___________ kg

PHYSICAL TESTS

5. Active Straight Leg Raise Test

5.1 Test 1

5.1.1 Participants' experience of ASLR

	R	L
Not difficult at all		
Minimally difficult		
Somewhat difficult		
Fairly difficult		
Very difficult		
Unable to do		

5.1.2 Pressure Change

Right ASLR				Left ASLR			
	Pressure recorded at:				Pressure recorded at:		
	Right PSIS	Left PSIS	Left foot		Left PSIS	Right PSIS	Right foot
Trial 1				Trial 1			
Trial 2				Trial 2			
Mean				Mean			

5.2 Test 2 – Participant fitted with SIJ belt

5.2.1 Participant's experience of ASLR

	R	L
Not difficult at all		
Minimally difficult		
Somewhat difficult		
Fairly difficult		
Very difficult		
Unable to do		

5.2.2 Pressure Change

Right ASLR				Left ASLR			
	Pressure recorded at:				Pressure recorded at:		
	Right PSIS	Left PSIS	Left foot		Left PSIS	Right PSIS	Right foot
Trial 1				Trial 1			
Trial 2				Trial 2			
Mean				Mean			

6. Trunk Flexor Endurance

Total length of hold in seconds	

7. Trunk Extensor Endurance

Total length of hold in seconds	

8. Trunk Side-Flexor Endurance

8.1 Right side flexion

Total length of hold in seconds	

8.2 Left Side Flexion

Total length of hold in seconds	

APPENDIX J

Ethical Clearance Certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Division of the Deputy Registrar (Research)

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
R14/49 Lewis

CLEARANCE CERTIFICATE	PROTOCOL NUMBER M080959
PROJECT	The Association between Trunk Muscle Endurance and Lumbar-Pelvic Instability on Adolescent Low Back Pain
INVESTIGATORS	Miss F Lewis
DEPARTMENT	Physiotherapy Department
DATE CONSIDERED	08.09.26
DECISION OF THE COMMITTEE*	Approved unconditionally

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

DATE 08.09.29 CHAIRPERSON ....
pp (Professor P E Cleaton Jones)

*Guidelines for written 'informed consent' attached where applicable

cc: Supervisor : W Wood

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

APPENDIX K

Results of the Pilot Study

The Pearson correlation was used to assess intra-rater reliability for the continuous data.

Table 4.5 Intra-rater reliability of continuous data

	Pearson correlation (r)
Height (ht)	1
Weight (wt)	1
BMI	1
Schoolbag weight	0.64
Flexion endurance	0.98
Extension endurance	0.97
Right side flexion endurance	0.99
Left side flexion endurance	0.99

Observed agreement was used to assess intra-rater reliability of categorical data. A reliable test that takes into account chance agreement is Kappa. However with a pilot study sample size of 5 it cannot be used.

Table 4.6 Intra-rater reliability of categorical data

	Observed Agreement
Right ASLR	1
Right PSIS	1
Left Foot	0.8
Left ASLR	1
Left PSIS	0.6
Right Foot	0.8
Right ASLR- with SIJ Belt	1
Right PSIS - with SIJ Belt	0.6
Left Foot - with SIJ Belt	0.6
Left ASLR - with SIJ Belt	1
Left PSIS - with SIJ Belt	0.6
Right Foot - with SIJ Belt	1

APPENDIX L

Results of the Main Study

This appendix contains tables not used in the main study discussion but from which figures in the study were derived.

Table 4.7 Gender Representation

	Total Learners (n=80)	
	%	N
Male	42.5	35
Female	57.5	46

Table 4.8 Age Group representations

Age Group	Total (n)	Male	Female
12 year	2	1	1
13 year	18	8	10
14 year	24	12	12
15 year	19	4	15
16 year	11	7	4
17 year	6	2	4

Table 4.9 Prevalence of LBP by sports participation

Prevalence of LBP	Low		Moderate		High		p-value
	%	n	%	n	%	N	
Lifetime (n=66)	62.12	41	25.76	17	12.12	8	0.389
1 Year (n=63)	63.49	40	23.81	15	12.70	8	0.242
Point (n=19)	52.63	10	26.32	5	21.05	4	0.171
No LBP (n=14)	71.43	10	28.57	4	0	0	

Table 4.10 Prevalence of LBP by physical activity

Prevalence LBP	Low		Moderate		High		p-value
	%	n	%	n	%	N	
Lifetime (n=66)	80.30	53	13.64	9	6.06	4	0.640
1 Year (n=63)	79.36	50	14.29	9	6.35	4	0.530
Point (n=19)	84.21	16	15.79	3	0	0	0.510
No LBP (n=14	85.71	12	14.29	2	0	0	

Table 4.11 Prevalence of LBP by sedentary activities

Prevalence LBP	Low		Moderate		High		p-value
	%	n	%	n	%	N	
Lifetime (n=66)	31.82	21	59.09	39	9.09	6	0.145
1 Year (n=63)	33.34	21	57.14	36	9.52	6	0.308
Point (n=19)	21.05	4	68.42	13	10.53	2	0.280
No LBP (n=14)	57.14	8	42.86	6	0	0	

Table 4.12 Subjects perception of Right ASLR and LBP

ASLR	Lifetime Prevalenc		Year Prevalence		No LBP	
	%	n	%	n	%	n
1	0	0	0	0	0	0
2	1.51	1	1.59	1	0	0
3	6.06	4	6.35	4	0	0
4	12.12	8	12.70	8	0	0
5	43.94	29	42.86	27	35.51	5
6	36.36	24	36.51	23	64.29	9
p-value	0.275		0.274			

Table 4.13 Subject's perception of Left ASLR and LBP

L ASLR	Lifetime Prevalenc		Year Prevalence		No LBP	
	%	n	%	n	%	n
1	0	0	0	0	0	0
2	1.51	1	1.59	1	0	0
3	1.51	1	1.59	1	0	0
4	10.61	7	9.52	6	0	0
5	42.42	28	42.86	27	28.57	4
6	43.94	29	44.44	28	71.43	10
p-value	0.373		0.649			

Table 4.14 Right ASLR and pressure change at Right PSIS

R ASLR	Lifetime Prevalenc		Year Prevalence		No LBP	
R PSIS	%	n	%	n	%	n
Poor	51.52	34	52.38	33	28.57	4
Moderate	42.42	28	41.27	26	64.29	9
Good	6.25	5	6.35	4	7.14	1
p-value	0.287		0.214			

Table 4.15 Left ASLR test pressure change at Left PSIS

L ASLR	Lifetime Prevalenc		Year Prevalence		No LBP	
L PSIS	%	n	%	n	%	N
Poor	42.42	28	42.86	27	35.71	5
Moderate	54.55	36	53.97	34	54.14	8
Good	3.03	2	3.17	2	7.14	1
p-value	0.719		0.777			

Table 4.16 Right ASLR test and pressure change at Left Foot

R ASLR	Lifetime Prevalenc		Year Prevalence		No LBP	
L Foot	%	n	%	n	%	n
Poor	24.24	16	23.81	15	14.29	2
Moderate	71.21	47	71.43	45	85.71	12
Good	4.55	3	4.76	3	0	0
p-value	0.478		0.535			

Table 4.17 Left ASLR test pressure change at Right Foot

L ASLR	Lifetime Prevalenc		Year Prevalence		No LBP	
R Foot	%	n	%	n	%	N
Poor	43.94	29	44.44	28	21.43	3
Moderate	54.55	36	53.97	34	78.57	11
Good	1.52	1	1.59	1	0	0
p-value	0.245		0.236			

Table 4.18 Perception of right ASLR with and without SIJ belt

Right ASLR	Without SIJ Belt		With SIJ Belt	
	%	N	%	N
1	0	0	0	
2	1.51	1	0	
3	6.06	4	4.55	3
4	12.12	8	1.52	1
5	43.94	29	24.24	16
6	36.36	24	69.70	46
p-value	0.275		0.251	

Table 4.19 Perception of Left ASLR with and without SIJ belt

Left ASLR	Without SIJ Belt		With SIJ Belt	
	%	n (n=66)	%	n(n=66)
1	0	0	0	0
2	1.51	1	0	0
3	1.51	1	3.03	2
4	10.61	7	3.03	2
5	42.42	28	22.73	15
6	43.94	29	71.21	47
p-value	0.373		0.444	

Table 4.20 Right ASLR pressure change at Right PSIS with and without SIJ belt

R ASLR R PSIS	Without SIJ Belt		With SIJ Belt	
	%	N	%	N
Poor	51.52	34	45.45	30
Moderate	42.42	28	43.94	29
Good	6.25	5	10.61	7
p-value	0.287		0.509	

Table 4.21 Left ASLR pressure change at Left PSIS with and without SIJ belt

L ASLR L PSIS	Without SIJ Belt		With SIJ Belt	
	%	n (n=66)	%	n (n=66)
Poor	42.42	28	34.85	23
Moderate	54.55	36	57.58	38
Good	3.03	2	7.58	5
p-value	0.719		0.694	

Table 4.22 Right ASLR pressure change at Left foot with and without SIJ belt

R ASLR L foot	Without SIJ Belt		With SIJ Belt	
	%	N	%	N
Poor	24.24	16	27.27	18
Moderate	71.21	47	68.18	45
Good	4.55	3	4.55	3
p-value	0.478		0.269	

Table 4.23 Left ASLR pressure change at Right foot with and without SIJ belt

L ASLR R foot	Without SIJ Belt		With SIJ Belt	
	%	n (n=66)	%	n (n=66)
Poor	43.94	29	33.33	22
Moderate	54.55	36	63.64	42
Good	1.52	1	3.03	2
p-value	0.245		0.251	

Table 4.24 Mean values for trunk flexor muscle endurance

Flexor Endurance	n	%	Mean (sec)	Standard Deviation	p-value	Confidence Limits (CI 95%)
LBP (n=66)	66	100	56.95	39.86	0.044	47.15 – 66.75
No LBP (n=14)	14	14	40.36	23.18	0	26.98 – 53.76

Table 4.25 Mean values for trunk extensor muscle endurance

Extensor Endurance	n	%	Mean (sec)	Standard Deviation	p-value
LBP (n=66)	66	100	83.66	42.94	0.304
No LBP (n=14)	14	14	96.57	39.57	0

Table 4.26 Mean values for trunk right side flexor muscle endurance

Right Side Flexor Endurance	n	%	Mean (sec)	Standard Deviation	p-value
LBP (n=66)	66	100	53.33	38.56	0.838
No LBP (n=14)	14	14	51.11	25.44	0

Table 4.27 Mean values for trunk left side flexor muscle endurance

Left Side Flexor Endurance	n	%	Mean (sec)	Standard Deviation	p-value
LBP (n=66)	66	100	53.13	37.20	0.900
No LBP (n=14)	14	14	54.56	45.14	0

Table 4.28 Mean endurance scores and averaged ASLR

ASLR	Flex End		Ext End		R SideFlex End		L SideFlex End	
	Mean (sec)	n=80	Mean (sec)	n=80	Mean (sec)	n=80	Mean (sec)	n=80
Poor	52.10	45	79.72	45	51.36	45	52.93	45
Moderate	55.00	32	89.16	32	52.89	32	52.02	32
Good	73.18	3	144.20	3	77.14	3	74.68	3
p-value	0.642		0.031		0.501		0.622	
Confidence Limits (CI 95%)	Poor 42.30-61.90 Mod 40.85-69.15		Poor 68.03-91.41 Mod 74.40-100		Poor 41.34 - 61.38 Mod 40.60 - 65.18		Poor 41.69 - 64.16 Mod 39.70 - 64.34	

APPENDIX M

This appendix contains tables not used in the main study discussion but which was derived from the questionnaire.

Table 4.29 Behaviour of LBP in subjects with a one year prevalence (n=63)

Behaviour	n = 63	%
Time of onset		
• 1 to 3 months ago	23	36.5
• 4 to 6 months ago	6	9.5
• 7 to 12 months ago	19	30
• 13 months to 2 years ago	9	14.5
• More than 2 years ago	6	9.5
Mode of onset		
• Spontaneously	41	65
• Motor vehicle accident	1	1.6
• Sports injury	16	25.4
• Other trauma (fall, lifting)	5	8
• Other	0	0
Frequency		
• Everyday	8	12.5
• One to three times per week	10	16
• Once every two weeks	12	19
• Once per month	15	24
• Once every three to six months	11	17.5
• Less than once in six months	7	11
Duration of episodes		
• A few hours to one day	48	76
• Two to three days	7	11.2
• Four to five days	3	4.8
• One week	2	3.2
• Longer than one week	3	4.8

Table 4.30 LBP distribution (n=66)

Area of LBP	n=66	%
• Unilateral – localised to lumbar area	4	6.3
• Bilateral – localised to lumbar area	43	68.2
• Unilateral lumbar area – spreading to Buttocks	0	0
• Bilateral lumbar area – spreading to Buttocks bilaterally	11	17.5
• Unilateral lumbar – spreading to leg	2	3.2
• Bilateral lumbar – spreading to legs bilaterally	3	4.8

Table 4.31 Treatment pattern for those learners with a history of LBP (n=18)

	n = 18	%
Treatment received	18	28.6
Type of treatment		
• Rest in bed	5	27.7
• Medication	7	38.8
• Physiotherapy	6	33.3
• Exercise	3	16.7
• Other: - massage	1	5.5
- reflexology	1	5.5
- chiropractor	1	5.5
Effectiveness of treatment		
• No help at all	1	5.5
• Helped for a short while	3	16.7
• Pain relief, but still gets pain regularly	7	38.9
• Pain relief, still gets pain, but seldom	5	27.8
• Total pain relief, never had pain again	2	11.1