

**Specific Exercises as a Secondary Preventative
Intervention Programme for Low Back Pain in
12-13 year old Children**

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**Dissertation submitted to the Faculty of Health Sciences,
University of the Witwatersrand,
in fulfillment of the requirements for the degree
of
Master of Science in Physiotherapy**

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DECLARATION

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

Statisticians assisted with the statistical design and data analysis.

A research assistant, namely a qualified physiotherapist who was registered for a master's degree in physiotherapy at the University of the Witwatersrand at the time of this study, assisted with this study by conducting all of the exercise intervention classes.

Gina Lucia Fanucchi

Date

**I dedicate this study
to my husband Tibor,
my inspiration**

ABSTRACT

Specific Exercises as a Secondary Preventative Intervention Programme for Low Back Pain in 12-13 year old Children

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Many recent large epidemiological studies have shown that the incidence of non-specific low back pain (LBP) in adolescents is very similar to that in adults, and that LBP in children is predictive of LBP in adults. As a result, it has been suggested that programmes targeting the prevention of LBP should be implemented early. However, there is currently very limited literature available on LBP preventative interventions during childhood. Therefore, this study aimed to determine the efficacy of an eight-week specific exercise programme in reducing self-reported episodes and intensity of LBP, as well as modifying some of the identified risk factors for LBP in children.

A randomised control trial was used. Seventy-two 12-13 year old children, who had complained of LBP in the past three months, were included in the study. The intervention group completed an eight week school-based specific exercise programme, whilst the control group continued with normal school activity during this time. Data were collected at baseline, immediately post-intervention and at three months post-intervention, using a valid, reliable questionnaire and physical measurements.

Treatment groups were compared with respect to change from baseline to post-intervention, using an analysis of covariance (ANCOVA) with baseline values as covariates. Testing was done at the 0.05 level of significance. Significant improvements were observed in the exercise group for LBP prevalence ($p=0.02$), pain intensity VAS (3 months) ($p<0.01$) and VAS (1 month) ($p=0.01$), neural mobility ($p<0.00001$), hamstring flexibility ($p<0.00001$), iliopsoas flexibility ($p<0.001$) and lumbosacral position sense ($p=0.01$), immediately post-intervention, as well as three months post-intervention.

Therefore, it can be concluded that specific exercises are beneficial in the prevention of LBP in 12-13 year old children. In addition, specific exercise programmes should be implemented early, ideally as an integral component of school physical education programmes.

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TABLE OF CONTENTS

	Page
DECLARATION	ii
DEDICATION	iii
ABSTRACT	iv
ACKNOWLEDGEMENTS	v
TABLE OF CONTENTS	vi
LIST OF FIGURES	xiv
LIST OF TABLES	xv
LIST OF ABBREVIATIONS	xvii
CHAPTER 1 – INTRODUCTION	1
CHAPTER 2 – LITERATURE REVIEW	4
2.1 INTRODUCTION	4
2.2 LOW BACK PAIN	5
2.2.1 Definitions	5
2.2.2 LBP in the Adult Population	5
2.2.3 LBP in Children / Adolescents	6
2.2.4 LBP Adolescence to Adulthood	7
2.3 STABILIZING SYSTEM OF THE LUMBAR SPINE	8
2.3.1 Passive System	9
2.3.2 Active System	9
2.3.2.1 Local Muscular System	10
2.3.2.2 Global Muscular System	12
2.3.3 Neuromuscular Control System	13
2.4 CAUSES OF NON-SPECIFIC LOW BACK PAIN	13
2.4.1 Passive System Dysfunction	14
2.4.2 Active System Dysfunction	14

2.4.2.1 Local Muscular System Dysfunction	14
2.4.2.2 Global Muscular System Dysfunction	15
2.4.3 Neural Control System Dysfunction	16
2.4.4 Other	16
2.5 RISK FACTORS FOR LOW BACK PAIN IN CHILDREN	17
2.5.1 Lifestyle Risk Factors	18
2.5.2 School Related Risk Factors	19
2.5.3 Physical Risk Factors	20
2.5.3.1 Muscle Strength	20
2.5.3.2 Muscle Length	22
2.5.3.3 Neural Mobility	23
2.5.3.4 Lumbosacral Position Sense	24
2.5.4 Psychosocial Risk Factors	25
2.5.5 Growth Spurt	25
2.5.6 Risk Factor Summary	26
2.6 LOW BACK PAIN PREVENTION OUTCOME MEASURES	27
2.6.1 Pain	28
2.6.2 Back Pain Specific Functional Status	29
2.6.3 General Health Measure	29
2.6.4 Work-Loss	30
2.6.5 Physical Outcome Measures	30
2.6.6 Summary of LBP Outcomes in Children	31
2.7 PREVENTATIVE INTERVENTION PROGRAMMES FOR LBP	31
2.7.1 LBP Prevention Programmes in Adults	32
2.7.1.1 Acute LBP	35
2.7.1.2 Chronic LBP	36
2.7.1.3 Specific Stabilization Exercise Programmes	36
2.7.1.4 General Exercise Programmes	37
2.7.1.5 Summary of LBP Prevention in Adults	38
2.7.2 LBP Prevention Programmes in Children	38
2.8 SCHOOL BASED INTERVENTIONS	44
2.9 SPECIFIC EXERCISES IN LOW BACK PAIN PREVENTION	45
2.9.1 Warm Up	46

2.9.2 Core Stabilization	46
2.9.2.1 Beginners Lumbar Core Stabilization	47
2.9.2.2 Intermediate Lumbar Core Stabilization	48
2.9.2.3 Advanced Lumbar Core Stabilization	48
2.9.3 Diaphragmatic Breathing	49
2.9.4 Pelvic Floor Exercise	49
2.9.5 Balance Retraining	49
2.9.6 Functional Exercises	50
2.9.7 Stretching	50
2.9.8 Neural Mobilization Exercises	51
2.10 CONCLUSION OF LITERATURE REVIEW	51
CHAPTER 3 – METHODOLOGY	54
3.1 STUDY DESIGN	55
3.2 SAMPLE SELECTION	55
3.2.1 Sample Population	55
3.2.2 Inclusion and Exclusion Criteria	55
3.2.3 Sample Size Calculation	56
3.2.4 Ethical Considerations	56
3.3 MEASURING INSTRUMENTS	57
3.3.1 Questionnaire	57
3.3.2 Digital Inclinometer	58
3.3.3 Pressure Biofeedback Units	58
3.4 PHYSICAL MEASUREMENTS	58
3.4.1 Functional Integrity of the Lumbar Stabilizing Muscles	59
3.4.2 Neural Mobility	59
3.4.3 Muscle Length Tests	59
3.4.3.1 Hamstring Muscle Length Test	60
3.4.3.2 Iliopsoas Muscle Length Test	60
3.4.3.3 Rectus Femoris Muscle Length Test	61
3.4.4 Lumbosacral Position Sense / Proprioception	61

3.5 PROCEDURE	61
3.5.1 Pilot Study	61
3.5.2 Main Study	62
3.6 EXERCISE PROGRAMME	65
3.6.1 Exercise Class	65
3.6.1.1 Warm-up	66
3.6.1.2 Diaphragmatic Breathing	67
3.6.1.3 Core Activation Sequence	67
3.6.1.4 Bridging Progressions	68
3.6.1.5 Hamstring and Lumbar Spine Stretches	68
3.6.1.6 Postural Alignment and Progressions in Four-Point Kneeling	69
3.6.1.7 Balance Exercises	70
3.6.1.8 Functional Exercises	70
3.6.1.9 Iliopsoas and Quadriceps Stretches	70
3.6.1.10 Diaphragmatic Breathing and Relaxation	70
3.6.2 Home Exercise Programme	71
3.7 DIFFICULTIES ENCOUNTERED	72
3.8 STATISTICAL ANALYSIS	76
3.9 CONCLUSION	76
CHAPTER 4 – PILOT STUDY RESULTS	77
4.1 PILOT STUDY	78
4.1.1 Demographics	78
4.1.2 Reliability	78
4.1.2.1 Questionnaire	78
4.1.2.2 Physical Measurements	78
4.1.3 Pilot Study Results	79
4.1.3.1 Low Back Pain	79
4.1.3.2 Physical Measurements	81
4.1.3.3 Sense of Well-Being	82
4.1.3.4 Perception of Exercise	83
4.1.4 Summary of Pilot Study Results	83

CHAPTER 5 – MAIN STUDY RESULTS

5.1 DEMOGRAPHICS	85
5.2 LOW BACK PAIN	86
5.2.1 Low Back Pain Prevalence	86
5.2.1.1 Low Back Pain Prevalence – Comparison between schools	86
5.2.2 Onset and Cause of Low Back Pain	87
5.2.3 Low Back Pain Behaviour	88
5.2.4 Areas of Low Back Pain	89
5.3 PAIN INTENSITY – VISUAL ANALOGUE SCALES	90
5.3.1 VAS Baseline Data	90
5.3.2 Changes in VAS from Baseline	91
5.3.2.1 Changes in VAS from Baseline – Comparison between schools	95
5.4 SUMMARY OF LBP PREVALENCE AND INTENSITY	99
5.5 LUMBAR STABILITY – ACTIVE STRAIGHT LEG RAISE	101
5.5.1 Baseline Data – Lumbar Stability	101
5.5.2 Changes in Lumbar Stability from Baseline	102
5.5.2.1 Changes in Lumbar Stability from Baseline – Comparison between schools	103
5.6 NEURAL MOBILITY – PASSIVE STRAIGHT LEG RAISE TEST	103
5.6.1 Baseline Data – Neural Mobility	103
5.6.2 Changes in Neural Mobility from Baseline	104
5.6.2.1 Changes in Neural Mobility from Baseline – Comparison between schools	105
5.7 HAMSTRINGS - MUSCLE LENGTH	105
5.7.1 Baseline Data – Hamstrings Muscle Length	106
5.7.2 Changes in Hamstrings from Baseline	106
5.7.2.1 Changes in Hamstrings from Baseline – Comparison between schools	107
5.8 ILIOPSOAS – MUSCLE LENGTH	107
5.8.1 Baseline Data – Iliopsoas Muscle Length	108
5.8.2 Changes in Iliopsoas from Baseline	108
5.8.2.1 Changes in Iliopsoas from Baseline – Comparison between schools	109
5.9 RECTUS FEMORIS – MUSCLE LENGTH	109

5.9.1	Baseline Data – Rectus Femoris Muscle Length	110
5.9.2	Changes in Rectus Femoris from Baseline	110
5.9.2.1	Changes in Rectus Femoris from Baseline – Comparison between schools	111
5.10	LUMBOSACRAL POSITION SENSE / PROPRIOCEPTION	111
5.10.1	Baseline Data – Lumbosacral Position Sense	112
5.10.2	Changes in Lumbosacral Position Sense from Baseline	112
5.10.2.1	Changes in Lumbosacral Position Sense – Comparison between schools	113
5.11	SUMMARY OF PHYSICAL RISK FACTORS	113
5.12	SENSE OF WELL BEING – MHI-5	115
5.12.1	Baseline Data – MHI-5	115
5.12.2	Changes in MHI-5 from Baseline	115
5.13	SENSE OF WELL-BEING – FACE SCALES	116
5.13.1	Baseline Data – Face Scales	116
5.13.2	Changes in Face Scales from Baseline	116
5.14	SUMMARY - SENSE OF WELL-BEING	117
5.15	PERCEPTION OF PHYSICAL EDUCATION (PE) CLASSES	119
5.15.1	Baseline Data – Perception of PE	119
5.15.2	Changes in PE perception from Baseline	119
5.16	PERCEPTIONS OF THE IMPACT OF PE ON HEALTH AND FUNCTION	120
5.16.1	Baseline Data – Impact of PE on Health and Function	120
5.16.2	Changes in the Perceptions of the Impact of PE from Baseline	121
5.17	SUMMARY OF EXERCISE PERCEPTIONS	122
5.18	EXERCISE ADHERENCE	123
5.18.1	Exercise Classes	123
5.18.2	Home Exercise Programme	123
5.18.3	Continuation of Home Exercises Post-Intervention	125
5.19	PERCEPTION OF EXERCISE INTERVENTION PROGRAMME	125
5.19.1	Exercise Group	125
5.19.2	Control Group	127
5.20	SUMMARY OF MAIN STUDY RESULTS	127

CHAPTER 6 – DISCUSSION	129
6.1 INTRODUCTION	129
6.2 LOW BACK PAIN	129
6.2.1 LBP Prevalence	130
6.2.2 LBP Intensity	132
6.2.3 Summary and Clinical Implications	135
6.3 PHYSICAL RISK FACTORS	136
6.3.1 Lumbar Stability	136
6.3.2 Neural Mobility	137
6.3.3 Muscle Length	138
6.3.4 Lumbosacral Position Sense / Proprioception	139
6.3.5 Summary and Clinical Implications	139
6.4 SENSE OF WELL-BEING	140
6.4.1 Summary and Clinical Implications	142
6.5 PERCEPTION OF EXERCISE	142
6.5.1 Summary and Clinical Implications	143
6.6 COMPARISON BETWEEN SCHOOLS	143
6.6.1 Summary and Clinical Implications	144
6.7 SCHOOL-BASED INTERVENTION PROGRAMMES	144
6.7.1 Summary and Clinical Implications	144
6.8 EXERCISE PROGRAMME	145
6.8.1 Summary and Clinical Implications	145
6.9 CLINICAL RECOMMENDATIONS	146
6.10 RECOMMENDATIONS FOR FUTURE RESEARCH	148
6.11 CRITICAL REVIEW OF THE STUDY	149
6.12 CONCLUSION	150
CHAPTER 7 – CONCLUSION	154
REFERENCE LIST	155

APPENDICES	164
APPENDIX A: Ethical Clearance Certificate	165
APPENDIX B: Department of Education Letter	166
APPENDIX C: Information Sheet - Schools	168
APPENDIX D: Information Sheet - Parents	171
APPENDIX E: Information Sheet - Pupils	174
APPENDIX F: Informed Consent and Assent Forms	175
APPENDIX G: Participant Medical History Questionnaire	176
APPENDIX H: Questionnaire	177
APPENDIX I: Visual Analogue Scales	184
APPENDIX J: Questionnaire Scoring	185
APPENDIX K: Data Collection Sheets	188
APPENDIX L: Exercise Intervention Questionnaire	190
APPENDIX M: Home Exercise Sheets	192
APPENDIX N: Home Exercise Diary	200
APPENDIX O: Exercise Class Breakdown	212

LIST OF FIGURES

	Page
Figure 3.1 Outline of Sub-Sections included in Chapter 3 (Study Methodology)	54
Figure 3.2 Sample Description and Procedure	64
Figure 3.3 Proposed Timeline - School A + B	74
Figure 3.4 Actual Timeline	75
Figure 4.1 Outline of sub-sections included in the results chapters	77
Figure 4.2 Summary - Pilot Study Results	84
Figure 5.1 Changes in VAS (3 months)	91
Figure 5.2 Changes in VAS (1 month)	92
Figure 5.3 Changes in VAS (1 week)	93
Figure 5.4 Changes in VAS (current pain)	94
Figure 5.5 Changes in VAS (3 months) - Comparison between schools	95
Figure 5.6 Changes in VAS (1 month) - Comparison between schools	96
Figure 5.7 Changes in VAS (1 week) - Comparison between schools	97
Figure 5.8 Changes in VAS (current pain) - Comparison between schools	98
Figure 5.9 Summary - LBP Prevalence and Intensity	100
Figure 5.10 Changes in Lumbar Stability (ASLR)	102
Figure 5.11 Changes in Neural Mobility (PSLR)	104
Figure 5.12 Changes in Hamstring Muscle Length	106
Figure 5.13 Changes in Iliopsoas Muscle Length	108
Figure 5.14 Changes in Rectus Femoris Muscle Length	110
Figure 5.15 Changes in Lumbosacral Position Sense	112
Figure 5.16 Summary - Physical Risk Factors	114
Figure 5.17 Summary - Sense of Well-Being	118
Figure 5.18 Summary - Perceptions of PE	122
Figure 5.19 Summary - Main Study	128

LIST OF TABLES

	Page
Table 4.1 Questionnaire Reliability	78
Table 4.2 Intra-rater Reliability – Physical Measurements	79
Table 4.3 Low Back Pain Behaviour – Pilot Study Data	80
Table 4.4 Physical Risk Factors – Summary of Pilot Study Data	81
Table 4.5 Sense of Well-being – Summary of Pilot Study Data	82
Table 4.6 PE Perceptions – Summary of Pilot Study Data	83
Table 5.1 Demographics – Gender and Race	85
Table 5.2 Demographics – Age	85
Table 5.3 Low Back Pain Prevalence	86
Table 5.4 Low Back Pain Prevalence – Comparison between schools	87
Table 5.5 Onset and Cause of LBP	87
Table 5.6 Low Back Pain Behaviour	88
Table 5.7 Areas of Low Back Pain	89
Table 5.8 Baseline VAS scores	90
Table 5.9 Baseline Data – Lumbar Stability	102
Table 5.10 Changes in Lumbar Stability (ASLR) – Comparison between schools	103
Table 5.11 Baseline Data – Neural Mobility	104
Table 5.12 Changes in Neural Mobility (PSLR) – Comparison between schools	105
Table 5.13 Baseline Data – Hamstring Muscle Length	106
Table 5.14 Changes in Hamstring Muscle Length – Comparison between schools	107
Table 5.15 Baseline Data – Iliopsoas Muscle Length	108
Table 5.16 Changes in Iliopsoas Muscle Length – Comparison between schools	109
Table 5.17 Baseline Data – Rectus Femoris Muscle Length	110
Table 5.18 Changes in Rectus Femoris Muscle Length – Comparison between schools	111
Table 5.19 Baseline Data – Lumbosacral Position Sense	112
Table 5.20 Changes in Lumbosacral Position Sense – Comparison between schools	113

Table 5.21	Baseline Data – MHI-5	115
Table 5.22	Changes from Baseline – Sense of Well-being (MHI-5 scores)	115
Table 5.23	Baseline Data – Face Scales	116
Table 5.24	Changes from Baseline – Sense of Well-being (Face Scales)	117
Table 5.25	Baseline Data – Perception of PE	119
Table 5.26	Changes from Baseline – Perception of PE	119
Table 5.27	Baseline Data – Impact of PE on Health and Function	121
Table 5.28	Changes from Baseline – Perception of the Impact of PE on Health / Function	121
Table 5.29	Exercise Class Adherence	123
Table 5.30	Home Exercise Programme Adherence	124
Table 5.31	Continuation of Home Exercise Programme Post-Intervention	125
Table 5.32	Exercise Group – Perception of the Exercise Intervention Programme	126
Table 5.33	Control Group – Perception of the Exercise Intervention Programme	127

LIST OF ABBREVIATIONS

ASIS	Anterior superior iliac spine
ASLR	Active straight leg raise
CI	Confidence intervals
IAP	Intra abdominal pressure
LBP	Low back pain
MHI-5	Mental Health Inventory - 5
PE	Physical education
PSIS	Posterior superior iliac spine
PSLR	Passive straight leg raise
RCT's	Randomised controlled trials
SD	Standard deviation
SIJ	Sacroiliac joint
TA	Transversus abdominis
VAS	Visual analogue scale

CHAPTER 1

INTRODUCTION

Low back pain (LBP) has been identified as one of the most common reasons for a patient to consult a health-care practitioner. In addition, chronic and recurrent LBP have been identified as the highest single cause of work loss in the adult population. As a result, LBP places a large financial burden on the health care system, as well as having an effect on the economy, due to production loss (Burton et al 2004).

Initially, LBP in children was always thought to be related to serious underlying pathology. However, many recent, large epidemiological studies have shown that the incidence of non-specific LBP in children and adolescents is very similar to that observed in adults (Burton et al 2004). Jordaan et al (2005a) conducted a large epidemiological study in the Northern Gauteng district to determine the prevalence of LBP in South African adolescents. Their findings indicated a high prevalence of LBP in adolescents, with the lifetime or cumulative prevalence being 52.6%, one-year prevalence 50% and point prevalence 14.7%. These findings are similar to those of studies carried out in other countries (Kovacs et al 2003; Watson et al 2002; Leboeuf-Yde and Kyvik 1998).

In addition, there is evidence to indicate that back pain in children has a predictive value for LBP in adults (Hestbaek et al 2006a; Harreby et al 1995). Other adult studies have also shown that a strong predictor for LBP later in life is a previous history of LBP (Watson et al 2002; Adams et al 1999). As a result, it has been suggested that programmes which target the prevention of LBP should be implemented early. However, whilst there are extensive international epidemiological studies available on LBP in children, there is currently very limited literature available on the effectiveness of preventative interventions for LBP during childhood (Cardon and Balagué 2004).

Burton et al (2004) conducted an extensive review of the literature to compile 'The European Guidelines for Prevention in Low Back Pain'. Only five studies relating to children were found. Although the results of these studies were promising, the level of evidence was not strong enough to be conclusive for evidence-based practice. Similar results were found in a review by Steele et al (2006). Both reviews highlighted the need for further intervention studies on LBP in children, ideally comprising well conducted randomised control trials.

In contrast, prevention of LBP in adults has been extensively researched. There is strong evidence to indicate that programmes which incorporate information, advice and education alone, are not successful in preventing LBP in adults (Burton et al 2004; Frost et al 1995). However, there is strong evidence to indicate that exercise is successful in preventing LBP in adults (Ferreira et al 2006; Hayden et al 2005; Burton et al 2004; van Tulder et al 2000). In particular, specific exercises which focus on improving spinal and pelvic stability, have been shown to be the most effective in preventing LBP in adults (Ferreira et al 2006; Hodges 2003; Richardson et al 2002; O'Sullivan et al 1997).

However, until very recently no studies had investigated the efficacy of exercise as a preventative intervention for LBP in children. Currently there is only one, recent available study on exercise as an intervention for LBP during adolescence. This study had promising results, and thus concluded that a specific exercise programme appears to provide positive benefits for adolescents suffering from recurrent non-specific LBP (Jones et al 2007). During periods of rapid growth, the body is very susceptible to stresses placed on it (Grimmer and Williams 2000). Considering that the peak onset of LBP is between 12-14 years, it appears that the onset of LBP is related to the growth spurt in children, when the rapidly growing spine is very sensitive to excessive loads (Jordaan et al 2005a; Grimmer and Williams 2000). It can thus be hypothesized that, during the adolescent growth spurt, specific stabilizing exercises and stretches could place positive 'stresses' on the body, and so promote better development of the 'deep muscle' stabilizing mechanism and correct alignment of the spine. Furthermore, it can be hypothesized that a well-functioning stabilizing system in children could protect the body against the repetitive loads placed on it during normal physical activity, as well as activities of daily living.

PROBLEM STATEMENT

The high incidence of LBP in adolescents has been well documented worldwide. Findings in South African adolescents have also indicated a high prevalence of LBP in this population. Taking into account the possible link between adolescent and adult episodes of LBP, it has been suggested that programmes targeting the prevention of LBP should be implemented early. However, there is currently no literature available on the effectiveness of exercise as a preventative intervention for LBP in children in South Africa.

RESEARCH QUESTION

Is a specific exercise programme effective as an intervention in preventing LBP in 12-13 year old children?

AIM

This study aims to determine the efficacy of a school-based specific exercise programme, as a secondary preventative intervention for LBP in 12-13 year old children.

RESEARCH OBJECTIVES

The primary objectives of this study are to determine whether a school-based exercise programme for 12-13 year old children is effective in:

- reducing self-reported episodes of LBP
- reducing LBP intensity

The secondary objectives of this study are to determine whether a school-based exercise programme for 12-13 year old children is effective in:

- modifying some of the identified physical risk factors for LBP in children, namely: lumbosacral position sense, functional integrity of the sacroiliac joint to transfer loads to the lumbar spine, neural mobility, muscle length of hamstrings, iliopsoas and rectus femoris
- positively influencing emotional sense of well-being and perception of exercise

RELEVANCE

The nature, cause, appropriate treatment and prevention of non-specific LBP remain largely a mystery. Despite many years of research directed at the prevention of LBP in adults, the incidence of LBP remains very high. Therefore, it has been proposed that preventative interventions should ideally be targeting a younger population. School-based interventions are effective in reaching a large population, irrespective of social factors and access to healthcare facilities. However, the curricula at most schools are already fairly full, and therefore, it is essential to ensure that only the most effective, evidence-based components of LBP interventions are implemented during school hours. Exercise has been identified as one of the most promising interventions for LBP in adults. Although LBP in children should be considered as a specific subset of LBP which is not necessarily comparable to LBP in adults, it can be hypothesized that exercise could have the same beneficial preventative effects in a younger population.

This dissertation will present a detailed review of the literature relating to this study in Chapter 2. A description of the study design and methodology will be included in Chapter 3. The results of the pilot study will be presented in Chapter 4. The results of the main study will be presented in Chapter 5, and a detailed discussion of these results will follow in Chapter 6. Finally, Chapter 7 will present the main findings and conclusions which emerged from this study.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Extensive worldwide epidemiological studies have indicated that LBP in children is a common occurrence, with the high prevalence of LBP in this age group being similar to that found in the adult population. Considering the emerging evidence supporting the link between LBP in childhood and adulthood, it would appear that prevention interventions should ideally target the younger population. However, whilst extensive research has been conducted on the prevention of LBP in adults, very few studies have addressed the impact of preventative interventions in childhood (Burton et al 2004).

This literature review will present the definitions and prevalence of LBP, in order to clarify the target population of this study. The stabilization system of the lumbar spine will be discussed in detail, as well as the relationship between dysfunction in the stabilizing system and LBP. Numerous risk factors for LBP in children have been identified and will be discussed, particularly with regard to the degree that these risk factors can be modified by intervention programmes. Due to the limited research available on LBP prevention in childhood, this review will present current literature on relevant outcome measures and preventative interventions for LBP in both adults and children. School-based intervention studies will be discussed in more detail. Children spend a large proportion of their day at school and therefore, school-based interventions have been identified as an effective method of reaching this specific population. Considering the emphasis of exercise as a specific intervention for LBP in this study, this review will also present the literature to support and describe the relevance of exercise as a preventative intervention for LBP.

Therefore, this literature review will discuss:

- the definitions and prevalence of LBP
- the stabilizing system of the lumbar spine
- causes of non-specific LBP
- identified risk factors for LBP in children
- LBP prevention outcome measures
- preventative intervention programmes for LBP
- school-based interventions
- exercises as a specific intervention for LBP

2.2 LOW BACK PAIN

Low back pain is a very common condition. The lifetime prevalence of LBP has been reported to be over 70% (Ferreira et al 2006; Burton et al 2004). The consequences of LBP are numerous and costly. LBP not only affects the individual, but also has a large impact on society as a whole. A substantial burden is placed on health-care services and disability pensions, the economy suffers due to work loss, and fear avoidance behaviours interfere with individuals' involvement in work, sport and recreational activities (Burton et al 2004).

2.2.1 DEFINITIONS

Low back pain (LBP) is defined as pain and discomfort, localised below the costal margin and above the inferior gluteal folds, with or without leg pain. Non-specific (common) LBP is defined as LBP which is not attributed to recognisable, known specific pathology, e.g. infection, tumour, osteoporosis, ankylosing spondylosis, fracture, inflammatory process, radicular syndrome or cauda equine syndrome (Burton et al 2004). The focus of this review will be on non-specific LBP - severe spinal injury and pathology fall out of the scope of this study and literature review.

LBP can be further described as acute, sub-acute, chronic or recurrent LBP. Acute LBP is defined as an episode of LBP persisting for less than six weeks: sub-acute LBP as an episode of LBP persisting for between six to twelve weeks; and chronic LBP as an episode of LBP persisting for longer than twelve weeks. However, not all LBP is persistent. It is common for LBP symptoms to be episodic. Therefore recurrent LBP is defined as a new episode of LBP after a symptom-free period (Burton et al 2004).

Present evidence indicates that LBP is rarely a once-off occurrence. Rather, it frequently leads to a temporary, as opposed to a permanent, remission. Subsequent episodes of LBP are unpredictable, fluctuating and of variable pain status (Hestbaek et al 2006a). Recurrent episodes of LBP are also associated with increased care-seeking, higher medical costs and longer periods of sick leave, absenteeism and work-loss (Wasiak et al 2006). Therefore, the first episode of LBP should be acknowledged for its significant importance in managing and preventing LBP in all age groups.

2.2.2 LBP IN THE ADULT POPULATION

A large percentage of the adult population suffers from LBP, with a high frequency of recurrent episodes (Wasiak et al 2006). The prevalence of LBP in adults has been well

documented with a life-time prevalence of over 70%, one-year period prevalence of over 50% and a point prevalence of over 20%, although some studies have reported it to be as high as 40% (Kovacs et al 2003; Leboeuf-Yde and Kyvik 1998).

Acute LBP was generally considered to be a self-limiting condition, with only 2-7% of episodes leading to chronic LBP (Burton et al 2004). However, more recent research has indicated that acute episodes of LBP evolve into chronic or recurrent conditions more frequently than previously suspected (Wasiak et al 2006). Previous statistics were based only on the clinical definitions of acute and chronic pain. However, one has to acknowledge the frequent occurrences of recurrent LBP. Recent evidence has indicated that LBP manifests in an unpredictable pattern of symptomatic periods, interspersed with less troublesome or symptom-free periods (Burton et al 2004). Therefore, although the percentage of individuals suffering from persistent chronic LBP may be small, a large proportion of people will experience recurrent episodes of LBP, which can be just as debilitating, costly and distressing for individuals.

Wasiak et al (2006) found that over a third of people who had been treated for a work-related, non-specific LBP injury, needed to access medical care and / or take time off work for subsequent recurrent episodes of LBP. Interestingly, the medical costs were greater and the absences from work longer for the recurrent episodes of LBP. Once again this highlights the importance of preventing recurrent episodes of LBP.

2.2.3 LBP IN CHILDREN / ADOLESCENTS

Non-specific LBP in schoolchildren is much more frequent than previously thought (Burton et al 2004). Jordaan et al (2005a) conducted a large epidemiological study in the Northern Gauteng district of South Africa to determine the prevalence of LBP in South African adolescents. Their findings indicated a high prevalence of LBP in adolescents, with the lifetime or cumulative prevalence being 52.6%, one-year prevalence 50% and point prevalence 14.7%. These findings are similar to those of studies carried out in other countries (Kovacs et al 2003; Watson et al 2002; Sjölie and Ljunggren 2001; Leboeuf-Yde and Kyvik 1998).

Jordaan et al (2005a) noted that the lifetime prevalence, one-year prevalence and point prevalence of LBP increased steadily from 13 to 17 years of age. At 13 years of age, lifetime prevalence was 40.6%, one-year prevalence 36.4% and point prevalence 9.5%. By 17 years of age, the lifetime prevalence was 57.2%, the one-year prevalence 54.1% and the point prevalence 16.9%. Once again, these findings in South African adolescents

are similar to those of studies carried out internationally. These studies also show that the incidence of LBP increases steadily from 12 years of age into early adulthood (Hestbaek et al 2006b; Trevelyan and Legg 2006; Kjaer et al 2005; Burton et al 2004; Watson et al 2002; Balagué et al 1999).

Numerous studies have observed the peak onset of LBP to be between 12 and 13 years of age for girls and between 13 and 14 years of age for boys (Grimmer and Williams 2000; Leboeuf-Yde and Kyvik 1998). This confirms the theory that the onset of LBP is at the beginning of adolescence, and coincides with the pubertal growth spurt (Grimmer and Williams 2000; Balagué et al 1999; Leboeuf-Yde and Kyvik 1998).

There have been varied reports on the prevalence of LBP between genders in adolescence / childhood. Some studies have indicated a higher prevalence of LBP in girls (Hestbaek et al 2006b, Watson et al 2002; Sjölie and Ljunggren 2001, Grimmer and Williams 2000), a few indicated a higher prevalence in boys (Balagué et al 1999), whilst others have found there to be no gender difference (Trevelyan and Legg 2006; Jordaan et al 2005a, Newcomer and Sinaki 1996; Harreby et al 1995). Therefore, it can be concluded that LBP is a condition which affects both boys and girls during childhood and adolescence.

Current research has led to an increasing realization that LBP in children can no longer be ignored as insignificant. Rather, it needs to be acknowledged as a serious problem which could have far reaching consequences on the child's health and well-being as an adult.

2.2.4 LBP ADOLESCENCE TO ADULTHOOD

Research has shown that there is a strong correlation between LBP in childhood / adolescence and LBP in adulthood. LBP in the adolescent period is associated with an increased frequency of LBP as an adult (Hestbaek et al 2006a; Harreby et al 1995). Other adult studies have shown that a strong predictor for LBP in adults is a previous history of LBP (Watson et al 2002; Adams et al 1999).

Hestbaek et al (2006a) conducted a cohort study of 9600 twins over an eight year period. They found that LBP at an early age is a strong predictor of LBP later in life. The results of their study also demonstrated a dose-response relationship between the number of days of LBP as a child and the occurrence of LBP as an adult i.e. the more persistent childhood LBP is, the higher the risk of LBP as an adult.

Taking into account the high prevalence of LBP in childhood, the link between LBP in childhood and adulthood, and the huge impact of LBP on individuals, the health care system and the economy, it can be concluded that the focus of future research in LBP preventative interventions should ideally be in childhood.

2.3 STABILIZING SYSTEM OF THE LUMBAR SPINE

In order to understand the cause and aetiology of non-specific LBP one needs to consider the anatomy of the lumbar spine and the structures which can contribute to LBP. Current literature identifies dysfunction in the stabilizing system of the lumbar spine as one of the primary contributors of LBP. When a sudden load or force is applied to the body, stability of the lumbar spine is considered to be crucial in protecting the body against injury (Essendrop et al 2002).

In order to appreciate spinal stability, one needs to understand that the spine is a dynamic system. Spinal stability cannot be simply explained by an increase in 'spinal stiffness' in a static posture. Rather, one has to consider the changing demands placed on the dynamic spinal system, as well as its ability to maintain and control spinal stability during movement. Reeves et al (2007) presented a very detailed review on the definition of spinal stability with regard to spinal biomechanics. They identified three key components which contribute to dynamic spinal stability namely: stability, robustness and performance.

To define stability in the spinal system, whether it is static or dynamic, Reeves et al (2007) considered the effects of perturbations on the spinal system. They described a system as inherently stable or unstable. The spinal system is considered stable if:

- following a perturbation to the system, the individual vertebrae stay within the vicinity of their initial position (neutral zone), and return to their initial position within a sufficiently short time, and
- that the spinal system is able to limit the size / effect of the perturbation on the system, thus limiting the movement in individual vertebrae.

In addition, they used the term robustness to further describe the ability of the spine to maintain stable behaviour for both large and small perturbations, uncertainties and disturbances. Systems that can significantly change their parameters (i.e. spinal stiffness) without the loss of stability are also considered to be robust (Reeves et al 2007).

Finally, spinal stability is dependent on the performance of the system. Performance refers to the efficiency of the system to respond rapidly and precisely, ensuring that adequate control and spinal stability is maintained (Reeves et al 2007).

An earlier model for spinal stability, consisting of three components has been described by Panjabi (1992 as cited by Barr et al 2005). Although advancements have been made in the research and definitions of spinal stability, this model still provides a valuable contribution to the understanding of spinal stabilization. The first component of this model is the passive system, which consists of the bone and ligament structures in the spine. The second component is the active system, which consists of the muscles which surround the spine. The third component is the neuromuscular system, which provides neural input and control to the muscles surrounding the spine. The stabilizing systems in the spine need to be functioning precisely, and concurrently, in order to ensure that optimal spinal stability is obtained and maintained during all static and dynamic postures. These three systems will be discussed below.

2.3.1 PASSIVE SYSTEM

The passive system, comprising of bones and ligaments, mostly provides stability and restraint of movement at the end of spinal range of motion. It does not offer much support to the spine when it is in neutral. A dysfunction in the passive system can be compensated for by effective activity in the muscular and neural control systems (Barr et al 2005). Therefore, even when there are degenerative changes and injuries present in the passive system, it is still possible for spinal stability to be maintained.

With reference to Reeves et al's (2007) definition of spinal stability described earlier, one can consider a spinal system with an undamaged passive system to be inherently stable, whilst an injured passive system would result in an inherently unstable spinal system.

2.3.2 ACTIVE SYSTEM

The active system of the spine consists of both the local (deep) and global (superficial) muscular systems. Both of these muscular systems contribute in varying degrees to spinal stability during static and dynamic postures, and will be discussed in further detail later.

The active system contributes to the robustness of the spinal stabilizing system i.e. the active muscular system has the ability to maintain spinal stability during movement, different postures and in response to perturbations as a result of expected and

unexpected disturbances. Therefore, dysfunction in the active system could result in injury and damage to the spinal structures (Reeves et al 2007). If a sudden load or force is applied to the spine, the active system needs to be able to compensate effectively to protect against injury, which may result from increased forces and stresses placed on the spinal structures. Both the abdominal and back muscles have an important role in providing dynamic stability to the spine, and in decreasing movements at intravertebral level which can be caused by sudden loading of the spine e.g. in work situations (MacDonald et al 2006; Essendrop et al 2002).

The active system of the lumbar spine also plays a significant role in all limb movements. The muscular “corset” surrounding the lumbar spine is often referred to as the “core” or the “powerhouse” of all limb movements, as it serves as the centre of the functional kinetic chain (Akuthota and Nadler 2004). Therefore, dysfunction in the active stabilizing system of the lumbar spine may contribute to injuries and pain elsewhere in the body as well.

2.3.2.1 Local Muscular System

The local or deep muscular system has been the focus of many studies with regard to the key role it plays in spinal segmental stabilization. It has been found that this system is often dysfunctional in people with LBP (Barr et al 2005).

The local muscular system comprises the deep stabilizing muscles which have direct attachments to the lumbar spine, control intervertebral movement, function at a low load and do not produce movement in the trunk or spine. Transversus abdominis and the lumbar multifidi have been identified as two of the most important deep stabilizing muscles. The diaphragm, pelvic floor muscles and posterior fibres of the psoas muscles also contribute to the deep stabilizing system (Barr et al 2005).

The thoracolumbar fascia contributes to active stabilization in the lumbar spine and functions together with the local muscular system. It consists of three layers: the anterior, middle and posterior layers. It provides a link between the lower and upper limbs, and also functions as an activated proprioceptor in the lumbar spine, providing feedback during movements (Akuthota and Nadler 2004).

Transversus abdominis (TA) attaches to the vertebrae through the middle and posterior layers of the thoracolumbar fascia. Activity in the TA is related to an increase in intra abdominal pressure (IAP). As the IAP increases, so does the overall spinal ‘stiffness’ and stability increase (Barr et al 2005; Essendrop et al 2002). However, studies have found

that the increase in IAP is not only explained by an increase in TA muscle activity alone. An increase in back muscle activity has also been noted and therefore, the increase in IAP can be better explained by the co-activation of the transversus and back muscles (Essendrop et al 2002). TA also contributes to force closure at the sacroiliac joint (SIJ), which results in decreased laxity at the SIJ. This augments TA's role in providing and enhancing lumbar-pelvic stability (Richardson et al 2002).

The lumbar multifidi consist of multiple small fascicles, with origins and attachments two to five vertebral levels apart. The deep muscle fibres of the multifidi only cross two spinal levels and are therefore anatomically and biomechanically suited to the control of segmental spinal stabilization. They play an important role in preventing excessive vertebral movement during static and dynamic postures, thus protecting the joints, discs and soft tissues from injury (MacDonald et al 2006).

TA and multifidi have a greater percentage of type I muscle fibres (slow twitch) than type II (fast twitch) muscle fibres and are therefore, fatigue resistant and ideally suited to low load tonic activity. However, it has been proposed that type I muscle fibres are also more susceptible to the adverse effects of pain and immobilization than type II muscle fibres (MacDonald et al 2006).

Studies in pain free subjects show that TA and the deep fibres of the multifidi are the first muscles to become active in a motor sequence when a limb is moved or when loads are placed on the spine. This ensures that unwanted trunk movement with limb movement is limited. The two muscles have also been found to be active in static postures (Barr et al 2005; Akuthota and Nadler 2004).

Although TA and multifidi are both important deep stabilizers, they only make up part of the deep cylinder of muscles surrounding the spine. There are other deep muscles which contribute to lumbar stability. The deep cylinder of muscles surrounding the spine also has a roof, consisting of the diaphragm, and a floor, consisting of the pelvic floor muscles. Both of these muscle groups play an important role in contributing to increased IAP and therefore, lumbar stability. In order for the TA to increase tension in the thoracolumbar fascia, diaphragm activity is needed to prevent displacement of the abdominal viscera. The diaphragm also contributes to an increase in IAP prior to the initiation of movement, independently of the respiratory phase. The pelvic floor muscles contract involuntarily before the abdominal muscles during tasks which elevate IAP to maintain continence and to contribute to a further increase in IAP (Barr et al 2005). Both the diaphragm and the

pelvic floor muscles are therefore considered to be important components of the deep muscular stabilizing system.

Anatomically, the attachments of the posterior fibres of iliopsoas indicate that it could possibly have a prime role in contributing to spinal stability. The oblique fibres of the quadratus lumborum are also considered to contribute significantly to spinal stabilization (Akuthota and Nadler 2004). However, further research is needed to identify the role of iliopsoas in spinal stability, and to further define the roles that other deep muscles play in spinal stabilization.

2.3.2.2 Global Muscular System

In contrast to the deep local stabilizers, the global muscular system comprises of the larger, more superficial muscle groups which cross the trunk. Their main function is to produce and control trunk movements (Richardson et al 2002). However, the global muscular system also contributes to lumbar stability through co-contraction of both the lumbar flexors (abdominal muscles) and lumbar extensors (back muscles) (MacDonald et al 2006). These muscles play an important role in dissipating loads through the trunk and preventing unwanted trunk movements. This is essential in movements or activities which exert directional forces, torque forces or loading on the trunk and spine (Barr et al 2005).

The rectus abdominis and long erector spinae are anatomically designed to produce and control movements in the sagittal plane in the lumbar spine. Quadratus lumborum, as well as the internal and external obliques abdominis muscles, produce and control movement in the frontal and rotational planes. Torsional stability in the lumbar spine is reliant primarily on activity in the internal and external obliques (Jull et al 1993). Other examples of muscles which contribute to the global lumbar spinal muscular system include the gluteus maximus and the hamstrings.

In order for the active system to function effectively, the neuromuscular control system needs to be functioning efficiently. The neural control centre anticipates the effect the movement will have on the body and activates appropriate muscle activity accordingly. For example, in rapid shoulder extension, the rectus abdominis is activated before the movement, to prevent excessive trunk extension from occurring with the shoulder movement (Barr et al 2005).

2.3.3 NEUROMUSCULAR CONTROL SYSTEM

The final component of the lumbar stabilizing system is the neuromuscular control system. This system is essential in co-ordinating muscle activity, and ensuring that the correct muscles are activated, at the correct intensity and at the correct time in response to expected and unexpected forces. Therefore, dynamic stability and control will be maintained by different muscle patterns, depending on the position of the joints and load on the spine (Barr et al 2005).

One can appreciate that the neural control system needs to be functioning optimally and effectively in order to achieve static and dynamic stability in the spinal system. The neural control system will impact on the performance of the stability system as described by Reeves et al (2007).

Feedback and feedforward pathways in the spine are utilized to provide the information necessary for the system to constantly adapt to the changing positions, demands and loads which are placed on the spine. There are intrinsic pathways, reflexive and voluntary pathways in the feedback control system in the spine. The intrinsic pathways result in instantaneous responses, e.g. increased TA or trunk muscle co-activation prior to a movement. The reflexive and voluntary pathways result in a delayed response, as they are responding to a perturbation or movement which has already been initiated (Reeves et al 2007). A dysfunction in any of the feedback control pathways will result in impairment in spinal stability which contributes to LBP.

2.4 CAUSES OF NON-SPECIFIC LOW BACK PAIN

LBP cannot be attributed to pathology or neurological encroachment in 85% of people (Burton et al 2004). Therefore, the extensive research into the stabilizing system of the lumbar spine, has led to a clearer understanding of some of the proposed factors which contribute to LBP. Although spinal instability alone cannot be held accountable for all episodes of LBP, the three systems described above can provide useful insight into the mechanisms contributing to episodes of acute and chronic LBP.

To further clarify spinal instability, a distinction between gross instability and functional instability needs to be made. Gross instability refers to a true displacement of vertebrae, such as with traumatic disruption of two of the three vertebral columns, or as in

spondylolisthesis. Functional instability is defined as a relative increase in the range of the neutral zone of individual vertebrae (Akuthota and Nadler 2004).

2.4.1 PASSIVE SYSTEM DYSFUNCTION

Injuries to the bone, ligaments, joints, discs could all lead to LBP and result in either a gross or functional instability in the lumbar spine. Obviously, an acute injury will result in pain, swelling and stiffness usually associated with tissue damage. However, once the acute symptoms have settled, the individual may still experience pain or subsequent recurrences of pain. Damage to the passive system may result in a decreased ability of the vertebrae to stay within the vicinity of their initial position following a perturbation and thus, predispose the system to further injury and pain. It could also lead to impaired feedback control through the ligament and joint receptor pathways and subsequently, result in impairment of the functioning of the muscular system (Reeves et al 2007, Akuthota and Nadler 2004).

2.4.2 ACTIVE SYSTEM DYSFUNCTION

It has been noted that the biomechanics of individuals with LBP differ from those who do not have LBP (Barr et al 2007). This can, in part, be explained by dysfunction in the active muscular system, as well as by impairment in the neuromuscular control system.

2.4.2.1 Local Muscular System Dysfunction

Studies have shown that both TA and multifidi are dysfunctional in people with LBP. Biopsies and ultrasound images of people with LBP indicate atrophy in the multifidi, which gives them a “moth eaten” appearance. Delayed activation of TA in the motor sequence has been noted in individuals with LBP as opposed to pain-free controls (MacDonald et al 2006; Barr et al 2005; Akuthota and Nadler 2004).

Dysfunction in the deep stabilizing muscles results in excessive segmental movement at intervertebral levels as well as a reduction in intra abdominal pressure. This results in an impairment in the ability of the spinal system to maintain stable behaviour / lumbopelvic stability when both expected and unexpected perturbations, forces and loads are placed on the spine (Reeves et al 2007).

The relatively higher percentage of type I muscle fibres in the deep stabilizing muscles, makes them more susceptible to the adverse effects of pain and immobilization than the global muscles which have proportionally more type II muscle fibres (MacDonald et al 2006).

Although it has been found that pain inhibits and impairs the recruitment and functioning of the TA and multifidi, it is unclear whether a dysfunction in these muscles in pain-free individuals can lead to LBP. Some evidence indicates that these muscles may not always be optimally recruited or may fatigue in normal asymptomatic individuals. However, whether this can lead to LBP requires further research (Jull et al 1993).

Nevertheless, it can be concluded that LBP results in dysfunction of the deep stabilizing muscles. This results in an impaired ability of the spine to maintain dynamic spinal stability which, in turn, can lead to further pain and injury as a result of loads being placed on the functionally unstable spine. Pain and immobilization can lead to further muscle wasting, decreased endurance and strength of type I muscle fibres in the deep stabilizers which, in turn, can contribute to additional pain and dysfunction in the lumbar spine.

2.4.2.2 Global Muscular System Dysfunction

Dysfunction in the superficial, global muscles can also contribute to LBP. If there is dysfunction in the deep stabilizing muscles or the passive system, the global muscular system will try to compensate with co-activation. However, although the global muscle co-activation will increase spinal stiffness, without the intersegmental stability usually provided by the deep muscles, the global muscle co-activation will result in an increase in compressive load on the spinal segments which can lead to spinal pain. Activity in the global system, without the deep stabilizer activity, also results in a decreased ability to control shear forces on the spine and a restriction in spinal mobility. Compensatory movement patterns will also develop, as other muscles try to perform additional movements and functions, usually performed by the global stabilizers. Other unwanted actions may also be activated when the global muscular system acts primarily as a stabilizer, e.g. abdominals also depress the rib cage when acting as a stabilizer, compromising respiratory function (Barr et al 2005).

In a normal individual, when sudden loads are placed in the arms, the activity in rectus abdominis increases, resulting in an increase in flexion torque. The erector spinae should counteract this force by providing an increase in extension torque to stabilize the spine. The back muscles need to activate to provide an equal and opposite force to protect from shearing forces on the spine (Essendrop et al 2002). If a muscle imbalance is present in the abdominal and back muscles, the flexion torque may not be opposed and this could result in injury and pain in the lumbar spine.

There is more evidence to suggest that dysfunction in the global muscular system contributes to LBP. As mentioned previously, it has been found that individuals with LBP tend to have higher levels of co-activation of the trunk muscles than healthy, pain-free controls (Reeves et al 2007; Pirouzi et al 2006). Furthermore, the global muscles fatigue more readily than the stabilizers, which can also result in fatigue related pain. Muscle fatigue demands more muscle co-activation from the already fatigued muscles. This propagates a vicious pain cycle, as the fatigued muscles go into spasm to try to provide the necessary spinal stiffness. However, this spinal stiffness does not equate to stability, particularly when dynamic stability of the spine is required. It has been shown that these individuals have a decreased ability to respond to unexpected forces and to maintain balance during complex tasks, e.g. walking along a balance beam. The fatigued global muscles are using all their energy to ensure a stiff spine and, as a result, there is insufficient muscle force available to provide compensatory movements and muscle activation to protect against torsional forces and further pain and injury. All of this contributes further to LBP, as it leads to dysfunction in the neural control system (Reeves et al 2007). The above muscle spasm / fatigue / pain cycle can also be used to describe chronic pain resulting from inflammation, injury, sprains and tears in the trunk muscles.

2.4.3 NEURAL CONTROL SYSTEM DYSFUNCTION

It is clear that any dysfunction in the neuromuscular control system will lead to compromised functioning of the spinal system and could result in pain. There are many factors which could impair neural control: prolonged flexion, whole body vibration, muscle wasting, fatigue, delayed reflex responses, loss of sensory mechanoreceptors following injury, pain, tissue damage, swelling, poor spinal proprioception (Reeves et al 2007). Therefore, it is important to realise that impairment in the neural control system cannot be solely attributed to injury in the active or passive system, but can also be as a result of prolonged poor posture, repetitive poor movement patterns and external forces such as vibrations in a truck driving on a rural road.

2.4.4 OTHER

Whilst many structural and neural components have been identified as causes of LBP, one cannot disregard the psychosocial component of LBP. As advances are made in the understanding of pain processing, it has become clearer that the physical and emotional experiences of pain cannot be purely ascribed to biomechanical and structural components (Barr et al 2005). Rather, there is a complex interplay between one's psychological state of mind, one's psychosocial factors and one's previous experience of pain.

It is also interesting to note that painful muscle spasm can occur without injury or loss of spinal stability. Studies have found that a real or perceived threat of injury or pain leads to significant changes in the trunk muscle recruitment pattern, and it is hypothesized that this mechanism could be responsible for pain and muscle spasm associated with emotional and psychosocial factors (Reeves et al 2007).

2.5 RISK FACTORS FOR LOW BACK PAIN IN CHILDREN

It is commonly assumed that children have young, healthy spines, and that their spinal stabilization system is functioning optimally. However, this is based on the assumption that LBP is a very rare occurrence in children. Back pain with no organic cause is the most frequent primary diagnosis in children and the majority of LBP reported in childhood cannot be attributed to serious pathology (Hestbaek et al 2006a, Murphy et al 2004, Newcomer and Sinaki 1996). Therefore, the explanation in section 2.4 of this literature review, which details the causes of non-specific LBP, can also be used to describe childhood LBP.

Early degenerative changes of the spine on imaging have been found (Burton et al 2004). Kjaer et al (2005) conducted an epidemiologic study of MRI changes in the lumbar spine in a group of 439 12-14 year old children. They identified degenerative disc changes in one third of the study population. The majority of these degenerative changes were associated with some degree of LBP, which indicates that these changes can be considered abnormal in this population. These findings indicate that a large proportion of 'young' spines are already showing signs of degenerative changes. It has also been observed that disc degeneration soon after the phase of rapid physical growth, correlates with a significantly higher risk of recurrent LBP in adolescence and adulthood (Cardon and Balagué 2004; Balagué et al 1999; Salminen et al 1995).

Studies have also found a specific subgroup of LBP which is present in children / adolescents, but which is asymptomatic in adults. This is thought to be related to end-plate defects, which are associated with pain in children, but not in adults (Hestbaek et al 2006a; Kjaer et al 2005). Interestingly, Kjaer et al (2005) also noted that end-plate changes around L3, as well as at the thoracolumbar junction, were strongly associated with LBP and healthcare-seeking for LBP in childhood.

Many studies have been conducted to identify other risk factors for LBP in children. However, as in the adult population, there is no single risk factor which can be held accountable for all episodes of LBP in children. Therefore, it is important to remember that LBP is a result of a complex interaction between numerous, multifaceted risk factors in children (Trevelyan and Legg 2006; Adams et al 1999). Research in the adult population has indicated that the most powerful identified risk factor for a new episode of LBP is a previous history of LBP (Burton et al 2004). LBP during the growth period has also been shown to be an important risk factor for LBP later in life (Jordaan et al 2005a). Once again this emphasises the importance of early preventative interventions, especially considering all the evidence which is emerging to support the link between LBP in childhood and adulthood. Therefore, research now needs to focus on which of the identified risk factors are modifiable, and which will have an effect on LBP in children and adults if addressed at an early age (Geldhof et al 2006).

Burton et al (2004) described four subsections of potentially modifiable risk factors for LBP in children in their review of the literature, namely:

- lifestyle factors
- school-related factors
- physical factors
- psychosocial factors

For the purpose of this review, more focus will be given to the physical factors and psychosocial factors. Both of these risk factors have been identified as potentially modifiable with an exercise intervention (Jones et al 2007; Sollerhed et al 2005). Therefore lifestyle and school-related factors will only be discussed briefly, and more emphasis will be placed on the physical and psychosocial risk factors.

2.5.1 LIFESTYLE RISK FACTORS

Obesity, being overweight, smoking, alcohol intake, eating habits, working, sports participation, physical inactivity and sedentary behaviour have been identified in the literature as lifestyle risk factors for LBP (Hestbaek et al 2006b; Burton et al 2004).

Smoking, alcohol intake and obesity are strongly associated with current LBP in children. However, of the three, only smoking has been found to have a positive association with future LBP (Hestbaek et al 2006b; Cardon and Balagué 2004). It is hypothesized that smoking habits in school children indirectly reflect psychosocial and social problems,

which could be attributed as being the main causes of their LBP. Similarly, obesity, being overweight, alcohol intake and poor eating habits could also be associated with psychosocial problems (Burton et al 2004).

There are inconsistencies in the literature as to the relationship between physical activity / sedentary behaviour and LBP. Some studies indicate that sedentary behaviour may be linked to LBP. It has been proposed that LBP related to sedentary behaviour is mostly associated with poor prolonged sitting postures (Geldhof et al 2006; Sjölie and Ljunggren 2001). In fact, sitting has been identified as one of the main aggravating factors for LBP in children - particularly when sitting in excessively flexed postures and for long durations of time (Murphy et al 2004; Sjölie and Ljunggren 2001; Grimmer and Williams 2000; Balagué et al 1999). Studies have shown that children are spending more time in seated positions as a result of increased television viewing, computer games and homework (Trevelyan and Legg 2006; Balagué et al 1999). However, it also appears that high performance training in certain sports, as well as high levels of physical activity, can increase the risk of LBP in children (Burton et al 2004; Cardon and Balagué 2004; Kovacs et al 2003; Sjölie and Ljunggren 2001). Therefore, one can propose that moderate physical activity is the ideal in preventing LBP recurrence in children, although the definition of moderate physical activity may vary.

Many of the variable findings in lifestyle risk factors can be attributed to the effect that increasing time has on spinal tissue loading and on the variable stages of growth, i.e. the longer one sits in a poor posture or the more time one spends playing sport, the greater the load placed on the rapidly growing spine (Grimmer and Williams 2000).

It can be concluded that, although lifestyle risk factors contribute to LBP in children, there is currently little or no evidence to support preventative interventions targeting modifications in lifestyle risk factors in school-children (Burton et al 2004).

2.5.2 SCHOOL RELATED RISK FACTORS

Heavy school bags and inappropriate school furniture have been identified as school-related risk factors for LBP in children (Geldhof et al 2006; Burton et al 2004).

Various studies have described an association between school-bag loads and LBP in children. However, there is no consistent scientific evidence available to define the acceptable weight limit of school bags, the most appropriate type of school bag and the safest method of carrying school bags (Trevelyan and Legg 2006; Burton et al 2004).

Inappropriate school furniture has been identified as a possible risk factor for LBP. Standard furniture (desks and chairs) is used in classrooms, irrespective of the child's height and body dimensions (Trevelyan and Legg 2006; Burton et al 2004). Sitting in a poor posture for a prolonged period of time, on inappropriate school furniture, can contribute to postural discomfort and LBP (Murphy et al 2004). There have been various studies which have investigated the impact of school furniture modification on LBP in children. However, the possible preventative role of these modifications remains unclear, and there is insufficient evidence to support school furniture modification as a preventative measure for LBP in children (Burton et al 2004).

2.5.3 PHYSICAL RISK FACTORS

Physical fitness levels, mobility, flexibility, neural mobility, lumbosacral position sense, muscle strength and spinal instability have been identified as physical risk factors for LBP in children (Burton et al 2004).

Although Burton et al (2004) concluded that LBP in children cannot simply be attributed to muscle weakness, there is evidence to support the theory that insufficient muscle strength and stability in the lumbar spine are important risk factors for both current and future LBP in children. Studies have found that an imbalance in trunk muscle strength is associated with LBP, and that decreased spinal muscle strength increases the risk for LBP in schoolchildren. There is also evidence to support the theory that decreased flexibility of the hamstrings, rectus femoris and iliopsoas muscles, decreased neural mobility, as well as impaired lumbosacral position sense all contribute to LBP (Jordaan 2005b; Burton et al 2004; O'Sullivan et al 2003; Brumagne et al 2000). These specific physical risk factors will be discussed in more detail below.

2.5.3.1 Muscle Strength

Although there are limited studies describing the relationship between muscle strength and LBP in children, the available literature indicates that there is a correlation between muscle imbalances and impaired spinal stability with LBP (Burton et al 2004). Causal associations between LBP in children and decreased spinal strength and spinal instability have also been demonstrated (Cardon and Balagué 2004; Sjölie and Ljunggren 2001; Salminen et al 1995)

As described earlier, lumbar spine stability is determined by the function and integrity of the passive, active and neural control systems. These three systems are interdependent, and one system may compensate for deficits in another. Therefore, instability is often a

combination of dysfunction in two or more of the systems – tissue damage, insufficient muscle strength or endurance and ineffective neural control (Barr et al 2005).

However, spinal stability does not equate to a stiff and rigid spine. A stiff, rigid spine is unable to accommodate loads and compensate for torque-producing forces exerted on it, and is thus also susceptible to injury. Rather, spinal stability depends on the ability of the neuromuscular system to provide varying degrees of spinal stiffness through movement (Barr et al 2005).

Low muscular strength and poor endurance are considered to be one aspect of instability. Although both may be viewed as consequences of LBP, they are also considered risk factors as well. Sjölie and Ljunggren (2001) identified low muscle strength and high values for mobility-strength ratios as predisposing risk factors for both concurrent and future childhood LBP. High flexion and extension mobility in the lumbar spine, as such, were not associated with LBP. However, high flexion and/or extension lumbar mobility definitely became risk factors when they were associated with low muscular strength of the trunk extensors. It is possible that the combinations of high mobility and low strength may expose the lumbar spine to excessive strains. The low strength and high mobility-strength ratios may mirror a lack of ability to keep the low back stable in daily life. Therefore, these results confirm theories which propose that insufficient strength and stability are important risk factors which contribute to concurrent and future episodes of LBP in adolescents. These results support the theory suggesting causal associations between LBP and poor stability (Sjölie and Ljunggren 2001). As mentioned previously, instability can be the result of dysfunction in the trunk muscles and neuromuscular control systems.

Other studies have also identified an imbalance between trunk flexors and extensors in children with LBP. A relative weakness of trunk extensors has been observed in children with LBP (Barr et al 2005; Balagué et al 1999; Newcomer and Sinaki 1996). As discussed in section 2.4 of this literature review, it is essential to have a balance between the abdominals (trunk flexors) and the back extensors, in order to maintain dynamic spinal stability and to oppose excessive flexion torque during loading of the spine. An imbalance in the trunk muscles can predispose the spine to pain and injury, as a result of unopposed loads and forces being placed on the spine. The muscle strength imbalances which are present in adolescence may also be as a result of the imbalance between rapid bone growth and the relatively slower soft tissue growth, during the pubertal growth spurt (Newcomer and Sinaki 1996).

Decreased endurance of the abdominal and trunk muscles also predisposes children to LBP. Atrophy of the paraspinal muscles has been observed in children with LBP (Balagué et al 1999). There is also evidence to suggest that TA and the internal obliques may not always be optimally recruited and may fatigue in their stabilizing roles (Jull et al 1993). Adams et al (1999) found that muscle fatigue has a more significant influence than muscle strength on LBP. Muscles with decreased endurance fatigue quicker and lose their ability to generate maximal force. The underlying spinal structures are therefore more susceptible to injury from loads and sustained postures. Muscle fatigue can also lead to the muscle spasm / fatigue / pain cycle described in section 2.4 of this literature review.

Although weakness in the abdominal muscles is associated with LBP, it can be appreciated that excessive trunk flexion strength training is not appropriate in children. This will simply aggravate the imbalance present in the trunk muscles and further contribute to increased pain, as a result of repetitive strains being placed on the low back tissues (Balagué et al 1999). Therefore, it can be proposed that specific exercise programmes, targeting strength and endurance of the trunk muscles, as well as addressing muscle imbalances, would be appropriate preventative interventions, both before and during the pubertal growth spurt (Mikkelsen et al 2006; Jordaan et al 2005a).

2.5.3.2 Muscle Length

Once again, there are limited studies evaluating the relationship between muscle length / flexibility with LBP in children. The available literature indicates that there is a correlation between shortened thigh muscles (hamstrings and quadriceps muscles) and LBP (Pirouzi et al 2006; Burton et al 2004; Cardon and Balagué 2004; Balagué et al 1999). In particular, a combination of weak abdominal muscles and tight hamstrings appears to be linked to LBP in children (Balagué et al 1999). However, one study presented slightly conflicting results and indicated that there is only an association between hamstring tightness of less than 40 degrees and LBP in children (Harreby et al 1999).

Tight hip flexors are also linked to a previous history of LBP (Balagué et al 1999). Shortening of the iliopsoas muscle may contribute to some dysfunction in the lumbar spine. Taking into account its attachments, a shortened iliopsoas will exert an influence on the lumbar lordosis, as well as on intervertebral movement, which may result in anterior shear forces acting on the spine (Jorgensson 1993). Once again, this highlights the presence of muscular imbalances in children which can impact on the growing spine.

Generally, flexibility decreases in children over the pubertal growth period. The peak growth velocity in girls is between 12-13 years of age and in boys between 13-14 years of age (Leboeuf-Yde and Kyvik 1998). During the peak growth period, there is a rapid decrease in flexibility. This rapid decrease then stabilizes around 15 years of age, although adolescents do still continue to lose flexibility, and become stiffer, between 15 - 18 years of age. A possible explanation for these changes in flexibility can be attributed to the growth spurt. During the peak growth period, there is a rapid increase in longitudinal bone growth. However, different tissues grow at different rates, and the surrounding soft tissues adapt more slowly to the new length, resulting in tightness of the soft tissue structures (muscles, ligaments etc). After the peak growth velocity, the soft tissues continue to adapt slowly to the new length, but probably not to the same degree of flexibility as before the growth spurt (Jordaan et al 2005a). This creates soft tissue imbalances across the joints, which place increased stress and strain on the spinal structures, making them more prone to injuries, overuse and LBP.

2.5.3.3 Neural Mobility

Jordaan (2005b) identified decreased neural mobility in the passive straight leg raise (PSLR) test as a risk factor for LBP in South African children. Clinically this is also frequently observed. However, there is very little literature available to support these observations. Kuo et al (1997) assessed a group of 369 children, aged 0-16 years, to develop the hamstring index for normal healthy children. The PSLR range of each child was assessed as one of the measures to determine hamstring flexibility. The findings indicated that the average PSLR at birth is 100 degrees of hip flexion, peaking at 110 degrees around two years of age, before decreasing rapidly within three years to an average of 80 degrees by five to six years of age. Interestingly, they noted that the PSLR then remained constant throughout the growth period. The average values for PSLR between 11 and 16 years of age are between 75 and 85 degrees. Furthermore, they found little variation in the PSLR results across the stages of puberty. Therefore, Kuo et al (1997) concluded that in normal, healthy children, the PSLR range does not change in relation to growth after 6 years of age. In contrast, Idota and Yoshida (1991) reported that increased tension in the pelvic and leg muscles, resulting from rapid skeletal growth, is related to limited range in the PSLR test. However, due to variations in sample size, as well as selection in both of these studies, these results may not necessarily be comparable.

The PSLR test is a common diagnostic procedure for LBP (Butler 1991). Numerous mechanisms have been proposed to describe limitations in PSLR range. The original

explanation was that nerve root compression, particularly of the sciatic nerve, was the most likely cause of pain and limited range in the PSLR. Lumbar intervertebral disc herniation has been identified as the most common cause of nerve root compression and irritation. Taking into account the emerging evidence of early disc degeneration during adolescence, it could be a possible explanation as to why limited PSLR is a risk factor for LBP in children. A number of authors have also identified that a defensive hamstring muscle reaction is related to a limited PSLR. The hamstring defence reaction limits the extensibility of the hamstrings to protect the neural system, by avoiding excessive nerve stretch and protecting inflamed nerve roots. Once again this correlates with the theory that a limited PSLR reflects a heightened mechanosensitivity of the neural system and limited neural mobility (Rebain et al 2002). A limitation in the PSLR in individuals with LBP has also been shown to alter the biomechanics of the spine and hip during everyday functional activities. This contributes to the development of compensatory movement strategies which, in turn place abnormal stresses and loads on the spinal structures. It also contributes to imbalances in the trunk, between the abdominal and back muscles (Shum et al 2005).

2.5.3.4 Lumbosacral Position Sense

A close link has been identified between LBP and postural control, balance and lumbosacral proprioception / position sense (Barr et al 2005). Poor lumbosacral position sense has been identified as a risk factor for LBP in children (Jordaan 2005b).

Individuals with LBP have a reduced ability to reposition their lumbar spine accurately in a neutral spine position whilst seated. This indicates a deficiency in lumbosacral proprioceptive acuity in this population (O'Sullivan et al 2003; Brumagne et al 2000). Impaired postural control also contributes to poor balance performance, particularly with the eyes closed, i.e. when visual feedback is removed. Delayed muscle response times and impairment in anticipatory behaviours have been observed in individuals with LBP, as a result of poor proprioceptive feedback (Leinonen et al 2003; Radebold et al 2001).

The unisegmental muscles of the spine, such as the lumbar multifidi, have a large proportion of proprioceptive muscle spindles. Therefore, the inhibitory influences of pain on the deep stabilizing muscles may be one of the causes of lumbosacral proprioception deficits in people with LBP. Proprioceptive deficits may result in abnormal loading across the joint surfaces, contributing to further pain and the development of degenerative disorders in the spine. Furthermore, with a loss of postural position sense, individuals with LBP are unable to maintain a neutral spine. As a result, there will be increased end-

range loading of the spine during static postures and dynamic activity, as well as frequent excursions beyond the range of mechanical stability. This may further propagate the pain cycle and increase the risk of injury. In addition, it has been hypothesized that deficits in proprioceptive input to the spinal cord may reorganise spinal reflexes in such a way that the reflexes no longer protect the spinal structures from mechanical injury (O'Sullivan et al 2003; Brumagne et al 2000).

2.5.4 PSYCHOSOCIAL RISK FACTORS

Watson et al (2003) suggested that psychosocial factors may contribute more significantly than mechanical factors to LBP in the young population. Numerous studies provide compelling evidence to support this theory. There is a strong correlation between numerous psychosocial factors (such as poor general well being, stress, decreased parental support, low self-esteem, dislike of school, dissatisfaction with school work, poor school performance, depression, adverse psychosocial exposure, psychosomatic factors, psychological trauma, anxiety, poor quality of life) and LBP in children (El-Metwally et al 2007; Trevelyan and Legg 2006; Burton et al 2004; Cardon and Balagué 2004; Watson et al 2003; Balagué et al 1999). The presence of behavioural problems, such as anger, disobedience and violence, as well as high levels of hyperactivity, have also been linked to LBP in children (Cardon and Balagué 2004). Psychological factors also influence children's self-report of LBP (Watson et al 2002). Emotional difficulties may be transformed into pain experiences in children and reduce their ability to manage physical pain (Trevelyan and Legg 2006).

Interestingly, studies have also investigated the possible link between family history and heredity, with LBP in children. An association between parental LBP and that of their children has been found. However, it is debatable whether this can be purely ascribed to genetic predisposition or rather, if it is dependant on environmental and psychosocial factors. Chronic LBP in parents can also influence the child's pain behaviour response and reporting (Trevelyan and Legg 2006; Cardon and Balagué 2004; Balagué et al 1999).

2.5.5 GROWTH SPURT

LBP during the growth period has been shown to be an important risk factor for LBP later in life (Jordaan et al 2005a; Cardon and Balagué 2004). Numerous studies have shown that the first onset of LBP is related to the pubertal growth spurt in adolescence (Balagué et al 1999; Leboeuf-Yde and Kyvik 1998). As mentioned previously, peak growth velocity has been noted earlier in girls (12-13 years) than in boys (13-14 years). The peak onset of LBP has also been observed earlier in girls than in boys, and this can be explained by

the fact that girls enter their pubertal growth spurt before boys (Grimmer and Williams 2000).

The adolescent spine differs greatly from the adult spine in that, at any one point in time, the adolescent's spinal structures are in variable stages of sporadic and extreme growth. During the periods of rapid growth, the spinal structures are believed to be prone to structural damage, as they are less able to withstand stresses and loads which are placed on them (Jordaan et al 2005a; Grimmer and Williams 2000). Children are thought to be more susceptible to soft tissue injuries during this period, as the skeletal growth surpasses the growth of the muscles, tendons and ligaments. This leads to an imbalance in the soft tissues, which has been proposed to contribute to LBP (Jordaan et al 2005a; Newcomer and Sinaki 1996).

As mentioned previously, there is a relationship between tissue loading and growth rate. The increasing prevalence of LBP, from 12 years of age through adolescence, supports this theory. The effect of loading on growth is directly proportional to the speed of growth, and any load, applied even for a short period of time, during a phase of rapid growth may result in permanent deformation of a bone. The adolescent spine is also more sensitive to repeated loading of spinal tissue, once again, particularly during periods of rapid growth (Jordaan et al 2005a; Grimmer and Williams 2000).

Although extreme or excessive physical activity and loading during growth may result in injury; controlled, appropriate exercise may improve the development of the spinal structures, enabling them to withstand increased physical loading during adulthood (Mikkelsen et al 2006). Jordaan et al (2005a) identified the need for interventions, during or before the peak growth period, to encourage optimal growth, by creating optimal spinal dynamics and minimization of aberrant stresses. Ideally, exercises which promote muscle balance, normal muscle tone, optimal spine alignment and spinal weight bearing should be included. Additionally, exercises which improve trunk muscle strength, endurance and motor abilities may enhance back function and promote injury prevention (Mikkelsen et al 2006).

2.5.6 RISK FACTOR SUMMARY

Numerous risk factors have been identified in the literature. Studies have presented variable findings and associations between the proposed risk factors and LBP. However, several studies were limited by their cross-sectional design and therefore, were only able to describe associations and not indicate causal relationships. Many studies also raised

the question of whether the risk factors described were the causes of LBP, or whether they were actually rather the consequence of present or previous episodes of LBP. However, some studies did conclude that certain factors (e.g. poor muscle strength and endurance) could be considered both risk factors and consequences of LBP (Balagué et al 1999; Adams et al 1999). There is no simple explanation for LBP. Rather, it should be considered a symptom of a complex interplay between numerous physical, environmental and psychosocial risk factors (Trevelyan and Legg 2006; Adams et al 1999). Further research is needed in this area to clearly define the causal relationship between risk factors in childhood and LBP in adults, as well as the impact of interventions targeting risk factor modification.

2.6 LOW BACK PAIN PREVENTION OUTCOME MEASURES

Numerous risk factors for LBP in children, as well as in the adult population, have been identified. Appropriate LBP outcome measures are needed in order to determine the efficacy of preventative interventions on the prevalence and intensity of LBP, as well as the impact on modifiable risk factors for LBP.

Three primary outcome measures in LBP research in the adult population have been recommended, namely; pain (specifically the visual analogue scale), back pain specific functional status (e.g. Roland Disability Questionnaire, Oswestry Scale) and a global / general health measure (e.g. overall improvement, proportion of patients recovered) (Hayden et al 2005; van Tulder et al 2000). Another primary outcome measure which is also considered to be important in the adult population is work-loss (i.e. days off work and time taken to return to work). Other secondary outcome measures include: range of movement, spinal flexibility, degrees of straight leg raising, muscle strength, generic functional status (e.g. SF-36 [Short Form-36], Sickness Impact Profile) and medication use (Heymans et al 2005; van Tulder et al 2000).

Although there are clear recommendations for LBP outcome measures in the adult population, previous studies in children have largely ignored the above guidelines. The majority of previous studies used knowledge about the spine and spinal care behaviours as their primary outcome measures. In fact, many of the childhood preventative studies do not include pain as an outcome measure at all (Steele et al 2006). In addition, different techniques were used to measure the primary outcomes, making it very difficult to compare the results of previous LBP studies in children. Although many of the specific

outcome measures recommended in adult research are not applicable or considered to be valid and reliable in children, there are a few that may apply and there are others that can be adapted to the specific population. Therefore, it would be appropriate to use the three primary outcome measures and secondary outcome measures described above as guidelines to develop standardised outcome measures in LBP research in children. However, before these outcome measures can be used in LBP research in children, it is important to determine the validity and reliability of these measures, with regard to the specific target population and age group which is being assessed.

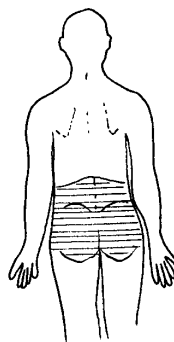
Data providing information on the primary outcome measures (i.e. pain, functional status, general outcomes, work-loss) are generally collected using a questionnaire. Secondary outcome measures (e.g. muscle length, muscle strength etc) are collected using physical measurements.

For the purpose of this literature review, the specific outcome measures which would be relevant to this study were reviewed, to determine appropriate outcome measures to meet this study's aim – i.e. to assess the efficacy of an exercise intervention in LBP prevention in children.

2.6.1 PAIN

Many epidemiological studies have used questionnaires to determine the prevalence and intensity of LBP in children. Valid and reliable questions to determine the three-month, one-month and point-prevalence, as well as the intensity of LBP in children have been identified (Jordaan et al 2005a; Watson et al 2002).

Two questions are used to determine the prevalence of LBP. (1) “In the past three months / one month, have you had pain or discomfort in the lower part of your back that lasted more than 24 hours (one day)?” (2) “In the past three months / one month, have you had pain or discomfort in the area indicated in the figure below?”



Point prevalence is determined with the question: “Do you have pain in the lower part of your back at the moment?”

The visual analogue scale (VAS) has been shown to be a valid and reliable measure of pain intensity in children (Sherman et al 2006; Schaufele and Boden 2003). The VAS is a standardised measure, which is exactly 100mm in length. The child draws a cross on the line to indicate the worst pain that they have experienced. Pain intensity is determined by measuring the length in mm’s to the child’s cross, with 0mm being no pain and 100mm being the worst possible pain (Sherman et al 2006; Schaufele and Boden 2003).

2.6.2 BACK PAIN SPECIFIC FUNCTIONAL STATUS

There are two commonly used, standardised measures to determine back pain specific functional status in the adult population – the Roland Morris Disability Questionnaire and Oswestry Disability Index (Wind et al 2005; Roland and Fairbank 2000). Both are used to determine the effect of chronic LBP on functional status. However, not all of the questions in these questionnaires are relevant or appropriate to children. It is also unclear whether they can be considered to be valid and reliable in children (Wind et al 2005). Previous epidemiological studies have used adapted, shorter questionnaires to determine the impact of LBP on children’s functional status - e.g. questions such as “Did you have to stop or change your sports activities due to pain in your lower back?” and “Did you do any of the following for you low back pain – stay home from school, take any medication, visit a doctor / physiotherapist?” (Jordaan et al 2005a; Watson et al 2002). Considering that it is only a small percentage of children who report disability in functional status as a result of LBP (Watson et al 2002), a functional outcome measure for children may not be as valuable a measure as it is in the adult population.

2.6.3 GENERAL HEALTH MEASURE

General or global health measures are used to determine the overall improvement in symptoms, as well as the proportion of patients recovered, after participation in a LBP preventative intervention programme (van Tulder et al 2000). An overall improvement in LBP behaviour is determined using questions such as: “How often did you have LBP in the past month?” and “How long did your LBP usually last for in the past month?” (Jordaan et al 2005a; Watson et al 2002).

Other important general health outcomes to consider are the psychosocial components of LBP and the perception of exercise. The psychosocial aspect of LBP in children has been well documented, and a correlation between fear avoidance beliefs in LBP patients and

the development of chronic LBP has been found (Burton et al 2004). However, in general, involvement in exercise and physical activity has been shown to have a high relation to positive attitudes in adolescents (Sollerhed et al 2005). Involvement in exercise programmes has also been shown to assist in the treatment of psychosocial factors related to LBP in the adult population (Barr et al 2007). Therefore, questions to determine the effectiveness of interventions in positively influencing the child's emotional sense of well-being, as well as their perception of exercise, should be included. With a large portion of the literature citing psychosocial factors as being more significant than mechanical risk factors for LBP in children (Watson et al 2003), it could be proposed that a psychosocial outcome measure should possibly be one of the primary outcomes in LBP research in children.

The Mental Health Inventory-5 (MHI-5) is a valid and reliable questionnaire which can be used to assess the child's emotional sense of well being (Rumpf et al 2001). Two face scales to determine how the child feels about school and life in general have also been shown to provide valuable information relating to the child's sense of well-being. Both face scales have been shown to be valid and reliable measures in children (Jordaan et al 2005a; Sollerhed et al 2005). Five valid and reliable questions relating to children's perception of exercise in physical education (PE) classes, as well as questions to determine subjective improvement in strength, health and function as a result of exercise, can be included to determine the child's perception of exercise (Sollerhed et al 2005).

2.6.4 WORK-LOSS

Work-loss (e.g. time off work) is considered an important outcome in LBP research in adults (van Tulder et al 2000). However, 'work-loss' in children may not be as relevant. Questions to determine if the child has stayed home from school as a result of LBP can be included. However, whether the child can stay at home or how long the child stays at home, may not be the child's decision and may depend on the child's circumstances, rather than on their experience of LBP. Therefore, it should possibly be considered as a secondary, rather than a primary, outcome measure in children.

2.6.5 PHYSICAL OUTCOME MEASURES

Numerous physical outcome measures can be used in LBP research. However, it is not practical for all of them to be included in all studies and therefore, only those relevant to the objectives of the specific study should be included. The availability of resources, equipment, budgets, number of researchers / research assistants and size of the sample

will also provide limitations as to which physical outcome measures are used (Beaton and Schemitsch 2003).

One focus of preventative LBP research in children is the ability of the intervention to modify identified risk factors. As discussed in section 2.5 of this review, impairments in muscle strength, muscle length, neural mobility and lumbosacral position sense have been identified as potentially modifiable physical risk factors for LBP in children. There are numerous standardised muscle strength, muscle length, neural mobility and lumbosacral position sense measurement techniques which can be used to measure the physical risk factors. However, the selection of which measurement techniques are used will often depend on the availability of time and resources (as mentioned above). Therefore, appropriate, reliable, standardised physical measurements should be selected to determine if there are any changes in the physical risk factors as a result of an active intervention for LBP in children (Beaton and Schemitsch 2003).

2.6.6 SUMMARY OF LBP OUTCOMES IN CHILDREN

Using current guidelines for LBP outcome measures in the adult population, it is possible to determine appropriate outcome measures for children. Primary outcome measures in children should also include the VAS (pain intensity), as well as appropriate functional and general health measures. A psychosocial outcome measure could possibly also be an important primary outcome in LBP research in children. Physical outcome measures of modifiable risk factors for LBP in children are valuable secondary outcome measures, particularly if the intervention includes an active / exercise component.

2.7 PREVENTATIVE INTERVENTION PROGRAMMES FOR LBP

It has been recognised that, due to the unpredictable, poorly understood nature and still largely undetermined primary causes of non-specific LBP, there is limited scope for preventing the first-time onset of LBP (Hestbaek et al 2006b). Therefore, LBP prevention research has focussed on the consequences of LBP, such as LBP recurrence, medical care-seeking, disability and work-loss. However, standard clinical treatment interventions targeting the management of current symptoms are not considered as preventative interventions for LBP (Burton et al 2004).

Burton et al (2004) conducted an extensive review of the literature to compile 'The European Guidelines for Prevention in Low Back Pain'. They found only five studies

relating to the prevention of LBP in children. Similar results were reported in systematic reviews conducted by Steele et al (2006) and Cardon and Balagué (2004). There is thus limited evidence available to recommend effective preventative intervention programmes for children. On the contrary, numerous studies relating to LBP prevention in the adult population were found (Burton et al 2004). Numerous systematic reviews and meta-analyses of specific components of LBP prevention in adults are also available (Liddle et al 2007; Ferreira et al 2006; Hayden et al 2005; Heymans et al 2005; van Tulder et al 2000). Whilst the results from the many studies carried out in the adult population cannot be generalised to children, they can provide valuable information and input to direct future preventative research in a younger population. Currently, the most promising interventions for LBP in adults involve physical activity / exercise and appropriate biopsychosocial education (Ferreira et al 2006; Burton et al 2004). Other preventative interventions such as lumbar supports, back belts and shoe insoles / orthotics are not effective in preventing LBP (Burton et al 2004). There is insufficient evidence for or against specific mattresses, chairs and ergonomic interventions in the prevention of LBP, and there is no evidence to support regular manipulation as a preventative intervention (Burton et al 2004). Therefore, this review will first present the current literature on physical activity / exercise interventions and education in LBP prevention in the adult population. It will then review all the current available literature on LBP preventative interventions in children.

2.7.1 LBP PREVENTION PROGRAMMES IN ADULTS

Chronic LBP in adults is a complex condition, which has been regarded as a problematic disorder with a low treatment success rate (Ferreira et al 2006). Research has found that the most effective interventions for chronic and recurrent LBP involve active physical rehabilitation, such as exercises (Ferreira et al 2006; Arokoski et al 2004; Soukup et al 2001). Cognitive behavioural therapy, together with exercises, can also be an effective intervention for chronic and recurrent LBP (Ferreira et al 2006).

Burton et al (2004) conducted an extensive review of the available literature on preventative interventions for LBP in the adult population. They concluded that there are consistent positive findings that exercise is effective in preventing LBP, reducing further recurrent episodes of LBP and decreasing work absence due to sick leave. In addition they noted that education alone, particularly if it is based on a biomedical or biomechanical model, is not effective in preventing recurrences in LBP. However, information and education, based on biopsychosocial principles, can have a positive effect on the outcomes of preventive interventions when included with an exercise intervention. Furthermore, they found that only back schools which included exercise in their

programme were effective in preventing LBP, whereas back schools based on a biomedical approach with a focus on biomechanical education (e.g. correct lifting techniques, optimal postures etc.) are not recommended in the prevention of LBP.

Back schools are defined as back care education and skill acquisition programmes, which are administered by a qualified medical therapist, to a group of individuals suffering from LBP (Heymans et al 2005). The original back schools only included education and advice. However, the relevance of exercise as a component in back school programmes has since been realised. This is evident in the fact that a recent systematic review only considered back schools which had incorporated exercise in their programmes for inclusion (Heymans et al 2005). Heymans et al (2005) found moderate evidence to suggest that back schools which include exercise are effective in reducing pain, as well as improving function and return to work outcome measures. However, these results should be interpreted with caution, as only six of the nineteen trials included in their review were of high quality. Furthermore, the content, frequency and duration of the back school programmes which were included in the review varied greatly, making it difficult to compare the different studies. The numerous variations in content also makes it difficult to isolate the most beneficial features of back schools, as well as to determine which components are primarily responsible for the positive changes in outcome measures (Liddle et al 2007). However, considering that back schools which include exercise as a component are more effective than those which do not; it may be proposed that exercise could be a fundamental component of successful back school LBP preventative interventions.

Although exercise has been identified as one of the key components in LBP prevention in adults, there is a debate in the current literature as to exactly what the most effective exercise intervention is. Many authors emphasize the importance of specific stabilization exercises in the treatment of LBP, whilst others feel that a supervised, controlled general exercise programme can be just as effective (Ferreira et al 2006, Koumantakis et al 2005a). Therefore, there is currently no consensus as to what the most ideal exercise programme for LBP is.

In one systematic review (van Tulder et al 2000) 39 randomised controlled trials (RCT's) on exercise therapy for LBP were included and in a meta-analysis (Hayden et al 2005) 61 RCT's on exercise therapy met the inclusion criteria. Further RCT's have been published since both reviews. It would appear that, with all this available literature, it should be obvious what the most effective exercise programme is. However, many

variations in the above studies make it difficult to compare the results. Even though guidelines have been presented recommending the use of standardised LBP outcome measures, not all of the studies followed these recommendations and various primary outcome measures have been used. Furthermore, the target populations in these studies have varied greatly, with some being well defined, whilst others were not as well defined or included a mixture of LBP patients (e.g. acute LBP, chronic LBP, mixture of acute and chronic LBP, non-specific LBP, discogenic LBP, undefined group of LBP patients) (Hayden et al 2005; van Tulder et al 2000).

The conflicting results can also be attributed to the large variety of different exercise programmes which have been used. Often no explanation or description of the exercise programmes is given. The frequency and intensity of the exercise interventions, as well as the length of the interventions vary greatly. The exercise intensity varied from low-intensity (e.g. walking), to high intensity exercise (e.g. intense graded endurance training), and the duration and frequency of the interventions also varied from three treatment sessions in five days, to 12 months of home exercise training. Some studies also describe individual exercise programmes as opposed to others with group exercise interventions. The level of supervision and instruction (e.g. by qualified physiotherapist, exercise professional) also varies greatly between studies. Some interventions describe programmes which require constant individual supervision, whilst others describe home exercise programmes with minimal instruction and supervision for only one session at the start of the programme. The control groups also varied in that they received a variety of other active or inactive treatments (Hayden et al 2005; van Tulder et al 2000).

Other irregularities between studies include different genders, sample sizes, drop-out rates, compliance to exercise programmes, long term follow-ups and methodological quality flaws (e.g. non-blinding of researchers). As a result, many of the studies in both the systematic review and meta-analysis were rated as low quality studies. Therefore, although there is a large volume of literature on exercise therapy in LBP, a need has still been identified for studies which investigate the efficacy of specific exercise intervention strategies in well-defined populations of individuals with LBP (Hayden et al 2005; van Tulder 2000).

All of the above considerations should be taken into account when reviewing the available literature regarding exercise therapy in LBP, as low quality trials can provide misleading evidence. Also, due to the nature of exercise intervention studies, it is impossible to blind the subjects to the intervention, which will always impact on the quality of the study. It is

necessary to divide the studies into sub-groups in order to obtain a more accurate understanding of the effect of exercise on LBP. The two main sub-group divisions, which will be discussed in this literature review, are:

- exercise therapy in acute versus chronic LBP
- specific stabilizing versus general exercise interventions in LBP prevention.

2.7.1.1 Acute LBP

There is strong evidence to suggest that exercise is not more effective than other conservative treatments, or even than no treatment, in improving outcomes in acute LBP (Hayden et al 2005; Burton et al 2004; van Tulder et al 2000). However, considering that acute LBP is generally thought to be a self-limiting condition, which will resolve after six weeks, it could be debated whether any intervention is appropriate for episodes of acute LBP. This is reflected in the significantly smaller number of intervention studies available for acute, as opposed to chronic, LBP. In van Tulder et al's (2000) systematic review, only 12 of the 39 studies reported on acute LBP, and in Hayden et al's (2005) meta-analysis only 11 of the 61 included studies reported on acute LBP, with another six reporting on subacute LBP. Hayden et al (2005) described acute LBP as pain persisting for less than six weeks and subacute LBP as pain persisting between six to twelve weeks, whilst van Tulder et al (2000) grouped acute and subacute LBP (12 weeks or less) together under the heading acute LBP.

Limited studies have been conducted to determine the effectiveness of specific stabilization exercises on episodes of acute LBP. However, current literature also indicates that specific stabilization exercises have no effect on pain and disability related to acute episodes of LBP. Although this could be used to provide further support for the evidence that exercise has no value in the management of acute LBP, studies have shown that there is a reduced recurrence of LBP in people who have taken part in specific exercise programmes for acute LBP (Ferreira et al 2006; Barr et al 2005). Therefore, it could be proposed that exercise prescription during acute episodes of LBP may be beneficial as a preventative intervention, by decreasing further pain and disability from subsequent recurrences of LBP. Therefore, future research into interventions for acute LBP should ideally include well structured, cohort studies with long follow-up periods and more appropriate outcome measures (e.g. frequency of LBP recurrence, impact on muscle strength, spinal stability, exercise choices and participation).

2.7.1.2 Chronic LBP

In contrast, exercise has been identified as one of the few clearly effective treatments for chronic and recurrent LBP. Furthermore, the effect size appears to be sufficiently large and durable to suggest that it is clinically significant (Maher 2004). Numerous studies evaluating the effect of exercise therapy on chronic LBP are available. These also include studies which evaluate recurrent episodes of LBP, as they are most often also referred to as studies on chronic LBP (Liddle et al 2007). Of the 39 studies included in van Tulder et al's (2000) systematic review, 23 reported on chronic LBP, and of the 61 studies included in Hayden et al's (2005) meta-analysis, 43 reported on chronic LBP. Other studies have also been published since both these reviews.

Due to the numerous variations in the available studies (as described above), conflicting results are also presented in the literature regarding the effectiveness of exercise in chronic LBP. However, even without taking into account these differences, there is still strong evidence to suggest that exercise is more effective than usual care by a general practitioner, that exercise is at least as effective as other conservative treatments (e.g. conventional physiotherapy) and that specific stabilization programmes are particularly effective as interventions in LBP (Ferreira et al 2006; Hayden et al 2005; Burton et al 2004; van Tulder et al 2000). To limit the possible exaggeration of these effects by the inclusion of low quality studies, Hayden et al (2005) conducted a further meta-analysis including only the subgroup of high quality trials in their paper. They found that the pain outcomes in the exercise groups still remained statistically significantly better than those in the control groups.

2.7.1.3 Specific Stabilization Exercise Programmes

Studies to determine the effectiveness of specific stabilization exercise programmes in adults with chronic LBP have shown promising results. Lumbar stabilization exercise programmes have been shown to be effective in reducing pain and improving function in people with chronic LBP, as well as in reducing recurrence of LBP in people with acute and chronic LBP (Ferreira 2006; Barr et al 2005). Numerous randomised controlled trials have compared the effectiveness of specific stabilization exercises with standard medical care, back education, spinal mobilization, conventional physiotherapy and spinal surgery with physiotherapy treatments. In a recent systematic review, Ferreira et al (2006) presented the results of 12 of these randomised controlled trials. Only one of the studies included in their review was considered to be of low quality. The results of some of the studies indicated that stabilization exercises are more effective than standard medical care and education. Other studies indicated that stabilization exercises are as effective as

spinal mobilization, conventional physiotherapy and even spinal surgery with physiotherapy for patients with disc degeneration.

2.7.1.4 General Exercise Programmes

Burton et al (2004) found insufficient evidence either for or against general exercises versus specific stabilizing exercises. However, Koumantakis et al (2005a) conducted a high quality study to compare the effect of general exercise only, versus general exercise plus stabilization training. Their results indicated that there were significant improvements in all outcomes for both groups, which were maintained at the three month follow-up visit. However, there were no significant differences between the groups immediately post intervention or three months later. Therefore, they concluded that general exercise is as effective as a programme which also includes spinal stabilization training. However, it is important to note that it was mostly the same exercises which were included in both exercise groups, albeit progressed at slightly different rates. The main difference between the two groups was that the stabilization group focussed on correct, conscious activation of the deep stabilisers for the first two to three sessions, before progressing to the exercises which the general exercise group had already started with. Therefore, although it would appear from this study that general exercise is an effective intervention, what comprises a general exercise programme may vary. In the above study, the authors used all the principles of spinal stabilization training in selecting the 'general' exercises for the general exercise programme. Although the general programme did not teach the participants specifically how to isolate and activate the deep stabilisers, it is possible that the exercises promoted unconscious activation of these muscles.

O'Sullivan et al (1997) conducted a high quality study which indicated that specific stabilization exercises were significantly more effective than other commonly prescribed conservative treatment programmes, in individuals with chronically symptomatic instability of the lumbar spine (i.e. spondylolysis and spondylolisthesis). Whereas Koumantakis et al (2005a) excluded anyone with a diagnosed or symptomatic instability of the lumbar spine. Once again this highlights the fact that results can only be compared between studies which have clearly defined populations with similar characteristics. However, it could also be proposed that specific spinal stabilization training is essential for individuals with spinal instability, whereas it may not be as important to focus on the specific isolation and activation of deep stabilizing muscles in individuals who do not present with spinal instability. However, spinal stabilization principles and exercises are still an important component of effective LBP preventative exercise interventions.

2.7.1.5 Summary of LBP Prevention in Adults

Burton et al (2004) hypothesized that the positive effects of exercise are mainly related to an increase in physical activity and a possible reduction in fear avoidance beliefs and behaviours. Therefore, they concluded that exercise could essentially be considered a cognitive behavioural treatment. However, whichever way one looks at exercise, it must be concluded that it has a key role to play in LBP preventative intervention programmes. Although it has been shown that exercise does not have an effect on LBP outcomes in episodes of acute LBP, it is possible that exercise may reduce the impact of future recurrent episodes of LBP. Exercise, specifically stabilization exercise programmes, is clearly an essential component of LBP preventative interventions (Ferreira et al 2006). It can also be concluded that exercise programmes, which incorporate education based on biopsychosocial principles, can help promote more positive results (Burton et al 2004). Considering the costs associated with other conservative, individual treatment options, exercise is certainly a cost-effective alternative. Exercises can be taught to groups of individuals with LBP. Group classes not only cut costs and optimise the professional's time management, but they also have the added benefit of providing a 'support group' of other individuals who are also suffering from LBP (Moffett et al 1999).

However, considering all the numerous interventions aimed at the adult population, the prevalence of LBP still remains high. This would indicate that LBP interventions are currently introduced too late and are possibly not readily available or accessible to a large percentage of the population (Hestbaek et al 2006b). It is also possible that the debate surrounding the most effective preventative programme, results in a variety of different interventions being implemented in clinical practice. Furthermore, considering the evidence indicating the early onset and the high prevalence of LBP in children, perhaps preventative intervention studies have been missing the ideal target population.

2.7.2 LBP PREVENTION PROGRAMMES IN CHILDREN

Whilst there have been extensive epidemiological studies documenting the high prevalence of LBP in children, there have been very few studies focusing on preventative interventions. Numerous 'modifiable' risk factors have been identified, as discussed earlier. However, in order for a study to be considered a LBP preventative intervention, it cannot only modify risk factors; it also needs to be able to positively influence primary LBP outcomes (Burton et al 2004; Cardon and Balagué 2004). As mentioned in section 2.6 of this literature review, previous studies in children have not followed the recommended guidelines for appropriate outcome measures in LBP research. Furthermore, many of the

studies used measures which had not been tested for reliability or validity (Steele et al 2006).

Therefore, in order to determine inclusion criteria for their systematic review, Steele et al (2006) identified the following outcomes for LBP preventative interventions in children:

- improving knowledge about the spine / spinal care
- changing spinal care behaviours
- decreasing the prevalence of spinal pain

Only 12 studies met the inclusion criteria for the systematic review conducted by Steele et al (2006). However, all 12 of the studies were assigned a “weak” global quality rating, and therefore the results need to be interpreted with caution. Burton et al (2004) and Cardon and Balagué (2004) only included five of the 12 studies in their reviews, obviously as a result of more stringent inclusion criteria. Numerous limitations were identified in all of the studies, including inadequate sample sizes, study designs which produced biased results, poor consideration of confounding factors, measurement tools which had not been tested for reliability and validity, short duration (six of the studies described one-session interventions) and inadequate follow-ups. Therefore, all of the above systematic reviews concluded that well-conducted randomised controlled trials with adequate, appropriately powered sample sizes are needed.

The majority of the above studies (eight out of the 12) used a school-based educational intervention programme, including information on anatomy, spinal care principles, posture, risk factors for spinal injury, injury prevention and lifting techniques. All eight studies reported higher knowledge scores post-intervention. Only four studies assessed knowledge on more than one occasion post-intervention, and the knowledge scores in the intervention groups remained significantly higher than the control groups, even up to one year later (Steele et al 2006). This indicates that school children are receptive to back care knowledge and skills, although whether this equates to a reduced recurrence and incidence of LBP remains debatable (Cardon and Balagué 2004). Cardon et al (2007) found that although children retained back care related knowledge over a two year period, it had no impact on LBP prevalence in the experimental group. Currently, there are no long cohort studies available, which follow children through adolescence to adulthood, to provide evidence for or against the long term preventative effects of these interventions.

In Steele et al's (2006) review, the majority of the studies (10 of the 12) also evaluated spinal behaviours (e.g. correct lifting techniques, backpack wearing). Seven of the studies

indicated that spinal care behaviours can be positively influenced by participation in a spinal health intervention, whilst the other three provided inconclusive or statistically insignificant results. However, the interventions and measurement techniques varied across the studies and it is therefore difficult to compare the results. It is also important to consider that all of the above studies were assigned a 'weak' global rating (Steele et al 2006). Nevertheless, it would appear that spinal behaviour can be positively influenced by spinal health intervention programmes in school children.

The prevalence of LBP was only assessed in two studies in the above systematic review. Both studies indicated a significant reduction in the prevalence of LBP in the intervention group, and these findings were maintained at follow-up, one year later (Steele et al 2006). One-week prevalence of LBP was used as an outcome in both studies. LBP severity was also determined on a five-point scale, and frequency on a four-point scale (Cardon et al 2002).

Furthermore, in Steele et al's (2006) review, only one study included exercise as part of the intervention. A group of 106 nine year olds were divided, using a quasi-experimental design, into an intervention group and a control group. The intervention group took part in a postural hygiene programme. However, of the 11 sessions included in the programme, there were only three one hour physiotherapy exercise sessions, as opposed to eight two hour behavioural intervention sessions. No explanation of what was included in the physiotherapy exercises was given. Once again, only back care knowledge and postural habits were included as outcome measures. Although the results of this study were promising, with significant improvements in the experimental group being maintained at six and twelve months, it is difficult to assess the effect of the exercise component of the intervention on the results (Méndez and Gómez-Conesa 2001).

Other intervention studies have targeted modification of school furniture. However, Cardon and Balagué (2004) could not find any high quality studies relating to the possible preventative effect of furniture, and although numerous studies have concluded that the current school furniture is inappropriate, there is no conclusive evidence identifying the most appropriate furniture (Trevelyan and Legg 2006).

Cardon et al (2007) investigated the effect of a back education programme, which included a physical activity promotion programme. Obviously, this study was not included in any of the reviews mentioned above. Their aim was to promote physical activity, both inside and outside of school, through education as well as by increasing activity levels

during school physical education classes, the availability of extra-mural sport and the access to sporting material during school. Children aged eight to twelve years were divided into three groups – 190 in intervention group A (education and physical activity promotion programme), 193 in intervention group B (education only) and 172 in the control group (no intervention). Once again, their findings indicated significant improvements in back care knowledge and behaviour in both intervention groups, which were retained over two years. They also found that the level of physical activity in the intervention group A was positively influenced by the physical activity promotion programme. However, although this study focussed on increasing physical activity levels, it did not include any specific exercises in the programme. Despite these positive findings, there were no differences in one-week pain prevalence in either of the intervention groups or the control group post intervention. Considering that both high and low levels of physical activity have been identified as risk factors for LBP in children (Burton et al 2004), it is possible that merely increasing levels of physical activity is not enough. Perhaps guidelines, which define appropriate moderate levels of physical activity for children, need to be promoted to ensure that children who already have high levels of physical activity are not encouraged to do more. The majority of children who already participate in sport probably enjoy being physically active and are therefore, also more likely to respond positively to physical activity promotional programmes.

Another study which was published after the above reviews was a two year multifactorial school-based intervention programme conducted by Geldhof et al (2006). The programme included back education and the stimulation of postural dynamism through support and environmental changes in the classroom. Their aim was for children to develop a biomechanically healthy lifestyle to encourage optimal daily loading of the spine. Children aged nine to eleven years were divided into two groups, with 193 children allocated to the intervention group and 172 to the control group. The intervention resulted in significant changes in back posture knowledge, improved postural behaviour during material handling and decreased duration of trunk flexion and neck torsion in sitting. However, there were no significant changes in reports of LBP post-intervention in the control or intervention group. Once again, only a one-week prevalence of LBP was used. Severity was measured on a five-point scale and frequency on a four-point scale. Although this programme modified some of the identified risk factors for LBP, it did not change the prevalence of LBP in this population. Possibly if these children were followed up into adulthood the long term benefit of improved postural behaviour would be observed with a decreased recurrence of LBP later in life.

Both of the two most recent studies acknowledged the lack of pain prevalence assessments in previous research and therefore, both included a measure of pain prevalence as an outcome measure. However, neither of the two studies showed a change in pain prevalence post intervention, although positive findings were noted in their other outcome measures. As a result, both Cardon et al (2007) and Geldhof et al (2006) propose that pain is not a relevant outcome measure in LBP research in children. However, the majority of children in both studies had not yet entered the pubertal growth spurt. Research has shown that the peak onset of LBP is between 12-14 years of age (Grimmer and Williams 2000). Considering that a large percentage of children would fall into this age group two years post-intervention, it is possible that they were at a higher risk of developing LBP anyway. Not all of the children had LBP at baseline, so it is difficult to determine if the reports of LBP post intervention were new occurrences or recurrences of previous LBP. Therefore, perhaps more thought should be given to the pain outcome measures which are used in LBP research in children. Adult studies place more significance on the visual analogue scale (VAS) as a primary outcome measure for pain intensity. However, it is interesting to note that none of the above studies used the VAS as an outcome measure.

Jones et al (2007) recently published a study which evaluated the efficacy of exercise as an intervention for recurrent non-specific LBP in adolescents. Children aged 14-15 years were randomised, in matched pairs, into either the exercise group (31 children) or the control group (31 children). Only children who presented with symptoms of recurrent LBP were included. Children in the exercise group participated in an eight-week school-based exercise programme. A significant improvement in pain intensity (on a ten-point scale) was observed in the exercise group immediately post-intervention. In addition, significant improvements in trunk muscle endurance, lumbar mobility and hip range of movement were also observed. However, there was no significant association between the improvement in the physical risk factors and the reduction in pain intensity. Although these results are promising, they only monitored the children's LBP behaviour for a week before and a week after the exercise intervention. Therefore, as they did not include any subsequent follow-up visits, it is unknown whether this improvement was maintained. In addition, they only reported on the one week severity of LBP and did not include the post-intervention prevalence of LBP in both groups.

Although studies, focussing on LBP prevention in children, have shown promising results, the current findings are too limited to formulate evidence based guidelines. Commonly used primary outcome measures, as well as the long term effect on the prevalence and

intensity of LBP in these studies, are questionable. The majority of the above studies, including two of the most recent ones, used pre/post quasi-experimental designs which impact on the quality of the studies. Furthermore, the majority of the above studies were conducted by the same group of researchers on a similar population group. Therefore, it may not be possible to generalize these results to other populations. The multifactorial nature of LBP further complicates the determination of appropriate preventative interventions (Geldhof et al 2006). As a result, many of the above studies used multifactorial interventions, and whilst this may be the answer, it is necessary to determine which of the components are most effective. This is particularly important when the interventions are implemented during school hours, as teaching hours are valuable and school curricula are often already full (Cardon et al 2007). Therefore, it is essential to ensure that only the most effective components are included in school programmes. It has also been proposed that the scope for preventative interventions in childhood may well be limited by the strong association of psychosocial factors with LBP in children (Cardon and Balagué 2004). However, Cardon et al (2007) proposed that future research should rely on the positive effects and promising results from LBP intervention studies in adults in order to develop appropriate interventions for children, i.e. physical exercise / activity and biopsychosocial education.

In conclusion, there is evidence to support the inclusion of spinal health care programmes in school programmes to promote back-care-related knowledge and skills. However, whether this is synonymous with LBP prevention is unproven and debatable. There is very limited evidence available to show that these interventions even reduce the prevalence of current LBP in the children studied, and it is difficult to determine whether these interventions have long term preventative implications on adult LBP. It may be assumed that the most obvious benefits that one would hope to achieve with a LBP preventative intervention programme is the reduction in intensity and incidence of current LBP, as well as a reduced incidence of recurrent LBP. Numerous physical risk factors have been identified as being associated with LBP in children. Extensive literature has highlighted the susceptibility of the growing spine to stress and loads, and a need for appropriate exercise during the growth spurt has also been recognised. However, only one of the previous studies investigated the effectiveness of exercise as a preventative intervention for children. Furthermore, exercise has been identified as one of the few, clearly effective preventative interventions for recurrent and chronic LBP in the adult population. Therefore, it can be hypothesized that a specific exercise programme could be an effective intervention for LBP in children.

2.8 SCHOOL BASED INTERVENTIONS

Children spend a large proportion of their day at school, and the school environment has been recognised as having a powerful influence on their physical activity behaviour (Haerens et al 2006). The school environment is also an ideal setting, as it holds enormous potential to help children develop knowledge and skills to be healthy, whilst providing prolonged feedback to a large percentage of the population (Cardon et al 2007; Geldhof et al 2006). Previous school-based spinal health intervention programmes have indicated that school children are receptive to new knowledge and skill acquisition (Cardon et al 2007; Steele et al 2006; Cardon and Balagué 2004). Only a small percentage of children who complain of LBP receive treatment for their pain (Watson et al 2002). Social factors may impact further on childhood LBP, by limiting children's access to appropriate health care services. Therefore, implementing interventions in schools provides an equal opportunity for all children to access services, as well as to benefit from the interventions.

Sollerhed et al (2005) highlighted the importance of promotion of physical activity through school physical education (PE) classes. They identified that early positive experiences of exercise during school PE contribute to positive attitudes towards exercise, which children are likely to carry through to adulthood. The transition from childhood to puberty, with all its biological and social implications, has been identified as an important intervening phase for the transition of physical activity from childhood to adulthood. Furthermore, school-based interventions, targeting this age group, have been shown to have positive effects on physical activity levels (Cardon et al 2007; Haerens et al 2006).

Misconceptions and fear avoidance beliefs about LBP are widespread among the adult population. These have been shown to play a role in the development of long-term disability related to LBP. Concerns about the possible negative effects on fear avoidance beliefs and behaviours due to increased awareness following intervention programmes in school children have been raised (Burton et al 2004). However, a few school-based LBP interventions have shown that LBP intervention programmes do not have a detrimental effect on fear avoidance beliefs, nor do they reinforce fear avoidance behaviours (Cardon et al 2007; Geldhof et al 2006; Cardon and Balagué 2004). None of these studies, which included assessments of fear avoidance beliefs and behaviours, indicated negative effects on either as a result of the interventions. In fact, a significant increase in fear avoidance beliefs was noted in the control group in one of the studies, as opposed to a reduction in fear avoidance beliefs in the intervention groups (Cardon et al 2007). Intervention studies

in the adult population have observed a reduction in fear avoidance beliefs, after active involvement in LBP preventative interventions (Koumantakis et al 2005a; Frost et al 1995). It is possible that early LBP intervention programmes may also have a similar positive impact on fear avoidance beliefs in children.

Therefore, it may be proposed that well-structured interventions / health promotion programmes which are incorporated into life orientation and physical education classes at school, could be enormously beneficial in dispelling these misconceptions and providing children with valuable 'health tools' to manage their aches and pains. Actively educating children at school will empower them to make more informed decisions relating to their body, exercise, posture and good health.

2.9 SPECIFIC EXERCISES IN LOW BACK PAIN PREVENTION

Exercise has been identified as possibly the most effective preventative intervention for LBP in adults. Although there is a debate as to which exercise interventions are most appropriate, the majority of the current literature supports the theory that specific spinal stabilization programmes are most beneficial for individuals with LBP (Ferreira et al 2006; Barr et al 2005). The aim of a specific exercise programme for LBP is to improve control of intervertebral segmental motion and to optimise spinal alignment and lumbar-pelvic stability. As mentioned previously, the active (muscular) and neuromuscular control systems can compensate for instability present in the passive system. Therefore, the aim of exercise programmes for LBP is to restore, optimise and enhance the functioning of the muscles surrounding the trunk and the neural control systems (MacDonald et al 2006; Barr et al 2005).

Stability in the spinal system can be enhanced through the positive effects of exercise on the deep musculature (which provide intersegmental spinal stability and increase IAP), the global muscles (which dissipate forces and limit unwanted trunk movement) and the neural control of these muscles (Barr et al 2007). According to Reeves et al (2007) core stabilization exercises do not make the spine more stable, they make it more robust and improve performance of the system. These improvements in robustness and performance will enhance the spinal system's ability to maintain stable behaviour and respond rapidly and precisely to both large and small perturbations, thus reducing the risk of injury.

Research has identified a few essential components of exercise programmes which can enhance muscular activity and neuromuscular control, namely: joint stability (co-contraction) exercises, balance training, proprioceptive training, muscle endurance training, postural control, correction of muscle imbalances and sport specific skill / plyometric training (Barr et al 2007; Barr et al 2005; Akuthota and Nadler 2004). These many components should therefore be addressed in exercise programmes targeting LBP.

To ensure that specific exercise programmes for LBP are effective, it is essential to include a thorough explanation and education at the beginning of the programme. Research has found that outcomes in LBP programmes improve if the participants understand the cause of pain and why the exercises are being prescribed (Barr et al 2007; Soukup et al 2001).

Studies in the adult population have shown that improvements in pain, function and disability related to LBP, can be found after eight weeks of exercise, and can be maintained at three-month follow-up (Barr et al 2007; Koumantakis et al 2005a). The only available study which included exercise as an intervention during adolescence was published after this study was completed. Therefore, prior to commencing with this study, there were no previous studies which evaluated the efficacy of exercise as an intervention for LBP in children. Therefore, it was proposed that an eight week exercise programme, consisting of core stabilization exercises, stretching and strengthening, as described in previous literature and studies relating to LBP in adults, would be an effective intervention for LBP in children. These specific exercises, which have been identified as important components to include in LBP exercise interventions, are described below.

2.9.1 WARM UP

An exercise programme for LBP should ideally start with a short aerobic warm-up, to decrease spinal and pelvic viscosity (Akuthota and Nadler 2004). Fast walking is an ideal warm-up, as it appears to create less torque on the lumbar spine than slow walking. The “cat and camel” stretch has also been identified as an effective way to achieve spinal segment and pelvic accessory motion, before starting more aggressive exercises (Akuthota and Nadler 2004).

2.9.2 CORE STABILIZATION

In individuals who have not had LBP, about 10% of maximal co-contraction of the stabilizing muscles is sufficient to provide segmental stability. However, in individuals with LBP, slightly more may be needed. Motor relearning of inhibited muscles may also be

more important than strengthening in people with LBP, and muscle endurance appears to be more important than pure muscle strength (Akuthota and Nadler 2004). As a result, researchers have hypothesized that the focus in lumbar stabilization for LBP should be on muscular endurance, rather than absolute muscle strength (Barr et al 2005). However, core stabilization programmes should aim to restore both strength and endurance to the muscles which are involved in stabilizing the lumbar spine (Barr et al 2007).

Most research has focused on individual spinal stabilization programmes for LBP as opposed to group classes. Lumbar stabilization programmes progress through three stages, beginners, intermediate and advanced, depending on the progress made by the individual (Barr et al 2007).

2.9.2.1 Beginners Lumbar Core Stabilization

The initial goals of a lumbar core stabilization programme are to develop “core awareness” through the activation of the deep stabilizing muscles (TA and multifidus), and to train the participant to find and maintain a neutral spine position. The neutral spine position (i.e. the spine positioned in a pain-free, natural curve) is considered as a safe-place to begin exercise (Akuthota and Nadler 2004). It has been found that people can learn to activate their deep stabilizers, rather than the more superficial muscles, during exercise based on verbal and tactile cues, and that they can remember this for a week between sessions (Barr et al 2005). The objective is to encourage this activation and “core awareness” to carry over to daily activities, and hopefully, with enough practice, for it to become automatic (Barr et al 2007). Due to the predominance of type I muscle fibres in the deep stabilizers, low load exercise is advisable initially (MacDonald et al 2006).

Although activation and recruitment of TA and multifidus are initially emphasized in core stabilization programmes, all of the trunk muscles are considered to play an important role in the restoration of normal function. Therefore, it is important to include progressions in the exercise programme, to address the entire muscular system involved in supporting, stabilizing and moving the spine (Urquhart et al 2005).

Different techniques have been proposed to activate the core stabilizers. However, studies have found that the draw-in pattern / inward movement of the lower abdominal wall in supine is the most effective technique, as it minimizes global muscle activity during TA activation (Urquhart et al 2005; Richardson et al 2002). Urquhart et al (2005) observed that the most independent activity of TA occurred with the inward movement of the lower abdominal wall in the supine position, with hips flexed to 45 degrees and with

limited lumbopelvic motion. Significantly less / minimal activity was noted in the rectus abdominis, as well as the internal and external obliques abdominis muscles, during the same manoeuvre. These results indicate that, with training, it may be possible to activate TA almost independently from the other abdominal muscles. It is important to discourage substitutions from the global muscles, and to aim to achieve a precise, controlled 'isolated' contraction of TA (Richardson et al 2002).

Once the activation has been mastered, loading is added through gentle limb movements, whilst maintaining the contraction of the deep stabilizers. For example, adding hip flexion from crook position in supine (Barr et al 2007).

Most lumbar stabilization programmes focus on the activation of the deep stabilizers. However, some studies have found that specific training to activate the TA and multifidi are not an absolute necessity for a successful stabilization programme (Barr et al 2007; Koumantakis et al 2005a). Although further research needs to be done to further clarify these findings, it is currently still considered important to begin a lumbar stabilization programme with the activation of these two muscles, creating "core awareness" and enabling people to become aware of motor patterns. However, what can be agreed upon is that this alone is not enough and that the exercises do need to be progressed to the intermediate level.

2.9.2.2 Intermediate Lumbar Core Stabilization

Once the participants are able to perform the simple activations, they can progress to more advanced exercises. The intermediate exercises focus on the maintenance of spinal stability whilst increasing challenges, loads and forces are being applied to the trunk. The aim is to maintain a neutral, supported spine whilst performing exercises which involve moving the arms and legs through a larger range of movement (Barr et al 2007).

Many studies have shown that lumbar stabilization programmes are effective if progressed only to this level. However, theoretically there are reasons to progress patients beyond this point to include functionally relevant exercises (Barr et al 2007; Akuthota and Nadler 2004).

2.9.2.3 Advanced Lumbar Core Stabilization

Advanced core stability training includes activities performed on a labile surface to train the body to respond to unexpected forces and perturbations. The aim of these advanced exercises is to enable one to perform high level activities at work and sport, whilst maintaining spinal stabilization. However, these are based mostly on anecdotal evidence,

which supports that they are effective, and are often used in the training of sports people (Barr et al 2007).

2.9.3 DIAPHRAGMATIC BREATHING

As discussed previously, the diaphragm forms the roof of the cylinder of deep stabilizing muscles, and is involved in increasing IAP as well as contributing towards lumbar stability (Barr et al 2005). A disruption in the normal functioning of the diaphragm would contribute towards decreased lumbar stability and LBP. Studies have found a link between sacroiliac pain and impaired recruitment of the diaphragm. Promotion of optimal diaphragmatic functions is, thus, considered to be an important component of core stabilization programmes (Akuthota and Nadler 2004). In addition, in order to facilitate the correct activation of TA, one needs to be able to breathe diaphragmatically. Therefore, diaphragmatic breathing exercises should be included in a programme targeting LBP.

2.9.4 PELVIC FLOOR EXERCISES

The pelvic floor muscles form the floor of the cylinder of deep stabilizing muscles. Correct activation of TA should result in activity and co-activation of the pelvic floor muscles. However, this co-activation has been found to be dysfunctional in people with LBP and an impaired recruitment of pelvic floor muscles has been linked to LBP (Akuthota and Nadler 2004). Therefore, pelvic floor exercises should be included in a programme targeting LBP.

2.9.5 BALANCE RETRAINING

A close link has been identified between balance, posture, lumbar proprioception and lumbar stabilization. People with LBP have poor posture control and balance reactions, as opposed to pain-free controls. Multiple studies have also found that people with LBP have deficits in spinal proprioception and make repositioning errors. This could be related to impaired neuromuscular control and feedback, which results in muscle activation sequence dysfunction and delayed muscle reaction times (Barr et al 2005; O'Sullivan et al 2003; Brumagne et al 2000). Balance requires a multidimensional interaction between central, peripheral, motor and sensory systems. Core stability is an integral component of balance and, therefore, balance retraining may also contribute to core strength and stability (Akuthota and Nadler 2004). Exercises to improve balance and spinal proprioception such as single-leg stance, single-stance knee bend and lunges in different planes should be included (Barr et al 2007). It is important to address posture correction, balance retraining, promotion of optimal spinal alignment and precise controlled movements during exercise programmes for LBP (Barr et al 2007; Hodges 2003).

2.9.6 FUNCTIONAL EXERCISES

General muscle strength and endurance is often reduced in those with LBP (Barr et al 2005). Therefore, general functional exercises may help to promote general fitness and strength. This will enable children to cope better when loads are placed on their spines whilst increased demands are being placed on their general fitness e.g. when participating in sport.

Poor endurance and delayed firing of the hip extensor (gluteus maximus) and abductor (gluteus medius) muscles has been found in people with LBP. The hip musculature plays a significant role in transferring forces from the lower extremities to the pelvis and spine, and is therefore, an important link in the kinetic chain (Akuthota and Nadler 2004). Biomechanics of individuals with LBP have been observed to be different from those who do not have LBP (Barr et al 2007). This should be taken into account in LBP exercise programmes, and exercises such as bridging, lunges and squats should also be included.

Transverse or rotational movements are often neglected in core stability training. However, they are important components of functional and sporting activities which contribute to torsional loading of the spine (Akuthota and Nadler 2004). Therefore, functional activities which include rotational or transverse components should also be included.

2.9.7 STRETCHING

Postural muscle imbalances contribute to LBP, as they interfere with the neutral spine position. When the spine is in a neutral position, the muscles are able to function most efficiently and the soft tissue and structural spine structures are not under constant passive strain (Barr et al 2007). Many muscle groups can contribute to postural muscle imbalances, and it is essential to correct these imbalances, to ensure that the spine can attain and maintain its neutral position. Common muscle imbalances, related to LBP, involve the hamstrings, hip flexors, gluteal muscles, quadratus lumborum, latissimus dorsi, quadriceps, hip external rotators and thigh adductors (Barr et al 2007). As mentioned above, the hip is an important link in the kinetic chain and improving range of movement of the hip can help to dissipate forces from the lumbar spine (Akuthota and Nadler 2004). Therefore, stretches which target the above muscle groups should ideally be included in exercise programmes for LBP. However, caution should be taken with stretches that encourage end of range lumbar flexion. The risk of lumbar injury is greatly increased when the spine is fully flexed and when it undergoes excessive repetitive torsion (Akuthota and Nadler 2004).

2.9.8 NEURAL MOBILIZATION EXERCISES

A heightened mechanosensitivity of the neural system and limited neural mobility contribute to LBP. In order to protect the neural system from excessive stretch, the hamstring muscles demonstrate a defence reaction, which limits the flexibility of the hamstrings. This, in turn, results in altered biomechanics of the hip and spine, compensatory movement strategies and abnormal spinal loading during functional activities (Shum et al 2005; Rebain et al 2002). Therefore, appropriate neural mobilization exercises should be included to optimise the mobility and functioning of the neural system.

To summarize, a specific exercise programme targeting LBP prevention should ideally include the following components:

- warm up
- progressive spinal stabilization exercises
- diaphragmatic breathing
- pelvic floor exercises
- balance and postural control retraining
- functional exercises
- stretching
- neural mobilization exercises

Emphasis should be placed on a neutral spine starting position, optimal spinal alignment and precise, controlled movements during all of the exercises. It can be proposed that, if all the above components are included, the exercise intervention will have positive results on the prevention of LBP as well as in promoting optimal function of the active and neuromuscular spinal systems.

2.10 CONCLUSION OF LITERATURE REVIEW

Low back pain has been the focus of countless researchers and authors who have been trying to understand LBP and determine guidelines for evidence based practice. However, with all the available literature on LBP, the nature, cause, appropriate treatment and prevention of non-specific LBP still largely remains a mystery. What can be agreed upon is that LBP is a complex, multifaceted condition which can be attributed to a combination of a variety of possible risk factors in both adults and children. Currently, the most likely proposed explanations for non-specific LBP are a dysfunction in the spinal stabilizing system, numerous psychosocial factors or a combination of both.

Whatever the cause of LBP, numerous studies have documented the high prevalence of LBP in both adults and children. Over 70% of the adult population and over 50% of children will suffer from LBP at some point. Furthermore, the theory which proposes a link between LBP in childhood and adulthood, is slowly gaining strength as new evidence continues to emerge to support this connection.

However, the vast majority of studies have focussed on implementing preventative interventions in the adult population. It would appear that with more than half of the population experiencing LBP before the age of 20, the focus of LBP research needs to be on the younger population (Hestbaek et al 2006b). Perhaps this is why despite many years of research targeting the prevention of LBP, the incidence of LBP still remains very high.

Unfortunately, the available literature on LBP prevention in children is very limited. Although clear guidelines have been described for LBP preventative research and outcome measures in adults, none have been identified for children. As a result, the current studies in children have used a variety of outcome measures, which may not always be appropriate to determine the effect of interventions on LBP prevention. Therefore, it is necessary to review the considerable literature available on LBP preventative interventions in the adult population, in order to determine appropriate guidelines for studies in the younger population.

There is a wide variety of valuable evidence, from studies in the adult population, which can help to direct research in the younger generation. Firstly, the knowledge gained from the extensive research into the functioning and importance of the lumbar stabilizing system is invaluable. An understanding of the detailed mechanisms involved in dynamic lumbar stabilization, enables one to appreciate the consequences of dysfunction in this system and its impact on LBP. Therefore, it has been concluded that the deep spinal musculature, global trunk muscles and neuromuscular control systems need to be functioning optimally, in order to protect the spine from abnormal loads, stresses and injury. This correlates with all the evidence which indicates that exercise is one of the few clearly effective interventions for recurrent and chronic LBP in the adult population.

It has been shown that the onset of LBP in children is related to the pubertal growth spurt and that the growing spine is more susceptible to injury during this period. Muscle imbalances during periods of rapid growth result in impaired muscle strength and flexibility in certain muscle groups. Although dysfunction in the lumbar spinal stabilization system

has not been investigated as thoroughly in children as in adults, there is evidence to suggest that impaired spinal stability is linked to LBP in children. Therefore, it could be proposed that appropriate exercise interventions would also be effective as LBP preventative interventions in children, particularly during periods of rapid growth.

Previous school-based intervention studies have shown that children are receptive to back care knowledge and changes in spinal behaviours. The school environment has also been identified as having a powerful influence over their physical activity behaviour. Therefore, it can be proposed that a school-based exercise intervention would be an effective way to reach a large percentage of children, irrespective of social factors and access to healthcare facilities.

As a result of the strong association of psychosocial factors with LBP in children, the scope for preventative interventions during childhood has been questioned. However, involvement in exercise and physical activity has been shown to have a high relation to positive attitudes in children. Therefore, it may be further proposed, that involvement in school-based exercise programmes can help to promote a positive sense of well-being in children – particularly if the programme is appropriately structured, graded and progressed to ensure that all children can master the exercises, even those who do not excel at sporting extra-mural activities.

In conclusion, after reviewing the available literature on preventative interventions for LBP in children and adults, a clear need has been identified for randomised controlled trials to evaluate the efficacy of exercise as an intervention for LBP in children. The ideal target population would be children who are about to enter, or who have just entered, the pubertal growth spurt. Ideally, the exercise programmes should be implemented as school-based interventions, to allow an equal opportunity for all children to access and benefit from the intervention. Appropriate LBP outcome measures and exercise programmes for children should be adapted and developed from the guidelines and literature available on LBP research in the adult population. However, one study will obviously not be able to answer all the questions relating to LBP prevention in children. Rather, it would help to provide some insight into LBP preventative interventions in children and help to direct future research in this field. As Cardon and Balagué (2004) noted, if young people can learn good lifestyle habits early, then perhaps the burden of LBP can be lessened.

CHAPTER 3

METHODOLOGY

Figure 3.1 outlines the sub-sections which will be discussed in this chapter.

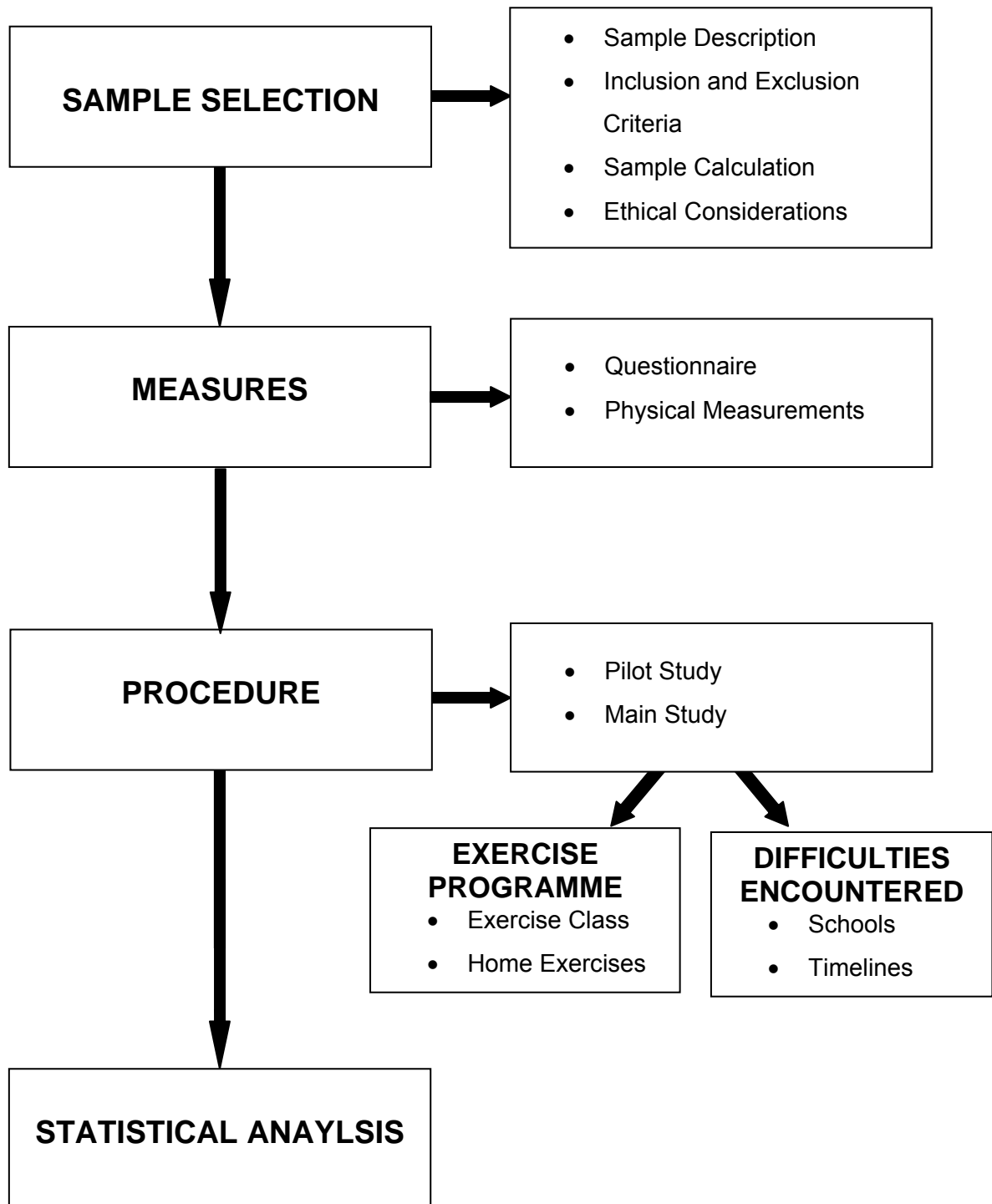


Figure 3.1 Outline of Sub-Sections included in Chapter 3 (Study Methodology)

3.1 STUDY DESIGN

A Randomized Control Trial was used for this study

3.2 SAMPLE SELECTION

3.2.1 SAMPLE POPULATION

Government primary schools in the Ekurhuleni West and Johannesburg East Districts of Gauteng were invited to participate in the study. Three primary schools in the Ekurhuleni West district agreed to allow their Grade 6 and Grade 7 pupils to participate in the study. One school participated in the pilot study and the other two schools in the main study.

3.2.2 INCLUSION AND EXCLUSION CRITERIA

The peak onset of LBP in adolescents has been noted to be between 12-14 years of age. It has also been ascertained that it is during this time that external loads place the greatest stress on the adolescent's spine, resulting in LBP (Grimmer and Williams 2000). Therefore, for the purpose of this study, 12-13 year old children were used.

Inclusion Criteria

1. Children aged 12-13 years in Grade 6 and Grade 7
2. Children who had complained of LBP in the past three months
3. Children who gave their assent to participate in the study and whose parents signed informed consent

Exclusion Criteria

1. Serious spinal pathologies or deformities (e.g. severe scoliosis, identified inflammatory conditions, spinal tumours), as these conditions fall out of the scope of this study
2. Neurological conditions which alter motor tone. These conditions also fall out of the scope of the study, as they alter motor control, biomechanics and muscle strength
3. Physical disabilities (e.g. spinal cord injuries) which prevent the child from being able to stand up on their own without an orthotic device or brace, or which prevent the child from taking part in normal PE classes.
4. Any other serious co-morbidities (e.g. cancer, severe lung pathology) which prevent the child from taking part in normal PE classes
5. Provincial sports participants, or children who were currently following a specific training programme with a biokineticist or physiotherapist, to exclude children involved in specialized exercise training
6. Current orthopaedic procedures or fractures of the spine, pelvis, lower or upper limbs

3.2.3 SAMPLE SIZE CALCULATION

There were no previous, similar studies available to use to determine the sample size. Therefore, with the assistance of a statistician, the sample size was calculated using the nQuery Advisor® 6.0 software package. The sample size determination was based on one of the primary objectives - i.e. on the difference between the intervention and control groups, with respect to change in pain intensity as measured on the visual analogue scale (VAS). The VAS is a standardized 100mm, non-hatched pain scale, which has been shown to be a valid and reliable measure of pain in children (Sherman et al 2006). Powell et al (2001) determined that the minimum clinically significant difference (MCSD) in visual analogue pain score for children aged 8-15 years is 10mm. Studies have determined that the MCSD in VAS pain scores for adults is between 9mm and 14mm. These studies have also shown that the MCSD in VAS pain score does not differ significantly with respect to gender, age, cause of pain or severity of pain (Kelly 2001; Kelly 1998). For the purpose of the sample size calculation for this study, a change of 20mm in pain scores was used to determine an adequate sample size.

Therefore, a difference of 20 percentage points (20mm on a scale of 100mm) between the groups was used in the sample size calculation. The standard deviation was taken as 23.6 ($=\sqrt{2} \times 16.7$) i.e. the total range of pain can be between 0 and 100 and represents six standard deviations, and since change is considered, the standard deviation needs to be multiplied by $\sqrt{2}$. Under the assumption that the changes have a normal distribution, the estimate for standard deviation is given by range divided by six (99.9% of the normal distribution is covered by six standard deviations). Since it is reasonable to expect that these changes will fall in a narrower range than 0 to 100, this estimate is conservative. Therefore, it was determined that a sample of 31 subjects per group would have 90% power to detect a difference of 20 percentage points between the groups.

3.2.4 ETHICAL CONSIDERATIONS

Permission was first obtained from the Gauteng Department of Education, and ethical clearance for this study was granted by the University of the Witwatersrand's Human Research Ethics Committee (HREC) - Reference number: M060334 (see Appendix A).

Schools were only included in the study once permission was obtained from the school's principal as well as the governing body. Only children who signed assent, and whose parents signed informed consent, were included in the study. Each child was informed that they were free to withdraw from the study at any time and that no adverse consequences would follow their withdrawal. The researcher was available to answer any queries or concerns parents or pupils had regarding the study.

All information and data remained strictly confidential. Once the parent / child had signed informed consent / assent, the child was allocated a number which was used on all documents, data collection sheets and related data for the rest of the study. The list of names and corresponding numbers was kept in a locked safe. Names and personal information were not, and will still not, be publicly divulged, and results published from the study will remain anonymous. The names of the schools used in the study will also not be included in this dissertation or in any publications. The physical measurements were carried out in an enclosed area, to ensure that the child's privacy was respected and any embarrassment avoided.

The research assistant, who conducted all of the exercise classes, was a qualified, experienced physiotherapist. The research assistant ensured that the exercises were executed safely and correctly, to prevent injuries and to minimize pain or discomfort. The home exercises were also monitored in the class to ensure that the children were executing them safely and correctly. The researcher, who took all of the measurements, was blinded to group allocation and intervention implementation. The researcher and research assistant ensured that their interactions with the schools, parents and pupils remained professional at all times.

3.3 MEASURING INSTRUMENTS

3.3.1 QUESTIONNAIRE

A questionnaire was used to determine the three month prevalence and intensity of LBP, as well as the child's sense of well-being and perception of exercise (see Appendices H and I). Groups of questions from various questionnaires, which have been shown to be valid and reliable in this age group, were combined to meet this study's outcome measures (Sherman et al 2006; Jordaan et al 2005a; Sollerhed et al 2005; Schaufele and Boden 2003; Watson et al 2002; Rumpf et al 2001).

Questions to determine the three month prevalence and intensity of LBP were included in the questionnaire (Jordaan et al 2005a; Watson et al 2002). These were used to determine whether the child had LBP and would be included in the study. They were also used to determine the difference in reported incidence and intensity of LBP from baseline to follow-up.

The VAS was used as the primary outcome measure to determine the intensity of reported LBP. VAS pain scales were used to determine the child's worst pain in the past three months, past one month, past one week, as well as their current pain. The VAS has been shown to be a valid and reliable measure in this age group. The standard 100mm

line was used. A smiling face, together with a figure '0' and the wording 'no pain at all' and 'no discomfort' were placed at the beginning of the line. A sad face, with a figure '10' and the wording 'worst pain you can imagine' and 'very uncomfortable' were placed at the end of the line (Sherman et al 2006; Schaufele and Boden 2003).

The Mental Health Inventory–5 (MHI-5) was used to assess the child's emotional sense of well-being (Rumpf et al 2001). Two face scales were also included, to determine how the child felt about school and life in general (Jordaan et al 2005a; Sollerhed et al 2005). Five sets of positive and negative statements relating to the perception of exercise in the PE class were also included. Six questions were also included to determine the child's perception of the impact of PE on their health and function (Sollerhed et al 2005).

To ensure that combining the questionnaires did not alter the validity, the questionnaire was reviewed by an expert panel of physiotherapists, who specialise in LBP. It was also administered to a group of 12-13 year old children. Comments and feedback were obtained from the physiotherapists, as well as the children, regarding the acceptability of the questions, language use and layout of the questionnaire. These were taken into account and the necessary adjustments made. To test the reliability of the questionnaire, it was administered to thirty 12-13 year old children on two different occasions, one week apart. The questionnaire was shown to be reliable in this age group of children.

3.3.2 DIGITAL INCLINOMETER

A Saunders Digital Inclinometer, manufactured by the Saunders Group Inc. in Chaska, Minnesota, United States of America, was used in this study. The Saunders Digital Inclinometer is a portable, hand-held inclinometer, with a liquid crystal screen displaying degrees digitally. No calibration is required.

3.3.3 PRESSURE BIOFEEDBACK UNITS

Two Chattanooga Stabilizer™ Biofeedback Units, manufactured in Australia for the Chattanooga group, a division of Encore Medical Corporation, were also used in this study. The pressure biofeedback unit is a simple device, consisting of a combined gauge/inflation bulb connected to a pressure cell which measures changing pressure.

3.4 PHYSICAL MEASUREMENTS

The physical measurements, which measured the modifiable risk factors for LBP, were the same as those used by Jordaan et al (2005a) to assess the risk factors associated with LBP in adolescents in Northern Gauteng, South Africa. An explanation of the measuring procedure is included below.

3.4.1 FUNCTIONAL INTEGRITY OF THE LUMBAR STABILIZING MUSCLES

The Active Straight Leg Raise Test (ASLR) was used to assess the functional integrity of the SIJ to transfer loads to the lumbar spine. The ability to effectively recruit the lumbar stabilizing muscles can be demonstrated by the functional integrity of the SIJ to transfer loads to the lumbar spine (Jull et al 1993). The child was positioned in supine, with straight legs and feet 20cm apart. Two pressure bio-feedback units were placed underneath the pelvis, below the posterior superior iliac spine (PSIS), one on the left and one on the right. The pressure in both units was inflated to a baseline pressure of 40mmHg. The child was instructed to lift one leg up 20cm above the bed, without bending the knee. The child was instructed to hold this position for five seconds to enable the researcher to make an accurate reading of the pressure change. The test was repeated three times on each side, using alternative legs. The amount of change in the pressure on the side of the lifted leg was measured, to indicate the amount of pelvic movement. The mean value for each side was calculated (Mens et al 2001; Jull et al 1993).

3.4.2 NEURAL MOBILITY

The passive straight leg raise test is a reliable, valid measure to determine the mobility of the neural structures in the lower limb (Butler 1991). The child was positioned in supine, with the test leg close to the side of the bed. The inclinometer was placed on the line on the lateral aspect of the thigh and set to zero. The researcher stood facing the child's head, to monitor the child's expression. The researcher placed one hand on the planter surface of the foot to maintain full dorsiflexion and the other hand was placed above the knee, to prevent any knee flexion. Maintaining the knee extension, the researcher passively lifted the child's leg by moving the leg as a solid lever at a fixed point in the hip joint. The leg was moved to a point where the child complained of discomfort, leg or back symptoms (such as pain, pins and needles, burning, numbness), or a feeling of stretching. The dorsiflexion was then released to reduce the tension on the neural structures, but the hip flexion and knee extension were maintained. The inclinometer was placed on the line on the lateral aspect of the thigh to measure the amount of hip flexion. The full procedure was only repeated twice, to prevent possible irritation of the sensitive neural structures and related symptoms. The mean value was calculated for each side (Butler 1991).

3.4.3 MUSCLE LENGTH TESTS

The flexibility of the hamstrings, iliopsoas and rectus femoris muscles were assessed, using standard muscle length tests as described by Kendall et al (1993) and Bandy and Irion (1994).

The child was positioned in supine. The lateral malleolus, lateral epicondyle of the femur and greater trochanter of the lower limbs were marked. A ruler was used to draw a line with a skin marker between:

- the greater trochanter and lateral epicondyle of the femur, on the lateral aspect of the thigh
- the lateral epicondyle of the femur and lateral malleolus, on the lateral aspect of the lower leg (Bandy and Irion 1994)

3.4.3.1 Hamstring Muscle Length Test

The child was positioned in supine, with the legs straight and the lumbar spine in neutral. The inclinometer was placed on the line on the lateral aspect of the thigh of the leg to be tested, and set to zero. Keeping the inclinometer on this line, the leg was positioned in 90 degrees hip flexion, with the knee relaxed in flexion. The researcher then passively extended the knee, by moving the lower leg, whilst maintaining the 90 degrees of hip flexion. The terminal position of knee extension was the point at which the child complained of a feeling of discomfort or tightness in the hamstring, or the researcher perceived resistance to the stretch. Once the terminal position of knee extension was reached, the inclinometer was moved to the line on the lower leg. The knee extension was measured in degrees. Full knee extension would indicate full hamstring muscle flexibility. No warm-up was done prior to the testing. The opposite thigh was held down, and the pelvis was stabilized to ensure that there was no compensatory movement. The test was repeated three times on each leg, and the mean value was calculated for each side (Bandy and Irion 1994).

3.4.3.2 Iliopsoas Muscle Length Test

The child was positioned in supine, and the inclinometer was placed on the lateral line on the thigh, and set to zero. The child was then asked to slide down the plinth to stand at its lower edge, on the floor. The child was then asked to lie supine on the plinth with the coccygeal region just over the end of the plinth, so that the lower limb to be tested would be free from any restraints offered by the plinth. The researcher flexed the child's opposite hip and knee, whilst palpating the lumbar spine, to ensure that it was flat and that the lumbar lordosis was eliminated. The child then held the flexed knee with both hands, maintaining the position. The child was told to let the leg to be tested hang relaxed and freely over the edge of the plinth. A 20 second period was allowed for adequate relaxation. The inclinometer was then placed on the line on the lateral thigh. A reading of less than zero degrees (hip flexion) would indicate a shortening of the iliopsoas muscle (Jorgenson 1993; Kendall et al 1993).

3.4.3.3 Rectus Femoris Muscle Length Test

The child remained in the above position. The inclinometer was moved to the line on the lateral aspect of the lower leg. The amount of knee flexion was measured in this position. An angle of knee flexion less than 80 degrees indicates shortening of the rectus femoris muscle (Kendall et al 1993).

After measuring the muscle lengths of iliopsoas and rectus femoris, the leg being tested was bent up to the child's chest. It was then allowed to relax into the free hanging position again, and both measurements were re-taken. Three readings for each muscle were taken, before repeating the same procedure on the other side. The mean values for both measurements were calculated for each side.

3.4.4 LUMBOSACRAL POSITION SENSE / PROPRIOCEPTION

The method below, described by Brumagne et al (2000), to measure lumbosacral position sense has been shown to be a reliable measure of lumbar position sense in people with and without LBP. The child was seated in an upright position, with the feet and thighs supported. The researcher corrected the posture as necessary to ensure a neutral lumbar spine. The child was shown how to tilt the pelvis anteriorly and posteriorly in a seated position. The child was then instructed to tilt the pelvis ten times as a warm-up. The full range of movement of pelvic-sacral tilting was measured, using an inclinometer. The researcher positioned the child in the criterion position – determined as the mid-range of the pelvic-sacral tilting measurement. The child was asked to maintain this criterion position for five seconds. The inclinometer was placed on the L5/S1 joint and set to zero in the criterion position. The child was then instructed to tilt the pelvis completely backwards and then to reposition the pelvis in the criterion position and maintain the hold for five seconds. Only the lower back and pelvis were allowed to move. This was repeated five times. No feedback on accuracy was given to the child (Brumagne et al, 2000). The inclinometer was used to measure the angular differences between the criterion position (zero degrees) and the actual sacral tilt angles. Repositioning accuracy was calculated by taking the mean of the angular differences (Brumagne et al 2000).

3.5 PROCEDURE

A pilot study was carried out in 2006 and the main study in 2007.

3.5.1 PILOT STUDY

A pilot study was conducted at a public school in Gauteng. Permission was obtained from the principal, head of grade, as well as the governing body of the school. Information

sheets, consent forms and assent forms were sent home with all the Grade 7 pupils (see Appendices C - G). Thirty-one children returned signed consent / assent forms and participated in the pilot study. The researcher administered the questionnaire to the same group of children on two separate occasions, one week apart. On both occasions, one week apart, the researcher also measured ten of the children, using all of the physical measurement procedures described above. Due to time constraints, the entire eight-week exercise programme could not be piloted. However, the physiotherapist went through the exercises, which would be included in the programme, with ten of the children. The purpose of the pilot study was to determine an accurate time frame and to get feedback on the questionnaire and exercise programme. Reliability and validity of the questionnaire was determined, as explained above. Feedback from the children regarding the exercise programme was taken into account, and necessary modifications were made. Intra-rater reliability of the researcher was determined for each physical measurement. Statistical analysis indicated that the children's responses to the questionnaire were reliable, and that the researcher's physical measurements were also reliable.

3.5.2 MAIN STUDY

The main study was conducted at two public schools in the Ekurhuleni West District of Gauteng. Permission was obtained from the principals, governing bodies and heads of grades at both schools. The researcher met with the teachers and Grade 6 and Grade 7 pupils at the participating schools to inform them about the study. Information sheets were sent home to the parents. Parents had to sign the informed consent forms, and the children signed assent forms as well (see Appendices C - G). Two weeks after sending the information sheets out, the researcher again met with the teachers and students. Reminder sheets, printed on yellow paper, with another copy of the consent form and assent forms were sent home with the children.

Approximately 280 children from the two schools were invited to participate in the study. Ninety-nine children returned signed consent and assent forms by the end of the first school term. In the first week of the second term, all of the children who had agreed to take part in the study completed the questionnaire to determine if they had experienced LBP in the past three months. Baseline data were collected for all of the children who had complained of LBP in the past three months.

The children completed the questionnaire in small groups, in the presence of the researcher. The researcher answered any questions relating to the questionnaire and ensured that all forms were filled in correctly. All the baseline physical measurements

were then taken by the researcher, who was blinded as to which group the children would be in. The measuring techniques were well practiced to ensure that the researcher was skilled in all the techniques.

All the children who complained of LBP in the past three months, and who met all of the inclusion criteria, were then randomly assigned to groups using computer generated randomization numbers. Seventy-two children met the inclusion criteria. A slightly larger group of children were included in the exercise group, as there was concern from the teachers that the drop-out rate from the exercise class would be high. Therefore, 39 children were included in the exercise group, and 33 in the control group.

The 39 children who took part in the exercise intervention were divided into three groups. At School A, 22 children were assigned to the exercise group. However, a maximum of 12 children could exercise together at one time in the space provided by the school. Therefore the children were divided into two groups – one class of twelve girls and another class of ten boys. At School B, 17 children were assigned to the exercise group. However, the exercise classes were taken in the hall at School B and therefore, all 17 children were able to attend the class together (twelve girls and five boys). The same research assistant took all three classes each week, and ensured that all the groups did the same exercises, as well as the same number of repetitions, each week. The exercise intervention consisted of eight classes, which were structured to last 40-45 minutes each. However, to enable the research assistant to ensure that each child received the necessary individual attention and correction in each class, a full hour was allocated to the larger exercise class at School B. The research assistant was a qualified, registered physiotherapist with five years experience in exercise rehabilitation, who was also completing a master's degree in physiotherapy. In addition, the research assistant received further training and instruction in the specific exercise programme which was included in this study.

The researcher collected all of the post-intervention data (using the same questionnaire and physical measurements) at two subsequent follow-up visits;

- (1) Immediately post-intervention (one week after the last exercise class was completed)
- (2) Three months post-intervention.

The researcher took all of the baseline and post-intervention follow-up measurements for all of the children. The researcher was blinded as to which groups the children were in, as well as to the children's previous measurements, at every follow-up measuring session.

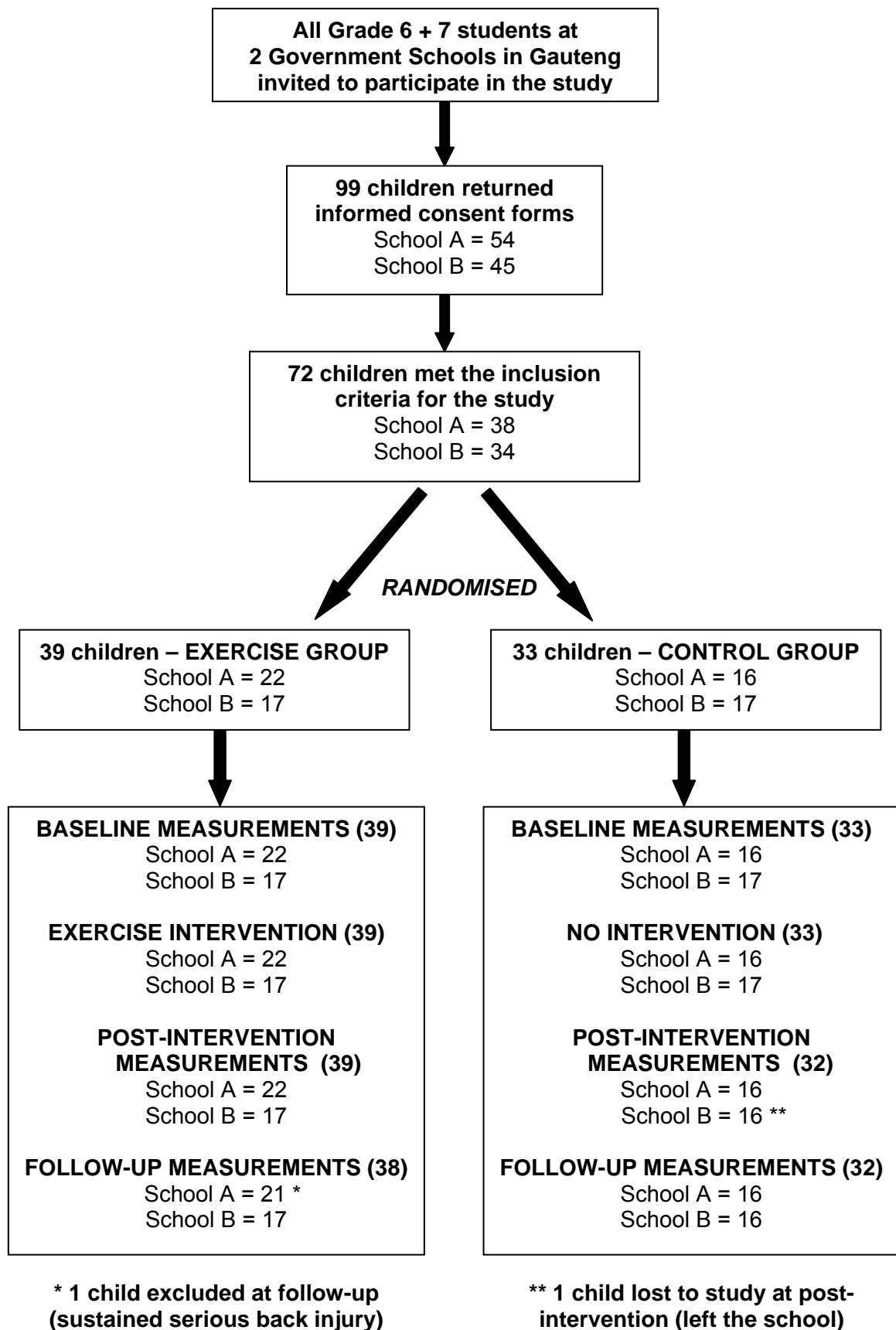


Figure 3.2 Sample Description and Procedure

3.6 EXERCISE PROGRAMME

The experimental group took part in the specific exercise programme once a week, during either a hymn singing practice, assembly or arts/crafts 'extramural' period. This ensured that the children did not miss any school work. The control group did not attend the exercise classes nor did they take part in the home exercise programme. Both groups continued with their normal PE, sports and physical activity.

An explanation of the exercise and home exercise programmes is included below, and the breakdown of the eight weekly exercise classes and home exercise sheets / diary are included as Appendices (M – O). The research assistant, who conducted all of the exercise classes, will be referred to as the physiotherapist in the descriptions below.

3.6.1 EXERCISE CLASS

Studies have shown that the most effective LBP programmes include a combination of exercise with education, where the participants understand the mechanisms of LBP and why the exercises are being prescribed (Barr et al 2007; Soukup et al 2001). Therefore, the exercise intervention in this study was initiated with a 10-15 minute educational session, given by the physiotherapist who was taking the exercise class. The physiotherapist discussed the importance of the exercises which the children would be doing and how the exercises related to their LBP. Richardson et al (1999) described the "core" musculature as a box, which has four sides, a roof and a floor. In order to explain the "core" muscles and how they function to the children, an analogy of a cardboard box was used, to explain how the muscles support the spine. The physiotherapist held up a cardboard cereal box, demonstrated and explained the following: The box has four sides, a top and a bottom. If you take one side of the box away - it gets a bit weaker. If you take two sides away – it gets even weaker and you are able to squash the box. If you take three sides away – it gets much weaker and the box collapses. The physiotherapist then showed the children "their box" - the top is your diaphragm, the back is your back muscles, the front is your stomach muscles, the two sides are also part of your stomach muscles and the bottom is your pelvic floor muscles. It was then explained that, just like the cardboard box, if one of these muscles is weak, then the back becomes weaker and is more susceptible to injury. The analogy of the box was carried through to each class - it was used to assist with teaching of the exercises and its importance was reinforced with each exercise. Correct posture and spinal alignment was also explained and reinforced with each exercise. Only the first exercise class included an "official" education session.

In all other classes, the principles of the “education” session were reinforced throughout the class, during the different exercises.

The exercise programme consisted of eight classes based on a similar structure, which was progressed steadily over the eight weeks. The class was structured in such a way so as to limit disturbances and time delays, which would be caused by the children changing positions frequently and moving around excessively. For example, all the exercises which could be done in supine were completed, before moving into the next position.

The exercise class structure included the following:

- Warm-up
- Diaphragmatic breathing
- Core activation and progressions in crook lying
- Bridging progressions
- Hamstring and lumbar spine stretches
- Core activation, postural alignment and progressions in 4-point kneeling
- Balance exercises
- Functional exercises
- Iliopsoas and quadriceps stretches
- Diaphragmatic breathing and relaxation

3.6.1.1 Warm-up

The same warm-up was used for all the classes. This ensured that the children could work through the exercises fairly quickly, making the warm-up more effective.

The class started with five deep breaths, in and out. As the children breathed in they lifted their arms up the front of the body and as they breathed out, the arms were opened out into abduction with some thoracic spine extension, opening up the front of the chest. This was followed with brisk high walking on the spot, with the opposite arms swinging forwards and backwards. Trunk rotation was encouraged with the arms swinging. The children then stood with their arms abducted at about 60 degrees, elbows bent and twisted from side to side (thoracic and lumbar rotation). The children then performed five cat and camel stretches in four-point kneeling. They completed the warm-up with a prayer stretch; from four-point kneeling the children put their feet together, knees slightly apart, sat back onto their feet and extended their arms and spine out forwards, extending the lumbar spine (Koumantakis et al 2005a; Akuthota and Nadler 2004).

3.6.1.2 Diaphragmatic Breathing

Diaphragmatic breathing was taught using the method described by Chitkara et al (2006). The children lay supine in a relaxed position. They were instructed to place one hand on their upper chest, and the other hand was placed on the abdomen, just below the rib cage, at the bottom of the sternum. They were then instructed to take slow, deep breaths in and out, ensuring that the hand on the chest remained still, whilst the hand on the abdomen rose with inhalation and lowered with exhalation. The physiotherapist went around checking that each child in the class understood the technique and was breathing correctly, using the diaphragm. Ten slow breaths in and out were completed, with each inhalation and exhalation lasting about three seconds. The diaphragmatic exercises helped to focus the child's attention on their centre / core / abdominal area and to quieten their minds to promote concentration for the core activation sequence which followed.

3.6.1.3 Core Activation Sequence

The majority of time in the first lesson was used to teach the children how to activate and isolate TA. The physiotherapist first instructed the group how to activate TA, and then checked each child independently to ensure that they understood and could perform the technique correctly.

The physiotherapist first instructed the children to find the bony point on their hip, the anterior superior iliac spine (ASIS), and to place their fingers two fingers-width inwards from the ASIS on the lower stomach muscles. The physiotherapist checked each child and corrected their positioning as necessary. TA activation was taught by instructing the children to breathe in using the diaphragm (as they had just been shown - which would make the abdomen rise), then as they breathed out, to gently pull the navel (belly button) to the spine (Urquhart et al 2005; Akuthota and Nadler 2004). Once the children managed to master this technique, the pelvic floor activation was included. The children were instructed to pull the pelvic floor muscles (the muscles at the bottom of their 'box') up towards their stomach. It was further explained that this would feel similar to when one needs to go to the bathroom, but has to hold it in.

The TA activation and pelvic floor muscles were then included in the 'ball squeeze' exercise (Arokoski et al 2004). The children lay in crook lying, with a small ball between their knees. They were instructed to: "breathe in with your diaphragm, as you breathe out gently pull your belly button to your spine and hold, keeping that muscle tight, also tighten your pelvic floor muscles (pull the bottom of your 'box' up) and hold, and then, whilst keeping the stomach muscle and pelvic floor muscles tight, now squeeze the ball and

hold". This basic core activation technique was included in every class and progressed with an increase of 5 seconds in holding time each week.

The core activation sequence was also progressed each week, by adding loading through the limbs in crook lying as follows:

- Active hip flexion (knees flexed to 90 degrees)
- Active hip abduction with external rotation (knees flexed to 90 degrees)
- Heel slides on the floor
- Heel slides with feet off the floor
- Heel slides with feet off the floor and opposite shoulder elevation

Before each of the exercise progressions, the physiotherapist instructed the children to first activate TA. The aim of the exercises was to perform them slowly, with control. The children were reminded with each exercise not to move their back or pelvis. This was to avoid unwanted anterior or posterior pelvic tilting, as well as unilateral anterior or posterior pelvic rotation, from occurring with the hip movements (Koumantakis et al 2005a).

3.6.1.4 Bridging Progressions

Bridging in crook lying was included from the third exercise class. The children were first instructed to start with their spines in neutral and to activate TA, before lifting their hips up off the floor. The physiotherapist ensured that the children kept their hips and pelvis level. The number of repetitions, and length of holding time, was progressed each week. From the fifth class, bridging with alternate legs lifted was included. Control in this position was emphasized and if any children were unable to perform the technique correctly, the physiotherapist let them continue with basic bridges until they were strong enough to progress (Koumantakis et al 2005a; Arokoski et al 2004).

Side bridging, with the knees bent, was included from the sixth class. If any children were able to progress to side bridging with the knees straight, they were encouraged to try this in the last two classes. However, most of the children found the side bridging fairly challenging and continued to side bridge with knees bent, up to and including the last class. Holding time and repetitions were increased each week (Koumantakis et al 2005a).

3.6.1.5 Hamstring and Lumbar Spine Stretches

The hamstring stretching sequence was included in all classes. The number of repetitions and holding time remained the same throughout the programme. The sequence started with a 30 second static stretch, holding the knee to the chest (upper hamstring). The

opposite leg was extended and the children were encouraged to press the extended leg down into the floor. This was followed by a neural mobilization technique. The children were instructed to hold the leg at 90 degrees, with the knee flexed and foot dorsiflexed. They were then instructed to slowly bend and straighten the knee, ten times. After the neural mobilization, the children remained in the same position, relaxed the foot and extended the knee as much as possible, into a static hamstring stretch. The stretch was held for 30 seconds. The same sequence was repeated twice with both legs, alternating legs between each sequence.

Two simple lumbar spine stretches / mobilizations were included: bilateral hip flexion in supine (hugging both knees to chest) and gentle lumbar rotations in crook lying (Koumantakis et al 2005a).

3.6.1.6 Postural Alignment and Progressions in Four-Point Kneeling

Spinal alignment and core activation in four-point kneeling were included from the first class. Dowel sticks (120cm long) were used to facilitate posture correction in four-point kneeling. The dowel stick was balanced on the child's back in four-point kneeling. The position was corrected to ensure that the stick only touched at the back of the head, between the shoulder blades (mid thoracic spine) and at the base of the spine (sacrum). There also had to be a gap at the cervical and lumbar spine, which was large enough to slide a hand between the stick and the spine. The physiotherapist encouraged optimal spinal alignment and encouraged the children to look at one another's postures and to help to correct each other. TA activation was encouraged in this position, and the children held the position for 30 seconds with three repetitions. Keeping the stick on their back and maintaining good spinal alignment the children then rocked backwards and forwards, in four-point kneeling, five times. Spinal alignment and rocking in four-point kneeling with the dowel sticks, were included in each class before the progressions for that week were started (Koumantakis et al 2005a).

The progressions in four-point kneeling included the following:

- Alternative arm lifts
- Alternative leg lifts
- Alternative lifts of the opposite arm and leg together
- 'Horse stance' – lifting the opposite arm and leg up only a few centimetres off the floor

The children were encouraged to keep the stick balanced on their back during the progressions, to promote optimal spinal alignment and to prevent unwanted trunk rotation and movement.

3.6.1.7 Balance Exercises

Balance exercises in standing were included in each class. The balancing exercises on one leg were progressed each week with: eyes open, eyes closed, arm movements (e.g. write your name in the air) with eyes open and closed, opposite leg movements with eyes open and closed. Controlled 'leg swinging' on one leg was also included (Arokoski et al 2004). The children balanced on one leg, whilst alternatively moving the other leg from 90 degrees hip flexion, back into hip extension, and then up into hip flexion again. They also moved their arms forwards and backwards, as in walking.

3.6.1.8 Functional Exercises

Other functional exercises were included each week from the third class. These included: side lunges, 'apple picking' squats (the children reached up and rotated to pick the apples from behind them, and then bent down and rotated to put the apples next to them on the opposite side) and mini squats on one leg (Akuthota and Nadler 2004).

3.6.1.9 Iliopsoas and Quadriceps Stretches

The iliopsoas and quadriceps stretching sequence was included in all classes. The number of repetitions, as well as the holding time, remained the same throughout the programme. The sequence started with a 30 second static stretch in a forward lunge, with the back knee extended. The back knee was then relaxed and the children remained in the lunge, with their back knee resting on the floor, in a flexed position. This stretch was held for 30 seconds. The children then reached back, held their ankle and bent the foot up towards their buttocks, to stretch the quadriceps. If the children were unable to reach their ankle, they were given a length of theraband which they wrapped around their ankle to bring the foot up towards their buttocks, thus assisting them with the stretch. However, some children still found this very difficult, and the physiotherapist positioned them in side lying in the same stretch position, ensuring that the quadriceps was still on stretch. This stretch was also held for 30 seconds. The entire sequence was repeated twice with both legs, alternating sides between sets (Winters et al 2004).

3.6.1.10 Diaphragmatic Breathing and Relaxation

The class was completed with relaxed diaphragmatic breathing in supine.

3.6.2 HOME EXERCISE PROGRAMME

A home exercise programme was included in the exercise intervention. The home programme included exercises that the children had been taught in class by the physiotherapist. The home programme was designed to take 10-15 minutes, and the children were asked to do the exercises three times a week at home. The children were given an 'exercise diary' which included simple explanations with pictures of the exercises, as well as pages to mark each day that they completed the exercises at home. They were asked to fill in the exercise diary honestly.

Other studies have noted difficulties in obtaining adherence to individual exercise and home programmes over the long term (Soukup et al 2001). Therefore, every effort was made to ensure that the home exercise programme's booklet was user-friendly, attractive and appealing, to try to encourage the children's participation. The physiotherapist, who conducted the exercise classes, reinforced the importance of doing the home exercises each week. However, she also reiterated each week that the children must be completely honest in filling in the exercise sheet, as she would be able to tell if they were not telling the truth.

Each child was given a home exercise folder at the start of the intervention (See Appendix M). The home exercise folders included an explanation of which muscles support the back and their role in protecting the back against injury – also using the 'box' analogy. The exercises included in the home programme were printed on different coloured paper each week. The exercise diary pages, which the child was required to complete, included the exercises with the number of repetitions they needed to do each week (see Appendix N). These were printed on white paper, and only had the child's reference number recorded on them. The child had to tick a block on this page for each day they completed each exercise and return it each week to the class. As the exercises in the class progressed, so did the home exercise programme. Each week, the child received the new exercise sheet and home exercise programme in a plastic folder with their name on. Therefore the children only received the sheets describing the exercises once the physiotherapist had taught them the specific exercises in the class. This ensured that the children only did exercises at home that they had already been instructed and corrected in, to prevent possible injury or harm which could result from doing the exercises incorrectly. The children added the coloured exercise sheets to their original exercise folders which they kept at home, and returned only the exercise diary sheet each week. By the end of the intervention, each child had a complete set of the home exercise programme, which would enable them to continue with the exercises on their own if they so wished.

3.7 DIFFICULTIES ENCOUNTERED

It was intended for the main study to commence in the first term of the new school year. The proposed plan was for the intervention to run over eight weeks commencing in the first week of term. It was proposed that the data would be collected at baseline, three months, six months and one year. However, many difficulties were encountered in getting the intervention up and running in the schools. The majority of the schools which were approached, including the school which had taken part in the pilot study, were unable to accommodate the intervention in their school timetables, or they did not want to participate in the study. Lengthy delays were encountered at each school as the information was processed through the different channels, and approval or disapproval was determined by the necessary individuals in the school. By the fourth school term, it was impossible to get feedback from any of the schools as they were all very busy and not ready to address new plans for the following year. Therefore, in the second week of the first term of the following school year, another 15 schools were approached. Three of these schools indicated their willingness to participate in the study, and permission was obtained from the principals and governing bodies of these three schools. However, one of the three school's timetable structure was very different to the other two schools, and they were therefore, unable to participate in regular weekly exercise classes as required by the study. Consequently, only two of the three schools participated in the main study.

The intervention was implemented in the second school term which was ten weeks long. It was intended for the eight weekly classes to run over the term, allowing for a week at the beginning and a week at the end of term, to collect the data. Follow-up measurements were planned for three months and six months post-intervention. Unfortunately, during the sixth week of the exercise intervention, a nationwide public servants' strike was initiated and all teachers at public schools joined in the strike. As a result, School A was closed for five days, after which time their teaching staff returned and school resumed as normal. However, School B was closed for the remaining three weeks of the second term, due to the extreme intimidation and violent threats that the teachers and school received. The strike lasted over three weeks, and by the time that the strike was resolved the schools were closed for the school holidays.

Therefore, School A had a one week break in the exercise intervention, but once they returned to school, the physiotherapist completed the exercise programme with the children. The researcher collected all the data and follow-up measurements in the last week of the school term.

However, School B only returned to school in the third term, after the three-week strike as well as the three-week school holiday, which followed the strike. Therefore, School B had a six-week break in the exercise programme. The physiotherapist then continued with the exercise programme in the third term and completed the final three exercise classes over the first three weeks of term. The researcher collected all the data and follow-up measurements in the fourth week of the third term.

As a result of the school strike, it was not possible to include both the three month and six month post-intervention follow-up measurements and data collection in the school year. Therefore, the study was adjusted once again, and only one set of follow-up measurements and data collection was done at both schools, three months post-intervention.

Figure 3.3 and Figure 3.4 on the following pages summarise the proposed and actual timelines for this study.

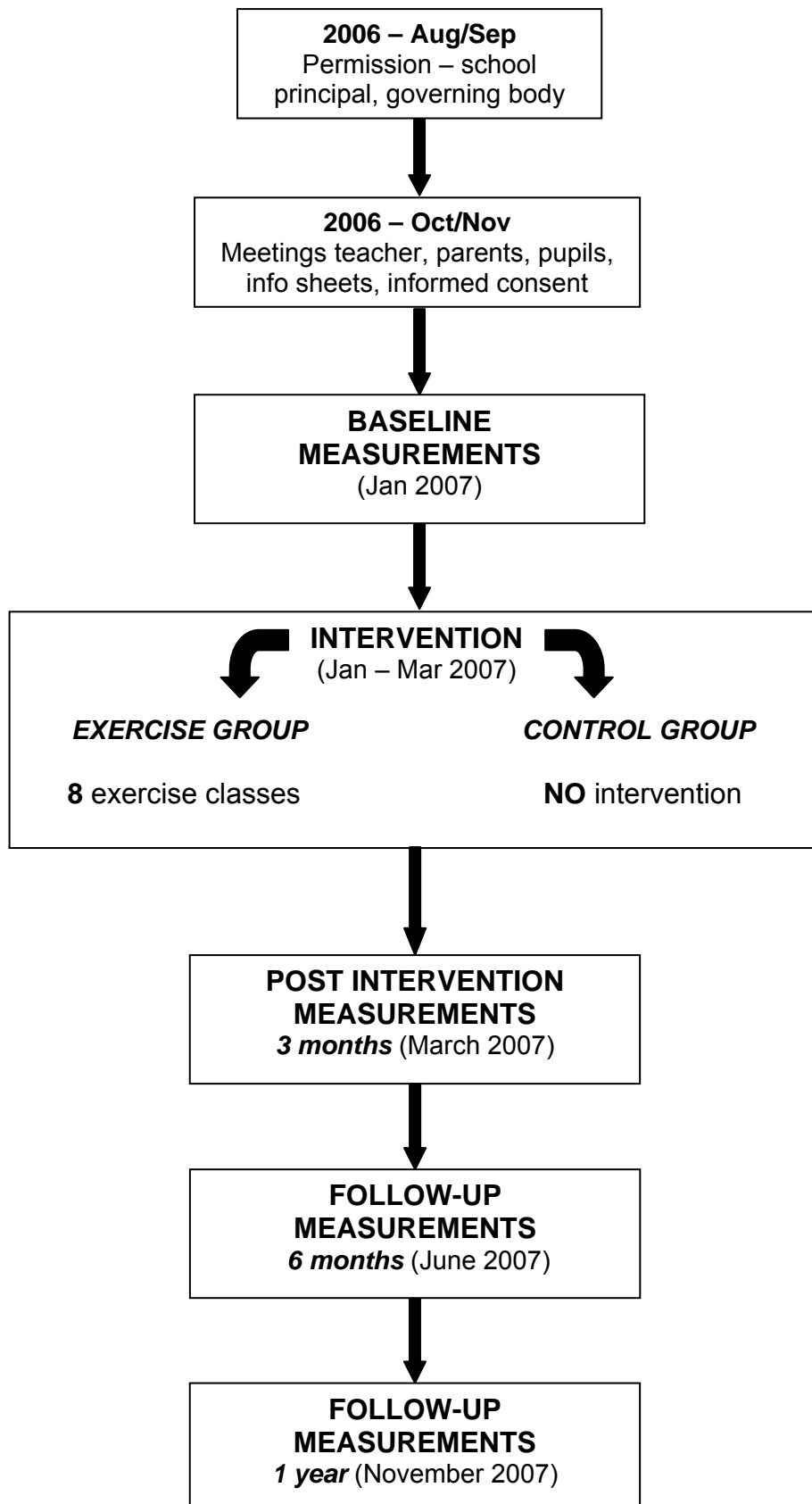


Figure 3.3 Proposed Timeline - School A + B

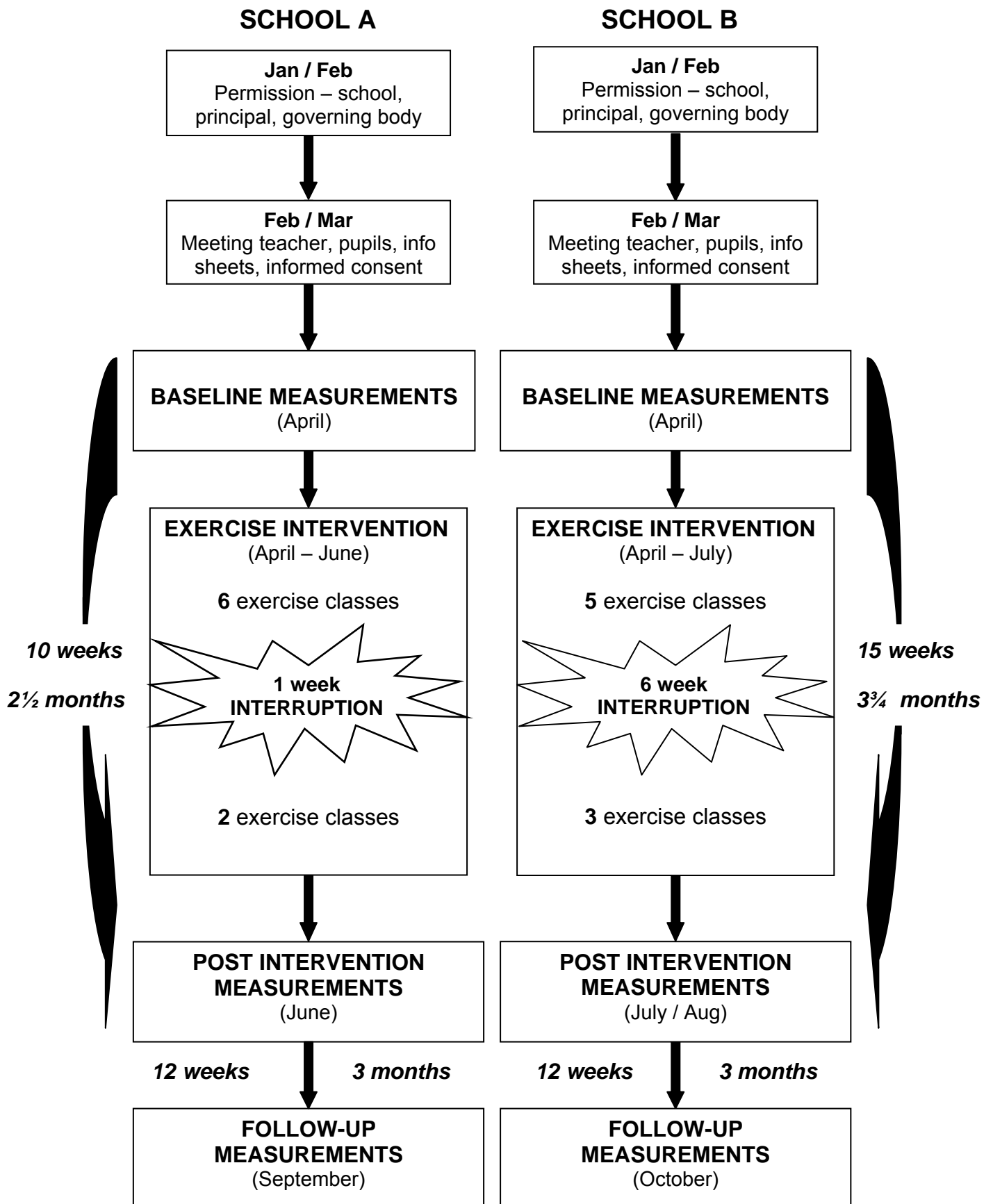


Figure 3.4 Actual Timeline

3.8 STATISTICAL ANALYSIS

As a result of the interruption in the intervention, the data were first analysed together and then, separately, for each school. An intention to treat analysis was followed.

Treatment groups were compared at baseline using the Student's t-test. Schools were also compared at baseline using the Student's t-test. Pain on the VAS, physical measurements, as well as the total scores for emotional sense of well-being and perception of exercise, were summarized over treatment groups and visits, using descriptive measurements, means, standard deviations, confidence intervals, minimums and maximums (range = minimum – maximum). Treatment groups were then compared with respect to change, from baseline to immediately post-intervention and from baseline to the three month follow-up visit, using analysis of covariance (ANCOVA) with baseline values as covariates. The results from the t-test and ANCOVA were confirmed using Wilcoxin's rank sum test and the non-parametric ANCOVA based on ranks. Treatment groups were also compared with respect to change from baseline to post-intervention, using Fisher's exact test. Testing was done at the 0.05 level of significance.

3.9 CONCLUSION

This study used a randomised control trial to determine the effectiveness of a specific exercise programme in reducing self-reported incidence and intensity of LBP in children. As secondary outcomes, it also determined if there was an effect of the intervention on the child's emotional sense of well-being and perception of exercise, as well as on certain modifiable physical risk factors. Even though there were many unplanned, unavoidable interruptions during the study, the researcher tried, as far as possible, to limit the impact of these disturbances on the quality of the study. Although the results of this study must therefore be interpreted with these interruptions in mind, they still provide a valuable contribution to the limited research currently available on LBP preventative interventions in schoolchildren.

CHAPTER 4

PILOT STUDY RESULTS

The results will be presented in Chapter 4 (pilot study) and Chapter 5 (main study) under the sub-sections detailed in Figure 4.1. Results pertaining to the primary and secondary objectives of this study were subjected to statistical analysis, and will be presented together with a description of the results. However, the other data will only be presented descriptively.

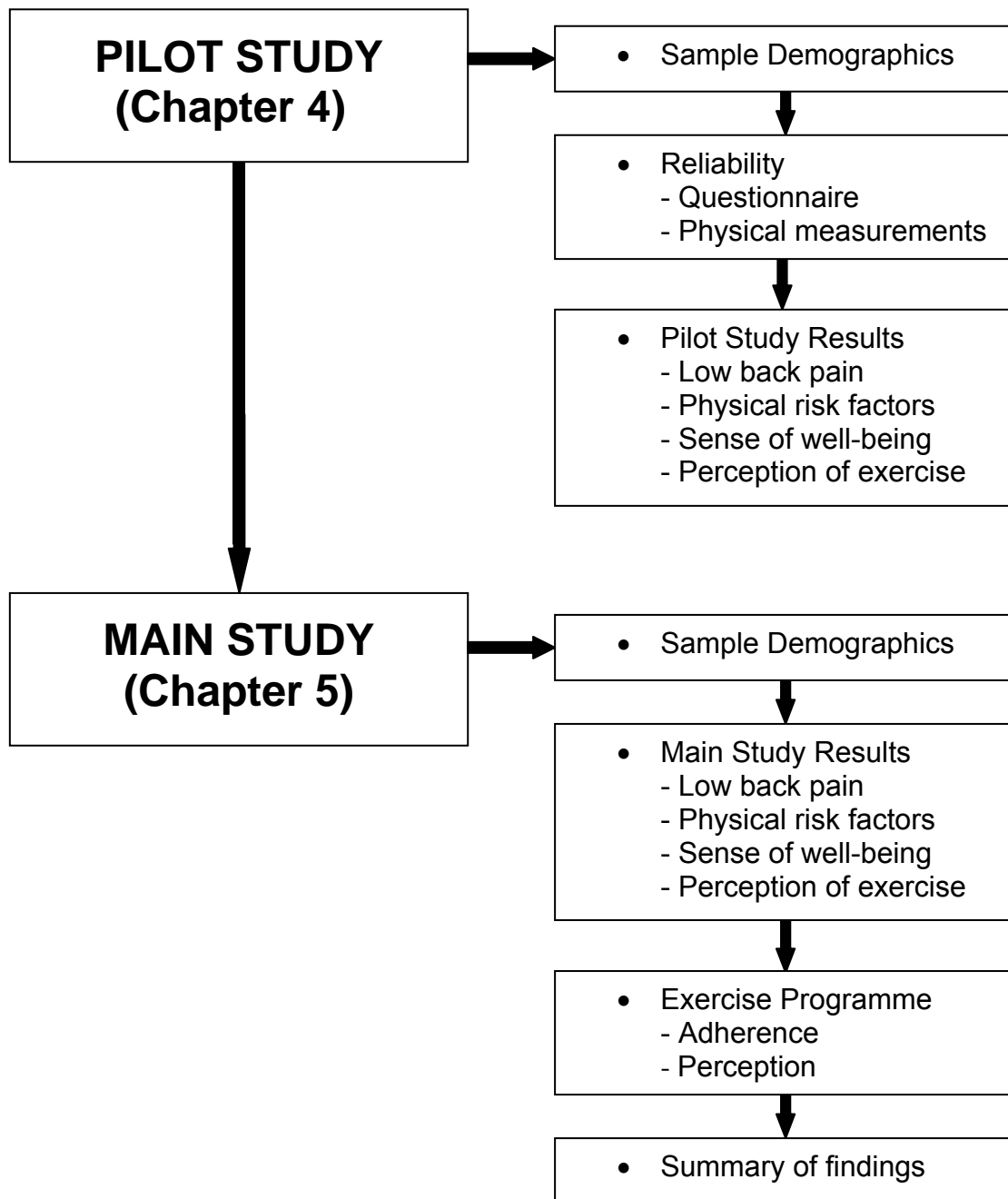


Figure 4.1 Outline of sub-sections included in the results chapters

4.1 PILOT STUDY

The pilot study was conducted primarily to check the outcome measures and to determine the reliability of the questionnaire, as well as the intra-rater reliability of the researcher. However, the results from the pilot study have also been presented descriptively in this chapter, to show possible findings and trends which could be expected in the main study.

4.1.1 DEMOGRAPHICS

A total of 31 children participated in the pilot study – 19 girls and 12 boys. Twenty-nine of the children filled in the questionnaire on both occasions (one week apart) and the other two children only filled in the questionnaire once. All of the physical measurements were completed, for ten of the children, on both occasions (one week apart). The mean age of the sample was 12.88 ± 0.56 years of age.

4.1.2 RELIABILITY

4.1.2.1 Questionnaire

The reliability of the questionnaire was determined in the pilot study. Table 4.1 indicates the Pearson correlation coefficients and p-values for the questionnaire.

Table 4.1 Questionnaire Reliability

Questions	Pearson Correlation Coefficient	p-value
LBP		
LBP prevalence	0.92	< 0.01
VAS	0.92	< 0.01
Sense of well-being		
MHI-5	0.71	< 0.01
Face scales	0.89	< 0.01
Exercise Perceptions		
PE as a subject	0.97	< 0.01
Impact on health + function	0.89	< 0.01

All of the questions in the questionnaire, in particular the primary outcome measures of LBP prevalence and VAS, were shown to be reliable in this age group of children.

4.1.2.2 Physical Measurements

The intra-rater reliability of the researcher, who took all of the physical measurements, was also determined. Table 4.2 below indicates the Pearson correlation coefficients and p-values for each measurement.

Table 4.2 Intra-rater Reliability - Physical Measurements

Physical Measurement	Pearson Correlation Coefficient	p-value
ASLR - Right	0.96	<0.0001
ASLR - Left	0.84	0.02
PSLR - Right	0.96	<0.0001
PSLR - Left	0.98	<0.0001
Hamstrings - Right	0.98	<0.0001
Hamstrings - Left	0.98	<0.0001
Iliopsoas - Right	0.99	<0.0001
Iliopsoas - Left	0.97	<0.0001
Rectus Femoris - Right	0.87	0.01
Rectus Femoris - Left	0.99	<0.0001
Proprioception	0.28	0.65

Although it was concluded that the researcher was reliable in taking all of the physical measurements, the Pearson correlation coefficient and p-value for proprioception (lumbosacral position sense) indicated that the researcher was unreliable in this measurement. However, it is important to remember that this measurement aims to determine the repositioning accuracy in a lumbosacral position sense test. If an individual has poor lumbosacral position sense, he/she will obviously demonstrate a repositioning error in the test. In addition, the repositioning error will be different each time the test is performed. The proprioception value was determined by taking the mean of five attempts. Therefore, an individual with poor lumbosacral position sense will always give a wide range of different angular measurements in the proprioception test. Due to the current lack of available LBP research in this age group, it was decided that the proprioception outcome measure could still provide additional, beneficial insight into the relationship between proprioception and LBP during childhood (see results section 5.10, page 113). Therefore, proprioception was still included as an outcome in this study. For the rest of the physical measurements, the Pearson correlation coefficients and p-values indicate that the researcher is highly reliable in all of the remaining measurements.

4.1.3 PILOT STUDY RESULTS

4.1.3.1 Low Back Pain

Table 4.3 summarises responses to the questions relating to LBP behaviour in the questionnaire. Data are presented for session one and session two of the pilot study.

Table 4.3 Low Back Pain Behaviour – Pilot Study Data

	SESSION 1 (n=31)		SESSION2 (n=29)	
	n	%	n	%
LBP 3 month prevalence				
LBP	20	64.52	19	65.52
No LBP	11	35.48	10	34.48
When did it start?				
• 1 to 3 months ago	15	75.00	14	73.68
• 4 to 6 months ago	2	10.00	2	10.53
• 7 to 12 months ago	1	5.00	1	5.26
• 13 months to 2 years ago	1	5.00	0	0
• more than 2 years ago	1	5.00	2	10.53
How did it start?				
• spontaneously	8	40.00	9	47.37
• motor vehicle accident	0	0	0	0
• sports injury	4	20.00	2	10.53
• other injury (fall, lifting object)	5	25.00	5	26.32
• other	3	15.00	3	15.78
How often did you have low back pain in the past 3 months?				
• everyday	5	25.00	3	15.79
• one to 3 times per week	1	5.00	2	10.53
• once every 2 weeks	3	15.00	4	21.05
• once per month	7	35.00	6	31.58
• only once in the last 3 months	4	20.00	4	21.05
How long did your low back pain usually last for in the past 3 months?				
• a few hours to one day	13	65.00	15	78.95
• 2 to 3 days	4	20.00	1	5.26
• 4 to 5 days	1	5.00	2	10.53
• one week	1	5.00	0	0
• longer than one week	1	5.00	1	5.26
Did you have to stop or change your sport activities due to pain in your lower back in the past 3 months?				
• yes	2	10.00	1	5.26
• no	18	90.00	18	94.74
Did you have to do any of the following for your low back pain in the past 3 months?				
• stay home from school	1	5.00	0	0
• take any medicine	7	35.00	5	26.32
• visit a doctor	1	5.00	0	0
• visit a physiotherapist	2	10.00	1	5.26
• other	1	5.00	2	10.53
• none of the above	13	65.00	13	68.42
Area of LBP				
• only one side	4	20.00	3	15.79
• both sides	12	60.00	13	68.43
• one side and buttock	0	0	0	0
• both sides and buttocks	1	5.00	1	5.26
• one side, buttock and leg	1	5.00	1	5.26
• both sides, buttocks and legs	2	10.00	1	5.26

A fairly high three-month prevalence of LBP was reported in the pilot study, with over 60% of children complaining of LBP at both sessions. However, the pilot study sample is too small to comment on the relevance of this finding with regards to the general population. The majority of the children reported a recent, spontaneous onset of LBP. Over half of the sample reported infrequent episodes of LBP (once / twice a month or once every three months), with the majority indicating that their pain lasted on average a few hours to one day. Only a very small percentage of the children reported having to stop or adjust their sporting activities as a result of LBP. In addition, the majority also reported that they did not access health care services, receive treatment or try any other interventions for their LBP. In addition, the majority of the sample reported LBP which was localised to the low back (either one side or both sides), with only a small percentage of children reporting referral pain. On average, children reported a moderate intensity of LBP on the VAS. The mean and standard deviation for VAS (3 months) in this sample was: 5.16 ± 2.73 at session one and 5.18 ± 2.70 at session two. VAS scores ranged between 0.5 and 9.6.

4.1.3.2 Physical Measurements

Table 4.4 summarises the physical risk factor measurements from the pilot study.

Table 4.4 Physical Risk Factors – Summary of Pilot Study Data

		n	Mean	SD	Median	Min	Max
SESSION 1	ASLR - Right (mmHg)	10	18.13 ± 15.29		15.33	6.7	56.7
	ASLR - Left (mmHg)	10	18.13 ± 10.21		19.33	16.0	58.7
SESSION 2	ASLR - Right (mmHg)	10	19.60 ± 13.46		16.00	11.3	44.7
	ASLR - Left (mmHg)	10	18.57 ± 8.33		17.67	17.3	60.7
SESSION 1	PSLR - Right (degrees)	10	67.50 ± 18.27		68.75	32.0	101.5
	PSLR - Left (degrees)	10	61.45 ± 17.54		59.50	35.5	100.5
SESSION 2	PSLR - Right (degrees)	10	67.45 ± 20.26		68.75	30.0	97.0
	PSLR - Left (degrees)	10	63.30 ± 18.65		65.75	27.0	95.0
SESSION 1	Hamstrings - Right (degrees)	10	48.80 ± 19.65		53.67	10.0	76.7
	Hamstrings - Left (degrees)	10	47.90 ± 17.58		49.67	19.7	83.7
SESSION 2	Hamstrings - Right (degrees)	10	50.63 ± 19.16		51.50	15.3	79.7
	Hamstrings - Left (degrees)	10	48.00 ± 17.69		52.00	13.0	79.3
SESSION 1	Iliopsoas - Right (degrees)	10	25.27 ± 10.25		27.00	7.3	46.3
	Iliopsoas - Left (degrees)	10	19.97 ± 10.33		19.50	6.0	48.0
SESSION 2	Iliopsoas - Right (degrees)	10	25.83 ± 10.98		27.50	5.7	32.7
	Iliopsoas - Left (degrees)	10	21.26 ± 9.88		18.00	6.0	35.7
SESSION 1	Rec Fem - Right (degrees)	10	75.10 ± 10.18		75.00	58.7	89.0
	Rec Fem - Left (degrees)	10	75.17 ± 11.90		77.33	64.3	98.7
SESSION 2	Rec Fem - Right (degrees)	10	80.33 ± 10.96		80.17	59.0	97.3
	Rec Fem - Left (degrees)	10	75.43 ± 12.67		77.67	55.3	97.7
SESSION 1	Proprioception (degrees)	10	7.46 ± 4.32		6.50	3.4	18.4
SESSION 2	Proprioception (degrees)	10	4.66 ± 2.22		4.60	1.2	8.2

The mean scores for the ASLR and PSLR tests indicate that in general, children in this sample demonstrated poor lumbar stability and moderate neural mobility respectively. Findings in the muscle length tests indicate that, on average, the length of the hamstrings was moderate, the iliopsoas good and the rectus femoris moderate to good. The average proprioception values indicate that lumbosacral position sense varied between moderate to poor in this sample.

It is important to remember that only ten children were measured in this pilot study, primarily to determine the intra-rater reliability of the researcher. Furthermore, as the ten children were randomly selected, only three of the children did not have LBP, as opposed to seven who did have LBP. Therefore, it is difficult to draw conclusions, compare children with and without LBP, or to comment on the relevance of these results in the general population.

4.1.3.3 Sense of Well-being

The MHI-5 and the face scale totals are summarised in Table 4.5 below. The minimum possible score for the MHI-5 is five and the maximum score is thirty. The minimum score for the face scales total is two and the maximum score is twelve.

Table 4.5 Sense of Well-being – Summary of Pilot Study Data

	n	Mean	SD	Median	Min	Max
SESSION 1						
MHI-5	31	21.9 ± 2.43		23	18	29
Face scales – Totals	31	8.81 ± 2.88		9	4	12
SESSION 2						
MHI-5	29	22.83 ± 2.36		23	18	27
Face scales – Totals	29	9.41 ± 1.45		10	6	12

The mean MHI-5 score indicates that, on average, children in this sample expressed a moderate sense of well-being. Responses to the face scales indicated a similar finding.

There were minimal differences between children who had LBP and those who did not, for both the MHI-5 scores and face scale totals. Therefore, these findings were not illustrated separately. The mean MHI-5 for children with LBP was 22.69 ± 2.63, as opposed to 22.64 ± 2.01 for those with no LBP. The mean face scale total was 9.11 ± 1.82 for children with LBP, as opposed to 10.00 ± 1.41 for those with no LBP. However, the pilot study sample is too small to comment on the significance of these results in the general population.

4.1.3.4 Perception of Exercise

Table 4.6 summarises the total scores relating to the perception of PE as a subject, as well as the impact of PE on health and function. The possible range of scores for PE as a subject is zero to five, and for the impact of PE on health and function; it is six to twenty-four.

Table 4.6 PE Perceptions – Summary of Pilot Study Data

	n	Mean	SD	Median	Min	Max
SESSION 1						
PE as a subject	31	4.10 ± 1.68		5	0	5
Impact of PE on health + function	31	14.19 ± 6.89		16	6	24
SESSION 2						
PE as a subject	29	4.14 ± 1.43		5	0	5
Impact of PE on health + function	29	15.79 ± 6.01		16	6	24

The majority of children expressed a positive perception of PE as a subject. On average the children reported that PE had a moderate effect on their health and function.

Once again, there were minimal differences between children who complained of LBP and those who did not. The mean for PE as a subject was 4.31 ± 1.45 for children with LBP, as opposed to 4.50 ± 1.08 for those with no LBP. The mean for impact of PE on health and function was 14.89 ± 5.51 for children with LBP, as opposed to 15.7 ± 6.99 for those with no LBP.

4.1.4 SUMMARY OF PILOT STUDY RESULTS

The results from the pilot study have been presented in this chapter to indicate the possible findings, to be confirmed in the main study. The findings from the pilot study are summarised in Figure 4.2 on the following page. As a result of the small sample size, as well as the minimal differences which were noted between children with and without LBP for the identified risk factors, Figure 4.2 presents a summary of the findings for the sample as a whole.

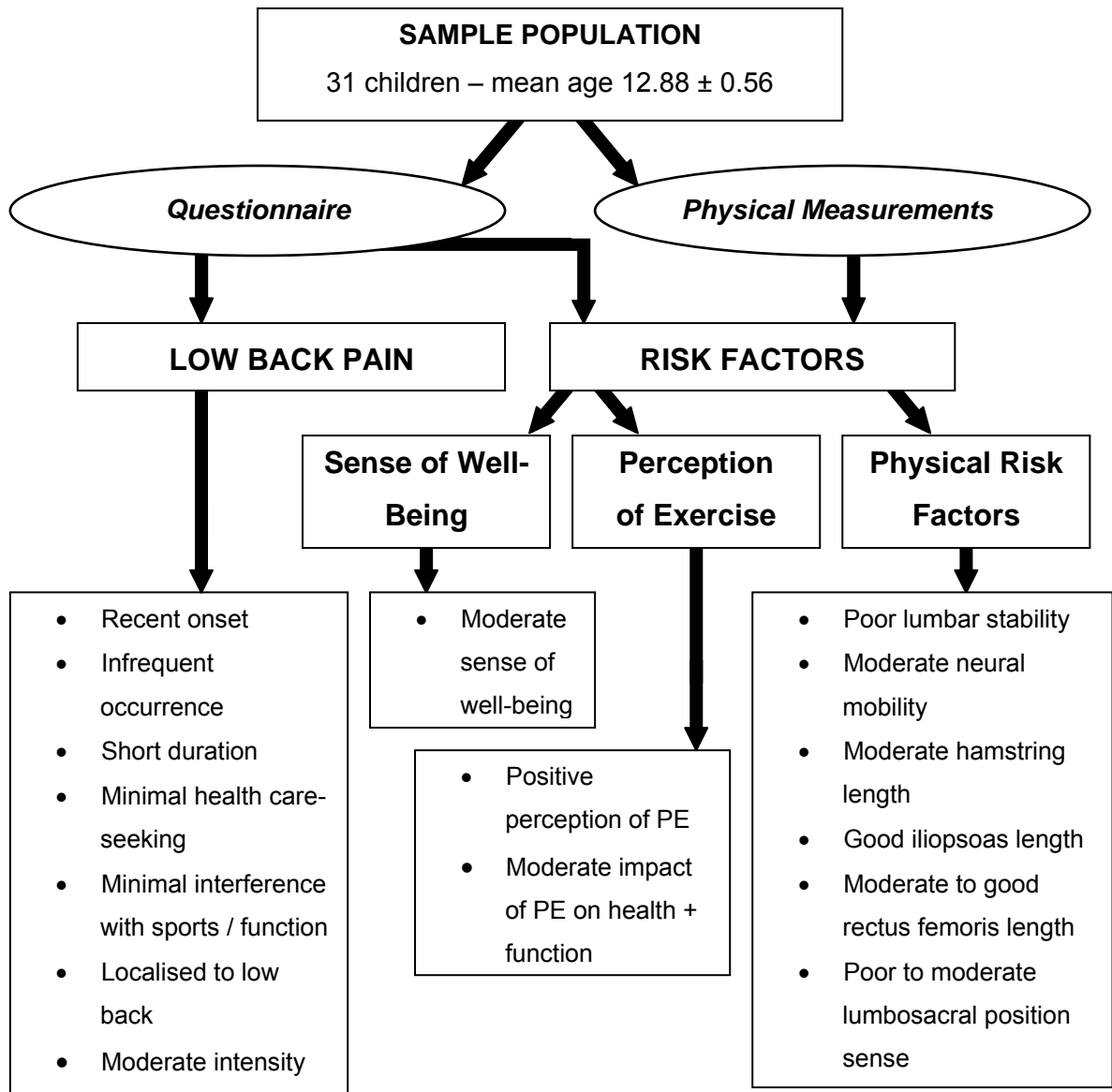


Figure 4.2 Summary - Pilot Study Results

CHAPTER 5

MAIN STUDY RESULTS

5.1 DEMOGRAPHICS

A total of 72 children participated in the main study – 38 children from School A and 34 children from School B. The children were randomly assigned to either the control group or intervention (exercise) group, irrespective of school. Table 5.1 summarises the gender and race demographics for the total sample, as well as for School A and School B.

Table 5.1 Demographics – Gender and Race

	TOTAL SAMPLE (n=72)			SCHOOL A (n=38)			SCHOOL B (n=34)		
	Control	Exercise	Total	Control	Exercise	Total	Control	Exercise	Total
Gender									
Boys	18	15	33	5	10	15	13	5	18
Girls	15	24	39	11	12	23	4	12	16
Race									
Black	18	19	37	1	2	3	17	17	34
White	12	20	32	12	20	32	0	0	0
Indian	3	0	3	3	0	0	0	0	0

Table 5.2 summarises the mean age of the sample population. Children were included in the study if they were already aged 12 to 13 years, or if they were going to turn 12 years old within the next few months.

Table 5.2 Demographics – Age

	TOTAL SAMPLE (n=72)		SCHOOL A (n=38)		SCHOOL B (n=34)	
	Mean	SD	Mean	SD	Mean	SD
Control Group	12.39	± 0.70	12.00	± 0.73	12.76	± 0.44
Exercise Group	12.21	± 0.66	12.00	± 0.69	12.47	± 0.51
Total	12.29	± 0.68	12.00	± 0.70	12.62	± 0.49

Only two children were lost to the study over the course of the year. One child in the control group (School B) left the school in the second term, and she is therefore not included in the post-intervention or three month follow-up analyses. One child in the exercise group (School A) was excluded from the three month follow-up data analysis, as he sustained a serious back injury a week prior to the three month follow-up. An intention to treat analysis was used to analyse the data. Data is first presented for the total sample and then for each school.

5.2 LOW BACK PAIN

One of the primary outcome measures in this study was self-reported LBP. Three month prevalence of LBP was used as the LBP outcome.

5.2.1 LOW BACK PAIN PREVALENCE

All of the children complained of LBP at baseline. Table 5.3 summarises the prevalence of LBP immediately post-intervention, as well as at the three month follow-up.

Table 5.3 Low Back Pain Prevalence

	BASELINE		POST-INTERVENTION		FOLLOW-UP	
	n	%	n	%	n	%
LBP						
Control Group	33	100	29	90.62	26	81.25
Exercise Group	39	100	26	66.67 *	16	42.11 **
No LBP						
Control Group	0	0	3	9.38	6	18.75
Exercise Group	0	0	13	33.33 *	22	57.89 **

Significantly fewer ($p=0.02$) children complained of LBP in the exercise group, as opposed to those in the control group, immediately post-intervention. This improvement was still significant ($p=0.001$) at the follow-up visit, three months post-intervention.

The absolute risk reduction was 24% (95% CI 7% to 41%) immediately post-intervention and 39% (95%CI 22% to 56%) three months post-intervention. This indicates that the effect of the exercise intervention on the prevalence of LBP in this group was large.

The number of children complaining of LBP in the exercise group decreased significantly immediately post-intervention. Not only was this significant improvement maintained at the three month follow-up visit, even fewer children in the exercise group complained of LBP three months post-intervention. However, although there was also a decrease in LBP reporting in the control group over the six month period, the percentage of children who still complained of LBP at three month follow-up in the control group remained remarkably high.

5.2.1.1 Low Back Pain Prevalence – Comparison between Schools

Table 5.4 compares the prevalence of LBP at the two schools (A and B), immediately post-intervention and at three month follow-up.

Table 5.4 Low Back Pain Prevalence – Comparison between schools

	BASELINE		POST-INTERVENTION		FOLLOW-UP	
	n	%	n	%	n	%
LBP						
Control Group (A B)	16 17	100 100	16 13	100 81	15 11	94 69
Exercise Group (A B)	22 17	100 100	13 13	59* 76	11 5	52* 29*
No LBP						
Control Group (A B)	0 0	0 0	0 3	0 19	1 5	6 31
Exercise Group (A B)	0 0	0 0	9 4	41* 24	10 12	48* 71*

At School A, significantly fewer children complained of LBP in the exercise group immediately post-intervention ($p=0.01$). This improvement was still significant at the three month follow-up ($p=0.01$).

At School B, there was no significant difference immediately post-intervention ($p=0.54$). However, at three month follow-up significantly fewer children complained of LBP in the exercise group ($p=0.03$).

Therefore, the decrease in LBP prevalence at School A immediately post-intervention, accounts for the significant improvement which was observed when the sample was analysed as a whole. In contrast, the significant improvement at School B accounts for the further decrease in LBP prevalence which was observed at the three month follow-up.

5.2.2 ONSET AND CAUSE OF LOW BACK PAIN

The reported onset and causes of LBP at baseline are summarised in Table 5.5.

Table 5.5 Onset and Cause of LBP

	CONTROL (n=33)		EXERCISE (n=39)		TOTAL (n=72)	
	n	%	n	%	n	%
When did it start?						
• 1 to 3 months ago	22	66.67	26	66.67	48	66.67
• 4 to 6 months ago	10	30.30	6	15.38	16	22.22
• 7 to 12 months ago	1	3.03	1	2.56	2	2.78
• 13 months to 2 years ago	0	0	1	2.56	1	1.39
• more than 2 years ago	0	0	5	12.82	5	6.94
How did it start?						
• spontaneously	7	21.22	8	20.51	15	20.83
• motor vehicle accident	1	3.03	3	7.69	4	5.56
• sports injury	9	27.27	8	20.51	17	23.61
• other injury (fall, lifting object)	11	33.33	16	41.03	27	37.50
• other	5	15.15	4	10.26	9	12.50

The majority of children reported a recent onset of LBP (in the past three months). A variety of causes were reported. Slightly more children cited an injury (fall, lifting) as the cause of their LBP. Sports injuries and spontaneous onset were also fairly common causes of LBP. Other causes included gardening, being hit or kicked on the spine, hiking, heavy school bags, dancing and getting friends to click their backs.

5.2.3 LOW BACK PAIN BEHAVIOUR

Low back pain behaviour is summarised in Table 5.6.

Table 5.6 Low Back Pain Behaviour

	BASELINE		POST-INTERVENTION		FOLLOW-UP	
	Control (n=33) %	Exercise (n=39) %	Control (n=29) %	Exercise (n=26) %	Control (n=26) %	Exercise (n=16) %
How often did you have low back pain in the past 3 months?						
• everyday	9.09	7.69	6.90	7.69	11.54	18.75
• one to 3 times per week	30.30	33.33	24.13	30.77	34.61	25.00
• once every 2 weeks	6.06	12.82	27.59	23.08	23.08	25.00
• once per month	24.25	25.65	20.69	23.08	23.08	6.25
• only once in the last 3 months	30.30	20.51	20.69	15.38	7.69	25.00
How long did your low back pain usually last for in the past 3 months?						
• a few hours to one day	63.64	64.10	58.62	73.08	57.69	62.50
• 2 to 3 days	18.18	23.08	24.14	15.38	26.93	25.00
• 4 to 5 days	6.06	0	3.45	3.85	7.69	0
• one week	6.06	2.56	3.45	0.00	7.69	0
• longer than one week	6.06	10.26	10.34	7.69	0	12.50
Did you have to stop or change your sport activities due to pain in your lower back in the past 3 months?						
• yes	9.09	17.95	13.79	23.08	23.08	18.75
• no	90.91	82.05	86.21	76.92	76.92	81.25
Did you have to do any of the following for your low back pain in the past 3 months?						
• stay home from school	21.21	17.95	10.34	3.85	15.38	0
• take any medicine	9.09	15.38	20.69	19.23	11.54	12.50
• visit a doctor	9.09	20.51	10.34	23.08	11.54	6.25
• visit a physiotherapist	3.03	2.56	0	15.38	0	18.75
• other	0	5.13	3.45	0	0	6.25
• none of the above	72.73	56.41	68.97	57.69	69.23	56.25

The percentages for each variable remained fairly consistent from baseline to follow-up, and did not differ much between the control and exercise groups. Although the number of children who complained of LBP decreased in both the control and exercise group over the year, it is interesting to note that there was little difference in pain behaviour reporting in those who still complained of LBP at follow-up.

From baseline to three month follow-up, over half of the sample reported infrequent episodes of LBP (once / twice a month or once in the last three months), whereas only a small percentage of children complained of LBP everyday. The majority of children reported LBP which lasts for a few hours to one day. Only a small percentage of children indicated that they had to stop or change their sporting activities because of their LBP. The majority of children did not consult a medical practitioner or physiotherapist, take any medication or miss school as a result of their LBP. It is interesting to note that the percentage of children who were absent from school due to LBP decreased substantially in the exercise group. However, only a relatively small percentage of children reported absenteeism from school at baseline, so one cannot place too much weight on these findings in this study.

5.2.4 AREAS OF LOW BACK PAIN

Table 5.7 summarises the reported areas of LBP.

Table 5.7 Areas of Low Back Pain

	BASELINE		POST-INTERVENTION		FOLLOW-UP	
	Control (n=33) %	Exercise (n=39) %	Control (n=29) %	Exercise (n=26) %	Control (n=26) %	Exercise (n=16) %
Area of LBP						
• only one side	18.18	17.95	10.34	15.38	3.85	6.25
• both sides	51.52	48.72	51.73	38.46	57.68	43.75
• one side and buttock	6.06	10.26	3.45	3.85	3.85	0
• both sides and buttocks	12.12	0	20.69	11.54	19.23	37.50
• one side, buttock and leg	6.06	15.38	3.45	19.23	3.85	6.25
• both sides, buttocks and legs	6.06	7.69	10.34	11.54	11.54	6.25

The majority of children reported LBP which was localised to the low back (either one side or both sides) and did not radiate to the buttocks or legs. Once again the distribution of percentages for each reported area was similar for the control and exercise groups over the year. It is also interesting to note that both the pilot study and the main study reported similar findings on the causes, onset, behaviour and area of LBP in this age group.

5.3 PAIN INTENSITY - VISUAL ANALOGUE SCALES

Pain intensity was also included as a primary outcome measure in this study. VAS scales were used to assess the child's worst pain in the past three months (VAS 3 months), the past one month (VAS 1 month), the past one week (VAS 1 week), as well as their current LBP intensity (VAS current pain).

VAS scores can range from no pain (0) to worst possible pain (10). Mild pain is defined as a VAS score of between 0.1 to 3, moderate pain as 3.1 to 6.9 and severe pain as 7 to 10 (Kelly 2001). A change of one point (1cm / 10mm) out of ten points (10cm / 100mm) on the 100mm long VAS is considered to be the minimum clinically significant difference (MCSD) in visual analogue pain score for children aged 8-15 years (Powell et al 2001). All VAS scores in this dissertation are presented as scores out of ten.

5.3.1 VAS BASELINE DATA

Table 5.8 summarises the baseline data for all four VAS scales.

Table 5.8 Baseline VAS scores

	n	Mean	SD	95% CI	Min	Max
VAS (3 months)						
Control Group	33	4.14 ± 2.99		3.08 - 5.20	0.2	10
Exercise Group	39	4.67 ± 2.60		3.83 - 5.51	0.6	10
Combined	72	4.43 ± 2.78		3.78 - 5.08	0.2	10
VAS (1 month)						
Control Group	33	4.04 ± 2.90		3.01 - 5.07	0.2	10
Exercise Group	39	4.98 ± 2.84		4.07 - 5.90	0.2	9.8
Combined	72	4.55 ± 2.89		3.87 - 5.23	0.2	10
VAS (1 week)						
Control Group	33	3.15 ± 2.88		2.13 - 4.17	0	10
Exercise Group	39	2.65 ± 3.10		1.65 - 3.66	0	9.4
Combined	72	2.88 ± 2.99		2.18 - 3.58	0	10
VAS (current pain)						
Control Group	33	2.55 ± 3.18		1.42 - 3.68	0	9.7
Exercise Group	39	2.39 ± 3.02		1.41 - 3.37	0	9.6
Combined	72	2.47 ± 3.07		1.74 - 3.19	0	9.7

There were no significant differences between the two groups for any of the VAS scores at baseline, (VAS (3 months) p=0.42, VAS (1 month) p=0.17, VAS (1 week) p=0.49, VAS (current pain) p=0.83).

The mean scores for VAS (3 months) and VAS (1 month) indicate that, on average, the worst LBP that the children experienced was of moderate intensity. For VAS (1 week) and VAS (current pain), the majority of children reported LBP of mild intensity. However, there were also reports of severe LBP for all of the four VAS scales, with some children reporting VAS pain scores of as much as ten.

5.3.2 CHANGES IN VAS FROM BASELINE

- **VAS (3 months)**

Figure 5.1 illustrates the changes in VAS (3 months) from baseline. Data are presented as means and standard deviations.

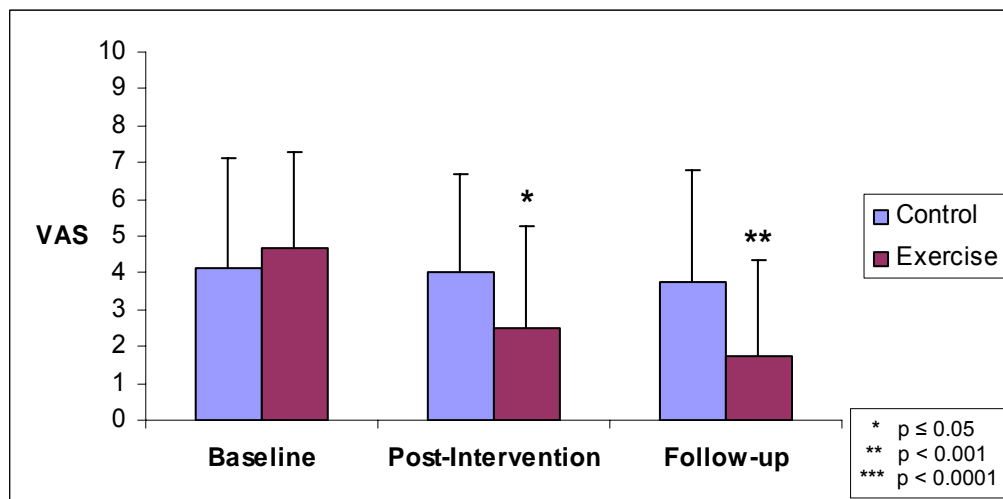


Figure 5.1 Changes in VAS (3 months)

There was a significant difference between the two groups immediately post-intervention ($p < 0.01$). A significant difference from baseline was maintained at the three month follow-up ($p < 0.001$).

The exercise group showed a statistically significant improvement in VAS (3 months), which was maintained at the three month follow-up. Furthermore, this change is also clinically significant, as the difference between the changes in the two groups (without adjusting for baseline) immediately post-intervention was 2.23 and at the three month follow-up it was 2.55.

The 95% confidence intervals for the differences between the means, after adjusting for baseline, were 0.17 to 2.85 immediately post-intervention and 0.56 to 3.38 at the three month follow-up.

- **VAS (1 month)**

Figure 5.2 illustrates the changes in VAS (1 month) from baseline. Data are presented as means and standard deviations.

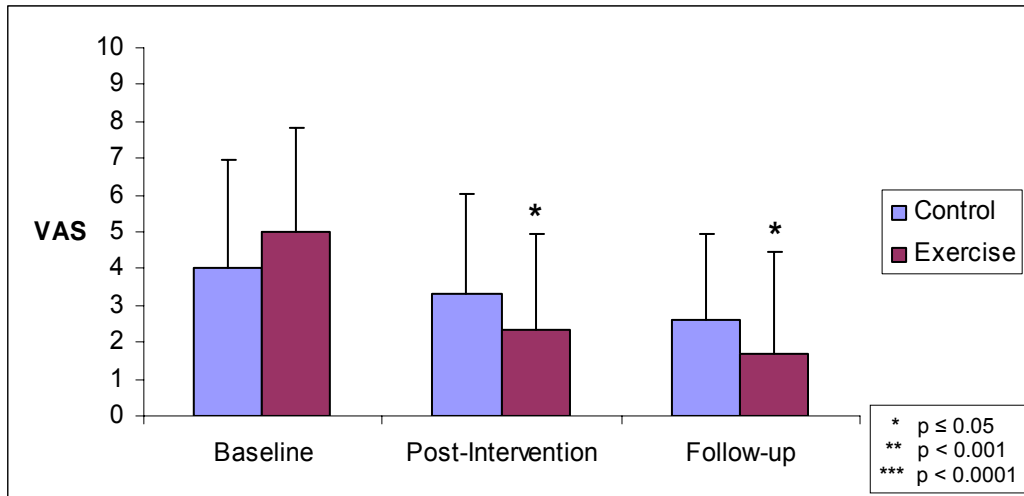


Figure 5.2 Changes in VAS (1 month)

There was a significant difference between the two groups immediately post-intervention ($p=0.01$). A significant difference from baseline was maintained at the three month follow-up ($p=0.04$).

The exercise group showed a statistically significant improvement in VAS (1 month), which was maintained at the three month follow-up. Furthermore, this change is also clinically significant, as the difference between the changes in the two groups was 2.14 immediately post-intervention and 1.98 at the three month follow-up.

The 95% confidence intervals for the differences between the means, after adjusting for baseline, were -0.33 to 2.35 immediately post-intervention and -0.34 to 2.24 at the three month follow-up.

- **VAS (1 week)**

Figure 5.3 illustrates the changes in VAS (1 week) from baseline. Data are presented as means and standard deviations.

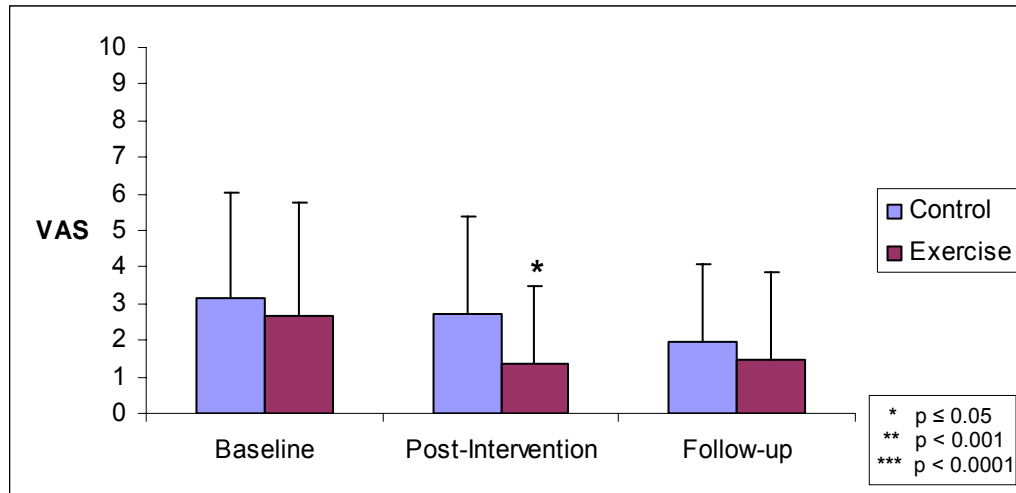


Figure 5.3 Changes in VAS (1 week)

There was a significant difference between the two groups immediately post-intervention ($p=0.02$). The difference from baseline was no longer significant at the three month follow-up ($p=0.46$).

The exercise group showed a statistically significant improvement in VAS (1 week) immediately post-intervention. This change is also clinically significant, as the difference between the changes in the two groups immediately post-intervention was 1.09. Although this is a smaller difference than those observed in VAS (3 months) and VAS (1 month), it should be taken into account that the mean baseline value was lower for VAS (1 week). Therefore, the relative change can be expected to be smaller. However, the change from baseline to three month follow-up was neither statistically nor clinically significant. The difference between the changes in the two groups at three month follow-up was only 0.06.

The 95% confidence intervals for the differences between the means, after adjusting for baseline, were 0.17 to 2.59 immediately post-intervention and -0.63 to 1.63 at the three month follow-up

- **VAS (current pain)**

Figure 5.4 illustrates the changes in VAS (current pain) from baseline. Data are presented as means and standard deviations.

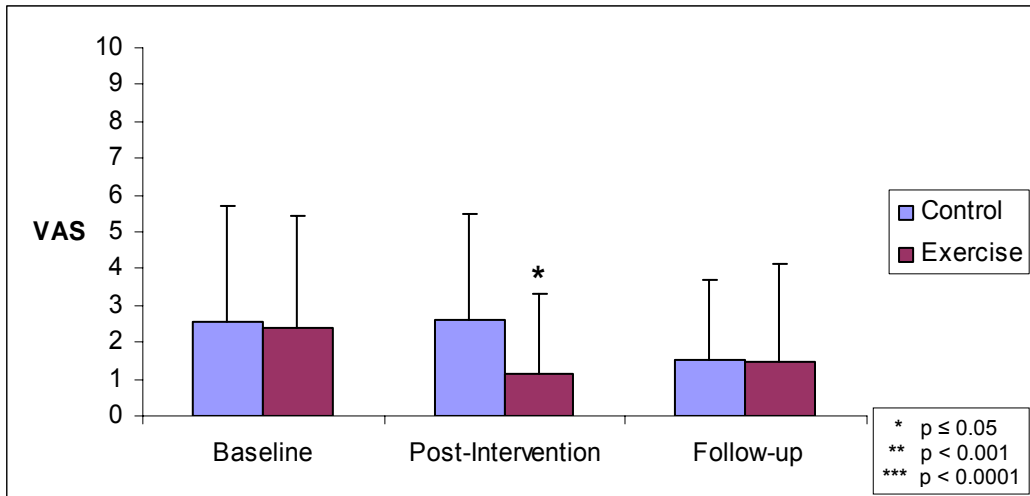


Figure 5.4 Changes in VAS (current pain)

There was a significant difference between the two groups immediately post-intervention ($p=0.01$). The difference was no longer significant at the three month follow-up ($p=0.91$).

The exercise group showed a statistically significant improvement in VAS (current pain) immediately post-intervention. This change is also clinically significant, as the difference between the changes in the two groups immediately post-intervention was 1.22. However, the change from baseline was no longer statistically or clinically significant at the three month follow-up. The difference between the changes in the two groups at the three month follow-up was -0.32. As for VAS (1 week), the baseline mean for VAS (current pain) was lower than the baseline mean for VAS (3 months) and VAS (1 month) in both groups.

The 95% confidence intervals for the differences between the means, after adjusting for baseline, were 0.19 to 2.71 immediately post-intervention and -1.18 to 1.26 at the three month follow-up.

5.3.2.1 Changes in VAS from Baseline - Comparison between Schools

- **VAS (3 months) – Comparison between schools**

Figure 5.5 illustrates the comparison between the two schools, for change in VAS (3 months) from baseline. Data are presented as means and standard deviations.

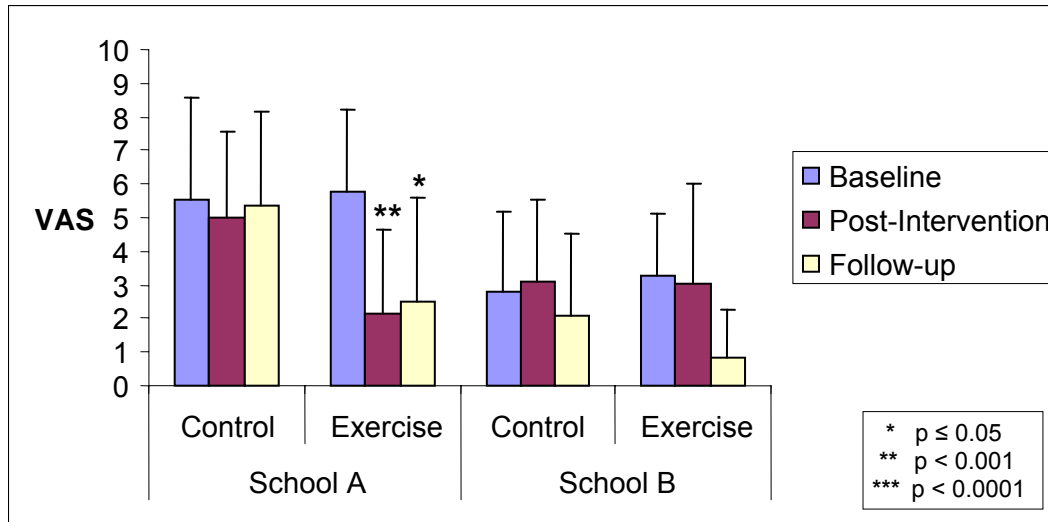


Figure 5.5 Changes in VAS (3 months) – Comparison between schools

At School A, there was a significant difference between the two groups immediately post-intervention ($p < 0.001$), as well as at three month follow-up ($p < 0.01$).

At School B, there was no significant difference between the groups immediately post-intervention ($p = 0.51$). However, there was a marginally significant difference from baseline at the three month follow-up ($p = 0.08$).

Only the exercise group at School A showed a statistically significant improvement in VAS (3 months) immediately post-intervention. This change is also clinically significant, as the difference between the changes in the two groups immediately post-intervention was 3.08. However, the between group change at School B was only 0.49 immediately post-intervention, which was neither statistically nor clinically significant. Therefore, the post-intervention improvement at School A accounts for the significant change observed in VAS (3 months) when the sample was analysed as a whole.

However, an improvement was observed in the exercise group from baseline to the three month follow-up at both schools. Although the improvement at School B was only marginally significant, the improvements at both schools were clinically significant at the

three month follow-up. The difference between the changes in the two groups post-intervention was 2.87 at School A and 1.70 at School B.

There was a significant difference in VAS (3 months) scores between the two schools at baseline ($p < 0.01$). The children at School B reported a significantly lower intensity of LBP at baseline.

- **VAS (1 month) – Comparison between schools**

Figure 5.6 illustrates the comparisons between the two schools, for change in VAS (1 month) from baseline. Data are presented as means and standard deviations.

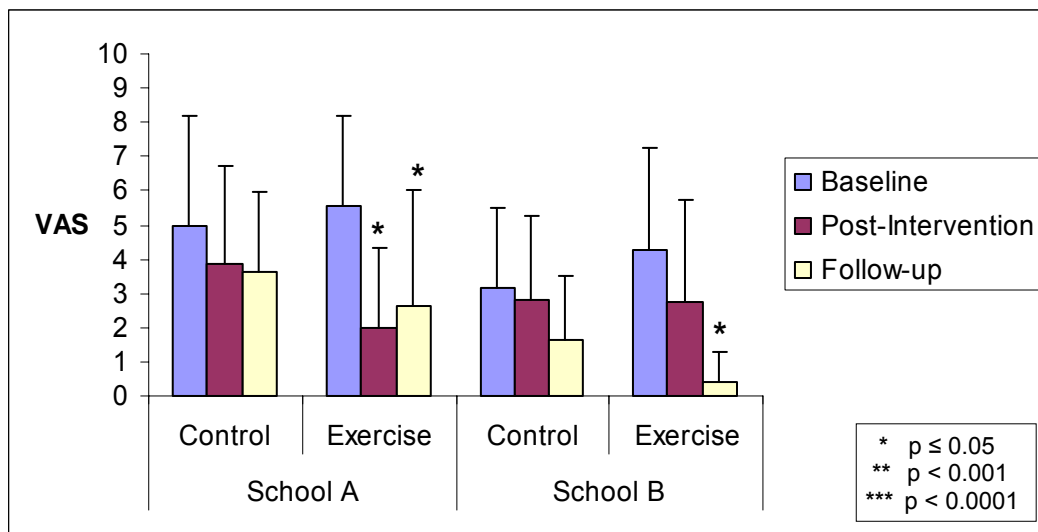


Figure 5.6 Changes in VAS (1 month) – Comparison between schools

At School A, there was a significant difference between the two groups immediately post-intervention ($p=0.01$), as well as at the three month follow-up ($p=0.01$).

At School B, there was no significant difference between the two groups immediately post-intervention ($p=0.18$). However, there was a significant difference at the three month follow-up ($p=0.01$).

Once again a statistically significant improvement in VAS (1 month) was only observed at School A immediately post-intervention. However, the differences between the changes in the two groups (School A = 2.45 and School B = 1.13) indicate that the improvements at both schools were clinically significant.

Statistically and clinically significant improvements in VAS (1 month) were observed in the exercise groups at both schools at the three month follow-up. The differences at three month follow-up were 1.38 for School A and 2.26 for School B.

There was a significant difference in VAS (1 month) scores between the two schools at baseline ($p=0.02$). Once again, the children at School B reported a lower intensity of LBP on the VAS. In addition, the children at School B demonstrated a larger improvement in both VAS (1 month) and VAS (3 months) scores from immediately post-intervention to the three month follow-up, as opposed to change from baseline to immediately post-intervention.

- **VAS (1 week) – Comparison between schools**

Figure 5.7 illustrates the comparison between the two schools, for change in VAS (1 week) from baseline. Data are presented as means and standard deviations.

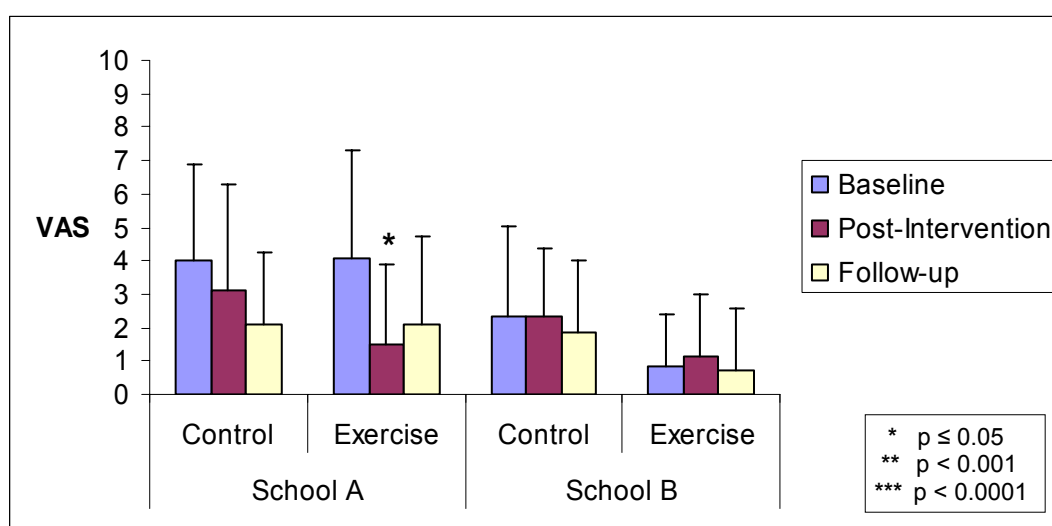


Figure 5.7 Changes in VAS (1 week) – Comparison between schools

At School A, there was a significant difference between the two groups immediately post-intervention ($p=0.03$). However, at the three month follow-up the difference was no longer significant ($p=0.83$).

At School B, there were no significant differences between the groups either immediately post-intervention ($p=0.12$), or at the three month follow-up ($p=.28$).

A significant improvement in the exercise group for VAS (1 week) was only observed at School A immediately post-intervention. This change is also clinically significant, as the post-intervention difference between the changes in the two groups was 1.62. The post-

intervention difference was neither statistically or clinically significant at School B. Therefore, the post-intervention improvement at School A accounts for the significant change in VAS (1 week) which was observed when the sample was analysed as a whole. At three month follow-up, neither school demonstrated a statistically or clinically significant change in VAS (1 week).

Once again there was a significant difference between the two schools for VAS (1 week) at baseline ($p < 0.01$), with the children at School B reporting a lower intensity of LBP than the children at School A.

- **VAS (current pain) – Comparison between schools**

Figure 5.8 illustrates the comparison between the two schools for change in VAS (current pain) from baseline. Data are presented as means and standard deviations.

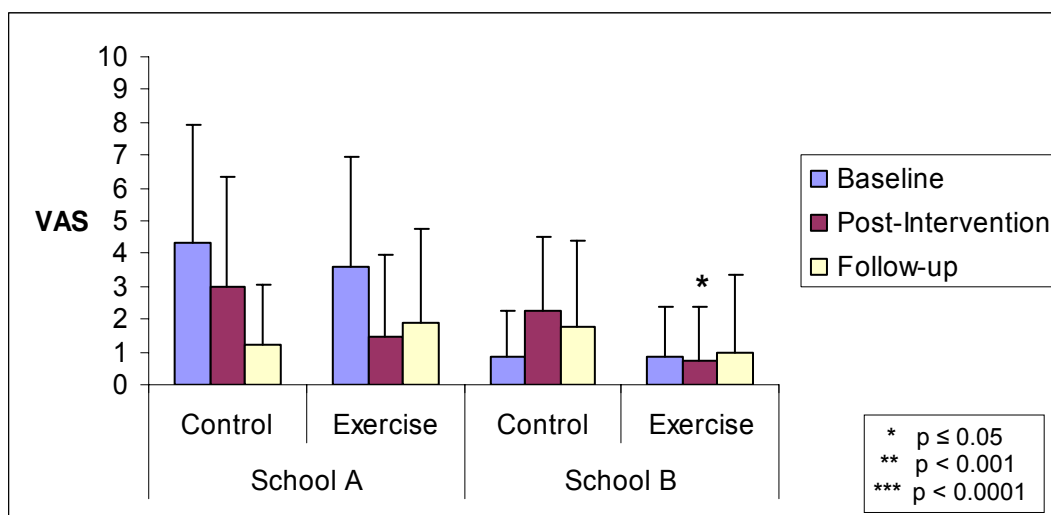


Figure 5.8 Changes in VAS (current pain) – Comparison between schools

At School A, there was no significant difference between the two groups immediately post-intervention ($p = 0.11$), or at the three month follow-up ($p = 0.63$).

At School B, there was a significant difference between the groups immediately post-intervention ($p = 0.04$). However, at the three month follow-up the difference was no longer significant ($p = 0.37$).

Although there was a significant change in VAS (current pain) immediately post-intervention at School B, this change was not due to an improvement in the exercise group. Rather it was as a result of a higher reported intensity of VAS (current pain) in the control group immediately post-intervention. The difference between the changes in the

two groups immediately post-intervention may be considered to be clinically significant as it was 1.50. However, at the three month follow-up there was no longer a statistically or clinically significant difference in VAS (current pain) at School B. The difference between the changes in the two groups was only 0.80 at the three month follow-up.

At School A, improvements were observed in both the control and exercise groups for VAS (current pain). None of the improvements in the exercise group were statistically or clinically significant. However, the improvement at the three month follow-up in the control group may be considered to be clinically significant. The differences in the changes between the groups at School A was 0.73 immediately post-intervention and -1.56 at the three month follow-up.

When VAS (current pain) was analysed for the full sample, significant improvements were noted post-intervention. The relative increase in VAS (current pain) in the control group at School B can explain why, even though a significant change was noted in the whole group, no significant improvements in the exercise groups were observed when the schools were analysed separately.

Once again, there was a significant difference between the two school for VAS (current pain) at baseline ($p < 0.01$). It is interesting to note that the children at School B consistently reported a lower intensity of LBP at baseline for all of the VAS measures.

5.4 SUMMARY OF LBP PREVALENCE AND INTENSITY

The LBP prevalence and intensity (VAS) findings for the whole group are summarised in Figure 5.9 on the following page.

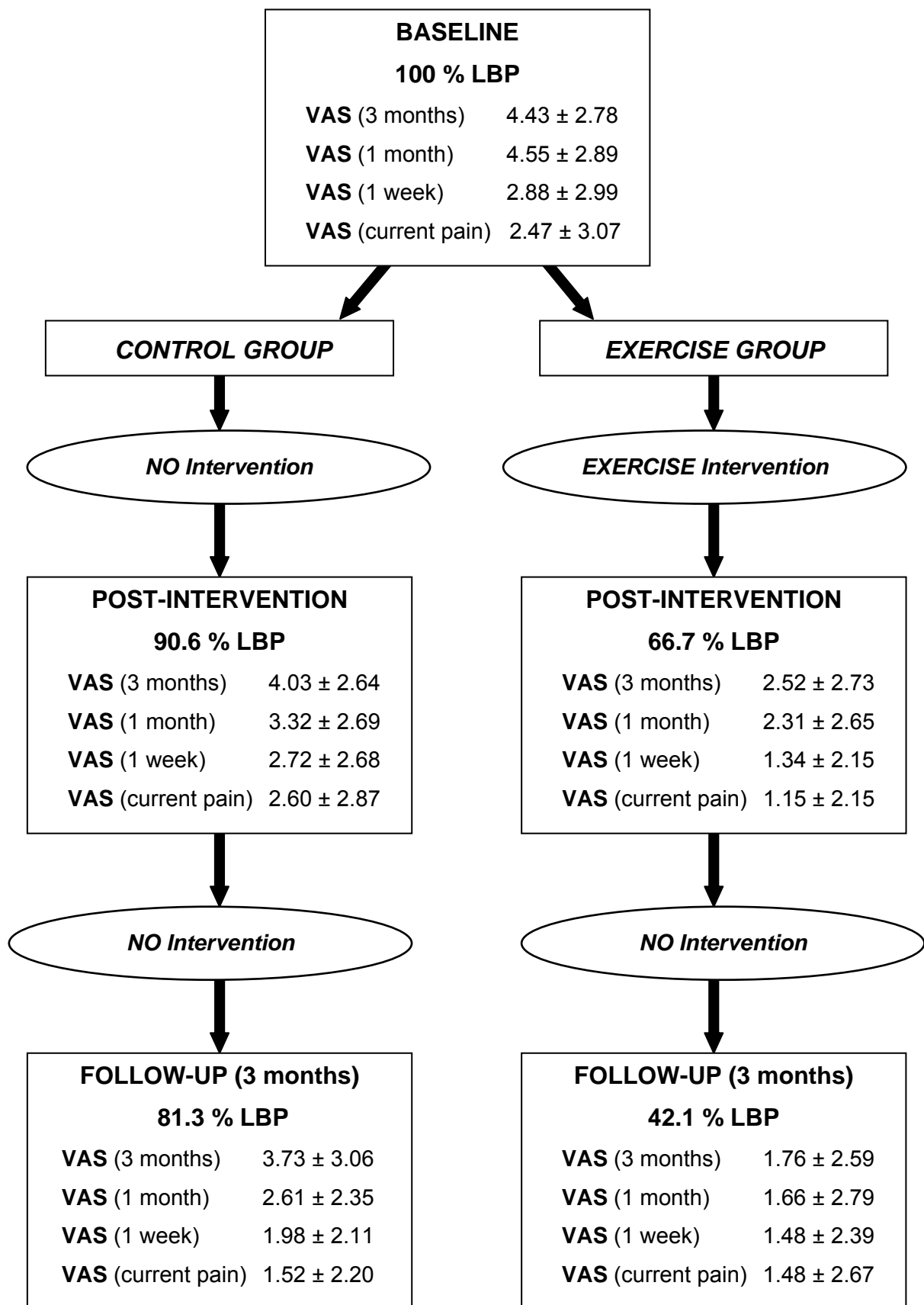


Figure 5.9 Summary - LBP Prevalence and Intensity

The differences between the two schools for LBP prevalence and intensity (VAS) are summarised below (all significant improvements were observed in the exercise groups).

- LBP prevalence decreased significantly at School A at both post-intervention follow-up visits. However, it was only at the three month follow-up visit that a significant improvement in LBP prevalence was observed at School B.
- VAS (3 months) improved significantly at School A at both post-intervention follow-up visits. However, it was only at the three month follow-up visit that a marginally significant improvement in VAS (3 months) was observed at School B.
- VAS (1 month) improved significantly at School A at both post-intervention follow-up visits. However, it was only at the three month follow-up visit that a significant improvement in VAS (1 month) was observed at School B.
- VAS (1 week) was only significantly better at School A immediately post-intervention.
- VAS (current pain) was only significantly better at School B immediately post-intervention.

5.5 LUMBAR STABILITY – ACTIVE STRAIGHT LEG RAISE

The Active Straight Leg Raise (ASLR) test was used to assess the functional integrity of the SIJ to transfer loads to the lumbar spine. This is a measure of lumbar stability. The change in pressure from baseline is used to determine the degree of pelvic rotation which accompanies the ASLR. The larger the change in pressure from baseline, the greater the amount of pelvic rotation and therefore, the poorer the ability of the stabilising system to provide dynamic lumbar stability. For the purpose of this study, good stability is defined as minimal pelvic rotation during the ASLR, with an increase in pressure from baseline of 0-8 mmHg, moderate stability an increase of 9-15 mmHg and poor stability as an increase of greater than 15 mmHg (Jordaan 2005b; Mens et al 2001; Jull et al 1993).

5.5.1 BASELINE DATA – LUMBAR STABILITY

Table 5.9 summarises the baseline data for lumbar stability (ASLR).

Table 5.9 Baseline Data – Lumbar Stability

	n	Mean	SD	95% CI	Min	Max
ASLR– Left (mmHg)						
Control Group	33	18.26 ± 7.94		15.45 - 21.08	5.67	40.00
Exercise Group	39	18.45 ± 6.48		16.35 - 20.55	7.33	32.67
Combined	72	18.37 ± 7.13		16.69 - 20.04	5.67	40.00
ASLR – Right (mmHg)						
Control Group	33	16.80 ± 7.17		14.26 - 19.34	2.00	36.00
Exercise Group	39	15.14 ± 5.37		13.40 - 16.88	0	25.33
Combined	72	15.90 ± 6.27		14.43 - 17.37	0	36.00

There were no significant differences between the two groups for lumbar stability (ASLR) at baseline, left ($p=0.91$) and right ($p=0.27$).

The mean baseline scores for ASLR indicate that, on average, children in this study demonstrated poor lumbar stability. Slightly more pelvic rotation was noted when the test was performed with the left leg.

5.5.2 CHANGES IN LUMBAR STABILITY FROM BASELINE

Figure 5.10 illustrates the changes in lumbar stability (ASLR) from baseline. Data are presented as means and standard deviations.

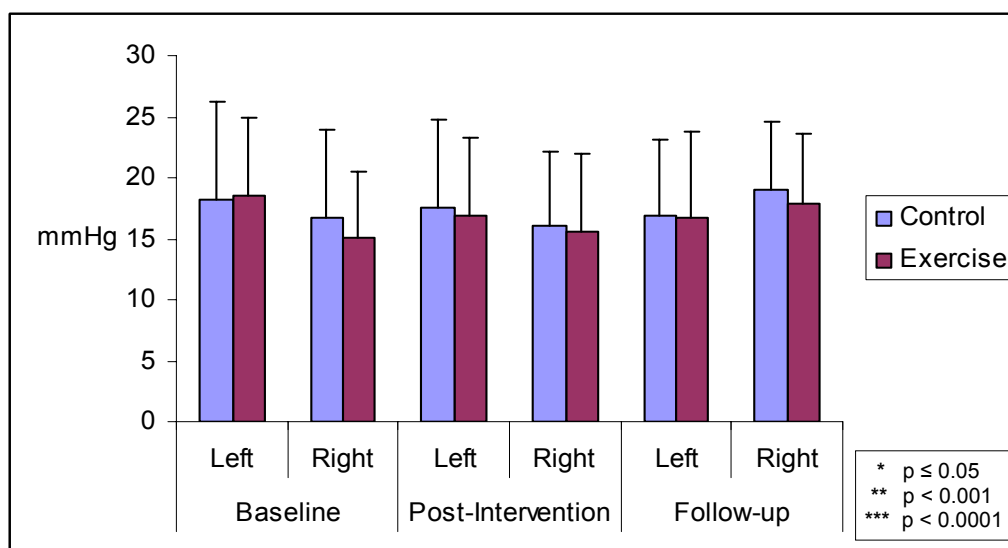


Figure 5.10 Changes in Lumbar Stability (ASLR)

There were no significant differences between the two groups, for the ASLR (left or right), immediately post-intervention ($p=0.64$ / $p=0.67$), or at the three month follow-up ($p=0.99$ / $p=0.74$).

Children in both the control group and exercise group continued to demonstrate poor lumbar stability from baseline to the three month follow-up. In addition, neither group showed a significant improvement or deterioration in lumbar stability.

5.5.2.1 Changes in Lumbar Stability from Baseline – Comparison between Schools

Table 5.10 summarises the comparison between the two schools for the change in lumbar stability (ASLR) from baseline.

Table 5.10 Changes in Lumbar Stability (ASLR) – Comparison between schools

	CONTROL			EXERCISE			p-value
	n	Mean	SD	n	Mean	SD	
SCHOOL A							
• Left (mmHg)							
Baseline	16	18.38 ± 8.23		22	18.70 ± 6.68		
Post-Intervention	16	18.34 ± 6.91		22	16.68 ± 7.62		0.39
Follow-up	16	17.37 ± 5.78		21	16.97 ± 6.92		0.78
• Right (mmHg)							
Baseline	16	16.29 ± 7.79		22	14.24 ± 6.40		
Post-Intervention	16	15.60 ± 7.59		22	15.65 ± 4.80		0.44
Follow-up	16	18.81 ± 4.18		21	18.14 ± 7.15		0.81
SCHOOL B							
• Left (mmHg)							
Baseline	17	18.16 ± 7.90		17	18.14 ± 6.40		
Post-Intervention	16	16.81 ± 7.49		17	17.16 ± 4.80		0.76
Follow-up	16	16.27 ± 6.81		17	16.51 ± 7.15		0.56
• Right (mmHg)							
Baseline	17	17.27 ± 6.73		17	16.29 ± 5.49		
Post-Intervention	16	16.42 ± 4.23		17	15.61 ± 5.14		0.76
Follow-up	16	15.61 ± 6.81		17	17.59 ± 5.42		0.56

When the two schools were compared, similar findings were observed at baseline, immediately post-intervention and at the three month follow-up for lumbar stability (ASLR). Children at both schools consistently demonstrated poor lumbar stability from baseline to three month follow-up, irrespective of which group they were in.

5.6 NEURAL MOBILITY – PASSIVE STRAIGHT LEG RAISE TEST

The PSLR test was used to determine neural mobility. For the purpose of this study, good neural mobility was defined as a measurement of hip flexion of greater than 70 degrees, moderate as between 50 – 70 degrees and poor as less than 50 degrees (Jordaan 2005b; Butler 1991).

5.6.1 BASELINE DATA – NEURAL MOBILITY

Table 5.11 summarises the baseline data for neural mobility (PSLR).

Table 5.11 Baseline Data – Neural Mobility

	n	Mean	SD	95% CI	Min	Max
PSLR – Left (degrees)						
Control Group	33	43.23 ± 15.99		37.56 - 48.90	6.00	80.50
Exercise Group	39	49.44 ± 18.17		43.55 - 55.33	10.00	89.00
Combined	72	46.59 ± 17.37		42.51 - 50.67	6.00	89.00
PSLR – Right (degrees)						
Control Group	33	51.09 ± 15.25		45.68 - 56.50	3.00	83.50
Exercise Group	39	57.62 ± 17.19		52.04 - 63.19	26.00	90.50
Combined	72	54.62 ± 16.55		50.74 - 58.51	3.00	90.50

There were no significant differences between the two groups for neural mobility (PSLR) at baseline, left ($p=0.13$) and right ($p=0.10$). The mean baseline scores for PSLR indicate that on average, children in this sample demonstrated poor neural mobility on the left and moderate neural mobility on the right.

5.6.2 CHANGES IN NEURAL MOBILITY FROM BASELINE

Figure 5.11 illustrates the changes in neural mobility (PSLR) from baseline. Data are presented as means and standard deviations.

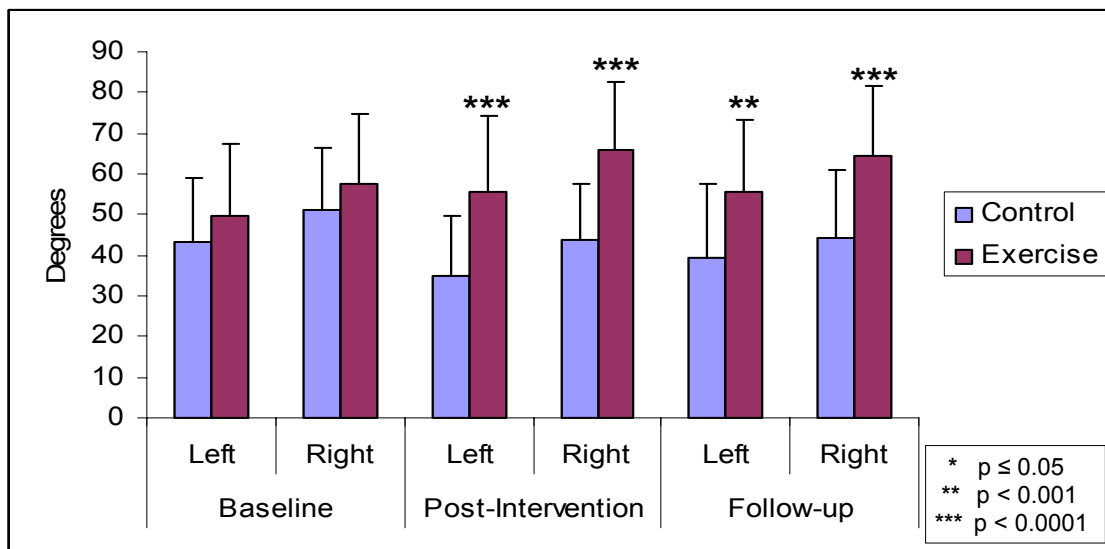


Figure 5.11 Changes in Neural Mobility (PSLR)

There were significant differences between the two groups, for both the left ($p<0.00001$) and the right ($p<0.00001$) PSLR, immediately post-intervention. These differences were still significant at the three month follow-up, left ($p<0.001$) and right ($p<0.00001$).

Neural mobility (PSLR) improved significantly in the exercise group post-intervention. In comparison, neural mobility decreased from baseline in the control group.

5.6.2.1 Changes in Neural Mobility from Baseline – Comparison between schools

Table 5.12 summarises the comparison between the two schools for change in neural mobility from baseline.

Table 5.12 Changes in Neural Mobility (PSLR) – Comparison between schools

	CONTROL			EXERCISE			p-value
	n	Mean	SD	n	Mean	SD	
SCHOOL A							
• Left (degrees)							
Baseline	16	40.53 ± 15.00		22	44.39 ± 18.12		
Post-Intervention	16	35.87 ± 9.87		22	51.20 ± 17.55		<0.001 **
Follow-up	16	37.16 ± 19.35		21	52.29 ± 19.41		<0.01 *
• Right (degrees)							
Baseline	16	46.33 ± 15.98		22	50.64 ± 19.73		
Post-Intervention	16	39.69 ± 9.80		22	60.39 ± 15.98		<0.00001 ***
Follow-up	16	44.94 ± 17.67		21	59.76 ± 16.93		0.02 *
SCHOOL B							
• Left (degrees)							
Baseline	17	45.76 ± 16.93		17	55.97 ± 16.52		
Post-Intervention	16	34.25 ± 18.19		17	61.62 ± 18.87		0.001 **
Follow-up	16	41.84 ± 16.75		17	59.82 ± 14.47		0.01 *
• Right (degrees)							
Baseline	17	55.56 ± 13.50		17	66.65 ± 11.25		
Post-Intervention	16	47.38 ± 16.85		17	72.59 ± 16.16		<0.01 *
Follow-up	16	43.94 ± 15.92		17	70.15 ± 15.97		0.001 **

There were significant improvements in neural mobility in the exercise groups at both schools immediately post-intervention. These improvements were maintained at the three month follow-up. In comparison, neural mobility appeared to worsen in the control group.

There were significant differences between the two schools at baseline for PSLR measures, left ($p=0.05$) and right ($p<0.01$). At baseline, children tended to demonstrate poor neural mobility at School A, as opposed to moderate neural mobility at School B. After the intervention, children in the exercise group at School A demonstrated moderate neural mobility, whilst the children at School B demonstrated moderate to good neural mobility.

5.7 HAMSTRINGS - MUSCLE LENGTH

For the purpose of this study, hamstring muscle length was defined as good if the measurement of knee extension was greater than 80 degrees, as moderate between 60 to 80 degrees and as short for measurements less than 60 degrees (Jordaan 2005b; Kendall et al 1993).

5.7.1 BASELINE DATA – HAMSTRINGS MUSCLE LENGTH

Table 5.13 summarises the baseline data for hamstring muscle length.

Table 5.13 Baseline Data – Hamstring Muscle Length

	n	Mean	SD	95% CI	Min	Max
Hamstrings – Left (degrees)						
Control Group	33	48.14 ± 9.50		44.77 - 51.51	23.00	76.33
Exercise Group	39	50.85 ± 12.27		46.87 - 54.82	23.33	80.00
Combined	72	49.61 ± 11.09		47.00 - 52.21	23.00	80.00
Hamstrings – Right (degrees)						
Control Group	33	49.59 ± 15.14		44.23 - 54.96	-20.00	79.33
Exercise Group	39	55.60 ± 10.89		52.07 - 59.13	35.33	82.00
Combined	72	52.85 ± 13.26		49.73 - 55.96	-20.00	82.00

There were no significant differences between the two groups at baseline for hamstring muscle length, left ($p=0.31$) and right ($p=0.06$). The mean scores for hamstring muscle length indicate that on average, the children in this sample had short hamstrings at baseline. Slightly more hamstring flexibility was observed on the right.

5.7.2 CHANGES IN HAMSTRINGS FROM BASELINE

Figure 5.12 illustrates the change in hamstring muscle length from baseline. Data are presented as means and standard deviations.

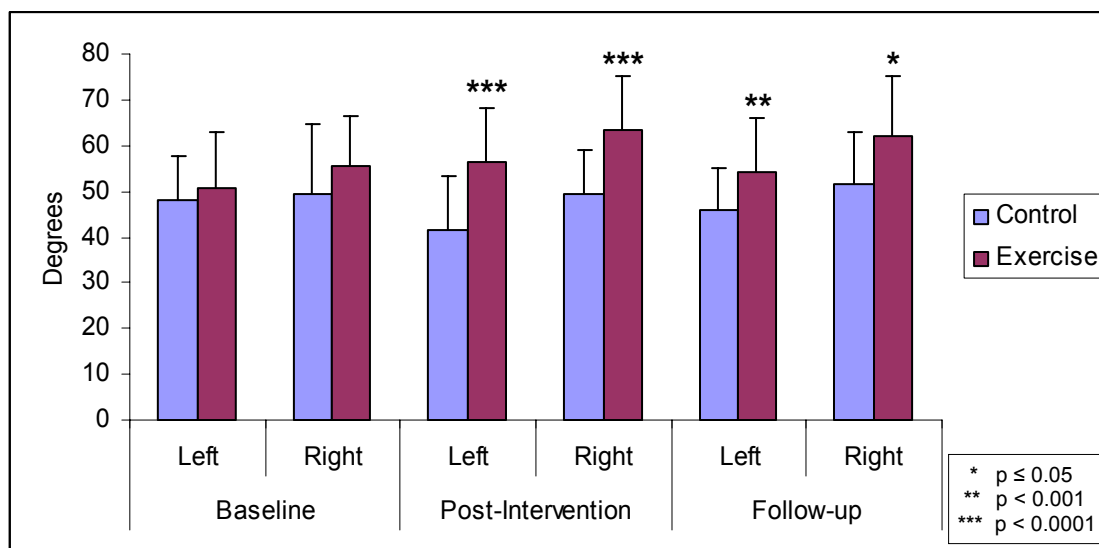


Figure 5.12 Changes in Hamstring Muscle Length

There were significant differences between the two groups, for both the left ($p<0.00001$) and the right ($p<0.00001$) hamstrings, immediately post-intervention. These differences were still significant at the three month follow-up, left ($p<0.001$) and right ($p<0.01$).

Children in the exercise group showed a significant improvement in hamstring muscle length immediately post-intervention. This improvement was maintained at the three month follow-up. In contrast, children in the control group did not show any improvement and consistently demonstrated short hamstring muscle length.

5.7.2.1 Changes in Hamstrings from Baseline – Comparison between schools

Table 5.14 summarises the comparison between the two schools for the changes in hamstring muscle length from baseline.

Table 5.14 Changes in Hamstring Muscle Length – Comparison between schools

	CONTROL			EXERCISE			p-value
	n	Mean	SD	n	Mean	SD	
SCHOOL A							
• Left (degrees)							
Baseline	16	44.75 ± 8.35		22	49.79 ± 12.50		
Post-Intervention	16	36.46 ± 11.13		22	54.09 ± 11.56		<0.00001 ***
Follow-up	16	41.88 ± 9.66		21	52.17 ± 12.56		0.02 *
• Right (degrees)							
Baseline	16	44.73 ± 18.27		22	53.30 ± 12.39		
Post-Intervention	16	44.13 ± 8.83		22	61.17 ± 13.07		0.0001 ***
Follow-up	16	47.00 ± 11.92		21	58.51 ± 14.49		0.06
SCHOOL B							
• Left (degrees)							
Baseline	17	51.33 ± 9.63		17	52.22 ± 12.20		
Post-Intervention	16	46.54 ± 10.14		17	59.63 ± 11.09		0.0001 ***
Follow-up	16	49.65 ± 7.26		17	56.26 ± 10.90		0.03 *
• Right (degrees)							
Baseline	17	54.18 ± 9.98		17	58.57 ± 7.96		
Post-Intervention	16	54.63 ± 7.41		17	66.61 ± 9.06		<0.001 **
Follow-up	16	55.94 ± 9.53		17	66.78 ± 9.25		0.01 *

Significant improvements in hamstring muscle length were observed at both schools immediately post-intervention, and maintained at the three month follow-up.

There was a significant difference between the schools at baseline for hamstring muscle length, left (p=0.05) and right (p=0.03). Children at School B demonstrated more hamstring flexibility at baseline, than the children at School A.

5.8 ILIOPSOAS – MUSCLE LENGTH

The muscle length of iliopsoas was defined as good if it was greater than 10 degrees of hip extension, moderate between 0 to 9.99 degrees and poor as less than 0 degrees (Jordaan 2005b; Jorgenson 1993; Kendall et al 1993).

5.8.1 BASELINE DATA – ILIOPSOAS MUSCLE LENGTH

Table 5.15 summarises the baseline data for iliopsoas muscle length.

Table 5.15 Baseline Data – Iliopsoas Muscle Length

	n	Mean	SD	95% CI	Min	Max
Iliopsoas – Left (degrees)						
Control Group	33	8.59 ± 10.96		4.70 - 12.47	-20.00	24.33
Exercise Group	39	10.62 ± 12.49		6.57 - 14.67	-13.33	32.67
Combined	72	9.67 ± 11.78		6.92 - 12.45	-20.00	32.67
Iliopsoas – Right (degrees)						
Control Group	33	5.67 ± 10.26		2.03 - 9.30	-25.00	22.33
Exercise Group	39	6.12 ± 10.89		2.59 - 9.65	-19.00	23.00
Combined	72	5.91 ± 10.53		3.44 - 8.39	-25.00	23.00

There were no significant differences between the groups at baseline for iliopsoas muscle length, left ($p=0.47$) and right ($p=0.86$). The mean scores for iliopsoas muscle length indicate that on average, children in this sample demonstrated moderate iliopsoas muscle length at baseline. The left iliopsoas was on average more flexible than the right iliopsoas.

5.8.2 CHANGES IN ILIOPSOAS FROM BASELINE

Figure 5.13 illustrates the change in iliopsoas muscle length from baseline. Data are presented as means and standard deviations.

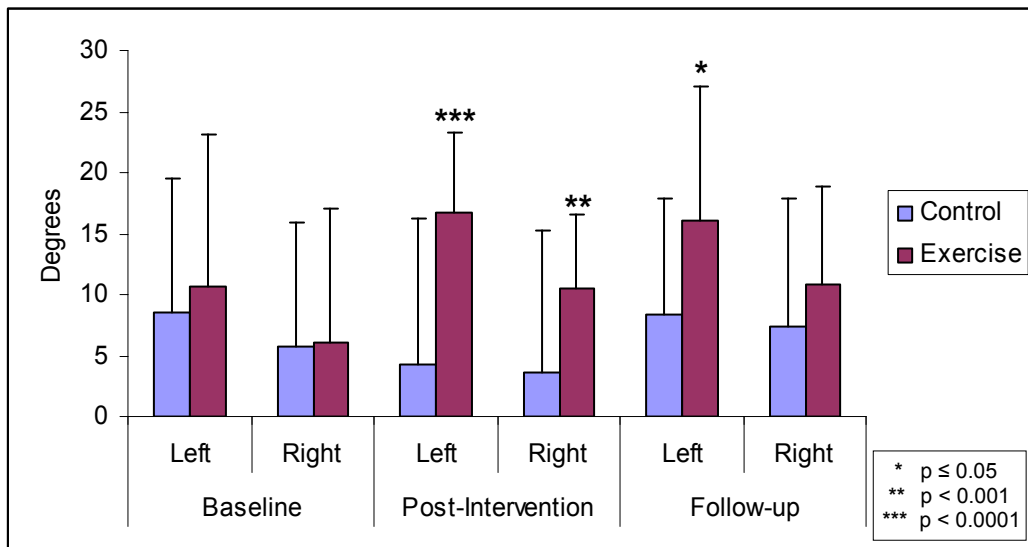


Figure 5.13 Changes in Iliopsoas Muscle Length

There were significant differences between the two groups, for both the left ($p<0.00001$) and the right ($p<0.001$) iliopsoas muscle length, immediately post-intervention. These

differences were still significant for the left ($p < 0.01$), and only marginally significant for the right ($p = 0.08$), at the three month follow-up.

Iliopsoas muscle length improved significantly in the exercise group. Children in the exercise group demonstrated good iliopsoas muscle length post-intervention, as opposed to the moderate iliopsoas muscle length which was maintained in the control group.

5.8.2.1 Changes in Iliopsoas from Baseline – Comparison between schools

Table 5.16 summarises the comparison between the two schools for changes in iliopsoas muscle length from baseline.

Table 5.16 Changes in Iliopsoas Muscle Length – Comparison between schools

	CONTROL			EXERCISE			p-value
	n	Mean	SD	n	Mean	SD	
SCHOOL A							
• Left (degrees)							
Baseline	16	9.33 ± 11.55		22	9.89 ± 11.42		
Post-Intervention	16	4.94 ± 14.99		22	17.70 ± 7.19		0.0001 **
Follow-up	16	9.79 ± 11.05		21	17.90 ± 10.55		0.02 *
• Right (degrees)							
Baseline	16	5.50 ± 11.40		22	5.86 ± 11.59		
Post-Intervention	16	3.79 ± 15.12		22	11.03 ± 6.16		0.01 *
Follow-up	16	6.17 ± 12.94		21	11.40 ± 8.23		0.03 *
SCHOOL B							
• Left (degrees)							
Baseline	17	7.88 ± 10.69		17	11.57 ± 14.06		
Post-Intervention	16	3.44 ± 8.46		17	15.53 ± 5.77		0.0001 **
Follow-up	16	7.05 ± 7.67		17	13.69 ± 11.40		0.05 *
• Right (degrees)							
Baseline	17	5.82 ± 9.41		17	6.45 ± 10.26		
Post-Intervention	16	3.50 ± 6.91		17	9.73 ± 5.99		0.01 *
Follow-up	16	8.67 ± 7.25		17	10.12 ± 7.82		0.50

Iliopsoas muscle length improved significantly in the exercise group at both schools. There were no significant differences between the two schools for iliopsoas muscle length at baseline, left ($p = 0.98$) and right ($p = 0.86$). However, children at School A tended to demonstrate a larger improvement in iliopsoas muscle length than children at School B.

5.9 RECTUS FEMORIS – MUSCLE LENGTH

The muscle length of rectus femoris was defined as good if the measurement of knee flexion was greater than 80 degrees, moderate between 70 to 80 degrees and poor as less than 70 degrees (Jordaan 2005b; Kendall et al 1993).

5.9.1 BASELINE DATA – RECTUS FEMORIS MUSCLE LENGTH

Table 5.17 summarises the baseline data for rectus femoris muscle length.

Table 5.17 Baseline Data – Rectus Femoris Muscle Length

	n	Mean	SD	95% CI	Min	Max
Rec Fem – Left (degrees)						
Control Group	33	75.90 ± 14.88		70.62 - 81.18	35.00	101.33
Exercise Group	39	78.69 ± 8.90		75.81 - 81.58	61.33	106.33
Combined	72	77.41 ± 12.01		74.59 - 80.23	35.00	106.33
Rec Fem – Right (degrees)						
Control Group	33	69.48 ± 18.29		63.00 - 75.97	3.00	95.33
Exercise Group	39	70.17 ± 11.02		66.60 - 73.74	43.67	97.00
Combined	72	69.86 ± 14.69		66.40 - 73.31	3.00	97.00

There were no significant differences between the two groups at baseline for rectus femoris muscle length, left ($p=0.33$) and right ($p=0.85$). The mean baseline scores indicate that on average, the rectus femoris muscle length in this sample was moderate for the left leg and marginally poor for the right leg.

5.9.2 CHANGES IN RECTUS FEMORIS FROM BASELINE

Figure 5.14 illustrates the changes in rectus femoris muscle length from baseline. Data are presented as means and standard deviations.

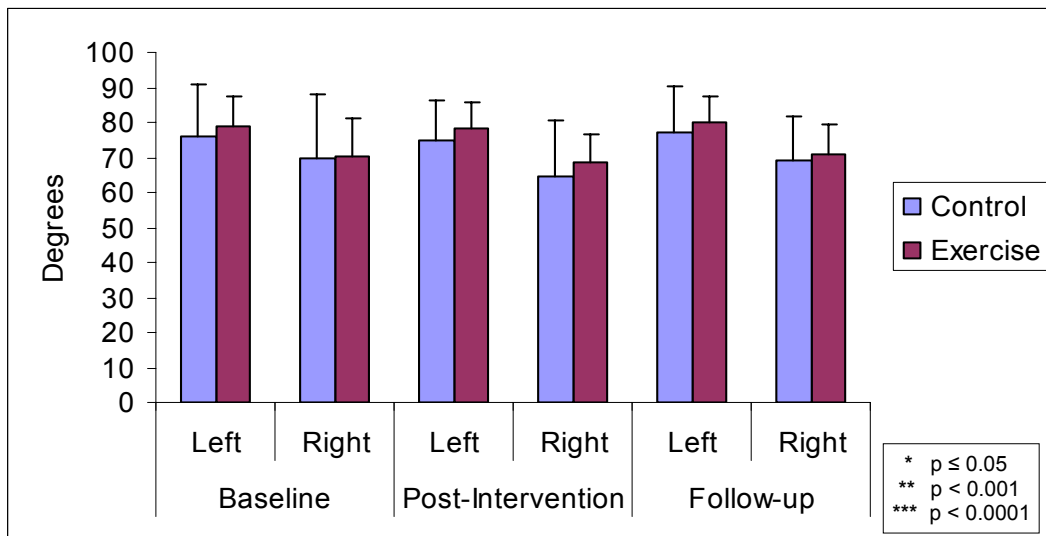


Figure 5.14 Changes in Rectus Femoris Muscle Length

There were no significant differences between the two groups for rectus femoris muscle length immediately post-intervention, left ($p=0.22$) and right ($p=0.26$), or at three month follow-up, left ($p=0.45$) and right ($p=0.55$).

The rectus femoris muscle lengths remained fairly constant in both the control and exercise group. On average, the length of the rectus femoris remained moderate on the left and marginally short on the right, in both groups.

5.9.2.1 Changes in Rectus Femoris from Baseline – Comparison between schools

Table 5.18 illustrates the comparison between the two groups for change in rectus femoris muscle length from baseline.

Table 5.18 Changes in Rectus Femoris Muscle Length – Comparison between schools

	CONTROL			EXERCISE			p-value
	n	Mean	SD	n	Mean	SD	
SCHOOL A							
• Left (degrees)							
Baseline	16	76.19 ± 14.02		22	78.80 ± 8.13		
Post-Intervention	16	78.19 ± 8.18		22	79.30 ± 8.34		0.79
Follow-up	16	80.85 ± 12.41		21	80.14 ± 6.66		0.65
• Right (degrees)							
Baseline	16	71.65 ± 21.70		22	72.56 ± 9.38		
Post-Intervention	16	69.44 ± 9.28		22	72.21 ± 6.50		0.28
Follow-up	16	69.73 ± 12.80		21	72.30 ± 7.87		0.47
SCHOOL B							
• Left (degrees)							
Baseline	17	72.63 ± 16.08		17	78.55 ± 10.06		
Post-Intervention	16	71.79 ± 13.42		17	76.90 ± 6.45		0.22
Follow-up	16	73.06 ± 13.34		17	79.84 ± 8.74		0.12
• Right (degrees)							
Baseline	17	67.45 ± 14.77		17	62.08 ± 12.45		
Post-Intervention	16	60.23 ± 19.98		17	63.31 ± 7.34		0.57
Follow-up	16	68.81 ± 12.61		17	69.49 ± 9.54		0.64

There were no significant changes in rectus femoris muscle length at either school. On average, the children at School A demonstrated moderate rectus femoris muscle length, whilst the children at School B demonstrated moderate muscle length on the left, and poor to moderate muscle length on the right. However, there were no significant differences between the two schools for rectus femoris muscle length at baseline, left (p=0.83) and right (p=0.15).

5.10 LUMBOSACRAL POSITION SENSE / PROPRIOCEPTION

Lumbosacral position sense was defined as good if the repositioning error was less than two degrees, as moderate between two and five degrees and as poor if it was greater than five degrees (Jordaan 2005b).

5.10.1 BASELINE DATA – LUMBOSACRAL POSITION SENSE

Table 5.19 summarises the baseline data for lumbosacral position sense.

Table 5.19 Baseline Data – Lumbosacral Position Sense

	n	Mean	SD	95% CI	Min	Max
Proprioception (degrees)						
Control Group	33	2.86 ± 1.41		2.36 - 3.36	1.00	6.60
Exercise Group	39	2.48 ± 1.01		2.16 - 2.81	1.00	5.20
Combined	72	2.66 ± 1.21		2.37 - 2.94	1.00	6.60

There was no significant difference between the two groups at baseline for lumbosacral position sense ($p=0.19$). The mean baseline scores indicate that, on average, children in this sample demonstrated moderate lumbosacral position sense.

5.10.2 CHANGES IN LUMBOSACRAL POSITION SENSE FROM BASELINE

Figure 5.15 illustrates the changes in lumbosacral position sense from baseline. Data are presented as means and standard deviations.

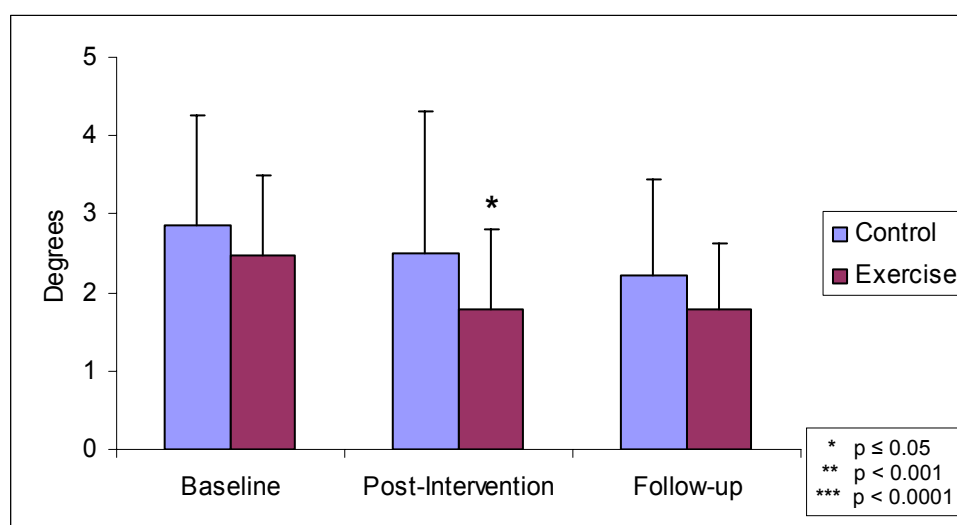


Figure 5.15 Changes in Lumbosacral Position Sense

There was a significant difference between the two groups immediately post-intervention ($p=0.01$). This difference was no longer significant at the three month follow-up ($p=0.10$).

Children in the exercise group showed a significant improvement in lumbosacral position sense immediately post-intervention. On average, the mean lumbosacral position sense scores remained moderate for the control group. In comparison, after the exercise intervention, the mean lumbosacral position sense scores were good in the exercise group.

5.10.2.1 Changes in Lumbosacral Position Sense – Comparison between schools

Table 5.20 summarises the comparison between the two schools for the changes in lumbosacral position sense from baseline.

Table 5.20 Changes in Lumbosacral Position Sense – Comparison between schools

	CONTROL			EXERCISE			p-value
	n	Mean	SD	n	Mean	SD	
SCHOOL A							
• (degrees)							
Baseline	16	2.56 ± 1.19		22	2.10 ± 0.93		
Post-Intervention	16	2.60 ± 1.09		22	1.89 ± 1.05		0.09
Follow-up	16	2.39 ± 1.36		21	1.89 ± 0.80		0.32
SCHOOL B							
• (degrees)							
Baseline	17	3.14 ± 1.57		22	2.98 ± 0.91		
Post-Intervention	16	2.40 ± 1.28		22	1.67 ± 0.97		0.08
Follow-up	16	2.08 ± 1.09		21	1.67 ± 0.89		0.26

Only a marginally significant improvement was observed in the exercise groups at both schools immediately post-intervention. Although this improvement was maintained in the exercise group at both schools, an improvement was also observed in the control groups, particularly at School B.

5.11 SUMMARY OF PHYSICAL RISK FACTORS

Although there were significant differences between the two schools for neural mobility and hamstring muscle length at baseline, both schools showed similar significant improvements in both of these physical risk factors post-intervention. Therefore, similar clinical improvements were observed at both of the schools. The physical risk factor findings for the whole sample are summarised in Figure 5.16 on the following page.

It is interesting to observe the baseline differences between the left and the right sides in this sample. On average, the children demonstrated less pelvic rotation (ASLR), as well as better neural mobility (PSLR) and hamstring flexibility on the right. In comparison, they demonstrated better iliopsoas and rectus femoris flexibility on the left. It is possible that these findings could be related to dominance and / or to the location of their LBP symptoms (i.e. right or left side of the low back). However, data relating to dominance or the specific side of LBP symptoms was not included in this study.

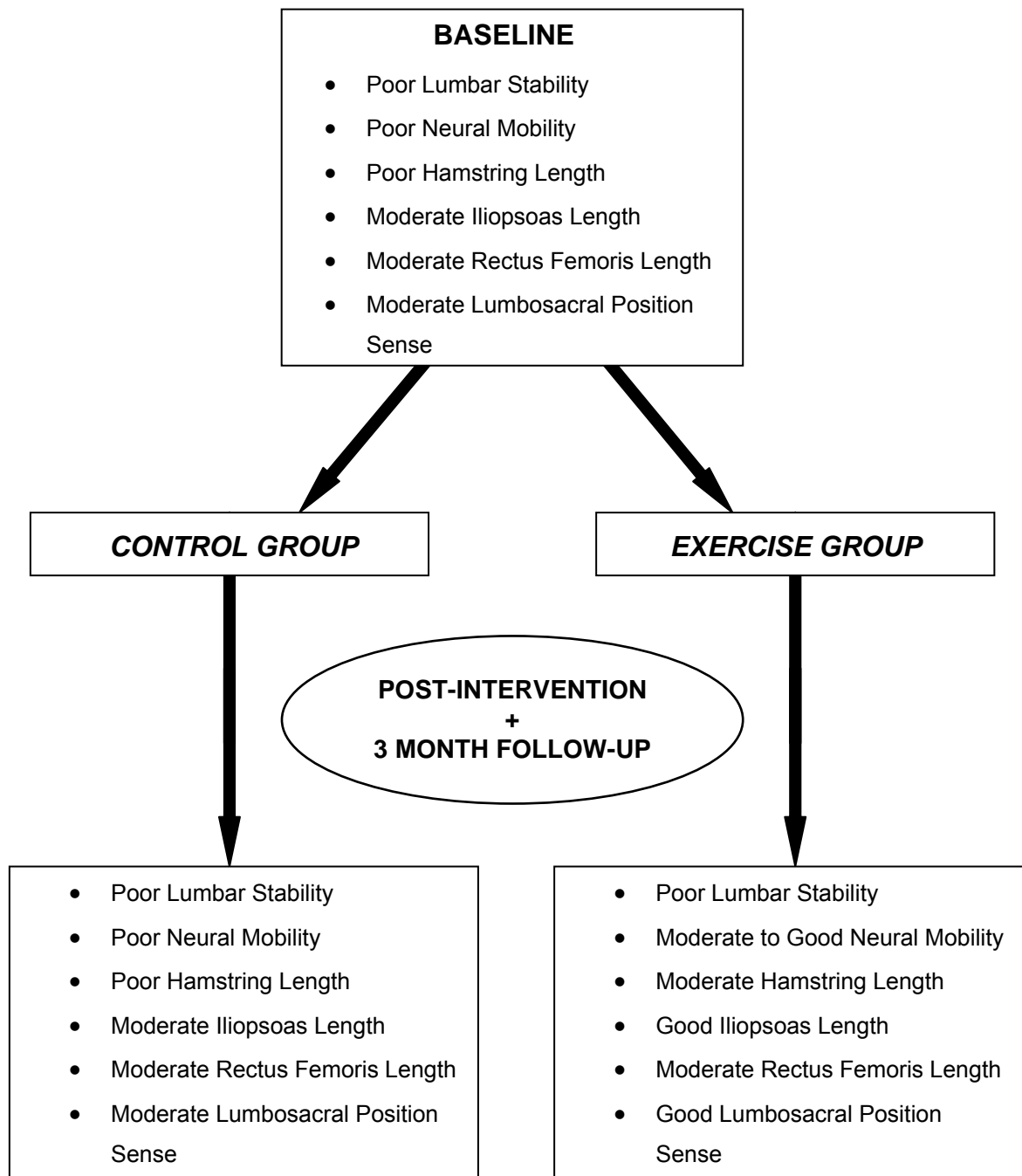


Figure 5.16 Summary - Physical Risk Factors

5.12 SENSE OF WELL BEING – MHI-5

Scores for the MHI-5 questionnaire range between five and thirty (see Appendix J). High scores indicate psychosocial well-being and an absence of psychological distress. For the purpose of this study a good sense of well-being is defined as a MHI-5 score of greater than 24, moderate as 15 to 24 and poor as less than 15 (Rumpf et al 2001).

5.12.1 BASELINE DATA – MHI-5

Table 5.21 summarises the baseline data for the sense of well-being MHI-5 scores.

Table 5.21 Baseline Data – MHI-5

	n	Mean	SD	95% CI	Min	Max
MHI-5						
Control Group	33	21.42 ± 3.69		20.12 - 22.73	14	28
Exercise Group	39	21.79 ± 4.10		20.47 - 23.12	12	29
Combined	72	21.63 ± 3.89		20.71 - 22.54	12	29

There was no significant difference between the groups at baseline for MHI-5 ($p=0.69$). The mean baseline scores for MHI-5 indicate that, on average, children in this sample expressed a moderate sense of well-being.

5.12.2 CHANGES IN MHI-5 FROM BASELINE

Table 5.22 summarises the changes from baseline for sense of well-being (MHI-5 scores) for the whole sample, as well as for School A and School B

Table 5.22 Changes from Baseline – Sense of Well-being (MHI-5 scores)

	BASELINE			POST-INTERVENTION				FOLLOW-UP			
	n	Mean	SD	n	Mean	SD	p-value	n	Mean	SD	p-value
TOTAL											
Control Group	33	21.42 ± 3.69		32	22.18 ± 5.11		0.63	32	22.50 ± 3.98		0.45
Exercise Group	39	21.79 ± 4.10		39	22.79 ± 4.04			38	23.54 ± 4.63		
SCHOOL A											
Control Group	16	21.38 ± 3.56		16	22.31 ± 2.44		0.56	16	23.94 ± 2.82		0.68
Exercise Group	22	21.00 ± 3.89		22	23.23 ± 3.01			21	23.20 ± 4.30		
SCHOOL B											
Control Group	17	21.47 ± 3.92		16	22.06 ± 6.83		0.83	16	21.06 ± 4.51		0.23
Exercise Group	17	22.82 ± 4.25		17	22.24 ± 5.13			17	23.94 ± 5.09		

There were no significant changes in MHI-5 scores from baseline at either school. Children in this sample consistently reported a moderate sense of well-being (MHI-5),

irrespective of which group they were in. There were slight improvements in the MHI-5 score for both groups from baseline to three month follow-up. It is possible that this improvement was related to the lower prevalence of LBP at the follow-up visits. However, as the differences were not very large or significant, the slight variation in MHI-5 scores could most likely be attributed to many other factors, e.g. if the students were writing tests or if they had an argument with a friend, parent, sibling or teacher that day.

There were no significant differences in MHI-5 scores between the two schools at baseline ($p=0.29$).

5.13 SENSE OF WELL-BEING – FACE SCALES

Two face scales were used to determine sense of well-being with regard to school and life in general (see Appendix J). For the purpose of this study, happiness was defined as faces A and B (scores greater than five), indifference as faces C and D (scores between three and five) and sadness as faces D and E (scores less than three) (Jordaan 2005b).

5.13.1 BASELINE DATA – FACE SCALES

Table 5.23 summarises the baseline data for the two face scales.

Table 5.23 Baseline Data – Face Scales

	n	Mean	SD	95% CI	Min	Max
School						
Control Group	33	4.82 ± 1.10		4.43 - 5.21	1	6
Exercise Group	39	5.05 ± 1.02		4.72 - 5.38	2	6
Combined	72	4.94 ± 1.06		4.70 - 5.19	1	6
Life in General						
Control Group	33	4.88 ± 1.17		4.47 - 5.29	1	6
Exercise Group	39	5.08 ± 0.93		4.78 - 5.38	3	6
Combined	72	4.99 ± 1.04		4.74 - 5.23	1	6

There were no significant differences at baseline for either face scale, school ($p=0.36$) and life in general ($p=0.43$). The mean face scale scores indicate that, on average, children in this sample expressed indifference with regard to school and life in general. However, for both face scales the scores were on the borderline between indifference and happiness.

5.13.2 CHANGES IN FACE SCALES FROM BASELINE

Table 5.24 summarises the changes in sense of well-being (face scales) from baseline for the whole sample, as well as for each school.

Table 5.24 Changes from Baseline - Sense of Well-being (Face Scales)

	BASELINE			POST-INTERVENTION				FOLLOW-UP			
	n	Mean	SD	n	Mean	SD	p-value	n	Mean	SD	p-value
TOTAL											
• <i>School</i>											
Control Group	33	4.82 ± 1.10		32	4.88 ± 1.10		0.42	32	4.67 ± 1.18		0.21
Exercise Group	39	5.05 ± 1.02		39	4.87 ± 1.06			38	5.05 ± 1.03		
• <i>Life in General</i>											
Control Group	33	4.88 ± 1.17		32	5.09 ± 0.89		0.67	32	4.95 ± 1.10		0.91
Exercise Group	39	5.08 ± 0.93		39	5.00 ± 1.19			38	4.97 ± 1.17		
SCHOOL A											
• <i>School</i>											
Control Group	16	4.56 ± 0.89		16	4.81 ± 0.75		0.22	16	4.28 ± 1.18		0.24
Exercise Group	22	4.59 ± 1.01		22	4.45 ± 1.06			21	4.70 ± 1.03		
• <i>Life in General</i>											
Control Group	16	4.50 ± 1.15		16	5.00 ± 0.73		0.27	16	5.03 ± 0.59		0.24
Exercise Group	22	4.95 ± 1.00		22	4.82 ± 1.18			21	4.75 ± 1.29		
SCHOOL B											
• <i>School</i>											
Control Group	17	5.06 ± 1.25		16	4.94 ± 1.39		0.56	16	5.06 ± 1.06		0.55
Exercise Group	17	5.65 ± 0.70		17	5.41 ± 0.80			17	5.47 ± 0.87		
• <i>Life in General</i>											
Control Group	17	5.24 ± 1.09		16	5.19 ± 1.05		0.87	16	4.88 ± 1.45		0.40
Exercise Group	17	5.24 ± 0.83		17	5.24 ± 1.20			17	5.24 ± 0.97		

There were no significant post-intervention differences in sense of well-being (face scales) between the two groups at either school, as well as when the sample was analysed as a whole.

However, there was a significant difference between the two schools at baseline for both face scales, school ($p < 0.01$) and life ($p = 0.03$). In general, the children at School B reported a higher sense of well-being (face scales) than the children at School A. On average, the children at School B consistently reported that they were happy with their schoolwork and with life in general. In comparison, the children at School A consistently reported indifference to school and life in general.

5.14 SUMMARY - SENSE OF WELL-BEING

The sense of well-being findings are summarised in Figure 5.17 on the following page.

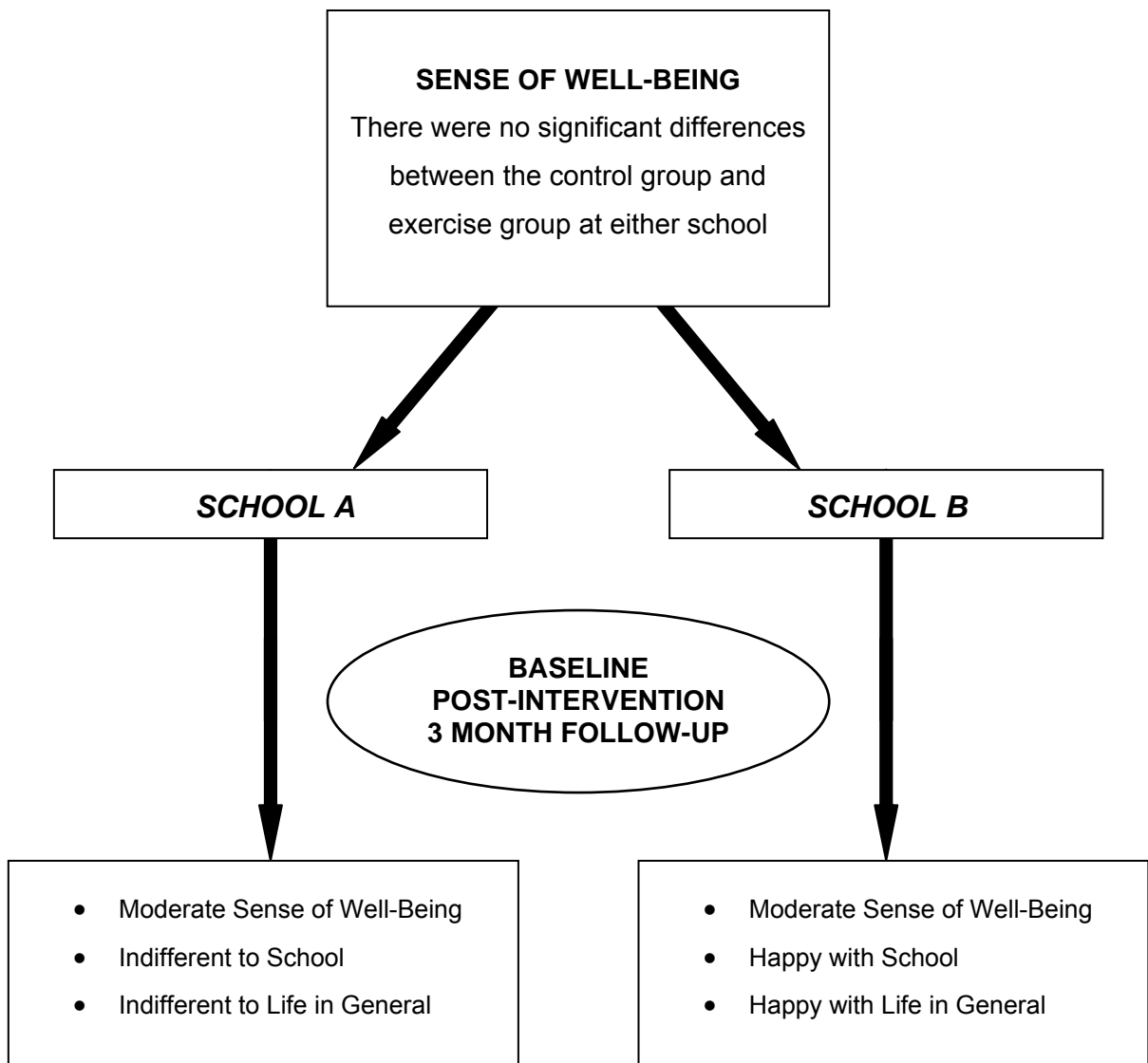


Figure 5.17 Summary - Sense of Well-Being

5.15 PERCEPTION OF PHYSICAL EDUCATION (PE) CLASSES

Five sets of corresponding positive and negative statements relating to PE were used to determine the child's perception of PE. The children scored one if they marked a positive statement and zero if they marked a negative statement (see Appendix J). Therefore, scores range between zero and five. For the purpose of this study, a positive perception of PE was defined as a score of 3.5 and above and a negative perception of PE as a score of less than 3.5 (Sollerhed et al 2005).

5.15.1 BASELINE DATA – PERCEPTION OF PE

Table 5.25 summarises the baseline data for the perception of PE.

Table 5.25 Baseline Data – Perception of PE

	n	Mean	SD	95% CI	Min	Max
PE - Perception						
Control Group	33	4.00 ± 1.68		3.41 - 4.59	0	5
Exercise Group	39	4.31 ± 1.28		3.89 - 4.72	0	5
Combined	72	4.17 ± 1.47		3.82 - 4.51	0	5

There were no significant differences between the two groups at baseline for perception of PE ($p=0.38$). The mean baseline scores for perception of PE indicate that, on average, children in this sample had a positive perception of PE.

5.15.2 CHANGES IN PE PERCEPTION FROM BASELINE

Table 5.26 summarises the changes from baseline in perceptions of PE for the total sample, as well as for each school.

Table 5.26 Changes from Baseline – Perception of PE

	BASELINE			POST-INTERVENTION				FOLLOW-UP			
	n	Mean	SD	n	Mean	SD	p-value	n	Mean	SD	p-value
TOTAL											
Control Group	33	4.00 ± 1.68		32	4.03 ± 1.29		0.67	32	4.22 ± 1.21		0.61
Exercise Group	39	4.31 ± 1.28		39	4.28 ± 1.32			38	4.58 ± 1.17		
SCHOOL A											
Control Group	16	3.56 ± 1.90		16	4.19 ± 1.17		0.03	16	4.13 ± 1.31		0.15
Exercise Group	22	4.18 ± 1.30		22	3.82 ± 1.59			21	4.05 ± 1.47		
SCHOOL B											
Control Group	17	4.41 ± 1.37		16	3.88 ± 1.41		0.01	16	4.31 ± 1.14		0.03
Exercise Group	17	4.47 ± 1.28		17	4.88 ± 0.33			17	4.94 ± 0.24		

Statistically significant improvements in the perception of PE were observed in the control group at School A and in the exercise groups at School B. However, it is unlikely that these findings have much clinical significance. The majority of between group changes were small and therefore, on average, all of the children in both groups consistently reported a positive perception of PE from baseline to three month follow-up.

5.16 PERCEPTIONS OF THE IMPACT OF PE ON HEALTH AND FUNCTION

Six questions were used to determine the child's perception of the impact of PE on their health and function. The first three questions were grouped together to get a score for the subsection health, and the last three for the subsection function. However, none of the children at School B had done PE in the three months prior to the start of the study and would, therefore, have had scores of zero. In addition, apart from the study's exercise intervention; School B did not have any PE classes during the year. Therefore, only data from School A is included in the analyses of the impact of PE exercises on health and function.

All six questions were group together to determine the impact of PE on both health and function (see Appendix J). Therefore, scores could range between six and twenty-four. For the purpose of this study, a positive impact on health and function was defined as scores of greater than eighteen, moderate as between eleven and eighteen, and low as less than eleven. For both the subsections of health / function, scores could range between three and twelve. A positive impact was defined as scores of greater than nine, moderate as between five and nine, and low as less than five.

5.16.1 BASELINE DATA – IMPACT OF PE ON HEALTH AND FUNCTION

Table 5.27 summarises the baseline data for the perception of PE exercises, with regard to their impact on health and function. Only data from School A is included in the table.

Table 5.27 Baseline Data – Impact of PE on Health and Function

	n	Mean	SD	95% CI	Min	Max
Health + Function						
Control Group	16	11.44 ± 4.75		8.91 – 13.97	6	20
Exercise Group	22	11.41 ± 5.80		8.84 – 13.98	6	22
Combined	38	11.42 ± 5.32		9.67 – 13.17	6	22
Health						
Control Group	16	5.44 ± 2.31		4.21 - 6.67	3	10
Exercise Group	22	5.68 ± 2.87		4.41 - 6.95	3	11
Combined	38	5.58 ± 2.62		4.72 - 6.44	3	11
Function						
Control Group	16	6.00 ± 2.71		4.56 - 7.44	3	10
Exercise Group	22	5.73 ± 3.48		4.18 - 7.27	3	12
Combined	38	5.84 ± 3.14		4.81 - 6.87	3	12

There were no significant differences between the groups at baseline for any of the perception of PE exercises scores, health and function ($p=0.99$), health ($p=0.78$) and function ($p=0.80$).

The mean baseline values for the perception of PE exercises indicate that, on average, children in this sample felt that the exercises which they did in PE in the past three months had a moderate impact on their health and function.

5.16.2 CHANGES IN THE PERCEPTIONS OF THE IMPACT OF PE ON HEALTH AND FUNCTION FROM BASELINE

Table 5.28 summarises the changes from baseline in perceptions of PE, with regard to the impact of PE on health and function. Only data from School A is included.

Table 5.28 Changes from Baseline - Perception of the Impact of PE on Health / Function

	BASELINE			POST-INTERVENTION				FOLLOW-UP			
	n	Mean	SD	n	Mean	SD	p-value	n	Mean	SD	p-value
SCHOOL A											
• Health+Function											
Control Group	16	11.44 ± 4.75		16	15.31 ± 5.63		0.73	16	13.69 ± 5.55		0.91
Exercise Group	22	11.41 ± 5.80		22	15.95 ± 5.58			21	13.90 ± 6.82		
• Health											
Control Group	16	5.44 ± 2.31		16	7.44 ± 2.90		0.42	16	6.63 ± 2.73		0.51
Exercise Group	22	5.68 ± 2.87		22	8.18 ± 2.44			21	7.35 ± 3.48		
• Function											
Control Group	16	6.00 ± 2.71		16	7.88 ± 3.14		0.97	16	7.06 ± 3.07		0.69
Exercise Group	22	5.73 ± 3.48		22	7.77 ± 3.44			21	6.44 ± 3.83		

Both the control group and the exercise group consistently reported similar scores for health and function. On average, the children indicated that the exercises which they did in PE had a moderate impact on their health and function. It is possible that children in the exercise group did not consider the exercise intervention classes as a component of their PE programme and therefore, only reported on the exercises which they did in their usual PE class.

5.17 SUMMARY OF EXERCISE PERCEPTIONS

Findings relating to the perceptions of PE are summarised in the Figure 5.18 below

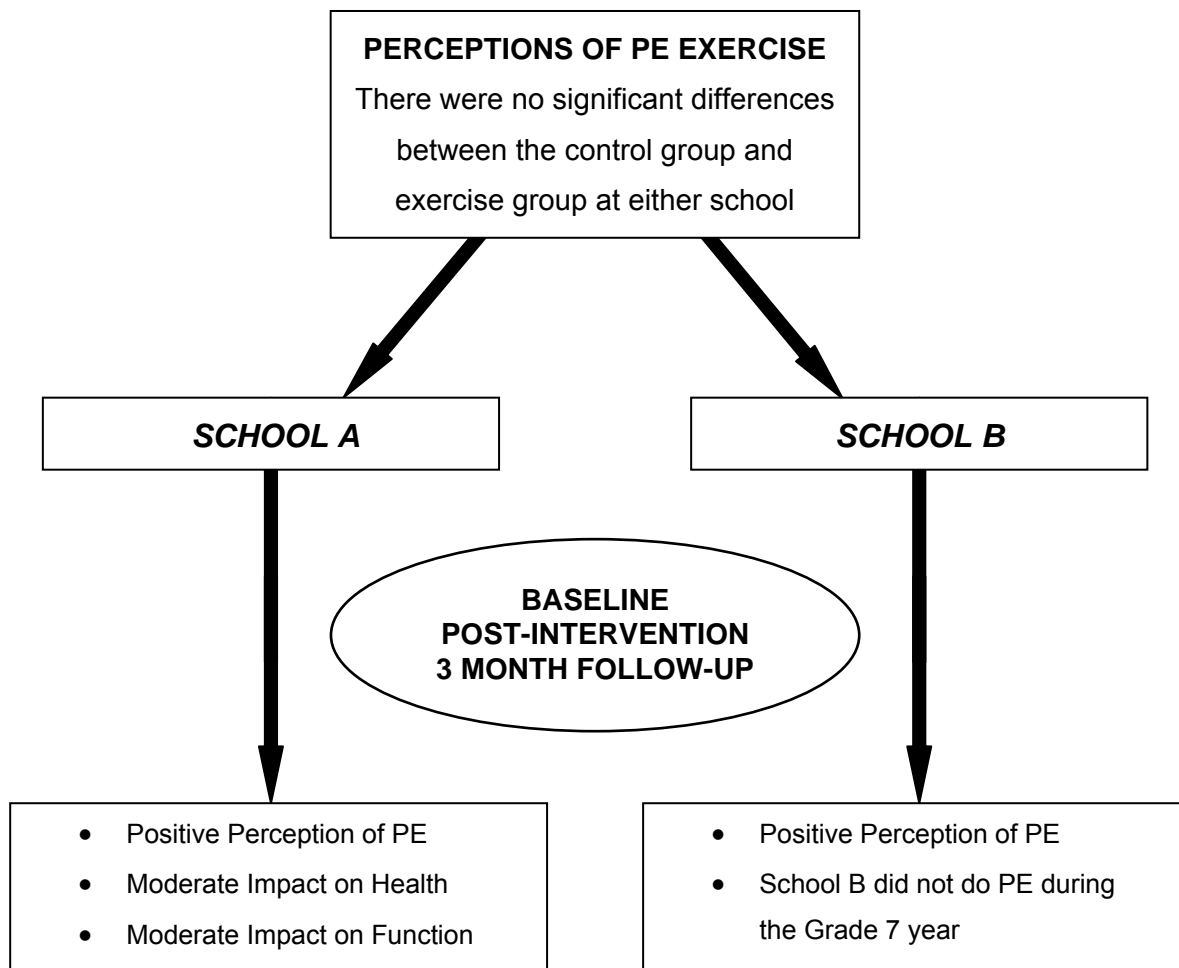


Figure 5.18 Summary – Perceptions of PE

5.18 EXERCISE ADHERENCE

Children in the exercise groups at both schools participated in an eight week exercise intervention, which consisted of eight exercise classes. The physiotherapist kept an attendance register at each exercise class. In addition, the children were requested to do the home exercise programme on their own, three times a week during the intervention period. The children completed a home exercise diary to record their adherence to the home exercise programme (see Appendix N).

5.18.1 EXERCISE CLASSES

The attendance at the exercise classes is summarised in Table 5.29.

Table 5.29 Exercise Class Adherence

	TOTAL (n=39)		SCHOOL A (n=22)		SCHOOL B (n=17)	
	n	%	n	%	n	%
Exercise Class Attendance						
• 100 % (classes missed = 0)	26	66.7	11	50.0	15	88.2
• 87.5 % (classes missed = 1)	8	20.5	6	27.3	2	11.8
• 75.0 % (classes missed = 2)	3	7.7	3	13.6	0	0
• 62.5 % (classes missed = 3)	2	5.1	2	9.1	0	0
• < 50 % (classes missed > 3)	0	0	0	0	0	0

The majority of the children attended every exercise class during the intervention period. Almost all of the children at School B attended every exercise class, whereas only 50% of the children at School A did not miss any of the classes. However, most of the children who missed classes were either absent from school or had to write a test during that time. Therefore, it is unlikely that non-attendance at the classes was due to children avoiding the class or not wanting to do the exercises.

5.18.2 HOME EXERCISE PROGRAMME

The children were asked to do the exercises at home three times a week. However, many of the children either did the home exercises more or less than three times a week. In addition, some of the children did not do the exercises every week during the intervention period. Table 5.30 summarises the children's self-reported adherence to the home exercise programme, from the home exercise diaries.

Table 5.30 Home Exercise Programme Adherence

	TOTAL (n=39)		SCHOOL A (n=22)		SCHOOL B (n=17)	
	n	%	n	%	n	%
> 3 times / week						
• more than 80% of the time	7	17.9	1	4.5	6	35.3
• 60 - 80% of the time	4	10.3	1	4.5	3	17.5
• 40 - 60% of the time	0	0	0	0	0	0
• less than 40% of the time	2	5.1	1	4.5	1	5.9
TOTAL	13	33.3	3	13.6	10	58.7
3 times / week						
• more than 80% of the time	2	5.1	1	4.5	1	5.9
• 60 - 80% of the time	1	2.6	0	0	1	5.9
• 40 - 60% of the time	2	5.1	1	4.5	1	5.9
• less than 40% of the time	2	5.1	1	4.5	1	5.9
TOTAL	7	17.9	3	13.6	4	23.6
1 - 2 times / week						
• more than 80% of the time	4	10.3	3	13.7	1	5.9
• 60 - 80% of the time	2	5.1	1	4.5	1	5.9
• 40 - 60% of the time	4	10.3	3	13.7	1	5.9
• less than 40% of the time	1	2.6	1	4.5	0	0
TOTAL	11	28.3	8	36.4	3	17.7
< 1 time / week						
TOTAL	8	20.5	8	36.4	0	0

Less than half of the exercise group reported doing the exercises at home three or more times a week during the intervention period. Only eight children reported minimal adherence to the home exercise programme (less than once a week), and only one of these eight reported not doing the home exercises at all. However, only a third of the children reported doing the exercises regularly during the intervention (i.e. every week or nearly every week). It appears that some of the children were very adherent, doing the home exercises every day during the intervention, whilst others were not very adherent, only completing the home exercises once or twice during the intervention period.

It is interesting to note that over 80% of the children at School B reported good adherence to the home exercise programme (three or more times a week). In addition, nearly half of the children at School B reported exercising at home every week during the intervention period. However, children at School A reported poor adherence to the programme, with almost half of the children reporting infrequent and irregular adherence to the home exercise programme.

5.18.3 CONTINUATION OF HOME EXERCISES POST-INTERVENTION

The children were given a short questionnaire at the three month follow-up visit to determine if they had continued with their home exercise programme once the intervention programme was completed (see Appendix L). Table 5.31 summarises their responses.

Table 5.31 Continuation of Home Exercise Programme Post-Intervention

	TOTAL (n=36)		SCHOOL A (n=20)		SCHOOL B (n=16)	
	n	%	n	%	n	%
Did you carry on with the exercises at home once the classes were finished?						
• yes	16	44.4	7	35.0	9	56.3
• no	20	55.6	13	65.0	7	43.7
Are you still doing some of the exercises at home?						
• yes	23	63.9	11	55.0	12	75.0
• no	13	36.1	9	45.0	4	25.0

Over half of the children at School B, and 35% of the children at School A, indicated that they continued with the home exercise programme once the intervention was completed. A larger percentage (75% at School B and 55% at School A) reported that they still do some of the exercises at home. These findings imply that although the children may not have continued with the full home programme, they still do some of the exercises e.g. cat and camel and hamstring stretches.

5.19 PERCEPTION OF EXERCISE INTERVENTION PROGRAMME

Children, in both the exercise group and control group, filled in a short questionnaire at the three month follow-up visit to determine their perceptions of the exercise intervention programme (see Appendix L). Their responses are summarised below.

5.19.1 EXERCISE GROUP

Table 5.32 summarises the exercise group's perception of the exercise intervention programme.

Table 5.32 Exercise Group - Perception of the Exercise Intervention Programme

	TOTAL (n=36)		SCHOOL A (n=20)		SCHOOL B (n=16)	
	n	%	n	%	n	%
Did you enjoy the exercise classes?						
• yes - all of the time	20	55.6	6	30.0	14	87.5
• yes - most of the time	11	30.5	9	45.0	2	12.5
• yes - a good bit of the time	4	11.1	4	20.0	0	0
• yes - some of the time	1	2.8	1	5.0	0	0
• yes - a little of the time	0	0	0	0	0	0
• no - none of the time	0	0	0	0	0	0
Do you think that the exercises helped you in any way?						
• yes - a lot	22	61.1	9	45.0	13	81.3
• yes - quite a bit	13	36.1	10	50.0	3	18.7
• yes - but only a little	1	2.8	1	5.0	0	0
• no - not at all	0	0	0	0	0	0
Do you think that the exercises made your back stronger?						
• yes - a lot stronger	17	47.2	7	35.0	10	62.5
• yes - quite a bit stronger	12	33.3	7	35.0	5	31.3
• yes - but only a little bit stronger	7	19.5	6	30.0	1	6.2
• no - not at all	0	0	0	0	0	0
Do you think that the exercises helped to make your low back pain feel better?						
• yes - a lot better	21	58.3	7	35.0	14	87.6
• yes - quite a bit better	8	22.2	7	35.0	1	6.2
• yes - but only a little bit better	5	13.9	4	20.0	1	6.2
• no - not at all	2	5.6	2	10.0	0	0

The majority of the children indicated that they enjoyed the exercise class. Some children at School A even wrote that they preferred the exercise classes to their normal PE classes. The majority of the children also indicated they felt that the exercises helped them to feel better and to make their backs stronger.

The children at School B consistently reported a higher percentage of positive responses. In addition, they also had better attendance at the exercise classes, were more likely to adhere to the home exercise programme, as well as to continue with the exercises at home once the programme was complete. It is interesting to note, that in the absence of regular PE classes and exercise in their timetable, the children at School B appeared to be more enthusiastic and positive about the exercise intervention programme than the children at School A.

5.19.2 CONTROL GROUP

Table 5.33 summarises the control group's perception of the exercise intervention programme.

Table 5.33 Control Group – Perception of the Exercise Intervention Programme

	TOTAL (n=31)		SCHOOL A (n=15)		SCHOOL B (n=16)	
	n	%	n	%	n	%
Would you have liked to take part in the exercise classes?						
• yes	22	71.0	12	80.0	10	62.5
• no	9	29.0	3	20.0	6	37.5
Did any of your friends show you the exercises which they did in the class?						
• yes	7	22.6	3	20.0	4	25.0
• no	24	77.4	12	80.0	12	75.0
Did you try any of the exercises which they did in the class?						
• yes	9	29.0	2	13.3	7	43.8
• no	22	71.0	13	86.7	9	56.2

The majority of the children in the control group indicated that they would have liked to have participated in the exercise intervention programme. Just over a quarter of the children in the control group reported that they had tried some of the exercises. However, it is likely that once the novelty of the intervention wore off, that most of the control group lost interest in the exercise classes. It is also unlikely that children in the control group continued with the exercises long enough on their own, in order for the exercises to have had a significant clinical impact.

5.20 SUMMARY OF MAIN STUDY RESULTS

Significant improvements in LBP prevalence, LBP intensity, as well some of the physical risk factors for LBP were observed in the exercise group post-intervention. The main findings for the total sample, as well as for each school, are summarised in Figure 5.19 on the following page.

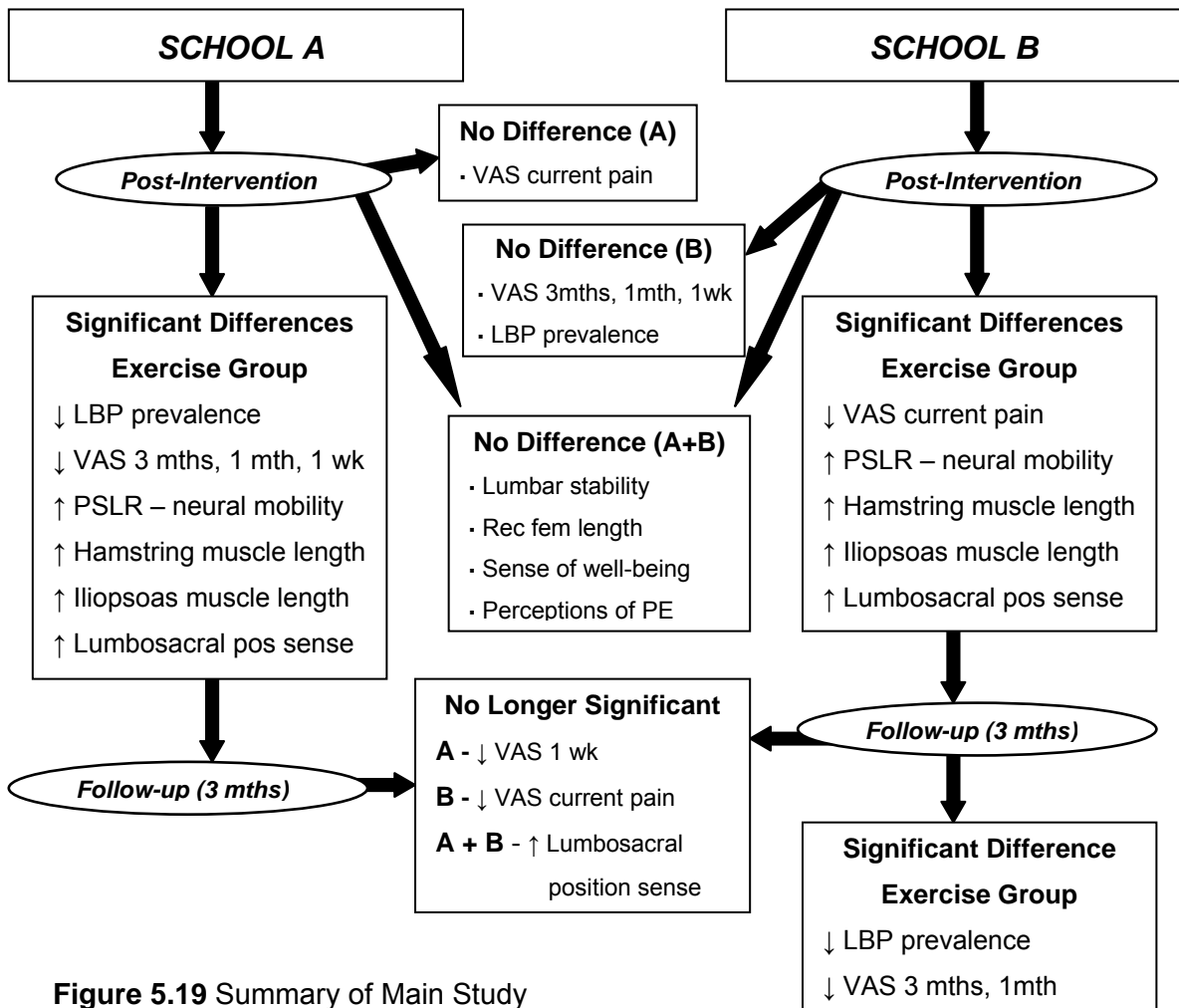
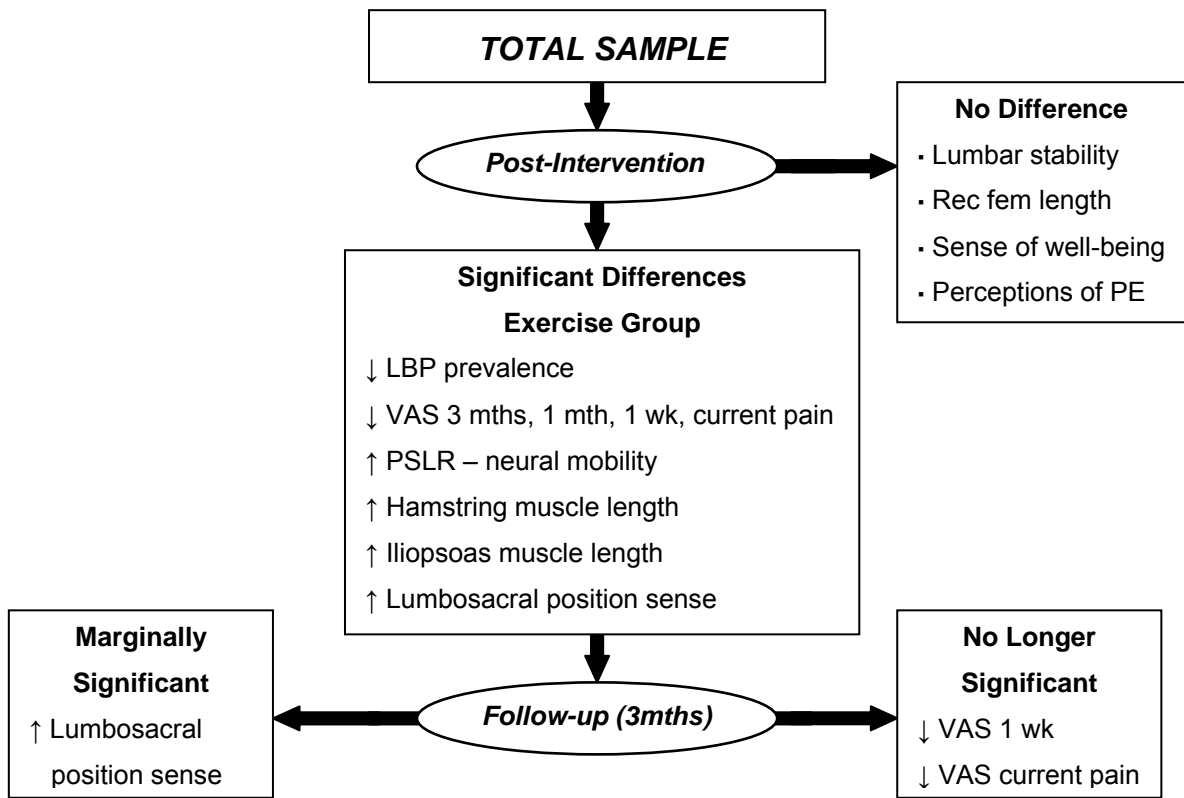


Figure 5.19 Summary of Main Study

CHAPTER 6

DISCUSSION

6.1 INTRODUCTION

The results were presented in Chapter 5. This chapter will discuss these results in detail, with particular reference to the objectives of the study. The primary objective was to determine if an exercise intervention programme would decrease self-reported episodes, as well as the intensity of LBP in 12-13 year old children. Secondary objectives included the ability of the exercise programme to modify some of the identified physical risk factors for LBP in children, as well as to positively influence the children's emotional sense of well-being and perception of exercise. The clinical recommendations, as well as the recommendations for future research which have emerged from the outcomes of this study, will also be discussed. Finally, a critical review of this study will be included in this chapter.

6.2 LOW BACK PAIN

LBP was defined as pain and discomfort, localised below the costal margin and above the inferior gluteal folds, with or without leg pain (Burton et al 2004). Only children who presented with non-specific LBP were included in this study. In both the main and the pilot study, the majority of children reported a recent onset of LBP. This is in line with current literature which indicates that the peak onset of LBP occurs during pre-puberty and early adolescence. Previous studies have found that there is a rapid increase in LBP reporting around 11 to 14 years of age, which is most likely associated with the onset of the rapid growth spurt (Trevelyan and Legg 2006; Grimmer and Williams 2000; Leboeuf-Yde and Kyvik 1998).

Although the number of children who complained of LBP in this study decreased over the six month period, there was little difference in the pain behaviour reporting of those who still complained of LBP at both follow-up visits. In addition, pain behaviour reporting of children in the main study was similar to that observed in the pilot study. The majority of children reported infrequent episodes of LBP (once / twice a month or once every three months), which lasted an average of a few hours to one day. These findings indicate that LBP in this age group is more likely to be recurrent, as opposed to chronic, in nature. On average, the children reported a moderate intensity of LBP, with only a small percentage of children indicating that they had to stop or change their sporting activities as a result of

LBP. The majority of children did not consult a medical practitioner or physiotherapist, take any medication or stay home from school due to LBP. This indicates that LBP in this age group is not likely to be very severe, nor is it associated with the level of functional disability which is observed in adults with chronic and recurrent LBP. It is interesting to note that the percentage of children who stayed home from school due to LBP, decreased substantially in the exercise group. Numerous LBP studies in the adult population have reported a decrease in absenteeism, as well as the number of sick days taken, after participation in an exercise intervention programme. However, only a relatively small percentage of children reported staying home from school at baseline, so one cannot place too much significance on these findings, in this study. The majority of children reported LBP which was localised to the low back (either one side or both sides) and which did not radiate to the buttocks or the legs. Considering that most of the reported pain appears to be isolated to the low back, with relatively fewer reports of referred pain and radiculopathy, it is likely that the cause of LBP is generally not serious in this age group. Therefore, it can be concluded that LBP in children is most likely recurrent, generally not severe or disabling and that it is uncommon for LBP in this age group to be as a result of serious underlying pathology. All of these findings are similar to those observed in previous studies (Kovacs et al 2003; Watson et al 2002).

A possible limitation of this study is the fact that it relied on self-reported LBP. Some authors have stated that self-reported LBP should be guarded by a degree of uncertainty (Kjaer et al 2005). However, there is good evidence that young people are accurate historians of events of recent pain (Kovacs et al 2003; Grimmer and Williams 2000; Adams et al 1999). In addition, self-reported LBP is used for the diagnosis of LBP in the *International classification of diseases* (Mikkelsen et al 2006). The consistency of pain behaviour reporting in this study also indicates that self-reported LBP in this age group can provide valuable, reliable insight into the nature of LBP in children.

6.2.1 LBP PREVALENCE

A significant reduction in the three-month prevalence of LBP was observed in the exercise group immediately post-intervention and maintained at the three month follow-up visit. In comparison, a very high percentage of children in the control group still complained of LBP at the three month follow-up. The large proportion of children in the control group who still reported LBP at the three month follow-up is possibly more intriguing than the significant reduction which was observed in the exercise group. Prior to commencing the study, the probability of a spontaneous resolution of LBP in this age group was identified as a possible limiting factor. However, it is interesting to note that only a few children in

the control group demonstrated a 'spontaneous' resolution of LBP. Therefore, one can assume that it was possibly only a similar small percentage of children in the exercise group who also had a 'spontaneous' resolution of their LBP. In addition, Watson et al (2002) has observed that there are no significant differences in children's pain behaviour reporting at different times of the year. Therefore, it can be concluded that the majority of the improvement, which was observed in LBP prevalence in the exercise group, may be attributed to the positive effect of the exercise intervention programme on the children's LBP.

Although there are many exercise intervention studies for LBP in adults, there is currently only one LBP exercise study available in a younger population. Therefore, the results of this study will also be compared to the findings of previous adult LBP intervention studies. However, it must be taken into account that non-specific LBP in children should be considered as a specific subset of LBP, which is not necessarily comparable to episodes of chronic or recurrent LBP in adults. Nevertheless, exercise interventions in the adult population have shown similar post-intervention improvements in LBP prevalence. A significant decrease in the recurrence of LBP, following participation in a specific exercise programme, has been observed in numerous adult studies, with the improvements being maintained at subsequent follow-up visits, even up to three years later (Suni et al 2006; Koumantakis et al 2005a; Hayden et al 2005; Hodges 2003; Hides et al 2001; Kankaanpää et al 1999; O'Sullivan et al 1997; Frost et al 1995).

Only one of the previous LBP preventative studies in children included a specific exercise programme as an intervention (Jones et al 2007). However, as with many of the other available studies, this study did not include LBP prevalence / recurrence as an outcome measure. In their systematic review, Steele et al (2006) could only find two studies which included pain prevalence as an outcome measure. Both studies reported a significant decrease in one-week pain prevalence post-intervention. In comparison, no significant changes in one-week LBP prevalence were observed in two of the more recent studies (Cardon et al 2007; Geldhof et al 2006). However, it is difficult to compare these results as the components of all of the intervention programmes were different. In addition, these studies included all children, whether they had previously complained of LBP or not. It is also possible that the outcome measure of one-week prevalence, which was used in all of the above studies, did not give an accurate representation of LBP prevalence in the samples. Considering that the majority of children reported infrequent episodes of recurrent LBP in this study, it is possible that the three-month prevalence of LBP is a more appropriate outcome measure in this age group.

Once again, the high prevalence of LBP observed in the control group over the six month period indicates that episodes of LBP during childhood are most likely to be recurrent in nature. Balagué et al (1999) noted that LBP in children and adolescents is most often recurrent (50% on average). In addition, they observed that 8% of children already presented with symptoms of chronic LBP at a young age. Studies have shown that the severity of LBP, the degree of disability associated with LBP and the need to access medical care for LBP, increases with age (Kovacs et al 2003; Watson et al 2002). Therefore, Watson et al (2002) concluded that, whilst LBP during childhood is generally not severe, it should also not be considered as completely trivial either. Results from this study indicate that severe, disabling LBP is rare in children of 12-13 years of age. In addition the exercise programme significantly decreased the prevalence and recurrence of LBP in this age group. Therefore, it can be concluded that 12-13 year olds, as well as even younger children, are an ideal target population for LBP preventative interventions, which aim to minimize the impact of LBP on their health and function as they grow older.

Considering the recurrent nature of LBP, as well as the likelihood of children developing early chronic or disabling LBP during childhood, preventative interventions in this age group should ideally target the reduction of LBP episodes. However, in order to determine the long-term effect of preventative interventions on LBP, it is necessary to follow the children through adolescence to adulthood. As the nature of LBP still remains largely a mystery, long term follow-up would also help to determine the long term consequences of childhood LBP, as well as the natural course of LBP from childhood to adulthood.

6.2.2 LBP INTENSITY

A significant reduction in the reported intensity of LBP was also observed in the exercise group, for VAS (3 months), VAS (1 month), VAS (1 week) and VAS (current pain), immediately post-intervention. However, only the improvements in VAS (3 months) and VAS (1 month) remained significant at the three month follow-up. All of the above findings were both clinically and statistically significant.

The larger, more significant improvements in the VAS scores for worst pain in the past three months and past one month can be attributed to the recurrent nature of LBP in this age group. The majority of children reported infrequent episodes of LBP only once / twice a month or once every three months, as well as higher intensity of pain at baseline for VAS (3 month) and VAS (1 month). Therefore, the relevance of both the VAS (1 week) and VAS (current pain) as appropriate outcome measures in determining the efficacy of LBP preventative interventions in children is questionable. Considering that children

reported infrequent episodes of LBP, it is likely that studies which only use VAS (1 week) or VAS (current pain) as an outcome measure may well obtain an inaccurate perception of LBP intensity.

It is interesting to note that the children at School B reported a lower intensity of LBP at baseline, in comparison to the children at School A. Although every effort was made to choose two schools which were as similar as possible, the race demographics did differ between the schools. The sample at School A was majority white, whilst the sample at School B was majority black. However, previous studies have indicated that the prevalence of LBP is similar, irrespective of different culture, race, lifestyle and geographic location (Kovacs et al 2003). In contrast, differences in body awareness, pain perception, styles of reporting and personality may influence LBP reporting (El-Metwally et al 2007; Kovacs et al 2003). Chronic LBP in parents can also influence the child's pain behaviour response and reporting (Trevelyan and Legg 2006; Cardon and Balagué 2004; Balagué et al 1999). Therefore, it is most likely that the difference in LBP intensity reporting between the schools cannot purely be ascribed to race. Rather, it is as a result of a complex interaction between different personality types, personal pain experiences and exposure to parental LBP, which is not necessarily related to school or race. In addition, children at School A consistently reported indifference to school and life in general, whereas children at School B consistently reported that they were happy with school and life in general. Therefore, it is also possible that the apparent indifference (lower sense of well-being) at School A could explain the higher LBP intensity reports, whereas the relatively happier children at School B reported a lower intensity of LBP. However, by the three month follow-up, significant improvements in VAS (3 months) and VAS (1 month) were observed in the exercise group at both schools. In addition, there were no significant differences in VAS (1 week) and VAS (current pain) at either school at the three month follow-up.

School A demonstrated a larger improvement in LBP prevalence and intensity, from baseline to the first follow-up visit immediately post-intervention. In comparison, School B demonstrated a larger improvement from the first post-intervention follow-up visit to the second follow-up visit, three months post-intervention. It is possible that the extended interruption in the exercise intervention at School B, as a result of the strike, could account for these differences. In addition, a larger percentage of children at School B, as opposed to School A, reported that they continued with the exercises at home once the classes were finished. This could also provide a possible explanation as to why the exercise group at School B showed a larger improvement at the three month follow-up, as opposed to immediately post-intervention.

Once again, due to the lack of similar childhood studies, these findings will once again be compared to exercise intervention studies in the adult population. Similar clinically significant improvements in LBP intensity have been observed in adult exercise intervention studies, with the improvements in pain intensity being maintained at subsequent follow-up visits, even up to three years later. These studies assessed VAS scores for either the worst pain experienced in the past month, past six weeks or past two months. The follow-up visits ranged between three months and three years post-intervention (Sun et al 2006; Koumantakis et al 2005a; Soukup et al 2001; Kankaanpää et al 1999; O'Sullivan et al 1997). Interestingly, some of these studies also observed that the reported pain intensity decreased significantly at each subsequent follow-up visit in the intervention group (Sun et al 2006; Soukup et al 2001; Kankaanpää et al 1999). As mentioned previously, this was also observed at School B in this study. Although the exercise intervention programmes and study samples differed in each of the above studies, significant improvements in pain intensity were observed post-intervention and maintained as long as three years later.

Studies have found that adults, who are more fearful and less optimistic about their abilities to function with LBP, are more likely to report a higher intensity of pain and related disability. In contrast, involvement in exercise programmes has been shown to improve an adult's self-efficacy and functional ability and, as a result, they are more likely to report a lower intensity of pain (Koumantakis et al 2005a; Frost et al 1995). Therefore, Koumantakis et al (2005a) proposed that it is the involvement in activity through safe exercises and not necessarily the particular type of exercise, which is responsible for the improvement of LBP intensity in adults. However, considering that it was only a small percentage of children who reported severe, disabling LBP in this study, it is questionable whether this would apply to children as well.

Only three of the available childhood preventative intervention studies reported on LBP severity. None of these studies used the VAS to determine LBP intensity. The recent exercise intervention study used a ten-point pain scale for worst pain the past week. Jones et al (2007) reported a significant improvement in LBP severity in the exercise group immediately post-intervention. However, they did not include any subsequent follow-up visits, so it is unknown whether this improvement was maintained.

The other two studies used a five-point pain scale for worst pain in the past week. Cardon et al (2002) found that the majority of children reported minimal pain at baseline and that there was no significant change in pain intensity post-intervention. Geldhof et al (2006)

also observed that the majority of children reported a low intensity of pain at baseline, and found that an even larger percentage of children, in both the intervention and the control group, reported low pain intensity post-intervention. As a result, both authors concluded that LBP outcomes (prevalence and intensity) were perhaps not relevant as short term primary outcome measures for LBP preventative intervention programmes in children. However, the results of this study have shown that an exercise intervention can significantly decrease LBP intensity (VAS scores), as well as LBP prevalence, after only eight weeks. In addition, Suni et al (2006) identified that it is the effective treatment of pain which is the key issue in the prevention of chronic LBP and disability. Although Jones et al (2007) also reported a significant improvement in LBP intensity immediately after an eight week exercise intervention; they only assessed worst pain experienced in the past week. It is possible that, by limiting their assessment of pain intensity to worst pain experienced in the past one week, all of the above studies did not obtain an accurate representation of pain intensity in their sample. Nevertheless, considering the current lack of evidence that LBP preventative interventions are effective in reducing the intensity and recurrence of LBP in children, the significant improvements which were observed in this study are very promising. In addition, although Jones et al's (2007) assessment of pain intensity and LBP prevalence were very limited, their results also indicated that involvement in exercise programmes is beneficial for children suffering from LBP. Therefore, it can be concluded that future school-based intervention studies should ideally include exercise as a component of their LBP prevention programmes.

6.2.3 SUMMARY AND CLINICAL IMPLICATIONS

The aim of a secondary preventative intervention programme is to prevent episodes of LBP from becoming chronic or recurrent. The results of this study indicate that this specific exercise intervention programme was effective in reducing the prevalence of LBP in this age group. In addition, an improvement in pain intensity was also observed. Considering that the majority of the 12-13 year old children in this study had not yet reported severe or debilitating LBP, it would appear that this is an ideal target age for LBP preventative interventions. Therefore, LBP exercise prevention programmes should be implemented early, to minimize the impact of LBP on children's health and function, as well as to curb the development of LBP related fear-avoidance behaviours as they grow older.

6.3 PHYSICAL RISK FACTORS

Physical risk factor modification was included as a secondary objective in this study. There has been much debate in the literature regarding the modification of risk factors in the prevention of LBP in children. Interventions which simply modify risk factors cannot be considered as LBP preventative interventions. In order for a study to be considered as a LBP preventative intervention, it needs to be able to positively influence primary LBP outcomes (Burton et al 2004; Cardon and Balagué 2004). Therefore, this study used LBP prevalence and intensity as primary outcome measures. However, certain identified modifiable risk factors for LBP in children were also included, as secondary outcome measures.

Improvements were observed in the exercise group for the majority of the identified physical risk factors which were assessed in this study. However, the correlations and associations between the changes in the physical risk factors and LBP prevalence / intensity were not analysed for this dissertation. Therefore, although the exercise intervention resulted in improvements in some of the physical risk factors, this does not necessarily imply that modification of identified risk factors lowers the risk or recurrence of LBP.

6.3.1 LUMBAR STABILITY

Although the physiotherapist, who instructed all the exercise classes, felt that there was a clinical improvement in the muscle strength of the deep stabilizing muscles, no improvement was observed in the ASLR test in the exercise group. Children in both the exercise and the control group consistently demonstrated poor lumbar stability in the ASLR test over the six month period. However, research into the area of deep stabilizing muscles is very difficult. The majority of the muscles which need to be tested are deep and require invasive, expensive procedures to accurately determine muscle activity. In addition, the optimal measure to test strength and co-ordination remains unclear (Barr et al 2007; Barr et al 2005).

Jull et al (1993) noted that conscious activation of the stabilizing muscles made little difference to rotatory stability. They concluded that conscious activation did not change the ability of these muscles to control the spinal position in the ASLR, and that the ASLR test was, thus, a good measure of automatic muscle support and control. Therefore, although it is possible that there was an improvement in the conscious activation and endurance of the deep stabilizing muscles in the exercise group in this study, this

obviously did not translate to the automatic activation and integration which is required to maintain dynamic stability during the ASLR. It could be argued that the ASLR test is not the most appropriate measure of lumbar stability. However, improvements in some of the other clinical tests for stabilizer endurance have not been shown to correlate with symptomatic improvement of LBP, or with an enhanced ability to stabilize the spine (Barr et al 2007). Therefore, it would appear that testing the efficacy of the automatic, dynamic stabilization system is more appropriate. In addition, the ASLR is a cost effective measure, which does not require large, invasive equipment and can be carried out easily in any environment.

Numerous adult exercise intervention studies have observed an improvement in LBP outcomes, which were not related to changes in physical outcome measures, such as improvement in muscle strength or endurance (Suni et al 2006; Koumantakis et al 2005b; Hodges 2003; Kankaanpää et al 1999). However, changes in neural activation of the trunk musculature and neural drive adaptations have been shown to occur after involvement in exercise interventions for LBP (Koumantakis et al 2005b; Mannion et al 2001). These changes promote optimal muscle activation patterns, improve performance and improve control of the lumbar neutral zone, which decreases harmful loading of the structures in the lumbar spine (Suni et al 2006; Hodges 2003). It appears that, whilst neural drive adaptations can be observed after only eight weeks of exercise (Koumantakis et al 2005b), it obviously takes longer for measurable changes to be observed in the deep stabilizing muscles of the lumbar spine.

6.3.2 NEURAL MOBILITY

A significant improvement in neural mobility (PSLR) was observed in the intervention group immediately post-intervention, and this improvement was maintained at the three month follow-up. Poor neural mobility has been identified as a risk factor for LBP. The PSLR tests all aspects of the nervous system mechanics from the toes to the brain, including the sympathetic trunk (Butler 1991). A limited PSLR has been shown to alter the biomechanics of the lumbar spine and lower limbs during functional activities, further contributing to the development and maintenance of LBP (Shum et al 2005; Rebain et al 2002). However, despite the identified link between poor neural mobility and LBP, no exercise intervention studies were found which included neural mobility as an outcome measure.

On average, children in this study demonstrated poor neural mobility at baseline. Considering the negative effects of poor neural mobility on the biomechanics of the

lumbar spine, the improvement observed in neural mobility in this study has clinical significance as well. Good neural mobility promotes optimal movement patterns which, in turn, limit the child's susceptibility to the adverse effects of abnormal stresses and loads which may be placed on the spinal structures.

Interestingly, the children at School A demonstrated, on average, poor neural mobility at baseline, whilst the children at School B demonstrated significantly better neural mobility at baseline. A recent, cross-sectional study observed a similar, statistically significant association between neural mobility and race in South Africa. The findings indicated that black children were more likely to demonstrate moderate to good neural mobility, whilst white children demonstrated poor to moderate neural mobility (Jordaan 2005b). It is possible that there may be a link between neural mobility and LBP intensity in this sample. Children at School A reported a higher pain intensity and had poor neural mobility, whilst children at School B reported a lower pain intensity and had moderate neural mobility. However, the statistical significance of this relationship was not analysed in this dissertation, as it was not one of the study objectives.

6.3.3 MUSCLE LENGTH

Significant improvements were observed in hamstring and iliopsoas muscle length in the exercise group immediately post-intervention, as well as at the three month follow-up. However, there were no significant differences in rectus femoris muscle length in either group at both follow-up visits. Although the available literature indicates that there is a correlation between LBP and tight hamstrings, iliopsoas and rectus femoris muscles in children, there is no evidence to indicate that lengthening these muscles will decrease LBP in children (Burton et al 2004; Cardon and Balagué 2004; Balagué et al 1999).

It is interesting to note that there was no change in rectus femoris muscle length in the exercise group. Children in both groups, at both schools consistently demonstrated moderate rectus femoris muscle length. However, most of the children found the rectus femoris stretch, which was included in the exercise programme, very difficult. In addition, theraband was used to assist the children with the stretch if they were unable to reach their ankle. Theraband is an elastic material and it is not therapeutically optimal to use an elastic material to sustain a static stretch. The exercise may have been more effective if a rigid material was used to assist the children with the stretch. Therefore, it is possible that it was not the most effective, appropriate stretching exercise for this age group.

In comparison, an improvement in hamstring and iliopsoas muscle length appears to be associated with decreased episodes and intensity of LBP in this study. However, whether or not these associations are significant was not included in the statistical analysis in Chapter 5, as it was not one of the study objectives.

A significant difference was observed between the two schools for hamstring muscle length at baseline. The children at School B (majority black) demonstrated, on average, better hamstring flexibility than the children at School A (majority white) at baseline. Once again, Jordaan (2005b) observed a similar, statistically significant association between hamstring muscle length and race in South Africa. The findings indicated that black children were more likely to demonstrate moderate to good hamstring muscle length, whilst white children demonstrated poor to moderate hamstring muscle length.

6.3.4 LUMBOSACRAL POSITION SENSE / PROPRIOCEPTION

A significant improvement in lumbosacral position sense was observed in the exercise group immediately post-intervention. However, the improvement was only marginally significant at the three month follow-up. Brumagne et al (2000) proposed that interventions which enhance proprioceptive acuity may reduce the recurrence of LBP and aid in the recovery of LBP. However, it is unclear whether balance and proprioceptive deficits in adults with LBP improve with a lumbar stabilization programme (Barr et al 2005). Leinonen et al (2003) found that in the adult population, impaired postural control and proprioception remained unchanged after three months of active rehabilitation and, in fact, that it deteriorated even further in some patients. Kuukkanen and Mälkiä (2000) followed up adults over one year, and also observed that there were no changes in postural sway and postural control, after a three month intervention. It is, therefore, very interesting to note that, in this study, the exercise group demonstrated an improvement in lumbosacral position sense immediately post-intervention. Whilst the ability to modify proprioceptive deficits in the adult population appears to be limited, children in this study demonstrated an improvement after only eight weeks of exercise. Proprioceptive deficits result in abnormal loading, particularly end of range spinal loading, which leads to degenerative disease and the maintenance of chronic pain (O'Sullivan et al 2003). Therefore, it is possible that improving lumbosacral proprioception in childhood could be one of the key links in preventing LBP in adults.

6.3.5 SUMMARY AND CLINICAL IMPLICATIONS

An eight-week specific exercise programme is effective in improving neural mobility, hamstring muscle length, iliopsoas muscle length and lumbosacral proprioception in 12-13

year old children. No improvements were observed in the ASLR test for lumbar stability or in rectus femoris muscle length. However, whether an improvement in muscular function and other physical risk factors is associated with a reduction in LBP recurrence and intensity remains debatable. Studies in the adult population have indicated that LBP outcomes improve without significant changes in muscular function, and simply modifying risk factors in children has not been proven to prevent LBP either.

However, the baseline measurements in this study indicated that musculoskeletal imbalances were already present in this group of 12-13 year old children with LBP. This is consistent with findings in previous studies that have identified musculoskeletal imbalances, which occur during the growth spurt, as one of the prime underlying causes of LBP in childhood (Grimmer and William 2000; Newcomer and Sinaki 1996). Inappropriate physical activity or sudden increases in physical activity during the growth spurt have also been identified as risk factors for LBP (Adams et al 1999; Newcomer and Sinaki 1996). During periods of rapid growth, the spinal structures are believed to be prone to structural damage, as they are less able to withstand stresses and loads which are placed on them, making them more susceptible to injury, sprains and strains (Jordaan et al 2005a; Grimmer and Williams 2000).

Therefore, the improvements which were observed in the physical risk factors in this study may also be considered to be of clinical importance. Appropriate exercise can promote optimal muscle length, neural mobility and proprioception. In addition, although there were no significant changes in lumbar stability, it is likely that neural drive adaptations occurred as a result of the exercise intervention. Considering that changes were observed after only eight weeks of exercise, it would appear that regular involvement in specific exercise programmes during childhood will promote optimal spinal alignment and tissue loading during the growth spurt. If abnormal movement patterns, musculoskeletal imbalances and associated abnormal spinal loading, are corrected during childhood, it may be possible to prevent the onset of chronic and recurrent LBP syndromes.

6.4 SENSE OF WELL-BEING

A strong link has been identified between psychosocial risk factors and LBP in children (Watson et al 2003). In addition, involvement in exercise and physical activity has been shown to have a high relation to positive attitudes in adolescents (Sollerhed et al 2005). Therefore, sense of well-being was included as a secondary outcome measure in this study. However, the exercise intervention did not have a significant impact on sense of

well-being in the exercise group. Children in both the exercise and control group consistently reported a moderate sense of well-being (MHI-5). Children at School A consistently reported indifference to school and life in general, and children at School B consistently reported that they were happy with school and life in general, irrespective of which groups they were in.

Currently, there is no evidence to indicate that modification of psychosocial factors or sense of well-being has an impact on LBP outcomes in children (Burton et al 2004). The results from this study indicate that, although there was a significant reduction in episodes and intensity of LBP, there was no change in sense of well-being in the exercise group. This is an interesting finding, especially considering that Watson et al (2003) has suggested that psychosocial factors may contribute more significantly to LBP in children than mechanical factors.

Although this study did not include an extensive assessment of psychosocial factors, the MHI-5 is a commonly used, valuable, reliable screening test for symptoms of depression and anxiety. The two face scales provided additional insight into the children's general perceptions of school and life. Therefore, the sense of well-being outcomes in this study did provide a fairly comprehensive account of the children's emotional sense of well-being.

However, the children who were included in this study were in the transition phase between childhood and puberty. This is a difficult time for children as they go through hormonal changes, physical changes and emotional changes. In addition, they are facing the prospect of changing schools at the end of the year, as they leave primary school for high school. Therefore, it is not surprising that the eight week exercise programme did not have much impact on the children's sense of well-being in this study.

Koumantakis et al (2005a) included four psychological outcome measures in their adult LBP intervention study, an eight week exercise programme based on the biomechanical framework. They found significant improvements in three of the four psychological outcomes. However, many of the psychosocial risk factors for LBP in adults appear to be associated with fear avoidance beliefs. Exercise intervention studies in the adult population have indicated that improvements in self-efficacy, as well as a reduction in fear avoidance beliefs, are significantly associated with a reduction in LBP (Koumantakis et al 2005a; Frost et al 1995). There is also evidence to indicate that patients who attribute their improvements to their own efforts are less likely to relapse (Frost et al 1995). In

addition, it is also likely that participation in structured LBP exercise classes provides a psychological support structure for adult LBP sufferers. However, it is questionable whether a school-based exercise class would provide a similar support group benefit for children, or how significant fear avoidance beliefs are in contributing to recurrent LBP episodes in children.

6.4.1 SUMMARY AND CLINICAL IMPLICATIONS

Although an eight week specific exercise programme is effective in reducing the prevalence and intensity of LBP, it does not appear to be effective in positively influencing emotional sense of well being in 12-13 year old children. Nevertheless, psychosocial factors are still important risk factors for the development of LBP during childhood. Therefore, LBP intervention programmes should ideally also include components that address the psychosocial risk factors which are associated with LBP.

6.5 PERCEPTION OF EXERCISE

Children's perceptions of exercise, as well as their involvement in physical activity during their early teens, have both been identified for their importance in the transition of physical activity behaviours from childhood to adulthood (Cardon et al 2007; Cardon et al 2005). One of the secondary objectives of this study was to determine if the exercise intervention would positively influence children's perception of exercise and PE.

Children in this study consistently reported a positive perception of PE as a subject, irrespective of which group they were in. This is a very promising finding, as it indicates that children of 12-13 years of age are still keen to exercise and that they are aware of the importance of PE as a subject. The majority of the children in the exercise group also indicated that they really enjoyed the exercise classes. Once again, this highlights the suitability of this age group as a target population for LBP exercise intervention programmes. Children should be included in appropriate, specific exercise programmes early whilst they are still enthusiastic about exercise and are willing to participate and learn new skills. In this way, children can develop healthy exercise habits, which they will hopefully carry through adolescence to adulthood.

Children consistently reported that the exercises which they had done in PE only had a moderate impact on their health and function. In comparison, the majority of the children in the exercise group reported that the specific exercise classes helped them to feel better and to improve their back strength. In addition, some of the children even indicated that

they preferred the exercise classes to their normal PE classes. Therefore, it could be proposed that specific exercises would be a welcome addition to normal PE classes. This will provide an ideal opportunity to lay the foundation of positive exercise habits in a large population of children.

6.5.1 SUMMARY AND CLINICAL IMPLICATIONS

Children, aged 12-13 years, still express a positive perception of PE as a subject, and appear to recognise the importance of exercise in their school timetable. In addition, children in the exercise group in this study not only participated enthusiastically in the exercise programme, they also expressed a positive impact of the exercise intervention on their health. Therefore, children of 12-13 years of age are an ideal, receptive target population for exercise intervention programmes.

6.6 COMPARISON BETWEEN SCHOOLS

As a result of the prolonged public servants' strike, the exercise intervention was interrupted for six weeks at School B. Therefore, the results were also analysed separately for each school to determine if the interruption in the exercise programme influenced the outcomes. Interestingly, there were few discrepancies in the post-intervention findings between the two schools.

Both schools demonstrated statistically significant improvements in neural mobility, hamstring muscle length and iliopsoas muscle length immediately post-intervention and at the three month follow-up. Both schools also demonstrated a marginally significant improvement in lumbosacral position sense immediately post-intervention. In addition, there were no significant differences in lumbar stability, rectus femoris muscle length, sense of well-being or perception of PE at either school at both follow-up visits.

The only differences between the two schools were for LBP prevalence and VAS scores immediately post-intervention. There were significant improvements in LBP prevalence, VAS (3 months), VAS (1 month) and VAS (1 week) at School A immediately post-intervention, whereas there was only a significant improvement in VAS (current pain) at School B immediately post-intervention. However, it is questionable whether these differences were as a result of the disturbance in the exercise programme due to the strike, or whether they were as a consequence of the variation in pain intensity reporting which was observed between the two schools at baseline (as mentioned previously). In addition, by the three month follow-up visit these differences were no longer present. LBP

prevalence, VAS (3 months) and VAS (1 month) had all improved significantly in the exercise groups at both schools, by the three month follow-up.

6.6.1 SUMMARY AND CLINICAL IMPLICATIONS

Despite a six week interruption in the exercise programme at School B, by the three month follow-up there were no differences between the two schools for any of the LBP or risk factor outcome measures. Therefore, even when the eight week exercise intervention was interrupted for six weeks, similar improvements in both LBP and risk factor outcomes were still observed.

6.7 SCHOOL-BASED INTERVENTION PROGRAMMES

Schools have been identified as ideal environments for LBP intervention programmes, as they provide enormous potential to reach a large population of children who are receptive to new knowledge and skills acquisition (Cardon et al 2007; Geldhof et al 2006). However, in order for school-based interventions to be successful, they require the support and involvement of the school. Cardon et al (2007) recognised the difficulty of implementing intervention programmes in a school curriculum that is already full, and similar difficulties were also encountered in this study. It proved very difficult to find schools that were prepared to accommodate the exercise intervention in their school curriculum. It appears that schools are more willing to participate in cross-sectional studies, as opposed to intervention studies, which require a larger commitment of their time, as well as some involvement of their teaching staff. Nevertheless, the efficacy of school-based interventions is unquestionable. School-based interventions remain the first choice in LBP preventative studies in children. However, it is important to remember that there is only limited 'free' time available in the school curriculum. Therefore, only the most effective components of LBP preventative interventions should be included in the already busy school timetable.

6.7.1 SUMMARY AND CLINICAL IMPLICATIONS

School-based interventions provide a perfect environment and target population to promote LBP prevention during childhood. However, as school-based programmes should ideally form an integral part of the school curriculum, support and co-operation is required from the participating schools in order for the interventions to be successful. In order for this to be possible, collaboration from both the Department of Education and the Department of Health is essential. School-based interventions will only be successfully implemented, as an integral part of the school curriculum, if both the Department of

Education and the Department of Health endorse the LBP preventative intervention programmes.

6.8 EXERCISE PROGRAMME

The specific exercise programme which was included in this study was effective in reducing episodes and intensity of LBP in 12-13 year old children. Mikkelsen et al (2006) proposed that exercise during childhood and adolescence may modify the sensory perception of peripheral pain at the level of the central nervous system, which will result in fewer pain syndromes in adolescence and adulthood. Although this study only followed the children over six months, a progressively significant reduction in LBP prevalence was still observed in the exercise group at each subsequent follow-up visit. Therefore, it is possible that Mikkelsen et al's (2006) theory may well be relevant to this age group.

Simply advising children to exercise and be active is not effective as a LBP preventative intervention (Cardon et al 2007), and supervised exercise classes have been shown to be more effective in LBP prevention (Frost et al 1995). Appropriate exercise during the growth spurt can help to promote optimal spinal alignment, dynamics and loading, as well as enhance back function and minimize injury (Mikkelsen et al 2006; Jordaan et al 2005a). In addition, it can help children to learn to be responsible for their health, whilst acquiring valuable exercise knowledge as well as developing healthy exercise habits, which can help to prevent LBP (Méndez and Gómez-Conesa 2001).

The exercise programme in this study was only eight weeks long, and the children were required to do the home exercises three times per week on their own. However, adherence to the home exercise programme varied greatly. Nevertheless, the home exercise sheets ensured that the children received a valuable health tool which they could take home with them, and which empowered them to do the exercises on their own. Important goals of LBP preventative programmes are to change patient knowledge, change patient behaviour and promote self management (Henschke et al 2007). Therefore, although increasing the length and frequency of the exercise interventions will obviously have a greater impact on LBP and physical risk factor outcomes, ensuring that children receive the knowledge and power to manage their own LBP and health, is essential.

6.8.1 SUMMARY AND CLINICAL IMPLICATIONS

Specific exercise programmes are effective in reducing episodes and intensity of LBP in children. Involvement in specific exercise programmes at an early age, particularly during

the growth spurt, can help promote optimal growth and spinal loading, as well as help modify the sensory perception of peripheral pain at the level of the central nervous system.

6.9 CLINICAL RECOMMENDATIONS

Numerous, interesting findings were observed in this study. Considering the current lack of literature available on LBP exercise interventions in children, several clinical recommendations may be made from the results of this study.

LBP in children appears to be recurrent, with prevalence, severity and associated disability increasing with age. Therefore, preventative interventions should be implemented early, before LBP becomes more severe, disabling and burdensome on the economy, as well as the already overloaded health care system. Recommendations regarding LBP outcomes in preventative interventions in childhood are listed below:

- LBP prevalence should be included as a primary outcome measure in school-based intervention programmes, in order to determine the ability of an intervention to reduce the recurrence of LBP in children
- It is more appropriate to use the three month prevalence of LBP as a LBP outcome measure, in order to gain a clearer, more accurate understanding of the nature of LBP and the impact of preventative interventions on LBP in children
- VAS (3 months) and VAS (1 month) should be used as primary outcome measures in LBP research in children, as they appear to be more accurate, relevant measures of pain intensity in this age group, where the majority of children report recurrent episodes of LBP

The results of this study indicate that a specific exercise programme is effective in reducing episodes and intensity of LBP in 12-13 year old children. In addition, it was also effective in modifying some of the identified physical risk factors for LBP in children, namely; neural mobility, hamstring muscle length, iliopsoas muscle length and lumbosacral proprioception. The children reported a positive perception of PE and were enthusiastic about participating in the exercise intervention. Recommendations regarding specific exercise programmes as LBP preventative interventions are listed below:

- Children with LBP should take part in specific exercise programmes which target core stability, neural mobility, proprioception and muscular imbalances, in order to

promote correct alignment of the spine during growth, and to help minimise LBP recurrence

- Specific exercise programmes should be implemented early, even before 12 years of age, as children in this study already demonstrated poor neural mobility and musculoskeletal imbalances
- In addition, exercise intervention programmes should be implemented early, whilst children are still enthusiastic about exercise and PE
- Specific exercise intervention programmes could possibly provide additional benefits if they were more regular and continued for a longer period than eight weeks, ideally as an integral component of the school's PE programmes
- Specific exercise programmes should include a home exercise component, in order to provide the children with the health tools they may need to manage future episodes of LBP during adolescence and as adults
- Post-intervention follow-up should ideally be continued over an extended period of time, in order to determine the long term effect of preventative interventions on adolescent and adult LBP
- The development of more appropriate, cost effective measurements of the deep stabilizing muscles may prove beneficial for future research in this field
- The value of progressing core stability exercises further to include dynamic stabilization exercises should be investigated
- Stretches for rectus femoris may need to be modified, possibly to include contract / relax stretches, to help improve rectus femoris muscle length in this age group
- Lumbar proprioception should be a focus of regular LBP preventative exercise programmes in children, and the long term impact on LBP in adults investigated

Psychosocial factors have been identified as important risk factors for LBP in children. However, the exercise intervention did not appear to positively influence emotional sense of well-being in this study. Recommendations regarding psychosocial factors in LBP preventative interventions are listed below:

- A multi-disciplinary approach is required in LBP preventative interventions to address the psychosocial aspect of LBP
- Regular psychosocial screening tests should be conducted in school-going children and the appropriate referrals made, in order to identify psychosocial problems early and to try to curb the development of related somatic pain and disorders, such as LBP

School-based interventions have been identified as the most effective way to reach a large population of children. However, numerous obstacles were encountered in this study whilst trying to find a school which was prepared to incorporate the exercise programme in their busy curriculum. Recommendations regarding school-based interventions are listed below:

- LBP preventative interventions should be implemented as school-based programmes, ideally as an integral component of the school curriculum
- Evidence based LBP intervention programmes need to be accredited and endorsed by the Department of Education and the Department of Health, in order for them to be successfully implemented in schools across the country

In conclusion, in the absence of current, evidence-based guidelines for the prevention, treatment and management of LBP in children, the results of this study indicate that exercise is effective in reducing the prevalence, recurrence and intensity of LBP during childhood.

6.10 RECOMMENDATIONS FOR FUTURE RESEARCH

Studies on LBP preventative interventions in children are very scarce. Therefore further, extensive research is required in this field, in order to determine the most effective management of childhood LBP, as well as to understand both the short term and long term effects of early preventative intervention programmes. Due to the complex interaction between the numerous possible risk factors which may contribute to the development of LBP, LBP preventative interventions should ideally be multidisciplinary. However, it is important to determine the most effective components of multidisciplinary programmes, to ensure that only beneficial and relevant components are combined and included in LBP preventative interventions. This study only addressed exercise, which is one component of LBP preventative interventions. Future research should focus on other components of LBP preventative interventions individually, as well as on multidisciplinary interventions. Therefore, taking this and the results of this study into account, the following recommendations are made for future, related LBP preventative research in children:

- Longitudinal exercise intervention studies to determine the long term effect of exercise interventions on adolescent and adult LBP

- The same specific exercise preventative intervention programme, implemented in either a younger age group or a different geographical location
- Specific exercise preventative intervention programmes, comprising of more regular sessions and / or of a longer duration e.g. two classes a week, for twelve weeks
- LBP preventative exercise programmes which include advanced, dynamic core stabilization exercises
- LBP preventative intervention studies which compare a specific spinal stabilization exercise programme with a general exercise programme
- Specific exercise programmes which are incorporated as an integral component of PE classes for the full school year, and which include all children, whether or not they have experienced LBP previously
- Specific exercise programmes as a component of a multidisciplinary intervention e.g. combined with either psychosocial interventions or education on posture, sitting, ergonomics and back care behaviour
- Intervention studies which determine the relationship between LBP outcomes and risk factor modification
- Longitudinal intervention studies to determine the long term effect of risk factor modification on LBP
- Establish if the positive findings observed in LBP prevalence and intensity in this study are related to any of the identified risk factors which were assessed

6.11 CRITICAL REVIEW OF THE STUDY

The strengths and limitations of this study will be reviewed below.

Strengths of the study are as follows:

- A randomised controlled trial was used.
- A power calculation was used to determine an adequate sample size. Sixty-two children were required to provide power of 90%. Seventy-two children were included in this study.
- There was a very low drop out rate (only two children).
- The groups were similar at baseline.
- All of the outcome measures were tested for validity and reliability.
- The researcher was blinded to treatment group allocation, as well as to the child's previous measurements at each follow-up visit.

- The exercise programme was well researched and included evidence-based components from previous adult LBP studies.
- There was good adherence to the exercise classes.
- This was the first study which evaluated the efficacy of exercise as a preventative intervention for LBP in children in South Africa, and therefore, it provides a starting point for future research in this field.

Limitations of the study are as follows:

- As a result of the prolonged public servants' strike, there was an unplanned, unavoidable interruption in the exercise programme at School B. This created an inherent flaw in the study design. However, the researcher tried, as far as possible, to limit the impact of these disturbances on the quality of the study. In addition, despite the disruption in the exercise programme at School B, similar findings were observed at both schools.
- Due to the difficulties encountered in finding schools which were willing to participate in the study, as well as the delays which were encountered in implementing the intervention programme, both of the originally planned six-month and one-year follow-up visits had to be excluded.
- Only two schools, in a similar geographic and socioeconomic area were included, and therefore the results may not necessarily be generalized to a larger population.
- Due to the nature of exercise interventions, the subjects could not be blinded to group allocation.
- The baseline differences for pain intensity, neural mobility and hamstring muscle length were significantly different between the two schools, despite every effort being made to choose two schools which were as similar as possible.
- There were no similar, available studies in South Africa with which the results of this study could be compared.

6.12 CONCLUSION

The high prevalence of LBP during childhood and adolescence has been well documented. The prevalence and severity of LBP, as well as the functional disabilities which are related to LBP, increase with age. In addition, LBP at an early age, especially persistent LBP, is a strong predictor of LBP in later life, independent of age and gender. Although LBP prevention has been extensively researched in the adult population, the prevalence of LBP remains very high. In addition, LBP in adults is generally associated

with higher medical costs, functional disability, fear avoidance beliefs / behaviours, sick leave and absenteeism from work, than LBP in children. Therefore, it is counterproductive to postpone treatment and preventative interventions until the problems become more severe and chronic, and thus more difficult to treat (Hestbaek et al 2005b). Numerous authors have proposed that LBP preventative interventions need to target the younger population, ideally before the first onset or at the first onset of LBP during childhood.

Currently, there is very little literature available on LBP preventative interventions in children. As a result, there is insufficient evidence available to formulate evidence-based guidelines for LBP preventative interventions during childhood and adolescence. However, the extreme difficulties which are encountered in implementing school-based interventions may, to some degree, explain the current lack of available evidence. The majority of the previous school-based LBP preventative studies in children have been conducted by the same group of authors, in an area where the authorities were very supportive of the interventions. In addition, they were able to receive extensive funding for their projects. School-based intervention studies require a large sample population in order to determine the efficacy of the intervention in reducing LBP prevalence and intensity. In order to access such a large sample of children, numerous schools need to be involved. However, without Governmental support and endorsement this is very difficult. Therefore, whilst school-based interventions are the obvious choice for LBP prevention programmes, in order for future research in this field to be successful, the Department of Education and the Department of Health need to be intricately involved.

Nevertheless, despite the difficulties which were encountered in implementing this study, as well as the disturbance which was created by the public servants' strike, the results of this study are still very interesting and can provide valuable insight in the development of future research interventions for LBP in children. In addition, very few of the previous school-based intervention studies have found that their preventative interventions had a positive impact on the prevalence and intensity of LBP in their sample. Therefore, the improvements which were observed in LBP prevalence and intensity in this study are very promising.

Due to the prominent link which has been identified between psychosocial risk factors and LBP in children, numerous authors have expressed doubt about the ability of intervention programmes to reduce LBP in children (Cardon and Balagué 2004). Therefore, it is interesting to note that, whilst the exercise intervention significantly reduced the episodes and intensity of LBP in this sample, there were no significant changes in the children's

emotional sense of well-being. Once again, this highlights the complex nature of LBP in children. Some authors feel that psychosocial factors are more significant than mechanical risk factors for LBP in children. However, in this study, the 'biomechanical' exercise intervention, and subsequent modification of some of the physical risk factors, appeared to be effective in reducing the recurrence of LBP in this sample.

Therefore, although intervention studies which address psychosocial risk factors for LBP in children are needed, it is important to include appropriate LBP outcome measures in order to determine if they have any impact on LBP in children. Perhaps it would be more appropriate to include regular psychosocial screening tests during the school years, in order to identify any psychosocial problems early, which may contribute to the development of somatic pain disorders such as LBP. In this way, only the relevant children will be referred for the appropriate counselling and interventions. It is important not to over emphasize LBP during childhood. LBP interventions which target the general school population should rather focus on the importance of spinal health, good posture, strength and flexibility, to avoid the development of fear avoidance beliefs and behaviour in children, which may flow over into adulthood. School-based intervention programmes are an ideal opportunity to provide children with the appropriate health tools and knowledge, which they need to develop and maintain a biomechanically healthy lifestyle. In addition, they will gain a better understanding of LBP, as well as invaluable tools which they can use to manage future episodes of pain.

The results of this study indicate that specific exercises are effective in reducing the prevalence, recurrence and intensity of LBP in 12-13 year old children. However, specific exercise programmes should not be reserved for children who have already experienced LBP. Appropriate exercise during the growth spurt can help to promote optimal spinal alignment, posture, biomechanics and spinal loading. This will reduce the risk of injury when both expected and unexpected external loads are placed on the spine, e.g. whilst playing competitive sport. In addition, it is likely that involvement in specific exercise programmes will also reduce the incidence of other aches and pains, such as neck or leg pain, during childhood. Recently, the importance of physical activity and exercise during school hours has been re-acknowledged. Children no longer appear to be very active outside of school, as living arrangements, safety concerns, computer games and television appear to restrict children's involvement in active play. As a result, PE is now, once again, considered to be an important component of the school curriculum. Children in this sample were still enthusiastic about exercise and appeared to understand the importance of PE as a subject. Therefore, specific exercise programmes should ideally

be an integral part of primary school PE classes, e.g. half of the PE lessons could consist of specific exercises, and the other half involvement in sports / games. It is important for all children to enjoy exercising, not only those who would be more inclined to participate in sport anyway. Even children, who do not normally excel in sporting activities, would be able to monitor their own improvement in the specific exercise programme and thus be encouraged to continue exercising. Therefore, whilst the primary aim of specific exercise programmes may be to target the reduction of LBP in children, there may be many other additional benefits as well.

Perhaps the key to preventing the disabling consequences of LBP lies in childhood. If this is so, it will be a breakthrough for LBP prevention, as children are a captive, enthusiastic target group, who are easily accessible in large groups through the school system. Children are also willing to exercise and eager to learn. If LBP can be prevented early, not only will the disabilities and psychosocial distresses which are associated with LBP in adulthood be substantially decreased; there will also be a considerable positive impact on the already over-burdened health care system and economy.

The results, strengths and limitations of the study have now been discussed in detail, and recommendations for future research and clinical practice have been made. The following chapter will summarise all of the findings and conclusions which have been derived from this study.

CHAPTER 7

CONCLUSION

This study has shown that an eight-week specific exercise intervention programme is effective in reducing the prevalence and intensity of LBP, as well as modifying some of the identified physical risk factors for LBP, in 12-13 year old children.

The primary objectives of this study were to determine if a specific exercise intervention programme would be effective in reducing reported episodes and intensity of LBP. The results of this study were promising, as both statistically and clinically significant improvements in LBP prevalence and intensity were observed and maintained in the exercise group. LBP prevalence decreased significantly in the exercise group immediately post-intervention. A further significant improvement in LBP prevalence was observed in the exercise group at the three month follow-up visit. LBP intensity also decreased significantly in the exercise group. VAS (3 months), VAS (1 month), VAS (1 week) and VAS (current pain) all improved significantly in the exercise group immediately post-intervention. However, only the improvements in VAS (3 months) and VAS (1 month) remained significant at the three month follow-up visit.

The secondary objectives of this study were to determine if a specific exercise intervention programme would be effective in modifying some of the identified risk factors for LBP in children. Interestingly, there were only significant improvements in the exercise group for some of the identified modifiable risk factors for LBP. Significant post-intervention improvements were observed and maintained in neural mobility, hamstring muscle length, iliopsoas muscle length and lumbosacral position sense in the exercise group. However, there were no significant improvements in lumbar stability, rectus femoris muscle length, sense of well-being or perception of PE in either group. Therefore, it is possible that positive improvements in LBP outcome measures may not necessarily always be associated with positive changes in modifiable risk factors for LBP in children.

Nevertheless, it can be concluded that the school-based specific exercise programme was effective as secondary preventative intervention for LBP in 12-13 year old children. Specific exercise programmes should be implemented early, ideally as an integral component of school PE programmes. Although the results of this study were promising, further research is needed in this field to determine the long term effect of early preventative interventions on adolescent and adult LBP.

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APPENDICES

- A:** Ethical Clearance Certificate
- B:** Department of Education Letter
- C:** Information Sheet - Schools
- D:** Information Sheet – Parents
- E:** Information Sheet - Pupils
- F:** Informed Consent and Assent Forms
- G:** Participant Medical History Questionnaire
- H:** Questionnaire
- I:** Visual Analogue Scales
- J:** Questionnaire Scoring
- K:** Data Collection Sheets
- L:** Exercise Intervention Questionnaire
- M:** Home Exercise Sheets
- N:** Home Exercise Diary
- O:** Exercise Class Breakdown

APPENDIX A

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Division of the Deputy Registrar (Research)

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

R14/49 Fanucchi

CLEARANCE CERTIFICATE

PROTOCOL NUMBER M060334

PROJECT

Specific Exercises as a Preventative Intervention Programme for Low Back Pain in 12-13 Year Old Children

INVESTIGATORS

Ms GL Fanucchi

DEPARTMENT

Dept of Physiotherapy

DATE CONSIDERED

06.03.31

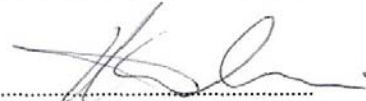
DECISION OF THE COMMITTEE*

Approved unconditionally

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

DATE 06.05.08

CHAIRPERSON



(Professor PE Cleaton-Jones)

*Guidelines for written 'informed consent' attached where applicable

cc: Supervisor : Prof A Stewart

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10005, 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

23-06-'06 11:25 FROM-

T-112 P02/03 U-335



UMnyango WezeMfundo
Department of Education

Lefapha la Thuto
Departement van Onderwys

Date:	15 June 2006
Name of Researcher:	Jina Fanucchi
Address of Researcher:	P.O. Box 257
	Bedfordview
	2008
Telephone Number:	N/A
Fax Number:	(011) 6163757/0866890810
Research Topic:	Specific exercises as a preventative intervention programme for low-back pain in 12-13 year old children
Number and type of schools:	6 Primary Schools
District/s/HO	Johannesburg East & North and Ekurhuleni West

Re: Approval in Respect of Request to Conduct Research

This letter serves to indicate that approval is hereby granted to the above-mentioned researcher to proceed with research in respect of the study indicated above. The onus rests with the researcher to negotiate appropriate and relevant time schedules with the school/s and/or offices involved to conduct the research. A separate copy of this letter must be presented to both the School (both Principal and SGB) and the District/Head Office Senior Manager confirming that permission has been granted for the research to be conducted.

Permission has been granted to proceed with the above study subject to the conditions listed below being met, and may be withdrawn should any of these conditions be flouted:

1. *The District/Head Office Senior Manager/s concerned must be presented with a copy of this letter that would indicate that the said researcher/s has/have been granted permission from the Gauteng Department of Education to conduct the research study.*
2. *The District/Head Office Senior Manager/s must be approached separately, and in writing, for permission to involve District/Head Office Officials in the project.*
3. *A copy of this letter must be forwarded to the school principal and the chairperson of the School Governing Body (SGB) that would indicate that the researcher/s have been granted permission from the Gauteng Department of Education to conduct the research study.*

Office of the Senior Manager – Strategic Policy Research & Development
Room 525, 111 Commissioner Street, Johannesburg, 2001 P.O.Box 7710, Johannesburg, 2000
Tel: (011) 355-0488 Fax: (011) 355-0286

23-06-'06 11:26 FROM-

T-112 P03/03 U-335

4. A letter / document that outlines the purpose of the research and the anticipated outcomes of such research must be made available to the principals, SGBs and District/Head Office Senior Managers of the schools and districts/offices concerned, respectively.
5. The Researcher will make every effort obtain the goodwill and co-operation of all the GDE officials, principals, chairpersons of the SGBs, teachers and learners involved. Persons who offer their co-operation will not receive additional remuneration from the Department while those that opt not to participate will not be penalised in any way.
6. Research may only be conducted after school hours so that the normal school programme is not interrupted. The Principal (if at a school) and/or Senior Manager (if at a district/head office) must be consulted about an appropriate time when the researcher/s may carry out their research at the sites that they manage.
7. Research may only commence from the second week of February and must be concluded before the beginning of the last quarter of the academic year.
8. Items 6 and 7 will not apply to any research effort being undertaken on behalf of the GDE. Such research will have been commissioned and be paid for by the Gauteng Department of Education.
9. It is the researcher's responsibility to obtain written parental consent of all learners that are expected to participate in the study.
10. The researcher is responsible for supplying and utilising his/her own research resources, such as stationery, photocopies, transport, faxes and telephones and should not depend on the goodwill of the institutions and/or the offices visited for supplying such resources.
11. The names of the GDE officials, schools, principals, parents, teachers and learners that participate in the study may not appear in the research report without the written consent of each of these individuals and/or organisations.
12. On completion of the study the researcher must supply the Senior Manager: Strategic Policy Development, Management & Research Coordination with one Hard Cover bound and one Ring bound copy of the final, approved research report. The researcher would also provide the said manager with an electronic copy of the research abstract/summary and/or annotation.
13. The researcher may be expected to provide short presentations on the purpose, findings and recommendations of his/her research to both GDE officials and the schools concerned.
14. Should the researcher have been involved with research at a school and/or a district/head office level, the Senior Manager concerned must also be supplied with a brief summary of the purpose, findings and recommendations of the research study.

The Gauteng Department of Education wishes you well in this important undertaking and looks forward to examining the findings of your research study.

Kind regards

ALBERT CHANEE
ACTING DIVISIONAL MANAGER: OFSTED

The contents of this letter has been read and understood by the researcher.	
Signature of Researcher:	
Date:	23/06/2006 .

SCHOOL PRINCIPAL – INFORMATION SHEET

STUDY TITLE: Specific exercises as a secondary preventative intervention programme for low back pain in 12-13 year old children
STUDY NUMBER: M060334
RESEARCHER: Gina Fanucchi BSc (Physiotherapy)
SUPERVISORS: Dr Ronél Jordaan PhD, Prof Aimee Stewart PhD (Physiotherapy)
INSTITUTION: University of the Witwatersrand

To the Principal of _____ Primary School,

Hello, my name is Gina Fanucchi. I am a registered physiotherapist, and I am currently completing a Masters degree in physiotherapy at Wits University. As part of my degree, I am studying low back pain in children. I would like to invite your school to be part of the study, and request your permission to allow the Gr6 and Gr7 pupils at your school to participate in the study.

Written permission from the Gauteng Department of Education has been obtained for this study. The GED has permitted Gr6 and Gr7 pupils attending schools in Gauteng to participate in this study. Written approval has also been granted by the University of the Witwatersrand, Human Research Ethics Committee (HREC).

I have included a description of the purpose of the study and what will be involved.

South African and international studies have found that over 50% of children will suffer from non-specific low back pain (LBP) during their early teens. I'm sure you will agree that this is a very high percentage of children. Research also indicates that low back pain in children is predictive of low back pain in adults. Therefore, a need has been identified for programmes aimed at preventing LBP in our schools.

However, before implementing programmes into our schools, research needs to be done to ensure that the most effective programmes are put in place. This study will help us to determine what works and what will be best for the children.

This study aims to determine if a specific exercise programme, in addition to normal PE, will help to improve children's back strength and flexibility. The exercise programme targets core stability and muscle flexibility. Improved back strength and flexibility may reduce their risk of developing low back pain as they grow older, as well as improve the child's ability to participate in sports and other activities.

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

The children's participation in this study is entirely voluntary. Each child is free to withdraw from this 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, pupils or parents.

I will provide the parents and pupils 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 children sign assent before they will be included in the study.

All children who agree to take part 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 15-20 minutes to complete. I will also measure each child's flexibility and muscle strength, using six simple, standard physiotherapy assessments. The measurements will take about 10 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 pupils. As mentioned above, the child's name will not appear on the questionnaire, and all results will remain anonymous and be handled with strictest confidentiality.

The children will be required to fill in the questionnaire at four different times during the year, and the measurements will also be taken four times during the year. This is to enable us to determine if there are any changes during the year.

All children who agree to take part in the study will be randomly allocated to two groups. One group is the control group. The children in the control group will continue with normal

PE classes and school activities for the term. They will only be required to fill in the questionnaire and have the measurements taken four times during the year.

The other group will take part in an eight week exercise programme. The exercises will be taught by a qualified physiotherapist either during one PE class or one additional extra-mural PE lesson per week, depending on what is most convenient for your school, teachers and pupils. The exercises are simple, and the physiotherapist will ensure that they are done correctly to minimise pain and discomfort and to prevent injury. The children will also be given exercises to do at home three times a week. These exercises are simple and should only take 10-15 minutes to complete.

The exercise programme will be implemented over eight weeks during the first school term in 2007. The questionnaire and measurements will be taken at the beginning and the end of the first term, at the end of the second term, and at a convenient time at the end of the year. This will enable us to determine if there is a significant change over the year. This will also help determine what the required duration and frequency of programmes should be.

Once the study is complete, we will inform your school, parents and pupils of the outcome of the entire study. Your pupil's participation in this study will help contribute to the development of an appropriate, effective prevention programme, which can then be implemented into schools across the country. We hope that this study will have a positive impact on low back pain in our children.

I would really appreciate your help by allowing your school to participate in this 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.

Thank you very much for your time!

Gina Fanucchi

Tel: 011 616 2977 / 011 616 4400

Cell: 082 325 4681

Email: gfanucs@mweb.co.za

PARENTS – INFORMATION SHEET

STUDY TITLE: Specific exercises as a secondary preventative intervention programme for low back pain in 12-13 year old children

STUDY NUMBER: M060334

RESEARCHER: Gina Fanucchi BSc (Physiotherapy)

SUPERVISORS: Dr Ronél Jordaan PhD, Prof Aimee Stewart PhD (Physiotherapy)

INSTITUTION: University of the Witwatersrand

Dear Parents of Grade 7 pupils,

Hello, my name is Gina Fanucchi. I am a physiotherapist, and I am currently completing a Masters degree in physiotherapy at Wits University. As part of my degree, I am studying low back pain in children. Your child's school has kindly allowed all Gr7 pupils who are willing to take part, to participate in my study. I would like to invite your child to participate, and will be very grateful if you would consider letting him/her join in my study. Before agreeing to participate, it is important that you read and understand this letter. It will explain the purpose of the study and what will be involved.

Previous studies have found that over 50% of children will suffer from non-specific low back pain (LBP) at some time during their school years. I'm sure you will agree that this is a very high percentage of children. Therefore, a need has been identified for programmes aimed at preventing LBP in our schools.

However, before implementing programmes into our schools, research needs to be done to ensure that the most effective programmes are put in place. This study will help us to determine what works and what will be best for your children.

The purpose of this study is to determine if specific exercises, in addition to normal PE (Physical Education) will help to improve children's back strength and flexibility. Improved back strength and flexibility may reduce their risk of developing low back pain as they grow older.

Written permission from the Gauteng Department of Education, as well as from the University of the Witwatersrand, Human Research Ethics Committee (HREC) has been obtained for this study.

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

Your child's participation in this study is entirely voluntary. Your child is free to withdraw from this study at any time. No reason is required and no adverse consequences will follow his/her withdrawal.

This study will include all children – whether they have previously complained of low back pain or not.

All children 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 15-20 minutes to complete and I will be there to help them fill it in.

I will also measure your child's flexibility and muscle strength, using six simple, standard physiotherapy assessments. This will be done in an enclosed, private area. As mentioned above, your child's name will not appear on the questionnaire, and all results will remain anonymous and be handled with strictest confidentiality.

Your child will be required to fill in the same questionnaire at four different times during the year, and the measurements will also be taken four times during the year. This is to enable us to determine if there are any changes during the year.

All children who agree to take part in the study will be randomly allocated to two groups. One group is the control group. The children in the control group will continue with normal classes and school activities for the term. They will only be required to fill in the questionnaire and have the measurements taken four times during the year.

The other group will take part in an eight week exercise programme. The exercises will be taught by a qualified physiotherapist during the extramural lesson each week. The programme consists of simple stretches and core stabilizing exercises. The physiotherapist will ensure that they are done correctly to minimise pain and discomfort and to prevent injury. The children will also be given exercises to do at home three times

a week. These exercises are simple stretches and should only take 10-15 minutes to complete.

Your child's participation in this study will help contribute to the development of an appropriate, effective prevention programme, which can then be implemented in schools across the country. This study hopes to have a positive impact on children's back strength and flexibility. This will help reduce the incidence of low back pain, as well as improve children's ability to cope with the physical demands of daily activities and sport.

The school is not directly involved in this study, and they will have no access to your child's personal results. However, once the study is complete, we will inform the school of the outcome of the entire study.

I would really appreciate your help by allowing your child to participate in this study. If you would like your child to take part, please fill in the attached consent form. Please fill in the section on your child's medical history carefully. If your child has any serious back problems or illnesses, he/she will not be required to take part in the study.

Please read through and discuss the attached letter with your child. Your child needs to sign his/her name on the consent form as well, to indicate that they also agree to participate in the study.

Please return the consent form to the school before the end of term (23 March 2007).

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.

Thank you very much for your help!

Gina Fanucchi

Tel: 011 616 2977

Cell: 082 325 4681

Email: gfanucs@mweb.co.za

PUPILS – INFORMATION SHEET

STUDY TITLE: Specific exercises as a secondary preventative intervention programme for low back pain in 12-13 year old children

STUDY NUMBER: M060334

RESEARCHER: Gina Fanucchi BSc (Physiotherapy)

SUPERVISORS: Dr Ronél Jordaan PhD, Prof Aimee Stewart PhD (Physiotherapy)

INSTITUTION: University of the Witwatersrand

Hello, my name is Gina Fanucchi. I am a physiotherapist, and I am studying low back pain in children. Your school has kindly allowed all Gr7 pupils who are willing to take part, to join in my study, and so I would like to invite you to take part in my study. Before you agree to participate, it is important that you read and understand this letter.

In this study, we want to see if some simple physiotherapy exercises will help to protect children's backs. If you are part of the study, you will need to fill in a simple questionnaire. This questionnaire is not a test, and I will be there to help you fill it in. Any information you tell me or write down in the study will remain private. I will also measure how strong and flexible your muscles are, using six easy tests. This will be done in a private area. You will need to fill in the questionnaire four times during the year, and the measurements will also be taken four times during the year. You might also have to take part in eight simple exercise classes given by a physiotherapist once a week, during your PE lesson. If at any time, you no longer want to be part of the study, you are allowed to say so and you don't need to give a reason.

I would be very grateful if you would agree to be part of this study. If you want to take part, please make sure that you and your parents sign the attached form and return it to school as soon as possible. It is important to return the form to school before the end of this term (23 March 2007).

Thank you very much for your help!

Gina Fanucchi

INFORMED CONSENT FORM

STUDY TITLE: Specific exercises as a secondary preventative intervention programme for low back pain in 12-13 year old children
STUDY NUMBER: M060334
RESEARCHER: Gina Fanucchi BSc (Physiotherapy)
SUPERVISORS: Dr Ronél Jordaan PhD, Prof Aimee Stewart PhD (Physiotherapy)
INSTITUTION: University of the Witwatersrand

- I hereby confirm that I have been informed by the researcher, Gina Fanucchi, about the purpose and nature of the above study
- I have received and read the attached information sheet regarding the above study
- I was given an opportunity to contact the researcher and ask questions
- I have received enough information and understand all that the study entails
- I am aware that all the results and information collected, including 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 that there will be no adverse consequences following his/her withdrawal

I have understood everything that has been explained to me regarding the above study and I consent to my child participating in this study.

PARENT / LEGAL GUARDIAN CONSENT:

Printed Name	Signature	Date
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PARTICIPANT (CHILD) ASSENT:

Printed Name	Signature	Date
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Please fill in the brief questionnaire on the back of this page regarding your child's medical history. Thank you very much for your time!

PARTICIPANT MEDICAL HISTORY QUESTIONNAIRE

STUDY TITLE: Specific exercises as a secondary preventative intervention programme for low back pain in 12-13 year old children
STUDY NUMBER: M060334
RESEARCHER: Gina Fanucchi BSc (Physiotherapy)
SUPERVISORS: Dr Ronél Jordaan PhD, Prof Aimee Stewart PhD (Physiotherapy)
INSTITUTION: University of the Witwatersrand

Dear Parent

Thank you for agreeing to let your child participate in this study. Please complete the questions below carefully. Unfortunately, due to the nature of the 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 a member of a provincial sports team?
Yes No
 4. Is your child currently following a specialised training programme with a biokineticist?
Yes No
 5. Is your child currently being treated for a fracture (broken bone) in the back, pelvis, legs or arms?
Yes No
 6. Is your child currently following a rehab programme after an operation on his/her bones, ligaments, muscles or tendons?
Yes No
 7. Has your child been diagnosed with a neurological condition which affects the tone in his/her muscles?
Yes No
 8. Does your child have a chronic or serious illness, which requires him/her to take daily medication or receive regular treatment?
Yes No
8.1 If **yes**, please list: _____
 9. Has your child been diagnosed with a serious spinal pathology (e.g. spinal tumour)?
Yes No
9.1 If **yes**, please list: _____
 10. Are there any reasons why your child cannot participate in normal PE classes at school?
Yes No
10.1 If **yes**, please list: _____



Hello, my name is Gina and I'm a physiotherapist from Wits University.

I would like you to help me to learn more about back pain in Gr 7 pupils by filling in this questionnaire.

Please answer all the questions carefully and honestly.

The questions are all about you – how you feel and what you think.

Your name will not appear anywhere on this questionnaire.

I am the only person who will read what you have written, and all your answers will remain strictly private and confidential.

I am here to help you if you don't understand anything – feel free to ask. Remember it's all about how you feel – so don't worry if your answers are different to anybody else's.

If there is a choice, always put a tick in the block which applies to you. Where you need to, write your answers on the lines provided.

Thank you for your help!



General Information

Reference number: _____

Date of birth: _____

How old are you now? 11 12 13 other _____

Boy **Girl**

SECTION 1:

Instructions:

Please read each question carefully.

Tick **ONE** box for each question that best describes how things have been **FOR YOU** during the past month.

There are no right or wrong answers.



1. During the past month, how much of the time were you a happy person?

- | | |
|---|---|
| <input type="checkbox"/> All of the time | <input type="checkbox"/> Some of the time |
| <input type="checkbox"/> Most of the time | <input type="checkbox"/> A little of the time |
| <input type="checkbox"/> A good bit of the time | <input type="checkbox"/> None of the time |

2. How much of the time, during the past month, have you felt calm and peaceful?

- | | |
|---|---|
| <input type="checkbox"/> All of the time | <input type="checkbox"/> Some of the time |
| <input type="checkbox"/> Most of the time | <input type="checkbox"/> A little of the time |
| <input type="checkbox"/> A good bit of the time | <input type="checkbox"/> None of the time |

3. How much of the time, during the past month, have you been a very nervous person?

- | | |
|---|---|
| <input type="checkbox"/> All of the time | <input type="checkbox"/> Some of the time |
| <input type="checkbox"/> Most of the time | <input type="checkbox"/> A little of the time |
| <input type="checkbox"/> A good bit of the time | <input type="checkbox"/> None of the time |

4. How much of the time, during the past month, have you felt downhearted and blue?

- | | |
|---|---|
| <input type="checkbox"/> All of the time | <input type="checkbox"/> Some of the time |
| <input type="checkbox"/> Most of the time | <input type="checkbox"/> A little of the time |
| <input type="checkbox"/> A good bit of the time | <input type="checkbox"/> None of the time |

5. How much of the time, during the past month, have you felt so down in the dumps that nothing could cheer you up?

- | | |
|---|---|
| <input type="checkbox"/> All of the time | <input type="checkbox"/> Some of the time |
| <input type="checkbox"/> Most of the time | <input type="checkbox"/> A little of the time |
| <input type="checkbox"/> A good bit of the time | <input type="checkbox"/> None of the time |

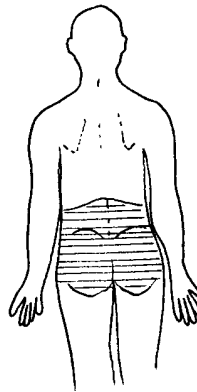
SECTION 2:

1. In the **past 3 months**, have you had pain or discomfort in the lower part of your back that lasted more than 24 hours (1 day)?

Yes No

2. In the **past 3 months**, have you had pain or discomfort in the area indicated in the figure below?

Yes No



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

Yes No

4. Have you ever had pain in the lower part of your back?

Yes No

5. If **you had pain** in the lower part of your back in the **past 3 months**, answer the following questions:

a) When did it start?

1 to 3 months ago	<input type="checkbox"/>
4 to 6 months ago	<input type="checkbox"/>
7 to 12 months ago	<input type="checkbox"/>
13 months to 2 years ago	<input type="checkbox"/>
more than 2 years ago	<input type="checkbox"/>

b) How did it start?

spontaneously	<input type="checkbox"/>
motor vehicle accident	<input type="checkbox"/>
sports injury	<input type="checkbox"/>
other injury (fall, lifting object)	<input type="checkbox"/>
other, name:	<input type="checkbox"/>



c) How often did you have low back pain in the **past 3 months**?

every day	
one to 3 times per week	
once every 2 weeks	
once per month	
only once in the last 3 months	

d) How long did your low back pain usually last for in the **past 3 months**?

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



e) Please mark with a cross on the line below the **worst pain** you had in your **lower back** during the **past 3 months**.



0

10



No pain at all
No discomfort

Worst pain
you can imagine
Very uncomfortable

f) Did you have to stop or change your sport activities due to pain in your lower back in the **past 3 months**?

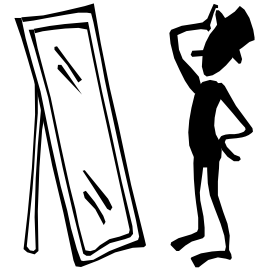
Yes No

g) Did you do any of the following for your low back pain in the **past 3 months**? (You can tick more than 1 block for this question)

stay home from school	
take any medicine	
visit a doctor	
visit a physiotherapist	
other, name:	
None of the above	

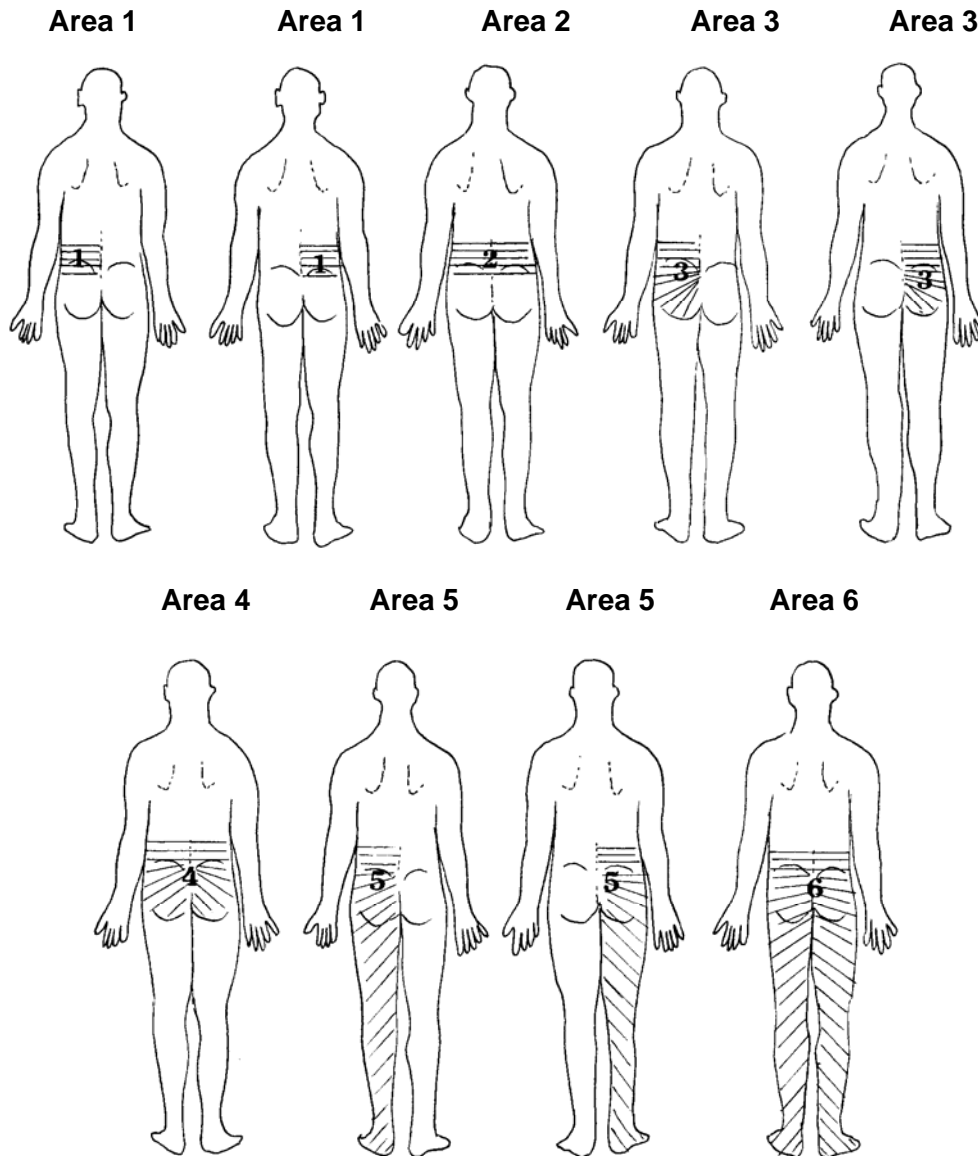


h) Look at the figures below and indicate the area in which you experienced your back pain in the **past 3 months**.



Please note:

The back pain can be only in the lower part of the back, (both sides or only on the 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 in the leg are pain, a tingling feeling, numbness or a feeling of heaviness.



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 buttock (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 buttock and leg on that side	
Area 6: both sides of the low back, spreading into both buttocks and legs	



SECTION 3:

How do you feel about PE (Physical Education)?

Read through the statements below.

Put a tick next in ONE block for EACH question, which best describes how YOU feel about PE.

Remember, there are no right or wrong answers.

1. PE is a fun subject
 PE is a boring subject

2. PE is an interesting subject
 PE is an uninteresting subject

3. PE is an important subject for future health
 PE is an unimportant subject for future health

4. PE is a welcome break in schoolwork
 PE is an unwelcome interruption in schoolwork

5. PE is a necessary subject
 PE is an unnecessary subject which could leave time for other subjects instead

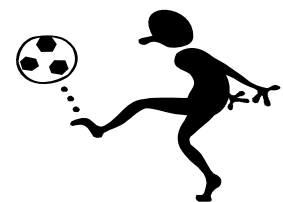
SECTION 4:

Circle the number next to each statement below which best describes how you feel.

1 = No difference
2 = Slightly
3 = Moderately
4 = A lot more

The PE exercises I did in the last month made me feel:

- Stronger 1 2 3 4
- Healthier 1 2 3 4
- Flexible (less stiff) 1 2 3 4



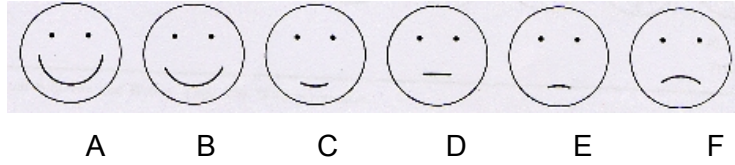
The PE exercises I did in the last month made it easier to:

- Play my sport / swim / dance / run 1 2 3 4
- Walk long distances 1 2 3 4
- Climb Stairs 1 2 3 4

SECTION 5:

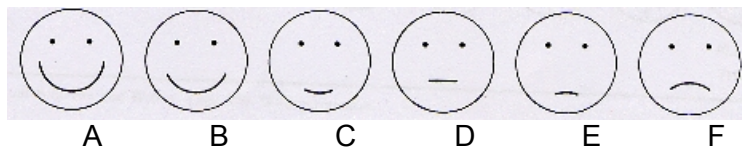
1. How do you feel about your schoolwork?

Mark the face that indicates your feelings, by circling the letter underneath it.



2. How do you feel about your life in general?

Mark the face that indicates your feelings, by circling the letter underneath it.



***Thank you for your participation!
This information will remain private and will be handled with the
strictest confidentiality.***

APPENDIX I

1. Please mark with a cross on the line below the **worst pain** you had in your **lower back** during the **past month**.



0

10



No pain at all
No discomfort

Worst pain
you can imagine
Very uncomfortable

2. Please mark with a cross on the line below the **worst pain** you had in your **lower back** during the **last week**.



0

10



No pain at all
No discomfort

Worst pain
you can imagine
Very uncomfortable

3. Please mark with a cross on the line below what you feel in **your lower back** at the **moment**.



0

10



No pain at all
No discomfort

Worst pain
you can imagine
Very uncomfortable

QUESTIONNAIRE SCORING

SENSE OF WELL-BEING – MHI-5

1. During the past month, how much of the time were you a happy person?

- | | | | |
|---|----------|---|----------|
| <input type="checkbox"/> All of the time | 6 | <input type="checkbox"/> Some of the time | 3 |
| <input type="checkbox"/> Most of the time | 5 | <input type="checkbox"/> A little of the time | 2 |
| <input type="checkbox"/> A good bit of the time | 4 | <input type="checkbox"/> None of the time | 1 |

2. How much of the time, during the past month, have you felt calm and peaceful?

- | | | | |
|---|----------|---|----------|
| <input type="checkbox"/> All of the time | 6 | <input type="checkbox"/> Some of the time | 3 |
| <input type="checkbox"/> Most of the time | 5 | <input type="checkbox"/> A little of the time | 2 |
| <input type="checkbox"/> A good bit of the time | 4 | <input type="checkbox"/> None of the time | 1 |

3. How much of the time, during the past month, have you been a very nervous person?

- | | | | |
|---|----------|---|----------|
| <input type="checkbox"/> All of the time | 1 | <input type="checkbox"/> Some of the time | 4 |
| <input type="checkbox"/> Most of the time | 2 | <input type="checkbox"/> A little of the time | 5 |
| <input type="checkbox"/> A good bit of the time | 3 | <input type="checkbox"/> None of the time | 6 |

4. How much of the time, during the past month, have you felt downhearted and blue?

- | | | | |
|---|----------|---|----------|
| <input type="checkbox"/> All of the time | 1 | <input type="checkbox"/> Some of the time | 4 |
| <input type="checkbox"/> Most of the time | 2 | <input type="checkbox"/> A little of the time | 5 |
| <input type="checkbox"/> A good bit of the time | 3 | <input type="checkbox"/> None of the time | 6 |

5. How much of the time, during the past month, have you felt so down in the dumps that nothing could cheer you up?

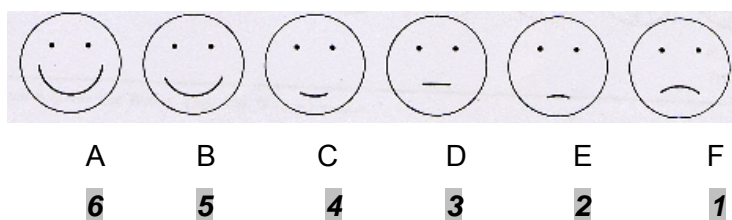
- | | | | |
|---|----------|---|----------|
| <input type="checkbox"/> All of the time | 1 | <input type="checkbox"/> Some of the time | 4 |
| <input type="checkbox"/> Most of the time | 2 | <input type="checkbox"/> A little of the time | 5 |
| <input type="checkbox"/> A good bit of the time | 3 | <input type="checkbox"/> None of the time | 6 |

The scores for each question are added together to determine the total MHI-5 score.

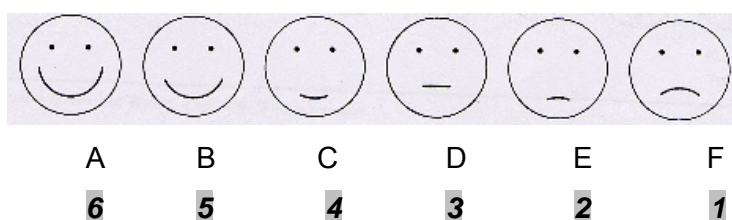
The MHI-5 has a maximum score of 30 and a minimum score of 5.

SENSE OF WELL-BEING – FACE SCALES

1. How do you feel about your schoolwork?
Mark the face that indicates your feelings, by circling the letter underneath it.



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



PERCEPTION OF PE

1. PE is a fun subject **1**
 PE is a boring subject **0**
2. PE is an interesting subject **1**
 PE is an uninteresting subject **0**
3. PE is an important subject for future health **1**
 PE is an unimportant subject for future health **0**
4. PE is a welcome break in schoolwork **1**
 PE is an unwelcome interruption in schoolwork **0**
5. PE is a necessary subject **1**
 PE is an unnecessary subject which could leave time for other subjects instead **0**

Positive statements are given a score of one and negative statements are given a score of zero. Therefore, perception of PE scores can range from zero to five.

**PHYSICAL ASSESSMENT
DATA COLLECTION SHEET**

Reference Number: _____ Date: _____ Time: _____

Consent form signed: _____ Questionnaire completed: _____

1. LUMBOSACRAL POSITION SENSE

	Criterion position	Repositioning after full flexion (degrees)
1	0°	
2	0°	
3	0°	
4	0°	
5	0°	

2. PELVIC STABILITY – ACTIVE STRAIGHT LEG RAISE TEST

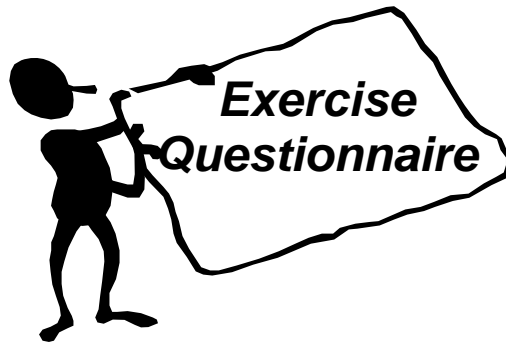
	RIGHT - ASLR Pressure change	LEFT - ASLR Pressure change
Trial 1		
Trial 2		
Trail 3		

3. NEURAL MOBILITY – PASSIVE STRAIGHT LEG RAISE TEST

	RIGHT Hip flexion (degrees)	LEFT Hip flexion (degrees)
1		
2		

4. MUSCLE LENGTH TESTS

	RIGHT	LEFT
	Hamstrings: Knee flexion (degrees)	
1		
2		
3		
	Iliopsoas: Hip flexion (degrees)	
1		
2		
3		
	Rectus Femoris: Knee flexion (degrees)	
1		
2		
3		



REF NO: _____

If you **DID NOT** take part in the exercise classes with Libby during the 2nd term – please fill in **SECTION 1**

If you **DID** take part in the exercise classes with Libby during the 2nd term - please fill in **SECTION 2**

SECTION 1:

Remember, you only need to fill in this section if you did not take part in the exercise classes.

Tick **ONE** box for each question.

There are no right or wrong answers – Please be honest.

1. Would you have liked to take part in the exercise classes?

YES

NO

2. Did any of your friends show you the exercises which they did in the class?

YES

NO

3. Did you try any of the exercises which they did in the class?

YES

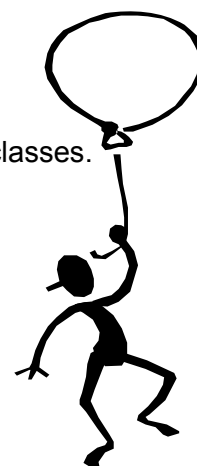
NO

SECTION 2:

Remember, you only need to fill in this section if you took part in the exercise classes.

Tick **ONE** box for each question.

There are no right or wrong answers – Please be honest.



1. Did you enjoy the exercise classes?

- | | |
|---|---|
| <input type="checkbox"/> YES - All of the time | <input type="checkbox"/> Yes - Some of the time |
| <input type="checkbox"/> YES - Most of the time | <input type="checkbox"/> Yes - A little of the time |
| <input type="checkbox"/> YES - A good bit of the time | <input type="checkbox"/> NO - None of the time |

2. Do you think that the exercises helped you in any way?

- | | |
|--|--|
| <input type="checkbox"/> YES – a lot | <input type="checkbox"/> Yes – but only a little |
| <input type="checkbox"/> YES – quite a bit | <input type="checkbox"/> NO – not at all |

3. Do you think that the exercises made your back stronger?

- | | |
|---|---|
| <input type="checkbox"/> YES – a lot stronger | <input type="checkbox"/> Yes – but only a little bit stronger |
| <input type="checkbox"/> YES – quite a bit stronger | <input type="checkbox"/> NO – not at all |

4. Do you think that the exercises helped to make your low back pain feel better?

- | | |
|---|---|
| <input type="checkbox"/> YES – a lot better | <input type="checkbox"/> Yes – but only a little bit better |
| <input type="checkbox"/> YES – quite a bit better | <input type="checkbox"/> NO – not at all |

5. Did you carry on with the exercises at home once the classes were finished?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> YES | <input type="checkbox"/> NO |
|------------------------------|-----------------------------|

6. Are you still doing some of the exercises at home?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> YES | <input type="checkbox"/> NO |
|------------------------------|-----------------------------|

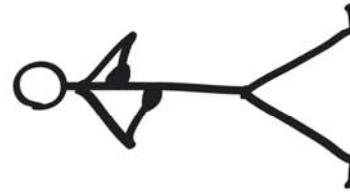
😊 *Thank you for taking part in this study!* 😊

EXERCISE 1**Cat and Camel into Prayer Stretch**

- Start on your hands and knees
- Roll your spine up like a cat – hold for 3
- Roll your spine down like a camel – hold for 3
- Repeat 5x



- Keep your feet together
- Open your knees out to the sides
- Reach forward with your arms on the floor
- Stretch out your back
- Hold for 30 counts

EXERCISE 2**Deep Breathing**

- Put 1 hand on your stomach, just below your ribs
- Put your other hand on your chest
- Take 10 slow, deep breaths in and out
- **Remember – only the hand on your stomach should move**
- It will **move up** when you **breathe in** and **down** when you **breathe out**

EXERCISE 3**Ball Squeeze**

- **FIRST - tighten the deep stomach muscle**
- Breathe in
- As you breathe out gently pull your belly button to your spine
- **Remember – you can check if the muscle is working by feeling if the muscle is tight next to your hip bone**



- **Keep holding the deep stomach muscle tight**
- Squeeze the ball
- **And**
- Tighten your pelvic floor muscles / the muscle at the bottom of your box
- Pull this muscle up towards your stomach
- This will feel like what you do when you need to go to the bathroom, but have to hold it in

EXERCISE 4**4 – point kneeling**

- Balance a stick or broom on your back
- Try to get your spine in the best position you can

- **Remember the stick should only touch**

- at the back of your head,

- between your shoulder blades

- and at the base of your spine

EXERCISE 5**Hamstring stretch**

- Lie on your back
- Pull your one knee up to your chest
- Hold for 30 counts



- Hold the leg at 90 degrees
- Slowly bend and straighten the knee
- 10x



- Straighten the knee as much as you can
- Hold for 30 counts

- **Do the same 3 stretches 2x with each leg**

EXERCISE 6**Lunge stretch**

- Take a big step forward into a lunge
- Keep your back leg straight
- Back knee off the floor
- Try to go as low as you can
- Hold for 30 counts



- Bend your back knee down to the floor
- Hold for 30 counts



- Wrap a towel around your back leg
- Pull your leg up towards your bottom
- Hold for 30 counts

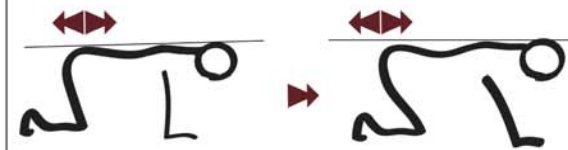
- **Do the 3 stretches 2x with each leg**

EXERCISE 7**Leg Lifts**

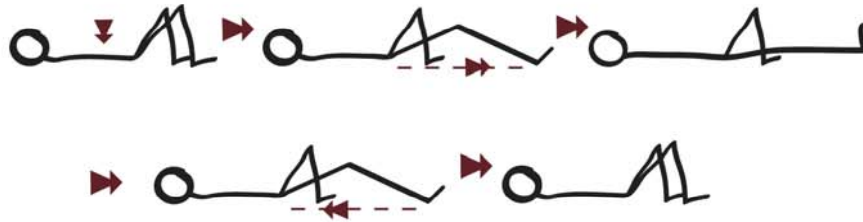
- **FIRST – tighten the deep stomach muscle** (pull your belly button towards your spine)
- SLOWLY lift up your one leg
- SLOWLY lower the leg
- **Remember**
 - hold your back very still
 - only the leg must move
 - don't let the hips move up or down
 - don't let the back move

EXERCISE 8**Frog Leg Rolls**

- **FIRST – tighten the deep stomach muscle**
- SLOWLY roll the bent knee out to the side
- Keep your foot by your knee
- **Remember**
 - only move your knee out as far as you can **WITHOUT** your hips or back moving
- From the top you will look like this

**EXERCISE 9****Rocking in 4 point kneeling**

- **FIRST – try to get your spine in the best position with the stick on your back**
- SLOWLY rock backwards and forwards
- **Remember**
 - don't let the stick roll off your back

EXERCISE 10**Heel slides on the floor**

- **FIRST – tighten your deep stomach muscles**
- Slide your one leg out along the floor
- Slide it back again
- Repeat with the other leg
- **Remember**
 - keep your back and hips very still

EXERCISE 11**Leg and Arm lifts in 4 point kneeling**

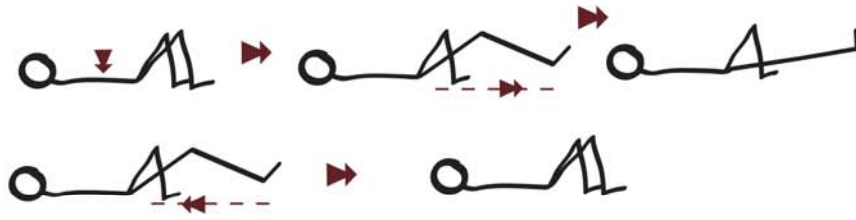
- **FIRST – get your spine in the best position with the stick**
- Lift your one arm
- Hold
- Lift the other arm
- Hold



- Lift your one leg
- Hold
- Lift the other leg
- Hold
- **Remember**
 - your back must stay as still as possible
 - don't let the stick roll on your back

EXERCISE 12

Heel slides off the floor



- **FIRST – tighten your deep stomach muscles**
- Straighten your one leg out – slightly off the floor
- Bend it back still keeping it slightly off the floor
- Repeat with the other leg
- **Remember**
 - keep your back and hips very still

EXERCISE 13

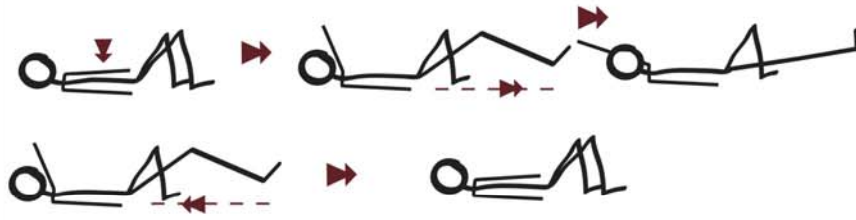
Bridging



- **FIRST – tighten your deep stomach muscles**
- Lift your hips up off the floor
- Hold

EXERCISE 14

Heel slides with arm movements



- **FIRST – tighten your deep stomach muscles**
- Lift your arm up over your head while you are sliding the opposite leg out
- Lower your arm while you bend your leg back
- Repeat with the other leg
- **Remember**
 - keep your back and hips very still
 - don't let your upper back arch up off the floor

EXERCISE 15

Opposite arm and leg lifts in 4 point kneeling



- **FIRST – get your spine in the best position with the stick**
- Lift your one leg
- Lift the opposite arm
- Hold
- **Remember**
 - your back must stay as still as possible
 - don't let the stick roll on your back

EXERCISE 16

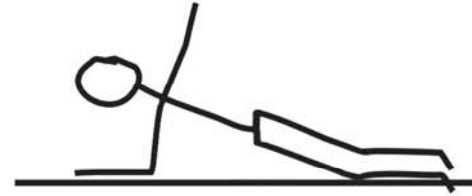
Bridge with leg lift



- **FIRST – tighten your deep stomach muscles**
- Lift your hips up off the floor
- Straighten your one knee
- Hold
- **Remember**
 - Don't let your hips drop down on one side when you straighten your knee

EXERCISE 17

Side bridge



- **FIRST – tighten your deep stomach muscles**
- Lie on your side with your knees bent
- Go up on your elbow
- Hold
- **Remember**
 - You should be in a straight line from your knees to your head

EXERCISE 18

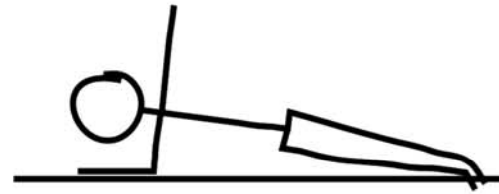
Horse



- **FIRST – get your spine in the best position with the stick**
- Lift your knee up 5cm off the floor
- Lift the opposite hand up 5cm off the floor at the same time
- Hold
- **Remember**
 - Hold your back still and don't let the stick roll

EXERCISE 19

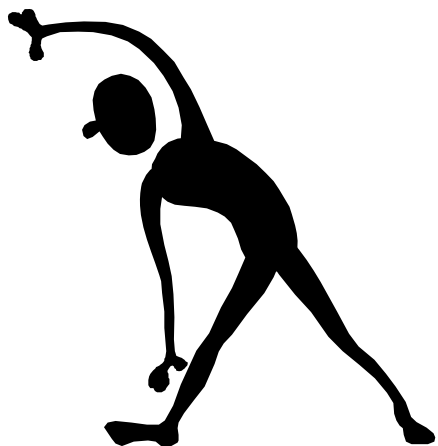
Side Bridge with legs straight



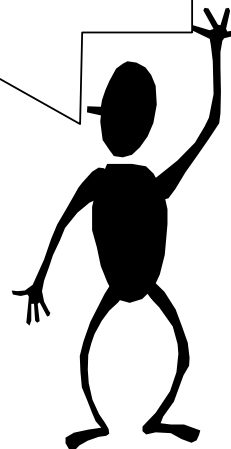
- **FIRST – tighten your deep stomach muscles**
- Lie on your side with your knees straight
- Go up on your elbow
- Hold
- **Remember**
 - You should be in a straight line from your feet to your head

MY EXERCISE DIARY

Reference No: _____



REMEMBER, You need to be completely honest when you fill in your exercise diary!



INSTRUCTIONS:

1. Put a tick in the block next to the exercises each day you do them
2. Remember, you need to do your exercises 3 times a week.
3. This is not for marks. We just want to know if you have done your exercises
4. Please do the exercises!
We will be able to tell if you haven't - so please be honest!
5. We will keep your exercise diary at the end of term.
We will make sure that all the information you have written in here remains private.

THANK YOU VERY MUCH FOR YOUR HELP!

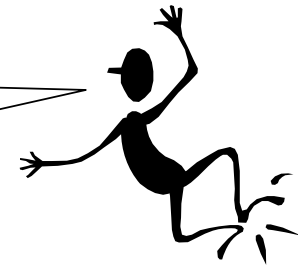
Why do we have to do these exercises?



- To make your back and stomach muscles strong
- Your stomach and back muscles are very important
- They help you to stand up straight, walk, run, play sports, dance... MOVE!
- They work together to protect your back
- If you keep these muscles strong - as you grow older you can protect your back from injury, pain and stiffness

So we are going to exercise our stomach and back muscles

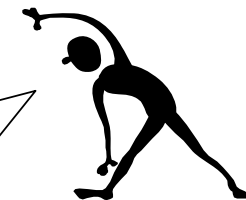
How do these muscles work?



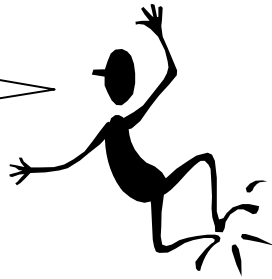
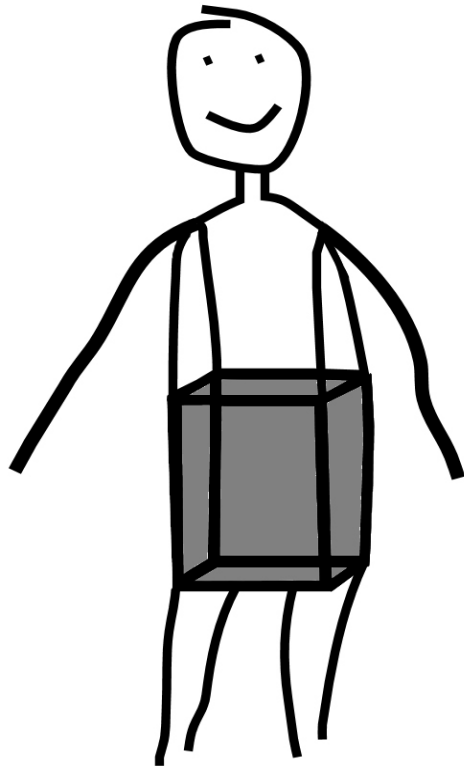
Think about a cardboard box...

- It has 4 sides, a top and a bottom
- If you take 1 side of the box away - it gets a bit weaker
- If you take 2 sides away - it gets even weaker and you are able to squash the box
- If you take 3 sides away - it gets much weaker and the box collapses

Your stomach and back muscles are similar to a cardboard box - they have 4 sides, a top and a bottom! Take a look at the picture on the next page



Take a look at our 'box'



Just like the cardboard box
if we take away any 1 of these
muscles
your back becomes weaker!



- The top is your diaphragm - this muscle helps you to take deep breaths
- The back is your back muscles
- The front is your stomach muscles
- The 2 sides are also part of your stomach muscles
- The bottom is your pelvic floor muscles






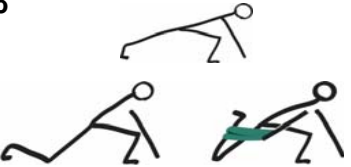
If these muscles are weak you can
easily hurt your back



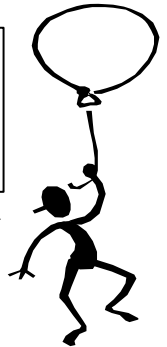
So we are going to exercise all of the
muscles in our 'box' to stay strong!

Ref No: _____

WEEK 1

EXERCISE	REPS	Mon	Tues	Wed	Thurs	Fri	Sat	Sun
1 	5X - cat and camel Hold - 30 counts for prayer stretch							
2 	10x							
3 	Hold 10 counts - 3x							
4 	Hold 30 counts - 3x							
5 	2x Both legs 1 - Hold 30 counts 2 - 10x 3 - Hold 30 counts							
6 	2x Both legs 1- Hold 30 counts 2- Hold 30 counts 3 - Hold 30 counts							

Here are your home exercises for the week
Enjoy :)



REMEMBER

Do each exercise **3 times** this week

Please be honest!

We will be able to tell if you haven't done your exercises!






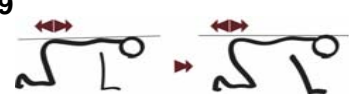


Put a tick in the block next to each exercise on the day you do them

You should have **3 ticks** for each exercise by the end of the week

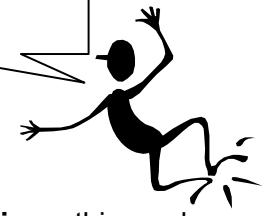
Bring this page to school next week Tuesday to the exercise class

Ref No: _____

WEEK 2

EXERCISE	REPS	Mon	Tues	Wed	Thurs	Fri	Sat	Sun
1 	5X - cat and camel Hold - 30 counts for prayer stretch							
2 	10x							
3 	Hold 15 counts - 3x							
7 	3x each side							
8 	3x each side							
9 	5x							
5 	2x Both legs 1 - Hold 30 counts 2 - 10x 3 - Hold 30 counts							
6 	2x Both legs 1- Hold 30 counts 2- Hold 30 counts 3 - Hold 30 counts							

Here are your home exercises for the week
Don't give up :)



REMEMBER

Do each exercise **3 times** this week

Please be honest!

We will be able to tell if you haven't done your exercises!

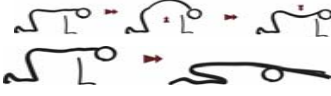


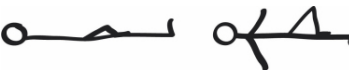
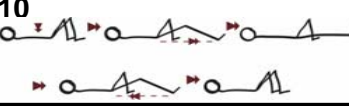
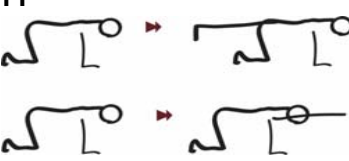

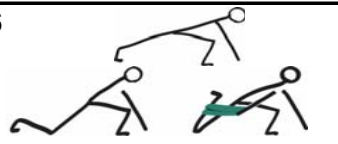
Put a tick in the block next to each exercise on the day you do them

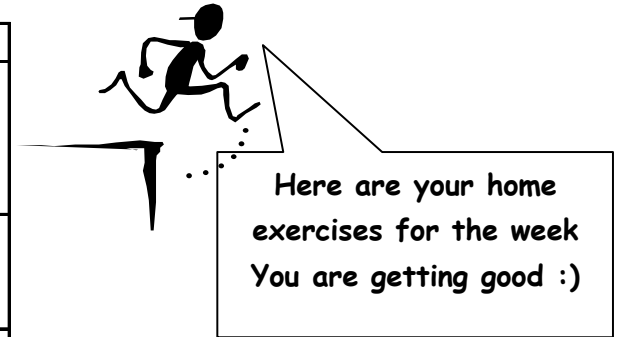
You should have **3 ticks** for each exercise by the end of the week

Bring this page to school next week Tuesday to the exercise class

Ref No: _____

WEEK 3

EXERCISE	REPS	Mon	Tues	Wed	Thurs	Fri	Sat	Sun
1 	5X - cat and camel Hold - 30 counts for prayer stretch							
2 	10x							
3 	Hold 20 counts - 3x							
8 	3x each side							
10 	3x each side							
11 	3x each							
5 	2x Both legs 1 - Hold 30 counts 2 - 10x 3 - Hold 30 counts							
6 	2x Both legs 1- Hold 30 counts 2- Hold 30 counts 3 - Hold 30 counts							



REMEMBER

Do each exercise **3 times** this week





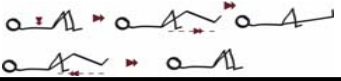
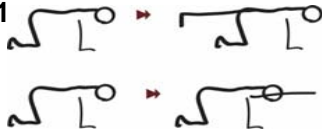



Please be honest!

We will be able to tell if you haven't done your exercises!

Put a tick in the block next to each exercise on the day you do them

You should have **3 ticks** for each exercise by the end of the week

Bring this page to school next week Tuesday to the exercise class

EXERCISE	REPS	Mon	Tues	Wed	Thurs	Fri	Sat	Sun
1 	5X - cat and camel Hold - 30 counts for prayer stretch							
2 	10x							
3 	Hold 25 counts - 3x							
8 	4x each side							
12 	4x each side							
11 	3x each							
13 	Hold 20 counts - 3x							
5 	2x Both legs 1 - Hold 30 counts 2 - 10x 3 - Hold 30 counts							
6 	2x Both legs 1- Hold 30 counts 2- Hold 30 counts 3 - Hold 30 counts							



REMEMBER

Do each exercise **3 times** this week

Please be honest!




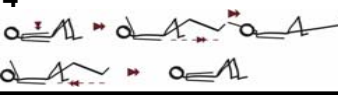




We will be able to tell if you haven't done your exercises!

Put a tick in the block next to each exercise on the day you do them
You should have **3 ticks** for each exercise by the end of the week

Bring this page to school next week Tuesday to the exercise class

Ref No: _____

WEEK 5

EXERCISE	REPS	Mon	Tues	Wed	Thurs	Fri	Sat	Sun
1 	5X - cat and camel Hold - 30 counts for prayer stretch							
2 	10x							
3 	Hold 30 counts - 3x							
14 	4x each side							
13 	Hold 30 counts - 3x							
15 	Hold 20 counts 4x each							
5 	2x Both legs 1 - Hold 30 counts 2 - 10x 3 - Hold 30 counts							
6 	2x Both legs 1- Hold 30 counts 2- Hold 30 counts 3 - Hold 30 counts							

Here are your home exercises for the week
You are a pro now :)



REMEMBER

Do each exercise **3 times** this week

Please be honest!

We will be able to tell if you haven't done your exercises!


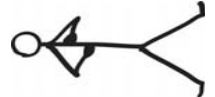

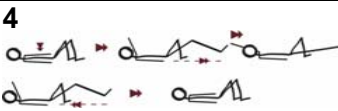




Put a tick in the block next to each exercise on the day you do them

You should have **3 ticks** for each exercise by the end of the week

Bring this page to school next week Tuesday to the exercise class

Ref No: _____

WEEK 6

EXERCISE	REPS	Mon	Tues	Wed	Thurs	Fri	Sat	Sun
1 	5X - cat and camel Hold - 30 counts for prayer stretch							
2 	10x							
3 	Hold 35 counts - 3x							
14 	4x each side							
16 	Hold 30 counts 2x each leg							
15 	Hold 30 counts 5x each side							
5 	2x Both legs 1 - Hold 30 counts 2 - 10x 3 - Hold 30 counts							
6 	2x Both legs 1- Hold 30 counts 2- Hold 30 counts 3 - Hold 30 counts							

Here are your home exercises for the week
You are doing so well :)



REMEMBER

Do each exercise **3 times** this week




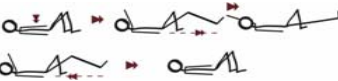
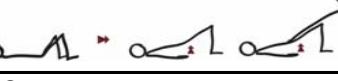
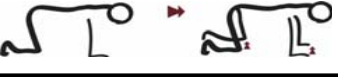

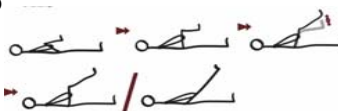

Please be honest!

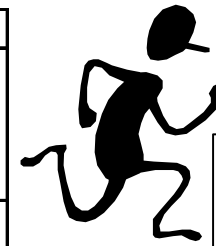
We will be able to tell if you haven't done your exercises!

Put a tick in the block next to each exercise on the day you do them

You should have **3 ticks** for each exercise by the end of the week

Bring this page to school next week Tuesday to the exercise class

EXERCISE	REPS	Mon	Tues	Wed	Thurs	Fri	Sat	Sun
1 	5X - cat and camel Hold - 30 counts for prayer stretch							
2 	10x							
3 	Hold 40 counts - 3x							
14 	5x each side							
16 	Hold 30 counts 3x each leg							
18 	Hold 30 counts 3x each side							
17 	Hold 30 counts 2x each side							
5 	2x Both legs 1 - Hold 30 counts 2 - 10x 3 - Hold 30 counts							
6 	2x Both legs 1- Hold 30 counts 2- Hold 30 counts 3 - Hold 30 counts							



Here are your home exercises for the week
You are an exercise star :)

REMEMBER

Do each exercise **3 times** this week

Please be honest!

We will be able to tell if you haven't done your exercises!




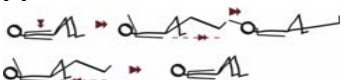

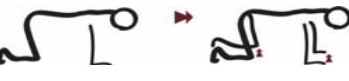



Put a tick in the block next to each exercise on the day you do them

You should have **3 ticks** for each exercise by the end of the week

Bring this page to school next week Tuesday to the exercise class

Ref No: _____

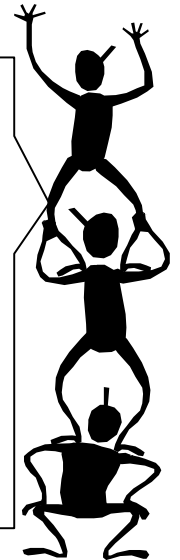
WEEK 8

EXERCISE	REPS	Mon	Tues	Wed	Thurs	Fri	Sat	Sun
1 	5X - cat and camel Hold - 30 counts for prayer stretch							
2 	10x							
3 	Hold 45 counts - 3x							
14 	5x each side							
16 	Hold 30 counts 3x each leg							
18 	Hold 30 counts 4x each side							
19 	Hold 30 counts 2x each side							
5 	2x Both legs 1 - Hold 30 counts 2 - 10x 3 - Hold 30 counts							
6 	2x Both legs 1- Hold 30 counts 2- Hold 30 counts 3 - Hold 30 counts							

**WELL DONE!
YOU ARE NEARLY
FINISHED! :)**

Here is your last set of home exercises for the week

Try to make them your best!



REMEMBER

Do each exercise **3 times** this week

Please be honest!

We will be able to tell if you haven't done your exercises!

Put a tick in the block next to each exercise on the day you do them

You should have **3 ticks** for each exercise by the end of the week

Bring this page to school next week Tuesday to the exercise class

You are finished!
WELL DONE!

Please make sure that you
have handed in all 8 pages
from the term



Thank you very much
for your help!



You Are A Star!

EXERCISE PROGRAMME – WEEKLY BREAKDOWN

WEEK 1

Warm up

- **5x** Standing breathing into extension
- **5x** High walk on spot
- **5x** Standing twists
- **3x** Side stretch
- **5x** Cat and camel stretch
- **30s-1min** Prayer stretch

Crook lying

- **10x** Diaphragmatic breathing
- TA activation
- **3x 10s** Ball squeeze
- Hamstring stretches – **2x each leg**
 - **30s** knee to chest
 - **10x** neural mobilization
 - **30s** static stretch
- **5x** Crook gentle lumbar rotations
- **30s-1min** Stretch knees to chest

Four-point kneeling

- **3x 30s** Correct alignment with stick

Standing

- Standing / Lunge stretch for iliopsoas and quadriceps – **2x each side**
 - **30s** Lunge knee **off** floor
 - **30s** Lunge knee **on** floor
 - **30s** Quadriceps

End class with diaphragmatic breathing in supine

WEEK 2

Warm up

- **5x** Standing breathing into extension
- **5x** High walk on spot
- **5x** Standing twists
- **3x** Side stretch
- **5x** Cat and camel stretch
- **30s-1min** Prayer stretch

Crook lying

- **10x** Diaphragmatic breathing
- TA activation – revise quickly
- **3x 15s** Ball squeeze
- **3x each side** Hip flexion
- **3x each side** Hip abduction / external rotation
- Hamstring stretches – **2x each leg**
 - **30s** knee to chest
 - **10x** neural mobilization
 - **30s** static stretch
- **5x** Crook gentle lumbar rotations
- **30s-1min** Stretch knees to chest

Four-point kneeling

- **3x 30s** Correct alignment with stick
- **5x** Rocking

Standing

- Alignment and activation
- **2x each side** Balance 1 leg
- Standing / Lunge stretch for iliopsoas and quadriceps – **2x each side**
 - **30s** Lunge knee **off** floor
 - **30s** Lunge knee **on** floor
 - **30s** Quadriceps

End class with diaphragmatic breathing in supine

WEEK 3

Warm up

- **5x** Standing breathing into extension
- **5x** High walk on spot
- **5x** Standing twists
- **3x** Side stretch
- **5x** Cat and camel stretch
- **30s-1min** Prayer stretch

Crook lying

- **10x** Diaphragmatic breathing
- **3x 20s** Ball squeeze
- **3x each side** Hip flexion
- **3x each side** Hip abduction / external rotation
- **3x each side** Heel slides feet on floor
- **3x 10s** Bridge arms by side
- Hamstring stretches – **2x each leg**
 - **30s** knee to chest
 - **10x** neural mobilization
 - **30s** static stretch
- **5x** Crook gentle lumbar rotations
- **30s-1min** Stretch knees to chest

Four-point kneeling

- Correct alignment with stick
- **5x** Rocking
- **3x 15s each side** Lift up alternate arms

Standing

- **1x each side** Balance 1 leg eyes with arm movements – e.g. write name
- **5x** Side lunges
- Standing / Lunge stretch for iliopsoas and quadriceps – **2x each side**
 - **30s** Lunge knee **off** floor
 - **30s** Lunge knee **on** floor
 - **30s** Quadriceps

End class with diaphragmatic breathing in supine

WEEK 4

Warm up

- **5x** Standing breathing into extension
- **5x** High walk on spot
- **5x** Standing twists
- **3x** Side stretch
- **5x** Cat and camel stretch
- **30s-1min** Prayer stretch

Crook lying

- **10x** Diaphragmatic breathing
- **3x 25s** Ball squeeze
- **3x each side** Hip abduction / external rotation
- **3x each side** Heel slides feet off floor
- **3x 20s** Bridge arms by side
- Hamstring stretches – **2x each leg**
 - **30s** knee to chest
 - **10x** neural mobilization
 - **30s** static stretch
- **5x** Crook gentle lumbar rotations
- **30s-1min** Stretch knees to chest

Four-point kneeling

- Correct alignment with stick
- **5x** Rocking
- **3x 15s each side** Lift up alternate arms
- **3x 15s each side** Lift up alternate legs

Standing

- **1x each side** Balance 1 leg eyes closed with arm / leg movements – e.g. write name
- **5x** Apple picking squats
- Standing / Lunge stretch for iliopsoas and quadriceps – **2x each side**
 - **30s** Lunge knee **off** floor
 - **30s** Lunge knee **on** floor
 - **30s** Quadriceps

End class with diaphragmatic breathing in supine

WEEK 5

Warm up

- **5x** Standing breathing into extension
- **5x** High walk on spot
- **5x** Standing twists
- **3x** Side stretch
- **5x** Cat and camel stretch
- **30s-1min** Prayer stretch

Crook lying

- **10x** Diaphragmatic breathing
- **3x 30s** Ball squeeze
- **3x each side** Hip abduction / external rotation
- **3x each side** Heel slides feet off floor with arm movements
- **3x 30s** Bridge (with arms crossed if can manage)
- **2x 10s** Bridge with alternate leg lifts
- Hamstring stretches – **2x each leg**
 - **30s** knee to chest
 - **10x** neural mobilization
 - **30s** static stretch
- **5x** Crook gentle lumbar rotations
- **30s-1min** Stretch knees to chest

Four-point kneeling

- Correct alignment with stick
- **5x** Rocking
- **1x 15s each side** Lift up alternate arms
- **1x 15s each side** Lift up alternate legs
- **3x 20s each side** Lift alternate arm and leg

Standing

- **5x each side** – high walking for balance and control
- **5x each side** - squats with apple picking
- Standing / Lunge stretch for iliopsoas and quadriceps – **2x each side**
 - **30s** Lunge knee **off** floor
 - **30s** Lunge knee **on** floor
 - **30s** Quadriceps

End class with diaphragmatic breathing in supine

WEEK 6

Warm up

- **5x** Standing breathing into extension
- **5x** High walk on spot
- **5x** Standing twists
- **3x** Side stretch
- **5x** Cat and camel stretch
- **30s-1min** Prayer stretch

Crook lying

- **10x** Diaphragmatic breathing
- **3x 35s** Ball squeeze
- **3x each side** Hip abduction / external rotation
- **4x each side** Heel slides feet off floor with arm movements
- **1x 30s** Bridge
- **3x 20s each side** Bridge with alternate leg lifts
- **3x 20s each side** Side-bridge with knees bent
- Hamstring stretches – **2x each leg**
 - **30s** knee to chest
 - **10x** neural mobilization
 - **30s** static stretch
- **5x** Crook gentle lumbar rotations
- **30s-1min** Stretch knees to chest

Four-point kneeling

- Correct alignment with stick
- **5x** Rocking
- **3x 30s each side** Lift alternate arm and leg

Standing

- **5x each side** High walking for balance and control
- **5x each side** Squats with apple picking
- **5x each side** One leg 'mini' squats
- Standing / Lunge stretch for iliopsoas and quadriceps – **2x each side**
 - **30s** Lunge knee **off** floor
 - **30s** Lunge knee **on** floor
 - **30s** Quadriceps

End class with diaphragmatic breathing in supine

WEEK 7

Warm up

- **5x** Standing breathing into extension
- **5x** High walk on spot
- **5x** Standing twists
- **3x** Side stretch
- **5x** Cat and camel stretch
- **30s-1min** Prayer stretch

Crook lying

- **10x** Diaphragmatic breathing
- **3x 40s** Ball squeeze
- **3x each side** Hip abduction / external rotation
- **4x each side** Heel slides feet off floor with arm movements
- **2x 30s** Bridge
- **3x 30s each side** Bridge with alternate leg lifts
- **3x 20s each side** Side-bridge with knees straight (if can manage or keep bent)
- Hamstring stretches – **2x each leg**
 - **30s** knee to chest
 - **10x** neural mobilization
 - **30s** static stretch
- **5x** Crook gentle lumbar rotations
- **30s-1min** Stretch knees to chest

Four-point kneeling

- Correct alignment with stick
- **5x** Rocking
- **3x 30s each side** Lift alternate arm and leg
- **3x 30s each side** Horse stance (lift opposite hand and knee off floor a few cm's)

Standing

- **5x each side** High walking for balance and control
- **5x each side** Squats with apple picking
- **5x each side** One leg 'mini' squats
- Standing / Lunge stretch for iliopsoas and quadriceps – **2x each side**
 - **30s** Lunge knee **off** floor
 - **30s** Lunge knee **on** floor
 - **30s** Quadriceps

End class with diaphragmatic breathing in supine

WEEK 8

Warm up

- **5x** Standing breathing into extension
- **5x** High walk on spot
- **5x** Standing twists
- **3x** Side stretch
- **5x** Cat and camel stretch
- **30s-1min** Prayer stretch

Crook lying

- **10x** Diaphragmatic breathing
- **3x 40s** Ball squeeze
- **3x each side** Hip abduction / external rotation
- **4x each side** Heel slides feet off floor with arm movements
- **2x 30s** Bridge
- **3x 30s each side** Bridge with alternate leg lifts
- **3x 20s each side** Side-bridge with knees straight (if can manage or keep bent)
- Hamstring stretches – **2x each leg**
 - **30s** knee to chest
 - **10x** neural mobilization
 - **30s** static stretch
- **5x** Crook gentle lumbar rotations
- **30s-1min** Stretch knees to chest

Four-point kneeling

- Correct alignment with stick
- **5x** Rocking
- **3x 30s each side** Lift alternate arm and leg
- **3x 30s each side** Horse stance (lift opposite hand and knee off floor a few cm's)

Standing

- **5x each side** High walking for balance and control
- **5x each side** Squats with apple picking
- **5x each side** One leg 'mini' squats
- Standing / Lunge stretch for iliopsoas and quadriceps – **2x each side**
 - **30s** Lunge knee **off** floor
 - **30s** Lunge knee **on** floor
 - **30s** Quadriceps

End class with diaphragmatic breathing in supine