THE RELATIVE EFFECTIVENESS OF SPINAL MANIPULATION IN CONJUNCTION WITH CORE STABILITY EXERCISES AS OPPOSED TO SPINAL MANIPULATION ALONE IN THE TREATMENT OF POST-NATAL MECHANICAL LOW BACK PAIN

By

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I, Dean Wilson, do declare that this dissertation is representative of my own work in both conception and execution.

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DEDICATION

I dedicate this to my wonderful parents for their love and support, particularly through these long years of study far from home. Having such a loving family to go home to for the holidays was all the motivation I needed to focus on completing my studies.

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ABSTRACT

Core strengthening has become a major trend in the rehabilitation of patients suffering with lower back pain.

Clinical trials have shown that core strengthening is beneficial for patients with low back pain. According to the literature, core strengthening consists of activating the trunk musculature in order to stabilize hypermobile symptomatic joints and thus lessen mechanical stress to the spine.

Spinal manipulative therapy has also proved itself to be beneficial, particularly in the case of post-natal low back pain sufferers, as manipulation may correct hypomobility associated with spinal subluxations.

Literature suggests that spinal manipulative correction of spinal subluxations in combination with core stability exercises, that stablise symptomatic hypermobile joints, may have more advantages than using these interventions singularly in the treatment of post-natal low back pain.

However, the combination of a core stability muscle training program with spinal manipulative therapy has yet to be investigated. In order to choose the most appropriate therapy for managing this condition, it is essential for research to be carried out to identify the most effective treatment, which would allow for better overall management of low back pain during the post-natal period.

Therefore this study was designed to establish the effectiveness of a combined protocol of spinal manipulation and core stability exercises in the treatment of post-natal mechanical low back pain and to establish whether this protocol should be utilized routinely in the management of this condition.

SUMMARY

Lower back pain is a common complaint amongst women during the post-natal period. As a result of this high incidence, some obstetricians, general practitioners and midwives tend to dismiss the pain as being inevitable and unimportant (Polden and Mantle, 1990:133).

In recent years the role of therapeutic exercise has shifted from improving strength, posture and mobility to stabilizing hypermobile segments and to decreasing mechanical stress to the spine. Core strengthening has become a major trend in rehabilitation which, despite its widespread use, has had meagre research.

Clinical trials, investigating the benefits of core stability muscle training programs for patients with low back pain, revealed encouraging results (Hides et al. 2001; Stanford, 2002; Stuge, 2004) as they may decrease the hypermobility of symptomatic joints that is associated with a weakening of the stabilizing system of the spine.

In addition to core strengthening, spinal manipulation has been shown to be of significant benefit in the treatment of mechanical low back pain. This is particularly evident in the case of post-natal low back pain sufferers (Fraser, 1976, Bailes, 1998) as manipulation may correct hypomobility associated with spinal subluxations.

However, the benefits of a rehabilitative core stability muscle training program in conjunction with spinal manipulative therapy has not been investigated as a means to improve overall patient management for post-natal low back pain.
For clinicians to choose the most appropriate therapy for managing this common condition it is essential for research to be carried out to define the most effective treatment.

According to the literature, treatment for this condition may yield positive effects if it is aimed at correcting subluxations of lumbar fact and sacroiliac joints, and/or

stablising symptomatic hypermobile joints using core stability exercises to rehabilitate the active stabilizing system of the spine.
Therefore, the aim of this study is to establish the effectiveness of a combined protocol of spinal manipulation and core stability exercises in the treatment of post-natal mechanical low back pain, and to establish whether this protocol should be utilized as opposed to spinal manipulation alone.

This randomized, comparative clinical trial study consisted of thirty subjects divided into two groups of fifteen. The method was that of self-selection sampling with random allocation, which is the gold standard method of allocation for research of this sort, with the advantage of this method being that it is an effective way to find subjects (Mouton, 1996).

The actual allocation of the thirty subjects into two equal groups, each consisting of fifteen subjects, was randomly performed as follows: Pieces of paper labelled from one to thirty were placed in a box, which was then shaken to mix the pieces. Subjects drawing numbers one through fifteen were allocated to the manipulation and exercise group, and subjects drawing numbers sixteen through thirty were allocated to the spinal manipulation group.

For both groups, spinal manipulative therapy was carried out twice a week for the first three weeks of the treatment protocol, which allowed sufficient time for the effects of spinal manipulation to occur (Kirkaldy-Willis, 1988, Gatterman et al. 1990; Erhard et al. 1996). If the patient became asymptomatic or if there was an absence of spinal fixations before the completion of the spinal manipulative therapy protocol, spinal manipulation was discontinued.
However, the manipulation and exercise group received core stability exercises in addition to the spinal manipulation. These exercises were performed twice a week for six weeks.

Statistical analysis was completed under the guidance of a statistician from the University of KwaZulu Natal Medical School. The subjective data was obtained using the Numerical Pain Rating Scale (Appendix H) and the Quebec Back Pain and Disability Scale (Appendix I). The objective data was obtained using the Stabilizer Biofeedback Device. Data were entered and analysed in SPSS version 11.5 (SPSS Inc. Chicago, Ill, USA). Baseline demographics and factors were compared between the two treatment groups to ensure completeness of randomization using students' t-tests in the case of quantitative data, and Fisher's exact tests or Pearson's chi square tests where appropriate for quantitative variables.

According to the statistical analysis, both groups showed improvements, subjectively and objectively, with regards to post-natal mechanical low back pain, which is in keeping with the literature. In terms of the inter-group analysis, significance was measured at a p-value of $p<0.05$. A p-value of 0.290 was noted for time prone measures of core stability endurance, 0.090 for time supine, 0.904 for Quebec back pain and disability scale measures and 0.751 for numerical pain rating scale measures.

Inter-group findings therefore revealed that a slight difference existed in favour of the manipulation and exercise group but not sufficient enough to conclude that it is more effective than manipulation alone.

It is recommended that more research be carried out to gain conclusive results indicating the least complicated and most beneficial treatment protocol.

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DEFINITION OF TERMS

Chiropractic:

Chiropractic is that discipline within the healing arts especially concerned with the etiology, pathogenesis, diagnostics, therapeutics and prophylaxis of functional disturbances, pathomechanical states, pain syndromes and other neurophysiologic effects related to the statics and dynamics of the neuromusculoskeletal system, particularly those related to the spine and the pelvis (Schafer and Faye, 1990).

Mechanical low back pain:

This is defined as pain resulting from the inherent susceptibility of the spine to static loads due to muscle, gravity forces and to kinetic deviation from the normal function (Gatterman, 1990: 129).

Manipulation:

A passive manoeuvre in which specially directed manual forces are applied to vertebral and extra-vertebral articulations of the body, with the object of restoring mobility to the restricted areas (Gatterman, 1990).

Adjustment:

A specific form of direct articular manipulation using, in the case of this study, short lever techniques with contacts, characterised by a dynamic thrust of controlled velocity, amplitude, and direction (Gatterman, 1990: 405).

Fixation:

The state whereby an articulation has become temporarily immobilised in a position that it may normally occupy during any phase of physiological movement (Haldeman, 1992: 623).

Joint dysfunction:

Joint mechanics with areas of disturbed joint function (Gatterman, 1990: 408).

Subluxation:

An aberrant relationship between two adjacent articular structures that may have functional or pathologic sequelae, causing an alteration in the biomechanical and/or neurophysiologic reflections of these articular structures, their proximal structures, and/or body systems that may be directly or indirectly affected by them (Bergmann et al. 1993).

Abdominal corset:

This refers to the abdominal muscles, particularly the recti abdominus muscles that will have been stretched and elongated as a result of the pregnancy (Polden and Mantle, 1990).

Core stabilization:

The rehabilitation and retraining of the so-called core stabilizers of the lumbar spine (transversus abdominus and multifidus), to provide increased stability around the neutral zone (Boden, 2002).

Antenatal:

Time period before delivery (Kitzinger, 1993).

Post-partum:

Time period directly after delivery (Kitzinger, 1993).

Post-natal:

Time period after birth (Kitzinger, 1993).

Objective clinical findings:

For the purpose of this study this refers to the data obtained from the measurement of the core stability muscle endurance using the Stabilizer Biofeedback Device.

Subjective clinical findings:

For the purpose of this study, these are defined as those clinical findings ascertained using the patient's perception of the pain, including the Numerical Pain Rating Scale and the Quebec Back Pain Disability Scale.

Contraindication:

Any condition, especially any disease condition, that renders one particular line of treatment improper or undesirable (Gatterman, 1990: 407).

CHAPTER 1

INTRODUCTION

1.1. The problem and its setting

Back pain is a common post-natal complaint, which may not have been troublesome during pregnancy but frequently develops following the birth (Polden and Mantle, 1990). According to Fast et al. (1987), 56% of patients suffer from low back pain during their pregnancy. Berg et al. (1988), state that two thirds of pregnant patients after delivery had backache persisting into their post-natal period and that, in some patients, the pain persisted for at least one year.

With the incidence and prevalence of low back pain being so high, it could be reasonably postulated that both sacroiliac and/or lumbar facet dysfunction could be instrumental as causative factors for low back pain (Bernard and Kirkaldy-Willis, 1987:2107-2130 and Toussaint et al. 1999).

As joint mechanics are amenable to spinal manipulation, particularly with respect to reduction of pain and restoration of motion, spinal manipulative therapy may be an effective treatment for post-natal mechanical low back pain, as evidenced by the study by Bailes (1998). A study done by Fraser (1976) indicated that post-natal low back pain improved 'dramatically' with manipulation after pregnancy.

The post-natal condition also results in the weakening of the entire abdominal 'corset' with little apparent mechanical control in the spine and resultant clinical instability. As a result, the back may be more vulnerable to injury resulting from incorrect use (Polden and Mantle, 1990).

Literature supports the theory that the most acceptable means to stabilize a hypermobile lumbar spine that may be symptomatic is to strengthen the abdominal core stability to decrease mechanical stress to the spine (Saal, 1988; Panjabi 1992; Jull and Richardson, 1994).

In response to this high incidence of post-natal mechanical low back pain, and the growing popularity of core stability strengthening in the treatment of mechanical low back pain, this study undertook to compare two different treatment protocols. The protocols compared were spinal manipulative therapy in combination with core stability exercises, as opposed to spinal manipulative therapy alone.

There are no clinical studies in which these protocols are compared for this condition and therefore this research is aimed at determining the efficacy of such techniques with respect to the objective and subjective findings.

1.2. The objectives of the study

Objective one: The first objective was to evaluate the efficacy of spinal manipulation in conjunction with core stability exercises in the treatment of post-natal mechanical low back pain, in terms of subjective and objective clinical findings.

- Hypothesis one: It was hypothesized that spinal manipulative therapy in conjunction with core stability exercises would be effective in the management of post-natal mechanical low back pain, in terms of both subjective and objective clinical findings.

Objective two: The second objective was to evaluate the efficacy of spinal manipulation alone in the treatment of mechanical low back pain in post-natal patients, in terms of subjective and objective clinical findings.

- Hypothesis two: It was hypothesized that spinal manipulative therapy alone would be effective in the management of post-natal mechanical low back pain, in terms of subjective and objective clinical findings.

Objective three: The third objective was to integrate the data obtained from objectives one and two, in order to determine which would be a more effective treatment of post-natal mechanical low back pain.

- Hypothesis three: It was hypothesized that no difference between these two groups should be found in the management of post-natal mechanical low back pain, in terms of subjective and objective clinical findings.

1.3. The rationale

Low back pain is a common complaint, particularly in the instance of pregnant and post-natal women. In this regard management protocols still require refinement.

A trend is applicable during and after pregnancy with an increase incidence of low back pain noted in the post-natal period as compared to during pregnancy (Fast et al. 1987; Berg et al. 1988). This increased incidence is based upon the post-partum physical condition, where the entire abdominal 'corset' is weakened with little apparent mechanical control. Because of this, in addition to the increase elasticity of its ligaments, the back may be more vulnerable to injury resulting from incorrect use (Polden and Mantle, 1990:223).

Treatment protocol for this study has been individually directed at the two conditions thought to be the primary causes of the post-natal low back pain. The theorised causative factors are: (i) hypomobility of the lumbar facet and sacroiliac joints due to subluxation of these joints and, (ii) symptomatic hypermobile joints with associated weakness of the dynamic stabilizing system of the spine, causing increased mechanical stress to the spine.

Spinal manipulation as a treatment protocol for the post-natal condition has been shown to be of significant benefit to these patients (Fraser, 1976; Bailes, 1998). Core strengthening has become a major trend in rehabilitation, which, despite its widespread use, has had meagre research.
Core stability muscle training as an adjunctive measure to spinal manipulation has yet to be investigated as a means to improve overall patient management for this condition by means of rehabilitating the abdominal 'corset' and stabilizing symptomatic hypermobile segments of the lumbar spine.

Upon review of the related literature, it appears that no controlled studies have been done, to the researcher's knowledge, to compare the clinical efficiencies of spinal manipulative therapy in combination with core stability exercises to spinal manipulative therapy alone in the management of post-natal mechanical low back pain.

A variety of treatment protocol may be used for the treatment of post-natal low back pain, and this study wishes to determine whether spinal manipulation in conjunction with core stability exercises should be routinely considered in the management of this subgroup of back pain sufferers.

To ensure that the practitioner can provide optimal care for each patient and their unique clinical setting, it is necessary to investigate other treatment options.

In the remaining chapters the researcher will outline pertinent literature around the topic (Chapter 2), describe the methodology of the study in detail (Chapter 3) and present the statistics (Chapter 4), results (Chapter 5) and subsequent conclusions (Chapter 6) drawn from them.

CHAPTER 2

LITERATURE REVIEW

2.1. Introduction

The following is a review of the current literature and clinical trials conducted on the subject of mechanical low back pain and more specifically, post-natal mechanical low back pain.

The epidemiology and etiology of low back pain in pregnancy and the post-natal period are discussed in relation to low back pain in the general population in order to determine whether similarities or differences exist. These are discussed as it may allow us to determine whether back pain in pregnancy and post-natally is a separate entity as compared to mechanical low back pain in the general population, which may influence the management approach for this subgroup of back pain sufferers.

The management of post-natal low back pain and mechanical low back pain in general are discussed, with the focus placed on the interventions utilized in the study. These were core stabilization exercises and spinal manipulative therapy.

The review of the literature aims to establish a greater understanding of the approach necessary in the management of post-natal low back pain.

2.2. Epidemiology of low back pain

2.2.1. Incidence and prevalence of mechanical low back pain

Incidence is the rate at which healthy people in a given population develop a disease or symptom over a specified period of time. Lifetime incidence therefore reflects the number of people who develop a condition at sometime in their lives. Prevalence is defined as a measure of the number of people in a certain population group, who have a symptom or disease at a specific time (Borenstein et al. 1995).

According to Burton and Cassidy (1992), low back pain has a lifetime prevalence of between 60% and 90% for any population. Cox (1990) supports this by stating that low back pain is only slightly less prevalent than the common cold amongst the population of the United States.

The lifetime incidence of low back pain in western society is 60-80% of the population (Koes, 1991). Jayson (1992) reported that racial differences in the frequency of low back pain had not been adequately studied. South Africa's lifetime incidence of low back pain in Indian and Coloured communities was in keeping with Koes (1991) findings, where it was found to be 78.2% and 76.6% respectively, and the prevalence was 45% and 32,6% respectively (Docrat, 1999). In the formal black South African settlement of Chesterville the prevalence of low back pain was found to be 53.1%, while the lifetime incidence was 57.6% (van der Meulen, 1997). Both these studies recommended larger sample sizes in the future.

2.2.2. Gender and low back pain

In the formal black South African settlement of Chesterville, the incidence and prevalence of low back pain was found to be higher for women than men.
The lifetime incidence for women was 61.7% as opposed to 51.8% for men, and the prevalence was 56.4% for women as opposed to 48.4% for men (van der Meulen, 1997). A significant association between gender and lifetime incidence was found. Gender was found to be significantly associated with low back pain prevalence and the female gender was more at risk of developing low back pain (van der Meulen, 1997).
This trend was also found in a study by Docrat (1999), in which the prevalence of low back pain in the Indian and Coloured communities in South Africa was found to be higher for women as compared to men.

2.2.3. Epidemiology of low back pain in pregnancy and post-natally

Back pain is a common post-natal complaint, which may interfere with the quality of life experienced by the new mother at this time. Back pain may not have been troublesome during pregnancy but it frequently develops following the birth (Polden and Mantle, 1990: 224).

For many mothers backache resolves in the first few weeks after delivery, but for some it may continue for months, and for a few it first presents post-partum (Ostgaard and Andersson, 1992).

An increase in the incidence of low back pain is noted in the post-natal period as compared to during pregnancy (Fast et al. 1987; Berg et al. 1988). According to Fast et al. (1987) 56% of patients suffer from low back pain during their pregnancy. Berg et al. (1988), state that after delivery, two thirds of pregnant patients had backache which persisted into their post-natal period, and that in some patients the pain persisted for at least one year.

In a study conducted by Ostgaard and Andersson (1992) in which eight hundred and seventeen women were followed through pregnancy and up to a period of twelve months after delivery, it was noted that 67% of women experienced low back pain directly after delivery. At the twelve month follow-up examination after delivery, 37% of the women still had some low back pain and on the 18 month follow-up examination, 7% of the women had serious low back pain.

With this high incidence of post-natal low back pain, some obstetricians, general practitioners and midwives may dismiss the pain as being inevitable and unimportant (Polden and Mantle, 1990:133).

The incidence of low back pain during pregnancy and the post-natal period is summarised in table 1 below:

Table 1: The incidence of low back pain during pregnancy and post-natally

Incidence of low back pain during pregnancy	
Author	**Incidence**
Fast et al. 1987	56%
Berg et al. 1988	49%
Mantle, 1994	50%
Incidence of low back pain post-natally	
Author	**Incidence**
Berg et al. 1988	66%
Ostgaard and Andersson, 1992	67% directly after delivery
Ostgaard and Andersson, 1992	37% at 12-month follow up

Although the information presented in the table above is dated, it can be seen that the incidence of low back pain during pregnancy ranges from 49 - 56%, whereas the incidence of low back pain in the post-natal population ranges from 66 - 67% for the period directly after birth, with 37% of women having persistent low back pain one year after the pregnancy. The higher incidence of low back pain in the post-natal period may be as a result of the post-natal physical condition and the increased demands placed on the new mother (Polden and Mantle, 1990; Conway, 1995; Macarthur et al. 1995).

According to Kristiansson et al. (1996), strong etiological evidence indicates that back pain during pregnancy may be a special entity, which may have another origin than back pain not related to pregnancy. As the most likely cause of post-natal low back pain is simply that it is a continuation of antenatal problems (Russell, 1997), post-natal low back pain sufferers also represent a specific subgroup.

In summary:

According to Burton and Cassidy (1992), low back pain has a lifetime prevalence of between 60% and 90% for any population. According to Walker (1997), low back pain is a major health problem throughout the world with the associated costs being significant.

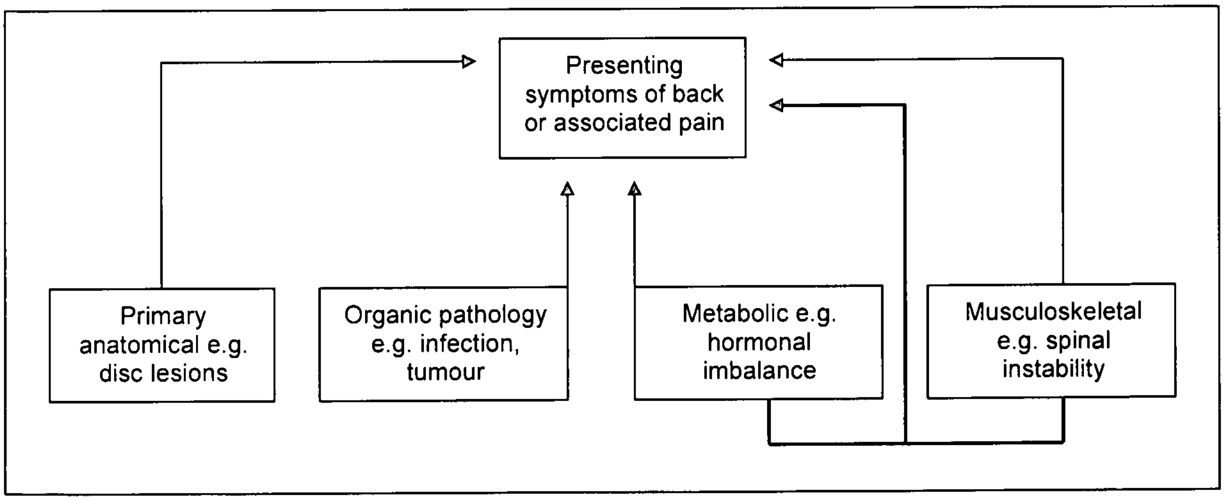
Studies suggest that gender may be significantly associated with low back pain prevalence, with the female gender being more at risk of developing low back pain as opposed to men (van der Meulen, 1997).

Post-natal low back pain is a common complaint among new mothers, which may or may not have been present during the pregnancy and frequently develops following birth (Polden and Mantle, 1990). The incidence of low back pain may be more common in the post-natal period rather than during pregnancy (Fast et al. 1987; Berg et al. 1988).
Evidence suggests that back pain during pregnancy may be a separate entity to back pain which is not related to pregnancy. As post-natal low back pain appears to be a continuation of antenatal problems, post-natal low back pain itself represents a specific subgroup of back pain sufferers (Kristiansson et al. 1996; Russell, 1997).

2.3. Etiology of low back pain

The multi-factorial nature of back pain is demonstrated in figure 1 below:

Figure 1: The multi-factorial nature of low back pain



There are many potential areas for the development of low back pain (Fairbank et al. 1990; Gatterman and Panzer, 1990; Haldeman, 2005) some of which have received a lot of attention in terms of research, whereas others have not. Of particular interest to this study is the relationship between metabolic (hormonal imbalance) and musculoskeletal (spinal instability) factors, which is demonstrated in the figure above. This relationship is theorised to be an important cause of post-natal lower back pain and is therefore thoroughly discussed in the literature that follows.

2.3.1. Etiology of mechanical low back pain in the general population

Musculoskeletal disorders are amongst the most common medical conditions reported, the primary site being the lower back. About 90% of patients with low back pain can be attributed to mechanical causes (Weiner and McCulloch, 2000).
It has been found that mechanical disorders of the low back are quite specific and local in nature, affecting certain anatomical regions (Giles and Singer, 1997).
In many cases, the precise cause of pain cannot be determined. Due to this fact, approaches to diagnosis and treatment differ and confusion ensues (Weiner and McCulloch, 2000).

There are commonly three diagnoses associated with mechanical low back pain (Schaefer and Faye, 1989):

1. Lumbar facet syndrome
2. Sacroiliac syndrome
3. Lumbar radicular syndrome (discogenic or mechanical in origin)

These syndromes may be caused by:

1. sprain/strain
2. poor posture
3. disuse
4. overuse
5. developmental abnormalities
6. joint dysfunction (fixation/hypermobility)
7. degenerative changes
8. combination of any of the above

(Schaefer and Faye, 1989).

According to Kirkaldy-Willis (1988) three further aspects must be considered when looking at the origins of low back pain. These include:

1. Emotional factors – anxiety, depression, fear, tension.
2. Changes in muscle – impaired local circulation, sustained muscle contraction, vasoconstriction, structural muscle changes and abnormal contraction.
3. Changes in the three joint complex – strains, synovitis, facet joint syndrome, degeneration and disc degeneration.

For the purpose of this study only patients with lumbar facet and/or sacroiliac syndrome were included in the research.

2.3.2. Etiology of low back pain in pregnancy and post-natally

There are a number of theories that attempt to explain the occurrence of low back pain during and after pregnancy.

Low back pain during pregnancy is commonly attributed to excessive lumbar lordosis, laxity of ligaments due to secretion of relaxin, fatigue and compensatory posture (Bullock et al. 1987; Fast et al. 1987; Berg et al. 1988). Significant postural changes are first noted from the 5th month antenatally and extend into the post-natal period. These may be compensatory, as a result of an increase in weight gain, change in centre of gravity and stretching or weakening of the abdominal muscles (Bullock, 1987).

In a study by Fast et al. (1987), it was found that contrary to what many expect, the age, weight gained by the mother during pregnancy, baby's birth weight, number of prior pregnancies, and number of prior children are not factors involved in back pain during pregnancy. However, it was noted that more disability occurred in women with prior pregnancies as compared with those who were not pregnant before. Fast et al. (1987) suggested that a change of posture or weaker trunk muscles might explain this observation.

Evidence in favour of biomechanical factors is that the back pain shows a strong correlation to heavy work and to twisting and bending when working. Evidence against mere biomechanical factors is that the back pain often starts when the weight gain by the mother and fetus is insignificant and that the incidence of back pain does not parallel the weight gain (Kristiansson et al. 1996).

Looking at the post-natal period, the following factors could play a role in the progression of low back pain: heavy enlarged breasts, swollen and achy legs, mood (post-natal depression) and increasing demands made by either the newborn infant or other children or the partner (Polden and Mantle, 1990: 224).

With the post-partum physical condition, the entire abdominal 'corset' will be weakened with very little apparent mechanical control. Because of this, in addition to the increased elasticity of its ligaments, the back will be more vulnerable to injury resulting from incorrect use (Polden and Mantle, 1990:223).

Epidural analgesia for labour has been implicated in the development of chronic backache in two retrospective studies. It was suggested that mothers receiving epidural analgesia adopted positions stressful to the lower back for prolonged periods and this, combined with muscle weakness and immobility, resulted in post-natal low back pain (Russell, 1997).

A clinical trial performed by Bailes (1998) indicated that spinal manipulative therapy is effective in the treatment of post-natal mechanical low back pain. A diagnosis of lumbar facet or sacroiliac syndrome as defined by the researcher was made, and spinal manipulative therapy was performed on those lumbar facet and sacroiliac joints involved. Thus the joint mechanics in post-natal patients are amenable to spinal manipulation, particularly with respect to reduction of pain and restoration of motion.

Most antenatal education ends with the birth of the newborn and many post-natal women are unprepared. The new mother will now be required to care for the newborn, doing daily lifting, breastfeeding and changing of nappies. The mother's sleep cycle will be disturbed which brings upon fatigue and tiredness, all of which will lead to the recurrence of the existing low back pain (Conway, 1995: 258).

In summary:

Musculoskeletal disorders are amongst the most common medical conditions reported, the primary site being the lower back. Low back pain in about 90% of patients can be attributed to mechanical causes (Weiner and McCulloch, 2000). Some authors suggest that mechanical low back pain is specific and local in nature (Giles and Singer, 1997), whereas others suggest that most diagnoses are unspecific (Frymoyer, 1988).

It is clear that the causes of post-natal low back pain are numerous and varied. The bulk of literature tends to focus on a few topics that are of significant interest in understanding the cause of low back pain in the post-natal period, these are:

- The role of the hormone relaxin (Calguneri et al. 1982 and Kristiansson et al. 1996).
- Epidural anaesthesia (Macarthur et al. 1995).
- Weakening of the abdominal musculature (Polden and Mantle, 1990; Panjabi, 1992 and Cosio-Lima, 2003).
- Lumbar facet and sacroiliac dysfunction (Bernard and Kirkaldy-Willis, 1987:2107-2130; Bailes, 1998 and Toussaint et al. 1999).

The literature with regards to these suggested causes of post-natal low back pain is presented in the pages to follow. It is important to make the point that the etiology is most often unknown and therefore the literature presented here is mostly theory and no one theory explains all the symptomatology or lack thereof in patients.

2.3.2.1. Relaxin

Relaxin is a hormone secreted by the corpus luteum and functions to prepare the endometrium for implantation, cervical ripening and inhibition of uterine activity during the gestation period. However, an important function of relaxin is the remodelling of connective tissue, leading to joint laxity in target organs to facilitate the delivery of the newborn infant (MacLennan, 1981). The laxity of the joints is not limited to the pelvic joints, but all joints of the body are affected to some degree (Mantle, 1988).

The body's ligamentous and collagenous connective tissue will be softer and more elastic than prior to pregnancy and will take four to five months for full recovery to take place. With the increase of relaxin post-natally, connective tissue and joint stability are compromised, resulting in abnormal stresses placed on these structures (Calguneri et al. 1982).
According to Kristiansson et al. (1996), how internal and hormonal factors may cause back pain can only be speculated. It is their opinion that there seems to be stronger evidence in favour of an internal or hormonal cause of back pain during pregnancy than in favour of a purely mechanical cause. This indicates that back pain during pregnancy may be a special entity and may have another origin than back pain not related to pregnancy.

According to Erhard et al. (1996), hormonally induced hypermobility causes subluxations to occur within the pelvic joints. The most common sites for pathology appear to be the iliosacral and sacroiliac joints.
After childbirth, the ligaments normally retighten and the locking mechanism becomes more effective. Occasionally, the locking may occur in a position of rotation of the hip bones that occurred during pregnancy. This creates a subluxation of the sacroiliac joint, which causes pain by placing unusual tension on the ligaments surrounding this joint (Erhard et al. 1996).

On the other hand, a study by Fast et al. (1987) concluded that the secretion of the hormone relaxin might contribute to pain, primarily in the first trimester of pregnancy,

whereas heavier babies, deconditioned trunk muscles, and vascular compromise may cause pain later on.
Additionally, Peterson et al. (1994), Hansen et al. (1996), Schauberger et al. (1996), dispute the effects of relaxin altogether.

In summary:

An important function of relaxin is the remodelling of connective tissue, leading to joint laxity in target organs to facilitate the delivery of the newborn infant (MacLennan, 1981). However, this laxity of the joints is not limited to the pelvic joints, but all joints of the body are affected to some degree (Mantle, 1988). Joint stability may be compromised and as a result, abnormal stresses may be placed on these structures causing low back pain (Calguneri et al. 1982).
This indicates that back pain during pregnancy may be a special entity and may have another origin than back pain not related to pregnancy (Kristiansson et al. 1996).

2.3.2.2. Epidural Anaesthesia

Two retrospective studies in the United Kingdom have suggested an association between epidural anaesthesia and long term low back pain of new onset after delivery. Both surveys, however, were compromised by their retrospective design and low response rate (Macarthur et al. 1995).

A prospective cohort study by Macarthur et al. (1995) showed that the association between epidural anaesthesia and post-partum low back pain was inconsistent over time with a significantly increased risk of low back pain (epidural versus non-epidural) noted only on the first day after delivery. The significantly increased incidence of low back pain in the epidural group on day one might be explained by the local musculoligamentous trauma associated with insertion of an epidural needle.

The immobility associated with epidural anaesthesia usually lasts less than 12 hours. It could be argued therefore that the physiological changes associated with pregnancy and the maternal workload after delivery are more biologically plausible risk factors for post-partum back pain (Macarthur et al. 1995).

In summary:

According to Macarthur et al. (1995), retrospective studies suggesting epidural anaesthesia as a cause of low back pain were flawed. Prospective studies indicate that epidural anaesthesia may be a cause of back pain only for the first day following an epidural, but is not a cause of chronic low back pain.
Further research is necessary to clarify the effects of epidural anaesthesia.

2.3.2.3. Abdominal musculature

As the abdomen becomes increasingly larger, increased pressure results in stretching and elongation of the two recti abdominis muscles with a possibility of split occurring along the linea alba. Thus, the entire abdominal 'corset' is weakened with little apparent mechanical control. Because of this, in addition to the increased elasticity of its ligaments, the back may be more vulnerable to injury resulting from incorrect use (Polden and Mantle, 1990:223).

This weakening of the abdominal musculature may lead to negative implications in terms of spinal stability with the possibility of resultant low back pain (Panjabi, 1992) as discussed in the section below:

2.3.2.3.1. Spinal stability

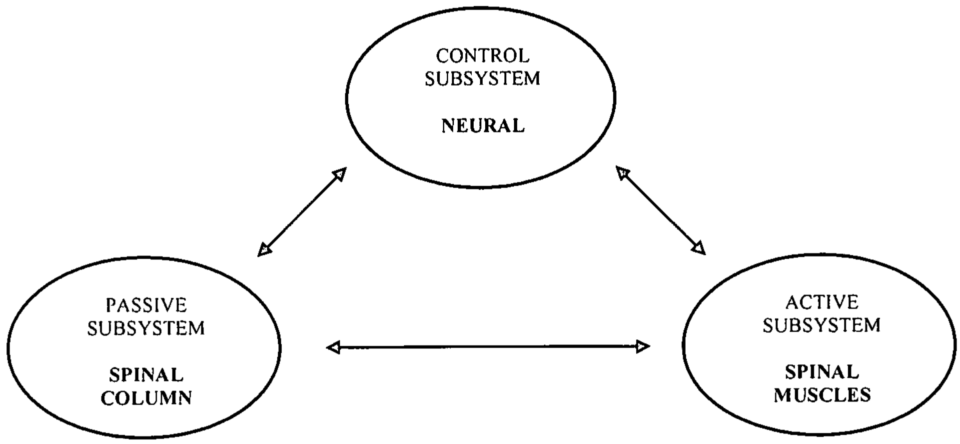
Spinal instability is considered to be one of the important causes of low back pain but is poorly defined. The basic concept of spinal instability is that abnormally large intervertebral motions cause either compression and/or stretching of the inflamed neural elements or abnormal deformations of ligaments, joint capsules, annular fibres, and end-plates, which are known to have a significant density of nociceptors. In both situations, the abnormally large intervertebral motions may produce pain (Panjabi, 1992:I).

The basic biomechanical functions of the spinal system are to allow movements, carry loads, and to protect the spinal cord and nerve roots. Mechanical stability of the spine is necessary to perform these functions and, therefore, it is of fundamental significance to the human body (Panjabi, 1992:I).

- **The spinal stabilizing system:**

Panjabi's theory of the spinal stabilizing system (1992) consists of three separate but intimately linked systems that play a major role in stabilizing the lower back: the passive spinal column, the active spinal muscles, and the neural control unit.

Figure 2: The relationship between the three spinal stabilizing subsystems



- <u>**Components of the spinal stabilizing system:**</u>

The three subsystems that play a role directly and/or indirectly in the stability of the spinal system are outlined by Panjabi (1992:I) as:

1. ***The passive musculoskeletal subsystem:***

   This includes vertebrae, facet joints, intervertebral discs, spinal ligaments and joint capsules, as well as the passive properties of the muscles.

Figure 3: The lumbar vertebra

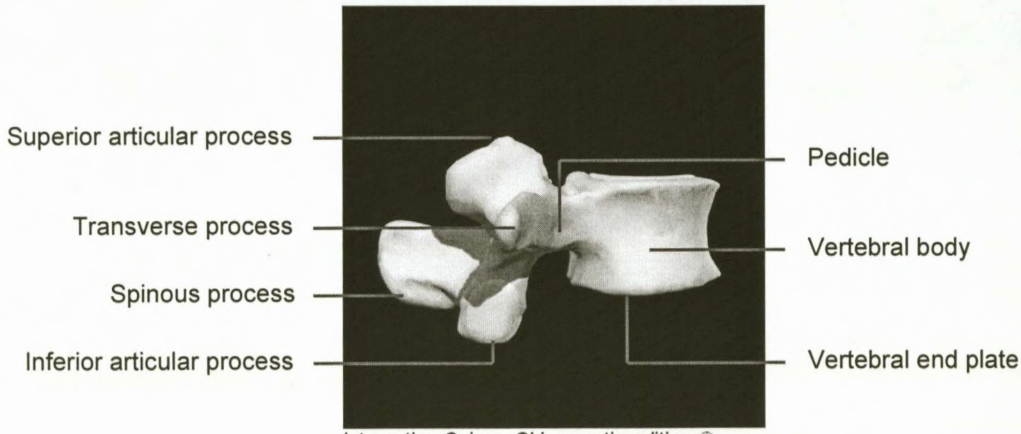
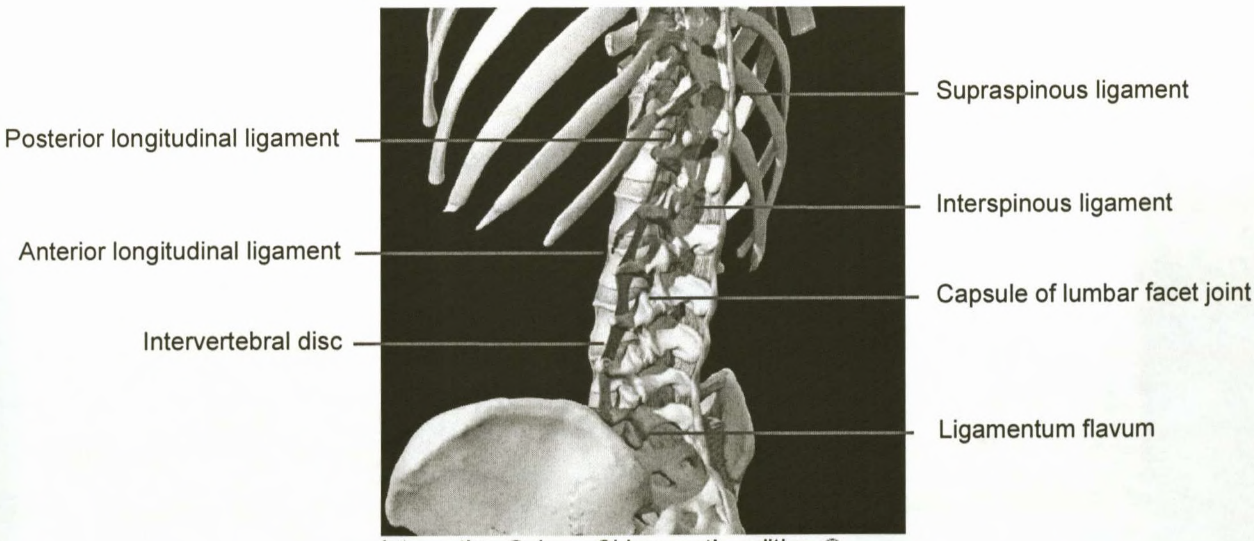


Figure 4: The ligaments of the lumbar spine



The lumbar zygapophyseal joints:

Anatomy

The zygopophyseal joint is formed by the junction between the superior and inferior facets of the articular processes, on one side of two adjacent vertebrae. A synovial membrane lines the articular capsule, ligamentum flavum and synovial joint folds. They are diarthroidal synovial joints surrounded by a capsule posterolaterally and the ligamentum flavum anteromedially (Gatterman, 1995).

The articular processes are large, thick, and strong. The superior articular processes are concave and face posterior and medial, while the inferior articular processes are convex and face anterior and lateral. The lumbar facets lie primarily in the sagittal plane, but become more coronal at the lumbrosacral junction (Bergmann et al. 1993).

Innervation

The zygopophyseal joint capsule receives a rich supply of sensory innervation. The sensory supply is derived from the medial branch of the posterior primary division (dorsal ramus) at the level of the joint and each joint also receives a branch from the posterior primary division of the level above (Gardner, 2000). Three types of sensory receptors occur in the facet joint capsule:

1. Type 1: sensitive static and dynamic mechanoreceptors that fire constantly due to continual joint motion.
2. Type 2: less sensitive mechanoreceptors that fire only on joint motion.
3. Type 3: slow conducting mechanoreceptors.

(Gatterman, 1995: 21).

Function

The lumbar facets normally carry 18 per cent of axial load and up to 33 per cent in extended postures. The facets with their articular capsules provide up to 45 per cent of the torsional strength of the lumbar spine (Bergmann et al. 1993).

The lumbar facet joints also guide and restrain movement between vertebrae and protect the discs from shear forces, excessive flexion and axial rotation (Giles, 1997).

The sacroiliac joints:

Anatomy

The sacroiliac articulation is a true synovial joint, having a joint cavity containing synovial fluid and enclosed by a joint capsule. The articular surface is described as auricular, a letter C, or a letter L lying on its side.

The articular surfaces have different contours, which develop into interlocking elevations and depressions.

The morphologic configuration of the sacroiliac joints are not static and are extremely variable from individual to individual (Bergmann et al. 1993).

Microscopic examination of the joint surfaces reveals a bluish fibrocartilage that covers the iliac side, while the sacral surface shows a thicker, whiter hyaline cartilage (Gatterman, 1990).

A number of strong ligaments aid in stabilizing the pelvic mechanism:

- The posterior sacroiliac ligaments
- The sacrotuberous ligaments
- The anterior sacroiliac ligaments
- The sacrospinous ligaments
- Sacroiliac interosseous ligaments
- Iliolumbar ligaments

(Bergmann et al. 1993).

There is scant mention in the literature of the structure of the capsule of the sacroiliac joint because the joint is so intimately surrounded by thick ligaments. Authors report that the posterior capsule is rudimentary or absent and the anterior sacroiliac ligament is a thickening of the anterior capsule (Gardner et al. 2000).

Innervation

The articular branches of these joints are derived from the superior gluteal nerves, the sacral plexus and the dorsal rami of the S1 and S2 nerves.

The posterior aspect of the sacroiliac joint is innervated by both posterior rami of L5-S2 spinal nerves, while the anterior aspect is innervated by both posterior branches from the L3-S2 roots and superior gluteal nerve L5-S2 (Moore et al. 1999).

Function

The shape and the configuration of the posterior joints are important to their function. The articular surfaces have different contours, which develop into interlocking elevations and depressions. This bony configuration produces what has been termed a keystone effect of the sacrum, effectively distributing axial compressive forces through the pelvic mechanism. Forces from the lower extremities divide, heading upward toward the spine and anteriorly toward the pubic symphysis, while downward forces of gravity on the spine split to both sides (Bergmann et al. 1993).

2. ***The active musculoskeletal subsystem:***

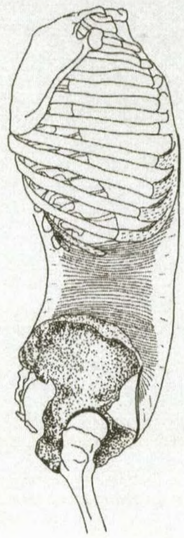
This system includes the muscles and tendons surrounding the spinal column. The muscles of the trunk can be divided into an outer global system and a deep local system. The global system consists of the large torque producing muscles that provide general spinal stability by countering external loads and produce large multiplanar movements of the spine. Examples include the quadratus lumborum and erector spinae (Stanford, 2002).

The local muscles of the spine attach directly to the vertebrae and are primarily responsible for segmental stability. The multifidus and transversus abdominus muscles are considered to be local muscles of the lumbar spine (Stanford, 2002).

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

Figure 5: The transversus abdominis muscle

TRANSVERSUS ABDOMINIS



Trunk—lateral view

Origin	Lateral part of inguinal ligament, iliac crest, thoracolumbar fascia, cartilage of lower six ribs	**Action**	Compresses abdomen
		Nerve	Seventh to twelfth intercostal, iliohypogastric, ilioinguinal nerves
Insertion	Abdominal aponeurosis to linea alba	**Relationships**	Deepest of the three lateral abdominal muscles

Note: Important in forced expiration, coughing, sneezing.

(The University of Auckland, Bioengineering Institute, www.auckland.ac.nz).

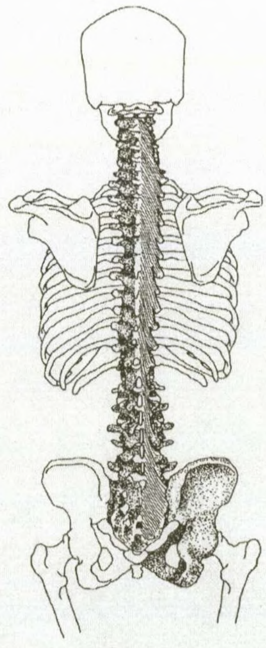
Figure 6: The multifidus muscle

MULTIFIDIS*

Origin	Sacral region—along sacral foramina up to posterior superior iliac spine Lumbar region—mamillary processes† of vertebrae Thoracic region—transverse processes Cervical region—articular processes of lower four vertebrae (C4–C7)
Insertion	Spinous process two to four vertebrae superior to origin
Action	Extend and rotate vertebral column
Nerve	Dorsal primary division of spinal nerves

*Part of transversospinalis.

†Posterior border of superior articular process.



Trunk—dorsal view

(The University of Auckland, Bioengineering Institute, www.auckland.ac.nz).

The spinal stabilizing functions of transversus abdominus and multifidus are discussed below:

a. The lumbar multifidi:

   The multifidi have been found to be the largest contributors to intersegmental stability within the neutral zone[1]. The lumbar multifidi do not appear to change in length during active lumbar movements, which supports the theory that the multifidi are responsible for stabilizing intersegmentally rather than assisting the global muscles in producing trunk movement (McGill, 1991).

   Multifidus, when compared to other muscles in close proximity to L4-L5, contributed two-thirds of the increased stiffness imparted by the contraction of the muscles (Wilke et al. 1995).

b. The transversus abdominus:

   This muscle functions differently from the other abdominal muscles. The transversus abdominus contracts regardless of the direction of trunk movement. Also, with trunk perturbations, it is recruited prior to all other abdominal muscles (O'Sullivan et al. 1998).

   Transversus abdominus (TrA) is the only abdominal muscle active during phasic movements, highlighting its role as an active stabilizer of the spine, and it prepares the body for the disturbances produced by movement of the lower limbs (Richardson, 1995).

   TrA is the only abdominal muscle that has an aponeurotic attachment to the middle layer of the thoracolumbar fascia (TLF) (Bogduk, 1997). TrA helps control intersegmental motion via production of lateral tension in the TLF, which raises intra-abdominal pressure (Evans and Oldrieve, 2000).

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[1] The neutral zone is that part of the range of physiological motion, measured from the neutral position, within which the spinal motion is produced with a minimal internal resistance. The neutral zone appears to be a clinically important measure of spinal stability function.

The contraction of the transversely orientated fibres of transversus abdominus, independently of the other abdominal muscles, reduces the laxity of the sacroiliac joints to a larger extent than a bracing action using all of the lateral abdominal muscles (Richardson et al. 2002).

3. ***The neural control and feedback subsystem:***

This includes the various force and motion transducers, located in ligaments, tendons and muscles and the neutral control centre (brain).

- **Normal functioning of the spinal stabilizing system:**

The spinal stabilizing system adjusts so that the neutral zone remains within certain physiological thresholds to avoid clinical instability. An increase in the neutral zone indicates clinical instability[2] (Panjabi, 1992:II).
Thus normal functioning of the subsystems of the spinal stabilizing system is important in providing spinal stability.

1. ***The passive (ligamentous) subsystem:***

Components of this subsystem do not provide any significant stability to the spine in the vicinity of the neutral position. It is towards the ends of the ranges of motion that the ligaments develop reactive forces that resist spinal motion.
This subsystem is passive only in the sense that it, on its own, does not generate or produce spinal motions, but is dynamically active in monitoring transducer signals for measuring vertebral position and motions (Panjabi, 1992:I).

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[2] Clinical instability is defined as a significant decrease in the capacity of the spinal stabilizing system to maintain the intervertebral neutral zones within the physiological limits so that there is no neurological dysfunction, no major deformity and no incapacitating pain. An increase in the neutral zone size is an indicator of clinical instability. Dysfunction within any of the three subsystems can lead to an increase in size of the neutral zone. (Panjabi, 1992:II)

2. ***The active (musculotendenous) subsystem:***

The muscles and tendons of the active subsystem are the means through which the spinal system generates forces and provides the required stability to the spine. The magnitude of the force generated in each muscle is measured by the force transducers built into the tendons of the muscles. Therefore this aspect of the tendons is part of the neural control subsystem (Panjabi, 1992:I).

3. ***The neural control subsystem:***

This subsystem receives information from the various transducers, determines specific requirements for spinal stability and causes the active subsystem to achieve the stability goal. Individual muscle tension is measured and adjusted until the required stability is achieved. The requirements for the spinal stability and therefore the individual muscle tensions, are dependent on dynamic posture, that is, variation of lever arms and inertial loads of different masses and external loads (Panjabi, 1992:I).

- **Dysfunction in the three subsystems:**

1. ***Passive subsystem dysfunction:***

Dysfunction may be caused by mechanical injury, such as overstretching of ligaments, development of tears and fissures in the annulus, development of micro-fractures in the end-plats and extrusion of disc material into the vertebral bodies (Panjabi, 1992:1). As the secretion of the hormone relaxin during pregnancy results in laxity of ligamentous structures, and particularly those of the spinal column, relaxin may be a cause of dysfunction within the passive subsystem, which may result in clinical instability and micro-trauma to the spine with resultant low back pain.

2. Active subsystem dysfunction:

This subsystem may develop deterioration of its ability to receive and/or carry out the neural commands, to provide accurate feedback of muscle tension information to the neural control unit or to produce co-ordinated and adequate muscle tensions; such deformation may result from disuse, degeneration, disease or injury (Panjabi, 1992:I). With the post-natal condition, the abdominal musculature is considerably weakened as a result of stretching and diastasis that may have occurred during pregnancy (Polden and Mantle, 1990). As the muscles and tendons of the active subsystem are the means through which the spinal stabilizing system generates forces and provides the required stability to the spine, the effect of the weakened abdominal muscles that occurs in this condition results in dysfunction within the active musculoskeletal subsystem, with resultant spinal instability and low back pain.

3. Neural subsystem dysfunction:

This system has the enormously complex task of monitoring and adjusting the forces in each of the muscles surrounding the spinal column. Errors in the firing of muscles may cause dysfunction in this subsystem. Too small or too large muscle forces and/or too early or too late firing of muscles can affect this subsystem. In addition to damaging the active subsystem, muscle force errors might lead to overload of a passive structure (e.g. Disc) (Panjabi, 1992:I).

There is evidence to suggest that the presence of chronic low back pain often results in a general loss of function and de-conditioning as well as changes to the neural control system, affecting timing of patterns of co-contraction, balance, reflex and righting responses (O'Sullivan et al. 1997).
Such dysruptions to the neuro-muscular system leave the lumbar spine potentially vulnerable to instability, particularly within the neutral zone (Cholewicki & McGill, 1996). This is supported by the clinical trial performed by Uys (2006), which showed that the spinal manipulative correction of joint dysfunction within the lumbar and sacroiliac regions of the spine allowed for improved endurance

time measures for the abdominal core stabilizing musculature in patients suffering with chronic mechanical low back pain.

In summary:

There is a great deal of literature with regards to the role of the abdominal musculature in the cause and treatment of low back pain.
It is clear that pregnancy results in weakening of the abdominal muscles due to stretching and possible diastasis of the muscles that occurs during pregnancy and labour (Polden and Mantle, 1990).
Literature supports the theory that the most acceptable means to stabilize a hypermobile lumbar spine that may be symptomatic, is to strengthen the abdominal core stability to decrease mechanical stress to the spine (Saal, 1988; Panjabi, 1992; Jull and Richardson, 1994).

According to Panjabi (1992) the resultant weakening of the abdominal muscles may have negative implications on spinal stability. This is because the muscles are responsible for maintaining the stability of the spine.
Panjabi (1992) stated that if there was an increased passive neutral zone – for example, due to degeneration or trauma – then the muscles would be potentially capable of decreasing the neutral zone and bringing it to within normal values, thus reducing the instability.
Therefore the literature supports the suggestion that weakened abdominal musculature in the post-natal population may be an important cause of low back pain in this subgroup of low back pain sufferers.

2.3.2.4. Lumbar facet and sacroiliac syndrome

Lumbar facet syndrome:

- Symptoms:

  Pain is often localised and unilateral, but may also be referred to the groin, greater trochanter, and posterior thigh as far as the knee (Kirkaldy-Willis et al. 1992). Activities that may increase the pain include sleeping on the abdomen, sitting in an upright position, and lifting a load in front of the body at or above the waistline. When symptoms are acute, sneezing and coughing may accentuate the pain (Gatterman, 1995).
- Clinical signs:

  Hyperextension movements of the back may increase the pain, whereas flexion reduces it (Gatterman, 1995).

  Range of motion abnormalities include changes in active, passive, and accessory joint motion. It is thought that a decrease in motion is a common component of joint dysfunction. Range of motion abnormalities are identified through motion palpation and stress radiography (Bergmann et al. 1993).

Sacroiliac syndrome:

- Symptoms:

  Pain accompanying the sacroiliac syndrome is typically unilateral, dull in character, and located over the buttocks. It may radiate posteriorly down the thigh or to the groin and anterior thigh. Occasionally it may extend down the lateral or posterior calf to the ankle, foot and toes. Sensory changes are rare (Gatterman et al. 1990).

  Pain may be worse with weight bearing, moving from sitting to standing, and walking. It is also relieved by recumbency (Gardner et al. 2000).
- Clinical signs:

  Focal tenderness over the involved sacroiliac joint which increases with joint challenge. This may be accompanied by a leg length in discrepancy, guarded gait and myospasm of gluteal/low back musculature.

Altered sacroiliac motion and joint play may be found along with palpatory and postural signs of misalignment (Gardner, 2000).

In summary:

With the incidence and prevalence of low back pain being so high, it could be reasonably postulated that both sacroiliac and/or lumbar facet dysfunction could be instrumental (Bernard and Kirkaldy-Willis, 1987:2107-2130 and Toussaint et al. 1999).
This is supported by research performed by Bailes (1998), which indicated that spinal manipulative therapy of lumbar and sacroiliac joint dysfunctions is an effective treatment for post-natal mechanical low back, as evidenced by the study by Bailes (1998). This shows that joint mechanics are amenable to spinal manipulation in post-natal low back pain patients, particularly with respect to reduction of pain and restoration of motion. A study done by Fraser (1976) indicated that post-natal low back pain improved 'dramatically' with manipulation after pregnancy.

2.4. Management of mechanical low back pain

2.4.1. The management of mechanical low back pain in the general population

A wide range of therapies, including rest, medications, physical modalities, and surgery, to name only a few, are available to treat mechanical low back pain. The variety of possible therapies has resulted in confusion for the primary care physician concerning appropriate treatment for specific forms of mechanical low back pain (Borenstein, 1995). This disparity leads to the meritable conclusion that more research is required to accurately identify solutions for the management of low back pain (Walker, 1997).

Patients should be encouraged to limit bed rest. A major thrust of the guidelines is to encourage movement and a return to full function. The recommendations on bed rest, spinal manipulation, and exercise may all be seen as methods to motivate patients to regain normal motion of the lumbosacral spine. Recommendations for medications maximize the use of agents with mild toxicities and little abuse potential. In general, investigation and invasive therapies are limited to those low back pain patients who fail to improve over a 4 to 12-week period. Only a small minority of patients require surgical intervention (Borenstein, 1995).

The therapy of low back pain patients can be frustrating for the busy primary care physician. A number of therapeutic options are possible for these patients, but none are clearly curative. Published guidelines are useful for treating most patients with low back pain. They are not applicable to the most difficult patients with lumbosacral disease including those with systemic causes of low back pain (Borenstein, 1995).

2.4.2. The management of post-natal mechanical low back pain

Spinal manipulative therapy has been shown to be effective in the treatment of post-natal mechanical low back pain (Fraser, 1976; Bailes, 1998), and clinical trials investigating the benefits of core stability muscle training programs for patients with low back pain revealed positive results (Hides et al., 2001; Stanford, 2002; Stuge, 2004).

As the aim of this study is to investigate the relative effectiveness of spinal manipulation in conjunction with core stabilization exercises as opposed to spinal manipulation alone in the treatment of post-natal mechanical low back pain, the discussion will focus on spinal manipulative therapy and core stability exercise.

2.4.3. Spinal manipulative therapy

2.4.3.1. The effects of spinal manipulative therapy

The chiropractic adjustment is defined by Bergmann et al. (1993) as a specific form of direct articular manipulation utilizing either long or short leverage techniques with specific contacts. It is characterised by a dynamic thrust of controlled velocity, amplitude and direction.

According to Calliet (1981), the possible effects of spinal manipulation are as follows:

- A facet joint is immobilised by an acute synovial reaction and adherence of joint surfaces of the facet takes place. A passive movement, which involves the mobilisation of the spinal motion segment back and forth through its passive range of motion, separates these surfaces.
- The mechano-receptors of the joint are desensitised by the abrupt movement of the joint (manipulation), and reflex protective muscle spasm is eliminated allowing the joint to move again.
- The manipulation allows entrapped menisci to exit the facet joint in which it became entrapped.
- The capsule of the facet joint becomes lodged between two adjacent articular surfaces and the manipulative process allows this capsule to be freed.
- The spindle systems of adjacent muscles are reflexly stimulated by the dynamic thrust of the manipulation and reciprocally relax the extrafusal muscle fibres.
- The spinal segments that are out of alignment are realigned to conform to the centre of gravity.

According to Hertzog et al. (1993), other benefits of spinal manipulative therapy such as the release of anti-inflammatory agents and the increase in joint motion, are directly associated with the magnitude of the treatment force.

2.4.3.2. Effects of spinal manipulative therapy in the post-natal period

According to Erhard et al. (1996), the use of manipulation in the post-natal period is not utilized to increase movement, but rather to restore normal joint alignment. Subluxation of the sacroiliac joint as a result of hormonally induced hypermobility, compromises the normal locking mechanism of the joint, and pain is a result of unusual tension and stresses imposed on the sacroiliac joints.
After childbirth, the ligaments normally retighten and the locking mechanism of the sacroiliac joints becomes more effective, but in some cases the locking mechanism

occurs in the position of rotation of the hip bones that occurs during pregnancy, with the possibility of recurrent sacroiliac joint subluxations.

The manipulative reduction of the sacroiliac joint subluxation results in the locking mechanism of the joint becoming more effective, thus relieving the strain on the ligaments around the joint (Erhard et al. 1996).

2.4.3.3. Effects of manipulation with respect to spinal stabilization

With respect to compromised spinal joint motion, Homewood (1977) described that a fixation may interfere with the nerve supply and result in a decrease in muscular activity. He hypothesized that removal of the subluxation could restore:

- normal physiological processes
- increase muscle activity and
- improve functional ability and normalize the torque ratios

These hypotheses are further supported by Rebechini-Zasadny et al. (1981), Nansel et al. (1993), Korr (Leach, 1994) and Herzog et al. (1999).

Rebechini-Zasadny et al. (1981) stated that muscle activity is dependent on the integrity of its innervation. Naidoo (2002) argued that any factor, which impacts on the nervous system at these levels, could affect the muscular activity supplied by those levels. Korr (Leach, 1994) supported this statement by proposing that manipulation of the spine could relax muscle spasm by affecting the central nervous system input into a muscle spindle. This is further supported by Herzog et al. (1999) who hypothesized that certain reflex responses following manipulation have been attributed to having an increasing effect on functional ability of the patient, pain reduction and inhibition of hypertonic muscle. Similarly Haldeman (1992) refers to Vernon et al. (1986) who states evidence that sensorimotor reflex connections are influenced by manipulation via stimulation of segmental motor pools, which in turn could reduce both pain and muscle hypertonicity.

One could therefore reasonably argue that any factor, which impacts on the nervous system at these levels, could affect the muscular activity supplied by those levels (Naidoo, 2002).

To support the above Hamilton et al. (2004) correlated that the number of motor-units innervating a muscle relates positively to the strength of that muscle. Thus it could be hypothesized that manipulation could have a positive effect on the motor units by applying the theories proposed by Homewood (1977), Vernon et al. (1986) and Korr (Leach, 1994). This could in turn indicate that manipulation may have an affect on the strength of the muscle innervated by those motor units.

This was supported by a study of the TrA where it was found that low back pain patients had reduced endurance and that its protective ability was decreased (Evans and Oldreive, 2000). In addition it was noted that wasting and inhibition of the other core stabilizer and co-contractor, multifidus, was present (Hides et al. 1994).

In this respect Rebechini-Zasadny et al. (1981) and Naidoo (2002) have all suggested further studies of manipulation-induced peripheral changes in the muscles. In addition Evans and Oldreive (2000), Hides et al. (1993) and Panjabi (1992) recommend research in this field.

Hence by investigating the effects of spinal manipulation to the lumbar spinal segments and sacroiliac joints as a possible added intervention for improving local core stabilizer muscle strength, a management protocol for chronic mechanical lower back pain and post-natal mechanical low back pain could be presented.

2.4.3.4. Effectiveness of manipulation in the treatment of low back pain

Treatment of neuromusculoskeletal dysfunction and disease has historically been the major complaint for which chiropractors are consulted.

Chiropractic patients have repeatedly expressed satisfaction with the quality and effectiveness of chiropractic care.

In comparative studies for the treatment of back pain, patients consistently rate chiropractic care as superior to medical care. Furthermore, authors who have

reviewed the literature on spinal manipulative therapy have concluded that sufficient evidence exists to support the use of spinal manipulation in the treatment of specific painful neuromusculoskeletal conditions.
(Bergmann et al. 1993)

Out of twenty four trials of assessing the efficacy of spinal manipulative therapy for the treatment of low back pain, it was agreed that spinal manipulative therapy is a safe therapeutic approach that in many cases offers the patient more relief than any other form of conservative treatment (Bronfort, 1992).

One of the most significant trials concerning manipulation and low back pain is that of Meade et al. (1990). This trial, which lasted nearly ten years, compared chiropractic care to outpatient care. The studied included 741 patients, one of the largest such studies ever done. The authors' essential conclusion was that chiropractic care was significantly more effective than the other care, especially so for patients with chronic or severe pain. Surprisingly, in light of other studies showing that manipulation had its greatest effects early in care, the most significant results here were demonstrated nearly two years after initial care.

A study performed by Manga et al. (1993) concluded that the chiropractic management of low back pain is found to be a more effective way of dealing with this medical, social and economic problem as compared to a variety of other forms of conventional treatment for low back pain.

2.4.3.5. Effectiveness of manipulation during the post-natal period

In terms of post-natal low back pain, joint mechanics are amenable to spinal manipulation, particularly with respect to reduction of pain and restoration of motion, as evidenced by the study that indicated that spinal manipulative therapy is effective in the treatment of post-natal mechanical low back pain (Bailes, 1998).
In addition, a study done by Fraser (1976) on one hundred and fifteen women with post-partum backache indicated that the condition improved 'dramatically' with manipulation after pregnancy.

Chiropractic is useful for treating a range of problems in pregnancy, but is notably valuable in the effective treatment of backache, sciatica and symphysis pubis diastasis. Other problems related to laxity of the joints caused by relaxin and progesterone, such as groin pain, legs 'giving away' and general pelvic instability, would respond well to treatment (Fraser and Cooper, 2003).

In summary:

In comparative studies for the treatment of back pain, patients consistently rate chiropractic care as superior to medical care (Bergmann et al. 1993).
Clinical trials concerning the effectiveness of spinal manipulation have consistently shown than it is effective in the treatment of low back pain (Meade et al. 1990; Bronfort, 1992; Bergmann et al. 1993; Manga et al. 1993).
Clinical trials investigating the effectiveness of spinal manipulation in the treatment of post-natal low back pain has yielded positive results (Fraser 1976; Bailes, 1998).
According to Erhard et al. (1996), the use of manipulation in the post-natal period is not utilized to increase movement, but rather to restore normal joint alignment. The subluxation of the sacroiliac joint as a result of hormonally induced hypermobility compromises the normal locking mechanism of the joint, and pain is a result of unusual tension and stresses imposed on the sacroiliac joints. Therefore the manipulative reduction of the sacroiliac joint subluxation results in the locking mechanism of the joint becoming more effective, thus relieving the strain on the ligaments around the joint. (Erhard et al. 1996)
Literature also revealed that manipulation as a singular intervention does in fact have an effect on peripheral musculature (Rebechini-Zasadny et al., 1981; Naidoo, 2002). Therefore the use of a high velocity low amplitude manipulation could restore the strength of the core muscles in patients suffering from chronic mechanical lower back pain (Uys, 2006).

Therefore spinal manipulation not only improves joint mechanics, thus relieving pain (Erhard et al. 1996; Bailes, 1998), but it may also improve core stability (Rebechini-Zasadny et al., 1981; Naidoo, 2002; Uys, 2006), which may have a beneficial effect as described earlier.

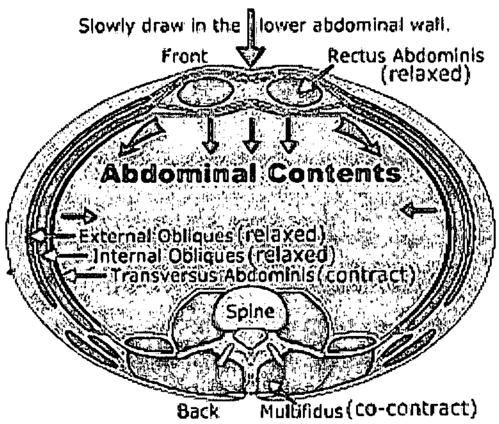
2.4.4. Core stabilization

2.4.4.1. Co-contraction between transversus abdominus and multifidus

Poor postural control places excessive stress on the body tissues and can leave the spine vulnerable to injury (Kendall et al. 1993). One important aspect of posture, with reference to the lumbar spine, is the ability of the trunk muscles to protect the spinal tissues from excessive motion. To do this the muscles surrounding the trunk must be able to co-contract isometrically in functional situations (Richardson et al. 1990).

The transverus abdominus and multifidus are two core stabilizers that have been found to be related through a co-contraction pattern, which is considered to provide support and joint stabilization (Richardson and Jull, 1995).

Figure 7: Co-contraction between transversus abdominus and multifidus muscles



(www.back-exercises.com. Retrieved on 9 April 2006).

2.4.4.2. Dysfunction of the co-contraction mechanism

The literature reports varying disruptions in the patterns of recruitment and co-contraction within and between different muscle synergies in low back pain populations (O'Sullivan et al. 1997b).

There is growing evidence that the deep abdominals and lumbar multifidus muscles are preferentially adversely affected in the presence of low back pain (Hides et al. 1996), chronic low back pain (Roy et al. 1989; Biedermann et al. 1991; Hodges & Richardson, 1996), and lumbar instability (Sihvonen et al. 1991; Lindgren et al. 1993; O'Sullivan et al. 1997d).

Evidence that the transversus abdominus and multifidi are significantly affected during and after episodes of low back pain indicates that rehabilitation should focus on retraining these muscles in particular. Further, the finding that the multifidi do not spontaneously recover is extremely relevant to clinical settings. It suggests that although patients may appear to be pain free, without stabilization exercise they may actually be vulnerable to future episodes of low back pain (Stanford, 2002).

There have also been reports that compensatory substitution of global system muscles occurs in the presence of local muscle system dysfunction. This appears to be the neural control system's attempt to maintain the stability demands of the spine in the presence of local muscle dysfunction (Richardson & Jull, 1995; Edgerton et al. 1996; O'Sullivan et al. 1997d).

2.4.4.3. Core stabilization exercises

Meticulous technique is imperative while performing these exercises. Each exercise is designed to develop isolated and co-contraction muscle patterns to stabilize the lumbar spine. Each patient should be monitored during the exercise program to define the optimal spine position. Care should be taken to ensure proper form and slow exercise-repetition speed (Saal, 1990).

A high level of awareness is demanded of subjects in order that they isolate the co-contraction of the local muscle system without global muscle substitution. The aim is to train the specific isometric co-contraction of transversus abdominus with lumbar multifidus at low levels of maximal voluntary contraction and with controlled respiration (O'Sullivan, 2000).

The transversus abdominus and multifidi consist primarily of slow-twitch, type-1 fibres that allow for low load, endurance contraction. Therefore, it follows that prolonged low-intensity isometric exercise would be most beneficial for re-educating and strengthening these muscles.

2.4.4.4. Benefits of core stabilization exercises utilizing the Swiss ball

Exercise beginning with isolated contraction of the transversus abdominus and multifidi followed by progressive stability training has been shown to be effective in improving muscle endurance (Stanford, 2002). Several clinicians have reported using the exercise ball in their spinal stabilization program to challenge balance and facilitate recruitment of spinal stabilizers once the patient has mastered the activity on the floor (Liggett, 1999).

The use of the Swiss ball has undergone exponential growth over the past decade, with empirical evidence showing benefits in improving joint range of motion, strength, spinal stabilization and proprioception. The incorporation of proprioception and kinesthetic sense exercises is necessary to stimulate joint receptors and for restoring normal muscular firing patterns necessary for functional activity. The premise of using an unstable base of support to stimulate joint proprioceptors, such as the Swiss ball, has been effective on other joints as well (Liggett, 1999).

A study by Liggett & Randolph (1999) compared abdominal strength gains from exercises performed on a mat in comparison to those performed on a ball and found that although both improved abdominal muscle strength, the ball exercises produced the largest strength gain.

Cosio-Lima et al. (2003) performed a study in which the effects of Swiss ball exercises and conventional floor exercises in women were compared. Results indicated that a short term core exercise program using the ball resulted in greater gains in torso balance and electromyographic neuronal activity in previously untrained women when compared to performing exercises on the floor.

Therefore, the use of dynamic core stability exercises utilizing the Swiss ball may be an effective means of progessing a core stabilization exercise program, which is important in the rehabilitation process (Liggett & Randolph, 1999; Cosio-Lima, 2003; Stanford, 2002).

2.4.4.5. Effects of the core stabilization exercises

The purpose of the exercise is to isolate the correct muscle action in all exercise positions and develop holding ability. The importance of isolating the muscle action relates to motor control issues (Richardson & Jull, 1995).
Exercise involving co-contraction of the deep abdominal and back muscles is in line with stabilization. Furthermore a simultaneous isometric co-contraction of transversus abdominus and multifidis, while maintaining the spine in a static neutral position, should help re-educate the stabilizing role of these muscles (Richardson & Jull, 1995).

Literature supports the theory that the most acceptable means to stabilize a hypermobile lumbar spine that may be symptomatic, is to strengthen the abdominal core stability to decrease mechanical stress to the spine (Saal, 1988; Panjabi, 1992; Jull and Richardson, 1994).

Panjabi (1992) stated that if there was an increased passive neutral zone – for example, due to degeneration or trauma – then the muscles would be potentially capable of decreasing the neutral zone and bringing it to within normal values, thus reducing the instability. Therefore in can be suggested that re-educating the stabilizing role of the core musculature would have this described effect of reducing the neutral zone and thus decreasing the instability within the lumbar spine.

In terms of post-natal low back pain, the effect of the hormone relaxin would result in an increase in the passive neutral zone as described by Panjabi (1992) above. In addition, the weakening of the abdominal 'corset' would also have this effect of increasing the neutral zone with resultant instability.

Therefore core stability exercises as a means to stabilize hypermobile segments and regain mechanical control of the spine may be particularly beneficial for these persons (Cosio-Lima et al. 2003).

2.4.4.6. Effectiveness of the core stabilization program

1. A single case study by Stanford (2002) to evaluate the effect of specific lumbar stabilizing exercises revealed that the subject had increased lumbar range of motion, decreased pain measures, increased functional ability and also gave a high self report of perceived improvement as compared to the initial consultation.
2. A study by Stuge (2004) examined the effects of a treatment program focusing on specific stabilizing exercises for pelvic girdle pain after pregnancy, after a 2-year follow-up period of a randomized clinical trial.
   Eighty-one women were assigned randomly to two treatment groups for 20 weeks. Results showed that minimal disability was found in 85% of the specific stabilizing group as compared to 47% in the control group. Minimal evening pain was reported by 68% in the specific stabilizing group versus 23% in the control group. The significant differences between the groups persisted with continued low levels of pain and disability in the specific stabilizing group 2 years after delivery.
3. A randomized clinical trial into the effectiveness of core stabilizing exercises involving the transversus abdominus and multifidus muscles showed that after one year, recurrence in the treatment group was 30% compared to 85% in the non-treatment group ($p<0.001$) and 35% in the treatment group compared to 75% in the non-treatment group after a 3-year follow-up (Hides et al. 2001).

In summary:

Clinical trials investigating the benefits of core stability muscle training programs for patients with low back pain revealed positive results (Hides et al. 2001; Stanford, 2002; Stuge, 2004).

It is clear that pregnancy results in weakening of the abdominal muscles due to stretching and possible diastasis of the muscles that occurs during pregnancy and labour (Polden and Mantle, 1990).

Core stabilization involves the transverus abdominus and multifidus muscles, which have been found to be related through a pattern of co-contraction, which is considered to provide support and joint stabilization (Richardson and Jull, 1995). Current evidence suggests that utilizing a dynamic stability approach to performing exercises may hold further advantages with respect to muscle activation in post-partum females (Liggett, 1999; Liggett & Randolph, 1999; Cosio-Lima et al. 2003).

Therefore, the literature supports the suggestion that core stabilization exercises may be effective in the treatment of post-natal mechanical low back pain.

2.5. Summary

The review of literature revealed that weakening of core stabilsing musculature (Panjabi, 1992; Richardson et al. 1999) and joint dysfunctions of the lumbar facet and sacroiliac joints (Manga et al. 1993; Bergmann et al. 1993) are important causes of low back pain.

Bailes (1998) showed that the correction of lumbar facet and sacroiliac joint syndromes using manipulation is effective in the treatment of post-natal mechanical low back pain. The use of manipulation in the post-natal period allows for reduction of the sacroiliac joint subluxation which results in the locking mechanism of the joint becoming more effective, thus relieving the strain on the ligaments around the joint (Erhard et al. 1996).

Literature also revealed that manipulation, as a singular intervention, does in fact have an effect on peripheral musculature (Rebechini-Zasadny et al., 1981; Naidoo, 2002). Therefore the use of a high velocity low amplitude manipulation could restore the strength of the core muscles in patients suffering from chronic mechanical lower back pain (Uys, 2006).

Literature supports the theory that the most acceptable means to stabilize a hypermobile lumbar spine, that may be symptomatic, is to strengthen the abdominal

core stability to decrease mechanical stress to the spine (Saal, 1988; Panjabi 1992; Jull and Richardson, 1994).
Clinical trials, investigating the benefits of core stability muscle training programs for patients with low back pain, revealed positive results (Hides et al., 2001; Stanford, 2002; Stuge, 2004).
Due to the role of the hormone relaxin on the ligaments and the weakening of the entire abdominal 'corset' that occurs in the post-natal population, core stability exercises as a means to stabilize hypermobile segments and regain mechanical control of the spine, may be particularly beneficial for these persons (Cosio-Lima et al. 2003).

The success, achieved through the effects of manipulative correction of spinal joint dysfunctions and the effects of core stability muscle training, is suggestive that a combination of these two approaches may be more beneficial than the singular intervention of spinal manipulative therapy alone.

The literature supports the outcome hypothesis that a combination of spinal manipulation and core stability exercises is more effective in terms of objective and subjective clinical findings, as opposed to spinal manipulation alone, in the treatment of post-natal mechanical low back pain.

Therefore this research aimed to test the hypothesis based upon the literature by determining whether the combined effects of spinal manipulation and core stability muscle training are indeed more beneficial than the effects of spinal manipulation alone in the management of this subgroup of lower back pain sufferers.

CHAPTER 3

MATERIALS AND METHODS

3.1. Introduction

This chapter includes the data, the subjects, inclusion and exclusion criteria, method, measurements used and the interventions employed. The method of data collection, the statistical analysis and the process of data evaluation are also provided.

Research design

The study was a quantitative, randomized, comparative clinical assessment of the effectiveness of spinal manipulation alone as opposed to a combination of spinal manipulation and core stability exercises in the treatment of post-natal mechanical low back pain.

3.2. Sampling

3.2.1. Method

The method was that of self-selection sampling with random allocation.
Random allocation of subjects is the gold standard method of allocation for research of this sort (Mouton, 1996). The advantage of this method is that it is an effective way to find subjects. Identification of subjects to participate would be difficult using a survey of the community, as the proportion of women who would qualify and be willing to participate would be low.

However, this method also allows for bias, as those persons who are more health conscious, and have a better education and socio-economic status were more likely to participate in the study. This is true of all randomized controlled trials.
Therefore, findings of this study can only apply to that population group and not to the general population itself (Esterhuizen, 2006).

3.2.2. Allocation

Subjects had to meet the inclusion and exclusion criteria that were employed to delineate the study, prior to their inclusion. The actual allocation of the thirty subjects into two equal groups, each consisting of fifteen subjects, was randomly performed as follows:

Pieces of paper labelled from one to thirty were placed in a box, which was then shaken to mix the pieces. Subjects drawing numbers one through fifteen were allocated to group one, and subjects drawing numbers sixteen through thirty were allocated to group two (Mouton, 1996).

Treatment group one received spinal manipulative therapy in combination with core stability exercises, and group two received spinal manipulative therapy alone.

3.2.3. Size

All subjects volunteered as per ethical requirements and all completed the study. The study included a total of thirty subjects divided into two groups of fifteen.

For logistical reasons, this research was performed as a pilot study which conformed to the parameters of a pilot study as described by Macleod (1999). Trends may be observed within the study, which would allow for recommendations suggesting larger study protocols in the future.

In addition, if no trends are observed, we may suggest that a larger study protocol in the future would be a waste of time and money (Esterhuizen, 2006).

3.3. Advertising

Patients were recruited by placing advertisements in local hospital maternity units, post-natal, antenatal and perinatal clinics, as well as nursery schools indicating that free treatment would be given to patients suffering from mechanical low back pain after giving birth.

The researcher attempted to promote the study to gynaecologists, pediatricians and midwives in order to obtain patient referrals of those patients suffering from post-natal mechanical low back.

In addition, an advertisement was placed in the monthly "Mum's Mail" magazine publication for a period of three months.

3.4. Telephonic screen

Pertinent questions were asked over the telephone to determine whether the patient was a suitable candidate for the research sample, these included:

- Are you between the ages of 18 and 35?
- Has it been 8 weeks since the delivery?
- Has 6 months passed since the delivery?
- Where is your area of pain?
- Would you rate your pain greater than 5 on a scale of 0 to 10?
- Do you have a history of trauma/surgery?
- Do you have any numbness, tingling, pins and needles, and muscle weakness in the legs etc?

The telephonic screen decreased the chance of candidates that would be unsuitable for the study, being called in for an initial consultation, and thus allowed for an appropriate referral at the telephonic screen stage for appropriate care on an outpatient basis.

During the initial consultation, the subject was assessed according to a case history (appendix A), physical examination (appendix B), and a lumbar regional examination (appendix C), in order to determine whether they complied with the following inclusion and exclusion criteria:

3.5. The inclusion criteria for this study were:

- Subjects had to sign an informed consent document in order to ensure that their participation was voluntary and based on an informed decision.
- The cut-point on the NRS was set at 5. Although the establishment of cut-points is still in its infancy, patients had to have an NRS rating of 5 or greater to be included in the study. This allows for greater group/sample homogeneity (Mouton, 1996). Grading pain intensity scales into simple categories provides useful information for both clinicians and epidemiologists, and methods to classify pain severity for numerical rating scales have been recommended (Fejer et al. 2005). Paula et al. (2005) determined that the boundary between a mild and a moderate level of pain is at 4 on a 0–10 numeric rating scale. Zelman et al. (2005) showed that cut-points of 4 and 7 optimally classified the sample for both worst pain and average pain, creating categories of mild, 0-3; moderate, 4-6; severe, 7 and higher.

  As the cut-point for this study was 5, patients with mild pain levels were excluded from the study, which allows for real changes to be observed in the research setting.
- Statistics regarding live births in South Africa for the year 2004 indicated that 67% of mothers were between the ages of 20 and 35, and a relatively high proportion of women were aged between 15-19 years (www.statssa.gov.za, 2006). Therefore, women between the ages of 18 and 35 years of age were chosen as it is the age group in which the incidence of pregnant women is at its greatest. In addition, this may have helped to lower the number of patients experiencing low back pain of other causes e.g. osteoarthritis.
- Patients were only eligible for the study 8 weeks following the delivery. Due to the inconsistencies within the literature in regard to the effects of the hormone relaxin, a waiting period of 8 weeks following delivery was suggested so that the effects of the hormone relaxin would be of minimal influence on the study.
- Women were not eligible for the study if more than 6 months had passed post-natally which improved sample homogeneity in terms of the effects of the hormone relaxin on the condition (Mouton, 1996).

- A prospective cohort study by Macarthur et al. (1995) showed that the association between epidural anaesthesia and post-partum low back pain was inconsistent over time with a significantly increased risk of low back pain (epidural vs non-epidural) noted only on the first day after delivery. Because of these literature inconsistencies, this study did not include or exclude patients based on whether or not they have had an epidural; this was however noted for statistical analysis.
- Patients who had given birth by Caesarean would need to wait at least six weeks to begin abdominal exercise on the ball (Craig, 2003). Therefore, patients having had a Caesarean were not contraindicated from performing the exercises, as the study only accepted patients eight weeks post-natally, and thus these patients were included in the study.
- Number of pregnancies:
  Contrary to what many expect, the age, weight gained by the mother during pregnancy, baby's birth weight, number of prior pregnancies, and number of prior children are not factors in back pain (Fast et al. 1987). However, Fast et al. (1987) also found that more disability is caused by backache in women with prior pregnancies as compared with those who were not pregnant before. Change of posture or weaker trunk muscles may explain this observation. Therefore, due to inconsistencies within the literature the number of prior pregnancies did not form part of the inclusion criteria.
- Women experiencing post-natal mechanical low back pain according to the Kirkaldy-Willis classification, which includes lumbar facet syndrome and sacroiliac syndrome. These two diagnoses have been included because it is apparent that core stability affects both the lumbar spine and pelvis (Richardson et al. 1999).
- Orthopaedic tests were not part of the diagnostic criteria for posterior facet and sacroiliac dysfunction. They were, however, utilized to confirm the diagnosis. For the purpose of this research two out of the four tests described below for either posterior facet or sacroiliac syndrome had to be positive (Kirkaldy-Willis et al. 1992) for the diagnosis to be confirmed.

As no one orthopaedic test has shown to be useful and no one test guarantees a diagnosis or rates severity consistently (Laslett and Williams, 1994), the clinician is tasked to make an informed decision regarding the clinical relevance of a particular test, its validity, reliability, specificity and sensitivity (Walsh, 1998). Thus it has been suggested that multiple tests triangulated are best in the clinical situation. Thus in this research the following were used:

a) For posterior facet syndrome:

1. **Kemp's Test:** This test is designed to place the facet joints under maximum stress. The patient is seated, unsupported with the examiner standing behind. The examiner then passively extends, rotates and laterally flexes the spine to the one side. A positive test is indicated by pain localised over the facet joint (Corrigan and Maitland, 1990:35).
2. **Facet Joint Challenge:** With the patient lying prone, a posterior to anterior force is applied on each spinous process of the lumbar vertebrae, to 'spring' or approximate each joint. A positive test is indicated by pain over the joint being tested (Gatterman et al. 1990:84).
3. **Prone hyperextension test:** With the patient lying prone and keeping their pelvis on the examination table, the patient pushes upwards with their arms thus extending their back. A positive test is indicated by pain in this position (Gatterman et al. 1990: 162).
4. **Palpable muscle spasm:** With the patient prone the examiner gently applies manual pressure to the paraspinal muscles. A focal point of tenderness as indicated by the patient gives a positive test (Helbig and Lee, 1998).

b) For sacroiliac joint syndrome:

1. **Posterior shear test:** The subject was supine. The hip was flexed and adducted while the examiner applied a force by pushing posteriorly along the line of the femur. A positive test was indicated by pain over the sacroiliac joint (Laslett and Williams, 1994).
2. **Gaenslen's test:** The subject was lying supine. The test hip was extended beyond the edge of the table. The subject had to draw both legs up to the

chest and then lower the test leg off the edge of the table into extension, with help from the examiner. The examiner placed a shearing pressure in the opposite direction. The other leg was tested similarly. A positive test was indicated by pain in the sacroiliac joint (Magee, 1997:446).

3. **Patrick Faber test:** The subject was lying supine. The examiner placed the subject's test leg so that the foot of the test leg was above the knee of the opposite straight leg. The examiner then pushed the test leg into abduction while stabilizing the opposite hemi-pelvis with the other hand. A true positive test was indicated by a decrease in abduction as well as pain in the sacroiliac joint, indicating sacroiliac dysfunction (Magee, 1997:473).
4. **Yeoman's test:** The subject lay prone. One hand applied pressure to the affected sacroiliac joint, while the other hand had lifted the ipsilateral leg into hyperextension, with the knee flexed at 90 degrees. Pain in the sacroiliac joint indicated a positive test (Schaefer and Faye, 1990:271).

- Motion palpation was used to identify segments in the lumbar spine and sacroiliac joints that were restricted and/or hypomobile. Motion palpation according to the Gillet-Liekens method (Schaefer and Faye, 1989) was used to identify restricted segments within the lumbar spine, whereas motion palpation according to Bergmann et al. (1993) was utilized to detect motion restrictions in the sacroiliac joints. Motion palpation was also used to identify in which plane the manipulative technique should be given, allowing the patient to have the least amount of discomfort and to restore maximum joint play to her spine (Schaefer and Faye, 1989).

a) The posterior facet joints:

- Flexion: This is determined by interspinous separation. The examiner's thumb was placed between the spinous processes while the patient's spine was passively flexed forward. The examiner then pushed anterosuperiorly on the superior spinous to see if a springy end feel existed. A distinct opening of the interspinous space should have been perceived between segments that were not fixated.

- Extension: This was indirectly tested by extending the patient's spine a few degrees and then pushing the articular process of the superior segment of the motion unit anteriorly, which would increase the extension, with the examiner's palpating thumb. A subtle springy movement under the thumb should have been felt, signifying that the joint had closed between segments that were not fixated.
- Lateral flexion: To check lumbar lateral flexion bending to the left, the examiner's thumb was placed against the left side of the spinous process of the superior segment of the motion unit being evaluated. As the patient was passively laterally flexed to the left with the examiner's stabilizing arm, the examiner's right thumb pushed against the left aspect of the spinous process to produce a greater opening between the contralateral facets. This slight movement should have been perceived. The examiner's position and procedures were reversed for testing opening of the left articulation during lateral bending to the right.
  Again, a springy end feel is normally sensed. A blocked resistance with a nonlingering painful discomfort indicated a fixation of significance.
- Rotation: In testing the capability of the inferior facet of the superior segment of the motion unit to rotate counterclockwise on the right, the examiner's thumb is placed against the right inferior process of the superior segment of the motion unit. The patient's trunk was rotated counterclockwise by the examiner's stabilizing arm, and, at the end of the ROM, checked for a springy end feel by pushing forward with the examiner's thumb. The positiion and procedures were reversed for the contralateral articulation.

c) The sacroiliac joints:

The subject had to stand upright with her hands against the wall (to keep her balance). The examiner was behind the subject placing one thumb on the ipsilateral posterior superior iliac spine and the other thumb on the second sacral tubercle. The subject was then asked to lift the ipsilateral leg to induce upper flexion of the sacroiliac joint.

With normal movement, it was expected that examiner's thumbs would move closer together as the posterior superior iliac spine moved inferior and posterior relative to the sacral tubercle.

To test for extension restrictions, the above procedure was followed with the exception of flexing the contra-lateral leg instead of the ipsilateral leg, which induced extension of the sacroiliac joint.

With normal extension movements, it was expected that the examiner's thumbs would move apart as the posterior superior iliac spine moved superior and anterior relative to the sacral tubercle.
For lower sacroiliac restrictions the same procedures as above were followed except for placing the one thumb on the fourth sacral tubercle instead of the second.

- In addition to the above inclusion criteria, the findings of the orthopaedic tests for posterior facet and sacroiliac syndrome for a certain level of the spine had to correlate with the motion palpation findings of a hypomobile joint for that same level. Only when this occurred was the patient accepted into the study and received spinal manipulation at that specific level.

3.6. The exclusion criteria for the study were:

- Subjects who failed to sign the informed consent form were excluded by default, as this was taken to mean that they were either unable to understand the constraints of the study, or were unwilling to participate or have their information made part of the study findings.
- Patients who had received low back surgery were excluded from this study as the source of their pain may be related to the surgery.
- Patients taking any form of medication for their pain had to comply with a 3-day washout period as proposed by Poul et al. (1993).
- Patients needed to be literate in order for them to read the subject information sheets that I required for feedback on in terms of improvement, as some of these

tools had only been validated in the English language. There are currently studies underway which are addressing the need for questionnaires in different languages.

- Individuals with confirmed vertebral malignancy; osteomyelitis; TB of the spine; acute vertebral fracture; infectious arthritis; extreme osteoporosis; disc prolapse; 2nd and 3rd degree vaginal tearing; episiotomy; severe diastasis recti; severe perineal pain (Bailes, 1998).
- Dvorak et al. (1992) used broader categories in which contraindications for spinal manipulative therapy was classified. These are the following:
    - a) Inflammation and infection e.g. rheumatoid arthritis.
    - b) Degeneration e.g. degenerative joint disease.
    - c) Discopathies e.g. disc degeneration.
    - d) Neoplasm e.g. primary and secondary tumours of the spine.
    - e) Metabolic disturbances e.g. pathological fractures.
    - f) Congenital malformations e.g. instability of spinal segment.
    - g) Trauma e.g. macro trauma to spine.
- Motion palpation was used to identify segments in the lumbar spine and sacroiliac joints which were restricted and/or hypomobile. Motion palpation according to the Gillet-Liekens method (Schaefer and Faye, 1989) was used to identify restricted segments within the lumbar spine, whereas motion palpation according to Bergmann et al. (1993) was used to identify restrictions within the sacroiliac joints. If there was an absence of restricted and/or hypomobile joints, the subject was excluded from the study.
- Additionally, in order to be accepted into the study, the findings of the orthopaedic tests for posterior facet and sacroiliac syndrome for a certain level of the spine had to correlate with the motion palpation findings of a hypomobile joint for that same level. Only when this occurred was the patient accepted into the study and received spinal manipulation at that specific level. Should this not have occurred, the subject was excluded from the study.
- Contraindications to abdominal muscle strengthening include: Glaucoma, pregnancy, hypertension, osteoporosis, spinal tumours, inflammatory diseases and impaired circulation (Harm-Ringhdal, 1993: 243).

- Patients with extreme discomfort on contracting the abdominal muscles were excluded.
- The post-natal patient was warned that too vigorous exercise or daily activities are contraindicated in the post-natal period. If the post-natal patient experienced any pain that becomes progressively worse during the exercise program or daily activities, the task was immediately ceased (Polden and Mantle, 1990: 235).
- Birth by Caesarean requires a wait of at least six weeks before performing abdominal exercises on the ball (Craig, 2003). Therefore, patients having had a Caesarean were not contraindicated from performing the exercises, as the study only accepted patients eight weeks post-natally, and thus these patients were included in the study.
- Severe symptoms were a contraindication, however they may have been short lived and part of the natural history. So, besides the absolute contraindications, patients who were unable to continue due to pain were excluded on the basis of agreement between doctor and patient.
- Patients who experienced leg pain of radicular origin were excluded, but those with leg pain referred from the sacroiliac or lumbar facet joints were accepted, as they may not have been suffering from neurological deficits. (Haldeman et al. 1993, In: Gatterman et al. 2001).
- No hard neurological signs could be present in order to participate in the study (Haldeman et al. 1993, In: Gatterman et al. 2001).
- Patients who required further clinical testing to confirm the diagnosis were excluded.
- No other adjunctive therapy, besides that of the dynamic stability (Swiss ball) exercises was allowed to be performed by the subjects participating in group one.
- No other adjunctive therapies, such as exercise therapy and home stretches, were allowed to be performed by the subjects participating in group two.

Those subjects who did not meet the inclusion criteria were referred to other interns in the Chiropractic Day Clinic for treatment of their condition, as this lay outside the scope of this research proposal.

3.7. Intervention

Group one

Subjects making up group one received a combination of spinal manipulation and core stability exercises. The protocol consisted of thirteen consultations.

- Spinal manipulative therapy was carried out twice a week for the first three weeks of the treatment protocol, which allowed sufficient time for the effects of spinal manipulation to occur (Kirkaldy Willis, 1988; Gatterman et al. 1990; Erhard et al. 1996). If the patient became asymptomatic or if there was an absence of spinal fixations before the completion of the spinal manipulative therapy protocol, spinal manipulation was discontinued.

  The manipulation was performed in accordance with the level and direction of the fixation located by means of motion palpation and orthopaedic testing. Motion palpation according to the Gillet-Liekens method (Schaefer and Faye, 1989) was used to identify restricted segments within the lumbar spine, whereas motion palpation according to Bergmann et al. (1993) was used to identify restrictions within the sacroiliac joints.

  The findings of the orthopaedic tests for posterior facet and sacroiliac syndrome for a certain level of the spine had to correlate with the motion palpation findings of a hypomobile joint for that same level. Only when this occurred was the patient accepted into the study and received spinal manipulation at that specific level.

  The Diversified Technique was used (Szaraz, 1990), which included the following adjustments to the lumbar spine and pelvis, depending on the preference of the researcher:

  a) lumbar roll
  b) upper and lower sacroiliac
  c) sitting lumbar
  d) side posture – lateral spinous
  e) spinous push
  f) spinous pull
  g) prone sacroiliac

- Core stability exercises began concurrently with spinal manipulation.
  A clinical trial by Stanton et al. (2004) showed that core stability exercises, performed twice a week for a period of six weeks, significantly affected core stability in the experimental group ($p<0.05$), compared to the control group, which did not perform the exercises.
  Therefore core stability exercises were performed twice a week for a period of six weeks for patients in group one.

1. Static core stability exercises were performed for the initial three weeks using the supine and supine loading positions to retrain the transversus abdominus, as used in the study by Boden (2002), as prescribed by the manufacturers, Chatanooga. Static core stability exercises are characterised by an absence of approximation of those parts of the body proximal and distal to the abdominal core, these were performed on the floor as opposed to the dynamic exercises, which were performed on the Swiss ball. These were performed as a precursor to the more strenuous dynamic core stability exercises, which were performed on the Swiss ball for the three weeks following the static exercises.

   This allowed the post-natal patient to ease in to the exercises and not put excess strain on the core muscles initially, which may have aggravated the post-natal condition.

2. Dynamic core stability exercises were performed for the following three weeks of the study, and utilized the Swiss ball. Dynamic core stability exercises are characterised by an approximation of those parts of the body proximal and distal to the abdominal core due to the nature of the exercises performed, and these were performed on the Swiss ball as opposed to the static exercises, which were performed on the floor.

   In the study by Cosio-Lima et al. (2003), curl-ups and back extensions on the Swiss ball were used while the same exercises were performed on the floor.

Therefore curl-ups and back extensions were performed on the Swiss ball by the patients in group one.

A baseline was established for each individual patient at the initial Swiss ball consultation, from which further increases in repetitions were made. This baseline was determined by the number of repetitions that they performed at this consultation until fatigue was reached. Increases were implemented at the start of the successive weeks. This increase was that of one repetition at each of the following two weeks.

All consultations for group one took place at the Chiropractic Day Clinic. The researcher observed all exercises performed during consultations, which allowed the maintenance of correct form while exercises were performed and to ensure adherence to the treatment protocol.

Group two

Subjects making up group two received only spinal manipulation as part of their treatment protocol. Therefore, these subjects did not perform the core stability exercises as for group one and, as a result, received fewer follow-up consultations than the subjects belonging to group one.

In addition, the number of follow-ups depended on the response of the patient to treatment. If the patient became asymptomatic or if there was an absence of spinal fixations before the completion of the spinal manipulative therapy protocol, spinal manipulation was discontinued. However, data collection occurred at intervals concurrent with that of the data collection of group one.

- Spinal manipulative therapy was carried out twice a week for the first three weeks of the treatment protocol, which allowed sufficient time for the effects of spinal manipulation to occur (Kirkaldy Willis 1988; Gatterman et al. 1990; Erhard et al. 1996).

The manipulation was performed in accordance with the level and direction of the fixation located by means of motion palpation and orthopaedic testing. Motion palpation according to the Gillet-Liekens method (Schaefer and Faye, 1989) was used to identify restricted segments within the lumbar spine, whereas motion palpation according to Bergmann et al. (1993) was used to identify restrictions within the sacroiliac joints. The findings of the orthopaedic tests for posterior facet and sacroiliac syndrome for a certain level of the spine had to correlate with the motion palpation findings of a hypomobile joint for that same level. Only when this occurred was the patient accepted into the study and received spinal manipulation at that specific level.

As for group one, the Diversified Technique was used (Szaraz, 1990).

3.7.1. Intervention frequency

- Group one: Subjects underwent thirteen consultations - twelve treatments and a final follow-up consultation with no treatment.

- Group two: Subjects underwent a maximum of six treatment consultations. If subjects became asymptomatic or an absence of spinal fixations was noted, these subjects may have received fewer treatment consultations in this case. This was followed by three follow-up consultations with no treatment for data collection, and was performed concurrently with data collection for group one.

3.8. Data collection

3.8.1. Frequency

Group One: Data collection took place prior to the: 1st, 3rd, 7th, 10th consultations and at the 13th consultation.

Group Two: Data collection took place prior to the: 1st, 3rd, 7th, 10th consultations and at the 13th consultation as for group one.

3.8.2. Measurements

3.8.2.1. Subjective data:

1. Numerical Pain Rating Scale:

   Pain has been considered to be immeasurable by some, but a number of subjective and objective methods have been devised. Subjective methods appear to be more satisfactory than objective methods. Several methods of subjective measurement have been reviewed.

   This method consists of an 11-point (0-10) scale with numbers being allocated in ascending order according to reported pain intensity and has the advantage that it is relatively easy for the patient to understand and use (Liggins, 1982).

   According to Jenson et al. (1986) the utility and validity of the 11-point numerical rating scale yielded similar results in terms of the number of subjects who respond correctly to them and their predictive validity when compared to five other methods of measurement of clinical pain intensity.

   Therefore, the 11-point numerical rating scale can be considered to be a reliable measure of clinical pain intensity.

2. Quebec Low Back Pain Disability Questionnaire:

   The Quebec Back Pain Disability Scale (Kopec et al. 1995) is a 20-item self-administered instrument designed to assess the level of functional disability in individuals with low back pain. It adopts a generally accepted conceptual definition of disability as a restriction of ability to perform daily activities.

   The scale contains 20 items and covers six empirically derived sub-domains of disability in back pain. All items contribute to the assessment of global disability and are relevant and acceptable to the patients. The items are scored 0 to 5 and the scale provides an overall disability score, ranging from 0 to 100, by simple summation of the scores for each item.

   The scale is brief and easy to self-administer. Comparisons with the Roland and Oswestry scales suggest that the Quebec scale may be more reliable and is at least as sensitive to change as the best available measures (Kopec et al. 1995).

3.8.2.2. Objective data:

Stabilizer Biofeedback Device:

Subjects had their core stability assessed using the Stabilizer Biofeedback Device. The presence of adequate core stability activation was assessed utilizing the abdominal draw-in test. The prone test for transversus abdominus and the supine position for training transverse abdominus were used to assess fatigability/endurance of the transversus abdominus (Stabilizer manual Chatanooga Group Inc., 4717 Adams Road, Hixson TN 37343, USA). This Stabilizer Biofeedback Device has been established as a satisfactory tool in the measuring and retraining of the transverse abdominus and multifidus muscles (Cairns, 2000).

- Core stability activation:

  In accordance with Richardson et al. (1999), before formal testing begins participants are taught to recruit transversus abdominus in four-point kneeling. This position provides a facilitated stretch to the deep abdominals resulting from the forward drift of the abdominal contents. This stretch leads to an inhibitory effect on the superficial muscles, particularly rectus abdominis (Richardson & Jull, 1995). When this ability was recognized to be present, participants were then instructed to lie prone on a chiropractic table with their head turned to one side. The Stabilizer Biofeedback Device was placed under their abdomen, with the centre at the navel and the distal edge at the anterior superior iliac spine. It was then inflated to the baseline pressure of 70 mmHg.

  Participants were then examined as to whether they could initiate transversus abdominus activation in this prone position. A drop in pressure of 6-8 mmHg was seen with a correct contraction.

  This test was performed at the initial consultation. It was noted yes/no, for statistical purposes, as to whether the subject could perform a correct activation of transversus abdominus. If the subject could not do this, the subject was retrained in the four point kneeling and prone positions to perform this activation satisfactorily, prior to taking the quantitative time-based readings. If the subject still could not manage a satisfactory activation, the subject was instructed to perform a contraction of transversus abdominus, as trained by the researcher, to the best of their ability and a time-based reading of this contraction was taken.

- Quantitative time-based readings of transversus abdominus endurance were taken using the Stabilizer Pressure Biofeedback Unit.

  a) The prone test for transversus abdominus and internal oblique:
  A 3-chamber pressure cell was placed centrally under the abdomen, with the umbilicus in the centre of the inflatable sleeve, and inflated to a baseline of 70 mmHg. The subject was then instructed to draw the abdominal wall up and in without moving the spine or pelvis. The pressure reading should have decreased by 6-10 mmHg.
  A variation of 2 mmHg was allowed for normal breathing pattern.
  A measurement was taken of the time at which the patient could no longer hold the contraction at the baseline level (70mmmHg – 6 to 10 mmHg).

  b) Supine position for testing transversus abdominus:
  A 3-chamber pressure cell was placed centrally under the lumbar spine with the bottom of the sleeve in line with the PSIS's, and inflated to a baseline of 40 mmHg. The patient was instructed to draw in the abdominal wall without moving the spine or pelvis. The pressure reading should have remained at 40 mmHg; i.e. no movement of the spine.
  A variation of 2 mmHg was allowed for normal breathing pattern.
  A measurement was taken of the time at which the patient could no longer hold the contraction at the baseline level (40 mmHg).

Table 1: Summary table of treatment and data collection protocol

Week	*Visit*	*Group 1*	*Group 2*
1	1	**Reading 1** Manipulation Exercises	**Reading 1** Manipulation
	2	Manipulation Exercises	Manipulation
2	3	**Reading 2** Manipulation Exercises	**Reading 2** Manipulation
	4	Manipulation Exercises	Manipulation
3	5	Manipulation Exercises	Manipulation
	6	Manipulation Exercises	Manipulation
4	7	**Reading 3** Exercises	**Reading 3**
	8	Exercises	
5	9	Exercises	
	10	**Reading 4** Exercises	**Reading 4**
6	11	Exercises	
	12	Exercises	
7	13	**Reading 5**	**Reading 5**

3.9. Statistical methodology

Data were entered and analysed in SPSS version 11.5 (SPSS Inc. Chicago, Ill, USA). Baseline demographics and factors were compared between the two treatment groups to ensure completeness of randomization using student's t-tests in the case of quantitative data, and Fisher's exact tests or Pearson's chi square tests where appropriate for quantitative variables.

Repeated measures ANOVA was used to compare the quantitative outcomes over time between the two treatment groups whilst controlling for number of visits with adjustments, and BMI as covariates in the model. A statistically significant time by group interaction ($p<0.05$) was taken as a significant treatment effect. Profile plots were generated to observe the trends over time by group. In order to examine the effect of the intervention separately in the two periods of the study (visit 1 to visit 3, and visit 3 to visit 5), additional repeated measures models were constructed using just 3 time points: visit1, visit 3 and visit 5. Repeated contrasts were generated to report the time by group interaction in the first and second period separately. This allowed comparison of the treatment effect in the first and second period of follow up to determine where the intervention had the most effect.

Pearson correlation was done to assess correlations between changes in outcome variables over time intra-group overall and separately within the two follow up time periods.

CHAPTER 4

STATSISTICAL METHODS AND RESULTS

4.1. Introduction

The statistical findings and results obtained from the data will be discussed in this chapter. The data utilized was collected exclusively from subjects that adhered to the inclusion and exclusion criteria of the study.

The primary data in this study consisted of:

1. Demographic data including age, race, body mass index, marital status and parity. In addition, epidural use, type of birth, age of baby and ability to activate was noted.
2. Objective and subjective findings consisting of the stabilizer biofeedback device, Quebec Low Back Pain Disability Questionnaire and NRS.

The secondary data consisted of information gleaned from the literature as found in books, journal articles, commentaries and Internet sources.

Abbreviations as appropriate in this chapter include the following:

SBD	- Stabilizer biofeedback device
NRS	- Numerical pain rating scale
QPD	- Quebec low back pain disability questionnaire
BMI	- Body Mass Index
p value	- Two tailed probability of equaling or exceeding

4.2. Definition of groups

Thirty participants who met the eligibility criteria were placed into two equal groups of fifteen.

4.2.1. Group 1: (n = 15)

Treatment group one contained fifteen subjects suffering with post-natal mechanical low back pain. They received a combination of spinal manipulation and core stability exercises. Subjects were excluded on the basis of the inclusion and exclusion criteria.

Treatment was split into two treatment periods:

Treatment period 1:

Three weeks of treatment, twice a week. Treatment included spinal manipulation and core stability exercises at each consultation. If the patient became asymptomatic or if there was an absence of spinal fixations before the completion of the spinal manipulative therapy protocol, spinal manipulation was discontinued.

Treatment period 2:

Three weeks of treatment, twice a week. Treatment included core stability exercises.

4.2.2. Group 2: (n = 15)

Treatment group two contained fifteen subjects also suffering with post-natal mechanical low back pain. These subjects received spinal manipulation alone. Subjects were excluded on the basis of the inclusion and exclusion criteria.

Treatment was split into two treatment periods:

Treatment period 1:

Three weeks of treatment, twice a week. Treatment included spinal manipulation at each consultation. If the patient became asymptomatic or if there was an absence of spinal fixations before the completion of the spinal manipulative therapy protocol, spinal manipulation was discontinued.

Treatment period 2:

Group 2 did not receive any treatment for this period.

4.3. Demographic results

4.3.1. Ethnicity / Race

Thirty participants were randomized into two equal groups of n=15. Because of small group sizes, there was a possibility of incomplete randomization. Thus the demographics were compared between the groups to identify if this had happened. The association between race group and treatment group was not quite statistically significant (p=0.079), but the proportions (Table 1) showed that the manipulation and exercise group contained no black Africans, while the proportions of Indians and other race groups in that group was higher than in the manipulation group.

Table 1: Race group by treatment group (n=30)

			Race group				Total
			Caucasian	Black African	Indian	Other	
Treatment group	Manipulation and exercise	Count	6	0	8	1	15
		% within Treatment group	40.0%	.0%	53.3%	6.7%	100.0%
	Manipulation	Count	5	5	5	0	15
		% within Treatment group	33.3%	33.3%	33.3%	.0%	100.0%
Total		Count	11	5	13	1	30
		% within Treatment group	36.7%	16.7%	43.3%	3.3%	100.0%

Pearson's chi square 6.783, p=0.07

Four race groups were represented in this study, white, Indian, black African and other. Midyear estimates for 2005 indicated that the black population are in the majority and constitute 79.4% of the total South African population.

The white population is estimated to be 9.3%, the coloured population 8.8%, and the Indian/Asian population 2.5% (www.statssa.gov.za, 2006).

No stratification in terms of age or race was executed due to the method of self-selection sampling with random allocation, and thus there was an overrepresentation of Indians (43.3%) followed by whites (36.7%) represented.

The population demographics of this study therefore do not concur with the population demographics of South Africa. This could be for a number of reasons:

(i). According to Russell et al. (2004), a more personalized form of advertisement may have attracted more of the black African population and thus a population demographic more representative of the population demographics of South Africa.
(ii). Lack of exposure to a form of treatment developed outside of the cultural context of the vast majority of South Africans, with the black population being the least exposed.
(iii). With the trend that the majority of South Africans expect a medicinal intervention (tablets, injection or something of the like), it becomes problematic when the health care profession does not provide such treatment as it is seen to be ineffective in dealing with the ailment presenting, as seen in the observer effect (Mouton, 1996).

The statistics reveal that there were no black Africans in the manipulation and exercise group whereas the manipulation group were made up of 33.3% black Africans. Although the association between race group and treatment group was not quite statistically significant (p=0.079), the group with manipulation had a population made up of 33.3% black Africans whereas the manipulation and exercise group contained no black Africans. In addition, as the group with manipulation and exercises contained higher percentages of Indian and other race groups, this may affect the treatment outcomes for the same reasons.
Therefore, this may have had some effect on the measurement outcomes for the same reasons that were provided to explain a low level of representation of the black African population (Scollen and Scollen, 1995; Baynham, 1995; Mouton, 1996). However, it is difficult to predict the effect this would have on measurement outcomes, in terms of which group would have an advantage over the other.

In summary:

The sample population was not representative of the population demographics of South Africa in terms of race distribution. This is because of the low percentage of black Africans that took part in the study as compared to the percentage of Caucasian, Indian and other race groups (http://www.statssa.gov.za/, 2006).
In addition, the manipulation group contained more black Africans as compared to the manipulation and exercise group which contained none, while the proportions of Indians and other race groups in that group was higher than in the manipulation group. This may have affected the measurement outcomes to some degree although statistically the effect was not considered to be significant (Scollen and Scollen, 1995; Baynham, 1995; Mouton, 1996). Whether one group had an advantage over the other because of this misrepresentation between groups is difficult to predict.

4.3.2. Epidurals

There was a slightly higher percentage of epidurals in the manipulation group (93.3%) than in the manipulation and exercise group (80%), but this difference was not statistically significant (p=0.598 – Table 2).

Table 2: Epidural by treatment group (n=30)

			Epidural		Total
			no	yes	
Treatment group	Manipulation and exercise	Count	3	12	15
		% within Treatment group	20.0%	80.0%	100.0%
	Manipulation	Count	1	14	15
		% within Treatment group	6.7%	93.3%	100.0%
Total		Count	4	26	30
		% within Treatment group	13.3%	86.7%	100.0%

Fisher's exact p value 0.598

Wide variations in the provision of an epidural service have been found (Fraser and Cooper, 2003). Due to the wide variations reported in the literature, and the small size of the sample group employed in this research, it is difficult to predict whether the percentage of women that had an epidural in this research sample group (86.7%) correlates with a larger sample of this demographic.

Two retrospective studies in the United Kingdom have suggested an association between epidural anaesthesia and long term low back pain of new onset after delivery, however both surveys were compromised by their retrospective design and low response rate (Macarthur et al. 1995).

A prospective cohort study by Macarthur et al. (1995) showed that the association between epidural anaesthesia and post-partum low back pain was inconsistent over time with a significantly increased risk of low back pain (epidural versus non-epidural) noted only on the first day after delivery. The significantly increased incidence of low back pain in the epidural group on day one might be explained by the local musculoligamentous trauma associated with insertion of an epidural needle.

Statistical analysis revealed that there was a slightly higher percentage of epidurals in the manipulation group (93.3%) than in the manipulation and exercise group (80%), but this difference was not statistically significant (p=0.598 – Table 2), however, as the literature shows that epidural anaesthesia is unlikely to cause pain beyond one day following labour (Macarthur et al. 1995), the slight difference between the two groups in terms of number of epidurals is found to be of even less significance, especially considering that an inclusion criteria of the study stated that women may only enter the study 8 weeks following the birth.
This is reflected in the NRS and QPD measurements as baseline measurements were very similar for both groups. In addition, the NRS and Quebec scores showed a general decrease over time in both groups, with the rate of decrease being very similar in both groups for both measurements (Figure 3 and Figure 4).

In summary:

Literature reveals that epidural use is highly variable from one study to the next (Morgan, 1993; Mander, 1995). Therefore it is not certain whether the percentage of the total sample population who had an epidural (86.7%) is comparable a larger sample of this demographic.

The use of an epidural is significantly linked to low back pain only for the first day after the birth. However, literature shows that it is not a cause of chronic low back pain (Macarthur et al. 1995).

Although the manipulation group had slightly higher percentage of epidural use than the manipulation and exercise group (Table 2), this difference is not statistically significant.
This is reflected in the results, as there were no significant differences in baseline measures between groups for NRS and QPD measures, and improvements for these measures were similar over time (Figures 3 and 4).

4.3.3. Type of birth

There was no difference between type of birth and treatment group (p=0.264 – Table 3). There was a slightly higher percentage of caesarian births in the manipulation group than in the manipulation and exercise group.

Table 3: Type of birth by treatment group (n=30)

			Type of birth		Total
			natural	caesarian	
Treatment group	Manipulation and exercise	Count	11	4	15
		% within Treatment group	73.3%	26.7%	100.0%
	Manipulation	Count	7	8	15
		% within Treatment group	46.7%	53.3%	100.0%
Total		Count	18	12	30
		% within Treatment group	60.0%	40.0%	100.0%

Fisher's exact p value = 0.264

The incidence of Caesarean sections in South Africa is 15 – 25% in teaching hospitals, but in private hospitals rates as high as 60% have been reported (Cronje and Grobler, 2003). Therefore, the total incidence of Caesarean sections in the study (40%) falls within those of the teaching and private hospitals of South Africa and may therefore be representative of the demographics of South Africa.

Polden and Mantle (1990) stated that as the abdomen becomes increasingly larger, stretching and elongation of the abdominal muscles results in the entire abdominal 'corset' becoming weakened with little apparent mechanical control. Because of this, in addition to the increased elasticity of its ligaments, the back may be more vulnerable to injury resulting from incorrect use.

One may argue that a Caesarean section may cause further weakness in the abdominal 'corset' resulting in an increased likelihood of pain and disability and poorer endurance time measurements for core stability, however, no studies been found in the literature that could suggest an association between post-natal low back pain and Caesarean section.

According to the statistical analysis (Table 3), the manipulation group contained more subjects having had a Caesarean (53.3%) than the manipulation and exercise group (26.7%).
However, it was shown that NRS and QPD scores at baseline level and their rate of improvement for both groups were very similar (Figure 3 and Figure 4).

In terms of the SBD measurements, the manipulation and exercise group showed a steeper rate of improvement over time than the manipulation group (Figure 1). Supine measurements showed a higher baseline level for the manipulation and exercise group, but rate of improvement was similar for both groups (Figure 2).
It is suggested that the improved rate of increase for prone measurements in the manipulation and exercise group may be due to the treatment effects rather than the manipulation group containing more subjects having had a Caesarean.
The difference in baseline levels for supine measurements with the manipulation and exercise group (Figure 2) may be as a result of the higher number of overweight individuals in the manipulation group as compared to the manipulation and exercise group, which is reflected in the statistics concerning BMI (Table 7), or it may be as a result of the higher number of Caesarean sections in the manipulation group (Table 3). However, the baseline levels for prone SBD measurements were very similar for both groups (Figure 1).

Therefore, although the manipulation group contained more subjects having had a Caesarean (53.3%) than the manipulation and exercise group (26.7%), this finding is considered to be non significant. In addition, the sample of the population of this study is small and few conclusions can be drawn from the literature and statistical analysis of the study concerning the effects of Caesarean sections. Further research is required in the field of Caesarean sections and their effects.

In summary:

The demographic of this study with regard to the incidence of Caesarean sections is comparable to the national average (Cronje and Grobler, 2003).

Literature suggests that Caesarean sections may have had an effect on the outcome analysis (Polden and Mantle, 1990). However, the statistics did not reveal any significant findings that may suggest that Caesarean sections may cause more pain and disability or core stability weakness than those subjects having had a natural birth (Figure 3 and Figure 4).

Baseline levels for supine SBD measurements were higher for the manipulation and exercise group than the manipulation group (Figure 2), which contained a higher percentage of subjects having had Caesarean sections (Table 3). This may be as a result of the higher incidence of Caesarean sections or the higher number of overweight subjects in the manipulation group as reflected in the BMI statistics (Table 7). However, baseline levels for prone SBD measurements were very similar (Figure 1).

Therefore it is suggested that the effects of Caesarean sections with regards to pain, disability and core stability weakness are no different to the effects of a natural birth.

4.3.4. Marital status

A greater proportion of the manipulation and exercise group were married than the manipulation group but this difference was not statistically significant (p=0.651).

Table 4: Marital status by treatment group (n=30)

			Marital status		Total
			married	single	
Treatment group	Manipulation and exercise	Count	13	2	15
		% within Treatment group	86.7%	13.3%	100.0%
	Manipulation	Count	11	4	15
		% within Treatment group	73.3%	26.7%	100.0%
Total		Count	24	6	30
		% within Treatment group	80.0%	20.0%	100.0%

Fisher's exact p value =0.651

Among many changes occurring over the years is the way fathers are now involved during the childbirth and child-rearing process. The changes within society, and particularly within the family structure from the extended family network to the nuclear family, have perhaps had the most profound effect upon men becoming more involved in the process (Fraser and Cooper, 2003).

Women's roles have also changed quite significantly within society. Women are less willing or able to stay at home and care for the baby full-time but want to be active contributors to the economy and therefore part of the workforce (Fraser and Cooper, 2003). It is suggested that as married women tend to have more support at home in taking care of the child, these women may experience less severe pain than those subjects that are single.

However this was not reflected in the statistical analysis.

Although the manipulation group had more single women than the manipulation and exercise group (Table 4), the baseline levels for NRS and QPD measurements were very similar and their rate of improvement over time was similar for both groups (Figures 3 and 4).

One may argue that women are more involved in the workplace now than in the past (Fraser and Cooper, 2003), however, this fact may apply to both single and married mothers and therefore cannot be taken into account here.

In summary:

Increased workload for the new mother may have a role in causing a new or recurrent episode of low back pain (Polden and Mantle, 1990; Conway, 1995). Married women tend to have the support of their partners at home, and therefore may experience less severe low back pain and disability (Fraser and Cooper, 2003). However, this was not reflected in the statistical analysis as, although the manipulation group had more single women than the manipulation and exercise group (Table 4), the baseline levels for the NRS and QPD measurements were very similar and response to treatment was similar over time (Figure 3 and Figure 4). Therefore the effect of marital status is not considered to be of any significance to the study.

4.3.5. Activation of the core muscles

There were similar proportions of participants in both groups who were able to activate the core musculature (46.7% and 40% respectively, p=1.000).

Table 5: Activation by treatment group (n=30)

			Activation		Total
			yes	no	
Treatment group	Manipulation and exercise	Count	7	8	15
		% within Treatment group	46.7%	53.3%	100.0%
	Manipulation	Count	6	9	15
		% within Treatment group	40.0%	60.0%	100.0%
Total		Count	13	17	30
		% within Treatment group	43.3%	56.7%	100.0%

Fisher's exact p value = 1.000

From the above information, it is evident that the groups are homogeneous in terms of the percentage able to perform adequate activation of the core muscles. Thus the results are more meaningful and comparisons between these subgroups can be made (Mouton, 1996).

This is reflected by the outcome measures for pain and disability. The NRS and QPD showed very similar readings at baseline level and rate of improvement was similar for both groups (Figures 3 and 4).

The rate of improvement for prone SBD measurements was greater for the manipulation and exercise group than the manipulation group (Figure 1), however this may have been due to treatment effect.
The baseline level of the supine SBD measurements was greater for the manipulation and exercise group than the manipulation group (Figure 2). However, as there were very similar percentages of women able to activate in each group (Table 5), it is suggested that BMI and Caesarean sections may have some sort of role in causing the discrepancy as the manipulation group had a higher

percentage of overweight women and Caesarean sections (Table 3 and Table 7) as compared to the manipulation and exercise group.

A cross-sectional cohort study by Robertson (2006), concluded that there was no significant difference between the mean pressure decrease in athletes and non athletes as recorded on the SBD in the prone position for core muscle activation, although athletes had a higher mean endurance time than non athletes in the population for prone SBD rmeasurements of core stability endurance.

Robertson (2006) states that an elite athlete has larger, stronger and more finely tuned global muscles relative to a non athlete and can recruit them to a greater degree. This is from strenuous training programs endured by elite sportsmen (Guyton and Hall, 1996). Robertson (2006) stated that although this study involved the testing of the core stabilizers, it was very difficult to prevent any global muscle input.

This was supported by Janda et al. (1987) who found that muscle movement patterns could be much the same in both global and local activation. The net result implies that if the athlete has global muscles that are trained for endurance purposes by virtue of the sporting code in which they participate, that the results of endurance obtained in this study could be a greater reflection of the endurance of compensating global muscles rather than the local muscle endurance.

As athletes can be likened to individuals with an ideal BMI and non athletes likened to individuals with a higher BMI, the research by Robertson (2006) would support the suggestion BMI is of little significance to the ability to activate the core muscles. In addition, the research by Robertson (2006) also would support the suggestion that BMI may have some effect on core stability endurance measurements. With endurance, the use of global muscles enable the person with the ideal BMI able to outperform the person with a high BMI.

This may explain the discrepancies in the prone and supine SBD measurements described above (Figure 1 and Figure 2).

In summary:

The groups appear to be homogenous according to the numbers that have the ability to activate the core musculature in each group (Table 4).
This is reflected by the similar baseline measurements and rate of improvement for both groups in terms of pain and disability (Figures 3 and 4).
The study by Robertson (2006), supports the suggestion that BMI and the ability to activate the core musculature are not related.

A steeper rate of improvement of the prone measures for the manipulation and exercise group (Figure 1) was attributed to treatment effect. A higher baseline reading for the supine SBD measurements for the manipulation and exercise group (Figure 2) may be attributed to the effect of BMI and Caesarean sections, as the manipulation group appeared to have more overweight women and Caesarean sections (Table 3 and Table 7). This may be suggested as a result of the homogenous nature of the activation variable between groups.
The suggestion that BMI may have an effect on core stability endurance measurements rather than the activation ability is supported by Robertson (2006).

4.3.6. Mean age, parity and age of baby

Table 6 shows that there were no significant differences in (i) mean age, (ii) parity, and (iii) age of baby between the treatment groups.

Table 6: T-test for the comparison of mean age, parity and baby's age between the treatment groups

	Treatment group	N	Mean	Std. Deviation	Std. Error Mean	P value
Age of participant in years	Manipulation and exercise	15	30.53	4.103	1.059	0.787
	Manipulation	15	30.07	5.203	1.343	
Number of children	Manipulation and exercise	15	1.47	.640	.165	0.756
	Manipulation	15	1.53	.516	.133	
Baby's age in months	Manipulation and exercise	15	4.40	1.639	.423	0.724
	Manipulation	15	4.20	1.424	.368	

(i) Age:

Statistics regarding live births in South Africa for the year 2004 indicated that 67% of mothers were between the ages of 20 and 35, and a relatively high proportion of women were aged between 15-19 years (http://www.statssa.gov.za/ 2006). Therefore, women between the ages of 18 and 35 years of age were chosen, as it is the age group in which the incidence of pregnant women is at its greatest and is therefore representative of the South African demographics concerning age and pregnancy. The average age of the participants is of no significance as it was not the concern of the research to compare age of women for their first, second or third child to those of another sample group.

(ii) Parity:

'Para' means 'having given birth'; a woman's parity refers to the number of times that she has given birth to a child, live or stillborn, excluding abortions (Fraser and Cooper, 2003).

According to a study by Ostgaard and Andersson (1991), although higher pain-intensity values were recorded during pregnancy for women with previous back pain, the number of earlier pregnancies did not statistically significantly increase the risk of back pain in pregnancy.

Fast et al. (1987) also stated that the number of prior children is not a factor in back pain. Mogren (2005) states that parity is a major determinant of low back pain during pregnancy but was not a determinant of low back pain after pregnancy.

The statistics reveal that the parity of both groups is very similar and is therefore of no significance to the study (Table 6).

(iii) Baby's age:

The average age of the babies for both groups was approximately 4 months of age (Table 6). Therefore it is suggested that mothers may have been exposed to the same routines and increased workload for both groups.

Patients were only eligible for the study eight weeks following the delivery. Due to the inconsistencies within the literature in regard to the effects of the hormone relaxin, a waiting period of eight weeks following delivery was suggested so that the effects of the hormone relaxin would be of minimal influence on the study.

In adddition, women were not eligible for the study if more than six months had passed post-natally. This indirectly allowed for the sample homogeneity in terms of the age of the babies (Mouton, 1996), which allows for the baby's age to be of no significance.

In summary:

The average age for both groups in this study was approximately 30 years of age (Table 6). Therefore, age is not a variable that requires further consideration in terms of this study.

Fast et al. (1987), Ostgaard and Andersson (1991) and Mogren (2005) found that parity was of no significance as a predictor of incidence or severity of low back pain post-natally. The statistics reveal that the parity of both groups is very similar and is therefore of no significance to the study (Table 6).

As was discussed under the subheading with regards to marital status, the new mother has to deal with increased workload, which may have a role in causing a new or recurrent episode of low back (Polden and Mantle, 1990; Conway, 1995).
Both groups showed a very similar age of the baby (Table 6) and therefore the effects of baby's age and mother's workload is of little significance to the study.

4.3.7. Body Mass Index (BMI)

According to Mogren (2005), when categorizing BMI at six months after delivery the risk of persistent low back pain was almost significant for women with BMI greater than or equal to 25kg/m^2 in relation to women less than or equal to 25kg/m^2. Stunkard (2003) states that overweight is defined as a BMI of 25 to 29.9, and obesity is defined as a BMI of 30 or more.

Table 7 shows that there was a greater than double percentage of participants with BMI over 25 kgm^{-2} in the manipulation group (46.7%) compared with the manipulation and exercise group (20%). Although this difference was not statistically significant, it was considered as clinically important and adjusted for in subsequent analyses. This is because this difference could have contributed towards differences in recovery between the groups.

Table 7: BMI category by treatment group (n=30)

			BMIGROUP		Total
			>25	<=25	
Treatment group	Manipulation and exercise	Count	3	12	15
		% within Treatment group	20.0%	80.0%	100.0%
	Manipulation	Count	7	8	15
		% within Treatment group	46.7%	53.3%	100.0%
Total		Count	10	20	30
		% within Treatment group	33.3%	66.7%	100.0%

Pearson's chi square value 2.40, p=0.121

Assessment of body type is done by the BMI and is calculated by dividing the weight in kilograms by the height in metres squared. It is a reflection of weight for height and therefore a high BMI identifies those people who are relatively overweight irrespective of their height (Fraser and Cooper, 2003).
Obesity is diagnosed when the BMI is more than 27 for women older than 20 years, more than 26 for women aged 18 – 19 years, and more than 25 for those aged 17 years and younger (Cronje and Grobler, 2003).

An optimum BMI for maximum fertility and for producing a healthy baby of normal birth weight appears to be around 23 (Wynn and Wynn, 1990).

In a study by Kristiansson et al. (1996) it was found that those subjects that reported back pain had a higher body mass index than those with no back pain, but the differences were not statistically significant.
According to Fast et al. (1990) previous studies found no evidence relating backache to the mother's weight gain during pregnancy or the newborn's weight.

However, one of the main findings in a study by Mogren (2005) was the importance of BMI as a determinant of persistent low back pain after pregnancy. Women with persistent low back pain after pregnancy had significantly higher weight, and higher pre-pregnancy and end-pregnancy BMI as well as higher BMI at 6 months after delivery than did women with remission of low back pain after pregnancy.

According to the statistical analysis for this study, it would appear that BMI had no effect on pain and disability. This is evidenced by the NRS and QPD measures as baseline levels and rate of improvement was very similar for both groups (Figure 3 and Figure 4), although the manipulation group had more women with high BMI readings (Table 7) than the manipulation and exercise group.

However, BMI may have an effect on SBD readings:

The BMI does not appear to have any effect on activation ability as both groups had similar numbers of women who could and could not activate the core musculature, although the manipulation group had more women with a high BMI that the manipulation and exercise group (Table 5).

However, BMI may have an effect on supine and prone SBD readings.
The baseline reading for the supine SBD measurement (Figure 2) was higher for the manipulation and exercise group than the manipulation group which contained a higher proportion of participants with a high BMI.

This discrepancy in baseline readings was maintained for all supine SBD readings, although the manipulation and exercise group did show a slightly greater increase in readings over time. This suggests that persons with a higher BMI may experience fatigue of the core stabilizing musculature before persons with an ideal BMI. However, the baseline measurements for prone SBD measurements (Figure 1) were very similar for both groups, which reduced the significance of the supine` measurement findings to some degree.

In addition, the rate of improvement for prone readings was of a higher rate in the manipulation and exercise group as compared to the manipulation group. This also occurred in the supine SBD readings, but to a lesser extent. This, however, may be attributed to treatment effect rather than the effect of the BMI.

Therefore the discrepancy in baseline readings between treatment groups at the initial supine SBD measurement may be the most significant indicator of the effect of BMI on core stability muscle endurance for this study.

A cross-sectional cohort study by Robertson (2006) concluded that athletes had a higher mean endurance time than non athletes in the population for prone SBD rmeasurements of core stability endurance.

This outcome was expected, as it is a common assumption that elite athletes have a stronger core stability musculature than the general population. This is based on the fact that athletes are supposed to be more able to activate and control movements relative to the general population because of their intensive training schedules. Stunkard (2003) suggests that physical inactivity is one of the main reasons for the increase in obesity among people in affluent societies.

Therefore, persons with an ideal BMI may be assumed to be more athletic than persons with a high BMI. As the manipulation group has more participants with a higher BMI than the manipulation and exercise group, this would explain why the baseline reading for the supine BMI measurement (Figure 2) revealed that the manipulation group was weaker than the manipulation and exercise group in terms of core stability endurance.

However, according to Robertson (2006), as an athlete also has larger, stronger and more finely tuned global muscles compared to a non athlete, athletes may recruit these muscles to a greater degree. This is as a result of strenuous training programs endured by elite sportsmen (Guyton and Hall, 1996). Janda et al. (1987) support the suggestion that global muscle activation may substitute for local muscle activation. Their study found that muscle movement patterns could be much the same for both global and local activation.

The net result implies that if the athlete has global muscles that are trained for endurance purposes by virtue of the sporting code in which they participate, then the results of endurance measures obtained in this study could be a greater reflection of the endurance of compensating global muscles rather than the local muscle endurance.

The research by Robertson (2006) would support the suggestion that the ability to activate is of little significance to the endurance readings for core stabilization, as both groups revealed similar numbers able to activate.

In addition, the study by Robertson (2006) reveals that the use of global muscles gives the person with the ideal BMI the ability to outperform the person with a high BMI in terms of time measurements for core stability endurance. It is the use of these global muscles rather than the local muscles that allow the person with the ideal BMI to outperform the person with the high BMI.

Therefore, the research by Robertson (2006) would help to explain the discrepancies between the two treatment groups in terms of the supine and prone SBD measurements.

In summary:

Statistical analysis for this study reveals that BMI has no effect on pain and disability as evidenced by the NRS and QPD measures as baseline levels and rate of improvement were very similar for both groups (Figure 3 and Figure 4), although the manipulation group had more women with high BMI readings (Table 7) than the manipulation and exercise group.

A study by Robertson (2006) revealed that the use of global muscles allows the person with greater athletic ability to outperform the non athlete in terms of time measurements for core stability endurance. Stunkard (2003) suggests that physical inactivity is one of the main reasons for the increase in obesity among people in affluent societies and therefore, persons with an ideal BMI may be assumed to be more athletic than persons with a high BMI. As the manipulation group has more participants with a higher BMI than the manipulation and exercise group, this would explain why the baseline reading for the supine BMI measurement (Figure 2) revealed that the manipulation group was weaker than the manipulation and exercise group in terms of core stability endurance.

It is the use of these global muscles rather than the local muscles that allow the person with the ideal BMI to outperform the person with the high BMI.
Therefore, the research by Robertson (2006) would help to explain the discrepancies between the two treatment groups in terms of the supine and prone SBD measurements.

4.4. Inferential statistics results

4.4.1. Comparison of adjustments between treatment groups

Table 7 shows that the number of visits with adjustments differed significantly between the treatment groups (p=0.009). This may have affected the outcome after treatment. Thus this factor had to be controlled for in subsequent analysis.

Table 8: T-test for the comparison of mean number of visits with adjustments and number of adjustments between the treatment groups

	Treatment group	N	Mean	Std. Deviation	Std. Error Mean	p value
Number of visits with adjustments	Manipulation and exercise	15	4.80	1.146	.296	0.009
	Manipulation	15	3.80	.775	.200	
Number of adjustments	Manipulation and exercise	15	9.07	4.079	1.053	0.350
	Manipulation	15	7.80	3.167	.818	

Spinal manipulative therapy was carried out twice a week for the first three weeks of the treatment protocol, which allowed sufficient time for the effects of spinal manipulation to occur (Kirkaldy-Willis, 1988; Gatterman et al. 1990; Erhard et al. 1996). If the patient became asymptomatic or if there was an absence of spinal fixations before the completion of the spinal manipulative therapy protocol, spinal manipulation was discontinued.

The manipulation was performed in accordance with the level and direction of the fixation located by means of motion palpation and orthopaedic testing. Therefore, in terms of number of visits with manipulation, each group could have received a maximum of six visits with manipulation. This is within the recommended parameters suggested by Gatterman et al. 1990, Erhard et al. 1996 and Kirkaldy-Willis, 1988.

As can be observed in Table 8, on average neither group required the maximum of six visits with manipulation. This is as a result of the participants becoming asymptomatic or as a result of the absence of motion palpation restrictions following the required number of adjustments to the affected segments of the spine.

However, on average, the manipulation and exercise group received more visits that included adjustments (4.80) than the manipulation group (3.80).
As a result of the manipulation and exercise group receiving more treatments that included manipulation than the manipulation group, a by-product of this is that the manipulation and exercise group also received more adjustments (9.07) as compared to the manipulation group (7.80).

The reason for the manipulation and exercise group receiving more visits with manipulation than the manipulation group may be as a result of the treatment effect of the core stability exercises.

According to Bergmann et al. (1993), when injury or degenerative disease results in contracture, stiffness, joint hypomobility and chronic pain or impairment, manual therapies are most effective when coupled with activities and exercises that promote soft tissue remodeling and muscle strength. However, applying spinal exercises, without first incorporating an assessment and treatment of joint dysfunction, may be detrimental. If joint hypomobility persists, active exercise may stimulate movements at the compensatory hypermobile joint, instead of the hypermobile joints. This may lead to further breakdown and attenuation of the joint stabilizing structures, further complicating joint instability.
Therefore the exercises may have been stimulating the hypermobile joints that resulted in the persistence of symptoms and patients therefore required more visits with adjustments.
In addition, the core exercises had the effect of stabilizing the spinal structures (Panjabi, 1992; Jull and Richardson, 1994; Saal, 1988), which causes a decrease in interverterbral motion and the reduction of mechanical stress to the spine. However, it is suggested by the researcher that these stabilizing effects of the core exercises may have acted upon hypomobile segments in addition to the hypermobile

segments. Therefore the desired effects for spinal manipulation to correct the symptomatic hypomobile motion segments and restore normal range of motion to these segments (Calliet, 1981; Hertzog et al. 1993), was challenged by the effect of the core exercises. Thus these hypomobile segments for the manipulation and exercise group required more adjustments to correct the hypomobillity than those hypomobile segments in the manipulation group, as the manipulation group did not have core stability exercises as a treatment intervention.

As spinal manipulation has been proven to be successful in the treatment of mechanical low back pain (Meade et al. 1990; Bronfort 1992; Bergmann et al. 1993; Manga et al. 1993) and particularly in post-natal low back pain (Fraser, 1976; Bailes, 1998), the manipulation and exercise group may have had the advantage of receiving more treatments with manipulation than the manipulation group.
This may have affected the results of the study.

Uys (2006) showed that spinal manipulation may have a positive effect on core stability muscle endurance. For the prone SBD readings, the manipulation and exercise group showed a steeper rate of increase over time than the manipulation group (Figure 1) and the time by group interaction (treatment effect) was more significant in the first period (first 3 measurements) than in the second period (Table 9), although neither period reached statistical significance. Therefore it may be suggested that this is as a result of the manipulation and exercise group receiving more adjustments, although literature may also suggest that this is rather as a result of core stability exercises (Richardson and Jull, 1995; Hides et al. 1996; Hagins et al. 1999).
Figure 2 shows that the manipulation and exercise group showed a slightly greater increase in time supine overall than the manipulation group, which, similarly to the prone SBD readings, may be as a result of the manipulation and exercise group receiving more adjustments, although literature may also suggest that this is rather as a result of effect of core stability exercises (Richardson and Jull, 1995; Hides et al. 1996; Hagins et al. 1999).

For NRS readings, Figure 4 shows that both groups decreased over time. The rate of decrease was slightly steeper in the manipulation and exercise group. The treatment effect in either of the two periods was not statistically significant (Table 12). This steeper rate of improvement may be as a result of the manipulation and exercise group receiving more adjustments as compared to the manipulation group, although this may also be explained as the effect of the core stability exercises, as the added intervention of core stability exercises to spinal manipulation revealed a slight advantage over spinal manipulation alone in the management of post-natal low back pain sufferers.

QPD readings showed no treatment effect between the groups (Figure 3; Table 11).

In summary:

On average, the manipulation and exercise group received more visits that included adjustments (4.80) than the manipulation group (3.80) and as a result of this the manipulation and exercise group also received more adjustments (9.07) as compared to the manipulation group (7.80).

This may be as a result of the treatment effect of the core stability exercises. Active exercise may stimulate movements at the compensatory hypermobile joint, instead of the hypermobile joints, which may lead to further breakdown and attenuation of the joint stabilizing structures, further complicating joint instability (Bergmann et al. 1993).
Therefore the exercises may have been stimulating the hypermobile joints that resulted in the persistence of symptoms and patients therefore required more visits with adjustments.

In addition, the stabilizing effect of the core exercises (Saal, 1988; Panjabi, 1992; Jull and Richardson, 1994) suggests that the desired effects for spinal manipulation to correct the symptomatic hypomobile motion segments and restore normal range of motion to these segments (Calliet, 1981; Hertzog et al. 1993), was challenged by the effect of the core exercises. Thus these hypomobile segments for the manipulation and exercise group required more adjustments to correct the hypomobillity than those hypomobile segments in the manipulation group as the manipulation group did not have core stability exercises as a treatment intervention.

As spinal manipulation is successful in the treatment of mechanical low back pain (Meade et al. 1990; Bronfort 1992; Bergmann et al. 1993; Manga et al. 1993) and particularly in post-natal low back pain (Fraser, 1976; Bailes, 1998), the manipulation and exercise group may have had the advantage of receiving more treatments with manipulation than the manipulation group.
This effect on the outcome of the study was discussed above.

4.4.2. Analysis of treatment effects

Inter-group analysis

4.4.2.1. Prone SBD measures for core stability endurance

All the repeated measures ANOVA models controlled for BMI and number of visits with adjustments as covariates.

Table 9 shows that there was no significant treatment effect for time prone (p=0.290). However, inspection of Figure 1 shows that the profiles of the two groups were not quite parallel over time. The manipulation and exercise group showed a steeper rate of increase over time than the manipulation group. However, this slight interaction trend was not statistically significant.

The time by group interaction (treatment effect) was more significant in the first period (first 3 measurements) than in the second period, although neither period reached statistical significance.

Table 9: Between and within subjects effects for time prone

Effect	Statistic	p value
Time	Wilk's Lambda=0.811	0.287 (0.05)
Time*group	Wilk's Lambda=0.813	0.290
Group	F=0.552	0.464
Time * group in period 1 (visit 1 to 3)	F=3.002	0.095
Time * group in period 2 (visit 3 to 5)	F=1.332	0.259

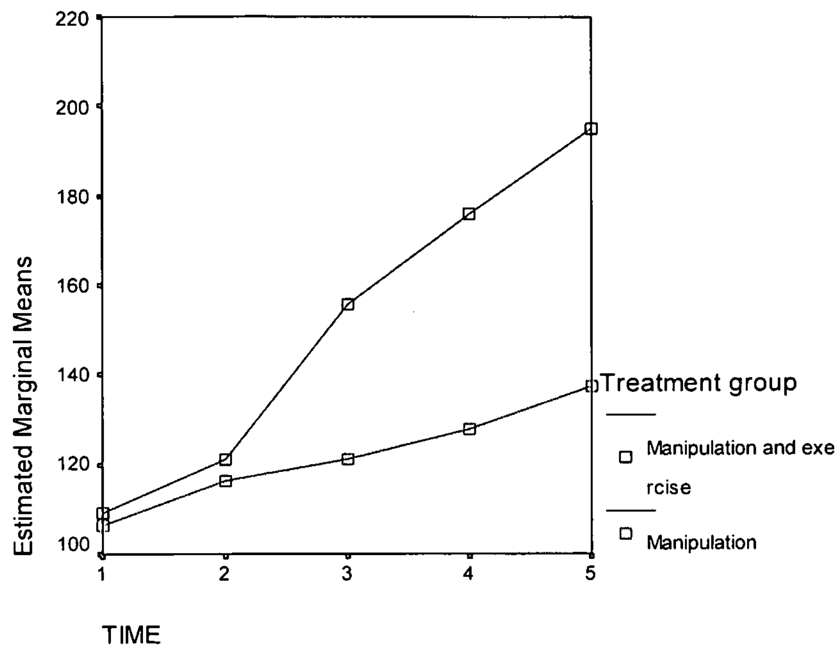


Figure 1: Profile plot of mean time prone over time by group

As can be seen in Figure 1, the baseline measurements for both groups were very similar which shows that the groups were homogenous from the outset in terms of prone SBD measurements.
This is convenient as it allows for a more accurate analysis of treatment effects between the groups. This similarity in baseline levels is also a good indication of good sample homogeneity in terms of the demographics between the groups (Mouton, 1996). This also indicates that although the manipulation group had more participants with Caesareans and a higher BMI than the manipulation and exercise group (Table 3 and Table 7), this had no effect on the baseline level for the prone SBD measurement.

A study by Uys (2006) revealed that spinal manipulative therapy improves SBD measurements of core stability for patients suffering with chronic low back pain. This may explain the improvement noted in prone SBD measures for the manipulation group (Figure 1), although this may also be due to natural progression and symptom relief provided by the manipulation.

Both groups showed an improvement in prone SBD measures, however the manipulation and exercise group showed a steeper rate of improvement than the manipulation group (Figure 1).
It is suggested that this may be due to the treatment effect of the core stabilization exercises as both groups received spinal manipulation.
According to Stanford (2002), numerous studies (Richardson and Jull, 1995; Hides et al. 1996; Hagins et al. 1999) have demonstrated that with varying amounts of practice, most patients can improve their ability to contract the lumbar stabilizers. Thus, the literature supports the finding that the manipulation and exercise group showed a steeper rate of improvement in prone SBD measures than the manipulation group (Stanford, 2002) and that this improved outcome over the manipulation group is as a result of the effect of the core stabilizing exercises.

When the time by group interaction in the first period (first 3 measurements) is compared (Table 9), it is clear that the first treatment period showed greater gains in prone SBD measures for the manipulation and exercise group. This suggests that a combination of spinal manipulation and exercise results in greater gains in core stabilser endurance than manipulation performed alone, which adds emphasis to the overall conclusion that a combination of manipulation and exercise is more effective than manipulation alone in the rehabilitation of core stability.

As the manipulation and exercise group received more adjustments than the manipulation group (Table 8), the effects of manipulation on core stability endurance (Uys, 2006) may have had more effect for this group, which may also be a reason for the manipulation and exercise group outperforming the manipulation group in terms of SBD measurements (Figure 1 and Table 9). However, all the repeated measures ANOVA models controlled for number of visits with adjustments as covariates.

For the second treatment period, the manipulation and exercise group received only core stability exercises, whereas the manipulation group did not receive any treatment. The statistics show that performing the exercises did not hold any advantage over not receiving treatment at all (Table 9). This contradicts the literature as core stability exercises have been shown to improve core stability muscle function according to SBD measurements in previous studies (Richardson and Jull, 1995; Hides et al. 1996; Hagins et al. 1999; Stanford, 2002).

In summary:

The baseline measurements for both groups (Figure1) were very similar which is an indication of good sample homogeneity (Mouton, 1996).

Both groups showed an improvement in prone SBD measures, however the manipulation and exercise group showed a steeper rate of improvement than the manipulation group (Figure 1).
The literature supports the finding that the manipulation and exercise group showed a steeper rate of improvement than the manipulation group (Stanford, 2002) and that this is as a result of the effect of core stabilizing exercises.

The time by group interaction revealed that for the first treatment period, the manipulation and exercise group demonstrated greater gains in prone SBD measures than the manipulation group (Table 9). This suggests that a combination of spinal manipulation and exercise results in greater gains in core stabilser endurance than spinal manipulation alone.

For the second treatment period, the statistics reveal that performing the core stability exercises did not hold any advantage over not receiving treatment at all (Table 9). This contradicts the literature as core stability exercises have been shown to improve core stability muscle function according to SBD measurements in previous studies (Richardson and Jull, 1995; Hides et al. 1996; Hagins et al. 1999; Stanford, 2002).

Therefore, from the above data, it may be suggested that the combined effects of core stability exercise and manipulation is more beneficial than the effects of manipulation alone in the rehabilitation of the core stabilizing muscles, which is supported by the literature. However, this conclusion was not supported statistically, possibly due to a type II error because of small sample size.

4.4.2.2. Supine SBD measures for core stability endurance

All the repeated measures ANOVA models controlled for BMI and number of visits with adjustments as covariates.

There was a borderline non-significant treatment effect for time supine (p=0.090). Figure 2 shows that the manipulation and exercise group showed a slightly greater increase in time supine over time than the manipulation group.

The marginally non significant group effect (p=0.061) meant that the group means were different from each other at all time points, which is not a treatment effect but an artifact of baseline differences which persisted over time.

Figure 2 shows that the means of the manipulation and exercise group were at all time points higher than the control group. When the treatment effect was split into periods, neither of the periods showed a significant treatment effect.

Table 10: Between and within subjects effects for time supine

Effect	Statistic	p value
Time natural history	Wilk's Lambda=0.714	0.089
Time*group treatment	Wilk's Lambda=0.714	0.090
Group	F=3.823	0.061
Time * group in period 1 (visit 1 to 3)	F=0.800	0.379
Time * group in period 2 (visit 3 to 5)	F=0.000	0.992

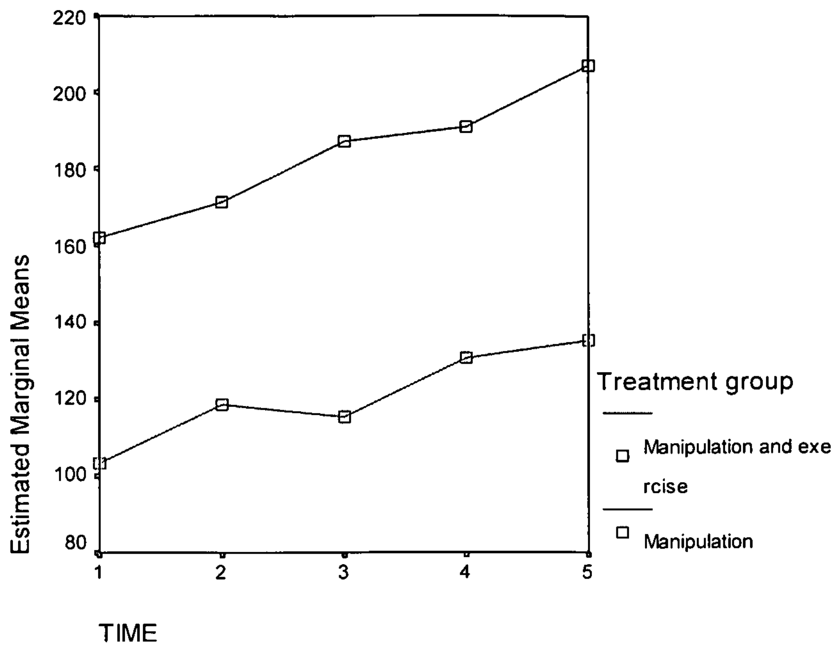


Figure 2: Profile plot of mean time supine over time by group

Figure 2 demonstrates that the manipulation and exercise group had consistently higher mean times overall than the manipulation group, although this difference was not quite significant (p=0.060).

In addition, it is clear that the rate of increase for both groups is very similar overall (p=0.90) and when the treatment effect was split into periods, neither of the periods showed a significant treatment effect (Figure 2).

These observations of similar rate and overall improvement for both groups in the supine SBD readings (Figure 2) are not in keeping with the findings of the prone SBD readings which indicated that the manipulation and exercise group had more substantial gains in endurance overall, and a greater rate of progression than the manipulation group (Figure 1).

The slightly better results in the manipulation and exercise group for supine SBD readings (Figure 2), may be explained for the same reasons as for the prone SBD measurements: As both groups received spinal manipulation, it is suggested that this may be due to the treatment effect of the core stabilization exercises, which is

supported by the literature (Richardson and Jull, 1995; Hides et al. 1996; Hagins et al. 1999; Stanford, 2002).
However, as the manipulation and exercise group received more adjustments than the manipulation group (Table 8), the effects of manipulation on core stability endurance (Uys, 2006) may also be a reason for the manipulation and exercise group outperforming the manipulation group in terms of SBD measurements (Figure 2 and Table 10).

When the time by group interaction for the first treatment period (first 3 measurements) was compared (Table 10), no treatment effect between the groups was observed.
This suggests that a combination of spinal manipulation and exercise does not hold further advantages over manipulation alone in the rehabilitation of core stabilser endurance. This is not in keeping with the findings of the prone SBD readings, which showed that a combination of manipulation and exercise had greater gains in the first period of treatment over the manipulation group (Table 9).
This suggests that a combination of spinal manipulation and exercise is no more beneficial than performing spinal manipulation alone in the rehabilitation of the core stabilsing musculature.
These results contradict the literature. As both spinal manipulation and core stability exercises have been shown to increase the SBD readings for core stabilizer endurance (Richardson and Jull, 1995; Hides et al. 1996; Hagins et al. 1999; Stanford, 2002; Uys, 2006), it may be reasonably assumed that a combination of these two treatment interventions would yield a better outcome over manipulation alone. However, for the supine SBD measurements, this does not appear to be the case.

Although both the supine and prone SBD measurements yielded similar results, it is not clear why the discrepancies described above should exist. Supine measurements were performed according to Stanford (2002), while the prone SBD measurements were performed according to Boden (2002).
Perhaps further research is required in the field of SBD measurements so that we may better understand the occurrence of these findings.

For the second treatment period, the manipulation and exercise group received only core stability exercises, whereas the manipulation group did not receive any treatment. The statistics show that performing the exercises did not hold any advantage over not receiving treatment at all (Table 10), which was also found for the prone SBD readings (table 9). This contradicts the literature as core stability exercises have been shown to improve core stability muscle function according to SBD measurements in previous studies (Richardson and Jull, 1995; Hides et al. 1996; Hagins et al. 1999; Stanford, 2002).

Figure 2 also demonstrates that there is a non-significant difference in the baseline reading for supine SBD measurement between the manipulation and exercise group and the manipulation group. It is clear from the baseline reading that the manipulation group was outperformed by the manipulation and exercise group in this regard. There is the possibility that this may be as a result of the manipulation group having a higher percentage of participants with a high BMI than the manipulation and exercise group, although BMI was controlled for in the analysis.

Robertson (2006) revealed that the use of global muscles gives an athlete the ability to outperform the non athlete in terms of time based measurements for core stability endurance.

If it may be assumed that athletes can be likened to persons with an ideal BMI, and non athletes with a higher BMI, the research by Robertson (2006) would help to explain the discrepancies between the two treatment groups in terms of the supine and prone SBD measurement at baseline levels and the persistence of the baseline difference over time.

In summary:

Supine SBD readings for the manipulation and exercise group showed slightly greater gains overall than the manipulation group (Figure 2). This suggests that a combination of spinal manipulation and exercise has advantages over using spinal manipulation alone in the rehabilitation of core stability musculature, although this effect is less than for the prone SBD readings.

The time by group interaction revealed that for the first treatment period, neither of the periods showed a significant treatment effect (Table 10). This suggests that a combination of spinal manipulation and exercise holds no advantage over manipulation alone, which also contradicts the findings of the prone SBD readings.

Although discrepancies between the prone and supine SBD measurements exist, both measurements were performed according to the literature (Boden, 2002; Stanford, 2002). Perhaps further research is required in the field of SBD measurements so that we may better understand the occurrence of these findings. However, the manipulation and exercise group received more adjustments (Table 8), which may be a reason for the manipulation and exercise group outperforming the manipulation group (Uys, 2006) in terms of SBD measurements (Figure 2 and Table 10).

For the second treatment period, core stability exercises did not hold any advantage over not receiving treatment at all (Table 10). This is in keeping with the prone SBD readings (Table 9), but contradicts the literature, as core stability exercises have been shown to improve core stability muscle function according to SBD measurements in previous studies (Richardson and Jull, 1995; Hides et al. 1996; Hagins et al. 1999; Stanford, 2002).

4.4.2.3. Quebec low back pain disability questionnaire measures (QPD)

For QPD score there was a general decrease over time in both groups, with the rate of decrease being very similar in both groups (Figure 3). There was no evidence of a treatment effect (p=0.904) overall or when the follow up period was split into two.

Table 11: Between and within subjects effects for QPD score

Effect	Statistic	p value
Time	Wilk's Lambda=0.810	0.281
Time*group	Wilk's Lambda=0.958	0.904
Group	F=0.199	0.659
Time * group in period 1 (visit 1 to 3)	F=0.177	0.677
Time * group in period 2 (visit 3 to 5)	F=0.000	0.997

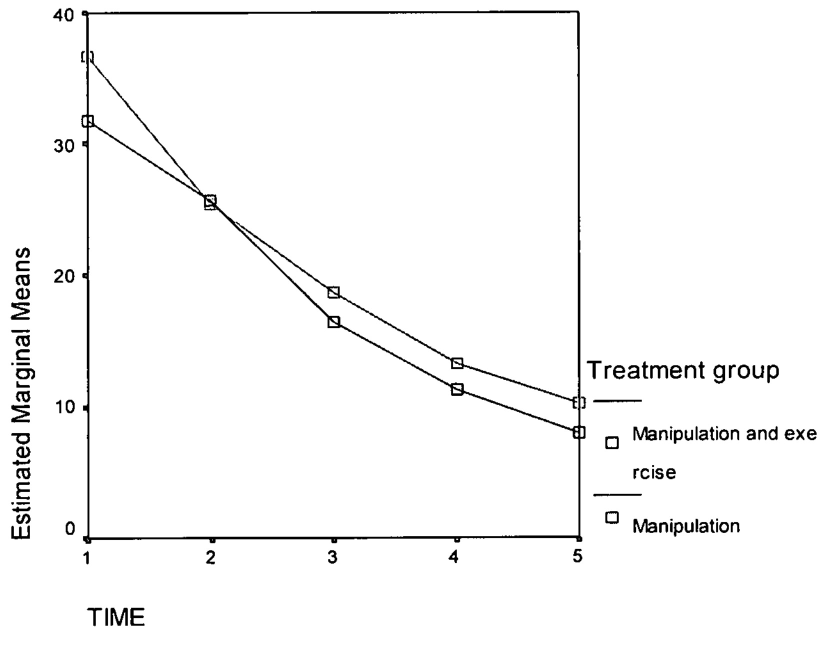


Figure 3: Profile plot of mean QPD score over time by group

Figure 3 demonstrates that the baseline levels, overall improvement and rate of improvement for both groups are very similar for QPD readings.

This similarity in baseline readings is an indication of good sample homogeneity between the groups. This is convenient as it allows for a more accurate analysis of treatment effects between the groups (Mouton, 1996).

The similarities in overall improvement and rate of improvement suggest that a combination of manipulation and exercise does not hold further advantages over manipulation alone with respect to the management of disability as a result of post-natal low back pain.

When the treatment periods are split (Table 11), period 1 adds emphasis to these findings. Participants in the manipulation and exercise group received both manipulation and exercise for period 1, whereas the manipulation group only received manipulation. As no treatment effect was observed between the groups, this suggests that a combination of manipulation and exercise does not hold further advantages with respect to the management of disability in post-natal low back pain when compared to spinal manipulation alone.

For the second treatment period the manipulation and exercise group only received exercises, whereas the manipulation group did not receive any treatment. Therefore, as no treatment effect was observed for this period (Table 11), it is suggested that core stability exercises alone do not hold further advantages with respect to the management of disability in post-natal low back pain.

Research into the effectiveness of core stabilization exercises has shown that these exercises are effective in the management of disability in low back pain sufferers (Hides et al. 2001; Stanford, 2002; Stuge, 2004). In addition, Fraser (1976) and Bailes (1998) demonstrated that manipulation effectively improved disability in post-natal low back pain sufferers. Therefore, according to the literature, the combined effects of manipulation and exercise should hold the advantage over manipulation alone in the management of disability for post-natal low back pain patients.

However, according to the statistical analysis (Table 11 and Figure 3), this does not appear to be the case.

Therefore it is suggested that spinal manipulative therapy is the treatment intervention that is principally responsible for the improvement noted in the QPD readings. This is because the added intervention of core stability exercises to spinal manipulation failed to show any advantage over spinal manipulation alone in the management of disability in post-natal low back pain sufferers.

In summary:

Figure 3 demonstrates that the baseline levels, overall improvement and rate of improvement for both groups are very similar for QPD readings.
The similarities in overall improvement and rate of improvement (Table 11 and Figure 3) suggest that a combination of manipulation and exercise does not hold further advantages over manipulation alone with respect to the management of disability as a result of post-natal low back pain.

For the first treatment period no treatment effect was observed between groups (Table 11), which suggests that a combination of manipulation and exercise does not hold further advantages with respect to the management of disability in post-natal low back pain when compared to spinal manipulation alone.

For the second treatment period, the results suggest that core stability exercises alone do not hold further advantages with respect to the management of disability in post-natal low back pain (Table 11).

The absence of treatment effects overall or for any treatment period is in contradiction to the literature (Hides et al. 2001; Stanford, 2002; Stuge, 2004), and is not in keeping with the overall findings and treatment effects of the first treatment period for the prone SBD readings (Figure 1).

4.4.2.4. Numerical pain rating scale measurements

NRS showed a statistically significant decrease over time in both groups (p=0.030), however the rate of decrease was the same in both groups, thus there was no evidence of a treatment effect (p=0.751).

Figure 4 shows that both groups decreased over time, but the rate of decrease was slightly steeper in the manipulation and exercise group. The treatment effect in either of the two periods was not statistically significant.

Table 12: Between and within subjects effects for NRS score

Effect	Statistic	p value
Time	Wilk's Lambda=0.639	0.030
Time*group	Wilk's Lambda=0.923	0.751
Group	F=0.895	0.353
Time * group in period 1 (visit 1 to 3)	F=0.951	0.339
Time * group in period 2 (visit 3 to 5)	F=1.153	0.293

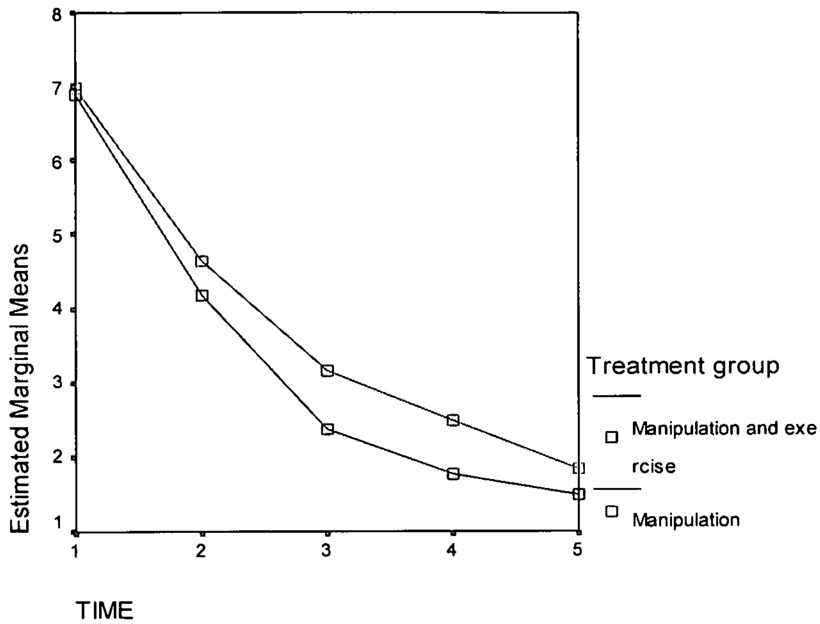


Figure 4: Profile plot of mean NRS over time by group

Similarly to the QPD readings, Figure 4 demonstrates that the baseline levels, overall improvement and rate of improvement for both groups are very similar for NRS readings, although the NRS showed a steeper rate of improvement for the manipulation and exercise group over the manipulation group.

The similar baseline reading (Figure 4) is convenient, as it allows for a more accurate analysis of treatment effects between the groups and is an indication of good sample homogeneity (Mouton, 1996).

The similarities in NRS readings between the two groups (Figure 4) suggest that a combination of manipulation and exercise does not have a significant advantage over manipulation alone with respect to the management of post-natal low back pain, however the steeper rate of improvement for the manipulation and exercise group is noted.

Manipulation is effective in the management of post-natal low back pain (Fraser, 1976; Bailes, 1998) and core stabilizing exercises have been shown to be effective in the management of low back pain (Hides et al. 2001; Stanford, 2002; Stuge, 2004). Therefore the literature suggests that a combination of these two interventions would be more effective than manipulation alone in the management of post-natal low back pain. Thus the steeper rate of improvement for the manipulation and exercise group (Figure 4) is in agreement with the literature and may be as a result of the advantages of core stability exercise, which the manipulation group did not have (Richardson and Jull, 1995; Hides et al. 1996; Hagins et al. 1999; Stanford, 2002), although, according to the statistics (Figure 4 and Table 12), this effect is very small.

This steeper rate of improvement may additionally be as a result of the manipulation and exercise group receiving more adjustments as compared to the manipulation group (Table 8). As spinal manipulation is effective in the management of post-natal low back pain (Fraser, 1976; Bailes, 1998), the effect of receiving more adjustments would give the manipulation and exercise group the advantage over the manipulation group in terms of the management of post-natal low back pain.

Although a steeper rate of improvement overall was observed for the manipulation and exercise group, when the treatment periods are split (Table 12), the treatment effect in either of the two periods was not statistically significant. As no treatment effect was observed for period 1 between the groups, this suggests that a combination of manipulation and exercise does not hold further advantages with respect to the management of post-natal low back pain when compared to spinal manipulation alone.

This applies similarly to the second treatment period. The manipulation and exercise group only received exercises, whereas the manipulation group did not receive any treatment. Therefore, as no treatment effect was observed for this period (Table 12), it is suggested that core stability exercises alone do not hold further advantages with respect to the management of post-natal low back pain.

These absences of treatment effects for any treatment period are in contradiction to the literature (Hides et al. 2001; Stanford, 2002; Stuge, 2004). According to the literature, the manipulation and exercise was expected to outperform the manipulation group for treatment period 1, and core exercises were expected to outperform the manipulation group, which received no treatment, in period 2.

Therefore, as results are similar to those observed for the QPD scores (Figure 3 and Table 11), it is suggested that spinal manipulative therapy is the treatment intervention that is principally responsible for the improvement noted in the NRS readings (Figure 4 and Table 12). However, the marginally steeper rate of improvement in NRS scores for the manipulation and exercises group overall (Figure 4) may be attributed to the effects of the core stability exercises.
This is because the added intervention of core stability exercises to spinal manipulation revealed a slight advantage over spinal manipulation alone in the management of post-natal low back pain sufferers.

In summary:

NRS scores for baseline levels, overall improvement and rate of improvement are similar for both groups, although the NRS showed a steeper rate of improvement for the manipulation and exercise group over the manipulation group (Figure 4).
The steeper rate of improvement for the manipulation and exercise group may be as a result of the advantages of core stability exercise, which the manipulation group did not have (Richardson and Jull, 1995; Hides et al. 1996; Hagins et al. 1999; Stanford, 2002).
When the treatment periods are split (Table 12), the treatment effect in either period was not statistically significant.
These absences of treatment effects for any treatment period are in contradiction to the literature (Hides et al. 2001; Stanford, 2002; Stuge, 2004). According to the literature, the manipulation and exercise was expected to outperform the manipulation group both periods.

Spinal manipulative therapy appears to be the treatment intervention principally responsible for the improvement noted in the NRS readings (Figure 4 and Table 12). However, the marginally steeper rate of improvement in NRS scores for the manipulation and exercises group overall (Figure 4) may be attributed to the effects of the core stability exercises as the added intervention of core stability exercises to spinal manipulation revealed a slight advantage over spinal manipulation alone in the management of post-natal low back pain sufferers.

4.5. Intra-group correlation analysis

Correlation between changes in outcome measurements over time

Introduction:

According to Esterhuizen (2006), a Pearson correlation value of less than .3 is not considered to be of any practical significance whatsoever. A value of less than .3 is just a random scatter of points and therefore cannot be used imply a correlation between variables as an absolute value or as being either negative or positive. Whether the slope of the line that that fits through the random scatter of points is negative or positive is arbitrary. This is because this slope may be strongly influenced by one or two influential points as a result of the sample size being too small.

Therefore one may only interpret a value and sign (positive or negative) of correlation coefficient where the value of the correlation coefficient is of moderate strength, i.e. greater than 0.5 ($p = 0.05$).

4.5.1. Manipulation and exercise group

4.5.1.1. Overall change (time 5 – time 1)

In this group there was a weak positive correlation between overall change in supine time and prone time (r=0.593, p=0.020). The other measurements were not correlated together.

Table 13: Pearson's correlation between overall changes in outcome variables in the manipulation and exercise group (n=15)

		Change in Prone	Change in Supine	Change in QPD score	Change in NRS
Change in Prone	Pearson Correlation	1	.593(*)	.069	.003
	Sig. (2-tailed)	.	.020	.806	.990
	N	15	15	15	15
Change in supine	Pearson Correlation	.593(*)	1	-.026	.015
	Sig. (2-tailed)	.020	.	.926	.957
	N	15	15	15	15
Change in QPD	Pearson Correlation	.069	-.026	1	-.173
	Sig. (2-tailed)	.806	.926	.	.538
	N	15	15	15	15
Change in NRS	Pearson Correlation	.003	.015	-.173	1
	Sig. (2-tailed)	.990	.957	.538	.
	N	15	15	15	15

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

- Similarly to the manipulation group, the correlation between supine and prone SBD readings for the manipulation and exercise group overall was also significant (.593). Therefore the degree of change for prone readings was similar to the degree of change for the supine readings. Thus a change in one of these variables will allow us to predict the degree of change in the other. However, when compared to the manipulation group (Table 13), the manipulation group showed a higher level of significance (p = 0.008) than the manipulation and exercise group (p = 0.020).

This was as a result of the prone SBD time showing greater increases than the supine SBD time for the manipulation and exercise group (Figure 1 and Figure 2).

- The other measurements were not correlated together. This is because all other correlation measurements were well below the level required for adequate strength of correlation (> 0.3). Therefore any negative or positive correlations in the table 16 cannot suggest a relationship between these variables.

4.5.1.2. Changes in period 1 (time 3-time 1)

There were no significant correlations between changes in measurements in period 1 in this group.

Table 14: Pearson's correlation between period 1 changes in outcome variables in the manipulation and exercise group (n=15)

		Period 1 change in time prone	Period 1 change in time supine	Period 1 change in QPD score	Period 1 change in NRS
Period 1 change in time prone	Pearson Correlation	1	.139	.241	.110
	Sig. (2-tailed)	.	.620	.387	.697
	N	15	15	15	15
Period 1 change in time supine	Pearson Correlation	.139	1	-.131	-.105
	Sig. (2-tailed)	.620	.	.641	.710
	N	15	15	15	15
Period 1 change in QPD score	Pearson Correlation	.241	-.131	1	.044
	Sig. (2-tailed)	.387	.641	.	.877
	N	15	15	15	15
Period 1 change in NRS	Pearson Correlation	.110	-.105	.044	1
	Sig. (2-tailed)	.697	.710	.877	.
	N	15	15	15	15

- All of the above correlation measurements were well below the level required for adequate strength of correlation (> 0.3). Therefore, although negative and positive correlations occur (Table 14), no suggestions may be made with regards to the relationship between the variables (Esterhuizen, 2006).

4.5.1.3. Changes in Period 2 (time 5 – time 3)

Changes over period 2 showed that in the manipulation group QPD score and NRS were positively correlated (r=0.661, p=0.007). Thus as QPD score decreased in period 2 so did NRS score.

Table 15: Pearson's correlation between period 2 changes in outcome variables in the manipulation and exercise group (n=15)

		Period 2 change in time prone	Period 2 change in time supine	Period 2 change in QPD score	Period 2 change in NRS
Period 2 change in time prone	Pearson Correlation	1	.467	.101	.028
	Sig. (2-tailed)	.	.079	.720	.920
	N	15	15	15	15
Period 2 change in time supine	Pearson Correlation	.467	1	.133	-.059
	Sig. (2-tailed)	.079	.	.636	.834
	N	15	15	15	15
Period 2 change in QPD score	Pearson Correlation	.101	.133	1	.661(**)
	Sig. (2-tailed)	.720	.636	.	.007
	N	15	15	15	15
Period 2 change in NRS	Pearson Correlation	.028	-.059	.661(**)	1
	Sig. (2-tailed)	.920	.834	.007	.
	N	15	15	15	15

** Correlation is significant at the 0.01 level (2-tailed).

- NRS and QPD readings for period 2 of the manipulation and exercise group were significantly positively correlated (.661). The manipulation and exercise group received core stability exercises for period 2. The significant correlation that occurred reveals that changes in NRS were comparative to the degree of change in QPD readings. Therefore we may say that a decrease in NRS will allow us to predict the degree of change in QPD for core stability exercise.

- Prone and supine SBD readings were positively correlated (.467) at a level just below that required for moderate significance (.500). Prone and supine times both increased for core stability exercise (Figure 1 and Figure2). However, as this correlation was not at a level of significance we cannot accurately predict the degree or direction of change in one of these variables based on the other.

- As the rest of the variables were well below the level required for adequate strength of correlation (> 0.3), no suggestions may be made with regards to the relationship between the variables. Any negative or positive correlations in table 15 cannot suggest a relationship between these variables (Esterhuizen, 2006).

4.5.2. Manipulation group

4.5.2.1. Overall change (time 5-time 1)

In this group there was a moderate positive correlation between change in supine time and prone time (r=0.652, p=0.008). The other measurements were not correlated together.

Table 16: Pearson's correlation between overall changes in outcome variables in the manipulation group (n=15)

		Change in Prone	Change in Supine	Change in QPD score	Change in NRS
Change in Prone	Pearson Correlation	1	.652(**)	-.023	-.149
	Sig. (2-tailed)	.	.008	.936	.597
	N	15	15	15	15
Change in supine	Pearson Correlation	.652(**)	1	-.044	-.076
	Sig. (2-tailed)	.008	.	.878	.789
	N	15	15	15	15
Change in QPD	Pearson Correlation	-.023	-.044	1	.322
	Sig. (2-tailed)	.936	.878	.	.242
	N	15	15	15	15
Change in NRS	Pearson Correlation	-.149	-.076	.322	1
	Sig. (2-tailed)	.597	.789	.242	.
	N	15	15	15	15

** Correlation is significant at the 0.01 level (2-tailed).

- Prone and supine SBD readings positively correlated to a significant degree (.652). This indicates that the degree of increase of SBD time measures for prone and supine positions are similar for the manipulation group overall.

These results show that the supine and prone methods of SBD measurement will yield similar results in the measurement of core stabilizing muscle endurance.

Therefore, if a supine SBD reading is taken for example, you may predict that a prone SBD measurement would yield a similar reading.
However, when compared to the manipulation and exercise group (Table 13), the manipulation and exercise group also showed a significant positive correlation between prone and supine measures, (.593) but this was at a slightly lower level of significance than the manipulation group. This was as a result of the prone SBD time showing greater increases than the supine SBD time for the manipulation and exercise group (Figure 1 and Figure 2). Therefore the power of prediction for the overall prone and supine readings was significant, slightly more so than for the manipulation and exercise group.

- A correlation between QPD and NRS scores is noted (.322) at a level lower than moderate significance (.500), but higher than the level of no significance (< .300) as suggested by Esterhuizen (2006).
  This suggests a slight level of correlation between NRS and QPD scores, therefore as NRS levels decrease, QPD levels will also decrease and possibly to a similar degree. However, as the level of correlation is below the level for moderate correlation, no conclusions regarding the relationship between these variables can be made with any accuracy.

- As the rest of the variables were well below the level required for significance (> 0.3), no suggestions may be made with regards to the relationship between the variables. Any negative or positive correlations in table 16, besides those already discussed, cannot suggest a relationship between these variables (Esterhuizen, 2006).

4.5.2.2. Changes in Period 1 (Time 3 – time 1)

In period 1 the manipulation and exercise group showed a positive correlation between NRS and Quebec score (r=0.670, p=0.006).

Table 17: Pearson's correlation between period 1 changes in outcome variables in the manipulation group (n=15)

		Period 1 change in time prone	Period 1 change in time supine	Period 1 change in QPD score	Period 1 change in NRS
Period 1 change in time prone	Pearson Correlation	1	.407	-.210	.144
	Sig. (2-tailed)	.	.132	.452	.608
	N	15	15	15	15
Period 1 change in time supine	Pearson Correlation	.407	1	-.250	-.346
	Sig. (2-tailed)	.132	.	.369	.207
	N	15	15	15	15
Period 1 change in QPD score	Pearson Correlation	-.210	-.250	1	.670(**)
	Sig. (2-tailed)	.452	.369	.	.006
	N	15	15	15	15
Period 1 change in NRS	Pearson Correlation	.144	-.346	.670(**)	1
	Sig. (2-tailed)	.608	.207	.006	.
	N	15	15	15	15

** Correlation is significant at the 0.01 level (2-tailed).

- NRS and QPD readings for period 1 of the manipulation group were significantly positively correlated (.670). The treatment for period 1 involved manipulation only. The significant correlation that occurred reveals that with manipulation, the change in NRS was comparative to the degree of change in QPD readings. Therefore we may say that any change in NRS will allow us to predict the degree of change in QPD if treatment for post-natal low back pain involved manipulation alone.

- Prone and supine SBD readings were positively correlated (.407) as expected at a level near that for moderate significance (.500). However, although the level of correlation was almost significant, given a change in one of these variables, we cannot predict with accuracy the degree of change in the other.
  On the other hand, we may say with some accuracy that change would be in the same direction for spinal manipulation.

- It was noted that supine SBD scores for period 1 of the manipulation group were negatively correlated with the NRS scores (-.346), at a level below that for moderate significance (.500), but above the absolute minimum requirement for correlation (.300) as suggested by Esterhuizen (2006).
  This negative correlation was expected and is in keeping with the literature (Bailes, 1998; Fraser, 1976). However, this correlation is not statistically significant and therefore we cannot accurately predict the degree of change in one of these variables based on the other.

- As the rest of the variables were well below the level required for significance (> 0.3), no suggestions may be made with regards to the relationship between the variables. Any negative or positive correlations in table 17, besides those already discussed, cannot suggest a relationship between these variables (Esterhuizen, 2006).

4.5.2.3. Changes in period 2 (time 5-time 3)

Prone and supine times were positively correlated in the intervention group in the second period (r=0.642, p=0.010), as were NRS and Quebec scores (r=0.615, 0-0.015).

Table 18: Pearson's correlation between period 2 changes in outcome variables in the manipulation group (n=15)

		Period 2 change in time prone	Period 2 change in time supine	Period 2 change in QPD score	Period 2 change in NRS
Period 2 change in time prone	Pearson Correlation	1	.642(**)	.496	.122
	Sig. (2-tailed)	.	.010	.060	.665
	N	15	15	15	15
Period 2 change in time supine	Pearson Correlation	.642(**)	1	-.040	-.383
	Sig. (2-tailed)	.010	.	.888	.159
	N	15	15	15	15
Period 2 change in QPD score	Pearson Correlation	.496	-.040	1	.615(*)
	Sig. (2-tailed)	.060	.888	.	.015
	N	15	15	15	15
Period 2 change in NRS	Pearson Correlation	.122	-.383	.615(*)	1
	Sig. (2-tailed)	.665	.159	.015	.
	N	15	15	15	15

** Correlation is significant at the 0.01 level (2-tailed).

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

- Prone and supine SBD readings for period 2 of the manipulation group showed that there was a statistically positive correlation between the two (.642). However, the manipulation and exercise group for period 2 did not receive any treatment and therefore, spinal manipulation cannot be taken into account for this period.
Prone and supine readings both increased for this period despite the absence of any treatment (Figure 1 and Figure 2).

The strong positive correlation allows us to assume that both variables change in the same direction and to the same degree when there is an absence of treatment intervention. This absence of treatment is an acceptable reason for this observation.

- NRS and QPD readings also changed to a similar degree and in the same direction (.615) as evidenced by the significant positive correlation observed in the statistical analysis (Table 18).
  As there was an absence of treatment intervention for period 2 of the manipulation group, this correlation reflects that pain and disability decrease to the same extent when no treatment takes place. The fact that no treatment took place is an acceptable reason to explain the significant correlation between NRS and QPD scores.

- Prone SBD scores and QPD scores showed a strong positive correlation (.496), which was very near to the level required for moderate significance (.500). This indicates that as prone time increases, the levels of functional disability increase to a similar degree.
  However, as the relationship between these variables was not significant, an increase in prone measures cannot suggest an increase for QPD scores. This positive correlation is therefore due to the scatter effect of random points as described by Esterhuizen (2006). This is supported by figures 1 and 3. From these figures it is clear that as prone time increases for period 2, the QPD time decreases. These figures represent the change in median value for these variables over time, and are therefore not influenced by the scatter effect of the Pearson correlation method of intra-group analysis.

- A negative correlation between supine and NRS scores for period 2 of the manipulation group was noted (-.383). However this correlation was not sufficient to be of significance (-.500). It is large enough for comment though, and shows that there is some small degree of correlation between pain and supine SBD scores. This suggests that as supine scores increase, pain scores decrease and therefore a treatment effect in the absence of any treatment. As the significance of the correlation was not of any significance, no conclusion can be drawn from this finding.

- As the rest of the variables were well below the level required for significance (> 0.3), no suggestions may be made with regards to the relationship between the variables. Any negative or positive correlations in table 17, besides those already discussed, cannot suggest a relationship between these variables (Esterhuizen, 2006).

4.6. Summary

The two treatments, manipulation alone and manipulation plus exercise, resulted in improvement over the 5 time points for all outcomes measured. However, there was no statistical evidence of any additional benefit of the exercise over and above the manipulation.

A non significant trend towards a beneficial effect was demonstrated for time in the prone and supine positions. These two measurements were positively correlated together, thus as one time increases, so will the other time.

However, we must remember, "absence of evidence is not evidence of absence" (Altman and Bland, 1995). The study was underpowered to detect small treatment effects, which may have been clinically significant. Thus it is possible that a type II error was made when the null hypothesis was not rejected, yet a positive trend was displayed.

4.7. Discussion of the objectives

Based on the results discussed above, the following can be stated with regard to the hypotheses:

Objective one: The first objective was to evaluate the efficacy of spinal manipulation in conjunction with core stability exercises in the treatment of post-natal mechanical low back pain, in terms of subjective and objective clinical findings.

- Hypothesis one: It was hypothesized that spinal manipulative therapy in conjunction with core stability exercises would be effective in the management of post-natal mechanical low back pain, in terms of subjective and objective clinical findings.

This hypothesis is **accepted** as the outcomes support the hypothesis.

Objective two: The second objective was to evaluate the efficacy of spinal manipulation alone in the treatment of mechanical low back pain in post-natal patients, in terms of subjective and objective clinical findings.

- Hypothesis two: It was hypothesized that spinal manipulative therapy alone would be effective in the management of post-natal mechanical low back pain, in terms of subjective and objective clinical findings.

  This hypothesis is **accepted** as the outcomes support the hypothesis.

Objective three: The third objective was to integrate the data obtained from objectives one and two, in order to determine which would be a more effective treatment of post-natal mechanical low back pain.

- Hypothesis three: It was hypothesized that no difference between these two groups should be found in the management of post-natal mechanical low back pain, in terms of subjective and objective clinical findings.

  This hypothesis is **accepted** as the outcomes support the hypothesis. There was no statistical evidence of any additional benefit of the exercise over and above the manipulation.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1. Introduction

Specifically, this chapter will concern itself with the study conclusions, methodological issues and recommendations for future studies.

5.2. Conclusions

The purpose of this study was to compare the relative effectiveness of spinal manipulation in conjunction with core stability exercises as opposed to spinal manipulation alone in the treatment of post-natal mechanical low back pain.

The manipulation and exercise group (Group one) showed an improvement in both the objective and subjective clinical findings, which was in agreement with the hypothesis set out at the beginning of the study.

The spinal manipulation alone group (Group two) showed an improvement in both the objective and subjective clinical findings, which was also in agreement with the hypothesis set out at the beginning of the study.

However, when the relative effectiveness of spinal manipulation in conjunction with core stability exercises was compared to spinal manipulation alone, the combination of spinal manipulation and exercise did not significantly outperform spinal manipulation alone. There was no statistical evidence of any additional benefit of the core stability exercise over and above the manipulation.

Therefore, this was not in keeping with the hypothesis set out at the beginning of the study, as it was hypothesised that the combination of spinal manipulation and core stability exercises would be more effective than spinal manipulative therapy alone in the management of post-natal mechanical low back pain.

5.3. Recommendations

The following improvements are suggested:

- It is recommended that future studies include a separate core stability group which does not receive manipulation.

- It is also suggested that patients be questioned regarding their previous exposure to core stability exercises as well as their fitness levels during pregnancy.

- A larger sample size is always desired which would allow for more accurate results. The sample size of this study was limited to thirty subjects. For logistical reasons, this research was performed as a pilot study. Therefore, the relatively small population group of thirty may not have yielded statistically significant results but trends observed within the study may allow for the recommendation of larger study protocols in the future. Further studies would benefit greatly from the use of larger sample sizes to improve the statistical relevance of the data.

- Less financial constraints would allow the researcher to produce a more efficient and valuable study in terms of a larger sample size, and improve sample homogeneity and representation of the general population within the study. South African studies should be more demographically balanced in order to give a fair and true reflection of what treatments work within a certain community. In South Africa we have a unique opportunity to do research within these different racial and economic groups, yet our focus tends to be on the demographics of our patients.

- Due to the broadening patient base into all races and cultures in South Africa it is recommended that the pain and disability questionnaires be multi-lingual. It is recommended that alternative ways of measuring levels of pain and disability be explored.

- Blinding of the researcher him/herself would benefit the study as this greatly reduces the chance of bias in this study. Although it was not possible for the researcher to be blinded due to various design and financial constraints, allowing a peer intern or clinician to perform the subject allocation, diagnosis and treatment interventions for the study could eliminate observer bias.

- No long term follow up evaluation was done which would help to address the cost-effectiveness of the treatment protocol utilized. The true benefit of the spinal manipulation in conjunction with core stability exercises as opposed to spinal manipulation alone in terms of severity and recurrence of low back pain may only have become apparent at a one-month or six month interval. This would also allow for the investigation of the long term benefit of the treatment.

- The experiences and reliability of the undergraduate researcher in the field may lead to biased results or the failure to bring out the true results. This is due to their inexperience in both research methodology and chiropractic practice.

- Measurement error may have occurred using the Stabilizer Biofeedback Device despite it being established as a satisfactory tool in the measuring and retraining of the transverse abdominus and multifidus muscles. Small but significant changes could be detected as more advanced technology is developed that is more accurate and sensitive.

- Stricter inclusion and exclusion criteria with respect to age, race, body mass index and extent of pain and disability. This should apply especially to the matching of treatment groups in terms of all the demographic variables. For this study it was noted that the manipulation group had more overweight subjects and black Africans as opposed to the manipulation and exercise group, which may have affected the results, although all the repeated measures ANOVA models controlled for BMI as a covariate.

- Patient compliance was not measured in this study, and it is suggested that this take place in future studies, particularly those of a long term nature such as this one.

- For this study the spinal manipulation protocol for the groups was variable as spinal manipulation was discontinued if the subject became asymptomatic or if there was an absence of spinal fixations. This resulted in the manipulation and exercise group receiving more adjustments than the manipulation group. This may have skewed the results even though repeated measures ANOVA models controlled for number of visits with adjustments as a covariate. It is suggested that the spinal manipulative therapy protocol should be the same for both groups in future studies, although the protocol for this study allowed for interesting discussion.

- The long term nature of this study, although allowing the effects of the treatment protocol to occur, presented difficulties in terms of data capture. Patients were instructed to continue with their normal daily activities and to not do anything out of the ordinary. However, for example, a patient may catch the common cold or influenza over the six-week treatment protocol, which may affect the outcome measures. It is suggested that these patients should, if possible, be eliminated from long term research studies in the future. This would however require a larger budget, more time allocation for the study, and a larger sample size.

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Appendix A:

Case History

DURBAN INSTITUTE OF TECHNOLOGY
CHIROPRACTIC DAY CLINIC
CASE HISTORY

Patient:_____________________________________ Date: __________

File # : ____________ Age: __________

Sex : __________ Occupation: _______________________________

Intern : ______________________________ _______________________

Signature

FOR CLINICIANS USE ONLY:
Initial visit
Clinician: Signature :

Case History:

Examination:
Previous: Current:

X-Ray Studies:
Previous: Current:

Clinical Path. lab:
Previous: Current:

CASE STATUS:

PTT:	Signature:	Date:

CONDITIONAL: Reason for Conditional:	
Signature:	Date:

Conditions met in Visit No:	Signed into PTT:	Date:
Case Summary signed off:		Date:

Intern's Case History:

1. **Source of History:**

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

3. **Present Illness:**

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

4. **Other Complaints:**

5. **Past Medical History:**

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

6. **Current health status and life-style:**

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

7. **Immediate Family Medical History:**

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

8. **Psychosocial history:**

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

9. **Review of Systems:**

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

Appendix B:

Physical

Durban Institute of Technology

PHYSICAL EXAMINATION: SENIOR

Patient Name : **File no :** **Date :**

Student : **Signature :**

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

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

SYSTEM SPECIFIC EXAMINATION:

CARDIOVASCULAR EXAMINATION

RESPIRATORY EXAMINATION

ABDOMINAL EXAMINATION

NEUROLOGICAL EXAMINATION

COMMENTS

Clinician: **Signature :**

Appendix C:

Lumbar Regional

REGIONAL EXAMINATION - LUMBAR SPINE AND PELVIS

Patient: ______________________________ File#: ______ Date: ____

Intern\Resident: ______________________ Clinician: ______________

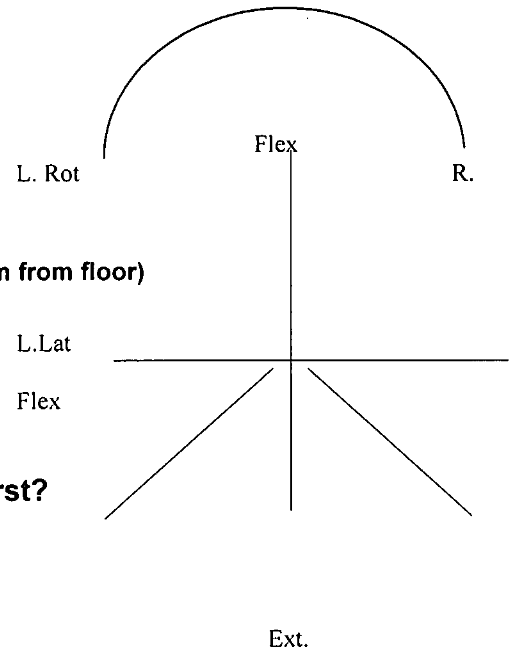
STANDING:

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

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

GAIT:

Normal walking
Toe walking
Heel Walking
Half squat



Rot

ROM:

Forward Flexion = 40-60° (15 cm from floor)

Extension = 20-35°
L/R Rotation = 3-18°
R.Lat
L/R Lateral Flexion = 15-20°
Flex

Which movt. reproduces the pain or is the worst?

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

SUPINE:

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

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

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

SITTING:

Spinous Percussion
Valsalva
Lhermitte

TRIPOD		Degree	LBP?	Location	Leg pain	Buttock	Thigh	Calf	Heel	Foot	Braggard
SI, +, ++											

Slump 7 test											

LATERAL RECUMBENT:

	L	R
Ober's		
Femoral n. stretch		
SI Compression		

PRONE:

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

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

NON ORGANIC SIGNS:

Pin point pain
Burn's Bench test
Hoover's test
Repeat Pin point test

Axial compressionTrunk rotation
Flip Test
Ankle dorsiflexion test

NEUROLOGICAL EXAMINATION

Fasciculations

Plantar reflex

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

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

BASIC THORACIC EXAM

History

Passive ROM

Orthopedic

BASIC HIP EXAM

History

ROM: Active

Passive : Medial rotation :

A) Supine (neutral) If reduced - hard \ soft end feel

B) Supine (hip flexed): - Trochanteric bursa

Appendix D:

SOAPE Note

DURBAN INSTITUTE OF TECHNOLOGY

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

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

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

0: *P:*

E:

Special attention to: *Next appointment:*

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

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

O: *P:*

E:

Special attention to: *Next appointment:*

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

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

O: *P:*

E:

Special attention to: *Next appointment:*

Appendix E:

Advertisement

DO YOU SUFFER FROM

LOW BACK PAIN AFTER PREGNANCY?

Research is currently being carried out at the Durban Institute of Technology

Chiropractic Day Clinic

FREE TREATMENT

Is available to those who qualify to take part in this study

For more information contact Dean on 2042205 / 2512

Appendix F:

Informed consent form

INFORMED CONSENT FORM

(To be completed by patient / subject)

Date :

Title of research project : **To determine the relative effectiveness of spinal manipulation in conjunction with core stability exercises as opposed to spinal manipulation alone in the treatment of post-natal mechanical low back pain.**

Name of supervisor : **Dr. Corrie Myburgh [Mtech: Chiropractic; CCSP; CCFC]**

Tel : **(031) 2042923**

Name of research student : **Dean Wilson**

Tel : **(031) 2042205 / 0822109754**

Please circle the appropriate answer YES /NO

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

Please ensure that the researcher completes each section with you
If you have answered NO to any of the above, please obtain the necessary information before signing

Please Print in block letters:

Patient /Subject Name:______________________Signature: __________

Parent/ Guardian:______________________Signature:__________

Witness Name:______________________Signature:__________

Appendix G:

Patient information letter

DURBAN INSTITUTE *of* TECHNOLOGY

DATE:

Dear Participant, welcome to my research project.

Title of Research:

To determine the relative effectiveness of spinal manipulation in conjunction with core stability exercises as opposed to spinal manipulation alone in the treatment of post-natal mechanical low back pain.

NAME OF RESEARCH STUDENT

Dean Wilson Contact number (0822109754 / 2042205)

NAME OF RESEARCH SUPERVISOR

Dr. Corrie Myburgh Contact number (031-2042923) or Fax (031-2023632)

[MTech-Chiropractic; CCSP; CCFC]

You have been selected to take part in a study comparing spinal manipulation in conjunction with core stability exercises as opposed to spinal manipulation alone in the treatment of post-natal mechanical low back pain.

Thirty people will be required to complete this study.

All participants, including you, will be randomly split into two equal groups.

Each of the groups will receive a standard clinical treatment, one of which will include both spinal manipulation and core stability exercises, and the other of spinal manipulation alone, for the purposes of this study.

Inclusion and Exclusion:

If you are taking any medication, a 3-day washout period is required before taking part in the study. This is because medications may have an effect on the symptoms, and you may be excluded from the study. I f you are undergoing any other form of treatment for your back pain you may be excluded from the study.

Please try not to alter your normal lifestyle or daily activities in any way as this could interfere with the results of the study.

Those taking part in the study must be between the ages of 18 and 35.

8 weeks must have passed since the pregnancy and no more than 12 months should have passed following the pregnancy if you wish to take part in the study.

Research process:

At the first consultation you will be screened for suitability as a participant using a case history, physical examination and lumbar spine regional examination. You will be asked to complete questionnaires, and specific measurements of your low back pain, and your core stability will be measured.

Treatments:

Summary table:

Week	Date	Visit	Group 1	Group 2
1		1	Reading 1 Manipulation Exercises	Reading 1 Manipulation
		2	Manipulation Exercises	Manipulation
2		3	Reading 2 Manipulation Exercises	Reading 2 Manipulation
		4	Manipulation Exercises	Manipulation
3		5	Manipulation Exercises	Manipulation
		6	Manipulation Exercises	Manipulation
4		7	Reading 3 Exercises	Reading 3
		8	Exercises	Observation
5		9	Exercises	Observation
		10	Reading 4 Exercises	Reading 4 Observation
6		11	Exercises	Observation
		12	Exercises	Observation
7		13	Reading 5	Reading 5

All treatments will be performed under the supervision of a qualified chiropractor by the research student and will be free of charge. If the patient wishes, consultations following the third week of the treatment protocol can take place at the patient's place of residence or work under the supervision of the researcher.

Risks and discomfort:
The treatment is safe and is unlikely to cause any adverse side effects, other than transient tenderness and stiffness that is common post manipulation. Patients may experience post exercise soreness, however this will be transient and the patients are not expected to have prolonged pain / soreness. Should this be the case they will be excluded from the study.

Remuneration and costs:
Treatment for the duration of the research process will be free of charge. Subjects taking part in the study will not be offered any other form of remuneration for taking part in the study. Upon completion of the research process, the normal cost of consultations will be charged for those patients wanting further treatment. All patient information is confidential and the results of the study will be made available in the Durban Institute of technology library in the form of a mini-dissertation.

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

Benefits of the study:
Your full co-operation will assist the Chiropractic profession in expanding its knowledge of this condition and thus making future rehabilitation of patients suffering from post-natal mechanical low back pain more successful.

Confidentiality and ethics:
All patient information will be kept confidential and will be stored in the Chiropractic Day Clinic for 5yrs, after which it will be shredded.
Please don't hesitate to ask questions on any aspect of this study. Should you wish you can contact my research supervisor at the above details or alternatively you could contact the Faculty of Health Sciences Research and Ethics Committee as per Mr. Vikesh Singh (031) 2042701.

Thank you.
Yours sincerely,

....	....
Dean Paul Charles Wilson	Dr Corrie Myburgh
(Research student)	(Supervisor)

Appendix H:

NRS

NRS Pain Rating Scale

Patient Name:

Date:

Pain Severity Scale:

Rate your usual level of pain today by checking one box on the following scale:

0	1	2	3	4	5	6	7	8	9	10

No pain — Excruciating pain

Adapted from Hsieh et al 1992

Appendix I:

Quebec back pain disability scale

THE QUEBEC BACK PAIN DISABILITY SCALE

Name: ______________________ Age: _____ Date: _______Score:_______

This questionnaire is about the way your back pain is affecting your life. People with back problems may find it difficult to perform some of their daily activities. We would like to know if you find it difficult to perform any of the activities listed below, because of your back. For each activity there is a scale of 0 to 5 (0 = normal; 5 = severe). Please choose one response option for each activity (do not skip any activities) and check the corresponding box.

Today, do you find it difficult to perform the following activities because of your back?	0	1	2	3	4	5
1. Get out of bed.						
2. Sleep through the night (sleep at least 6 hours).						
3. Turn over in bed.						
4. Ride in a car (travel 1 hour in a car).						
5. Stand up for 20 – 30 minutes.						
6. Sit for 4 hours in a chair.						
7. Climb one flight of stairs.						
8. Walk a few blocks (300 – 400 m).						
9. Walk several miles.						
10. Reach up to high shelves.						
11. Throw a ball.						
12. Run two blocks (about 200 m).						
13. Take food out of the refrigerator.						
14. Make your bed.						
15. Put on socks (panty hose).						
16. Bend over a sink for 10 minutes.						
17. Move a chair.						
18. Pull or push heavy doors.						
19. Carry two bags of groceries.						
20. Lift and carry a heavy suitcase (or 40 pounds).						
SUB-TOTAL						
TOTAL SCORE						

Comments: ____

____

____

Scored by: ______________________ SCORE: _________ DATE:_______

From Kopec JA, Esdaile JM, Abrahamowicz M, Abenhaim L, Wood-Dauphinee S, Lamping DL. The Quebec Back Pain Disability Scale: Measurement properties. Spine 1995; 20:341 – 352.

Appendix J:

Data collection sheet

Patient Name: **Date of initial visit:**

File no:

Prone test for transversus abdominus and internal oblique:

Reading	Visit	Time	mmHg
1	1		
2	3		
3	7		
4	10		
5	13		

Supine position for training transversus abdominus:

Reading	Visit	Time	mmHg
1	1		
2	3		
3	7		
4	10		
5	13		

Quebec Disability Scale		NRS Pain Rating Scale		Activation	
Reading	Value	Reading	Value	Yes	No
1		1			
2		2			
3		3			
4		4			
5		5			

Motion Palpation Findings:

Visit	RUF	LUF	RUE	LUE	RLF	LLF	RLE	LLE	L1	L2	L3	L4	L5
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
13													

Appendix K:

Core stability assessment tests

Core stability assessment tests: The Stabilizer Biofeedback Device

1. Testing for the presence of core stability activation:

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

When this ability was recognized to be present, participants were then instructed to lie prone on a chiropractic table with their head turned to one side. The Stabilizer Biofeedback Device was placed under their abdomen, with the centre at the navel and the distal edge at the anterior superior iliac spine (ASIS). It was then inflated to the baseline pressure of 70 mmHg.
Participants were then examined as to whether they could initiate transversus abdominus activation in this prone position. A drop in pressure of 6-8 mmHg was seen with a correct contraction.

This test was performed at the initial consultation. It was noted yes/no, for statistical purposes, as to whether the subject could perform a correct activation of transversus abdominus.

If the subject could not do this, the subject was retrained in the four point kneeling and prone positions to perform this activation satisfactorily, prior to taking the quantitative time-based readings.
If the subject still could not manage a satisfactory activation, the subject was instructed to perform a contraction of transversus abdominus, as trained by the researcher, to the best of their ability and a time-based reading of this contraction was taken for the prone and supine positions.

2. **The prone test for transversus abdominus and internal oblique:**

- A 3-chamber pressure cell was placed centrally under the abdomen, with the umbilicus in the centre of the inflatable sleeve, and inflated to a baseline of 70 mmHg.

- The subject was then instructed to draw the abdominal wall up and in without moving the spine or pelvis.

- The pressure reading should have decreased by 6-10 mmHg.

- A variation of 2 mmHg was allowed for normal breathing pattern.

- A measurement was taken of the time at which the patient could no longer hold the contraction at the baseline level (70mmmHg – 6 to 10 mmHg).

3. **Supine position for testing transversus abdominus:**

- A 3-chamber pressure cell was placed centrally under the lumbar spine with the bottom of the sleeve in line with the posterior superior iliac spines (PSIS), and inflated to a baseline of 40 mmHg.

- The patient was instructed to draw in the abdominal wall without moving the spine or pelvis.

- The pressure reading should have remained at 40 mmHg; i.e. no movement of the spine.

- A variation of 2 mmHg was allowed for normal breathing pattern.

- A measurement was taken of the time at which the patient could no longer hold the contraction at the baseline level (40 mmHg).

Appendix L:

Core stability exercises performed

1. Static Core Stability Exercises Performed

a) Training the corset action of transversus abdominus in supine:

- These were performed first.
- The 3-chamber pressure cell was placed centrally under the lumbar spine with the bottom of the sleeve in line with the PSIS's, and inflated to a baseline of 40 mmHg (green band).
- The patient was instructed to draw in the abdominal wall without moving the spine or pelvis.
- Pressure should have remained at 40 mmHg; i.e., no movement of the spine.
- The contraction was held for 10 seconds, breathing normally.
- Ten repetitions were performed.
- The examiners fingers were placed just medial to the ASIS as an additional monitoring tool to ensure contraction of the transversus abdominus.

b) **<u>Training the corset action of transversus abdominus in supine with leg loading:</u>**

- These were performed following those exercises performed above, and the patient was allowed a 2-minute period of rest before commencing these exercises.

- The 3-chamber pressure cell was placed centrally under the lumbar spine in line with the PSIS's, and inflated to a baseline of 40 mmHg (green band).

  - The patient was instructed to draw in the abdominal wall without moving the spine or pelvis.

  - Pressure should have remained at 40 mmHg; i.e., no movement of the spine.

  - The patient was instructed to slide one leg slowly down the table and then hold the leg above the table in a fully extended position.

  - The contraction was held for 10 seconds, breathing normally.

  - Perform 10 times with each leg.

- The examiners fingers were placed just medial to the ASIS as an additional monitoring tool to ensure contraction of the transversus abdominus.

2. Dynamic Core Stability Exercises Performed:

a) Curl-ups: (Set 1)

- Starting position: Patient sits on ball and walks feet forward while leaning backward. Allow ball to roll up spine until ball is under low back. Support head with hands and relax trunk over ball.

- Movement/exercise: The patient co-contracts the transverse abdominus and multifidus muscles. Curl up by simultaneously contracting abdominal and buttock muscles. Patient begins curl-ups. Hold position. Slowly curl down to starting position.

- The patient must maintain co-contraction and ensure that her feet remain on the floor throughout.

- Breathing: Exhale while lifting; inhale while relaxing.

- Caution: Patient must stay in pain free range, keeping her chin a fist's distance from the chest and must not press her head forward with her hands.

- Hold for 10 seconds.

- A baseline will be established for each individual patient at the initial Swiss ball consultation, from which further increases in repetitions will be made. The baseline is determined at this consultation by the number of repetitions a patient performs until fatigue is reached. Increases will be implemented fortnightly. This increase will be that of one repetition.

b) **<u>Back extensions:</u> (Set 2)**

- Starting position: Kneel behind ball. Rest trunk over ball and dig toes into floor. Patients may stabilize themselves by placing their feet at the junction of the wall. Raise arms out to side.

- Movement/exercise: Let ball roll down body while legs straighten. Lift trunk off ball as far as balance and comfort allow. If possible, ensure that the navel area raises clear of the ball with each repetition. Press hips into ball and squeeze buttocks. Slowly reverse and return to starting position.

- Breathing: Inhale when lifting; exhale when lowering.

- Hold for 10 seconds.

- A baseline will be established for each individual patient at the initial Swiss ball consultation, from which further increases in repetitions will be made. The number of repetitions they perform at this consultation until fatigue is reached will determine this baseline. Increases will be implemented at the start of the successive weeks. This increase will be that of one repetition at each of the following 2 weeks.