An investigation into the perceived performance of runners with low back pain and receiving spinal manipulation over time.

By

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I, Phillip Edward Rodda do declare that this dissertation is representative of my own work.

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DEDICATION

I dedicate this research to my mother, Claire. Your vision in seeing me achieve all that was set out for me, has been the engine room behind my continued perseverance in a race I thought, at times, I could not run. Thank you for your ongoing support, deep love, compassion and kindness toward me in every step of the way.

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ABSTRACT

Aims and Objectives: The aim of this study was to determine whether spinal manipulation affects the perceived performance of runners with low back pain. More specifically, the objective was to determine whether any relationships existed between spinal manipulation, a runner's perceived performance and their low back pain.

Method: Twenty subjects who ran thirty kilometers a week and had LBP were selected for a pre- post- cohort study according to criteria set out beforehand. The subjects received spinal manipulation applied to their lower back twice a week for a period of two weeks. At each consultation, they were requested to fill out a "Perception of Running Performance" questionnaire prior to each treatment, and one week following the final consultation.

Data were collected from the "Perception of Running Performance" questionnaire and from the Numerical Rating Scale (NRS) and analysed using SPSS version 13.0 (SPSS Inc., Chicago, IL).

Results: The results showed favorably in presenting that spinal manipulation significantly improved LBP. Similarly, according to the results found with the "Perception of Performance" questionnaire under the sub-sections "perceived performance", "motivation", and "clinical reality", significant improvements were noted with a course of spinal manipulative therapeutic care. No relationship was found though between the variables of the "Perception of Performance" questionnaire apart from that which lay between an increase in average mileage and a decrease in overall motivation. This correlation stands to reason in the light that, with an increase in average weekly mileage, a subsequent decrease in overall motivation may be expected.

Conclusion and Recommendations: Literature suggests that fatigue plays an important role in running performance. In the current study, although no direct relationships were found (apart from a correlation between an increase in average mileage and a decrease in overall motivation) between LBP and perceived performance, a significant association did exist between the subject initial perceptions and their perceived performance after spinal manipulation. Given a larger sample size there is the potential for a significant finding.

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LIST OF ABBREVIATIONS

LBP	-	Low back pain
CNS	-	Central nervous system
ATP	-	Adenosine TriPhosphate
PP	-	Perceived Performance
MT	-	Motivation
CR	-	Clinical Reality
PP1	-	Perceived Performance question 1
PP2	-	Perceived Performance question 2
PP3	-	Perceived Performance question 3
PP4	-	Perceived Performance question 4
PP5	-	Perceived Performance question 5
PP6	-	Perceived Performance question 6
MT1	-	Motivation question 1
MT2	-	Motivation question 2
MT3	-	Motivation question 3
MT4	-	Motivation question 4
MT5	-	Motivation question 5
CR1	-	Clinical Reality question 1
CR2	-	Clinical Reality question 2
CR3	-	Clinical Reality question 3
CR4	-	Clinical Reality question 4
CR5	-	Clinical Reality question 5
t1	-	Baseline (1^{st} sample data capture) time point
r	-	Reversed data score
Tx1	-	Treatment question 1
Tx2	-	Treatment question 2
Tx3	-	Treatment question 3
Tx4	-	Treatment question 4
Tx5	-	Treatment question 5
Physio	-	Physiotherapy
GP	-	General Practitioner
Chiro	-	Chiropractor

Chapter 1

Introduction

1.1 Introduction

It is clear that low back pain is a common problem in society, having major financial, medical, social, and personal implications (Giles, 1997). There is a lot of anecdotal evidence among the running fraternity that supports the claim that there is a similar, if not a higher incidence of low back pain (LBP) amongst runners for various reasons, the most common being that of impact-loading (Noakes, 1992). This indicates a need to examine its many facets in order to gain a greater understanding of its full implications for runners.

Noakes *et al.* (2004) propose a unique model for muscle fatigue that makes the following assumptions. (1) As at rest, during exercise all physiological functions are homoeostatically regulated by central nervous system control mechanisms to ensure that bodily harm does not result. (2) The conscious sensation of fatigue does not arise directly from the action of metabolites in the periphery, but rather from the regulatory centres in the subconscious parts of the brain. The sensation of fatigue is therefore not directly related to a physical end point, but is rather an interpretation of the effect of the current level of activity on future exercise capacity and any threats that immediate and future events pose to the maintenance of homoeostasis. (3) As the sensation of fatigue is an emotion rather than a physical state, pacing strategies and their control during self regulated exercise become important, making the journey and not just the end point an important phenomenon in exercise physiology. This gives fatigue over to central nervous system (CNS) control rather than being a physically based phenomenon (Noakes *et al.*, 2004).

This model suggests that fatigue is controlled by the CNS rather than being a physically based phenomenon. Thus, by implication, fatigue, if controlled by the CNS can affect a person's perception of performance. Indeed this model states that performance itself is most affected not by localised metabolites in the muscle, nor solely by recruitment of motor units but to a large extent, by the CNS at a subconscious level (Noakes *et al.*, 2004).

Many authors (Hultman *et al.,* 1993, Arendt-Nielsen *et al.,* 1995, Graven-Nielsen *et al.,* 1997, Suter and Lindsay, 2001, and Vogt *et al.,* 2003) have made the link between muscle inhibition and LBP as having a cause and effect relationship with each other, whilst also causing muscle fatigability, decreased muscle endurance and muscle weakness.

There are both allopathic (Hellman and Stone, 2000) and manual (Cull and Will, 1995) therapies available for the treatment of mechanical LBP. However, it has been found that allopathic intervention is generally less effective than manipulative therapy in successfully treating this condition (Gatterman, 1990).

This research is directed at determining whether spinal manipulation affects the perceived performance of runners with low back pain.

1.2 Aims and Objectives

1.2.1 The Aim

The author is unaware of any published literature of clinical studies that substantiate or refute the idea that spinal manipulation of the low back has an effect on perceived performance in runners. It is for this reason that a non-directional null hypothesis has been set for this research.

1.2.2 The Objectives

The specific objectives of the study are to:

(1) Determine the effect of spinal manipulation on low back pain in runners.

(2) Determine the effect of spinal manipulation on the perception of performance of runners.

(3) Determine the relationships between LBP, perceived performance and manipulation in runners.

1.2.3 The Null Hypothesis

In runners with low back pain, perceived performance and low back pain will not change pre- and post- spinal manipulative therapeutic care and will not be positively or negatively related after receiving spinal manipulation.

1.3 The Rationale

Noakes *et al.* (2004) propose, according to the "central governor" model, that muscle fatigue during exercise and the consequent performance of the athlete is most affected not by localised metabolites in the muscle, nor solely by recruitment of motor units but to a large extent, by the CNS at a subconscious level. This indicates a large variety of potential factors that might influence a runner's performance, not the least of which would include prior route knowledge, prior training pace and distance, and pain and injury levels.

The need for alternative forms of treatment increases the practitioner's ability to adapt to patient treatment requirements within the clinical setting to facilitate and optimise patient improvement. While the effect of spinal manipulation in treating low back pain has been shown to be effective in the general population (Meade *et al.*, 1990; and Burns and Mierau, 1997), has not been established in runners, hence the need for this study.

Chapter 2

Literature Review

2.1 Introduction

The review of the literature aims to create an understanding of the incidence and prevalence of LBP; the definitions of lumbar facet syndrome and sacroiliac syndrome as common causes of LBP; the anatomical and biomechanical relationship of the sacroiliac and lumbar facet joints to each other; the development of LBP; and the possibility of the psychological impact that LBP may have on performance in athletes.

2.2 Incidence and Prevalence of Low-Back Pain

It is clear that LBP is a common problem in society, having major financial, medical, social, and personal implications (Giles, 1997). In western society, LBP is the largest single cause of disability, with some estimates suggesting that it affects 50% to 80% of the population (McGregor *et al.*, 1998).

The high prevalence of musculoskeletal complaints in the lower back constitutes a major health problem in many sectors of society today (Giles, 1997). In South Africa, van der Meulen (1997) found a lifetime incidence of 57.6%, and a lifetime prevalence of 53.1% of LBP in a black South African township. Docrat (1999) found a lifetime incidence amongst a small sample of Indian and Coloured communities in South Africa to be 78.2% and 76.6% respectively. Chronic LBP is also shown as a common characteristic of patients who visit- and receive- treatment from chiropractors (French *et al*., 2000).

A study by Sedgwick *et al*. (1988) indicated that 40% of runners entering a jogging program complained of LBP, while Frymoyer *et al.* (1983) found that a disproportionate number of joggers complained of LBP. Noakes (1992) suggests that these high figures are due to excessive impact loading on the back during running as well as inherent muscle imbalances between the abdominal and paraspinal musculature and tightened hamstrings.

2.3 Anatomy of the Lumbar Facet and Sacroiliac Joints

2.3.1 Introduction

The articulations between two concurrent lumbar vertebrae are formed by a three-joint complex, namely the intervertebral disc found between the vertebral bodies, and two lumbar facet (or zygapophyseal) joints formed by the superior articular processes of one vertebra and the inferior articular processes of the vertebra above it. The lumbar facet joints are either j- or c-shaped dependant on the subject and spinal level. However, their orientation is most important in restricting anterior and rotary movements, while allowing some spinal motion and the activity of coupling forces (Dutton, 2004).

The sacroiliac joints are formed by the articulations between the sacrum and the ilium. These joints have an auricular shape and form an essential part of, while adding significant stability to, the pelvic ring (Giles and Crawford, 1997).

The sacroiliac joint is classified as a true diarthrodial joint as it contains synovial fluid between two matching articular surfaces. The iliac surface of the sacroiliac joint is covered by fibrocartilage, while the sacral surface is covered by hyaline cartilage. The joint is widest at its most superoanterior aspect. The bony elements of the joint include the anteromedial aspect of the ilium, adjacent to the posterior inferior iliac spine and the posterolateral aspect of the sacral ala at the level of the first and second sacral segments (Dutton, 2004).

2.3.2 Ligamentous Anatomy

The ligaments of the lumbar facet joints include:

a. An extension of the ligamentum flavum which strengthens the capsule ventrally.
b. The capsular ligaments which attach to the margins of the adjacent articular processes and which are particularly well developed in the lumbar spine. (Dupuis, 1992)

The ligaments of the sacroiliac joint are some of the toughest and strongest ligaments of the body (Dutton, 2004). These ligaments can be separated into the intrinsic and extrinsic sacroiliac ligaments.

The extrinsic ligaments include the iliolumbar, sacrotuberous, sacrospinous and pubic symphysis ligaments. These ligaments are found outside the fibrous capsule of the joint and assist in stabilising the joint (Mior *et al..* 1999).

The extrinsic sacroiliac ligaments include:

a. The iliolumbar ligaments which run from the transverse processes and the body of the fifth lumbar vertebra and which attach along the superior border of the iliac crest;
b. The sacrotuberous ligament which attaches to the anterolateral border of the sacrum and which runs anterolaterally to the ischial spine;
c. The sacrospinous ligament which is a thin, triangular ligament that runs from the ischial spine to the lateral margins of the sacrum and coccyx and to the capsule of the sacroiliac joint; and
d. The ligaments of the pubic symphysis which include the interpubic, arcuate pubic, and the superior pubic ligaments (Dutton, 2004).

The intrinsic ligaments strengthen the fibrous capsule anteriorly and posteriorly and as such are regarded as articular ligaments (Mior *et al*, 1999).

The intrinsic sacroiliac ligaments include:

a. The anterior sacral ligament which is a relatively weak anteroinferior thickening of the fibrous capsule which becomes thicker more inferiorly;
b. The strong dorsal sacroiliac ligament which attaches medially to the erector spinae and multifidus muscles, and to the thoracodorsal fascia and which blends laterally with the sacrotuberous ligament; and
c. The interosseous sacroiliac ligament which lies deep to the dorsal sacroiliac ligament and which connects the sacrum and innominate (Dutton, 2004).

These ligaments require an understanding in terms of the importance of the relationship they hold with the movement, and the restriction of movement, of their respective zygapophyseal and sacroiliac joints. This role is facilitated by the presence of various neurological receptors associated with the ligaments and muscles surrounding such joints (Leach, 1994).

2.3.3 Muscles of the Lumbar and Sacroiliac Joints

2.3.3.1 Muscles of Lumbar Motion

Most muscles in the back are concerned with maintenance of posture and movements of the vertebral column (Dutton, 2004).

Those muscles that are involved in movement of the intervertebral joints include:

a. Muscles that flex the back with the aid of gravity by bilateral action (Rectus abdominus and psoas major);
b. Muscles that flex the back by bilateral action (Erector spinae, multifidus and semispinalis thoracis);
c. Muscles that laterally bend the back by unilateral action (Iliocostalis thoracis, iliocostalis lumborum, longissimus thoracis, multifidus, external oblique, internal oblique and quadratus lumborum); and

d. Muscles that rotate the back by unilateral action (Rotatores, multifidus, external oblique acting synchronously with the opposite internal oblique and semispinalis thoracis.

2.3.3.2 Muscles of Sacroiliac Motion

Some 35 muscles attach to either the sacrum or ilium. Any muscle that attaches to a bone has the potential to move that bone, although the degree of potential varies. The purpose of the muscles of the sacroiliac joint however, function for the most part to apply stabilization to this joint (Dutton, 2004).

Joint motion within the sacroiliac joint is actually controlled for the most part by:

a. Movement of the sacrum when the spinal cord changes position; and
b. Movement of the sacrum when the lower extremities change position (Bernard and Cassidy, 1991).

There are three major muscle groups that are expected to create stability for effective load transfer during movement of the sacroiliac joint motion. These are:

a. Muscles that flex, extend, or rotate the vertebral column, moving the sacrum (Erector spinae, rectus abdominus, multifidus and iliopsoas);
b. Muscles that flex, extend, abduct, adduct, supinate, and pronate the thigh, moving the ilium (Iliopsoas, hamstrings, sartorius, piriformis and gluteus maximus); and
c. Muscles that tilt the pelvis anteriorly or posteriorly moving the sacrum, and those tilting the pelvis laterally, moving the ilium (Gluteus maximus, sartorius, rectus abdominus and iliopsoas) (Mior *et al.*, 1999).

Knowledge of these muscles and their function, in relation to the associated lumbar and sacroiliac joints, is integral to an understanding of their role in neurological control of locomotion as they are controlled by a number of muscle receptors. These receptors include muscle spindle receptors, Golgi tendon organs, pressure receptors, and unmyelinated pain receptors (Wyke types I – IV, respectively). These play important functions in:

a. Reflex contraction, called the stretch reflex;
b. Nociceptive and thermal detection; and
c. Detection of rapid mechanical deformation (Leach, 1994).

2.3.4 Innervation of the Zygapophyseal and Sacroiliac Joints

There is no doubt that the innervation of joints within the body is complex, with anomalies to what is considered normal being commonplace. This is shown more completely with the application of Hilton's law to the zygapophyseal and sacroiliac joints. The law states that any nerve crossing and supplying a joint gives a branch to that joint, the muscles controlling the joint and the stabilising ligaments, as well as the overlying skin (Hollinshead, 1982).

The zygapophyseal joint receives autonomic innervation from the medial branch of the posterior primary ramus which forms a complex of branches extending over the posterior elements of the lumbar vertebrae. Around the zygapophyseal joint, can be found complex encapsulated endings and free nerve endings. These are thought to mediate pain and proprioception at that joint (Dupuis, 1992).

Similarly, the sacroiliac joint capsule is innervated by complex nerves that provide pressure and position sense. The posterior capsule and ligaments are innervated by articular branches of the posterior primary rami of S1 and S2 spinal segments and anteriorly by involvement of the anterior primary rami of the L3 to S2 spinal segments (Ombregt, *et al.* 1995)

Sakamoto *et al.* (2001), state that the zygapophyseal and sacroiliac joints and their surrounding tissues also contain mechanosensitive afferent units, most of which are nociceptive receptors (Cassidy and Mierau, 1992; Sakamoto *et al.,* 2001). This could provide an understanding as to why small changes within the joint lead on to complex pain patterns in lumbar facet and sacroiliac syndromes. Furthermore, it may provide insight into the impact of psychological aspects on the muscles surrounding these joints, and how these aspects would affect the biomechanics involved with the joints.

2.4 Biomechanics of the Lumbar Spine and Pelvis in Running

2.4.1 An introduction to the differences between walking and running gaits

It is clear that there are significant differences in the gait of a human during walking and during running. Most of these differences are immediately apparent in the differences that occur in ground reaction forces. In human walking there is always one foot on the ground and there are short phases when both feet are in contact with the ground; while in running, there are a series of bouncing impacts with the ground, alternated with aerial phases where neither foot is in contact with the ground. This difference leads to a substantially higher magnitude of vertical ground reaction forces during running as opposed to walking (Farley and Ferris, 1998).

In human walking, there is little loss of energy (30-40%) due to the body's central mass being vaulted over a relatively stiff kinematic chain. This has become known as the "inverted pendulum mechanism". During running however, there is a significant loss of energy (approximately 95%) mechanically due to the nature of the gait which becomes a "bouncing gait". This means that energy must now be stored and returned through the function of the elastic tissues (Farley and Ferris, 1998). This occurs through changing joint position and contractile tensions in these elastic tissues. Understandably, there will be a higher stress upon the joints responsible for locomotion.

2.4.2 Biomechanics of the lumbar spine in running

During active movement in the pelvis, the lumbar spine becomes anchored by its adjoining muscles and, during lumbar spine movement, the sacrum becomes anchored in a similar fashion (Sim *et al.* 1995).

The lumbar spine has an intimate coordinative relationship to both the pelvis and the hip during running in most, if not all axes of motion. The lumbar spine has also been described as the pivotal point of the lower extremity lever system during running. It is believed that with the backward movement of the lower limb during the stance phase of running, there is a concurrent extension of the lumbar spine causing an anterior pelvic tilt which thus allows and may aid further limb extension, adding to the power output of the limb during toe-off. Furthermore, it has been postulated that an increase in overall pelvic tilt may also work as a compensatory mechanism for inadequate lower limb extension should the need arise (Schache *et al.* 1999).

2.4.3 Biomechanics of the sacroiliac joint in running

The pelvis has a unique mechanism, designed to support the inferior and anterior thrust transmitted to it by the weight of the torso. During locomotion, body weight is transferred alternately to each hip joint. Weight bearing forces are transmitted from the femur to the acetabulum, then through the arcuate lines superior to the sciatic notch to the sacroiliac joints, then into the spinal column through the sacrum. This region is called the femoral sacral arch (Sim *et al.* 1995).

In athletes, the sacroiliac joint comes under two vectors of force, which put it under great stress and predisposes this joint to sprains. The first of these comes from above through the lumbar spinal column and acts on the superior aspect of the sacrum. This tends to push the superior portion of the sacrum downward and forward at the same time as the coccygeal portion of the sacrum is moving upward and backward. These movements are limited by the tension of the sacrotuberous, sacrospinous, and anterior sacroiliac ligaments. The second force sees its way through the lower extremity, femoral head and into the acetabulum, finally being absorbed by the ilium and sacroiliac joint. The acetabulum is located anterior and inferior to the sacroiliac joint so any force that passes through it will tilt the ilium into a superior and posterior rotary motion. This force is opposed by the tension of both the anterior and posterior sacroiliac ligaments (Sim *et al.*1995).

During weight bearing, the anterior, inferior movements of the sacrum are met by the posterior, anterior movement of the ilium to create a significant shearing force on the sacroiliac joints. Whereas these shearing forces are normally controlled in the athlete, those with poor running technique and biomechanics will be prone to increases in this shearing force and ligamentous sprains around the sacroiliac joint (Sim *et al.*, 1995).

2.4.4 The running gait and its predisposition to injury

The running gait is a repetitive cyclic movement that involves the entire body and produces a sequence of support and airborne (or non-support) phases. The support phase includes the heel strike at initial contact, mid-stance and toe-off, to enter the airborne phase. During running, the pelvis rotates on the longitudinal axis in proportion to the amount of arm-swing obtained. Excessive arm movement laterally may in turn cause increased pelvic and spinal rotation, putting strain on the thoraco-lumbar muscles at their attachment to the iliac crest. In mid-stance, the contra lateral or airborne side drops, causing the pelvis to tilt downwards. This applies a shearing force to the sacroiliac joints and to both sides of the pubic symphysis (Brody, 1995).

Most fixations of the lumbar spine and pelvis occur during the phases of support of the lumbar spine and non-support mid-stance whilst running. This happens through repetitive micro-trauma to the motion segments in lumbar spine, and pelvis rotation and to the sacroiliac joints during their respective shearing movements (Kirkaldy-Willis, 1992).

Excessive uphill running tips the pelvis anteriorly, which limits forward flexion and puts greater stress on the muscles of the lower back. In downhill running, the lumbar spine is hyper-extended and the pelvis is tipped posteriorly (Brody, 1995). This may cause LBP, especially in runners with an exaggerated lumbar lordosis (Schache *et al.*, 1999).

Scache *et al.* (1999) noted that in many instances it has been found that an increase in lumbar lordosis and pelvic tilt is related to tightness of the hip flexor muscles. Prolonged or repetitive hyper-lordosis of the lumbar spine is related to impingement of the lumbar facet joints leading to an increased incidence of LBP particularly amongst long distance runners. Increased anterior pelvic tilt during running was cited as a likely predisposing factor for the onset of hamstring strains through the superior movement of the ischial tuberosities thus changing the length of the hamstring muscles and causing premature fatigue. Increased pelvic rotation was also found to have an increased association with iliotibial band friction syndrome and sacroiliac syndrome (Schache *et al.*, 1999).

2.5 Diagnosis of Low Back Pain

2.5.1 Introduction

The diagnosis of LBP continues to be a dilemma for practicing physicians with the majority being diagnosed as idiopathic (Greenman 1996). It is therefore important to elucidate the diagnosis from as much clinical assessment as possible including the patient’s history, a comprehensive physical examination and certain diagnostic radiographic investigations, all of which aid in localising the anatomical source of pain (Bernard and Kirkaldy-Willis, 1992). In some cases it is the response to treatment that ultimately confirms the diagnosis (Bernard and Kirkaldy-Willis, 1992).

It is possible for some conditions causing LBP to occur concurrently and as such, it is important to follow a method of approach in making a diagnosis. Norris (2004) divides this process into three distinct categories, namely simple backache, nerve root pain and spinal pathology. In spinal pathology, one must look for specific red flags which will drive resultant diagnostic testing according to the physician's suspicion. Norris (2004) gives simple clinical tests for differentiating between nerve root pain and simple backache (the straight leg raiser test and the slump test).

2.5.2 Diagnosis of Lumbar Facet Syndrome

Bernard and Kirkaldy-Willis (1992) have established a specific diagnosis of the posterior joint syndrome on the lower back by the following criteria:

- An ill-defined (sclerotoma) type of pain;
- Referred pain to the buttocks, posterior thigh, and below the knee with the absence of nerve root tension signs;
- Abnormal coupled motion on anteroposterior and lateral dynamic bending radiographs during the dysfunctional or unstable phase of spondylosis;
- Production and abolishment of familiar pain by injection into the suspected posterior joint;
- Successful manipulative treatment of the symptomatic posterior joint.

Gatterman (1990) indicates that motion palpation is the most definitive indicator in determining lumbar facet syndrome through the locking of the posterior facet joint on application of a directed force through the joint's plane of motion.

Orthopaedic testing however, allows for a more accurate differential diagnosis for which a variety of tests are applied. These tests include the straight-leg raiser test, hip flexion (Thomas Test), axial compression (Kemp's Test) (Gatterman, 1990), and the facet joint challenge.

Gatterman, (1990) states that because of the objective difficulties in gaining a definitive diagnosis for lumbar facet syndrome, the best proof of diagnosis lies in the success of the appropriate treatment.

2.5.3 Diagnosis of Sacroiliac Syndrome

Bernard and Kirkaldy-Willis (1992) establish specific diagnosis of the sacroiliac joint syndrome on the lower back by the following criteria:

- Referred pain from the sacroiliac joint radiating to the buttocks, posterior thigh, groin, and occasionally to the lateral calf and ankle (a lack of nerve root tension signs and motor, reflex or sensory deficits helps to distinguish sacroiliac joint syndrome from nerve root compression lesions);
- Successful manipulation or injection of the joint confirms the diagnosis.

Hertling and Kessler (1997) describes five typical characteristics of patients presenting with sacroiliac syndrome and which have been related to the diagnosis of sacroiliac joint syndrome. These include:

- Unilateral sacroiliac joint pain, localised to the joint itself but which may refer down the posterolateral aspect of the ipsilateral leg;
- The absence of lumbar articular signs and symptoms;
- A short period of morning stiffness that eases with movement and weight-bearing;
- Increased pain aggravated by extended periods of sitting and walking; and
- Pain aggravated by walking, climbing stairs and rolling over in bed.

Leach (1994) describes an alternate method of gauging the presence of sacroiliac joint dysfunction as it relates to sacroiliac syndrome through the detection of hypomobility within the joint. This method is called the Gillet-Liekens method of motion detection within the sacroiliac joint.

Included in the tools available for the diagnosis of sacroiliac syndrome are a number of other tests used specifically to confirm the likely diagnosis of sacroiliac syndrome specifically whilst not being part of the diagnostic criteria for sacroiliac syndrome (Kirkaldy-Willis *et al.*, 1992). These tests stress the sacroiliac joint in a variety of directions and in various positions, and include the Gaenslens test, Patrick's Faber test, Yeoman's test and the posterior shear test (Laslett and Williams, 1994).

2.6 Treatment of Lumbar Facet Syndrome and Sacroiliac Syndrome

Treatment for LBP includes both allopathic (Hellman and Stone, 2000), and manual therapies such as hydrotherapy and traction (Cull and Will, 1995). It has been found that allopathic interventions up to this point have been less effective than spinal manipulative therapy (Gatterman *et al.*, 2001), and McMorland and Suter (2000), found that spinal manipulation resulted in an average of 52.5% and 52.9% reduction in LBP, and disability, respectively.

According to Cailliet (1981), the possible effects of spinal manipulation are:

- Adhesion of synovial facet joint surfaces is broken by movement of the spinal motion segment through its passive range of motion;
- Mechanoreceptors of the joint are desensitised by the abrupt movement of a joint (manipulation), which releases protective muscle spasm, and allows joint movement;
- Manipulation allows entrapped menisci to exit the facet joint in which they became trapped;
- A capsule that may become lodged within a joint may be released by manipulation;
- Spindle fibre receptors of adjacent muscles are reflexively stimulated by a manipulative thrust and reciprocally relax the extrafusal muscle fibres, opposing muscle shortening (Guyton and Hall, 1997);
- The misaligned spinal segments are aligned to conform to the centre of gravity (Cailliet, 1981).

These indicate the extent of understood effects of spinal manipulation. As yet, no major adverse mechanical effects to spinal manipulation have been researched.

Leach (1994) proposes that, despite the theories set forth by Korr, Knutson, Patterson and Steinmetz, and Dvorak who mention effects of manipulation as being kinetic and kinematic, and neuromuscular, the large majority of clinical effects may be set forth by the increase in circulation within the joint itself.

2.7 Psychological aspects of performance

2.7.1 Muscle Inhibition

A pilot study (Nadler *et al.*, 2002) revealed a significant difference in performance times over a 20 metre shuttle run in participants without, and with, a history of LBP, with the former being markedly faster than the latter. They indicated that LBP could potentially cause a decrease in functional performance amongst athletes.

Studies by Lee *et al.* (1995) and Hultman *et al.* (1993) indicated that subjects with a previous history of LBP had a tendency towards low muscle strength in their trunk and lower extremities in comparison to the normal population. Research by Suter and Lindsay (2001) indicates not only a correlation between chronic LBP and decreased trunk muscle endurance, but also between the associated increase in trunk muscle fatigability and quadriceps inhibition.

Vogt *et al.* (2003) examined changes in the lumbar spine and hip extensor activation patterns in chronic LBP patients in a functional and complex test situation using the example of walking. The investigation demonstrated reductions in hip flexion and extension movements as well as reduced gait cycle durations. Their findings pointed towards a protective activation mechanism by means of a premature recruitment strategy of the lumbar spine and hip extensors and the prolonged activity of the gluteus maximus and lumbar spine extensors. This could be interpreted as a functional adaptation of the neuromuscular system to provide extra stability and to prevent additional pain. The study showed EMG changes coherent with a functional adaptation to muscle pain that agreed with similar studies by Arendt-Nielsen *et al.* (1995) and Graven-Nielsen *et al.* (1997).

Vogt *et al.* (2003) stated that their results pointed toward alterations of dynamic motor stereotypes and motor regulation, and changes of the neuromuscular coordination in association with functional disturbances as a possible underlying source of recurrent or chronic back pain symptoms.

Suter *et al.* (2000) investigated the principle that sacroiliac manipulation would alter the amount of muscle inhibition present in patients with significant muscle inhibition of the quadriceps. Their results showed a decrease of 7,5% in muscle inhibition post sacroiliac manipulation indicating positive benefits from sacroiliac manipulation in treating muscle inhibition. Suter and McMorland (2002) found similar results in muscle inhibition applied to elbow flexion following spinal manipulation of the cervical spine in subjects with chronic neck pain. This indicates a potential for applying the same principle to other areas of the musculoskeletal system.

2.7.2 "Central Governor" Model

An hypothesis regarding the "central governor" was proposed first by Hill *et al.* (1924), who stated that the limit to a muscle's ability was probably set, not by the exhaustion of that muscle, but rather by another entity which placed distress upon either the heart or cerebrum to limit saturation of oxygen in the blood to the muscles through a "central governor" (Noakes *et al.*, 2001). It is based on this hypothesis that Noakes *et al.* (2004) propose the "central governor" theory, which makes three critical assumptions.

Noakes *et al.* (2004) believe that as at rest, during exercise all physiological functions are homoeostatically regulated by central nervous system (CNS) control mechanisms to ensure that bodily harm does not result. They further state that because no rigor occurs in muscle during excessive muscle usage beyond fatigue, this indicates a high level of homoeostatic activity taking place between adenosine triphosphate (ATP) usage and ATP production. Noakes *et al.* (2004) proceed to explain that ATP reserves within the muscle itself would require approximately seven seconds of high muscle activity to deplete completely leading to the inevitable rigor. Similarly, slower anaerobic ATP synthesis is unlikely to solely take over oxidative ATP production, slowing muscle fatigue until exercise termination occurs. This prevents rigor because, as soon as the less efficient anaerobic ATP synthesis lags behind ATP production, the cycle of fatigue due to build up of catabolites within the muscle would rapidly deteriorate to the point of muscle rigor.

Since rigor does not occur generally during exercise, there must be another mechanism in place to maintain ATP synthesis at a rate homoeostatically matched to the range of ATP utilisation for prolonged periods (Noakes *et al.*, 2004).

This alternate mechanism suggests that it is unlikely that it is local muscle metabolites such as ATP or blood lactate, that are responsible for skeletal muscle function exclusively, but rather these metabolites act to regulate skeletal muscle function by influencing the number of skeletal muscle motor units that are recruited by the CNS by means of the release of calcium from the sarcoplasmic reticulum of the motor units following inputs from both the central and peripheral nervous systems (Noakes *et al.*, 2004).

Another premise of this model holds that the conscious sensation of fatigue does not arise directly from the action of metabolites in the periphery, but rather from regulatory centres in the subconscious parts of the brain. The sensation of fatigue is therefore not directly related to a physical end point, but is rather an interpretation of the effect of the current level of activity on future exercise capacity and any threats that immediate and future events pose to the maintenance of homoeostasis (Noakes *et al.*, 2004).

With the failure of the “catastrophe model”, as described by Edwards (1983) according to Noakes *et al.* (2004), to explain the mechanism of fatigue during exercise adequately, Noakes *et al.* (2004) propose an alternate “central governor model” based on evidence for the continual presence of a “recruitment reserve” whereby there are always skeletal muscle units available during muscle contraction, even during fatigue, indicating that the CNS regulates and limits skeletal muscle recruitment, specifically to ensure that homoeostasis is maintained and catastrophe avoided.

Noakes *et al.* (2004) maintain that during exercise, the CNS continuously modifies pace as a part of a complex dynamic system based on metabolic calculations at a subconscious CNS level. This system takes into account prior knowledge acquired during previous exercise experiences, the end point of the current exercise and the current metabolic rate among many other potential factors that may play a role.

This model makes the premise therefore, that fatigue is not necessarily a physical event, but a sensation that is the manifestation of the aforementioned subconscious CNS processes (St. Clair Gibson *et al.*, 2001). As such, the "central governor" model predicts that ultimate control of exercise performance lies in the ability of the CNS to vary the work rate and metabolic demand of a muscle by altering the number of skeletal muscle motor units recruited during exercise (Noakes *et al.*, 2004).

As the sensation of fatigue is an emotion rather than a physical state, pacing strategies and their control during self regulated exercise become important, making the journey and not just the end point the most important phenomena in exercise physiology. This gives fatigue over to CNS control rather than being a physically based phenomenon (Noakes *et al.*, 2004).

Noakes *et al.* (2004) note that factors such as prior knowledge gained from previous exercise experience, the planned end point of an exercise, and the current metabolic rate, amongst many other potential variables such as unexpected exercise duress (Baden *et al.*, 2005), may play a role in how the CNS processes and utilises current information. It is these potential variables that require further study and isolation in order to gain a better perspective as to what it is that effects exercise performance and fatigue.

2.8 Conclusion

Many authors (Hultman *et al.,* 1993, Arendt-Nielsen *et al.,* 1995, Graven-Nielsen *et al.,* 1997, Suter and Lindsay, 2001, and Vogt *et al.,* 2003) have made the link between muscle inhibition and LBP as having a cause and effect relationship with each other, while also causing muscle fatigability, decreased muscle endurance and muscle weakness.

Since the early 1920's and possibly before, one question brought to the fore of the scientific frontier has been "which factor or factors, has or have influenced the performance of the human being", particularly in athletes. In order to set about interrogating this, a number of theories have been postulated, such as the "catastrophe" theory of fatigue (Edwards, 1983) and more recently, the "central governor" theory (Noakes *et al.*, 2004).

This research sets out to investigate one aspect of these factors, namely the perceived performance in runners with LBP, receiving spinal manipulation over time in terms of subjective findings.

Chapter 3

Materials and Methods

3.1 Introduction

This chapter gives a detailed description of the methods employed in data collection from the subjects and the interventions utilised as well as the methods of statistical analysis and the process of the evaluation of the data. The study design was a pre-, post-cohort study. This involved a single group which received a spinal manipulation as the treatment of either lumbar facet or sacroiliac syndrome. A questionnaire was presented prior to each treatment in order to gather empirical data on the patients' perceived reaction to treatment and its effect on their running.

3.2 Advertising

For the purpose of the study the means of advertising included posters and leaflets. Leaflets regarding the research were handed out at running races and at club weekly time trials, and posters put up with the permission of the respective authorities, in order to attract potential participants. Talks were also given at weekly time trials regarding the study and the profession of Chiropractic as a whole.

3.3 Sampling

3.3.1 Size

The sample size required a total of 20 patients allocated to one group in order to achieve statistical validity. All subjects volunteered as per prevailing ethical requirements, and none withdrew from the study.

3.3.2 Allocation

Patients who met the requirements for the study according to the inclusion and exclusion criteria were assigned to a treatment group. For the purpose of the study 20 patients were selected by convenience sampling from the patients who satisfied the criteria.

3.3.3 Method

The method used for sampling was that of a non-probable convenience sample in order to attain a more accurate representation of the running population.

A telephonic interview was conducted initially, and pertinent questions were asked to determine whether the patients were suitable candidates for the research sample. These questions included:

- Are you between 18 and 45 years of age?
- Where is your area of pain?
- Do you have any associated radicular or leg pain?
- Do you have a history of trauma or surgery?
- Do you run weekly and what is your average mileage per week?
- Do you have any numbness, tingling, pins and needles, muscle weakness or other neurological signs?

These questions decreased the chance of unsuitable candidates being called upon for an initial consultation and referral was made at the telephonic screening stage where appropriate care was required.

Compliance with the following criteria was obtained at the first consultation from the patient history (appendix A), physical (appendix B), and regional lumbar and pelvic examinations (appendix C) in order to assess whether the subjects qualified for the study.

3.4 Inclusion criteria

Inclusion criteria included those detailed below:

- Patients had to be between the ages of 18 and 45 to avoid necessity for parent/guardian consent and to reduce the chances of sacroiliac ankylosis (Giles and Crawford, 1997).
- Patients had to have run more than 30km per week for a period of 6 months in order to establish their history as confirmed runners.
- Patients had to have LBP that measured between 3 and 8 on the NRS in order to retain the sample homogeneity (Mouton, 1996).
- Patients had to have had their current episode of LBP for at least 1 month and less than 2 years in order to establish the condition as a chronic low back condition while avoiding long-term degenerative changes due to their low back pain.
- Although orthopaedic testing is not diagnostic of sacroiliac or lumbar facet syndromes, these tests were used to confirm the diagnosis.
  At least 2 of the following had to be positive:
  - Erichsen's Test (Schafer and Faye, 1990).
  - Gaenslen's Test (Kirkaldy-Willis *et al.,* 1992).
  - Patrick's FABER (Flexion, ABduction and External Rotation) Test (Magee, 2002).
  - SI Compression Test (Schaefer and Faye, 1990).
  - Kemp's Test (Gatterman, 1990).
  - Facet Joint Challenge.
  - Straight leg raiser Test (Gatterman, 1990).
- No contra-indication to manipulation was allowed (Bergmann *et al.,* 1993):
  - Marked osteoporosis.
  - Ankylosing spondylitis.
  - The presence of fever, tumours, tuberculosis or any infectious disease.
  - Local inflammation, thrombosis, metal implants or hip prosthesis.
  - Spinal fusion or spinal surgery.
  - Acute disc herniation.

- Abdominal aortic aneurysm.

(Giles, 1997):

- Cancer or other destructive lesions of the spine.
- Severe osteopaenia.
- Active spondyloarthropathies.
- Cauda equina syndrome.
- Referred pain from visceral disease.
- Significant psychological overlay.

3.5 Exclusion criteria

Exclusion criteria included those detailed below:

- If the subject experienced an acute episode of LBP (Spitzer *et al.*, 1987).
- If the subject changed his or her medical and/or activity routine during the course of the study.
- Patients who wished to no longer participate in the study were automatically excluded and their data not used.
- Patients with radicular leg pain (Gatterman *et al.,* 2001).
- There must not have been any prior manual or modality intervention, or any form of medication taken within forty-eight hours prior to the research being conducted (Poul *et al*., 1993).
- Patients who had previously had lower back surgery as the source of their back pain that may have been related to the surgery (Maroon *et al.*, 1999).
- Patients who presented with a NRS score of lower than 3 and greater than 8, in order to retain a homogenous sample group (Mouton, 1996).
- A history of osteoporosis, osteomalacia or spinal fracture, osteomyelitis, seronegative arthritides, skeletal dysplasia, leukaemia, avascular necrosis, or bone tumours of the lumbar spine. (Flynn, *et al.,* 2003).

3.6 Intervention / Treatment Types

The patients were motion palpated (Murphy and Morris, 2005) for lumbar and sacroiliac fixations after the initial assessment, and a high velocity, low amplitude (HVLA) short lever manipulation was performed according to the fixations found within the sacroiliac joint and lumbar spine on motion palpation. They were then motion palpated again. The treatment was repeated in the same way on each of the three subsequent visits over a two week period.

The HVLA short lever thrust was performed in the side-lying position for both sacroiliac and lumbar manipulative thrusts and included the following descriptors detailed below (Bergmann *et al.*, 1993):

Doctor position:	Lumbar fixation: Initial square stance moving to fencer stance. Sacroiliac fixation: Square stance.
Patient Position:	Lumbar fixation: Patient lateral recumbent with fixation side up, in good side posture and headrest of bed elevated. Sacroiliac fixation: Patient lateral recumbent with fixation side up or down dependant on the performance of a flexion or an extension manipulation respectively, in good side posture and headrest of bed elevated.
Contact point on patient:	Lumbar fixation: Over facet joint of fixated spinal segment. Sacroiliac joint: Sacroiliac joint at level of fixation.
Contact point on doctor:	Pisiform contact on hand.
Vector of thrust:	Lumbar fixation: Posterior to anterior and inferior to superior. Sacroiliac fixation: Into the fixation in relation to the sacroiliac joint.

3.7 Intervention frequency

The patients underwent four consultations over a period of two weeks (Stig *et al.,* 2001) with two consultations a week. They received a HVLA manipulative thrust at each follow-up where necessary. The final consultation followed the last treatment within a week.

3.8 Data Collection

3.8.1 Frequency

The group completed a "Perception of Running Performance" questionnaire and a NRS scale (Jenson *et al.*, 1986) prior to the initial consultation. Prior to each follow up consultation and ultimately one week following the final consultation, they completed the same.

3.8.2 Data Collection Instruments

3.8.2.1 Subjective data:

Subjective data were collected using the following measuring instruments:

1) Numerical Rating Scale (NRS) (Jenson *et al.*, 1986)
2) "Perception of Running Performance" questionnaire.
   - This questionnaire was piloted by means of a pilot group on 7 June 2006 in which questions and format of the pilot study were discussed and alterations made as appropriate.
   - The questionnaire was scrutinised in the presence of, and with the help of, the researcher.

3.9 Description of statistics

Data were collected from the NRS and the "Perception of Running Performance" questionnaire. This was done five times, prior to each treatment and within one week following the final treatment.

3.10 Statistical Methods

The unit of analysis in this case were "runners" defined as those who ran more than 30-kilometres per week for six months, with mechanical LBP induced by running.

SPSS version 13.0 (SPSS Inc., Chicago, IL) was used to analyse the data. Raw scores for questionnaire items which were negatively phrased were reversed, and scores for items under the same headings were summed up to create a composite score, such that the higher the score was, the better the outcome. In the case of Perceived Performance, only the first three items were used in the composite score as these were the only items on the same scale. Items 4, 5 and 6 of the perceived performance section were analyzed and treated separately.

Non parametric Friedman tests were used to compare pain scores, raw scores and composite scores over time where there were five time points being compared. Where only two time points were compared, Wilcoxon signed ranks tests were used. Box and whisker plots were used to show the trends graphically. The change in scores from the first time point to the fifth time point were computed by subtracting the first time point score from the fifth time point score, and Spearman's rank correlation test was used to assess relationships between changes in outcome variables.

Cronbach's alpha statistic was used to assess the reliability of the scales using baseline (first time point) data.

Chapter 4

Results and Discussion of Results

4.1 Introduction

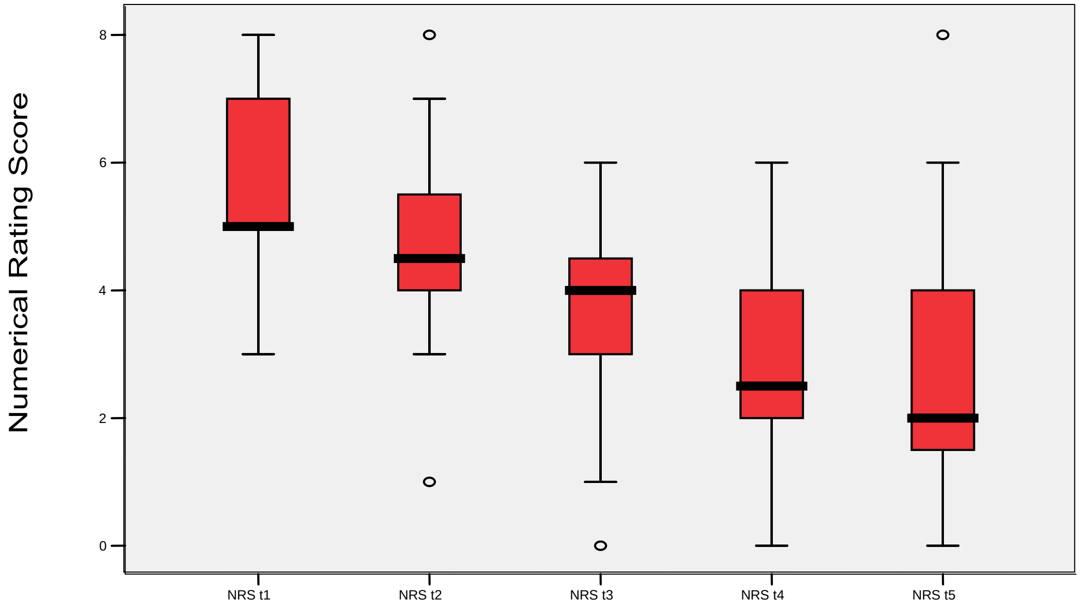
This chapter aims to statistically analyse the primary data. The data utilised were collected exclusively from participants who satisfied the inclusion and exclusion criteria of the study. The data were analysed in terms of demographics; the Numerical Rating Scale (NRS); the “Perceived Performance” questionnaire and its constituents, being Perceived Performance (PP), Motivation (MT) and Clinical Reality (CR); reliability of the scales used; and the relationships that exist between these components.

4.2 Demographics

The sample consisted of twenty participants with a mean age of 29.4 (± 6.2) years and an age range of 21 to 43 years. There were fifteen (75%) males in the sample and five (25%) females.

4.3 Numerical Rating Scale (NRS)

Figure 4.1 presents the subjects median pain rating scores prior to each of the four treatments and at a one week follow-up. It was demonstrated that there was a decrease in median pain in the sample over time, from five at visit one, on a scale of 0 to 10, to two at visit five.

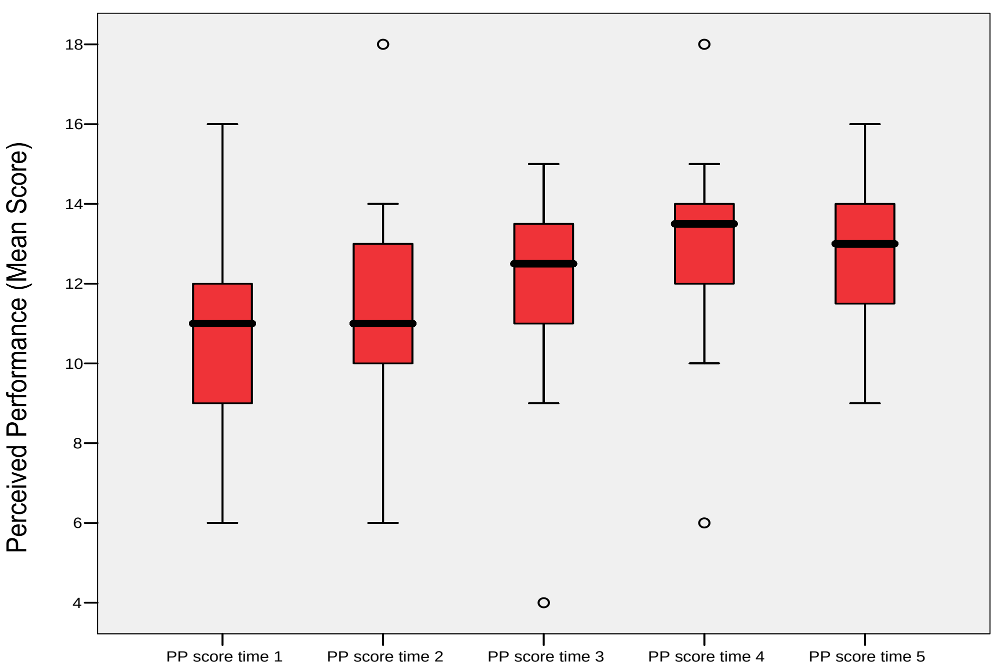


Friedman’s Test: n = 20; χ^2 = 45.264; df: 4; $p < 0.001$

Figure 4.1: Boxplot of pain scores (NRS) over time (visits 1 - 5)

This decrease was highly statistically significant according to the Friedman test ($p < 0.001$). Therefore there is evidence that spinal manipulation does reduce low back pain in runners.

4.4 “Perception of Running Performance” Questionnaire



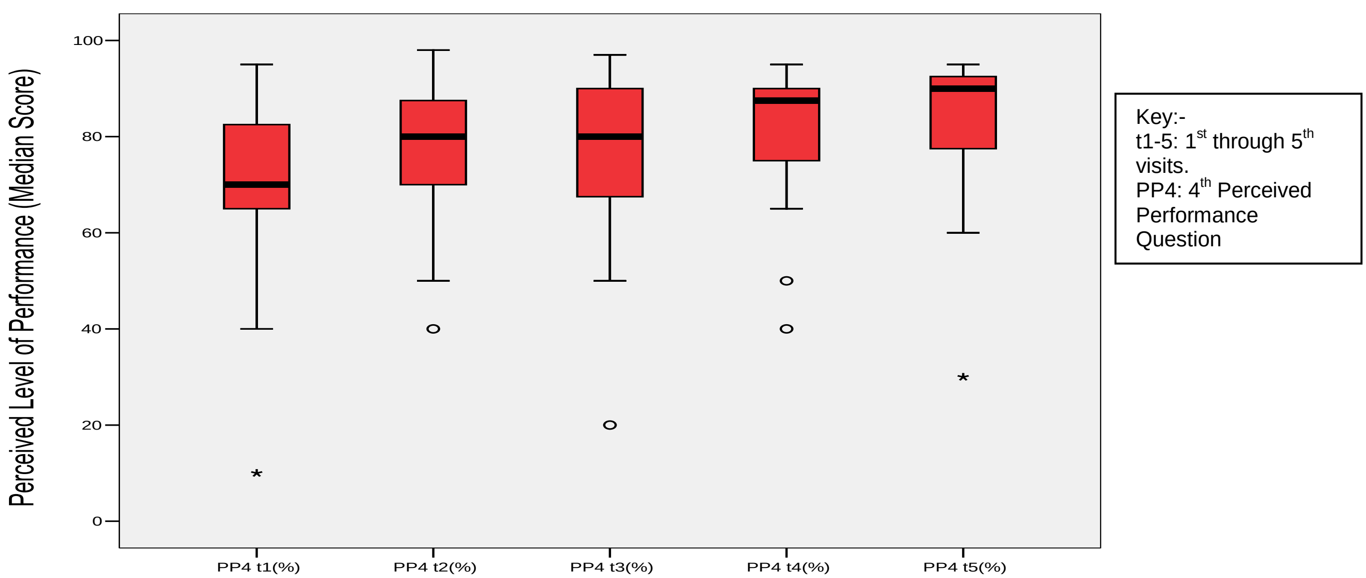
Friedman’s Test: n = 20; χ^2 = 29.238; df : 4; $p < 0.001$

Figure 4.2: Boxplot of Perceived Performance score over time

4.4.1 Perceived Performance

Figure 4.2 presents the subjects median perceived performance scores prior to each of the four treatments and at a one week follow-up. There was an increase in the median perceived performance scores over time from a median of 11 to a median of 14 at the fourth time point (visit 4), decreasing slightly to 13 at the fifth time point (visit 5). This increase over time was highly statistically significant (*p*<0.001).

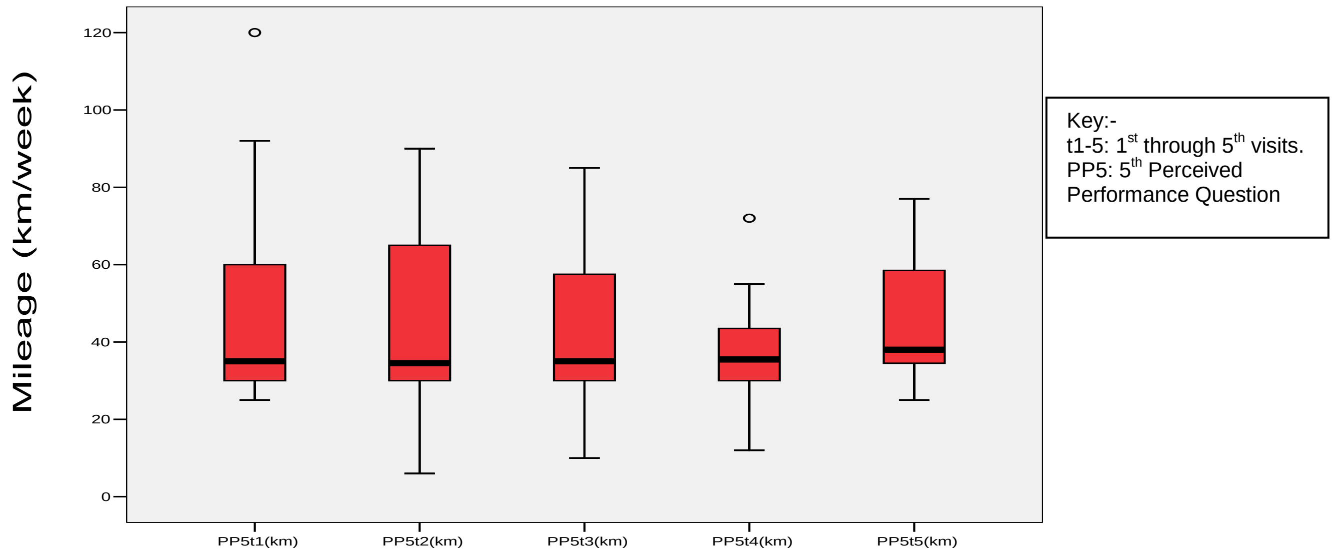
When the median perceived level of performance was analysed an increase was noted from 70% to 90% in terms of the performance level. This increase is shown graphically in Figure 4.3 and it was highly statistically significant (*p*<0.001).



Friedman's Test: $n = 20$; $X^2 = 37.566$; df : 4; $p < 0.001$

Figure 4.3: Boxplot of PP4 (Current level of performance) score over time

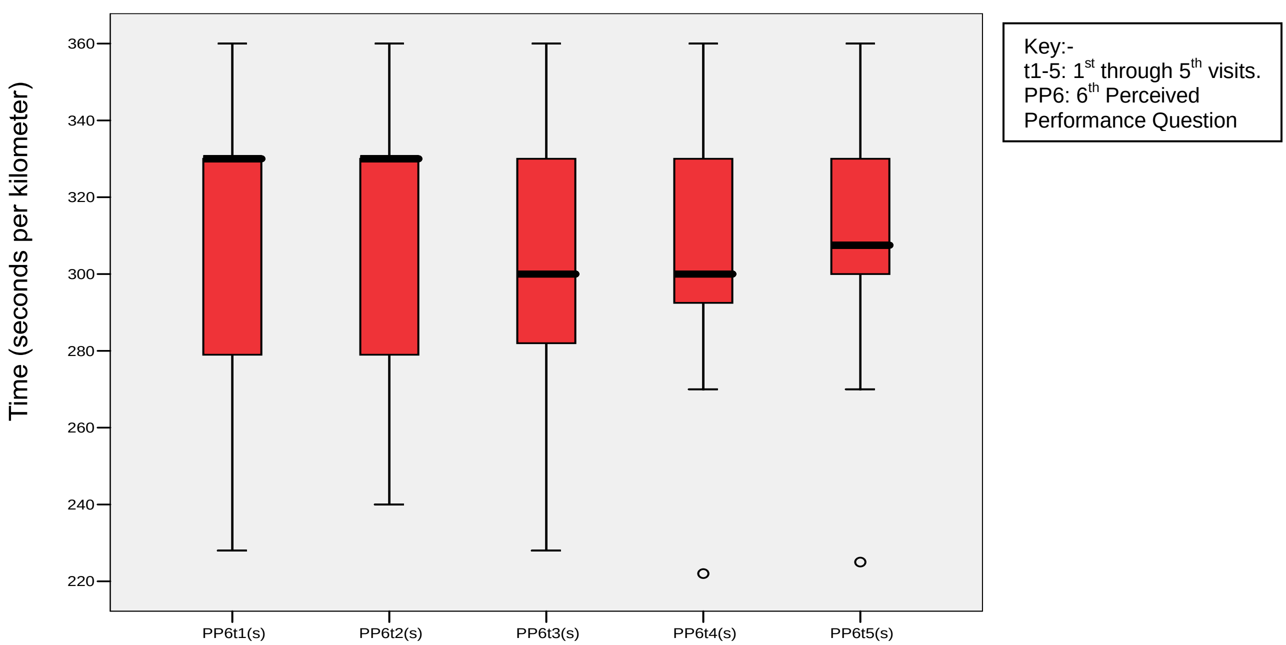
Mileage (Figure 4.4) increased slightly over the study period from a median of 35km to 38 km. This increase was not statistically significant (*p*=0.172).



Friedman's Test: n = 20; X^2 = 6.384; df : 4; p = 0.172

Figure 4.4: Weekly mileage over time

Pace decreased over the study period. This is shown in Figure 4.5. The starting pace was a median of 5:30 minutes per kilometer (330 seconds), but this improved to 5:08 minutes per kilometer (308 seconds) by the end of the study. This improvement was however not statistically significant (p=0.450).

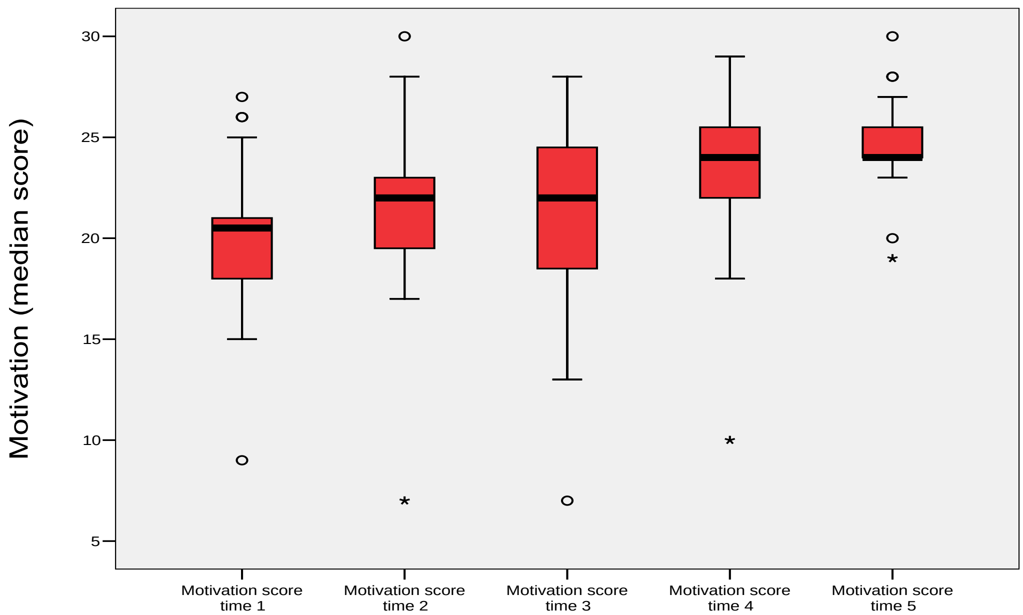


Friedman's Test: n = 20; X^2 = 3.686; df : 4; p = 0.450

Figure 4.5: Pace over time

4.4.2 Motivation

Motivation scores increased over time with treatment from a median of 21 before treatment to a median of 24 at the end of the study. This is shown in Figure 4.6. The increase was statistically significant (*p*<0.001).

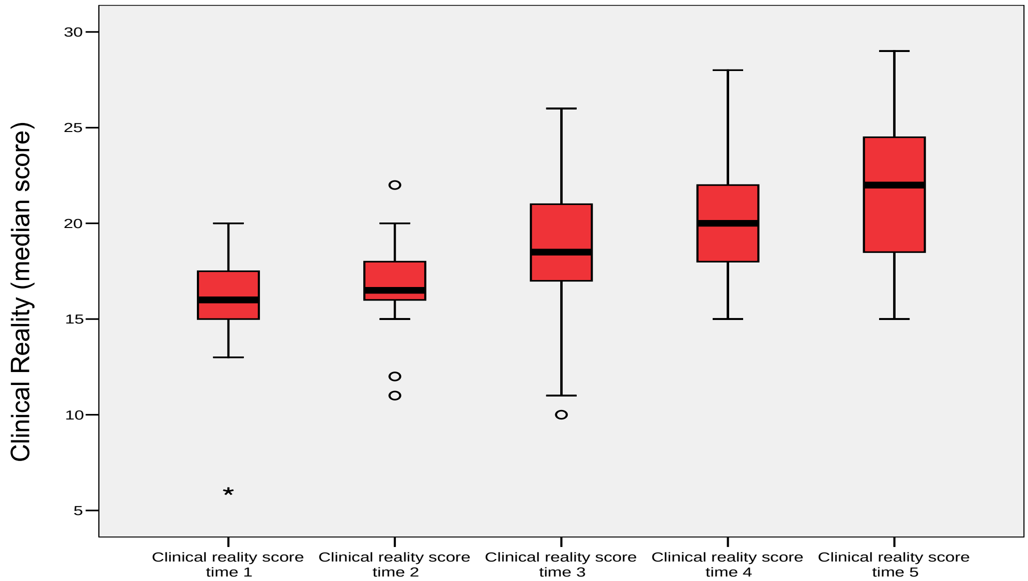


Friedman's Test: $n = 20$; $X^2 = 37.126$; df : 4; $p < 0.001$

Figure 4.6: Motivation scores over time

4.4.3 Clinical Reality

There was an increase in the clinical reality score over time from a median of 16 to 22. This is shown in Figure 4.7. This increase was statistically significant (*p*<0.001).



Friedman's Test: n = 20; X^2 = 38.930; df : 4; p < 0.001

Figure 4.7: Boxplot of Clinical Reality score over time

4.4.4 Individual Scores: "Perecption of Performance" Questionnaire

The median of the individual questions from the "Perceived Performance Questionnaire" is presented in Table 4.1. This shows the individual question scores for each question of the perceived performance, motivation and clinical reality sub-sections. The only question which did not change significantly (p=0.728) over time was MT3 (third motivation question). All others scores showed a significant increase over time (p < 0.05).

Table 4.1: Median item scores by time

	time					Friedman test p value
	1	2	3	4	5	
PP1r	5	5	5	6	6	<0.001
PP2	3	3	3	4	4	0.004
PP3	3	3	3	4	4	<0.001
MT1r	4	4	4	4	5	0.001
MT2r	3	4	4	5	6	<0.001
MT3	3	3	3	4	3	0.728
MT4r	5	5	6	6	6	0.001
MT5r	5	5	5	5	6	0.002
CR1	3	3	3	4	4	0.001
CR2	3	3	4	4	4	<0.001
CR3	3	4	4	5	5	<0.001
CR4r	3	4	4	5	5	0.001
CR5r	4	3	3	3	5	0.049

4.5 Assessment of the Reliability of the Scales, Using Cronbach's Alpha

Since this questionnaire was developed and used exclusively for the current study, the reliability of the scales was assessed. The baseline (time point 1) data were used.

4.5.1 Perceived Performance

This was composed of items PP1 (perceived performance question 1), PP2 (perceived performance question 2), and PP3 (perceived performance question 3). PP1 was a negatively phrased question therefore the scores were reversed to be comparable with the other questions in this sub-section. The overall Cronbach's alpha score for this scale was 0.602, which is moderately reliable. There were no items which would have resulted in an increased alpha if they had been deleted. Thus all items should remain in the scale and together they are moderately reliable.

Table 4.2: Item-Total Statistics for Perceived Performance Scale

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
pp1t1r	5.90	3.358	0.358	0.574
PP2 t1	7.50	2.053	0.488	0.405
PP3 t1	7.70	3.589	0.448	0.490

4.5.2 Motivation

There were five items which made up this scale. Since four of the questions were negatively phrased they were reversed (MT1 (motivation question 1), MT2 (motivation question 2), MT4 (motivation question 4) and MT5 (motivation question 5)). The total alpha was 0.767, indicating a high level of reliability. Item MT3 was the least reliable item and the alpha would have increased to 0.828 if it were deleted.

Table 4.3: Item-Total Statistics for Motivation Scale

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
MT1t1r	16.25	10.829	0.551	0.724
MT2t1r	16.35	9.292	0.733	0.644
MT3 t1	17.00	16.632	0.089	0.828
MT4t1r	15.05	11.313	0.698	0.671
MT5t1r	15.35	11.818	0.625	0.697

4.5.3 Clinical Reality

This scale was composed of five items, two of which were reversed namely CR4 (clinical reality question 4) and CR5 (clinical reality question 5). The alpha was 0.536, which was low reliability. Item CR4 was problematic and if it was deleted the alpha would have increased to 0.699.

Table 4.4: Item-Total Statistics for Clinical Reality Scale

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
CR1 t1	13.00	6.316	0.543	0.379
CR2 t1	12.90	5.989	0.698	0.315
CR3 t1	12.90	6.516	0.295	0.484
CR4t1r	12.15	6.766	0.035	0.699
CR5t1r	11.85	6.029	0.274	0.501

4.6 Relationships

Table 4.5 presents Spearman's correlation of each variable in comparison to another. There was only one significant correlation between changes in the outcome variables. This was between a change in mileage and a change in motivation score (rho = -0.478, *p*=0.033). Since this was a negative correlation an increase in mileage was related to a decrease in motivation. No other variables were correlated together. Thus a change in pain was not correlated with change in perception of running performance.

Table 4.5: Spearman's correlation analysis of relationships between changes in outcome variables

		Change in perceived performance score	Change in motivation score	Change in clinical score	Change in performance level	Change in mileage	Change in pace	Change in NRS
Change in perceived performance score	Correlation Coefficient	1.000	0.279	0.137	-0.123	-0.059	-0.212	0.085
	Sig. (2-tailed)	<0.001	0.233	0.566	0.607	0.804	0.369	0.722
	N	20	20	20	20	20	20	20
Change in motivation score	Correlation Coefficient	0.279	1.000	0.122	0.236	-0.478(*)	0.229	0.221
	Sig. (2-tailed)	0.233	<0.001	0.610	0.316	0.033	0.332	0.349
	N	20	20	20	20	20	20	20
Change in clinical reality score	Correlation Coefficient	0.137	0.122	1.000	0.180	-0.149	-0.040	-0.315
	Sig. (2-tailed)	0.566	0.610	<0.001	0.447	0.530	0.868	0.176
	N	20	20	20	20	20	20	20
Change in performance level	Correlation Coefficient	-0.123	0.236	0.180	1.000	-0.099	-0.070	-0.006
	Sig. (2-tailed)	0.607	0.316	0.447	<0.001	0.677	0.770	0.980
	N	20	20	20	20	20	20	20
Change in mileage	Correlation Coefficient	-0.059	-0.478(*)	-0.149	-0.099	1.000	-0.399	-0.047
	Sig. (2-tailed)	0.804	0.033	0.530	0.677	<0.001	0.081	0.844
	N	20	20	20	20	20	20	20
Change in pace	Correlation Coefficient	-0.212	0.229	-0.040	-0.070	-0.399	1.000	0.221
	Sig. (2-tailed)	0.369	0.332	0.868	0.770	0.081	<0.001	0.348
	N	20	20	20	20	20	20	20
Change in NRS	Correlation Coefficient	0.085	0.221	-0.315	-0.006	-0.047	0.221	1.000
	Sig. (2-tailed)	0.722	0.349	0.176	0.980	0.844	0.348	<0.001
	N	20	20	20	20	20	20	20

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

Those outcomes (Tx2 (Treatment question 2) to Tx5 (Treatment question 5)) which were only measured at two time points (visit one and visit five) were compared using Wilcoxon signed ranks tests. There was a significant difference between the first and the second time point (visit one and visit five) for Tx5 (p=0.008), but the other outcomes did not change significantly. Seven participants originally thought they would not need ongoing treatment for their condition, but after the manipulation, they all changed their responses to “yes”, meaning that they would require ongoing treatment for their condition. Tx1 (treatment question 1) was a qualitative question and could not be analysed statistically. Before treatment, eight participants mentioned other practitioners besides a chiropractor as their first choice of professional care, whilst after treatment they all stated “chiropractic” as their choice of professional care.

Table 6: Median item scores by time

	Time 1	Time 2	Wilcoxon signed ranks *p* value
Tx2	2	2	0.206
Tx3	4	4	0.244
Tx4	1	1	0.317
Tx5	1	1	0.008

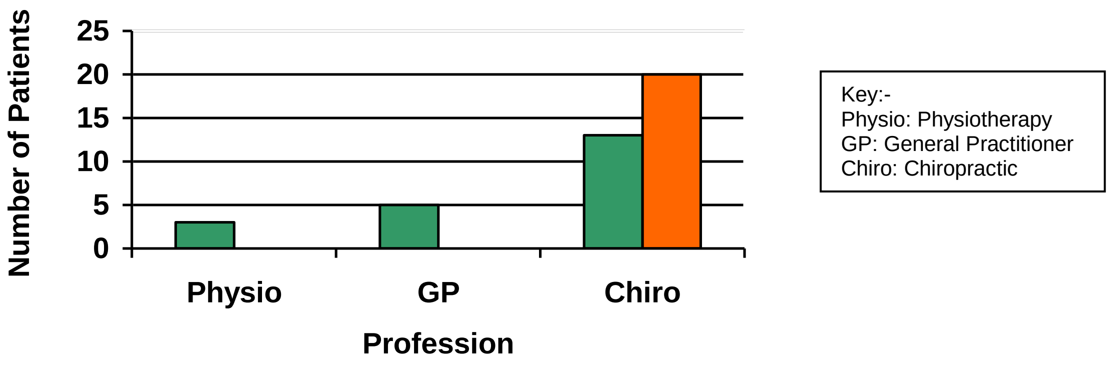


Figure 8: Subject Profession of Choice

4.7 Summary and Conclusion

This study shows strong evidence that spinal manipulation decreases low back pain in runners. It also demonstrates that there is an increase in the running performance, motivation and clinical reality for patients with treatment. However, the decrease in pain does not correlate with the increase in performance indicators. The reliability of measurement of the performance indicators according to the scales is fair, although it could have been improved upon by omission of certain questions from the questionnaire.

Chapter 5

Discussion and Conclusions

5.1 Introduction

This study comprised 20 subjects with sacroiliac syndrome or lumbar facet syndrome in a single group. Prior to the onset of the study, suitable subjects were established through a screening process of the prospective participants. As previously stated, participants underwent a case history, physical examination, and lumbar and pelvic regional examinations.

Data collection took place immediately prior to each of four treatments involving spinal manipulation, and one week following the final treatment.

5.2 Discussion

The research was based upon the “Perception of Running Performance” questionnaire which comprised of twenty-two questions placed into five major categories, being the NRS, Perceived Performance, Motivation, Clinical Reality and Treatment questions.

The results attained are discussed in terms of LBP, the above-mentioned sections of the “Perception of Performance” questionnaire and the correlations and relationships found between them.

5.2.1 Low Back Pain

Meade *et al.* (1990), and Burns and Mierau. (1997) found that spinal manipulation of the lower back in the general population was effective in reducing low back pain. This same has not yet been established in the literature regarding runners with low back pain.

Many authors (Hultman *et al.,* 1993, Arendt-Nielsen *et al.,* 1995, Graven-Nielsen *et al.,* 1997, Suter and Lindsay, 2001, and Vogt *et al.,* 2003) have made the link between muscle inhibition and low back pain as having a cause and effect relationship with each other, whilst also causing muscle fatigability, decreased muscle endurance and muscle weakness.

The results of this study show a marked and highly significant statistical decrease in the NRS between the first and last visits of the research protocol, indicating a strong improvement in low back pain in runners with spinal manipulation. This confirms the findings of Meade *et al.* (1990), and Burns and Mierau (1997), who found similar results amongst the normal population.

5.2.2 "Perception of Running Performance" Questionnaire

The "Perception of Running Performance" questionnaire was piloted with this study in mind and its three main sub-sections were the "Perceived Performance", "Motivation" and "Clinical Reality" which were the most pertinent factors influencing the subjects' overall perception of performance.

5.2.2.1 Perceived Performance

The purpose of this series of questions was to establish the external training variables and how they interacted to affect a subject's perceived performance. These external variables included the subjects' training schedule, weekly mileage, the average weekly speed of runs, and the perceived level of performance as altered by their LBP.

Nadler *et al.* (2002) noted that LBP could potentially cause a decrease in functional performance amongst athletes. This claim is also supported by Vogt *et al.* (2003) who found on EMG, changes that were coherent with a functional adaptation to muscle pain that agreed with similar studies by Arendt-Nielsen *et al.* (1995) and Graven-Nielsen *et al.* (1997). Research by Suter and Lindsay (2001) indicates not only a correlation between chronic LBP and decreased trunk muscle endurance, but also between the associated increase in trunk muscle fatigability and quadriceps inhibition. Suter *et al.* (2000) found a decrease of 7,5% in muscle inhibition post sacroiliac manipulation indicating positive benefits from sacroiliac manipulation in treating muscle inhibition.

The results of this study indicate that the participants' overall perceived performance score improved over the course of spinal manipulation, enough to be highly statistically significant. When asked to write down their current level of performance, again an improvement was shown that was highly statistically significant thus re-iterating the improvement in participants' perception of how low back pain affected their training schedule, mileage and pace.

This correlates strongly with the proposed "central governor" theory by Noakes *et al.* (2004) who maintain that during exercise, the CNS continuously modifies pace as a part of a complex dynamic system based on metabolic calculations at a subconscious CNS level.

It is interesting to note in this study, where the subjects were required to record actual figures of their average weekly mileage and pace, although there was a slight improvement in both, neither was statistically significant.

5.2.2.2 Motivation

In the “Motivation” section of questions, the purpose was to determine those intrinsic or mental factors, namely a change in motivation, depression, desire, expectation and effort that a runner with LBP could experience.

Another premise of the “central governor” model would be that the conscious sensation of fatigue, the controlling factor in perceived performance, does not arise directly from the action of metabolites in the periphery, but rather from regulatory centres in the subconscious parts of the brain. The sensation of fatigue is therefore not directly related to a physical end point, but is rather an interpretation of the effect of the current level of activity on future exercise capacity and any threats that immediate and future events pose to the maintenance of homoeostasis Noakes *et al.* (2004).

The factors of motivation as mentioned above were analysed and showed a statistically significant improvement between the first and last consultations, indicating that an improvement in low back pain would result in an improvement in motivation.

5.2.2.3 Clinical Reality

In the “Clinical Reality” questions, the purpose was to extract those physical factors that would influence a person’s perceived performance should they suffer from LBP, and included comfort, stride pattern, change in back pain, effort and endurance of their pain.

Noakes *et al.* (2004) make note that factors such as prior knowledge gained from previous exercise experience, the planned end point of an exercise, and the current metabolic rate, amongst many other potential variables such as unexpected exercise duress (Baden *et al.*, 2005), may play a role in how the CNS processes and utilises current information. These factors point toward the outer manifestation of what is happening at a CNS or subconscious level and would be correlated by such factors as mentioned above.

Statistically the mean score for this group of questions showed a significant improvement, suggesting that an improvement in LBP would be related to an improvement in those external factors that would have an impact on perceived performance.

Reliability analysis of the "clinical reality" scale revealed that question four (CR4) pertaining to fatigue and its effect on LBP, was unreliable and its exclusion from the questionnaire would have strengthened the "Clinical Reality" scale as a whole. Noakes *et al.* (2004) note that fatigue is an emotion rather than a physical state, making this a problem in discernment on behalf of the subjects when related to the other questions in the scale.

5.2.3 Relationships

In the above sections, the "central governor" model as proposed by Noakes *et al.* (2004) has been mentioned on several occasions with regard to its pertinence in understanding the results of the "Perception of Performance" questionnaire. One of the objectives of this study is to correlate the varying factors as they have been discussed above in order to get a perspective not only of their importance in how they affect low back pain individually, but also in how they relate to each other.

Spearman's correlation analysis was used to assess the various questions posed in the "Perception of Performance" questionnaire according to their relationships with each other. A correlation was found between the average weekly mileage and the overall motivation score, whereby an increase in mileage was related to a decrease in motivation. This indicated that as participants increased their mileage they found it difficult to maintain the motivation to train. It would thus stand to reason that the longer the distance covered in training, the less the motivation would be on behalf of the athlete.

Another important finding in the Spearman's correlation analysis was that there was no other significant statistical correlation between any other variable. This indicated that a change in LBP was not associated with a change in “perceived performance”, “motivation” or “clinical reality”. This lack of a statistically significant relationship between these factors did however; defy the general trends found in the results. A likely reason for the possibility of a lack of statistical correlation between variables is that a type II error in the Spearman’s correlation analysis due to the small sample size may have occurred. A larger sample size would be warranted in future studies of this nature.

The null hypothesis as stated at the beginning of this study, *viz.* in runners with low back pain, perceived performance and low back pain will not change pre- and post- spinal manipulative therapeutic care and will not be positively or negatively related after receiving spinal manipulation, was therefore accepted.

5.3 Conclusions

In conclusion, this study has shown favourable results in presenting that spinal manipulation significantly improved LBP. Similarly, according to the results found with the “Perception of Performance” questionnaire under the sub-sections “perceived performance”, “motivation”, and “clinical reality”, significant improvements were noted with a course of spinal manipulative therapeutic care. No relationship was found though between the variables of the “Perception of Performance” questionnaire apart from that which lay between an increase in average mileage and a decrease in overall motivation.

Literature suggests that fatigue plays an important role in running performance. In the current study, although no direct relationships were found (apart from a correlation between an increase in average mileage and a decrease in overall motivation) between LBP and perceived performance, a significant association did exist between the subject initial perceptions and their perceived performance after spinal manipulation. Given a larger sample size there is the potential for a significant finding.

5.4 Recommendations

The recommendation for future studies is as follows:

- A larger sample size would be required to increase the validity of the study, to prevent the likelihood of a Type II error from occurring in the analysis of data.

- The reliability of measurement of the performance indicators according to the scales was fair, although in future studies this could be improved upon by omission of certain items, namely MT3 (motivation question 3) and CR4 (clinical reality question 4) in the questionnaire. Further pilot study of the "Perception of Performance" questionnaire would add to the reliability of the study.

- As this study was a pilot study, further studies would need to be conducted in order to isolate and analyse those factors that would most affect a runner's perceived performance.

- A more homogenous group toward a specific performance standard of runner, such as elite or slow runners, as well as standardized training routines for the duration of the study might also provide a better sample of results.

- Any future questionnaire should include "Sensation of Fatigue" as a category.

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Appendices

Appendix A

DURBAN UNIVERSITY OF TECHNOLOGY
CHIROPRACTIC DAY CLINIC
CASE HISTORY

Patient: ______________________________ Date: __________

File # : ____________ Age: __________

Sex : __________ Occupation: ______________________

Intern : ______________________ Signature ______________

FOR CLINICIANS USE ONLY:
Initial visit
Clinician: Signature :

Case History:

Examination:
Previous: Current:

X-Ray Studies:
Previous: Current:

Clinical Path. lab:
Previous: Current:

CASE STATUS:

PTT:	Signature:	Date:

CONDITIONAL:
Reason for Conditional:

Signature: Date:

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

Page 1 of 4

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:		
▸ Cause:		
▸ Duration		
▸ Frequency		
▸ Pain (Character)		
▸ Progression		
▸ Aggravating Factors		
▸ Relieving Factors		
▸ Associated S & S		
▸ Previous Occurrences		
▸ Past Treatment		
▸ Outcome:		

4. **Other Complaints:**

5. **Past Medical History:**

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

6. Current health status and life-style:

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

7. Immediate Family Medical History:

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

8. Psychosocial history:

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

9. Review of Systems:

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

Appendix B

Durban University of Technology

PHYSICAL EXAMINATION: SENIOR

Patient Name : ______________________ **File no :**________ **Date :**________
Student : **Signature :**

VITALS:

Pulse rate:			Respiratory rate:	
Blood pressure:	R	L	Medication if hypertensive:	
Temperature:			Height:	

Weight:	Any recent change? Y / N		If Yes: How much gain/loss	Over what period

GENERAL EXAMINATION:

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

SYSTEM SPECIFIC EXAMINATION:

CARDIOVASCULAR EXAMINATION

RESPIRATORY EXAMINATION

ABDOMINAL EXAMINATION

NEUROLOGICAL EXAMINATION

COMMENTS

Clinician: **Signature :**

Appendix C

REGIONAL EXAMINATION - LUMBAR SPINE AND PELVIS

DURBAN UNIVERSITY of TECHNOLOGY

Patient:______________________________ File#:______Date:_________

Intern\Resident:________________________ Clinician:_________________

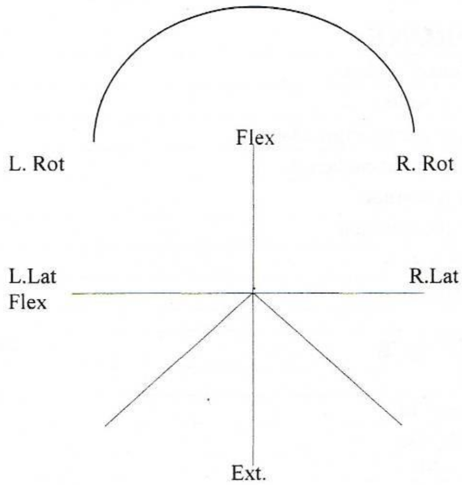
STANDING:

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

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

GAIT:

Normal walking
Toe walking
Heel Walking
Half squat



ROM:

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

Which movt. reproduces the pain or is the worst?

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

SUPINE:

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

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

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

SITTING:

Spinous Percussion
Valsalva
Lhermitte

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

Slump 7 test	**L**										
	R										

LATERAL RECUMBENT:

	L	R
Ober's		
Femoral n. stretch		
SI Compression		

PRONE:

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

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

NON ORGANIC SIGNS:

Pin point pain
Axial compression
Trunk rotation
Burn's Bench test

Flip Test
Hoover's test
Ankle dorsiflexion test
Repeat Pin point test

NEUROLOGICAL EXAMINATION

Fasciculations

Plantar reflex

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

MYOTOMES

Action	Muscles	Levels	L	R	
Lateral Flexion spine	Muscle QL				
Hip flexion	Psoas, Rectus femoris				5+ Full strength
Hip extension	Hamstring, glutes				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,				
Knee extension	Quad				W - wasting
Ankle plantarflex	Gastroc, soleus				
Ankle dorsiflexion	Tibialis anterior				
Inversion	Tibialis anterior				
Eversion	Peroneus longus				
Great toe extens	EHL				

BASIC THORACIC EXAM

History
Passive ROM
Orthopedic

BASIC HIP EXAM

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

MOTION PALPATION AND JOINT PLAY

	L	R
Upper Thoracics		
Lumbar Spine		
Sacroiliac Joint		

Appendix D

DURBAN UNIVERSITY OF TECHNOLOGY

DURBAN UNIVERSITY of TECHNOLOGY

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

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

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

0: **P:**

E:

Special attention to: **Next appointment:**

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

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

O: **P:**

E:

Special attention to: **Next appointment:**

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

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

O: **P:**

E:

Special attention to: **Next appointment:**

Appendix E

INFORMED CONSENT FORM

(To be completed by patient / subject)

Date :
Title of research project :

An investigation into perceived performance in runners with low back pain and receiving spinal manipulation over time.

Name of supervisor: Dr. N.L. de Busser (MTech: Chiropractic)

Tel : (031) 204 2244
Name of research student: Mr. P.E. Rodda

Tel : (031) 204 2205

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. Who have you spoken to?

7. Do you understand the implications of your involvement in this study?
Yes No

8. 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

9. Do you agree to voluntarily participate in this study?
Yes No

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: ______________

Witness Name: ______________________ Signature: ______________

Research Student Name: ______________________ Signature: ______________

Appendix F

Letter of Information

Dear Participant

Welcome to my study.
Title of Study:

An investigation into perceived performance in runners with low back pain and receiving spinal manipulation over time.

Supervisors: Dr. N.L. de Busser (MTech: Chiropractic)
(031) 204 2244

Research student: Phillip Edward Rodda (031) 2042205

Institution: Durban University of Technology

Purpose of the study:

The purpose of this study is to determine whether spinal manipulation improves low back pain in runners and to establish the relationship between low back pain and their subjective performance. The participants will be placed into a group of 40 runners with low back pain who will undergo spinal manipulation. Patients will fill out a questionnaire on the relationship of low back pain to their running before each consultation.

Procedures

The consultation for this appointment will take place at the at the Durban University of Technology Chiropractic clinic or at sports clubs around the greater Ethekweni (Durban) area. At this consultation, you will be required to have a case history taken, physical examination and lower back regional examination done. You will then be required to fill out a "Perceived Performance" questionnaire. This consultation will be approximately one hour long.

Risks/Discomfort

Mild discomfort may be felt during spinal manipulation due to the nature of the procedure, however the procedure will be fully explained beforehand, and you are free to withdraw from the research at any time.

Benefits:

Your contribution to this study by volunteering to partake will help us Chiropractors to build on our knowledge. This will benefit you as a patient, as we will be able to provide you with more effective health care in the future. This study will give you a better understanding on how low back pain will affect your running performance. On completion of your participation of this study, you will be eligible for 1 free FULL treatment at the Durban University of Technology Chiropractic Day Clinic.

New Findings:

You will be made aware of any new findings during the course of this study.

AS A VOLUNTARY PARTICIPANT IN THIS RESEARCH STUDY, YOU ARE FREE TO WITHDRAW FROM THE STUDY AT ANY TIME, WITHOUT GIVING A REASON.

Cost of the study

The testing procedure will be free of charge and your participation in this study is voluntary.

Confidentiality

All patient information is confidential. The results of this study will be used for research purposes only. Only individuals that are directly involved in this study (Dr. N.L. de Busser (MTech: Chiropractic) and myself) will be allowed access to these records.

Persons to contact should you have any problems or questions:

Should you have any questions that you would prefer being answered by an independent individual, feel free to contact my supervisors on the above numbers. If you are not satisfied with a particular area of this study, please feel free to forward any concerns to the Durban University of Technology Research and Ethics Committee.

Thank you for participating in my research study.

__________________ Date:__________________

Phillip Edward Rodda
(Research Student)

Appendix G: General Advertisement

Are you a

Runner between the ages

of 18-45?

Do you suffer with Low

Back Pain?

Male and female subjects are required to participate in research which is being conducted at the Chiropractic Day Clinic at **Durban University of Technology** to assess **the effect of LOW BACK PAIN in runners on performance.**

For a **FREE** assessment call **Phillip Rodda**

(031) 204 2205

Name: ____________________ File No.: __________

Appendix H

"Perception of running performance" Questionnaire

Which statement below most accurately represents how you feel about the following? Mark each answer with a cross.

Perceived Performance

My low back pain currently interferes with my training schedule	Not at all	Limits me slightly	Limits me somewhat	Limits me to a large extent	Severely limits me	Stops me altogether
My mileage has -	Greatly Decreased	Moderately Decreased	Slightly Decreased	Slightly Increased	Moderately Increased	Greatly Increased
The speed of my runs has -	Greatly Decreased	Moderately Decreased	Slightly Decreased	Slightly Increased	Moderately Increased	Greatly Increased
If your previous performance level without low back pain would be rated as 100 percent, how would you rate your current level of performance? (Write this down as a percentage between 0 and 100.)	0-100%					

What has your mileage for the week been? (Kilometres)
What has your average pace for the week been? (Minutes per kilometre)

Motivation

My motivation is currently affected by my pain -	Much Less	Moderately Less	Slightly Less	Slightly More	Moderately More	Much More
My low back pain gets me down when I think of its effect on my running -	Much Less	Moderately Less	Slightly Less	Slightly More	Moderately More	Much More
My desire to run, due to my current low back pain is -	Greatly Reduced	Moderately Reduced	Slightly Reduced	Slightly Improved	Moderately Improved	Greatly Improved
My low back pain currently has changed my expectations from running	Not at all	Slightly	Somewhat	To a large extent	Severely	Stops me altogether
Pain currently affects the amount of effort I require to run	Not at all	Slightly	Somewhat	To a large extent	Severely	Stops me altogether

Clinical Reality and Intervention

My comfort while running, due to my low back pain currently is -	Greatly Reduced	Moderately Reduced	Slightly Reduced	Slightly Improved	Moderately Improved	Greatly Improved
My stride pattern while running, due to my low back pain currently is -	Much Worse	Moderately Worse	Slightly Worse	Slightly Improved	Moderately Improved	Greatly Improved
My low back pain currently is -	Much Worse	Moderately Worse	Slightly Worse	Slightly Improved	Moderately Improved	Greatly Improved
The time it takes for me to fatigue while running, due to my low back pain currently is –	Much Slower	Moderately Slower	Slightly Slower	Slightly Quicker	Moderately Quicker	Much Quicker
I can endure my pain -	Completely	To a large extent	Generally	Somewhat	Slightly	Stops me altogether

Numerical Pain Rating Scale: 0 1 2 3 4 5 6 7 8 9 10

- Subjects will be required to circle the score which best indicates the severity of their pain.
- A pain score of zero indicates the absence of pain.
- A pain score of ten indicates severe pain.
- A pain score of five indicates moderate pain.

Please circle the most applicable response to the questions below.

What form of treatment would you consider most effective for your injury? ______________________________

After receiving treatment, what would you expect from it?

Complete recovery	Significant relief	Some relief

Would you expect the benefits of treatment to last for -

Hours	Days	Weeks	Months	Years

Do you feel that running puts you at greater risk for wear and tear?

Yes	No

Do you think that you will need ongoing treatment for this condition?

Yes	No

An investigation into the perceived performance in runners with low back pain and receiving spinal manipulation over time

Dr. Phillip Rodda (mtech: chiropractic)[1]

Dr. N.L. de Busser (mtech: chiropractic, MMed Sci.: Sports Medicine)[2]

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Journal Article

An investigation into the perceived performance in runners with low back pain and receiving spinal manipulation over time

Phillip Rodda

INTRODUCTION

It is clear that low back pain (LBP) is a common problem in society, having major financial, medical, social, and personal implications[1]. There is a lot of anecdotal evidence among the running fraternity that supports the claim that there is a similar, if not a higher incidence of low back pain amongst runners for various reasons, the most common being that of impact-loading[2]. This indicates a need to examine its many facets in order to gain a greater understanding of its full implications for runners.

A unique model, called the “central governor” model was proposed to explain the process of muscle fatigue that makes the following assumptions. (1) As at rest, during exercise all physiological functions are homoeostatically regulated by central nervous system control mechanisms to ensure that bodily harm does not result. (2) “The conscious sensation of fatigue does not arise directly from the action of metabolites in the periphery, but rather from the regulatory centres in the subconscious parts of the brain. The sensation of fatigue is therefore not directly related to a physical end point, but is rather an interpretation of the effect of the current level of activity on future exercise capacity and any threats that immediate and future events pose to the maintenance of homoeostasis.”[3] (3) As the sensation of fatigue is an emotion rather than a physical state, pacing strategies and their control during self regulated exercise become important, making the journey and not just the end point an important phenomenon in exercise physiology. This gives fatigue over to central nervous system (CNS) control rather than being a physically based phenomenon[3].

This model suggests that fatigue is controlled by the CNS rather than being a physically based phenomenon. Thus, by implication, fatigue, if controlled by the CNS can affect a person's perception of performance. Indeed this model states that performance itself is most affected not by localised metabolites in the muscle, nor solely by recruitment of motor units but to a large extent, by the CNS at a subconscious level[3].

Many authors[4-8] have made the link between muscle inhibition and LBP as having a cause and effect relationship with each other, whilst also causing muscle fatigability, decreased muscle endurance and muscle weakness.

There are both allopathic[9] and manual[10] therapies available for the treatment of mechanical LBP. However, it has been found that allopathic intervention is generally less effective than manipulative therapy in successfully treating this condition[11].

This research is directed at determining whether spinal manipulation affects the perceived performance of runners with low back pain.

METHODS

Subjects

Twenty (15 men and 5 women) subjects between the ages of 20 and 45 met the inclusion, exclusion and prevailing ethical requirements for this study and gave written informed consent to participate in the study. These subjects all had chronic LBP of more than 6 months and less than 2 years duration and ran an average of greater than 30 kilometers a week for more than 6 months.

Study Protocol

Patients who qualified for the research were assigned to a single treatment group using a non-probable convenience sample in order to attain a more accurate representation of the running population. All patients underwent a full medical history, physical and lumbar and pelvic regional examination prior to commencing the research in order to rule out contra-indications for manipulation and other exclusion criteria.

Before conducting the research, the protocol involved was carefully explained to the patients and the questions of the “Perception of Running Performance” questionnaire were discussed with them in order to familiarise them with the questions and to provide opportunity to clear up any misinterpretations of the questionnaire.

After completing the questionnaire, patients received a spinal manipulation of their lower back according to the findings on motion palpation of the spinal segments. This procedure was repeated twice a week for two weeks[12]. The “Perception of Running Performance” questionnaire was filled in prior to each spinal manipulation and at a consultation one week following the final spinal manipulation.

Measurement Techniques

- **“Perception of Running Performance” questionnaire.**

The research was based upon the “Perception of Running Performance” questionnaire which comprised of twenty-two questions placed into five major categories, being the NRS, Perceived Performance, Motivation, Clinical Reality and Treatment questions. The questionnaire was piloted for the purposes of this study.

The purpose of the "Perceived Performance" sub-section of questions was to establish the external training variables and how they interacted to affect a subject's perceived performance. These external variables included the subjects' training schedule, weekly mileage, the average weekly speed of runs, and the perceived level of performance as altered by their LBP.

The "Motivation" sub-section of questions was designed to determine those intrinsic or mental factors, namely a change in motivation, depression, desire, expectation and effort that a runner with LBP could experience.

The "Clinical Reality" questions were intended to extract those physical factors that would influence a person's perceived performance should they suffer from LBP, and included comfort, stride pattern, change in back pain, effort and endurance of their pain.

- **Numerical Rating Scale (NRS)**

The numerical rating scale was used to capture subjective data in order to assess the direct association of LBP with spinal manipulation.

Spinal Manipulation

The lower back functional assessment included active and passive range of motion, motion palpation of the spinal segments and sacroiliac joints, and orthopaedic testing. Symptomatic low back pain was categorized as that which elicited an exacerbation of pain with at least two of the following provocative tests:

- Erichsen's Test[13].

- Gaenslen's Test[14].
- Patrick's FABER (Flexion, ABduction and External Rotation) Test[15].
- SI Compression Test[13].
- Kemp's Test[11].
- Facet Joint Challenge.
- Straight leg raiser Test[11].

In addition to the lower back functional assessment, all patients received a manipulation of the sacroiliac joint or lumbar facet joint depending on the findings of the assessment. The spinal manipulation was performed by using a high-velocity low-amplitude thrust in the side-lying position. The contact point and direction of the thrust were chosen in accordance with the symptoms of a given patient. The lower back functional assessment was then repeated to evaluate whether the adjustment had corrected the involved joint dysfunction.

Statistics

The unit of analysis in this case were "runners" defined as those who ran more than 30-kilometres per week for six months, with mechanical LBP induced by running.

SPSS version 13.0 (SPSS Inc., Chicago, IL) was used to analyse the data. Raw scores for questionnaire items which were negatively phrased were reversed, and scores for items under the same headings were summed up to create a composite score, such that the higher the score was, the better the outcome. In the case of Perceived Performance, only the first three items were used in the composite score as these were the only items on the same scale. Items 4, 5 and 6 of the perceived performance section were analyzed and treated separately.

Non parametric Friedman tests were used to compare pain scores, raw scores and composite scores over time where there were five time points being compared. Where only two time points were compared, Wilcoxon signed ranks tests were used. Box and whisker plots were used to show the trends graphically. The change in scores from the first time point to the fifth time point were computed by subtracting the first time point score from the fifth time point score, and Spearman's rank correlation test was used to assess relationships between changes in outcome variables.

Cronbach's alpha statistic was used to assess the reliability of the scales using baseline (first time point) data.

Results and Discussion

- **Low Back Pain**

The results of this study show a marked and highly significant statistical decrease in the NRS between the first and last visits of the research protocol, indicating a strong improvement in low back pain in runners with spinal manipulation. This confirms findings[16-17] of similar results amongst the normal population.

- **Perceived Performance**

It is noted[18] that LBP could potentially cause a decrease in functional performance amongst athletes. This claim is also supported by findings[8] on EMG which showed changes that were coherent with a functional adaptation to muscle pain that agreed with similar studies[5-6]. Research[7] indicates not only a correlation between chronic LBP and decreased trunk muscle endurance, but also between the associated increase in trunk muscle fatigability and quadriceps inhibition. It was found[19] that a decrease of 7,5% in muscle inhibition post sacroiliac manipulation indicating positive benefits from sacroiliac manipulation in treating muscle inhibition.

These results indicate that the participants' overall perceived performance score improved over the course of spinal manipulation, enough to be highly statistically significant. When asked to write down their current level of performance, again an improvement was shown that was highly statistically significant thus re-iterating the improvement in participants' perception of how low back pain affected their training schedule, mileage and pace.

This correlates strongly with the proposed "central governor" theory[3] in which it is maintained that during exercise, the CNS continuously modifies pace as a part of a complex dynamic system based on metabolic calculations at a subconscious CNS level.

It is interesting to note in this study, where the subjects were required to record actual figures of their average weekly mileage and pace, although there was a slight improvement in both, neither was statistically significant.

- **Motivation**

Another premise of the "central governor" model would be that the conscious sensation of fatigue, the controlling factor in perceived performance, does not arise directly from the action of metabolites in the periphery, but rather from regulatory centres in the subconscious parts of the brain. The sensation of fatigue is therefore not directly related to a physical end point, but is rather an interpretation of the effect of the current level of activity on future exercise capacity and any threats that immediate and future events pose to the maintenance of homoeostasis[3].

The factors of motivation as mentioned above were analysed and showed a statistically significant improvement between the first and last consultations, indicating that an improvement in low back pain would result in an improvement in motivation.

- **Clinical Reality**

It is noted[3] that factors such as prior knowledge gained from previous exercise experience, the planned end point of an exercise, and the current metabolic rate, amongst many other potential variables such as unexpected exercise duress[20], may play a role in how the CNS processes and utilises current information. These factors point toward the outer manifestation of what is happening at a CNS or subconscious level and would be correlated by such factors as mentioned above.

Statistically the mean score for this group of questions showed a significant improvement, suggesting that an improvement in LBP would be related to an improvement in those external factors that would have an impact on perceived performance.

- **Relationships**

In the above sections, the “central governor” model as proposed by Noakes *et al.*[3] has been mentioned on several occasions with regard to its pertinence in understanding the results of the “Perception of Performance” questionnaire. One of the objectives of this study is to correlate the varying factors as they have been discussed above in order to get a perspective not only of their importance in how they affect low back pain individually, but also in how they relate to each other.

Spearman’s correlation analysis was used to assess the various questions posed in the “Perception of Performance” questionnaire according to their relationships with each other. A correlation was found between the average weekly mileage and the overall motivation score, whereby an increase in mileage was related to a decrease in motivation. This indicated that as participants increased their mileage they found it difficult to maintain the motivation to train. It would thus stand to reason that the longer the distance covered in training, the less the motivation would be on behalf of the athlete.

Another important finding in the Spearman's correlation analysis was that there was no other significant statistical correlation between any other variable. This indicated that a change in LBP was not associated with a change in "perceived performance", "motivation" or "clinical reality". This lack of a statistically significant relationship between these factors did however; defy the general trends found in the results. A likely reason for the possibility of a lack of statistical correlation between variables is that a type II error in the Spearman's correlation analysis due to the small sample size may have occurred. A larger sample size would be warranted in future studies of this nature.

CONCLUSIONS

In conclusion, this study has shown favourable results in presenting that spinal manipulation has significantly improved LBP. Similarly, according to the results found with the "Perception of Performance" questionnaire under the sub-sections "perceived performance", "motivation", and "clinical reality", significant improvements were noted with a course of spinal manipulative therapeutic care. No relationship was found though between the variables of the "Perception of Performance" questionnaire apart from that which lay between an increase in average mileage and a decrease in overall motivation.

Literature suggests that fatigue plays an important role in running performance. In the current study, although no direct relationships were found (apart from a correlation between an increase in average mileage and a decrease in overall motivation) between LBP and perceived performance, a significant association did exist between the subject initial perceptions and their perceived performance after spinal manipulation. Given a larger sample size there is the potential for a significant finding.

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