AN INVESTIGATION INTO THE EFFECT OF A HIGH VELOCITY LOW AMPLITUDE MANIPULATION ON CORE MUSCLE STRENGTH IN PATIENTS WITH CHRONIC MECHANICAL LOWER BACK PAIN.

BY

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DEDICATION

I dedicate this dissertation to my family who has given me inspiration, guidance and encouragement to follow my dreams, to keep looking to the future and achieve my goals.

And to my loving husband, Rowley, thank you for your constant love, support and belief in me.

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ABSTRACT

Brunarski (1984) says that philosophically and historically, chiropractic has been uniquely orientated toward an emphasis on preventative care and health maintenance with a mechanistic and hands-on model for treatment. Instead of reductionism, chiropractors focus on holism, non-invasiveness and the sharing of the responsibilities for healing between doctor and patient.

As stated in a Canadian report by Manga *et al.* (1993), lower back pain is a ubiquitous problem and there are many epidemiological and statistical studies documenting the high incidence and prevalence of lower back pain (Manga *et al*., 1993).

Evans and Oldreive (2000) revealed in a study of the transversus abdominis that low back pain patients had reduced endurance of the transverses abdominis and that its protective ability was decreased. In addition, it was noted that wasting and inhibition of the other core stabiliser and co-contractor, multifidus, was present (Hides *et al*.,1994), both of which have been linked to the presence of low back pain (Evans and Oldreive, 2000 and Hides *et al.,* 1994).

Thus, it stands to reason that manipulation, as an effective treatment for low back pain (Di Fabio, 1992), could be effective in restoring the strength and endurance of the core stability muscles.

This is theoretically supported by the fact that a restriction in motion and pain due to mechanical derangement in the low back can be effectively treated by manipulation (Sandoz, 1976; Korr (Leach, 1994); Herzog *et al.,* 1999; Homewood, 1979; Vernon and Mrozek, 2005 and Wyke (Leach, 1994)).

Homewood (1979) described that a subluxation may interfere with the nerve supply and result in a decrease in muscular activity. He hypothesized that removal of the subluxation could restore: normal physiological processes, increase muscle activity and; improve functional ability and normalize the torque ratios (Herzog *et al*., 1999; Korr (Leach, 1994); Nansel *et al.,* 1993 and Rebechini-Zasadny *et al.,* 1981).

In terms of an intervention, Rebechini-Zasadny *et al.* (1981) and Naidoo (2002) demonstrated and inferred that manipulation to the cervical spine could affect the muscular activity supplied by those levels. They, however, suggested further studies of manipulation-induced peripheral changes in the muscles are needed, due to unaccounted for variables and small sample sizes in their respective studies

This research aims to address the questions posed by the above literature, hence by investigating a high velocity low amplitude manipulation as a possible added intervention for improving local core stabilizer muscle strength, a management protocol for the chronic mechanical lower back pain could be developed.

This study therefore comprised of sixty participants suffering from chronic mechanical low back pain. The patients were allocated into one group, who underwent a single treatment protocol. Potential candidates were assessed at the initial consultation. Patients who complied with the inclusion criteria for the study were accepted into the research program. Patients who displayed any of the exclusion criteria were not accepted into the research program.

The initial consultation took place at the Chiropractic Day Clinic on the Durban Institute of Technology campus. During the first consultation the most symptomatic joints were (facet and/or sacroiliac joints) identified by motion palpation of the lumbar spine and sacroiliac joints (Schafer and Faye, 1990:211-217).

Subjective and objective findings were recorded using the NRS, RMQ, Inclinometer, Algometer and Stabilizer Biofeedback Device.

The patient was educated on how to contract the transverse abdominal muscle by using the four-point kneeling position test (Evans and Oldrieve, 2000). An abdominal draw in test with a pressure biofeedback unit was used to measure the participant's transverse abdominal muscle strength and fatigability in both the prone and supine position.

The results would seem to indicate that muscle activation and endurance are affected by the manipulation, whereas the strength of the muscle is affected to a limited extent by the manipulation. It would seem that the manipulation restores normal neurological and physiological parameters in order for muscular strength to improve over time. It therefore stands to reason that the limit of 48 hours on the re-assessment of the patient would not have allowed strength to have developed.

In support of the above conclusions, the correlations between the algometer readings and the changes indicated over the same periods showed that the degree of pressure that the patient could sustain was increased immediately after the intervention with a slight decrease over time. Thus, a neurological reflex is initiated (to varying degrees) and associated with a physiological response over time.

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LIST OF ABBREVIATIONS

SBD	- stabilizer biofeedback device
NDA	- non-digital algometer
NRS	- numerical pain rating scale
L	- lumbar vertebra
SI	- sacro-iliac
RMQ	- Roland Morris Questionnaire
SD	- Standard Deviation
TrA	- Transversus Abdominis
MF	- Multifidus
LBP	- Lower back pain
SMT	- Spinal Manipulative Therapy
QL	- Quadratus Lumborum
PSIS	- Posterosuperior iliac spine
AMI	- Arthrogenic muscle inhibition

DEFINITION OF TERMS

Dysfunction – The dysfunction implies that one of the three components of the joint is not functioning normally. It refers to any joint where there is decreased or aberrant mobility for which manipulation is indicated (Kirkaldy-Willis and Burton, 1992:105).

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

Manipulation – It is a passive movement of low amplitude and high velocity, which moves a joint into the paraphysiological space. This is accompanied by cavitation or gapping of the joint, which is thought to involve gas separating from fluid, and attempts to increase the manipulated joint's range of motion (Haldeman, 1993:103).

Mechanical Low Back Pain – This is defined as pain resulting from the inherent susceptibility of the spine to static loads due to muscle, gravity forces and to kinetic deviation from the normal function (Gatterman, 1990:129).
Uncomplicated mechanical lower back pain refers to low back pain within the dysfunction stage, according to Kirkaldy-Willis classification and specifically to the posterior facet syndrome and sacroiliac syndrome (Kirkaldy-Willis, 1988:133-135). Therefore for the purpose of this research mechanical lower back pain would specifically refer to posterior facet syndrome and sacroiliac syndrome.

Objective clinical findings – These are defined as those clinical findings ascertained using a full case history, physical examination, orthopaedic and neurological examinations including pain sensitivity, using an algometer, and range of motion of the lower back, using the inclinometer, and core muscle strength, using the biofeedback device.

Posterior facet syndrome - Has been described as pain often localised and unilateral at the level of the involved facet joint. In addition pain may be referred to the groin, greater trochanter and to the posterior thigh as far as the knee (Kirkaldy-Willis *et al*., 1992:106).

Sacroiliac (SI) Syndrome - Has been described as pain over one sacroiliac joint in the region of the posterior superior iliac spine with decreased mobility of the joint resulting from derangement of the sacroiliac joint. This may also be accompanied by referred pain to the buttock, groin and leg (Kirkaldy-Willis *et al.,* 1992).

Strength - Is defined by Lewis *et al.* (1991) as being a function of muscle cross-sectional area, motor-unit recruitment and neuromuscular coordination, which has the ability to develop force in a maximal-effort voluntary contraction of rested muscle. Strength is defined as the rotational effect of the force, generated by a single muscle or muscle group, about the joint under consideration, and is also termed the moment (Dvir, 2004). The common understanding of strength is the point in the range of motion where strength reaches its maximum; hence the term peak moment or peak torque is used in the literature to describe strength (Dvir, 2004).

Subjective clinical findings - These are defined as these clinical findings ascertained using the patient's perception of pain including the Roland – Morris Lower back pain Questionnaire and the Numerical Pain Rating Scale.

CHAPTER ONE

1. INTRODUCTION

1.1 THE PROBLEM AND ITS SETTINGS

As stated in a Canadian report by Manga *et al.* (1993), lower back pain is a ubiquitous problem and there are many epidemiological and statistical studies documenting the high incidence and prevalence of lower back pain (Manga *et al*., 1993). In this respect, lower back pain is estimated to effect between 60-90% of the world's population sometime during their lives, while between 20-30% of people suffer from low back pain at any given time (Cassidy and Burton, 1992:3). Locally, epidemiological studies into low back pain have revealed incidence rates of 57.6% among black South Africans (Van der Meulen, 1997) and the lifetime incidence of low back pain in Indian and Coloured communities in South Africa was found to be 78.2% and 76.6% respectively (Docrat, 1999).

Kirkaldy-Willis (1992:129) found that along with myofascial pain syndrome, posterior facet syndrome and sacroiliac joint syndrome accounted for 50% of cases of low back pain seen at the Royal University Hospital in Saskatoon over a 10-year period. The majority of these cases had been treated with the use of spinal manipulation, where the emphasis is on restoring joint mobility. This approach to treatment has been shown to be one of the most effective approaches in the management of low back pain of a mechanical origin (Di Fabio, 1992).

With respect to restriction in motion (as found in posterior facet syndrome and sacroiliac joint syndrome), Sandoz (1976) proposed a model, where he postulated that there is a paraphysiological space[1]. It is claimed that adjusting into this paraphysiological space can restore joint range of motion at or near the end of the joints' range of motion. And that through manipulation peripheral effects can also be induced [Korr (Leach, 1994), Herzog *et al.,* 1999 and Homewood, 1979].

[1] Beyond the passive range, but less than the anatomic limit (Sandoz, 1976).

Vernon and Mrozek (2005) challenge Sandoz's (1976) hypothesis by stating that it is not normal joints that are been manipulating, but clinically compromised joints. The range of motion available in the clinically compromised joint is less than that which is available at the end range of motion[2]. This, decreased range of motion in the clinical setting, is referred to as the "clinical physiological range" by Vernon and Mrozek (2005). Thus, it is implied that with a "clinical physiological range", when manipulation is performed we as chiropractors are unable to attain the paraphysiological space as previously thought by Sandoz (1976).

This minor difference implied by Vernon and Mrozek (2005) in conjunction with the theories of Wyke (Leach, 1994) has clinical implications for the improvement of the patient. This improvement is related to the degree of neurological stimulation that each of the two situations (asymptomatic and symptomatic) presents with. The asymptomatic patient has greater neurological stimuli, as the degree of tension placed in the joint is greater whereas the opposite is true of the symptomatic patient, when manipulation is applied.

This is supported by (Klein *et al.,* 2002) who proposed the "elastic zone" beyond the neutral zone (Panjabi *et al.,* 1988). In the "elastic zone", tissues undergo physiological levels of strain, but which are still less than the anatomical limit of integrity at which maximum tissue damage occurs (Vernon and Mrozek, 2005 and Sandoz, 1976).

However, it has also been noted that an asymptomatic patient may in the presence of an adhesion display similar responses to manipulation as a symptomatic patient (Vernon and Mrozek, 2005). This is supported by the adhesion hypothesis (Leach, 1994), which states that a fixation causes a restriction in movement or immobilization as well as an acute period of inflammation. This immobilization and inflammation is thought to cause "adhesion formation" within and between the connective tissues or as a result of haphazard fibrin deposits as a result of the inflammatory cycle. This limits the extensibility of the connective tissue and thus results in a further restriction of movement within the already fixated joint. Therefore, even after the resolution of the signs and symptoms as related to an acute period of lower back pain, the adhesion

[2] That is less than the elastic barrier as referred to by Sandoz (1976).

formation still remains as long as the patient does not seek treatment at the time of the acute pain or at a later date (Leach, 1994). This adhesion would limit the movement of the joint to within a "clinical physiological range" even though the patient may be asymptomatic.

Thus, the fixated segment group (symptomatic or asymptomatic with restriction) requires the breaking of the adhesions and therefore there is a decreased chance of entering the paraphysiological space. This would therefore imply that the degree of neurological stimulation of the surrounding tissues is less as the patient's joint is maintained within the "neural zone"[3] (Panjabi *et al.,* 1988).

In addition to this, a study of the transversus abdominis by Evans and Oldreive, (2000) found that low back pain patients had reduced endurance of the core stabilizer muscles and that its protective ability was decreased (Evans and Oldreive, 2000). Furthermore, it was noted that wasting and inhibition of the other core stabiliser and co-contractor, multifidus, was present (Hides *et al*., 1994) in chronic low back pain.

As a result, it stands to reason that manipulation, as an effective treatment for low back pain (Di Fabio, 1992), could be effective in restoring the strength and endurance of the core stability muscles.

This is theoretically supported by the fact that a restriction in motion and pain due to mechanical derangement in the low back can be effectively treated by manipulation [Sandoz, 1976; Korr (Leach, 1994); Herzog *et al.,* 1999; Homewood, 1979; Vernon and Mrozek, 2005 and Wyke (Leach, 1994)].

In addition to and with respect to compromised spinal joint motion, Homewood (1979) described that a subluxation may interfere with the nerve supply and result in a decrease in muscular activity. He hypothesized that removal of the subluxation could restore: normal physiological processes, increase muscle activity and, improve functional ability and normalize the torque ratios [Herzog *et al*., 1999; Korr (Leach,

[3] Panjabi *et al*. (1988) postulated a theory of a 'neutral zone' around which the passive lumbar spine operates and where there is little if no perceived stress on these tissues

1994); Nansel *et al.,* 1993 and Rebechini-Zasadny *et al.,* 1981]. Similarly Haldeman (1992) refers to Vernon *et al.* (1986) who states evidence that sensorimotor reflex connections are influenced by manipulation via stimulation of segmental motor pools, which in turn could reduce both pain and muscle hypertonicity. One could therefore reasonably argue then that any factor, which impacts on the nervous system at these levels, could affect the muscles supplied by those levels (Naidoo, 2002).

To support the above, Hamilton *et al.* (2004) correlated that the number of motor-units innervating a muscle relates positively to the strength of that muscle. Thus, it could be hypothesized that manipulation could have a positive effect on the motor units, which could in turn mean that manipulation may have an affect on the strength of the muscle innervated by those motor units.

Thus, this research aimed to address the questions posed by the above literature, by quantifying the immediate effect of a high velocity low amplitude manipulation, in terms of strength on the local core musculature in patients with chronic mechanical lower back pain, in order to assess the hypotheses put forward by Evans and Oldrieve (2002). Hence by investigating a high velocity low amplitude manipulation as a possible added intervention for improving local core stabilizer muscle strength, a management protocol for the chronic mechanical lower back pain could be developed.

1.2 AIMS AND OBJECTIVES OF THE STUDY

The aim of this investigation was to evaluate the effect of lumbar and sacroiliac manipulation on core muscle strength in a patient with chronic mechanical lower back pain.

Objective 1: To evaluate whether manipulation has an effect on the core stabilizer muscles strength.

Hypothesis 1

Manipulation had an effect on the core stabilizer muscles strength.

Objective 2: To evaluate whether manipulation has an effect on the core stabilizer muscles endurance.

Hypothesis 2

Manipulation had an effect on the core stabilizer muscle endurance

Objective 3: To evaluate whether changes in the core stabilizer muscle strength and core stabilizer muscle endurance correlate with the clinical indicators with respect to mechanical lower back pain.

Hypothesis 3

Improvement in core stabilizer muscle strength and/or core stabilizer muscle endurance will correlate with the clinical indicators (decrease in NRS and RMQ, and increase in algometer and inclinometer readings) with respect to mechanical lower back pain.

1.3 RATIONALE / NEED FOR THE STUDY

1) Brunarski (1984:243) says that philosophically and historically, chiropractic has been uniquely orientated toward an emphasis on preventative care and health maintenance with a mechanistic and hands-on model for treatment. Instead of reductionism, chiropractors focus on holism, non-invasiveness and the sharing of the responsibilities for healing between doctor and patient.

2) Health researchers have shown that low back pain is one of the most costly health problems in the world today (Manga *et al*., 1993). Thus, there may be an argument that chiropractors are uniquely posed to assist with resolving this costly health problem.

3) Furthermore, Evans and Oldreive (2000) revealed in a study of the transversus abdominis that low back pain patients had reduced endurance of the transversus abdominis and that its protective ability was decreased. In addition it was noted that wasting and inhibition of the other core stabiliser and co-contractor, multifidus, was present (Hides *et al*., 1994). Both of which have been linked to the presence of low back pain (Evans and Oldreive, 2000 and Hides *et al.,* 1994).

4) In terms of an intervention, Rebechini-Zasadny *et al.* (1981) and Naidoo (2002) demonstrated and inferred that manipulation to the cervical spine could affect the muscular activity supplied by those levels. They, however, suggested further studies of manipulation-induced peripheral changes in the muscles are needed, due to unaccounted for variables and small sample sizes in their respective studies.

As a result of the above 2 rationales (point 3 and 4) and Herzog *et al.* (1999), who showed a consistent reflex response associated with spinal manipulative treatments, which have been hypothesized to have a beneficial effect on functional ability, reducing pain and inhibiting hypertonic muscles; it would seem fair to state that manipulation should have an affect on peripheral musculature.

In support of this, Suter *et al.* (2000) revealed that muscle weakness has been attributed to muscle inhibition. The potential of muscle inhibition to limit functional recovery of muscles and joints after injury has been recognized and it has been suggested that one of the early goals in the rehabilitation process should be to reduce or eliminate muscle inhibition to achieve full recovery of the affected structures.

This rationale would therefore support the use of manipulation in order to restore the strength on the local core musculature in patients with chronic mechanical lower back pain.

1.4 CONCLUSION

In order to elaborate on the literature available in support of the suggestions presented in chapter 1, it will be presented in chapter 2. Chapter 3 will then address the materials and methods utilized in the study, were chapter 4 will present the results and the discussion of the results. In conclusion, chapter 5 will present the final analysis of the study with the recommendations stemming from the results obtained.

CHAPTER TWO

2. REVIEW OF THE RELATED LITERATURE

2.1 INTRODUCTION

This chapter aims to inform the reader of the relative effects that manipulation is thought to have on the core muscle strength and fatigability. In order to establish a greater understanding of low back pain, it is important to outline the relevant anatomy, biomechanics and pathogenesis of the structures related to this condition and the treatment approaches involved.

2.2 ANATOMY

2.2.1 LUMBOSACRAL SPINE

The lumbosacral spine is made of the five lumbar vertebrae, the sacrum and the coccyx. This is a complex structure that is made up of bony elements linked by joint capsules and ligaments, and protected by layers of muscles.

2.2.1.1 BONY ANATOMY

The body of the lumbar vertebrae is a large kidney shaped structure. The size of the vertebral body increases from L1-L5 due to the increase in load each body needs to carry (Moore, 1992).

The vertebral arch is a horseshoe-shaped structure that is made of the lamina and pedicles. Projecting from this are seven processes: superior and inferior processes, a spinous process and paired transverse processes (Moore, 1992).

The sacrum is made of five fused vertebrae. It articulates proximally with the fifth lumbar vertebra, laterally with the ilia and distally with the coccyx (Moore, 1992).

2.2.1.1.1 LUMBAR ZYGOPOPHYSEAL JOINT (Lumbar facet joint)

The lumbar zygopophyseal joint is a typical synovial joint and is formed by the articulation between the inferior articular process of the superior vertebral body, and the superior articular process of the vertebral body below (Kirkaldy-Willis, 1992:7). The lumbar zygopophyseal joints are biplanar, with the major posterior parts approximated to the sagittal plane, with the exception of the lower lumbar zygopophyseal joints that are rotating toward the coronal plat at the lumbosacral junction (Giles, 1997:13). These diarthrodial joints are surrounded by a capsule, ligamentum flavum and synovial joint folds that are lined by a synovial membrane.

2.2.1.1.1.1. FUNCTION

The function of the lumbar zygopophyseal joints is to guide and restrain movement between vertebrae and to protect the discs from shear forces, excessive flexion and axial rotation (Giles, 1997).

2.2.1.1.1.2 INNERVATION

The lumbar spinal nerves divide into anterior and posterior primary rami. The posterior primary rami provide innervations to the lumbar zygopophyseal joints. Each lumbar posterior primary ramus divides into a medial and lateral branch. The medial branch descends beneath the mamilloaccessory ligament and gives of branches to the fibrous capsule as it passes to lie directly superficial to the joint. According to Wyke (Leach, 1994) a zygopophyseal joint is innervated by no less than 3 adjacent posterior primary rami. Most authors, however found each joint to be supplied by only two spinal nerves: one supplying the superior aspect of the zygopophyseal joint capsule and the other supplying the inferior recess region of the zygopophyseal joint at the same level at which the spinal nerve passes through the foramen (Haldeman, 2005).

Gattermann (1995:21) describes three types of sensory receptors within the facet joints:

Type 1: Sensitive static and dynamic mechanoreceptors, which are continuously firing due to continual joint motion.

Type 2: Less sensitive mechanoreceptors which fire only on joint motion.

Type 3: Slow-conducting mechanoreceptors.

In addition to the above, Wyke (Leach, 1994) includes a Type 4 in his classification which is principally related to noxious stimuli and the transmission of nociceptive information to the central nervous system.

2.2.1.1.2. SACROILIAC JOINT

The sacroiliac joint is formed by the articulation between the sacrum and the ilium. The joint is a synovial joint within which the iliac surface is composed of thin fibro-cartilage and the articular surface of the sacrum is composed of hyaline cartilage (Kirkaldy-Willis, 1992:71). The sacroiliac joint is a combination of synarthrodial and diarthrodial joint characteristics, which makes it a unique joint in the body. It is characterized by strong fibrous connections within the joint and strong extra-articular supporting ligaments (McCulloch *et al*., 1997).

This atypical synovial joint is stabilised by various structures (Giles, 1997):

1. Powerful interosseus ligaments
2. A strong articular capsule
3. Posterior sacroiliac ligaments
4. Anterior sacroiliac ligaments
5. The iliolumbar ligament
6. The sacrotuberous ligament
7. The sacrospinous ligament

2.2.1.1.2.1 FUNCTION

This strong, weight bearing synovial joint differs from other synovial joints in that they possess very little mobility. The joint provides for stability and is responsible for transmitting the weight of most of the body to the hip. Because of the irregular articular surface of the sacrum and ilium, they fit securely together and are not easily dislocated. The movement in the sacroiliac joint is limited to a slight gliding and rotary movement, except when a considerable force is applied the force is transmitted via the vertebral column to the sacral base, which rotates anteriorly. The force is then transmitted to each ilium and lower limb (Moore, 1992:251).

2.2.1.1.2.2. INNERVATION

The articular branches to these joints are derived from the superior gluteal nerves, the sacral plexus, and the dorsal rami of S1 and S2 nerves (Moore, 1992:252). The posterior aspect of the sacroiliac joint is innervated by the posterior rami of L5-S2 spinal nerves, and the anterior aspect is innervated by the posterior branches from the L3-S2 nerve roots and the superior gluteal nerve L5-S2.

2.2.2 CORE STABILISATION

Bergmark (1989) categorised the trunk muscles into local and global muscle systems based on their biomechanical roles, thus these two subsystems have been termed Local and Global muscles.

2.2.2.1 GLOBAL MUSCLES

Global muscles are the larger, torque producing muscles. In terms of the abdominal synergy, the global muscles have been described as the muscles linking the thoracic cage to the pelvis (Bergmark, 1989). The role of the global muscles is to provide general trunk stabilisation and to balance external loads, thereby minimising the resulting forces on the spine (Richardson *et al.,* 1995). Examples of the global muscles are the erector spinae and quadratus lumborum muscle (Stanford, 2002).

2.2.2.1.1 PHYSIOLOGY OF GLOBAL MUSCLES

Global muscles or 'movement synergists' like the rectus abdominis, erector spinae and quadratus lumborum have predominantly type ll muscle fibres. Type ll muscle fibres are suited for rapid powerful contractions (Norris, 1995).

Attachments and innervations of the global muscles are summed up in the table 2.1 below.

Table 2.1: Attachments of the global muscles (Travell & Simon's, 1999)

MUSCLE	ORIGIN	INSERTION	INNERVATION
RA	Pubic symphysis and pubic crest	Xiphoid process and 5th to 7th costal cartilages	Ventral rami of the inferior six thoracic nn
QL	Medial half of inferior border of 12th rib and tips of lumbar transverse processes	Iliolumbar ligament and internal lip of iliac crest	Ventral branches of T12 and L1 to L4

2.2.2.2 LOCAL MUSCLES

Local muscles have their origin and insertion on the lumbar vertebrae and control the lateral stiffness and intervertebral relationship of the spinal segments and the posture of the lumbar spine (Bergmark, 1989). The transversus abdominis (TrA) and the multifidus (MF) muscles are considered to be local muscles of the lumbar spine (Evans and Oldreive, 2000).

2.2.2.2.1 PHYSIOLOGY OF LOCAL MUSCLES

Local muscles or 'stability synergists' like the ***transversus abdominis*** have been shown to demonstrate the properties of Type I muscle fibres (Norris, 1995). Type I muscle fibres are considered to be slow, fatigue resistant fibres that can contract for prolonged periods at a low force level (Evans and Oldreive, 2000).

Due to the anatomical attachments of the TrA muscle, it is classed as a postural type muscle as well as a stability synergist (Norris, 1995). The TrA contains slow twitch type I muscle fibres, which means that it is a tonically contracted muscle that has a certain level of muscle tone, continuously present and active to help stabilise joints and maintain posture (Evans and Oldreive, 2000).

TrA recruits its type I slow-twitch fibres at a low level of voluntary contraction (VC), which ensures that the muscle fibres are efficient and meet virtually all their needs via aerobic pathways (Evans and Oldreive, 2000). A relatively low level of muscle force, approximately 25% of maximum voluntary contraction (MVC), is needed to develop the increased muscle stiffness required for spinal stability (Richardson and Jull, 1995).

The ***multifidus muscle*** is also considered to be a local rather than a global muscle in the lumbar spine. The MF muscle also contains slow twitch tonic-type I muscle fibres, which fits its role as a stabiliser (Hides *et al*., 1996).

2.2.2.2.2 ATTACHMENTS OF THE LOCAL MUSCLES

The TrA muscle is the innermost layer of the three flat abdominal muscles. It arises from the lateral third of the inguinal ligament, the inner lip of the iliac crest inferiorly, the thoracolumbar fascia posteriorly and the inner surfaces of the costal cartilages of the lower six ribs superiorly. Its fibres run transversely around the abdominal wall to end in the aponuerotic sheath that attaches to the same muscle of the opposite side via the linea alba (Palastanga *et al.,* 1994).

The MF muscle covers the laminae of S4 to C2 vertebrae. Its fibres pass supero-medially from the vertebral arches to the spinous processes, spanning one to three vertebrae. Acting unilaterally, the multifidus muscle laterally flexes the trunk and rotates it to the opposite side. Acting bilaterally, the MF muscle extends the trunk and stabilises the vertebral column (Moore, 1992:355).

Attachments and innervations of the local muscles are summed up in the table 2.2 below.

Table 2.2: Attachments of the local muscles (Travell & Simon's, 1999)

MUSCLE	**ORIGIN**	**INSERTION**	**INNERVATION**
TrA	Midline linea alba via the rectus sheath and to the pubis through the conjoined tendon	The lateral one-third of the inguinal ligament, to the anterior three quarters of the crest of the ilium, to the thoracolumbar fascia and to the inner surface of the cartilages of the last six ribs.	The branches of the eighth to the twelfth intercostal nerves innervate the TrA muscle. Branches of the iliohypogastric- and ilioinguinal nerves, which stem from the first lumbar nerve, also supply the TrA
MF	Base of a vertebra spinous process	Cross 2-4 segments throughout the thoracic and lumbar spine and attach laterally to a transverse process.	The branches of the dorsal primary divisions of the lumbar spinal nerves innervate the multifidus muscle. The lumbar multifidi are arranged so that the fibers, that move a particular segment, are innervated by the nerve of that segment.

2.2.2.3 FUNCTIONS OF THE TRANSVERSUS ABDOMINIS AND MULTIFIDUS MUSCLES

Various studies involving techniques such as fine wire electromyograghy of the transversus abdominis muscle in response to various limb movements and perturbations of the trunk have revealed evidence of the core stabilising role of ***transversus abdominis*.**

These roles include:

1. TrA is controlled independently of the other trunk muscles, therefore allowing it to be isolated functionally from other abdominal muscles (Richardson *et al.,* 1995).

2. The TrA is involved in the preparation of the body for the disturbance produced by the movement of the lower limbs. Patients suffering from chronic low back pain, show a delayed contraction of TrA which may indicate dysfunction in the neuromuscular control of the local stabilising system, resulting in poor lumbar stabilisation (Richardson *et al.,* 1995).

3. The TrA is the only abdominal muscle active during various phasic movements, highlighting its role as an active stabiliser of the spine (Richardson *et al.,* 1995).

4. TrA is active prior to both upper and lower limb movements in subjects with no history of LBP (Hodges and Richardson, 1999).

5. Contraction of the TrA affects the laxity of the sacroiliac joints to a larger extent than a bracing action using all of the lateral abdominal muscles (Richardson *et al*., 2002).

6. TrA increases stiffness of the spine in a general manner by increasing the intra-abdominal pressure and / or by increasing tension in the thoracolumbar fascia (Evans and Oldreive, 2000). In lower back pain sufferers, a decrease

in endurance of TrA has been shown, which may result in a decrease in lumbar stability.

Recently, in vitro biomechanical studies have shown that the ***lumbar multifidus muscle*** is an important component of lumbar segmental stability (Hides *et al.,* 1996).

1. Acting bilaterally, the multifidus extends the trunk and stabilises the vertebral column (Moore, 1992:355).
2. It is able to provide segmental stiffness and control motion in the neutral zone (Wilke *et al.,* 1995).
3. The multifidus, when it is compared to other muscles in close proximity to L4-L5, contributed two thirds of the increased stiffness imparted by the contraction of the muscles (Wilke *et al.,* 1995).

2.2.2.4. CO-CONTRACTION BETWEEN THE TRANSVERSUS ABDOMINIS AND MULTIFIDUS MUSCLES

These two core stabilisers have been found to be related through a co-contraction pattern (Richardson and Jull, 1995). The recruiting muscles that are in co-contraction are considered to provide support and joint stabilisation even when contractions occur at low levels of maximum voluntary contraction (Richardson and Jull, 1995).

This is in congruence with Richardson (1997) who suggested the stabilizing function of the core musculature can be reduced when an injury to spinal structures occur. In this light the following section will discuss lumbosacral spine dysfunction, as it could be a possible cause of the reduced stabilization function of the local stabiliser.

2.2.3. LUMBOSACRAL SPINE DYSFUNCTION

2.2.3.1. DEFINITION

Joint dysfunction is described as an area of disturbance of function without structural changes yet affecting quality and range of joint motion (Bergmann *et al.,* 1993). Joint fixation is the state whereby an articulation has become temporarily immobilized in a position that it may normally occupy during any phase of physiologic movement (Bergmann *et al.,* 1993). Therefore, both fixation and dysfunction are used to describe a state of altered function commonly described as a subluxation in chiropractic terms.

Thus Haldeman (1992) defines the subluxation as an aberrant relationship between adjacent articular structures that may have functional or pathological sequelae, causing an alteration in the biomechanics and/or neurophysiological reflexes related to these articular structures.

2.2.3.2. CAUSES OF DYSFUNCTION

Soft tissue derangement is thought to be responsible for mechanical dysfunction and may be initiated by: trauma, repetitive motion injuries, postural decompensation, developmental anomalies, immobilization, reflex changes, aging and degenerative disease (Bergmann *et al.,* 1993).

2.2.4 LUMBAR FACET (POSTERIOR) SYNDROME

2.2.4.1. SYMPTOM PRESENTATION:

Pain is often localised and unilateral at the level of the facet / zygopophyseal joint involved. Pain may be referred to the groin, buttocks, greater trochanter and posterior thigh as far as the knee (Kirkaldy-Willis, 1992:203).

2.2.4.2. ASSOCIATED CLINICAL SIGNS:

There is usually tenderness to pressure on one side and at one level over the sacrospinalis and MF muscles. The muscle at the site of the lesion is usually hypertonic (Kirkaldy-Willis, 1992:106). Hyperextension movements of the back increase the pain, where as flexion reduces the pain. There are some activities that may increase the pain such as sleeping on the abdomen, sitting in an upright position, and lifting a load in front of the body at or above the waistline (Gatterman, 1995:162).

2.2.5 SACROILIAC SYNDROME

2.2.5.1. SYMPTOM PRESENTATION

It presents with pain over one sacroiliac joint, in the region of the posterior superior iliac spine. There may be referred pain to the groin, over the greater trochanter, down the back of the thigh to the knee, and occasionally down the lateral of posterior calf to the ankle, foot and toes (Kirkaldy-Willis, 1992:123).

2.2.5.2. ASSOCIATED CLINICAL SIGNS

There is joint tenderness of the sacroiliac joint or tenderness in the buttock. Movement in the joint is normally restricted (Kirkaldy-Willis, 1992:124). The pain is aggravated by provocation tests (McCulloch and Transfelt, 1997).

2.3. DIAGNOSING DYSFUNCTION BY MOTION PALPATION

Bergmann *et al.* (1993) defines palpation as the application of variable manual pressure through the surface of the body for the purpose of determining the shape size, consistency, position, inherent motility, and health of the tissues beneath.

2.4 REMOVAL OF THE DYSFUNCTION BY MANIPULATION

Edmond (1993) defines joint manipulation as a manual therapeutic technique, which involves the movement of one articular surface in relation to another that is performed on an articular structure that has been shown to be in dysfunction on physical examination.

Joint manipulation is further characterized by Bergmann (1993) by having a specific joint contact involving a dynamic thrust of a high-velocity and low-amplitude, delivered within the boundaries of the joint's anatomic integrity and usually associated with an audible articular click with subsequent improved joint mobility.

With respect to restriction in motion (as found in posterior facet syndrome and sacroiliac joint syndrome), Sandoz (1976) proposed a model where he postulated that there is a paraphysiological space[4]. It is claimed that adjusting into this paraphysiological space could restore joint range of motion at or near the end of the joints' range of motion. And, that through manipulation peripheral effects can be induced [Korr (Leach, 1994); Herzog *et al.,* 1999 and Homewood, 1979].

Vernon and Mrozek (2005) challenge Sandoz's (1976) hypothesis by stating that it is not normal joints that are been manipulated, but clinically compromised joints. The range of motion available in the clinically compromised joint is less than that which is available at the end range of motion[5]. This decreased range of motion in the clinical setting is referred to as the "clinical physiological range" by Vernon and Mrozek (2005). Thus, it is implied that with a "clinical physiological range", when manipulation

[4] Beyond the passive range, but less than the anatomic limit (Sandoz, 1976).
[5] That is less than the elastic barrier as referred to by Sandoz (1976).

is performed it is unable to attain the paraphysiological space as previously thought by Sandoz (1976).

This minor difference implied by Vernon and Mrozek (2005) in conjunction with the theories of Wyke (Leach, 1994), has clinical implications for the improvement of the patient. This improvement is thought to be related to the degree of neurological stimulation that each of the two situations (asymptomatic and symptomatic) presents.

The asymptomatic patient has greater neurological stimulus as the degree of tension placed in the joint is greater whereas the opposite is true of the symptomatic patient, when manipulation is applied.

This is supported by (Klein *et al.,* 2002) who proposed the "elastic zone" beyond the neutral zone (Panjabi *et al.,* 1988). In the "elastic zone" tissues undergo physiological levels of strain, but which are still less than the anatomical limit of integrity at which maximum tissue damage occurs (Vernon and Mrozek, 2005 and Sandoz, 1976).

However it has also been noted that an asymptomatic patient may, in the presence of an adhesion, display similar responses to manipulation as a symptomatic patient (Vernon and Mrozek, 2005). This is supported by the adhesion hypothesis (Leach, 1994), which states that a fixation causes a restriction in movement or immobilization as well as an acute period of inflammation. This immobilization and inflammation is thought to cause "adhesion formation" within and between the connective tissues or as a result of haphazard fibrin deposits as a result of the inflammatory cycle. This limits the extensibility of the connective tissue and thus results in a further restriction of movement within the already fixated joint. Thus, even after the resolution of the signs and symptoms as related to an acute period of lower back pain, the adhesion formation still remains as long as the patient does not seek treatment at the time of the acute pain or at a later date (Leach, 1994). Consequently the adhesion would limit the movement of the joint to within a "clinical physiological range" even though the patient may be asymptomatic.

Thus, the fixated segment group (symptomatic or asymptomatic with restriction) requires the breaking of the adhesions and therefore there is a decreased chance of entering the paraphysiological space. This would therefore imply that the degree of neurological stimulation of the surrounding tissues is less as the patient's joint is maintained within the "neural zone"[6] (Panjabi *et al.,* 1988).

In addition to and with respect to compromised spinal joint motion, Homewood (1979) described that a fixation may interfere with the nerve supply and result in a decrease in muscular activity. He hypothesized that removal of the subluxation could restore:

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

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

2.5 THE EFFECT OF MANIPULATION ON PERIPHERAL MUSCULATURE

Rebechini-Zasadny *et al*. (1981) state that muscle activity is dependent on the integrity of its innervation. As mentioned above, it could therefore be argued that any factor, which impacts on the nervous system at these levels, could affect the muscular activity supplied by those levels [Herzog *et al*., 1999, Korr (Leach, 1994), Nansel *et al.,* 1993 and Rebechini-Zasadny *et al.,* 1981].

Korr (Leach, 1994) supported this statement by proposing that manipulation of the spine could relax muscle spasm by affecting the central nervous system input into a muscle spindle.

This is further supported by Herzog *et al.* (1999) who hypothesized that certain reflex responses following manipulation have been attributed to having an increasing effect on functional ability of the patient, pain reduction and inhibition of hypertonic muscle.

[6] Panjabi *et al.* (1988) postulated a theory of a 'neutral zone' around which the passive lumbar spine operates and where there is little if no perceived stress on these tissues

Similarly Haldeman (1992) refers to Vernon *et al.* (1986) who states evidence that sensorimotor reflex connections are influenced by manipulation via stimulation of segmental motor pools, which in turn could reduce both pain and muscle hypertonicity. One could therefore reasonably argue that any factor, which impacts on the nervous system at these levels, could affect the muscular activity supplied by those levels (Naidoo, 2002).

To support the above, Hamilton *et al.* (2004) correlated that the number of motor-units innervating a muscle relates positively to the strength of that muscle. This supports the theories proposed by Homewood (1979), Korr (Leach, 1994) and Vernon *et al.* (1986), indicating that manipulation may have an affect on the strength of the muscle innervated by those motor units.

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

In this respect Rebechini-Zasadny *et al*. (1981) and Naidoo (2002) have all made suggestion for further studies of manipulation-induced peripheral changes in the muscles.

Some of the errors arisen from these authors research included:

- Small sample size and extrapolation of strength values from electromyogram (EMG) readings (Rebechini-Zasadny *et al.,* 1981).
- The use of a single diagnostic measure, which was also used as a measurement tool in assessing the presence and severity of the vertebra subluxation complex and investigation of strength (Bonci *et al.,* 1990).
- The interference of atmospheric noise that could have interfered with the sensitivity and thus with the accuracy of the surface EMG readings in Naidoo's (2002) study.

In addition Evans and Oldreive (2000), Hides *et al.* (1993) and Panjabi (1992) recommend research in this field for the following reasons:

- It was found that low back pain patients had reduced endurance of the TrA and that its protective ability was decreased (Evans and Oldreive, 2000).
- In addition Hides *et al.* (1994) noted that wasting and inhibition of the other core stabiliser and co-contractor, MF was present in patients that had a history of lower back pain.
- Therapeutic approaches to low back pain have been criticized for their largely passive approaches (Panjabi, 1992:2).

Hence by investigating lumbar manipulation to the L1 – L5 spinal segment and sacroiliac joint, as a possible added intervention for improving local core stabilizer muscle strength, a management protocol for the chronic mechanical lower back pain could be presented.

2.6 CONCLUSION

Within the motion unit segment, the function of the lumbar zygopophyseal joints is to guide and restrain movement between vertebrae and to protect the discs from shear forces, excessive flexion and axial rotation (Giles, 1997). However joint dysfunction (motion segment dysfunction) can occur and is defined as an area of disturbance of function without structural changes yet affecting quality and range of joint motion (Bergmann *et al*., 1993). As a result the lumbar zygopophyseal joints can become temporarily immobilized in a position that it may normally occupy during any phase of physiologic movement (Bergmann *et al*., 1993).

Thus Haldeman (1992) defines the subluxation as an aberrant relationship between adjacent articular structures that may have functional or pathological sequelae, causing an alteration in the biomechanics and/or neurophysiological reflexes related to these articular structures.

The transversus abdominis muscle has been shown to influence the motion unit segment, with respect to its optimum function. In this regard it is important to note that this muscle has properties related to Type I muscle fibres (Norris, 1995). These Type I muscle fibres are considered to be slow, fatigue resistant fibres that can contract for prolonged periods at a low force level (Evans and Oldreive, 2000). Thus the TrA recruits its type I slow-twitch fibres at a low level of voluntary contraction (VC), which ensures that the muscle fibres are efficient and meet virtually all their needs via aerobic pathways (Evans and Oldreive, 2000).

Compromise of the motion unit segment and / or the TrA have been shown to be linked, where patients suffering from chronic low back pain indicated a delayed contraction of TrA which may evidence dysfunction in the neuromuscular control of the local stabilising system, resulting in poor lumbar stabilisation (Richardson *et al*., 1995). Furthermore Evans and Oldreive (2000) revealed in a study of the TrA that low back pain patients had reduced endurance of the TrA and that its protective ability was decreased. In addition it was noted that wasting and inhibition of the other core stabiliser and co-contractor, multifidus, was present (Hides *et al*., 1994). Both of which have been linked to the presence of low back pain (Evans and Oldreive, 2000 and Hides *et al*., 1994) and the presence of motion unit segment compromise (Bergmann *et al*., 1993).

In support of this Herzog et *al.* (1999) showed a consistent reflex response associated with spinal manipulative treatments, which have been hypothesized to have a beneficial effect on functional ability, reducing pain and inhibiting hypertonic muscles; it would thus seem fair to state that manipulation should have an affect on peripheral musculature [Herzog *et al.,* (1999), Korr (Leach, 1994), Nansel *et al.,* (1993), Rebechini-Zasadny *et al.* (1981) and Homewood (1979)]. This is especially true with respect to Suter et al. (2000), who revealed that muscle weakness has been attributed to muscle inhibition by pain / motion unit dysfunction. The potential of muscle inhibition to limit functional recovery of muscles and joints after injury has been recognized and it has been suggested that one of the early goals in the rehabilitation process should be to reduce or eliminate muscle inhibition to achieve full recovery of the affected structures (Suter *et al.,* 2000).

Based on the foregoing literature it could be stated that the presence of a motion unit segment dysfunction could prevent the TrA from achieving its optimal functional ability. Therefore the use of a high velocity low amplitude manipulation could restore the optimal functional ability (strength) of the core muscles (TrA), by optimizing the motor unit recruitment in the muscles, in patients suffering from chronic mechanical lower back pain as defined in the definition (see definitions).

CHAPTER THREE

MATERIALS AND METHODS USED

3.1 THE OBJECTIVE

The purpose of this study was to objectively and subjectively investigate the effect of a high velocity low amplitude manipulation has on core muscle strength, in patients with chronic mechanical lower back pain.

3.2 STUDY DESIGN

This study was a pre and post experimental investigation (Nansel *et al*., 1993 and Naidoo, 2002).

3.3 ADVERTISING

Patients were recruited by advertisements (Appendix G), requesting participation in the free clinical trial of low back pain treatment at the Durban Institute of Technology Chiropractic Clinic. Notices were placed in local newspapers, notice boards at sports centres and universities and pamphlets were distributed into local post boxes. Patients presenting to the Chiropractic Day Clinic with mechanical LBP were also considered.

3.4 TELEPHONIC INTERVIEW

Potential patients were screened to determine if they were eligible for the study and were suffering with mechanical LBP.

An initial telephonic interview was conducted. Patients were only excluded from the study, if they did not fit the age criteria, have a natural lower back pain history for more than 3 months, have a NRS pain rating of greater then 4 and less then 8, and had associated radicular leg pain.

Patients who did not meet the inclusion criteria were referred to other interns in the chiropractic day clinic for treatment of their condition.

3.5 SAMPLE

3.5.1 SAMPLE METHOD

The method was that of convenience sampling. This occurred on a “first-come, first served” basis where, as the patient presented to the Chiropractic Day Clinic, they were treated as soon as they met the inclusion and exclusion criteria and it was convenient for the patient and the researcher (Mouton, 1996).

3.5.2 SAMPLE SIZE

The sample size was limited to sixty patients presenting with mechanical lower back pain (lumbar facet syndrome and sacroiliac syndrome).

3.5.3 SAMPLE ALLOCATION

The population size was limited to sixty patients presenting with mechanical LBP who were assigned to only one group, the SMT group. This study consisted of one group of sixty patients.

3.5.4 SAMPLE CHARACTERISTICS

Potential candidates were assessed at the initial consultation by means of a case history (Appendix A), a relevant physical examination (Appendix B), and a low back and pelvis regional examination (Appendix C) as according to the protocol of the Chiropractic Day Clinic. Patients, who complied with the inclusion criteria for the study, were accepted into the research program. Patients who displayed any of the exclusion criteria were not accepted into the research programme.

Patients found eligible for inclusion in the study had the procedure explained and a letter of information (Appendix E) was given to them. A letter of informed consent (Appendix F) was obtained from all patients before inclusion into the study.

3.5.4.1 INCLUSION CRITERIA

- Patients between the ages of 18 (to avoid parent / guardian consent) and 45 years, to avoid and reduce the chance of sacroiliac and / or spinal ankylosis (Kirkaldy-Willis, 1992:418) were included.
- Patients who had been suffering from untreated lower back pain for more than 3 months (Mouton, 1996).
- Patients accepted needed to have a pain rating scale on the NRS greater than 4 and less then 8. This improved the sample homogeneity (Mouton, 1996).
- Patients suffering from posterior lumber facet syndrome (Kirkaldy-Willis, 1992:203) and sacroiliac syndrome (Cox, 1998:225-227) were accepted.
- Both male and female patients were accepted into the study.

3.5.4.2 EXCLUSION CRITERIA

- Patients were excluded from the study according to the following contraindications to spinal manipulation treatment (SMT) (Bergmann *et al.,* 1993):
    - Marked osteoporosis that was previously diagnosed.
    - Ankylosing Spondylitis.
    - The presence of fever, tumours, tuberculosis or any infectious diseases.
    - Local inflammation, thrombosis, metal implants or a hip prosthesis.
    - Spinal fusion or spinal surgery.
    - Acute disc herniation.
    - Abdominal aortic aneurysm.
- Patients who presented with neurological signs and symptoms such as (Plaugher, 1993:216-217):
    - Presence of parasthesias.
    - Presence of neurological deficit.

  - Presence of root tension signs.
  - Presence of hip, buttock, or back pain on straight leg raise.
- Contraindication to abdominal muscle strengthening (Harms-Ringhdal, 1993:243):
  - Glaucoma
  - Hypertension
  - Osteoporosis
  - Spinal tumors
  - Inflammatory diseases
  - Impaired circulation.
- Patients who had extreme discomfort on contraction of the abdominal muscle.
- Patients currently receiving manual or medicinal intervention within 48hours prior to the onset of the study must comply with a 3-day washout period as proposed by Poul *et al.* (1993).
- Patients undertaking any specific abdominal or lower back exercise during the study, above and beyond normal exercise routines. As self - treatment for patients with undiagnosed lower back pain can include a progression from single plane to multi-plane exercises, and emphasis on dynamic stabilization (Barnes, 1995).
- Patients may not have participated in any research trials at the Durban institute of Technology Chiropractic day clinic within the last three months. To ensure memory decay with respect to research outcome tools (Mouton, 1996), as well as avoid long term effects of previous research in the outcome of the study.
- Patients who have received low back surgery will be excluded from this study as the source of their pain may be related to the surgery. Richardson (1997) suggested the stabilizing function of the core musculature can be reduced when an injury to spinal structures occur.
- Patients who required further clinical testing to confirm the diagnosis was excluded, as budget constraints of this research do not allow for further clinical evaluation of the patients.
- All patients who failed to complete the informed consent forms.

3.6 THE CLINICAL PROCEDURE

The sixty participants underwent 2 consultations.

The initial consultation took place at the Chiropractic Day Clinic on the Durban Institute of Technology campus and included applicant screening and establishment of suitability for the study. The patients were then approved and signed for by a clinician at the Chiropractic Day Clinic.

During the first consultation, the most symptomatic joints were (facet and/or sacroiliac joints) identified by motion palpation of the lumbar spine and sacroiliac joints (Schafer and Faye, 1990:211-217). Motion palpation was also used to identify in which plane the fixation was and therefore which manipulative technique should be given, allowing the patient to have the least amount of discomfort and to restore maximum joint play to their spine (Schafer and Faye, 1989:211-216, 256-259).

The patient was educated on how to contract the transverse abdominal muscle by using the four-point kneeling position test (Evans and Oldrieve, 2000). The patient was positioned with their shoulder directly over the hands and the hips over the knees. The examiner's hand was placed under the lower abdomen and the following was asked of the patient, "As you breathe out, gently draw your lower abdomen off my hand and maintain this position while breathing normally." This position was used, as the forward shift of the abdominal contents provides a facilitatory stretch of the deep abdominals, but provides an inhibitory effect for the superficial muscle, the rectus abdominus (Jull *et al*., 1995).

3.7 THE INTERVENTION

Symptomatic joints were identified by motion palpation (Schafer and Faye, 1989:211-216, 256-259) and orthopaedic tests, which included:

Orthopaedic test were not used to diagnose sacroiliac syndrome, they were however used to confirm the diagnosis (Kirkaldy-Willis, 1992:125) and were performed as follows:

Posterior facet syndrome: For the purpose of this research two out of the four tests described below must be positive (Kirkaldy-Willis, 1992:125):

a) Kemp's test

This involves a combination of lateral flexion and extension over the facet joints while the patient is in a seated position (Giles, 1997:346). The examiner reaches around the patient's shoulders from behind and laterally bends, rotates and extends the patient to the right and then the left while applying an axial force. Pain in the lumbar region indicates a positive test (Gatterman, 1990:141).

b) Facet joint challenge

The test is performed with the patient lying prone. 'Springing' the spinous process discerns the status of the facet joints. The examiner places one thumb on the spinous process above and one on the spinous process below. The force is applied horizontally in opposite direction (Gatterman, 1990:84).

A positive test would be if there is pain perceived at the area of palpation to the gentle pressure that is applied on the spinous processes (Gatterman, 1990:84).

c) Palpatory, tenderness and

The patient is in a seated position and should be supported as much as possible to ensure that the area to be palpated is as relaxed as possible. The examiner palpates a point in the midline, over L4-L5 interspace, and proceeds superiorly over the lumbar spinous processes looking for tenderness, muscle spasm and other signs of pathology. The examiner needs to move laterally 2-3 cm from the spinous processes to palpate the lumbar facet joints (McGee, 1992:283).

d) Spinous percussion

Spinal percussion may be applied by the pisiform of the doctor's hand or with a reflex hammer. In both circumstances, apply a gentle percussive force is applied sequentially to the spinous processes. A marked or persistent painful response to percussion may indicate underlying fracture or non-mechanical pathology, whereas a mild pain response may indicate local irritation and dysfunction (Bergmann, 1993:103).

For sacroiliac syndrome: for the purpose of this research two out of the four tests described below must be positive (Kirkaldy-Willis, 1992:125):

(a) Posterior shear/"thigh thrust test"

This test is described by Laslett and Williams (1994) in the supine position. The hip is flexed and adducted while the examiner applies a force by pushing posteriorly along the line of the femur. Increase in pain over the SI joint indicates a positive test.

(b) Gaenslen's test

This test is described by McGee (1997:446), with the patient lying supine. The test extends the hip beyond the edge of the table. The patient draws both legs up to the chest and then lowers the test leg off the edge of the table in to extension, with help from the examiner. The examiner places a shearing pressure in the opposite direction. The other leg is tested similarly. A positive test is indicated by pain in the sacroiliac joint(s).

(c) Patrick Faber test

McGee (1997:446) describes this test with the patient lying supine. The examiner places the patients test leg so that the foot of the test leg is above the knee of the opposite straight leg. The examiner then pushes the test leg into abduction while stabilising the opposite hemi-pelvis with the other hand. A decrease in abduction as well as pain in the sacroiliac joint indicates a true positive test, therefore indicating a sacroiliac dysfunction. False positives include possible hip joint and/or adductor pathologies.

(d) **Yeoman's test**

The patient lies prone. The examiner applies pressure with the one hand to the affected sacroiliac joint, while the other hand lifts the ipsilateral leg into hyperextension, while the patient’s knee is flexed at 90 degrees. Pain in the sacroiliac joint indicates a positive test (Schaefer and Faye, 1990:271).

Once the restricted joint and its direction were identified, an adjustment was given as follows: Patients received SMT in accordance the Diversified adjusting technique (Szaraz, 1990).

This included the following adjustments to the lumbar spine and pelvis:

a) Sitting lumbar

Indication (IND):

Restricted rotation and / or lateral flexion T12-L5; may be coupled with restricted extension or flexion. Rotation and /or lateral flexion malpositions at T12-L5; may be coupled with flexion or extension malpositions.

Patient Position (PP):

Patient sits with legs straddling the adjusting bench with knees locked against each side. The arms are folded across the chest with hands grasping the opposing shoulders.

Doctor Position (DP):

Doctor may sit behind the patient, straddle the bench or stand at the caudal end of the bench. In the standing position the doctor may support his elbow against his anterior ilium.

Contact Point (CP):

Pisiform of contact hand.

Specific Contact Point (SCP):

Spinous process of superior vertebra.

Indifferent Hand (IH):

The indifferent hand reaches around the patient to clasp the patient's opposite arm.

Vector (VEC):

Contact hand thrusts laterally and posterior to anterior as the indifferent hand pulls anterior to posterior.

Plan (P):

The patient is asked to sit with crossed arms. Pre-adjustive tension is typically developed by flexing, laterally flexing and rotating the patient in the direction of the joint restriction. Once tension is established, an impulse thrust is delivered through the contact hand assisted by a pulling and twisting thrust generated through the doctor's indifferent arm and trunk. The direction of induced lateral flexion and the point of adjustive contact are dependent on the restriction being treated.

b) Lumbar roll or side posture adjustment

Indication (IND):

Restricted rotation and/or lateral flexion at L1-L5. Rotation and/or lateral flexion malposition, L1-L5.

Patient Position (PP):

The patient lies in side posture with the head supported on the elevated cervical section or pillow. The patient's down side arm is crossed over the chest with the hand resting on the opposite shoulder or lateral rib cage. The patient's down side leg is extended along the length of the table and the upper leg and thigh are flexed. The patient's foot is placed over the poplitial space of the down side leg.

Doctor Position (DP):

Stand in a fencer stance angled approximately 45 degrees to the patient. Support the patient's pelvis by contacting the patient's thigh with the inferior thigh or by straddling the patient's upper leg between the thighs.

Contact Point (CP):

Hypothenar (pisiform) of the caudal hand with the fingers running parallel to the spine.

Specific Contact Point (SCP):

The mammillary process.

Indifferent Hand (IH):

The indifferent hand contacts the patient's up shoulder and overlapping hand.

Plan (P):

Ask the patient to lie on the appropriate side and to straighten the down leg. Position the patient's shoulders and flex the upper thigh to distract the interspinous space of the dysfunctional motion segment. Establish the vertebral and thigh contacts develop and pre-adjustive tension. At tension generate an impulse thrust by dropping your body weight and thrusting the shoulder.

c) Spinous push-pull

Indication (IND):

Restricted rotation or combined restrictions in rotation and opposite side lateral flexion, L1-L5. Rotation or combined rotation and ipsilateral lateral flexion malpositions, L1-L5.

Patient Position (PP):

The patient lies in the basic side posture position with the foot of the patient's flexed leg hooked behind the popliteal space of the down leg.

Doctor Position (DP):

Stand facing the patient with your inferior thigh contracting the patient's thigh or with the distal surface of your leg contacting the patient's flexed knee.

Contact Point (CP):

The fingertips of cephalic hand reach under the patient's up arm to contact the lateral surface of the superior spinous process. The fingertips of caudal hand hook the inferior spinous process while the forearm contacts the patient's posterolateral buttock and thigh.

Specific Contact Point (SCP):

Adjacent spinous processes.

Vector (VEC):

The superior hand thrusts lateral to medial and inferior to superior. The inferior hand thrusts lateral to medial in the opposing direction.

Plan (P):

Place the patient in side posture. Flex the patient's upper thigh to distract the interspinous space of the dysfunctional motion segment. Rotate the patient's shoulders posteriorly in the direction of segmental restriction and flex the trunk laterally toward the adjusting bench. The doctor establishes appropriate contact on adjacent spinous process and develops local joint tension by counter rotating the pelvis, shoulders and segmental contacts. As the shoulders are rotated posteriorly the patient's pelvis and contacted vertebra are counter rotated anteriorly. This should induce distraction in the motion segment between the established contacts. Posterior shoulder rotation is greater when treating upper lumbar dysfunction as compared with lower lumbar dysfunction. At tension deliver a high velocity counter torquing thrust through both contact hands reinforced by a body drop thrust and shoulder thrust through your cephalic shoulder. Take care not to apply undue pressure to the patient's lateral rib cage with the superior forearm contact.

d) Spinous pull

Indication (IND):

Restricted rotation or combined restrictions in rotation and opposite side lateral flexion, L1-L5. Rotation or combined rotation and ipsilateral flexion malpositions, L1-L5.

Patient Position (PP):

The patient lies in the basic side posture position with the foot of the patient's flexed leg hooked behind the popliteal space of the down leg.

Doctor Position (DP):

Stand facing the patient with your inferior thigh contracting the patient's thigh or with the distal surface of your leg contacting the patient's flexed knee.

Contact Point (CP):

Fingertips of first three fingers of your inferior hand with the forearm resting along the patient's posterolateral buttock and hip.

Specific Contact Point (SCP):

Lateral surface of the spinous process.

Indifferent Hand (IH):

The indifferent hand contacts the patient's up side shoulder and overlapping hand.

Vector (VEC):

Lateral to medial pulling movement to induce axial rotation.

Plan (P):

Ask the patient to lie on the appropriate side and to straighten the down side leg. Flex the patient's upper thigh to distract the interspinous space of the dysfunctional motion segment. Then establish contacts on the spinous process and the patient's flexed leg. The spinous contacts are established by hooking the down side of the spinous process with the second, third, and fourth fingers while the forearm rests against the patient's posterolateral buttock and hip. Contacts on the leg are established with the distal surface of your tibia against the patient's knee or with your inferior thigh. At tension, a pulling impulse is generated, by extending your contact shoulder while simultaneously inducing anterior pelvic rotation. With a ling lever contact, induce anterior pelvic rotation by quickly extending your contact knee. With a thigh-to-thigh contact, produce anterior pelvic rotation when you drop your body weight by flexing your hips and knees.

e) Upper and lower sacroiliac

Hypothenar ilium

Indication (IND):

Restricted sacroiliac extension. Flexion malposition of the ilium.

Patient Position (PP):

The patient lies in the basic side posture position.

Doctor Position (DP):

Stand in a fencer stance angled approximately 45 degrees to the patient. Support the patient's pelvis by contacting the patient's thigh with your inferior thigh or straddling the patient's bent upper leg between your thighs.

Contact Point (CP):

Hypothenar (pisiform) of caudal hand.

<u>Specific Contact Point (SCP):</u>

Medial margin of the posterosuperior iliac spine (PSIS).

<u>Indifferent Hand (IH):</u>

The indifferent hand contacts the patient's up side shoulder and overlapping hand.

<u>Vector (VEC):</u>

Posterior to anterior, medial to lateral, and inferior to superior.

<u>Plan (P):</u>

Place the patient in side posture with the involved side up. Flex the upper thigh to between 60 degrees and 80 degrees. Establish the ilial and thigh contacts and develop pre-adjustive tension by distracting and extending the involved sacroiliac joint. Produce joint distraction by lowering your body weight through the thigh contact. Produce joint extension by leaning anteriorly and cephalically through the torso and contact. The indifferent hand stabilizes the patient's shoulder and applies gentle traction cephalically and posteriorly; take care to avoid excessive posterior rotation of the patient's upper torso. At tension generate an impulse thrust by dropping the body weight and thrusting through the shoulder.

Hypothenar sacral base

<u>Indication (IND):</u>

Restricted sacroiliac flexion unilateral posterior superior malposition of the sacrum.

<u>Patient Position (PP):</u>

The patient lies in the basic side posture position.

<u>Doctor Position (DP):</u>

Stand in a fencer stance angled approximately 45 degrees to the patient. Support the patient's pelvis by contacting the patient's thigh with your inferior thigh or straddling the patient's bent upper leg between your thighs.

<u>Contact Point (CP):</u>

Hypothenar (pisiform) of caudal hand.

Specific Contact Point (SCP):

Superior sacral base just medial to the posterosuperior iliac spine (PSIS) on the side of sacroiliac dysfunction.

Indifferent Hand (IH):

The indifferent hand contacts the patient's up side shoulder and overlapping hand.

Vector (VEC):

Posterior to anterior and slightly inferior to superior.

Plan (P):

Place the patient in side posture with the dysfunctional sacroiliac against or away from the table. Flex the upper thigh to between 60 degrees and 80 degrees. Establish the ilial and thigh contacts and develop pre-adjustive tension by distracting and extending the involved sacroiliac joint. The indifferent hand stabilizes the patient's shoulder and applies gentle traction cephalically and posteriorly, take care to avoid excessive posterior rotation of the patient's upper torso.

f) Prone sacroiliac

Indication (IND):

Restricted sacroiliac extension. Posteroinferior (PI) malposition of the ilium and/or unilateral anteroinferior (AI) malposition of the sacrum.

Patient Position (PP):

The patient lies prone.

Doctor Position (DP):

Stand in a modified fencer stance on the side opposite the dysfunction.

Contact Point (CP):

Hypothenar contacts of both hands.

Specific Contact Point (SCP):

Medial superior margin of the posterosuperior iliac spine (PSIS) and sacral apex.

Vector (VEC):

Posterior to anterior, inferior to superior, and medial to lateral with the sacral apex contact.

Plan (P):

Position the patient in the prone position. Reach across the patient with the caudal hand and establish a hypothenar contact on the contralateral posterosuperior iliac spine (PSIS). With the cephalic hand, reach inferiorly to establish a contact on the sacral apex. Develop pre-adjustive tension by leaning anteriorly and superiorly with the iliac contact and anteriorly and inferiorly with the sacral contact.

3.8 THE READINGS / MEASUREMENT

Thereafter an abdominal draw in test with a pressure biofeedback unit (Stabiliser manual Chatanooga Group Inc., 4717 Adams Road, Hixson TN 37343, USA) was used to measure the participant's transverse abdominal muscle strength and fatigability in both the prone and supine position.

The prone test for transversus abdominus and internal oblique

- The 3-chamber pressure cell was placed under the abdomen and inflated to a baseline of 70 mmHg.
- The patient was asked draw the abdominal wall up and in without moving the spine or pelvis.
- Pressure had to decrease 6-10 mmHg. If the patient was unable to cause a decrease in mmHg, they were excluded from the study.
- Patient must have attempted to maintain this contraction for the set time period for this test, which was 40 seconds.
- Measurement of time at which the patient can no longer hold the contraction at the baseline level (70mmmHg – 6 to 10 mmHg), within the set time period for the test (40 seconds).
- Measurement of the change in mmHg from the baseline level (70mmHg – 6 to 10mmHg) up to the end of the set time period (40 seconds).
- Measurement of the rate at which the pressure changes from the time at which it began to change up to the end of the set time period of the test (40 seconds).

Supine position for training transversus abdominus

- The 3-chamber pressure cell was placed under the lumbar spine and inflated to a baseline of 40 mmHg.
- The patient was asked to draw the in the abdominal wall without moving the spine or pelvis.
- Pressure should have remained at 40 mmHg; i.e. no movement of the spine.
- Hold for 10 seconds; breathe normally.
- Patient must have attempted to maintain this contraction for the set time period for this test, which was 40 seconds.
- Measurement of time at which the patient could no longer hold the contraction at the baseline level (40 mmHg), within the set time period for the test (40 seconds).
- Measurement of the change in mmHg from the baseline level (40 mmHg) up to the end of the set time period (40 seconds).
- Measurement of the rate at which the pressure changed from the point at which it begins to change up to the end of the set time period of the test (40 seconds).

Substitution patterns including inhalation, dominant obliques and lifting of the pelvis off the testing surface was continuously monitored to ensure proper contraction of the muscles (Richardson and Jull, 1995). The same stopwatch and stabilizer was used throughout the study to ensure consistency.

Three sets of readings were recorded as follows:

Week	Visit	Group
1	1	***Assessment for inclusion*** into the study before the first reading was taken. Patient was educated on how to contract the core muscles on the four-point-kneeling position prior the measurement of the first reading.
		Reading 1 : Prone and supine readings were taken for both endurance and fatigability of the core muscles.
		Patient was then ***manipulated*** on the restricted areas found in the lower back.
		Reading 2 : Prone and supine readings were then taken immediately after the manipulation for both endurance and fatigability of the core muscles.
	2 (within 48 hours of previous evaluation)	***Reading 3 :*** Prone and supine readings were then taken on the second visit prior to any means of treatment for both endurance and fatigability of the core muscles.

3.9 THE DATA

The data used in this study was both primary and secondary data

3.9.1 The Primary Data – Objective Data

All measurements for objective data where taken prior to the intervention (manipulation), post manipulation and 48 hours later.

3.9.1.1 Stabilizer Biofeedback Device

Richardson *et al.* (1990) developed an abdominal drawing-in test for effective assessment of TrA using a pressure biofeedback unit (PBU). Their findings are supported by Cairns *et al.* (2000), Evans & Oldreive (2000), and Jull *et al.* (1995) therefore this test will be used to investigate the endurance of TrA in this study.
This Stabiliser Biofeedback Device has been established as a satisfactory tool in the measuring and retraining of the transverse abdominus and multifidus muscles (Cairns, 2000).

The Stabilizer Biofeedback Device was used to gather the objective measurements of the strength and endurance of the core muscles (Appendix L).

It is very simple to operate and the visual feedback optimizes muscle control in the patient and understanding of the principles of attaining neutral alignment. The device itself registers changing pressure in an air filled pressure cell. This allows body movement, especially spinal movement, to be detected during exercise. The unit consists of a combined gauge/inflation bulb connected to a pressure cell (Chattanooga Group, A Division of Encore Medical, 2002).

Core muscle strength and endurance was measured before, after and two days after the manipulation of the lumbar spine and/or sacroiliac joint

3.9.1.2 Algometer

The force dial algometer, which has shown to be a reliable tool to test pain threshold, was used to assess tenderness of the affected joint(s). This instrument measures the number of kilograms the patient can withstand before complaining of pain (Fischer, 1987). The measurements were taken by placing the rubber tip over the symptomatic facet and/or sacroiliac joint and a measurement in kilograms per square centimetre (kg/cm^2).

Pressure was gently applied and the patient was told to say stop as soon they felt pain / discomfort which was more than that of pressure being applied to the area (Appendix J).

The algometer's ability to measure pressure sensitivity and to identify aberrant tender areas provides a means of quantifying treatment, so as to identify patient improvement (Fischer, 1987).

3.9.1.3 Inclinometer

The inclinometer measured lumbar range of motion (Appendix I). Flexion, extension, lateral flexion and rotation were assessed. This instrument was found to be a highly reliable and valid tool to measure lumbar mobility (Saur *et al.,* 1996).

The following p-values were presented in this study and were closely related as indicated by inter-rater correlation:

- Total lumbar range of motion (r=0.94; p<0,001)
- Flexion (r=0.88; p<0.0001)
- Extension (r=0.42; p<0.05

The measurements were taken by placing the inclinometer over two areas of the lumbar spine:

- First over L1 and L2
- Second over L4 and L5

Then the average of these two measurements was taken to achieve an optimal reading for flexion, extension, left and right lateral flexion, and left and right rotation of the lumbrosacral spine.

3.9.2 The Primary Data – Subjective Data

All measurements for subjective data where taken prior to the intervention (manipulation), post manipulation and 48 hours later.

3.9.2.1 Roland Morris Lower Back pain Questionnaire

The Roland-Morris low back pain and disability questionnaire (Appendix K) was used for assessing the functional status of patients with low back pain (Yeomans, 2000:514). The Roland-Morris Questionnaire is a reliable and valid means for assessing the functional status of patients with low back pain. The concurrent validity of the questionnaire was r = 0.81 (Wiesinger *et al.,* 1999).

The Roland-Morris low back pain and disability questionnaire consist of 24 statements, of which the patient had to mark the statement that described the patient's ability on that day. Each patient was asked to answer three lower back pain questionnaires, one during the 1st consultation, before the manipulation, one during the 1st consultation, after the manipulation and the other after 48 hours from the 1st consultation (Appendix L).

3.9.2.2 Numerical Pain Rating Scale

The Numerical Pain Rating Scale (Appendix H) was used to give an objective rating of the severity of the lumbar facet syndrome and/or the sacroiliac syndrome. The NRS pain rating scale was used as it was found to be an effective and reliable tool to evaluate pain reduction with treatment and to what degree (Bolton and Wilkinson, 1998:1-7).

The numerical rating scale –101 (NRS) is a questionnaire used to measure the changing intensities of pain experienced by the patient. The questionnaire includes a graph ranging from 0 to 10, where 0 indicates ‘no pain’ and 10 indicates ‘pain at its worst’. Patients were asked to rate their pain pre, and post manipulation at the time of the first consultation and another at 48 hours to determine the immediate effect of the treatment on their pain.

3.9.3 The Secondary Data

The secondary data consisted of the comparative literature from textbooks, journals and Internet references to which the data in this study was compared.

3.10 STATISTICAL METHODS

Data was captured in MS Excel and exported into SPSS (Statistical Package for Social Sciences) version 12 (SPSS inc. Chicago, lll) for analysis.

Descriptive statistics for demographic variables was achieved by summarizing the quantitative variables and reporting mean, standard deviation and range. Categorical variables were reported as frequencies and percentages. Repeated measures ANOVA were used to assess changes over time in quantitative outcomes. Demographic factors were included in all models to assess their effect on the changes over time. Quantitative demographic factors were categorized into quartiles. Profile plots were generated for the changes over time in each outcome variable for each demographic factor. Pearson’s correlation was used to assess relationships between changes in outcome measurements. A p value of <0.05 was considered as statistically significant.

CHAPTER 4

4.0 Results and discussion of results

4.1) Introduction

The statistical findings and results obtained from the data will be presented and discussed in this chapter. At the conclusion of this chapter the hypotheses presented in chapter one will be revisited and accepted or rejected based on the data generated in this study as presented to that point.

The primary data in this study consisted of:

1. Demographic data consisting of age, gender, race, height, weight and occupation.
2. Objective and subjective findings consisting of the stabilizer biofeedback device, Algometer, Inclinometer, NRS and RMQ.

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

Abbreviations as appropriate in this chapter include the following:

SBD - Stabilizer biofeedback device
NDA - Non-digital algometer
NRS - Numerical pain rating scale
L - Lumbar vertebra
SI - Sacroiliac
RMQ - Roland Morris Questionnaire
SD - Standard Deviation
TrA - Transversus Abdominis
MF - Multifidus

<u>The following units were used in the diagrams:</u>

RANGE OF MOTION (flexion, extention, rotation and lateral flexion)	- Degree
AGE	- Years
WEIGHT	- Kilograms
HEIGHT	- Meters
STRENGTH AND ENDURANCE	- mm/Hg
ALGOMETER	- kg/cm²

4.2) Demographics

Sixty participants who met eligibility criteria were placed into one group comprising all participants.

4.2.1 Age, height and weight

Table 1: Summary statistics of age, height and weight in the sample (n=60)

	AGE	HEIGHT	WEIGHT
Mean	32.27	1.7173	73.42
Std. Deviation	8.044	.10594	15.733
Minimum	19	1.50	42
Maximum	45	1.92	110

Age

The sample consisted of 60 participants between the ages of 18 and 45 years with the mean age being 32.27 years (SD 8.0). This is in congruence with a study done by Horton *et al.* (2001) who had a mean age of 29.4 years, but somewhat higher than the study done by Bulbulian, Ball and Seaman (2001) who had a mean age of 26.5 years.

According to Kirkaldy-Willis and Burton (1992:4), age is an important factor in low back pain and low back pain tends to begin within the third decade of life and reaches maximal frequency during middle age. With Brandt (2002) reporting that degenerative changes do not usually occur before the age of 45. As a result of the exclusion of degenerative changes as much as possible in this study participants older than 45 were excluded. This could have influenced the age group to a lower mean average as compared to the international studies of Horton *et al.* (2001) and Bulbulian, Ball and Seaman (2001); however this does not seem to have influenced the comparability of this study's outcomes with those published internationally.

Height

Height of the 60 participants ranged from 1.5m to 1.92 m with a mean of 1.72 m (SD 0.106)

From literature it would seem that an individual's height does not seem to be strongly correlated to the occurrence of low back pain (Kirkaldy-Willis and Burton, 1992). This is in congruence by a study by Han *et al.* (1997), where they found no significant interactions between height and low back pain.

Weight

Weights of the 60 participants ranged from 42 to 110kg with the averaged being 73.4kg (SD 15.7). No studies reviewed indicated the weight of participants and significance with respect to lower back pain. Therefore no comparisons are possible in this respect.

4.2.2 Gender

Gender of participants was 65% male and 35% female.

This was shown in figure 1.

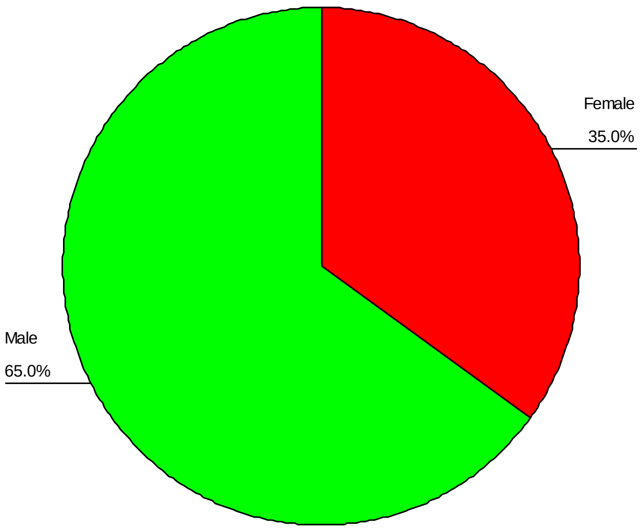


Figure 1: Distribution of gender in the sample (n=60)

This is contrary to the literature where there is no particular predilection for sex as a risk factor for low back pain, although according to Kirkaldy-Willis and Burton (1997), it is noted that operations for disc herniations are performed twice as often in males than in females (Kirkaldy-Willis and Burton, 1997). This indicates indirectly that there may be a predominance of lower back pain in males.

However, the results obtained with respect to gender are congruent with Frymoyer *et al.* (1983), who have shown that during a lifetime, 70% of men will have an episode of low back pain.

Notwithstanding the partial congruence with the literature, this study's higher rate of males presenting with low back pain, could have been as a result of:

- A larger male working population targeted by the advertising.
    - With respect to perceptions on alternative medicine versus western medicine care, it is determined by the paradigm of reference for each individual, male or female and the lived experience shows that gender

order can be maintained; challenged or changed (Johansen *et al.* 1999). As a result and in this respect it is generally found that sex differences do exist in the perception of care in musculoskeletal disorders, where men learn to adopt a more demanding attitude than women when seeking health care (Östlund *et al.* 2003) and as a result they are more comfortable with and respond better to manual therapies as opposed to non-manual therapies. Therefore a higher preponderance of males will seek manual therapy care for their low back pain as compared to the female counterparts. This may account for the higher percentage of males in this study.

- In addition to the above, women exhibit reduced tolerance for induced pain and greater sensitivity for pain than men (Jackson *et al*. 2005; Girdler *et al*. 2005; Hong-You *et al.* 2004 and Koegh *et al.* 2000), which may modify their care seeking patterns and their need for more immediate relief than their male counterparts. Thus, participation in research protocols may be perceived as delayed relief of their pain.

Nevertheless, the above factors would also be modified by the fact that it has been shown in literature that males spent more time doing sport, work- based physical activity and walking activities and females who spent more time on less sporty work (e.g. housework) (Teh and Ong, 2004). Furthermore it was found that people with an increased level of physical fitness from sports participation are associated with a lower risk of LBP due to their stronger core muscles (Biering-Sorensen, 1984). This implies that there should be fewer males seeking participation in a study with low back pain as a prerequisite.

4.2.3 RACE:

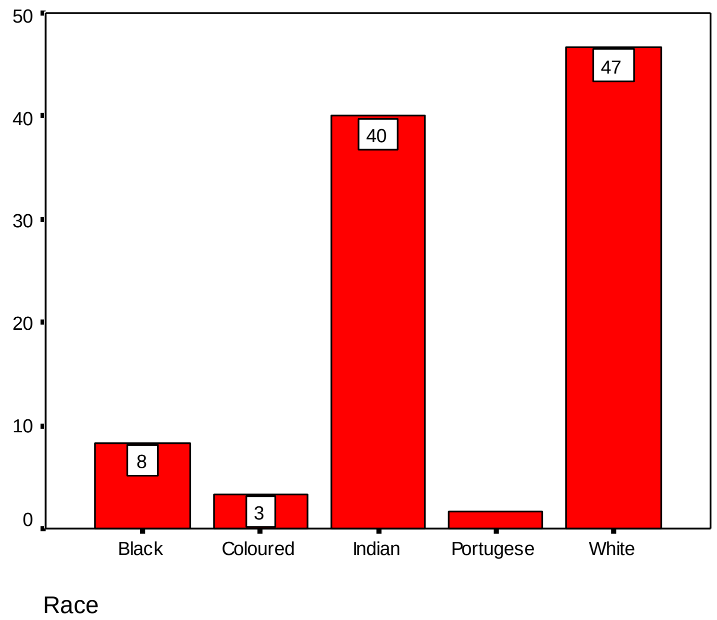


Figure 2: Racial distribution of sample participants (n=60)

Five race groups were represented in this study, White, Indian, Black, Coloured and Portuguese / Hispanic. Due to the consecutive convenient sampling method, no stratification in terms of age or race was executed and thus there was an overrepresentation of whites (47%) followed by Indian (40%) represented.
This breakdown by race is shown in figure 2.

For analytical purposes the race groups were further classified into White (46.7%), Indian (40%) and other (13.3%).

In the South African context, the incidence of low back pain in Lesotho mothers was found to be 58.84% (Worku, 2000), 78.2% in the Indian community (Docrat, 1999), 76.6% in the Coloured community (Docrat, 1999) and 53.1% in the South African black community of Chesterville (Van der Meulen, 1997). This it is comparable to the global norm of 75% to 85% (Hoiriis *et al.,* 2004) and would concur with the fact that ethnicity seems to be unrelated to the presence or development of low back pain.

Therefore, as this study had the opportunity to sample from a fairly large proportion of low back pain sufferers, which would be representative of global norms, it would have been expected that the patients presenting for this research would accurately reflect the norms in terms of population demographics of the country. This however was not the case in this instance, where the midyear estimates for 2005 indicated that the Black population are in the majority and constitute 79.4% of the total South African population. The White population is estimated to be 9.3%, the Coloured population 8.8%, and the Indian/Asian population 2.5% (www.statssa.gov.za/, 2006).

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

- Lack of exposure to a form of treatment developed outside of the cultural context of the vast majority of South Africans, with the Black population being the least exposed.
- This lack of exposure is further limited by access to a limited number of practitioners in South Africa (0.1%) (www.chiropractic.co.za, 2006 and www.statssa.gov.za/, 2006) of the population. In addition to which the majority of practitioners are based in private practice (www.chiropractic.co.za, 2006) which has greater limitations on accessibility as compared to public health care institutions such as hospitals or clinics (van As, 2005).
- Furthermore outside of the above patient expectations for treatment and care will dictate care-seeking behaviour. With the trend that the majority of South Africans expect a medicinal intervention (tablets, injection or something of the like), it becomes problematic when the health care profession does not provide such treatment as it is seen to be ineffective in dealing with the ailment presenting, as seen in the observer effect (Mouton, 1996).
- Language / understanding - An English questionnaire would have limited non-English speaking persons from participating. This assertion stems from research in the languages and translation where even if words are translated accurately, the meaning of a phrase or combination of words may be unclear, as meaning is not only determined by words or phrases, but also in their interpretation by others (Scollen and Scollen, 1995). This is because when words are taken out of context they will lose their meaning (Baynham, 1995). Therefore, meaning will differ between cultures even if the same words are used. Consequently, with translation some validity will be lost as the questions

themselves may not be understood and error will be introduced in the results of the questionnaire. Thus, the interpretation of the patient by the researcher's instructions may have resulted in incorrect responses. The ethnicity should not have influenced the perception of treatment, but rather the understanding of the subject of the study, which differed according to level of education and not according to ethnicity (Baynham, 1995 and Scollen and Scollen, 1995).

- Correlation between lower back pain and socio-economic class – A study by Hagen *et al.* (2000) revealed that disability from inflammatory back pain was moderately associated with socioeconomic status, and that there was a consistent upward trend in the association between disability retirement from non-inflammatory back pain and lower socioeconomic position. The consistent upward trend in the relation of disability retirement to lower levels of education and socioeconomic position, even for inflammatory back pain, shows that factors related to the occupational and social environment play an important role in the disabling process.

4.2.4 Occupation

There were many different occupations, which are shown in Table 2.

Table 2: Occupations of the sample participants (n=60)

	Frequency	Percent
Account Clerk	2	3.3
Admin Assistant	1	1.7
Admin Manager	1	1.7
Assistant Clerk	1	1.7
Assistant Mechanic	1	1.7
Auto Electrician	1	1.7
Chef	1	1.7
Chiropractic student	5	8.3
Church helper	1	1.7
Civil Engineering Student	1	1.7
Civil Engineering	1	1.7
Commercial Manager	1	1.7
Computer system student	1	1.7
Customer Service Agent	1	1.7
Draft manager	1	1.7
Electrical Engineer Student	1	1.7
Engineering manager	1	1.7
Estate Agent	1	1.7
Exhaust manufacturer	1	1.7
Financial Administrator	1	1.7
Food Technologist	1	1.7
Freelancing	1	1.7
Gardener	1	1.7
H.O.D	1	1.7
Hairstylist	1	1.7
Horticulturist	1	1.7
I. T. Manager	1	1.7
Internal messenger	2	3.3
Junior Architect	1	1.7
Manager	1	1.7
Manager at a college	1	1.7
Marketing consultant	1	1.7
Mechanical Engineer Student	1	1.7
Nurse	1	1.7
Office management and Technology Student	1	1.7
Own jewellery business	1	1.7
Personal Assistant	1	1.7
Production manager	1	1.7
Representative	1	1.7
Sales	3	5.1
Secretary	1	1.7

Self employed	5	8.4
Somatologist	1	1.7
Student	1	1.7
Teacher	1	1.7
Technician	2	3.3
Wood Worker	1	1.7
Total	60	100.0

Occupation has been found to have a great effect on low back pain, with those involved in more intensive and prolonged hours of manual labour more likely to suffer from low back pain than those involved in non manual labour (Krause *et al*., 2004, Hartvigsen *et al*., 2001).

This is in contradiction to the current study where there were considerably more subjects involved in non-manual occupations than in manual occupations (42 non-manual:18 manual), which could be due to the fact that manual labourers were unable to come in for consultations during working hours, whereas those involved in non-manual labour were far more able. Thus inducing a bias in the presenting sample.

Furthermore and according to the literature (Biering-Sorensen, 1984 and Janda *et al.,* 1984), it has been noted that people with an increased level of physical fitness from sports participation / activity are associated with a lower risk of LBP due to their stronger core muscles (Biering-Sorensen, 1984). Therefore supporting the outcomes of this study where there were more non-manual occupation participants than manual occupation participants.

In addition to the above, there were also a proportion of students involved in careers / professions utilising manual techniques such as somatology, chiropractic, civil engineering, but these were merely documented as students and not in their specific occupations thus the possibility exists that although they partake in manual activities as part of the learning process, this has not been documented.

4.3) Inferential statistics

4.3.1 Motion palpation findings

The level of the restrictions at time 1 and time 3 are shown in figure 49. At time 3 there were fewer restrictions at each level than at time 1. There were no restrictions present at time 2, immediately after the manipulation.

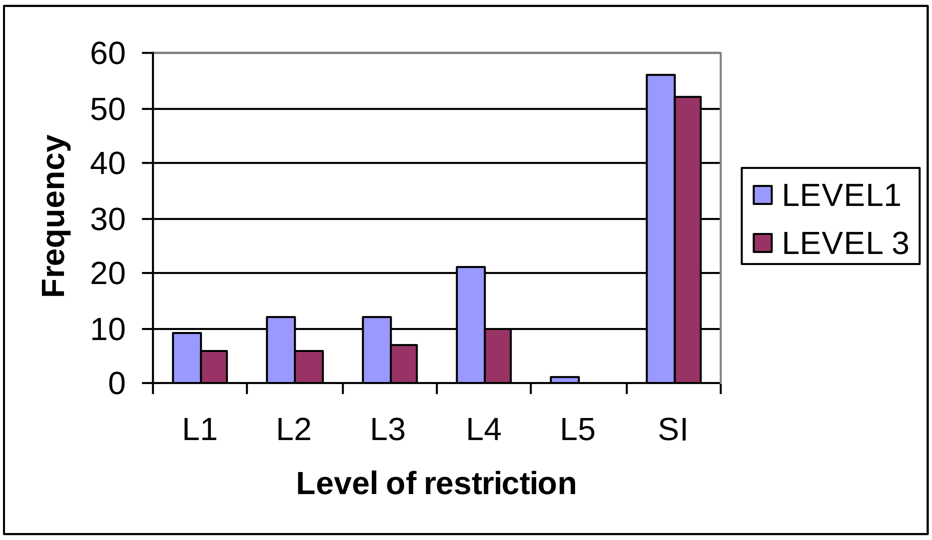


Figure 3: Level of restriction at time 1 and time 3

Sacroiliac joint restrictions were found in predominance when compared to the motion palpation findings overall, as seen in fig 3. This could be attributed to the fact that sacroiliac joint syndrome is thought to be a nociceptive source of lower back pain (Fortin *et al.,* 1994 and Bogduk, 1995). In this respect and according to Zelle *et al*. (2005), sacroiliac joint dysfunction is a significant source of lower back pain and posterior pelvic pain, where it is estimated that sacroiliac joint dysfunction makes up 15-30% of all lower back pain complaints (Schwarzer *et al.,* 1995). Therefore sacroiliac joint syndrome has become regarded as the main cause of lower back pain when compared to the overall causes of lower back pain.

This is therefore congruent with the findings of this study as reflected in fig 3 where most of the participants were diagnosed with sacroiliac joint syndrome.

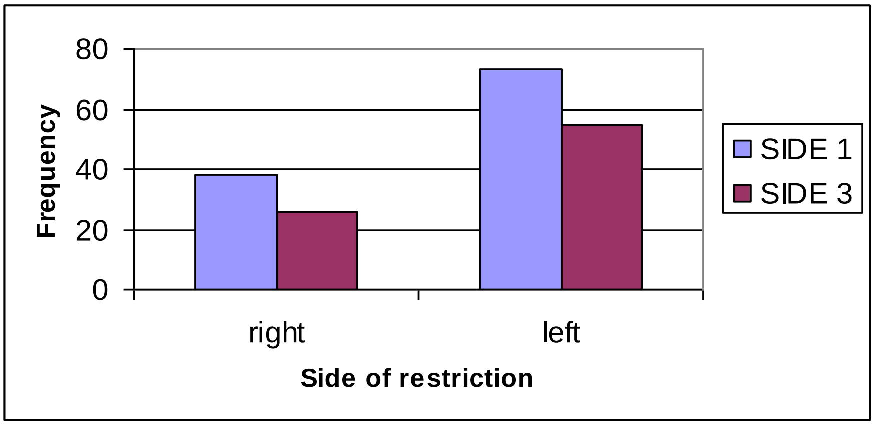


Figure 4: Side of restriction at time 1 and time 3

Figure 4 shows the side of the restriction at both time 1 and time 3. There were fewer left and right restrictions at time 3 than at time 1.

For the most part sacroiliac fixations were found on the left hand side with fewer restrictions on the right and even fewer fixations found at each level of the lumbar spine.

Handedness is the most common human behaviour asymmetry. According to research 2-30% of any population is left handed, and the majority of any population is right handed (Cagnie *et al.,* 2005). Thus with most of the population being right handed and doing most of the activities with the right hand (e.g. moving the mouse of the computer or reaching for an object). It is hypothesised that the individual needs to rotate the lumbar spine to the left (right posterior to anterior movement) and flex forward to be able to do the activity. Anatomically this results in shortening / contraction of the paraspinal muscles on the left, (e.g. QL and multifidus), and lengthening the paraspinal muscles on the right. Thereby placing more strain on the left sacroiliac joint, hence the reason for more left sided sacroiliac fixations than on the right.

According to Kirkaldy-Willis and Burton (1992), accumulated microtrauma, (e.g. overuse) can lead to vasoconstriction of the muscles involved causing abnormal muscle contraction and leading to myofascial syndrome. Physical changes that follow as soon as the individual delays obtaining treatment can then be divided twofold:

- Muscles that are disused lead to a progressive atrophy and fibrosis of the muscle
- Sustained contraction in the muscle, (e.g. multifidus), can cause progressive atrophy of the muscle, which takes away the splinting effect of muscle. Thereby increasing the load in the lumbar and sacroiliac joints and predisposing them to irritation and inflammation, which presents as low back pain (Kirkaldy–Willis and Burton, 1992).

This is therefore congruent with the literature when analysing the results found in figure 4.

Figure 5: Direction of restriction at time 1 and time 3

Figure 5 shows the direction of restriction at time 1 and time 3. There was a decrease in number of restrictions in most directions, especially for rotation. However, extension restrictions remained the same at both time points.

Uncontrolled / unilateral contractions of the multifidus produce torsional injury to facet joints and disc. Injury to these structures leads to reflex sustained contraction of the muscle. In other words, the multifidus myofascial syndrome is an integral part of the posterior joint or facet syndrome and the development of sacroiliac syndrome (Kirkaldy-Willis and Burton, 1992).

In addition:

- Flexion restrictions are likely to be present in patients with lumbar instability or multifidus hypertonicity as a result of psoas muscle involvement in the stabilisation of the function unit (antagonist to multifidus) (Bergmann, 1993). As the psoas muscle has a longer lever of attachment (Moore, 1992) and is therefore stronger when compared to the multifidus.
- Extension restrictions are likely to be present in patients with posterior facet syndrome or sacroiliac syndrome, as these movements would increase the pain levels for the patients, where compression in the joints increases stress on the capsule due to accumulation of inflammatory exudates, limiting extension (Kirkaldy-Willis and Burton, 1992 and Mackey, 1995). This would be enhanced by the associated muscular spasm in the multifidi muscles that would maintain an extension restriction (Korr, Dvorak, Gatterman and Goe, Mense, all as cited in Leach, 1994).
- Rotation restrictions are likely to be present in-patients with capsular adhesion (Vernon and Mrozek, 2005), multifidus hypertonicity and facet joint pathology (Kirkaldy-Willis and Burton, 1992). This is especially true if these factors are present unilaterally.
- Lateral flexion is likely to be present in-patients with muscle hypertonicity, (e.g. quadratus lumborum (QL), multifidus) (Moore, 1992).

In addition to the above and as a possible modifier to the factors mentioned, Gatterman (1990) suggested that if an area becomes hypomobile an area of hypermobility develops elsewhere. Thus, if the sacroiliac joints were to be restricted, as a result more flexibility is demanded from the lumbar spine and it would result in an increased likelihood of symptoms developing in the lumbar spine and producing the literature described facet syndromes (Mackey, 1995). Due to the hypermobility that has developed in the lumbar spine, muscle hypertonicity would be found such as quadratus lumborum (QL) and multifidus. Both the quadratus lumborum QL and sacroiliac fixation would limit the degree of flexion available to the patient. With intervention this flexion should improve due to the effects of manipulation of the sacroiliac and quadratus lumborum (QL) (Bergmann, 1992:123-125).

This is supported by Leach (1994), who described a cavitation as a process by which manipulation enables the range of motion of a joint to enter the paraphysiological space and by doing so a ‘crack’ is heard. Sandoz (Leach, 1994) further describes the audible ‘crack’ as altered subatmospheric pressure in the joint space, causing gases to be released from the synovial space when the joint surfaces are suddenly separated. This in turn is hypothesized to have a reflex effect on the neuromuscular system by inhibiting pain, increasing range of motion and causing relaxation of spastic muscles (Herzog, 1996). Thus one could suggest that with an increase in the number of cavitations one hears, there is a more significant increase in the reflex effects on the joint and peripheral musculature. However further studies into the role of cavitations would be of much value in widening our understanding of manipulation induced effects of peripheral musculature.

Furthermore and according to the gait control theory by Melzack and Wall (1965), manipulation inhibits pain, decreasing paraspinal hypertonicity and breaks articular adhesion, which could be responsible for the restricted range of motion in the lumbar spine / sacroiliac joints, would result in a decrease joint pathology.

Accordingly it would seem in principle that the findings of this study are supported in the literature. Nevertheless, it is suggested that more incidence and prevalence studies be conducted with respect to the presence of restrictions in order to validate the findings of the study and in order to assess more closely the possible predisposing demographic characteristics of the patient.

4.4) Effect of the treatment manipulation

Range of motion

4.4.1 Flexion

Table 3: Tests of within-subjects and between–subjects effects for flexion

Effect	Statistic	p value
Time	Wilk's lambda=0.076	<0.001
Time*gender	Wilk's lambda=0.999	0.962
Time*race	Wilk's lambda=0.937	0.946
Time*age quartiles	Wilk's lambda=0.478	0.185
Time*height quartiles	Wilk's lambda=0.263	0.014
Time*weight quartiles	Wilk's lambda=0.200	0.004

Table 3 shows that flexion changed statistically significantly over time due to the manipulation (p<0.001) however the change over time was not significantly related to age, gender and race but significantly influenced by height (p=0.014) and weight (p=0.004) of the participant.

This is shown in fig 6, 7 and 8.

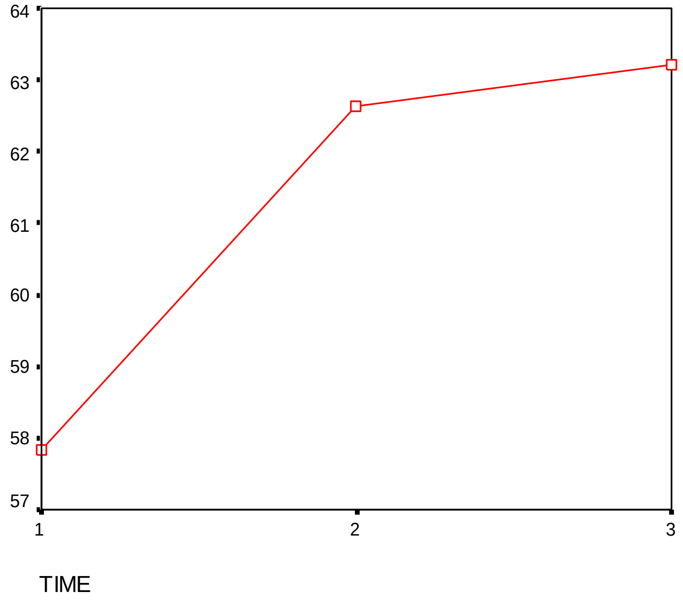
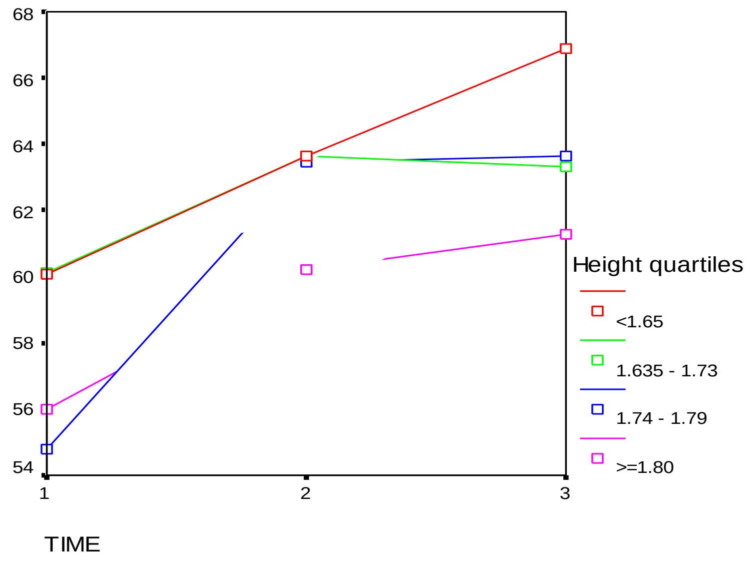


Figure 6: Profile plot of mean flexion over time



<u>Figure 7: Profile plot of mean flexion over time by height quartiles</u>

Figure 7 shows that the effect was greatest in the shortest participants.

From the above it would seem to suggest that in patients with low back pain, the response to treatment is better in shorter patients as opposed to taller patients. This seems to imply that the nature of the low back pain syndromes (sacroiliac syndrome and facet syndrome), in shorter patients seems to be of a lesser degree as compared with the taller counterparts. This assertion is supported by the baseline readings where the range of flexion movement is greater in the shorter individuals (60º versus 56º).

In order to clinically restrict a patient's range of motion in flexion, the patient would need to have compromised one or more of the following structures with respect to the following parameters:

- Tight quadratus lumborum (QL), paraspinal muscles
- Restricted sacroiliac motion
- Hamstring flexibility
- Compromised core muscle ability (multifidi)
- Disc pathology

Tall people would have tighter quadratus lumborum (QL) and paraspinal musculature due to the fact that constant activation of these muscles needs to occur to keep the body in upright position. An epidemiological study has demonstrated a relationship between LBP and working postures especially "stooping" and "kneeling". This study found "stooping" as the worst working postures and that stooping for more than 4 hours a day increased prevalence of LBP in all age groups. According to the literature there is therefore a dose-response association between LBP and stooping, (Han *et al*. 1997), where taller people are more prone to stooping to achieve the height of the "normal population", thus supporting the results presented in this study.

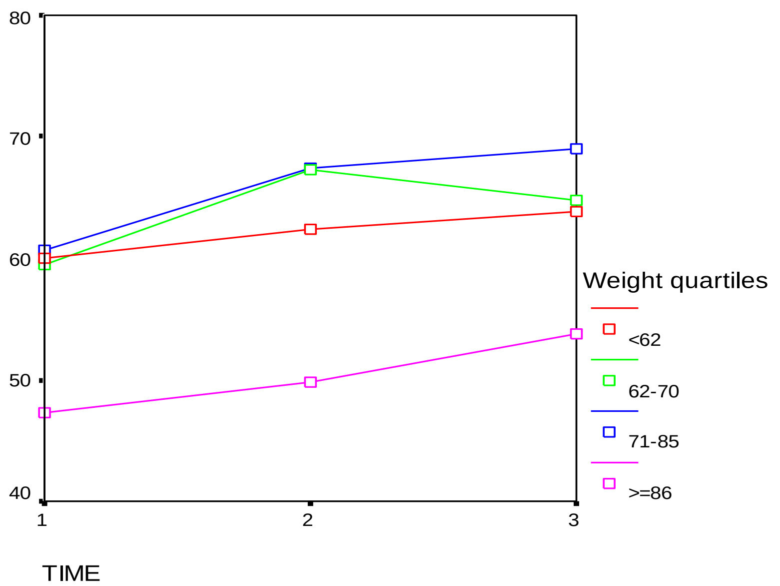


Figure 8: Profile plot of mean flexion over time by weight quartiles

In fig 8 the effect was greatest in the 71-85kg group.

From the above, it would seem to suggest that in patients with low back pain, the response to treatment is better in lighter patients as opposed to heavier patients. This seems to imply that the nature of the low back pain syndromes (sacroiliac syndrome and facet syndrome) in lighter patients seems to be of a lesser degree as compared with the heavier counterparts. This assertion is supported by the baseline readings where the range of flexion movement is greater in the shorter individuals (60º versus < 50º).

In order to clinically restrict a patient's range of motion in flexion, the patient would most likely be compromised through the following mechanisms:

- Weak core muscles.
- Forward shift of the centre of gravity, especially with respect to central obesity (Kirkaldy-Willis and Burton, 1992 and Cox, 1999).
- Poor posture with respect to both a and b above.
- Increased load on the facets due to increased lumbar lordosis (Kirkaldy-Willis and Burton, 1992 and Cox, 1999).
- Overweight and obesity individuals are negatively related to physical activity (Garaulet *et al.,* 2000) and according to Lee, Ooi and Nakamura (1995), a lack of daily activity in sedentary individuals might result in reduced muscle strength, as well as increased low back pain (Biering-Sorensen, 1984).

4.4.2 Extension

Table 4: Tests of within-subjects and between–subjects effects for extension

Effect	Statistic	p value
Time	Wilk's lambda=0.202	<0.001
Time*gender	Wilk's lambda=0.940	0.712
Time*race	Wilk's lambda=0.811	0.661
Time*age quartiles	Wilk's lambda=0.371	0.066
Time*height quartiles	Wilk's lambda=0.510	0.235
Time*weight quartiles	Wilk's lambda=0.653	0.532

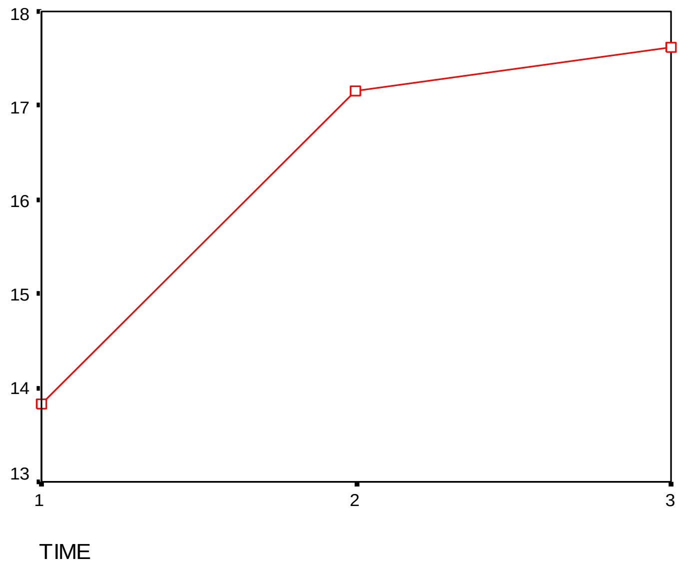


Figure 9: Profile plot of mean extension over time

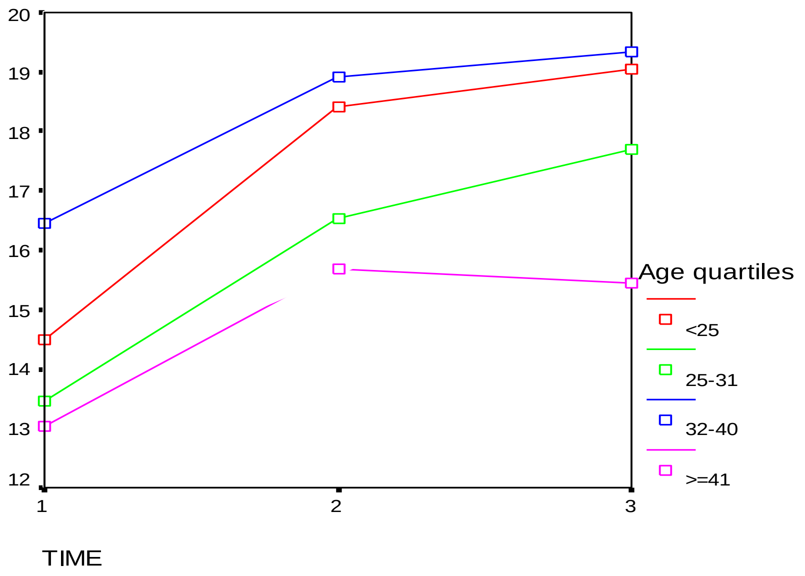


Figure 10: Profile plot of mean extension over time by age quartiles

There was a highly statistical significant increase in extension over the three time points (fig 9). However, this increase was not affected by demographics to any great extent. The only factor that approached statistical significance was age ($p=0.066$). This is shown in fig 10.

The profiles of the 4 age groups were almost parallel, except for the oldest group (>=41yrs), which showed a slight decrease between time 2 and 3. When assessing the above graph, it seems likely that the degenerative changes as divided into three phases, by Kirkaldy-Willis and Burton (1992), are applicable, with:

Phase 1 – The dysfunctional phase affecting the <25 and 25-31 year age groupings. As a result two groups would have similar patterns of baseline readings and improvement over the treatment period. The rationale behind this is related to the fact that for the most part this age group is within the skeletal development stage (skeletal maturation) with little or no degeneration of the osseous structures to impede the movement of extension.

Phase 2 – Or the unstable phase (which tends to affect the age 32-40), is characterised by increased instability within the lumbar spine (as a result of laxity of the ligaments, capsules and the disc). Panjabi and White (1988) indicate that this could be as a result of creep deformity after repeated or repetitive trauma to the ligamentous structures in the form of sprains. As a result of this laxity increased pressure is placed on the axial skeleton for support during locomotion, resulting in increased instability within the lumbar spine.

This results in the development of phase 3 or Stabilization Phase, where the osseous structures start to degenerate as a result of the abnormal forces placed on them by the aberrant ligamentous function. Changes in lumbar spine posture may influence the load borne by the zygapophyseal joints, which have been estimated to bear 16-40% of the total compressive spine load in the erect posture. If this is continued, Brandt (2002) reports that degenerative changes are more common. As a result, this phase rarely occurs before the age of 45, after which the changes become more clinically evident.

As a result of the above it would seem reasonable to suggest that the oldest age group has the most limited motion to start with and the least improvement, whereas the 32 – 40 year age group has the most movement at baseline with the greatest propensity for improvement.

4.4.3 Right lateral flexion

Table 5: Tests of within-subjects and between–subjects effects for right lateral flexion

Effect	Statistic	p value
Time	Wilk's lambda=0.348	0.003
Time*gender	Wilk's lambda=0.993	0.964
Time*race	Wilk's lambda=0.934	0.940
Time*age quartiles	Wilk's lambda=0.815	0.874
Time*height quartiles	Wilk's lambda=0.726	0.699
Time*weight quartiles	Wilk's lambda=0.747	0.746

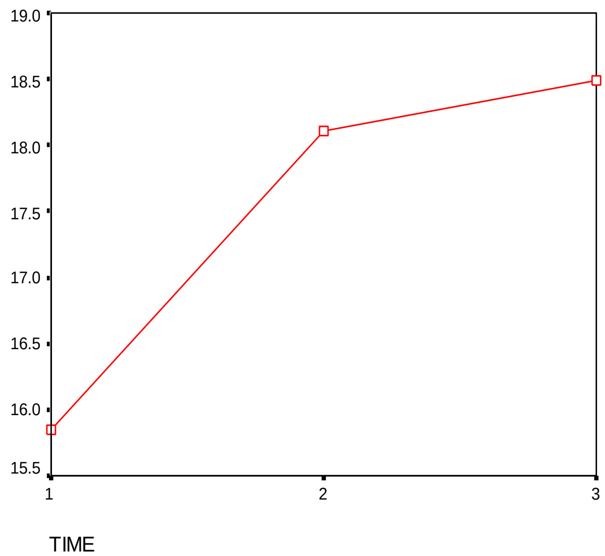


Figure 11: Profile plot of mean right lateral flexion over time

There was a statistically significant change over time for this outcome in the sample as a whole (p=0.003). None of the demographic factors influenced the change. This is shown in Table 5 and fig 11.

Could be as a result of a natural history.

4.4.4 Left lateral flexion

Table 6: Tests of within-subjects and between–subjects effects for left lateral flexion

Effect	Statistic	p value
Time	Wilk's lambda=0.253	0.001
Time*gender	Wilk's lambda=0.948	0.745
Time*race	Wilk's lambda=0.968	0.985
Time*age quartiles	Wilk's lambda=0.862	0.939
Time*height quartiles	Wilk's lambda=0.756	0.041
Time*weight quartiles	Wilk's lambda=0.684	0.605

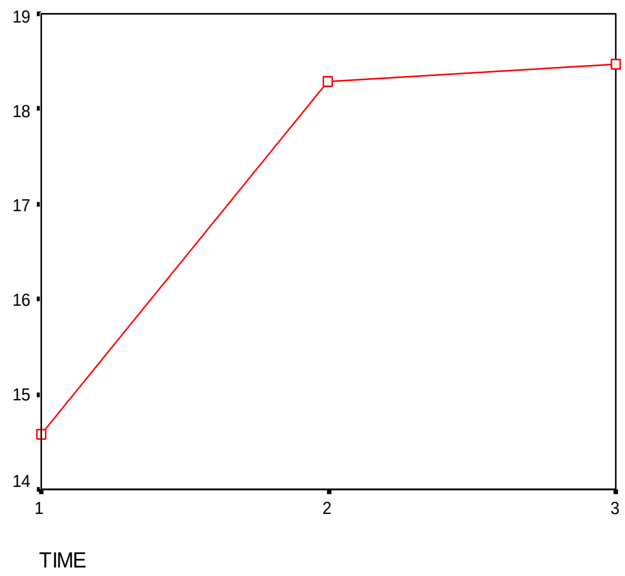


Figure 12: Profile plot of mean right lateral flexion over time

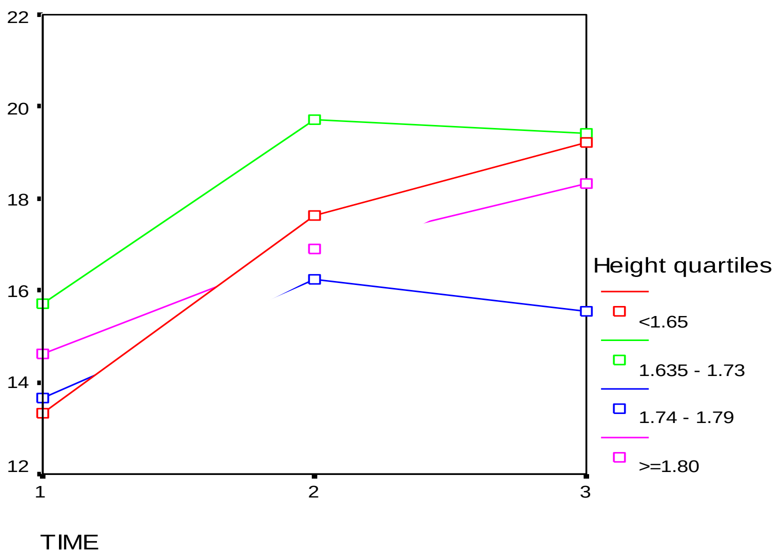


Figure 13: Profile plot of mean left lateral flexion over time by height quartiles

There was a statistically significant treatment effect (p=0.001). The treatment effect was influenced significantly by height of the participant (p=0.041). Figure 13 shows that the shortest height group showed the greatest improvement over time.

When comparing left to right lateral flexion, it becomes evident that an asymmetry is responsible for the lack of association with right lateral flexion and the significant association between left lateral flexion and height. As there is no direct relationship between height and left lateral flexion, a third entity must exist to establish a relationship as well as differentiate right from left lateral flexion.

One possible explanation could be related to the presence or absence of sacroiliac dysfunction on one side (left) and not the other (right). As the patient would be able to achieve normal lateral flexion away from the side of the lesion and decreased on the side of the lesion – increased pain due to compression of the inflammatory exudates being compressed against the capsule(s) of the joint(s) involved eliciting pain. This hypothesis is supported by the analysis of the motion palpation findings in fig 4 where it was as found that the predominant listings where that of left sided dysfunctions supporting the ability of the patient in maintaining full ranges of right lateral flexion and decreased ranges of left lateral flexion. It therefore stands to reason, that the greater improvement was possible in left lateral flexion post manipulation, thus allowing a greater chance of significant association between left lateral flexion and demographic variables analysis.

Another explanation could be related to the position in which the manipulation is administered.

- There is an increased degree of stretch being imparted to the hamstrings / quadratus lumborum (QL) during side posture manipulation (on the ipsilateral side to manipulation), resulting in an additive effect of both manipulation and stretch which would have a twofold effect according to Korr as cited in Leach (1994).
- A biomechanical change in the alignment of the sacroiliac joint surfaces (on the ipsilateral side to manipulation) resulting in increased joint gapping (Sandoz as cited in Leach, 1994 and Vernon and Mrozek, 2005).

- In some participants, there was a lumbar facet syndrome as well as a sacroiliac syndrome that could have possibly been on the ipsilateral side. In this case the most symptomatic restriction was chosen. Thus the possibility also exists that one side was stretched twice – with the application of a manipulation to the sacroiliac and lumbar spine with the patient in exactly the same position. This may have magnified the results on the side manipulated.

However the following factors cannot be excluded:

- Dominance – right hand dominance leading to syndromes related to activities that are predominated by the handedness of the patient (Cagnie *et al.,* 2005).
- The effect of restrictions on the musculature - If more left fixations are recurring (e.g. LUF), the PSIS is rotated superior and anterior, shortening the quadratus lumborum (QL) on the left side decrease its ability to contract therefore restricting the degree of left lateral flexion.

4.4.5 Right rotation

Table 7: Tests of within-subjects and between–subjects effects for right rotation

Effect	Statistic	p value
Time	Wilk's lambda=0.471	0.016
Time*gender	Wilk's lambda=0.923	0.644
Time*race	Wilk's lambda=0.562	0.157
Time*age quartiles	Wilk's lambda=0.442	0.136
Time*height quartiles	Wilk's lambda=0.574	0.356
Time*weight quartiles	Wilk's lambda=0.470	0.173

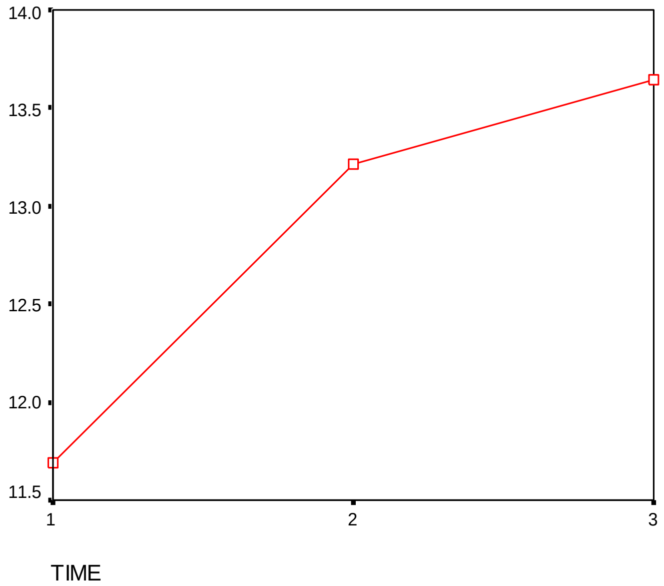


Figure 14: Profile plot of mean right rotation over time

There was a statistically significant effect of the manipulation (p=0.016). Figure 14 shows that there was an overall increase in mean values for right rotation. No other factor significantly affected the results.

Could be as a result of a natural history.

4.4.6 Left rotation

Table 8: Tests of within-subjects and between–subjects effects for left rotation

Effect	Statistic	p value
Time	Wilk's lambda=0.363	<0.001
Time*gender	Wilk's lambda=0.954	0.336
Time*race	Wilk's lambda=0.892	0.258
Time*age quartiles	Wilk's lambda=0.872	0.379
Time*height quartiles	Wilk's lambda=0.924	0.713
Time*weight quartiles	Wilk's lambda=0.812	0.135

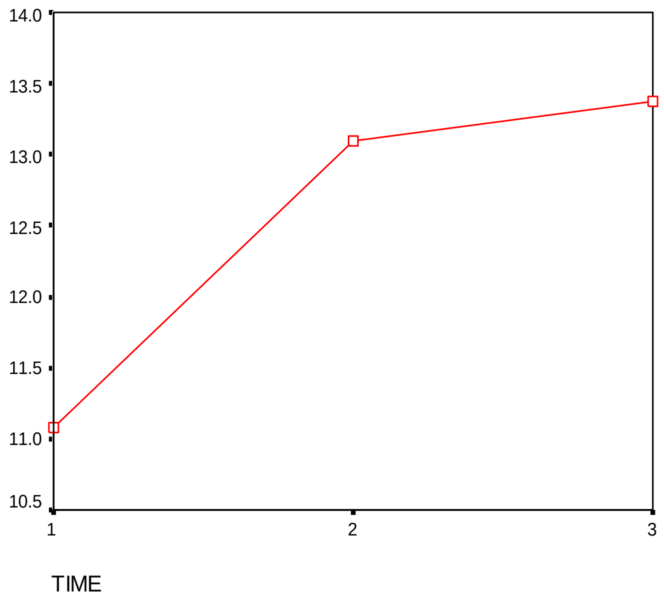


Figure 15: Profile plot of mean left rotation over time

There was a statistically significant treatment effect for left rotation (p<0.001). See fig 15.

The average number of restrictions found on either side must have been similar due to the results found in both left and right rotation graphs where the plotting indicates similar trends unlike the trends seen in left and right lateral flexion.

Could be as a result of a natural history.

4.5) Strength and Endurance

4.5.1 Strength-Prone

With the patient in prone position and the stabilizer biofeedback device placed under the patient, the pressure recorded first is the pressure prior the contraction of the core muscles. With the patient contracting the core muscle, weight is taken from the stabilizer biofeedback device and therefore the pressure drops. When taking the 2nd reading and subtracting the 1st, a negative marginal means is produced, as seen in fig 16.

Table 9: Tests of within-subjects and between–subjects effects for strength (prone)

Effect	Statistic	P value
Time	Wilk's lambda=0.419	<0.001
Time*gender	Wilk's lambda=0.946	0.282
Time*race	Wilk's lambda=0.946	0.629
Time*age quartiles	Wilk's lambda=0.933	0.776
Time*height quartiles	Wilk's lambda=0.895	0.520
Time*weight quartiles	Wilk's lambda=0.800	0.107

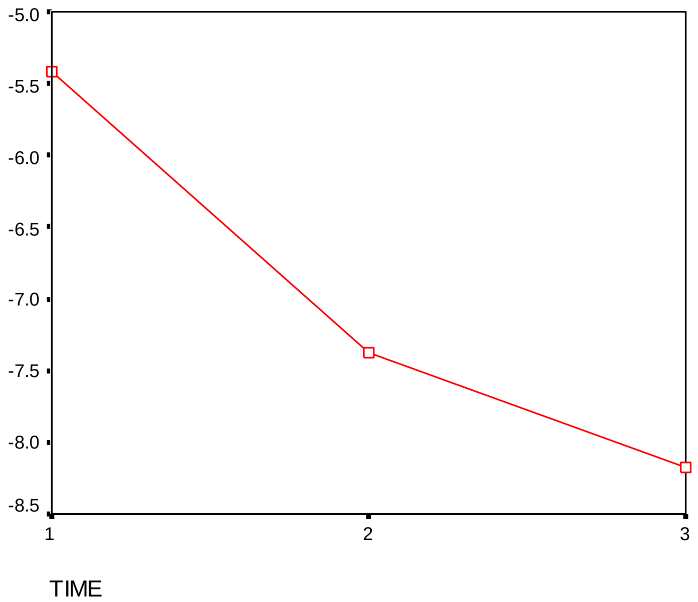


Figure 16: Profile plot of mean strength (prone) over time

Strength increased significantly over the time periods (p<0.001). No demographic factors were associated with the change over time.

Figure 16 shows the change in all participants.

- Between reading 1 and 2 the result would thus have to be a neurological response (as defined by Korr as cited in Leach (1994)) where immediate effects are shown with the reading between 2 and 3 the resulting from biomechanical / physiological responses based on the resolution of inflammation, adhesion formation / resolution oedema reduction (as explained by Dvorak, Gatterman and Goe, Mense, all as cited in Leach, 1994), which take time to manifest and therefore show a distinct difference in the readings taken.

4.5.2 Endurance

4.5.2.1 Endurance-Prone

Table 10: Tests of within-subjects and between–subjects effects for time (prone)

Effect	Statistic	p value
Time	Wilk's lambda=0.665	<0.001
Time*gender	Wilk's lambda=0.982	0.655
Time*race	Wilk's lambda=0.967	0.820
Time*age quartiles	Wilk's lambda=0.929	0.748
Time*height quartiles	Wilk's lambda=0.811	0.132
Time*weight quartiles	Wilk's lambda=0.892	0.486

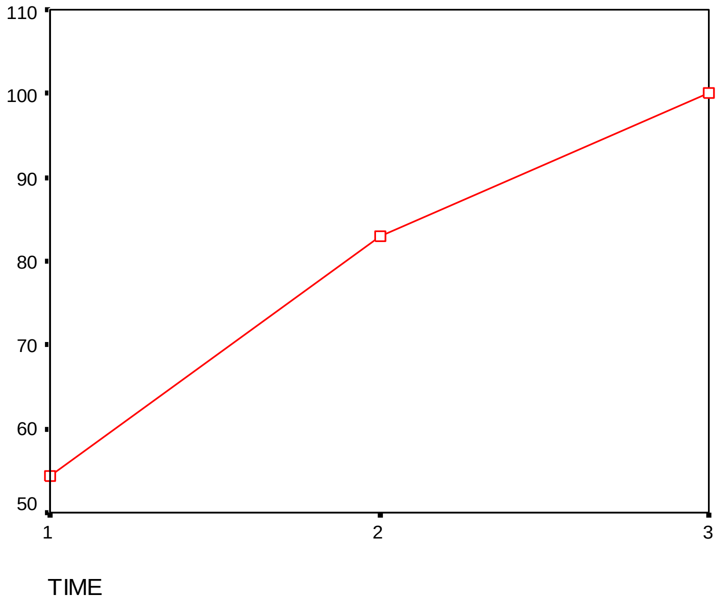


Figure 17: Profile plot of endurance (prone) over time

Time in the prone position increased highly significantly over time (p<0.001). This is shown in fig 17. None of the demographic factors were associated with the change over time.

4.5.2.2 Endurance-Supine

Table 11: Tests of within-subjects and between–subjects effects for time (supine)

Effect	Statistic	P value
Time	Wilk's lambda=0.750	0.001
Time*gender	Wilk's lambda=0.911	0.117
Time*race	Wilk's lambda=0.945	0.623
Time*age quartiles	Wilk's lambda=0.885	0.455
Time*height quartiles	Wilk's lambda=0.880	0.424
Time*weight quartiles	Wilk's lambda=0.901	0.554

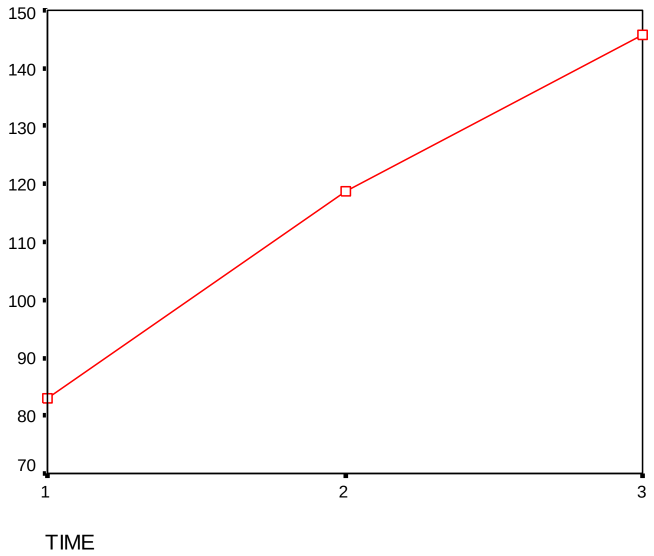


Figure 18: Profile plot of mean endurance (supine) over time

Endurance in the supine position increased highly significantly over time (p=0.001). The demographic factors did not influence the change over time. The increase in mean endurance is shown in fig 18. It was an almost linear increase.

From the above figures, results showed that the rate of improvement over time is consistently proportional between supine fig 18 and prone fig 17 readings, indicating that the multifidus and transverses abdominus have a reciprocal relationship where the rate of improvement by ratio is similar where the extent differs. These changes in the multifidus and transverses abdominus are also congruent with the prone strength test fig 16 where the initial rates of improvement (endurance) correspond with the increased difference noted in the strength testing.

This supports the discussion found in the reviewed literature in chapter 2, where co-contraction was found between the multifidus and transverse abdominus muscles (Richardson and Jull, 1995). Therefore with the graphs being very similar in fig 17 and fig 18, it gives a good indication that there is a co-contraction relationship between these two muscles.

In addition there could also be a suggestion that there is increased ability of the patient to recruit the muscle(s) more appropriately over time, either as a result of:

- ☑ Improved neurological co-ordination in recruiting the motor units required or
- ☑ Through the increased ability of the muscle fibres to maintain a contraction for a longer period or to a greater degree.

This suggestion is evident from research conducted by Patterson and Steinmetz (1986), who have been able to show that with repeated stimuli to a particular region set responses can be elicited and that these responses can over time also be initiated by stimuli other than the inciting stimulus. Thus their suggestion for spinal learning of set routines or tasks implies that that patient could have “learnt” the appropriate response required.

4.6) Pain and disability findings

In summary, the following theories were used to explain the reduction in pain using the NRS and the algometer:

1. The correction of the mechanical dysfunction of the sacroiliac joint resulting in normal joint motion and relaxation of surrounding muscles (Bergmann, 1993), and therefore decreasing pain.
2. The gait control theory whereby the stimulation of the bigger A-fibres overrides the smaller nociceptive C-fibers (Melzack and Wall, 1965). The decrease in reported pain (through the NRS as seen in fig 42) indicates that the manipulation of the fixated joints plays a large role in the reduction of pain (Melzack and Wall, 1965). Furthermore, the increased level of daily activities (by means of the RMQ as revealed in fig 48) indicates that the manipulation of the fixated joints, plays a large role in the increase of muscle relaxation and breaking of articular adhesions, thereby inducing resolutions of the syndromes (Melzack and Wall, 1965).

The gait control theory - elaborated:

The spinal gating mechanism is found within the Rexed's lamina ll (substantia gelatinosa) of the dorsal horn of the spinal cord. It controls the central transmission of sensory information including pain, touch, temperature, and proprioception. The articular capsules of the spinal facet joints are populated by mechanoreceptors. These encapsulated nerve endings relay proprioceptive information on joint position and mobility through large A myelinated fibres which have been implicated in overriding the smaller type C nociceptive unmyelinated fibres to the substantia gelatinosa. These fibres thereby induce a gait control effect (Melzack and Wall, 1965). Hence, increased proprioceptive input in the form of spinal mobility tends to decrease the central transmission of pain from adjacent spinal structures by closing the gate. Wyke (Leach, 1994) has also shown that articular mechanoreceptor stimulation has a reflexogenic effect on motor unit activity in the muscles over the joint being stimulated. Stretching of apophyseal joint capsules can therefore reflexely inhibit a facilitated motoneuron pool that is responsible for the increase muscle excitability and spasms that commonly accompany low back pain. In more chronic cases, there is shortening of periarticular connective tissue and intra-articular adhesions may form. Manipulation may stretch or break these adhesions (Mrozek and Vernon, 2005). Thus joint movement that was previously restricted in both acute and chronic spinal pain, is increased by spinal manipulation that causes spastic paraspinal muscle to relax. Increased movement causes an increase in proprioceptive input, which in turn has a reflex inhibition on the transmission of pain as previously explained.

Furthermore, manipulation could cause a reduction in the mechanical dysfunction of the joint by re-aligning the depressions and ridges of the joint surfaces as described by Wyke (Leach, 1994). Returning it to its normal position allowing for the return of normal movement and thus, stimulating the large mechanoreceptor fibres (Wyke type I, II and III). Wyke (Leach, 1994) states that all synovial joints have the following types of receptor nerve endings:

Type I: Globular corpuscles in the outer layers of the fibrous capsule; thinly encapsulated mechanoreceptors.

Type II: Conical corpuscles in the deeper layers of the fibrous capsule; thickly encapsulated mechanoreceptors.

Type III: Larger corpuscles on the surface of joint ligaments; thinly encapsulated mechanoreceptors.

Type IV: Unmyelinated nerve fibres that weave throughout the capsule; nociceptors.

3. In addition to the above 2 points, the inflammatory theory states that, with the resolution of the restriction through the adjustment, the resultant increased circulation in the area (Leach, 1994), will wash inflammatory products away, decreasing pain. At the same time, the adjustment eliminates the initial stimulus (the restriction), which evoked the inflammatory changes as described by Dvorak (Leach, 1994).

4.6.1 Numerical Pain Rating Scale-101 (NRS)

NRS was evaluated at 3 time points, with the pre and post manipulation recordings for each session: thus, the short terms effects were evaluated.

Table 12: Tests of within-subjects and between–subjects effects for NRS

Effect	Statistic	p value
Time	Wilk's lambda=0.227	<0.001
Time*gender	Wilk's lambda=0.996	0.917
Time*race	Wilk's lambda=0.953	0.688
Time*age quartiles	Wilk's lambda=0.763	0.048
Time*height quartiles	Wilk's lambda=0.850	0.267
Time*weight quartiles	Wilk's lambda=0.932	0.769

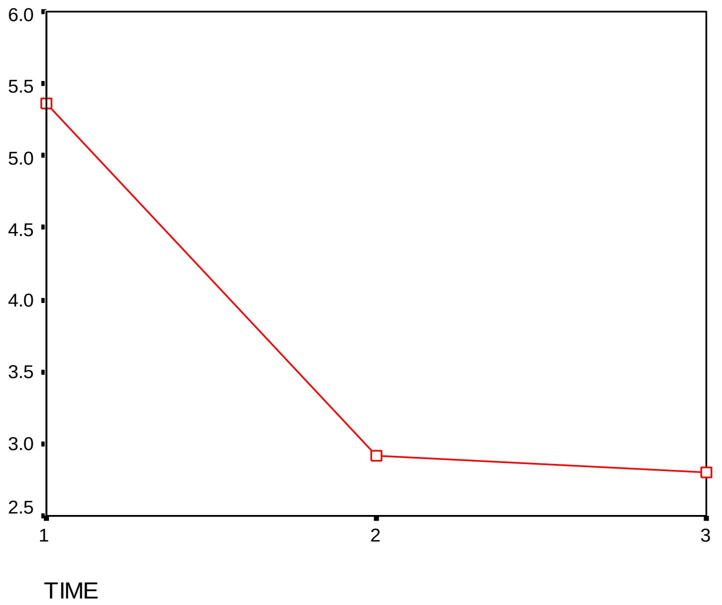


Figure 19: Profile plot of mean NRS over time

There was a significant interaction between time and treatment (p<0.001) for NRS. Figure 19 shows that the mean NRS values in the group decreased over the treatment period. Accordingly there was a significant beneficial treatment effect for NRS. We can therefore conclude that the manipulation provided significant pain relief to the patients in the group.

This effect is in congruence with the literature (Kirkaldy-Willis and Burton, 1992: 249 and Cassidy and Mierau, 1992: 223) that indicates a decrease in pain is expected post manipulation or after a course of manipulative treatments as a result of one or more of the proposed mechanisms discussed under 4.6.

Furthermore, the effect of the intervention also could have been as a result of the restoration of mechanical mobility (Gatterman, 1990 and Bergmann, 1993), whereby the increased movement within the restricted joints would have allowed for normal movement and the stimulation of mechanoreceptors within the now mobile joint. This increased stimulation of the mechanoreceptors would have lead to an improvement in pain levels, which is attributed to Melzack and Wall's 'Gate Control Theory' (1965).

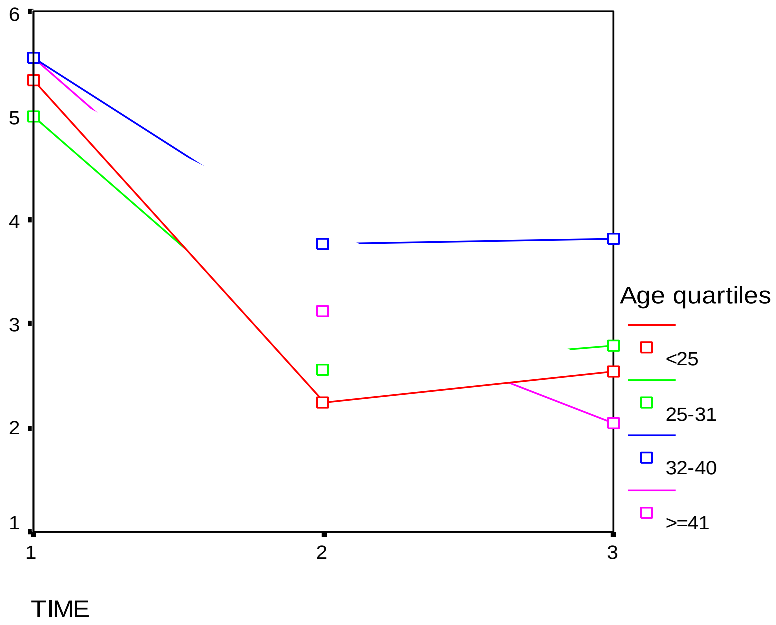


Figure 20: Profile plot of mean NRS over time by age quartiles

There was a highly significant decrease over time for NRS in all participants (<0.001). However, the decrease was dependant on age group (p=0.048). Figure 20 shows that the oldest age group (>=41) benefited the most from the manipulation as they continued to show a decrease after time 2, whereas the other age groups levelled off and even showed a slight increase in NRS score after time 2.

With respect to the three phases of degeneration discussed in section 4.4.2, it could be expected that in Phase 1 the <25 and 25-31 year age groupings would have similar patterns of baseline readings and decreased NRS readings over the treatment period. As the presentation / pathogenesis of the presenting inflammatory processes is normally acute in nature without a chronic history of pain, as well as the ability for healing to occur at a more rapid and efficient rate in younger individuals (Vizniak and Carnes, 2004), it stands to reason that their improvement should be better than the older individuals.

In Phase 2 the 32-40 age groups is the least improved group in relation to the baseline reading and the improvement of pain over the treatment period of this study. This is as a combined result of the decrease in healing ability as well as the more chronic nature (even thought there may be acute episodes these are superimposed on a chronic condition) of the syndromes and the low back pain that results.

And phase 3, the 40-45 age group, had a baseline reading similar to the 32-40 age group but improved the best over the treatment period when compared to all the age groups. This seems to contradict the suggestions for phase 1 and 2 as one would expect to find that these patients improve the least. However, one also needs to consider that the degree of inflammation is decreased as a result of the limitation that is provided for by the stabilisation process in the older individual.

4.6.2 Algometer (1) – sacroiliac joint

Algometer (1) refers to the first site that was measured (sacroiliac joint).

Table 13: Tests of within-subjects and between–subjects effects for algometer (1)

Effect	Statistic	p value
Time	Wilk's lambda=0.429	<0.001
Time*gender	Wilk's lambda=0.838	0.017
Time*race	Wilk's lambda=0.914	0.383
Time*age quartiles	Wilk's lambda=0.864	0.333
Time*height quartiles	Wilk's lambda=0.883	0.438
Time*weight quartiles	Wilk's lambda=0.764	0.049

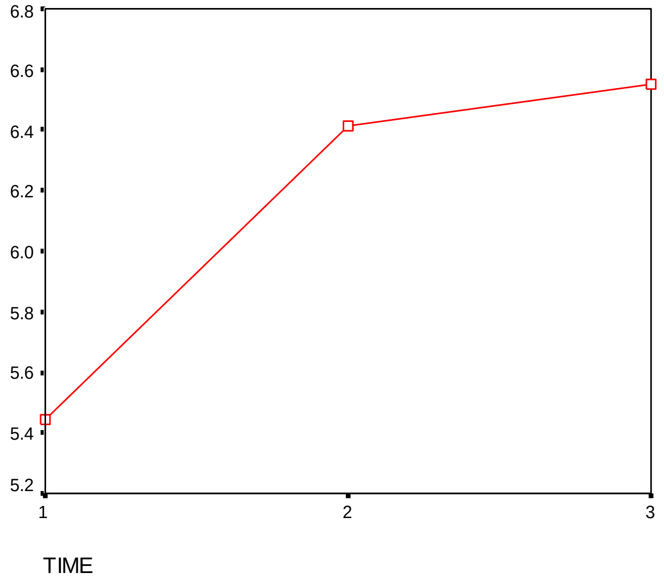


Figure 21: Profile plot of mean algometer (1) over time

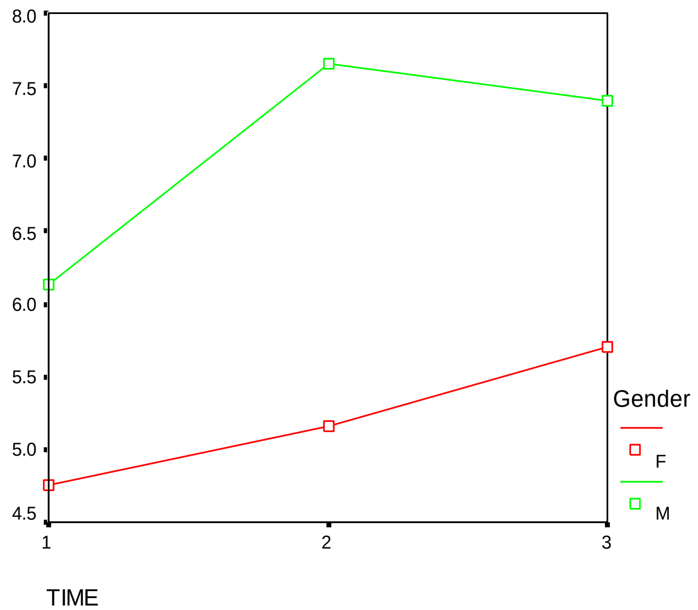
There was a highly significant change over time (p<0.001). However, this change was dependant on gender (p=0.017) and weight (p=0.049).

The reason for the significant improvement of algometer readings in time could be

- Manipulation seems to be able to elicit reflexes that have the potential to reduce hypertonicity (spasm) in the surrounding muscles (Korr as cited in Leach, 1994: 99 and Kirkaldy-Willis and Burton, 1992: 250).
- Inflammatory theory which states that, with the resolution of the restriction

through the adjustment, the resultant increased circulation in the area (Leach, 1994), which will wash inflammatory products away and decreasing pain.

- The decrease in inflammatory exudates post treatment (Bergmann,1993:123-125) allowing for a decrease in sensitivity to pressure over the region of the capsule related to the sacroiliac joint or corresponding facet where the reading(s) where taken.
- Restoration of mechanical restrictions (Gatterman, 1990 and Bergman, 1993), whereby the increased movement within the restricted joints would have allowed for normal movement and the stimulation of mechanoreceptors within the now mobile joint. This increased stimulation of the mechanoreceptors would have lead to an improvement in pain levels (Melzack and Wall, 1965).



<u>Figure 22: Profile plot of mean algometer (1) over time by gender</u>

As mentioned previously, females have a higher pain tolerance than males and lower sensitivity for pain than men (Jackson *et al.,* 2005; Girdler *et al*., 2005; Hong-You *et al.,* 2004 and Koegh *et al*., 2000). Hence the increase sensitivity in females seen in fig 22 after initial reading when compared to males, may be accounted for by increased sensitivity over the point at which the algometer reading was taken.

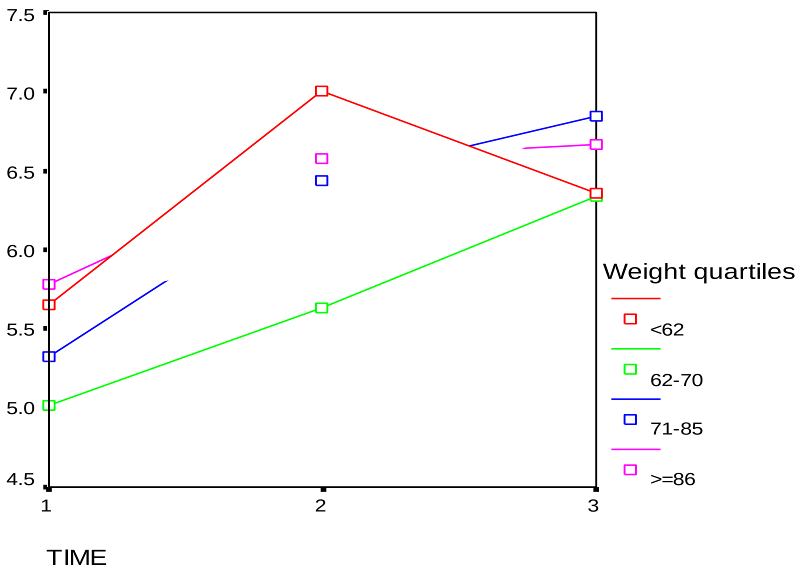


Figure 23: Profile plot of mean algometer (1) over time by weight

Figure 23 shows that males displayed the highest rate of increase between time 1 and 2, but thereafter showed a decrease, while the females showed a steady increase throughout. Figure 23 shows that the <62 kg weight group had a mean decrease in algometer measurements between time 2 and 3, while the other groups continued to increase.

Patients in the heaviest quartile had the highest algometer reading at baseline, which could be attributed to the cushioning effect provided for by increased soft tissues over the joint where measurements were taken. In addition to the cushioning effect, it leads to a masked improvement, which may not reflect the joint pathology accurately. Patients in the lightest quartile had substantial initial improvement based more accurately on the joint pathology as the algometer readings are more likely to reflect the syndrome improvement. However, with subsequent readings it seems that there is a decrease in the improvement, which may be related to an increased reflection of periosteal discomfort induced by the algometer being placed repeatedly over the same point in order for readings to be taken.

Furthermore, the algometer readings are a reliable means to measure tissue consistency which could have been affected by muscle hypertonicity, spasm and inflammation, and therefore these readings should be done over soft tissue structures and not hard bony structures which could give a false positive reading (Fisher, 1987), which may have been the case in instances where the reading was taken near / on the posterosuperior iliac spine (PSIS) of a lighter individual.

The centre quartiles seem to reflect a median between these two extreme quartiles, indicating that weight and algometer placement are affected by the soft tissue structures as well as the algometer placement.

4.6.3 Algometer (2)- facet

Only 47 participants had a 2nd algometer measurement (over an associated facet).

Table 14: Tests of within-subjects and between–subjects effects for algometer (2)

Effect	Statistic	p value
Time	Wilk's lambda=0.393	<0.001
Time*gender	Wilk's lambda=0.860	0.083
Time*race	Wilk's lambda=0.827	0.174
Time*age quartiles	Wilk's lambda=0.921	0.835
Time*height quartiles	Wilk's lambda=0.854	0.496
Time*weight quartiles	Wilk's lambda=0.922	0.840

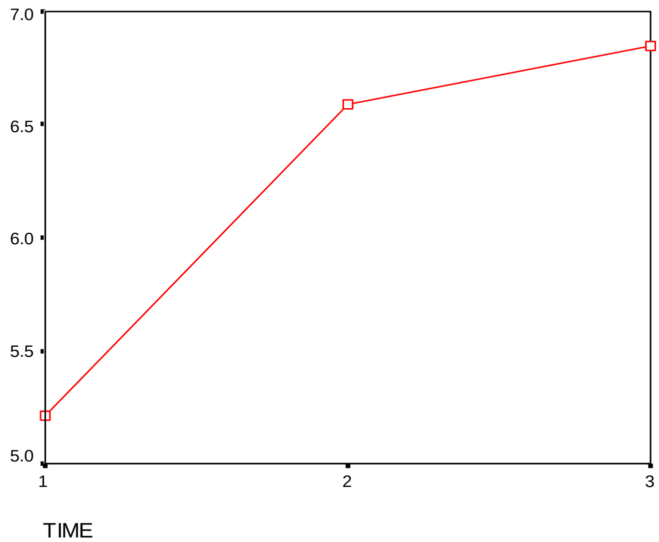


Figure 24: Profile plot of mean algometer (2) over time

There was also a highly significant change over time for this outcome. Demographic factors did not affect the change over time. Figure 24 shows the change in the sample over time.

Algometer readings were taken over the tender lumbar facet joints. These facet joints are covered with layers of soft tissue (e.g. QL, multifidus, and iliocostalis muscles Moore, 1992), and therefore have a decreased sensitivity of the periosteum when comparing it to the sacroiliac joint, where bony contact by the algometer was more likely as the sacroiliac joint is a more superficial joint with less soft tissue covering, making this joint more sensitive to periosteal irritation.

Nonetheless the algometer readings showed improvement, which could be attributed to and is consistent with decreased muscular tonicity over time, which is noted to be less than the improvement seen over the joint of the sacroiliac.

4.6.4 Roland Morris Lower Back Pain Questionnaire (RMQ)

RMQ score was also evaluated at 3 time points, with the pre and post manipulation recordings for each session, thus the short terms effects were evaluated. The subjects had to state which (if any) of 24 lower back pain disabilities they experienced.

Table 15: Tests of within-subjects and between–subjects effects for RMQ score

Effect	Statistic	p value
Time	Wilk's lambda=0.605	<0.001
Time*gender	Wilk's lambda=0.970	0.498
Time*race	Wilk's lambda=0.885	0.224
Time*age quartiles	Wilk's lambda=0.849	0.262
Time*height quartiles	Wilk's lambda=0.850	0.264
Time*weight quartiles	Wilk's lambda=0.908	0.607

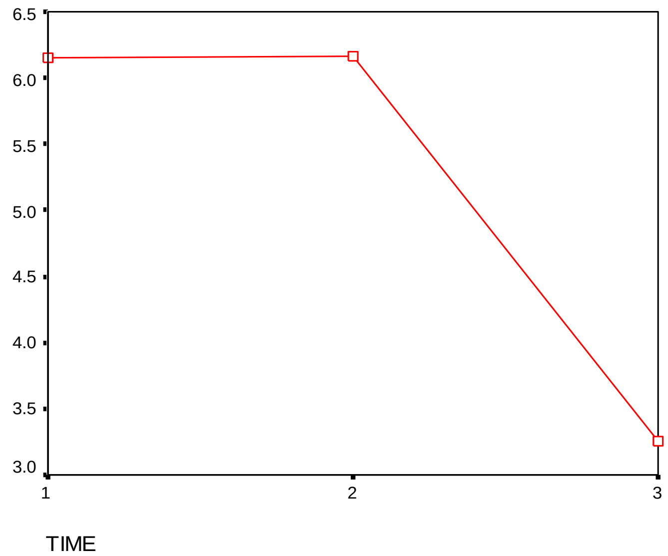


Figure 25: Profile plot of mean RMQ score over time

The effect of the manipulation was statistically significant (p<0.001). None of the demographic factors affected the change in RMQ. Figure 25 shows that the decrease in mean score happened after time 2. There was a significant time*group interaction for RMQ score (p=0.047). Figure 25 shows that the mean score for the group decreased over time.

As seen on the fig 25, there is no change between reading 1 and 2 due to the fact that the first reading was taken before the manipulation and the second reading directly after the manipulation during the first consultation. The reason for no change in the reading is that the participants were not able to do the activities that the questionnaire required them to answer questions in response to. However, the third reading was taken two days after the first consultation, allowing the patients to complete various or all the activities of daily living asked about in the questionnaire and thus they were able to respond to any improvement or lack thereof at the point where the 3rd reading was taken. Accordingly the results seen in the fig 25 indicate that there was an improvement, which is denoted as being significant.

Thus, there was a significant beneficial treatment effect for RMQ with a single treatment however multiple treatments have shown to be more effective than the single interventions as supported by Patterson and Steinmetz (1986) and Leach (1994). Patterson and Steinmetz as cited by Leach (1994) stated that in an area of spinal joint dysfunction with accompanying motion disorder and muscle tension, if the initial stimulus is sufficient or lasts long enough, there may be segmental facilitation even after the initial stimulus is removed (Leach, 1994:101). The resultant abnormal segmental reflex circuit participates in maintaining the symptoms, thus creating a cycle of increased output with any sensory input (Leach, 1994:101). Once the excitability changes were fixated in the cord, a “neural scar” of subliminally exited neurons would remain, which would be abnormally responsive to additional stimuli (Leach, 1994:101). Alterations in these spinal reflex circuits would not be easy to remove and therefore multiple treatments would be needed. As a result, future research should be directed in this line.

It is of particular interest that the following questions on the RMQ were those most commonly answered:

1 Changing position frequently to get back comfortable (75%).
2 Standing up only for short periods (47%).
3 Avoiding heavy jobs (47%).
4 Less comfort during sleep (35%),

Which correlate well to the presentation of sacroiliac syndrome as found in clinical practice (fig 24).

4.7) The effect of baseline restrictions (level, side and direction) on strength, endurance, and algometer measurements

There was no change on the treatment effect due to level, side or direction of restrictions for strength in the prone position. Figures 26-31 show that the profiles of the different groups all showed a decrease over time with almost parallel lines.

.7.1 Strength

Table 17: Tests of two-way interaction effects for strength (prone) with motion palpation findings

Effect	Statistic	p value
Time*level a	Wilk's lambda=0.991	0.785
Time*side a	Wilk's lambda=0.949	0.246
Time*direction a	Wilk's lambda=0.939	0.187
Time*level b	Wilk's lambda=0.907	0.870
Time*side b	Wilk's lambda=0.951	0.386
Time* direction b	Wilk's lambda=0.990	0.825

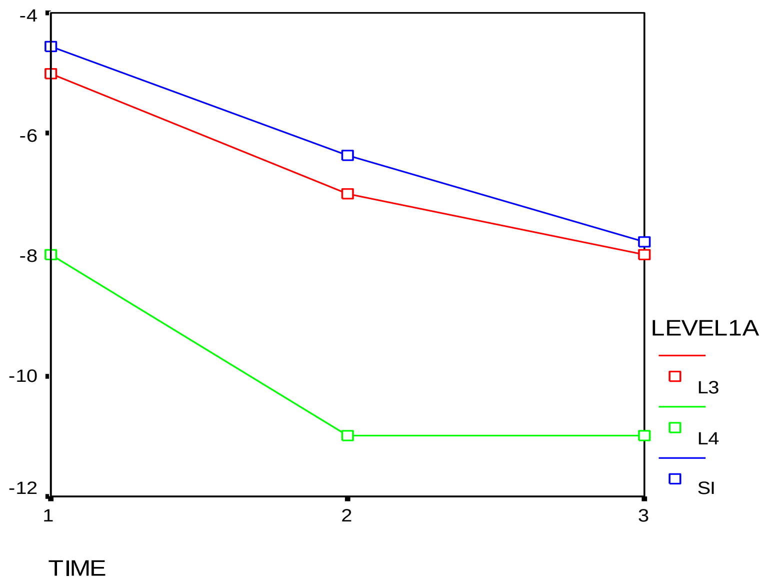


Figure 26: Profile plot of mean strength (prone) by level of restriction at baseline (a)

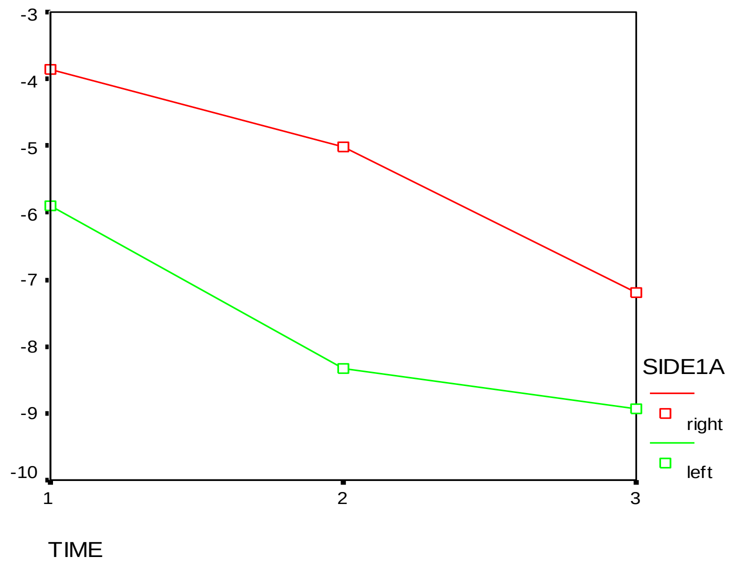


Figure 27: Profile plot of mean strength (prone) by side of restriction at baseline (a)

From the above figure, the trend shows that L4 manipulations had the most effective outcome on the mean strength of the core muscles over the treatment period and the left and right sides had the similar results over the treatment period. Although the results were insignificant, it is markedly different or could imply that L4 manipulations could be effective in strengthening the core muscle.

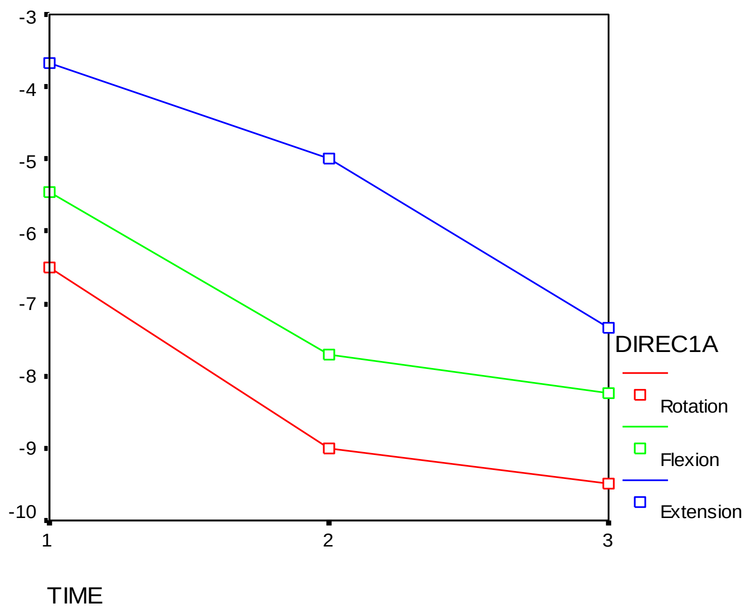


Figure 28: Profile plot of mean strength (prone) by direction of restriction at baseline (a)

As mentioned in Chapter two, manipulation seems to be able to elicit reflexes, which have the potential to reduce hypertonicity (spasm) in the surrounding muscles (Korr as cited in Leach, 1994: 99 and Kirkaldy-Willis and Burton, 1992: 250). This reduction of muscle hypertonicity is supported by (Suter *et al.,* 2000), who described arthrogenic muscle inhibition (AMI) as the inability of a muscle to recruit all motor units of a muscle group to their full extent during a maximal effort voluntary muscle contraction (Hopkins, 2000).

Spinal manipulative therapy on a joint has therefore been proposed to activate mechanoreceptors from structures in and around the manipulated joint, with the stimulation of these receptors causing an altered afferent input which is thought to cause changes in the motor neuron excitability, with a subsequent decrease in AMI (Suter *et al.,* 2000 and William, 1997). Taking this into account, it can be concluded that spinal manipulative therapy has an effect on pain (in congruence with the previously reported NRS scores seen under 4.5.1), muscle hypertonicity and muscle weakness, which are closely associated with AMI and its implications of decreased ability and endurance.

In addition possible factors that are responsible for the changes / influences on core stability activation and endurance, include:

- The type of muscle fibres found in the local and global stabilizers e.g. fast twitch versus slow twitch fibers. Fast twitch fibres (global muscles) can deliver extreme amounts of power for a few seconds to a minute or so. On the other hand, slow twitch fibres (local muscles) provide endurance, delivering prolonged strength of contraction over many minutes to hours (Guyton and Hall, 1996).
- The degree of physiological preparedness with respect to glycogen stores and fuel supply for any given activity. The performance of a muscle, to a great extent, depends on the nutritive support to the muscle- more than anything else on the amount of glycogen that has been stored in the muscle before the period of exercise. This is also related to the type and the amount of training muscles undergoes (Guyton and Hall, 1996).
- The degree of neurological stimulation that is afforded to the respective muscle types as well as the neurological pathways that exist, either normal or

compensatory – with respect for e.g. to the presence or absence of changes if the person has had low back pain (Leach, 1994 and Patterson and Steinmetz, 1965).

- Furthermore and according to Panjabi (1992), the spinal stabilizing system consists of three interrelating sub-systems-
    1. Control sub-system (neural)
    2. Passive sub-system (spinal column, joints, ligaments)
    3. Active sub-system (muscular)

  A dysfunction of any component of any of the sub-systems can result in an immediate response from the other sub-systems to successfully compensate, which would result in normal function of the system as a whole. If there were however, a long-term adaptive response of one or more sub-systems, this would result in normal function but with altered spinal stabilization. Finally, an injury to one or more component of any sub-system would result in overall system dysfunction leading to painful conditions (Panjabi, 1992).

Furthermore Hides *et al.* (1996) states that when compared to other muscles in close proximity to L4-L5, the multifidus muscle contributed two thirds of the increased stiffness imparted by contraction of the muscles. He concluded from this that the multifidus muscle is an important muscle for lumbar segmental stability (Hides *et al*., 1996), which correlates well to the high number of L4-L5 restrictions found in the lumbar spine and suggests that this region is a key to activating the multifidus muscle and its co-contractor the transversus abdominis.

In addition, the following also need to be considered:

1. The trunk muscle (external oblique / rectus abdominus) coordination may be compromised by muscle fatigue and result in decreased trunk stability, with an increased risk of injury to the lower back (O'Brien and Potvin, 1997).

2. It has been hypothesized that the abdominal muscles tend to fatigue more easily than the low back muscles, especially in individuals with chronic low back pain (Fischer, 1987). In support of this unilateral wasting of the multifidus (on the symptomatic side) was found using ultrasound in patients with low back pain (Hides *et al.,* 1994). Indicating that there may be a

compromise of the multifidus through the same mechanism of fatigue / overload, resulting in decreased use of the muscle as well as atrophy. This is significant as once the multifidus muscle is injured there is no spontaneous muscle recovery even on remission of painful symptoms (Hides *et al.,* 1996).

3. To add complexity to the discussion, it has also been found that the lattisimus dorsi as one of the principle muscles of force transfer between the lower and the upper extremity (Seaman, 1999), could be a cause of low back pain, especially if there is an imbalance between the lattisimus dorsi and its antagonists, the gluteus medius and maximus on the contralateral aspect of the thoracolumbar fascia (Mould, 2003). This imbalance could result in the development of restricted motion within the sacroiliac joints (Thompson, 2002) as one of the functions of the thoracolumbar fascia is that of sacroiliac compression as an aid for energy transfer from the gluteal muscles on the one side to the latissmus dorsi of the opposite side (Harrison *et al.,* 1997: 610). Unrelated to the joint structures of the low back, the use of non-contractile tissues in energy transfer (Seaman, 1999), with the resultant changes due to creep and hysteresis (Foreman and Croft, 1995), will ultimately place more stress on the joints which these non-contractile structures are to protect, thereby precipitating the presence of low back pain in either the facet joints (L4-L5) or the sacroiliac joints.

These three discussions are self explanatory and is based on good literature. Therefore one can not be favoured above the other and should therefore be seen as an entity.

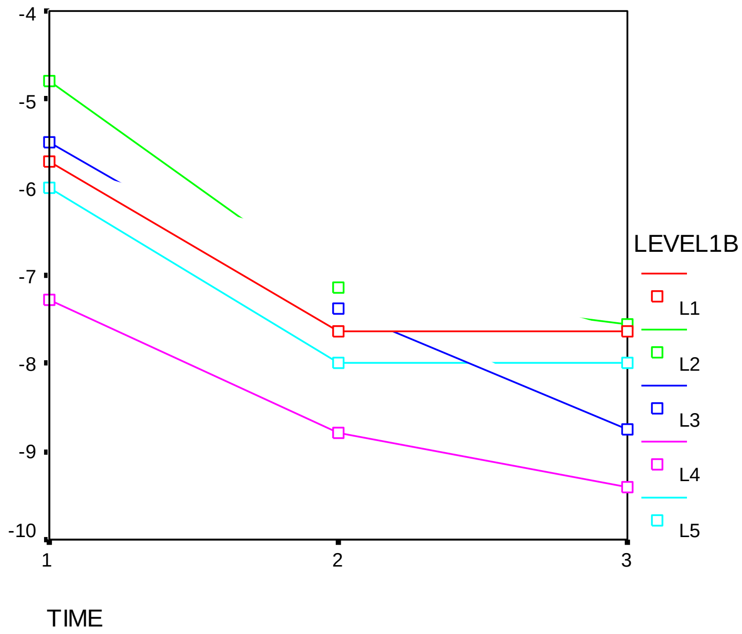


Figure 29: Profile plot of mean strength (prone) by level of restriction at baseline (b)

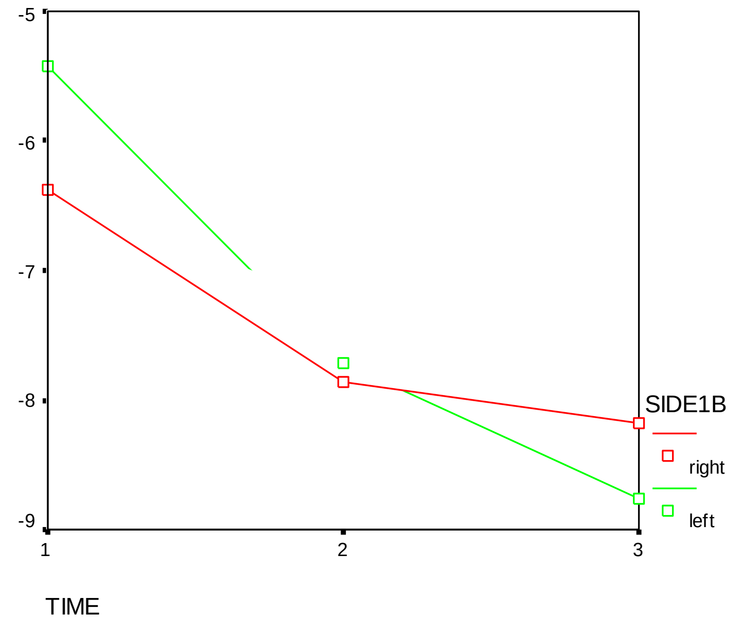


Figure 30: Profile plot of mean strength (prone) by side of restriction at baseline (b)

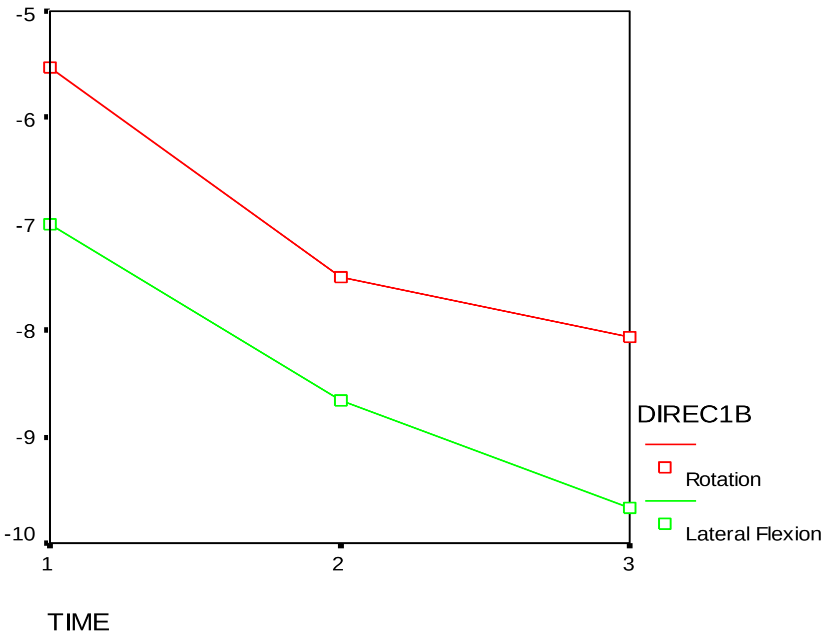


Figure 31: Profile plot of mean strength (prone) by direction of restriction at baseline (b)

L1, L2, L3, L4 and L5 fixations, all played a role in the mean strength (prone) outcome in this study. L3 and L4 manipulations were found to have the most effect on the core muscle strength during the intervention period as seen in fig 29. Which is congruent with the discussion above.

The facets of the lower lumbar spine are in the coronal plane allowing more flexion and extension than rotation (Moore, 1992) making the lower lumbar spine more susceptible to rotation injuries. This observation concurs with Seaman (1999) who stated that spinal rotation begins at the lumbosacral junction, where he indicated that the limits of rotation for the L5-S1 joint are 0º-2º, and for the L4-L5 through T10-T11, rotation is limited to 1º-3º (Seaman, 1999). L3 is a more transitional vertebral of the lumbar spine and therefore may not be aligned with the other areas of the lumbar spine (Moore, 1992: 462/3).

This rotation may however be complicated by the limitations that the iliolumbar ligaments place on the L5 level (Moore, 1992) which, may make the L5 presentation relate more directly with the sacroiliac joint fixations than to the mechanics specific to the region of L5. This seems to be particularly so on the left side (left upper flexion), where a propensity of left sacroiliac restrictions seem to be related to L4-L5 restrictions.

The neurological innervations of the following divisions are as follows:

Ventral rami of L1-L3	Iliopsoas muscle
Ventral branches of T12-L1-L4	Quadratus Lumborum
Femoral nerve L3 and L4	Quadratus femoris
Sciatic nerve L5-S2	Hamstrings
Superior gluteal nerve L4, L5-S1	Gluteus medius and Gluteus minimus (prone pelvis stabilizers)

In the lumbar spine the application of the adjustment allows for greater effect on the stretch receptors in the muscles, tendons and ligaments, than when compared to the application of a manipulation in the sacroiliac joint. This concurs with the theory of Mrozek and Vernon (2005) where it is indicated that the degree to which the adjustment is effective is directly related to the neurological stimulation that the adjustment produces through the neurological receptors as identified by Wyke (Leach, 1994).

Therefore in this research, both the lumbar facet and the sacroiliac syndrome were required to be clinically symptomatic in order for the patient to enter the research. The only difference that could have affected the outcome, would / could have been that of the difference in the underlying mechanics of the different regions, where the SI is inherently more stable than the lumbar spine (specifically the L2-L4 region). Therefore even though the clinical syndromes were present, the degree to which the adjustment affected the neurological structures, as proposed by Wyke (Leach, 1994) and suggested by Mrozek and Vernon (2005), indicate that the lumbar spine outcomes achieved in this study may have been amplified by the inherent motility difference in the 2 regions being compared at this point in the study. Consequently the results may suggest an artificial scenario in which the lumbar spine produces greater clinical effects. Therefore caution must be exercised in accepting these results in the knowledge that the baseline readings as well as the subsequent results are based on the incorrect premise that the 2 regions have the same inherent mobility in this study may have been.

Time prone (a), time supine (a) and algometer (a) refers to the initial consultation where a pre and post treatment measurements were taken for the respective objectives. Time prone (b), time supine (b) and algometer (b) refers to the second consultation, that only took place 48 hours after the initial consultation, are the third set of readings for the respective objectives.

4.7.2 Time (prone)

The side at which the second restriction was located had a significant effect on the time in the prone position. Figure 62 shows that those who were affected on the right side increased at a faster rate than those affected on the left side. There are also non-significant trends shown in fig 58 – 63. For example, in fig 58 it appears that those who were affected at the L3 level showed a faster rate of improvement than those at the other levels.

Table 18: Tests of two-way interaction effects for time (prone) with motion palpation findings

Effect	Statistic	p value
Time*level a	Wilk's lambda=0.944	0.218
Time*side a	Wilk's lambda=0.999	0.970
Time*direction a	Wilk's lambda=0.967	0.406
Time*level b	Wilk's lambda=0.827	0.486
Time*side b	Wilk's lambda=0.797	0.013
Time* direction b	Wilk's lambda=0.940	0.310

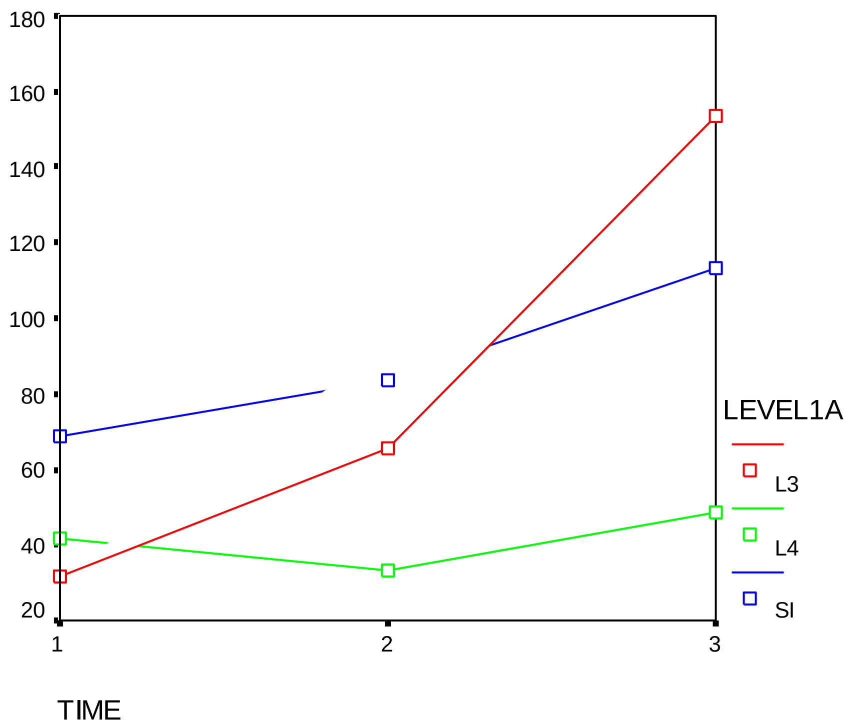


Figure 58: Profile plot of mean time (prone) by level of restriction at baseline (a)

It would seem that the adjustment of L3 is most closely related to the improvement of time that the contraction is held or the pressure of the bladder is maintained once the contraction has been affected. Literature indicates that there are 2 possible reasons for :

- Neurological stimulation of the multifidus by means of the stimulation of the Wyke receptors indicates that there should be a perceived decrease in pain and discomfort allowing the patient decreased inhibition of the multifidus antagonists, which are then able to work more effectively and therefore maintain the contraction (Korr as cited in Leach, 1994 and Hopkins and Ingersoll, 2000).
- Change in the lumbar mechanics, whereby there is a decrease of perceived pain by the patient that is lying on their stomach. This position (prone) is known to aggravate the acute facet syndrome, by means of the induced hyperextension brought to the lumbar spine as the patient lies down with the pain principally directed at the apex of the lumbar curve. The patient would have been uncomfortable in this position, resulting in possible painful inhibition of the multifidus and its co-contractors for "fear of aggravating the pain: (Kirkaldy-Willis and Burton , 1992 and Bergmann *et al.,* 1993).

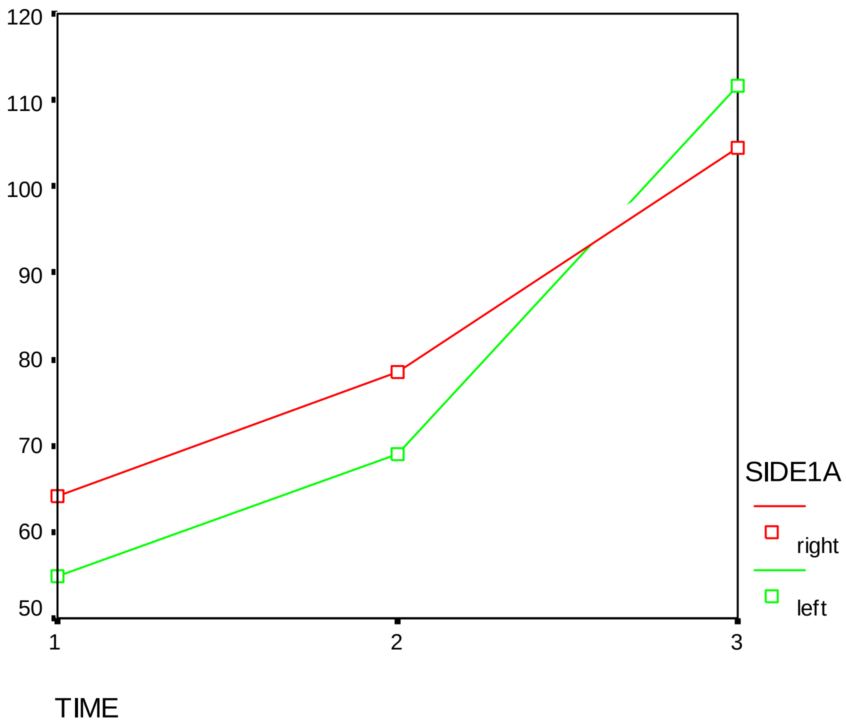


Figure 59: Profile plot of mean time (prone) by side of restriction at baseline (a)

The side of the restriction seems to concur with the prevalence of sidedness found with respect to restrictions, therefore this supports the suggestion above (fig 58), where there is a relationship between the removal of the restriction, reduction of pain and increased endurance whether the sacroiliac or the facet are manipulated to reduce the discomfort in the spine allowing for decreased inhibition (Hopkins and Ingersoll, 2000) and thus prolonged ability to perform the manoeuvre.

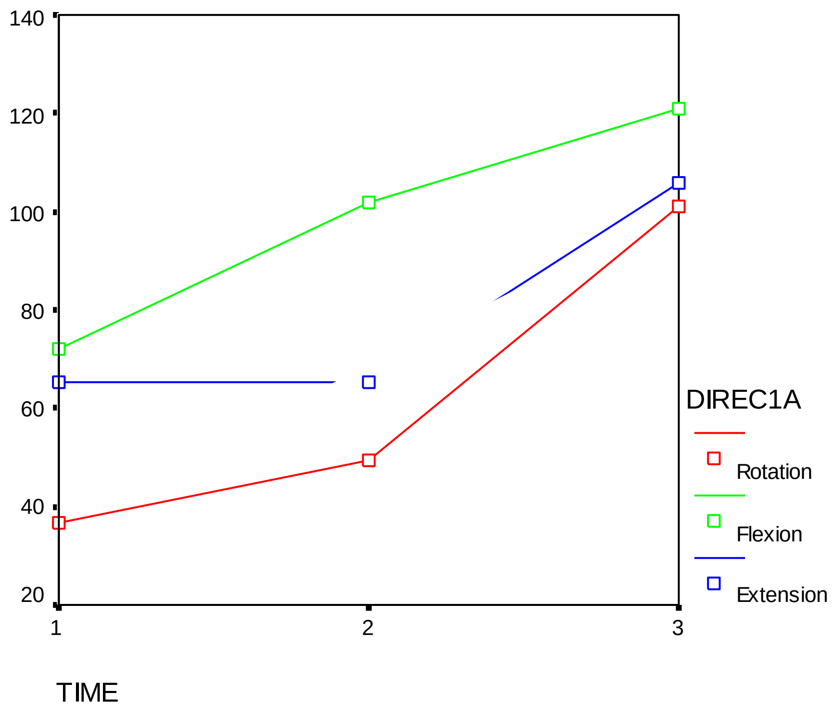


Figure 60: Profile plot of mean time (prone) by direction of restriction at baseline (a)

In concurrence with the side and the level, it was also found that the most improvement in prone time was related to the movement of rotation, which started out at being associated with the lowest / shortest time prone, but improved to a greater extent over the course of the study. This concurs with the 2 previous graphs (fig 58 & 59). In that the rotation that most greatly affects the multifidus and thus would impart the greatest degree of neurological stimulation (in rotation). Thus it would stand to reason that this movement would yield the greatest change in time prone, when compared to the other possible restrictions of movement noted.

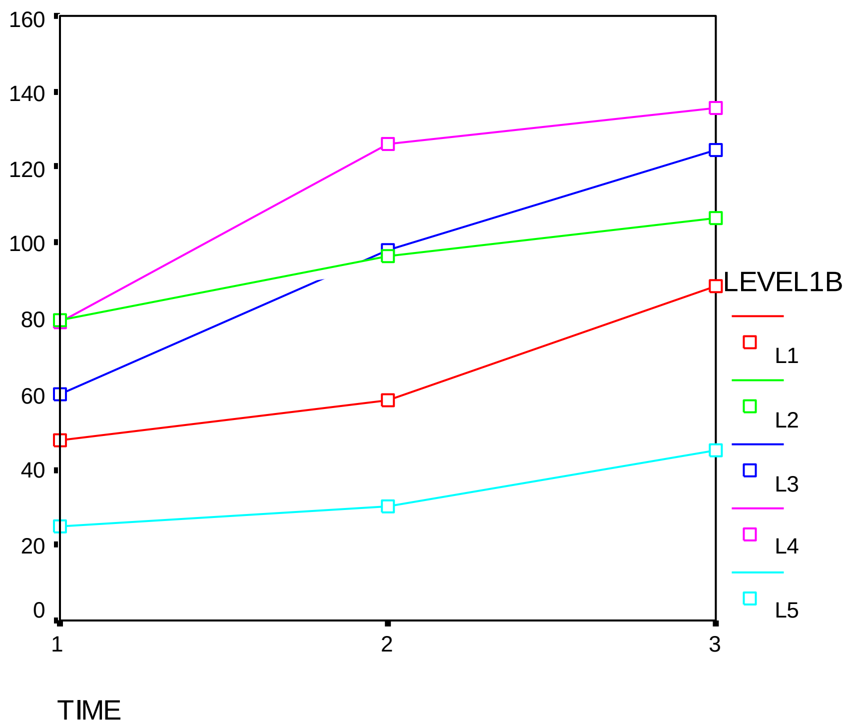


Figure 61: Profile plot of mean time (prone) by level of restriction at baseline (b)

It would seem from the above graph (fig 61), that the most notable changes with specific respect to the lumbar spine would be L3-L4 and L1. This would concur with the findings of the previous set of graphs (fig 58 – 60), in addition to which there is a suggestion for a direct effect on the antagonist of the multifidus with respect to the level of L1, which innervates the lower 1/3 of the rectus abdominis muscle.

An argument could also be made for the stimulation of the iliopsoas through the levels L1-L3, as these levels are the primary innervators of the iliopsoas (Moore, 1992). The effect of a relaxed iliopsoas muscle would have resulted in an increased ability for the patient to maintain the lumbar curve in a more natural posture, thereby decreasing the load on the lumbar facets (Bergmann *et al.,* 1993).

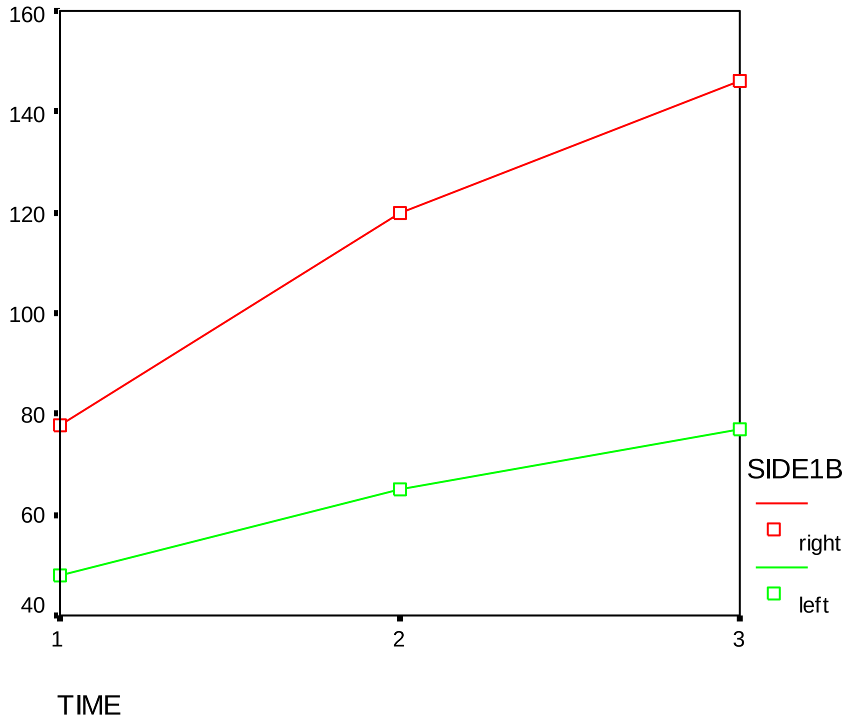


Figure 62: Profile plot of mean time (prone) by side of restriction at baseline (b)

As pertinent to the fig 59, it would seem that the type of restriction in the lumbar spine seems to be more related to the rotation on the right that is a related factor. This is possible as the number of left sided restrictions was noted to a greater degree in the sacroiliac, whereas the lumbar restrictions, which were smaller in number, could have revealed a greater degree of right-sided restrictions. This association is plausible as with a restriction of the left sacroiliac joint there is rotation of the vertebra from posterior-to-anterior (P-A) on the same side, which would induce an anterior-to-posterior (A-P) motion exaggeration on the left and therefore restricted posterior-to-anterior (P-A) movement on the left (Bergmann, 1993).

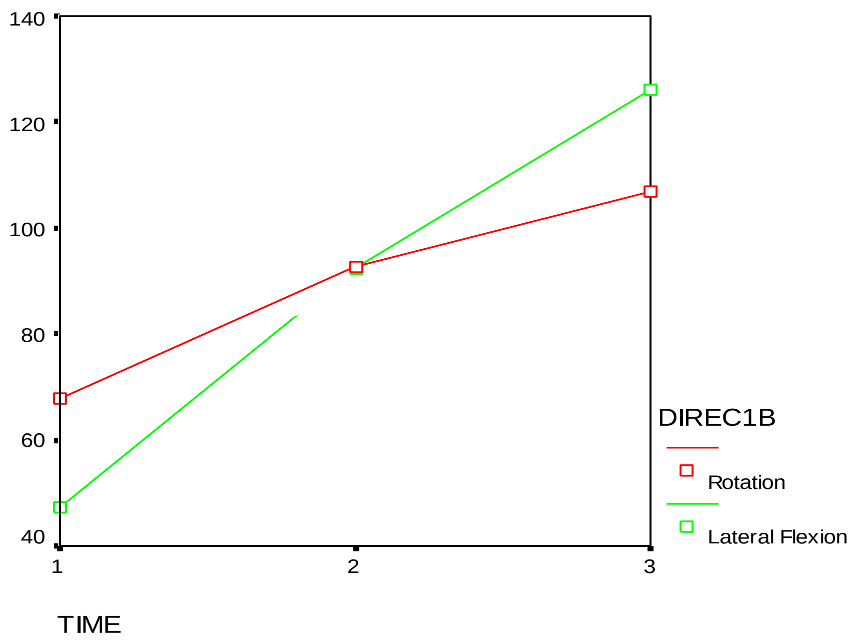


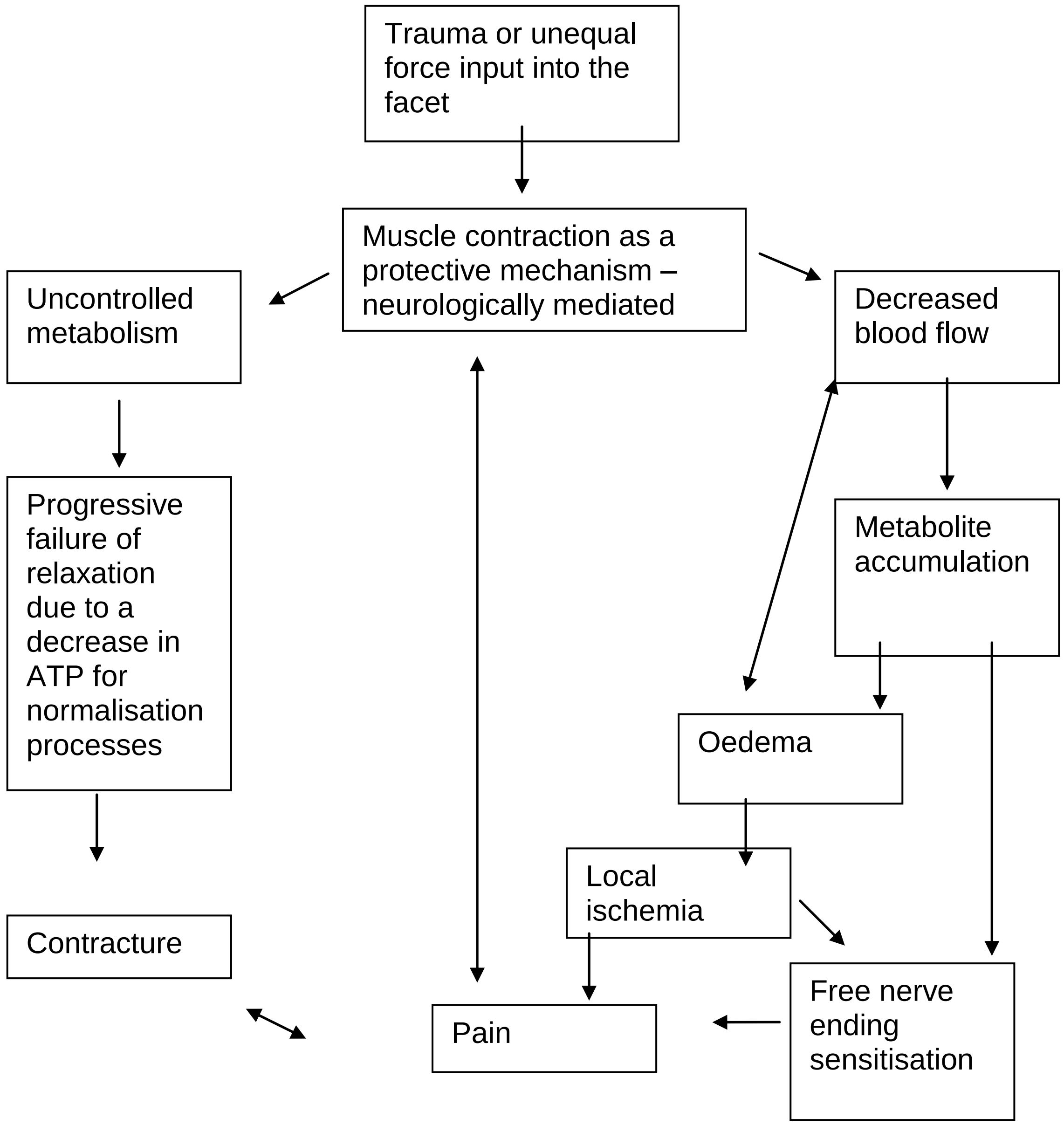
Figure 63: Profile plot of mean time (prone) by direction of restriction at baseline (b)

With the increased left- sided sacroiliac restrictions and the corresponding right-sided facet restrictions; rotation of the lumbar vertebrae would be the most common (Bergmann, 1993). With a decreased amount of rotation, there is decrease in the corresponding lateral flexion, especially in the lower lumbar spine (Bergmann, 1993).

Thus, with the restriction of rotation having been alleviated by both facet and sacroiliac manipulation, the degree of lateral flexion at the facet level would have improved, both by virtue of the decrease in restriction of rotation (Sandoz, 1976), as well as the degree to which the quadratus lumborum would have tethered the lateral flexion movement. Therefore, improving the lateral flexion in a 2-fold manner as compared to any other movement available in the lumbar spine.

Elimination of the restricted movement as well as improved resolution of the associated muscle hypertonicity would have decreased the amount of inhibition of action on the transversus abdominis, thereby allowing for increased time ability or endurance to manifest.

Thus it could be concluded when comparing readings a versus readings b that, there is no immediate effective change (no p value significance) in the time period for which contractions of the transversus abdominis are possible. This concurs with the findings of Dvorak, Gatterman and Goe, and Mense all as cited in Leach (1994), which indicates that even though there was a high correlation between the types of levels, sides and direction of restriction in both instances; that the effect of a single adjustment is affected through a neurological mechanism, but will only show changes after the neurological effect has become evident physiologically through the reduction of inflammation. The p value of 0.013 for time period b indicates that there is a significant change, indicating that the above hypothesis is the most likely.



4.7.3 Time (supine)

Improvement in time in the supine position, due to the manipulation, was affected significantly by the level of restriction (a) (p=0.011). This is shown in fig 64, where it can be seen that while L4 and sacroiliac were very similar, L3 restrictions improved at a very fast rate between T1 and T2, where after they levelled off.

Table 19: Tests of two-way interaction effects for time (supine) with motion palpation findings

Effect	Statistic	p value
Time*level a	Wilk's lambda=0.842	0.011
Time*side a	Wilk's lambda=0.982	0.616
Time*direction a	Wilk's lambda=0.989	0.754
Time*level b	Wilk's lambda=0.834	0.518
Time*side b	Wilk's lambda=0.918	0.197
Time* direction b	Wilk's lambda=0.994	0.886

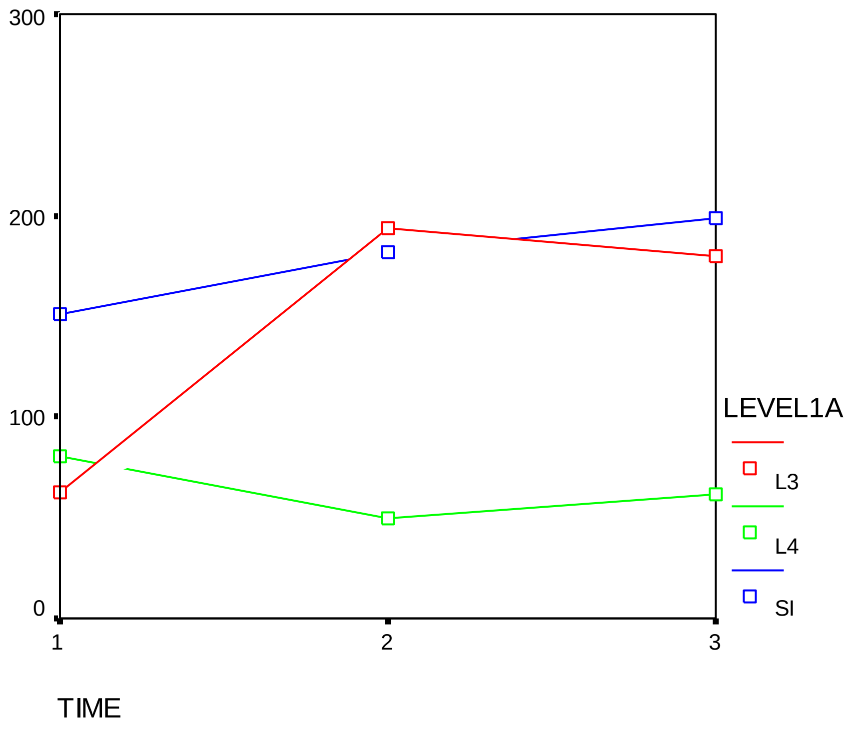


Figure 64: Profile plot of mean time (supine) by level of restriction at baseline (a)

Once again it would seem that the adjustment of L3 is closely related to the improvement over the time that the contraction is held or the pressure of the bladder is maintained once the contraction has been affected.

Literature indicates that there are 2 possible reasons for this as indicated in the above discussion, these would be related to the degree of neurological stimulation / reflex responses post manipulation as well as the improvement of inflammation and motion over the intermediate term, as discussed for the prone positioning.

The significant differences between prone and supine are that with prone we found the greatest degree of improvement related to the side of the restriction, which may have been biomechanically linked to the sacroiliac restrictions and therefore necessitated a greater time period to show resolution of muscle spasm, inflammation and resultant increase in improvements. On the contrary, we now find that in the supine position the level of the restriction at the outset is of greater significance. The level of L3 is significant to the p value of 0.011.

This change in status quo may relate directly to increased function of the multifidus as a stabiliser of the spine in the supine position (Kirkaldy Willis and Burton, 1992 and Wilke *et al.,* 1995). This is thought to be related to the fact that increased contraction of the multifius would stand to increase the degree of extension possible in the spine (bowing the spine) around the axis of the lumbar spine apex, which co-incidentally is L3 (Moore, 1992 and Panjabi, 1992). Therefore it would stand to reason that the removal of the restriction of motion would allow for an instantaneous increase in the ability of the lumbar spine to act like an archers bow as the multifidus contracts to stabilise for the contraction of the transversus abdominis (Richardson and Jull, 1995).

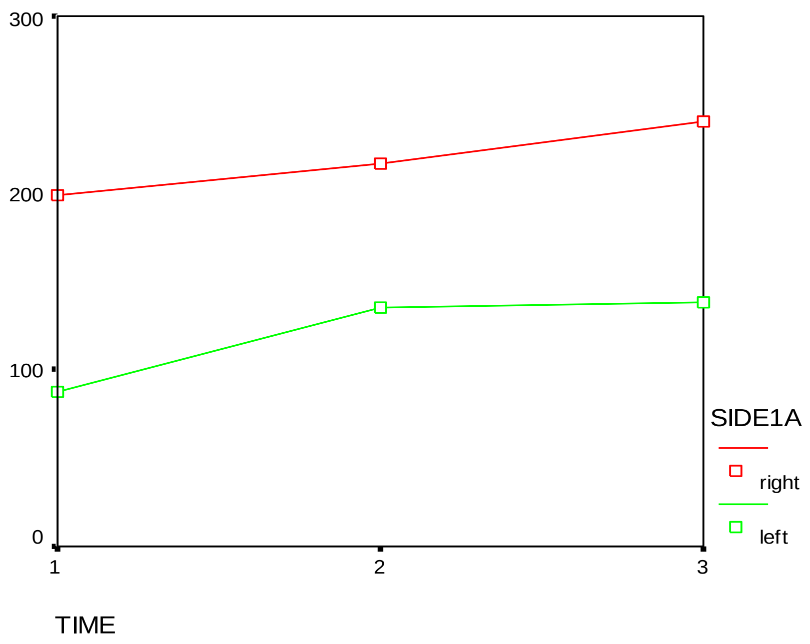


Figure 65: Profile plot of mean time (supine) by side of restriction at baseline (a)

The side of the restriction seems to concur with the prevalence of sidedness found (i.e. left sided sacroiliac joint fixations and right sided facet restrictions), where there is a relationship between the removal of the restriction, reduction of pain and increased endurance whether the sacroiliac or the facet are adjusted, allowing for the increased bowing effect of multifidus as it stabilises the spine in the supine position (Richardson and Jull, 1995).

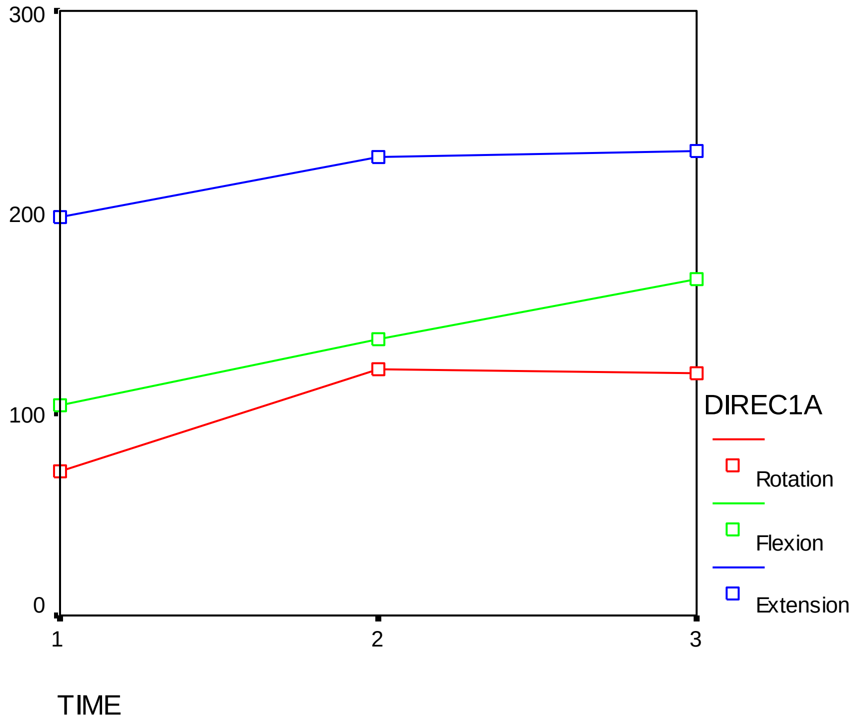


Figure 66: Profile plot of mean time (supine) by direction of restriction at baseline (a)

In concurrence with the level, it was found that the most improvement in supine time was related to the movement of flexion. This movement was only noted for the sacroiliac joints and therefore by implication, it would indicate that the degree of restriction in the flexion of the sacroiliac joint has the greatest effect on endurance supine.

This would concur with the attachments of the multifidi, which are principally over the posterior superior iliac spine, the posterior sacroiliac ligaments, the iliolumbar ligaments and the origins of the thoraco-lumbar fascia as indicated by their origin (Moore, 1992). Their principle insertions then being into the mamillary processes of the corresponding segmental levels of the lumbar vertebrae.

Therefore it would stand to reason that either the effect of the manipulation is affected to a greater extent based on the size of the sacroiliac joint whereby more receptors (Wyke as cited in Leach, 1994) are activated, stimulating a large neurological response and a resultant decrease in muscular spasm (Korr as cited in Leach, 1994) or inhibition (Hopkins and Ingersoll, 2000) or it is as a resultant combination of the manipulation of the sacroiliac joint in conjunction with the lumbar spine that indicates a greater response in terms of the endurance of contraction.

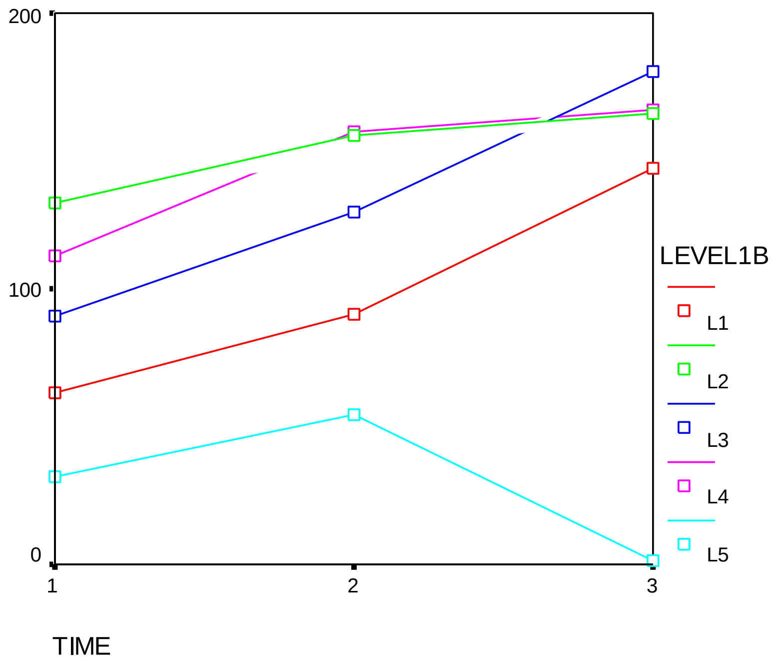


Figure 67: Profile plot of mean time (supine) by level of restriction at baseline (b)

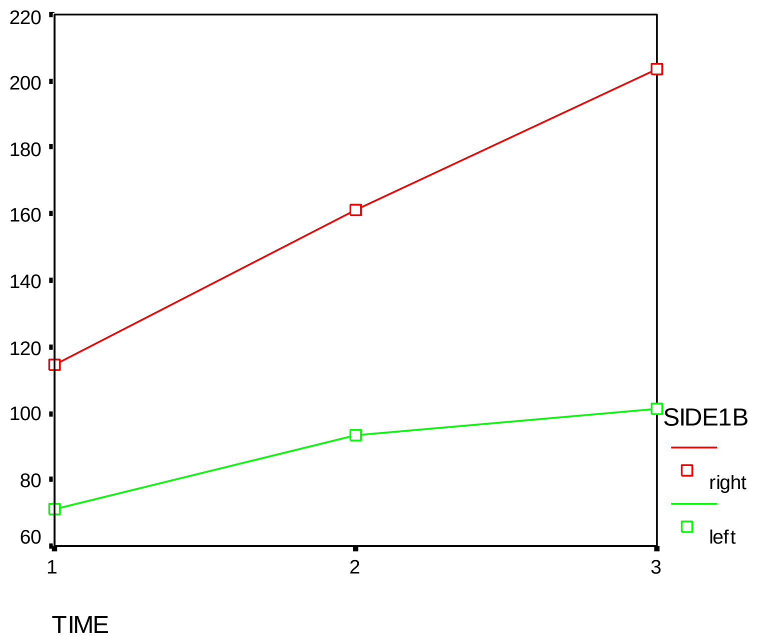


Figure 68: Profile plot of mean time (supine) by side of restriction at baseline (b)

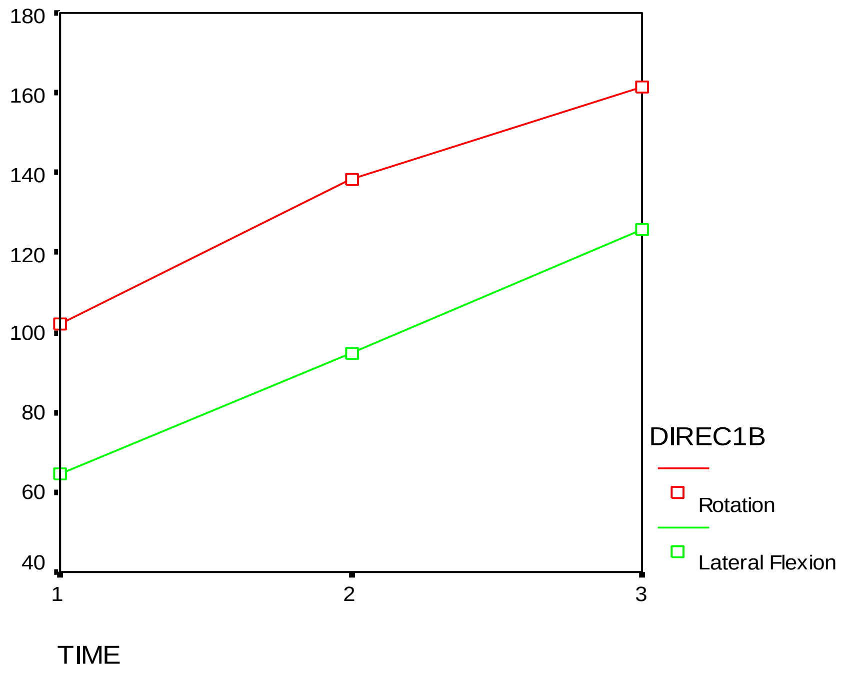


Figure 69: Profile plot of mean time (supine) by direction of restriction at baseline (b)

This concurs with the discussion for the prone position (fig 61-63).

Therefore in summary

	Neurological	**Physiological**	**Muscle**	**Facet involvement**	**Sacroiliac involvement**
Prone	Neurological reflexes negated by pain stimuli (based on position*). Transversus abdominis being a peripheral muscle is not as greatly affected by neurological stimuli.	Improvement seen with time, irrespective of the degree of neurological stimulus negation.	Little activation of multifidi, greater reliance on transversus abdominis	*Position induces facet jamming	Limited and not seen based on the results.
Implication : Prone seems to be a more accurate measure of the rate of physiological change to the facet / sacroiliac syndrome.					
Supine	Neurological reflexes 2 fold – large sacroiliac joint stimulation associated with decreased muscle spasm (multifidi affected directly by manipulative stimulus).	Improvement significance not manifested after 48 hours as the bulk of improvement is seen from a neurological response.	Greater activation of multifidi, similar activation of transversus abdominis	Position does not induce facet jamming	Greater than for the prone position.
Implication : Supine seems to be a more accurate measure of the rate of neurological change to the facet / sacroiliac syndrome.					

4.6.4 Algometer (a)

There were no significant motion palpation findings, which influenced the rate of improvement in algometer (a) measurement.

Table 20: Tests of two-way interaction effects for algometer (a) with motion palpation findings (a)

Effect	Statistic	p value
Time*level a	Wilk's lambda=0.977	0.537
Time*side a	Wilk's lambda=0.960	0.337
Time*direction a	Wilk's lambda=0.979	0.577

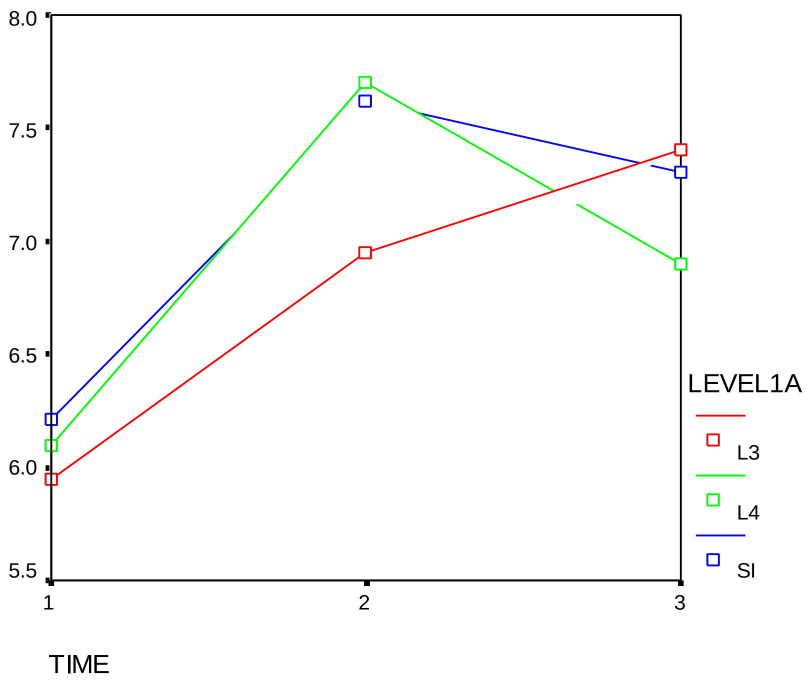


Figure 70: Profile plot of mean algometer (a) by level of restriction at baseline (a)

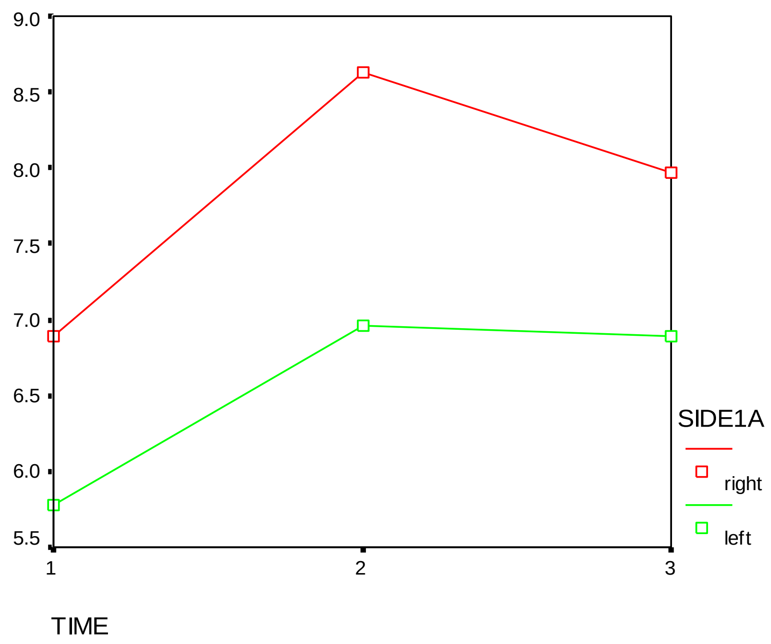


Figure 71: Profile plot of mean algometer (a) by side of restriction at baseline (a)

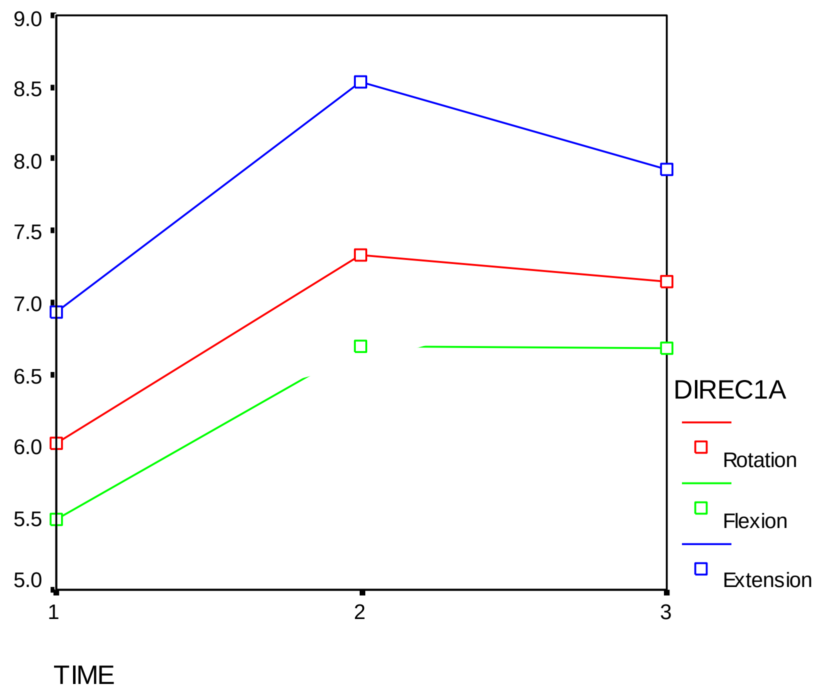


Figure 72: Profile plot of mean algometer (a) by direction of restriction at baseline (a)

From the above graphs (fig 70-72), it can be seen the corresponding associations of L3, with sacroiliac restrictions on the left are again highlighted, as was found for the prone position readings above (4.7.2). The interesting aspect to the above graphs (although insignificant) is the fact that the algometer registers improved readings (increased kg/cm^2) for most of the readings between time points 1 and 2. This indicates that there is a decrease in the perceived pain by the patient, related to the soft tissues structures measured with the algometer (as indicated by Fischer, 1987). Nevertheless, we noted earlier that the patients in the prone position had no significant readings in terms of endurance (time of contraction) and thus it would seem that the suggested mechanisms for pain reduction are in some manner inhibited (i.e. the effect of the manipulation on the transversus abdominis is less than would be of the multifidi thereby affecting inhibition of the muscle to a lesser degree) or alternatively less effective (as the prone position is an irritation to the facet joints, which are inherently jammed as the lumbar spine is extended to get to a prone position or arise from the prone position increasing the level of neurological inhibition of muscle contraction).

4.6.4 Algometer (b)

Motion palpation findings did not significantly influence the change in algometer (b) measurements over time

Table 21: Tests of two-way interaction effects for algometer (b) with motion palpation findings (b)

Effect	Statistic	p value
Time*level b	Wilk's lambda=0.799	0.483
Time*side b	Wilk's lambda=0.982	0.729
Time* direction b	Wilk's lambda=0.979	0.693

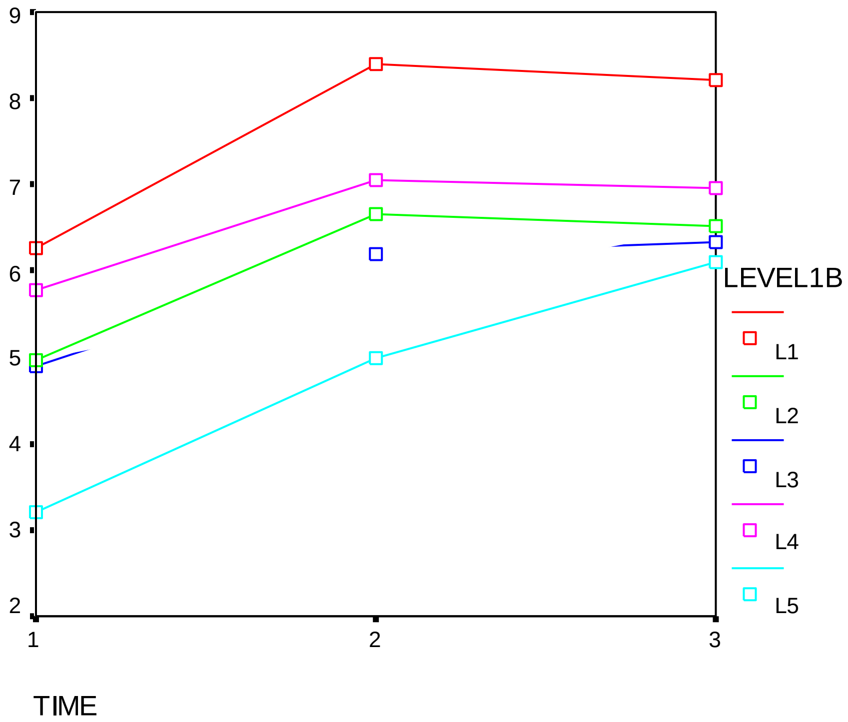


Figure 73: Profile plot of mean algometer (b) by level of restriction at baseline (b)

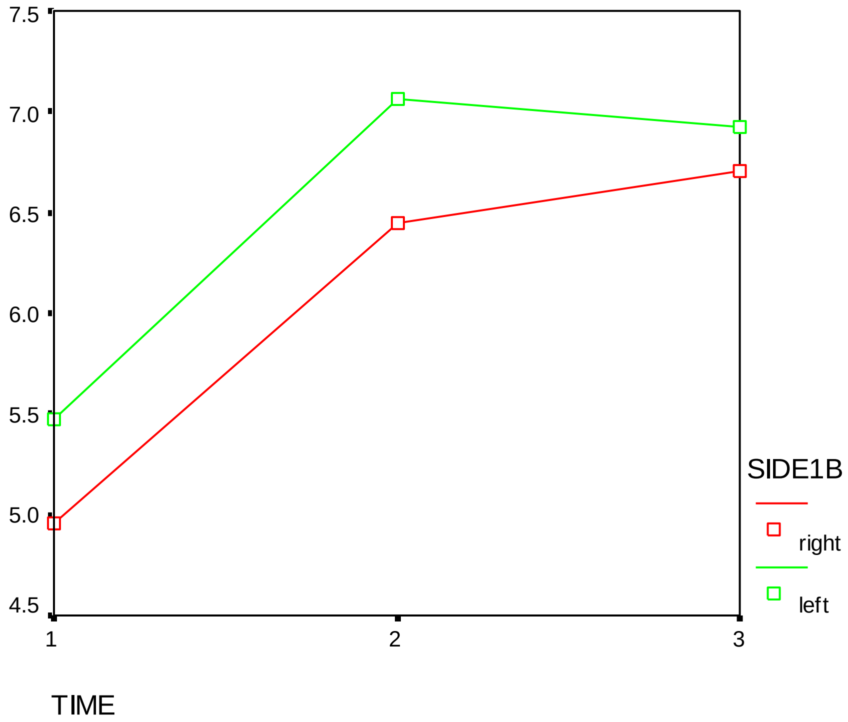


Figure 74: Profile plot of mean algometer (b) by side of restriction at baseline (b)

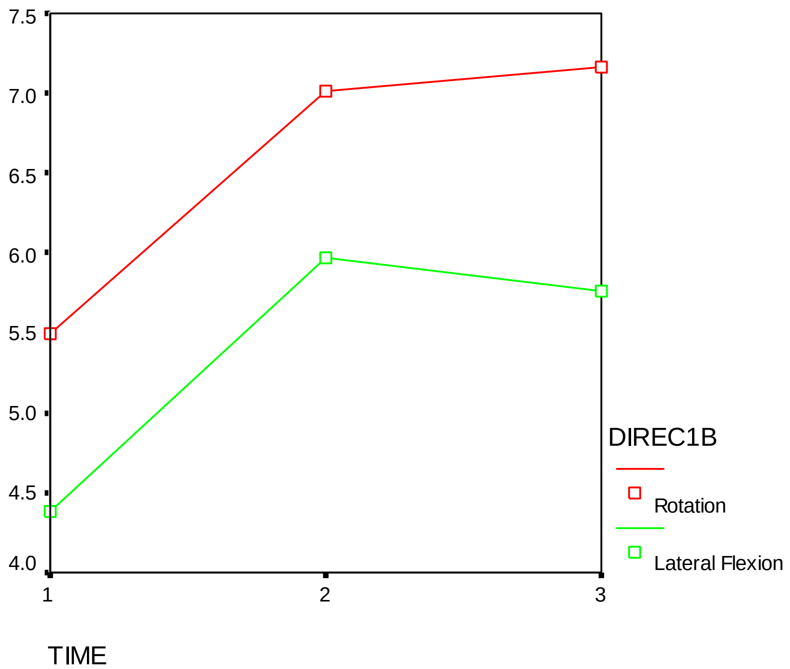


Figure 75: Profile plot of mean algometer (b) by direction of restriction at baseline (b)

Here the associations are related to L5 on the right and in rotation. This would agree with the suggestions as given in 4.7.3 and also lend further support of the suggestion that the sacroiliac joint has a greater role in lumbar stabilisation than the individual facets, principally as it affects the lumbar stabiliser (the multifidi) directly through the application of the manipulation (neurologically through the large numbers of Wyke receptors (Sakamoto *et al.,* 2001) as well as through decreasing painful inhibition by removing the compensatory lumbar spine facet restrictions that are present because of sacroiliac joint dysfunction (Bergmann, 1993).

4.8 Correlations between changes in outcome measures

Changes in outcome measurements were cross-correlated and revealed that NRS and RMQ scores were not correlated with any other outcome measures. Algometer measurements at the first site were correlated with algometer measurements at the second site (r=0.484, p=0.001). There was a negative correlation between change in algometer at the first site and change in time in the supine position (r=-0.319, p=0.013). The algometer measurements at the second site were negatively correlated with change in time in the prone position (r=-0.323, p=0.027). Change in extension was positively correlated with change in time in the supine position (r=0.342, p=0.007). Right and left lateral flexion were positively correlated (r=0.643, p<0.001), as were right and left rotation (r=-0.439, p<0.001). Time in the prone and supine position was also positively correlated together (r=0.467, p<0.001). The correlation matrix is shown in Table 16.

Table 22: Pearson's correlation between changes in outcome measurements

		Change in NRS	Change in RMQ	Change in Algometer (1)	Change in Algometer (2)	Change in Flexion	Change in Extension	Change in Right lateral flexion	Change in Left lateral flexion	Change in Right rotation	Change in left rotation	Change in Prone strength	Change in prone time	Change in supine time
Change in NRS	Pearson Correlation	1	.246	.003	.047	.103	-.040	-.133	-.118	.041	.158	-.038	-.060	-.097
	P value	.	.058	.981	.755	.434	.763	.312	.370	.758	.228	.771	.651	.459
Change in RMQ	Pearson Correlation	.246	1	-.232	-.262	.028	.200	-.148	.006	-.079	-.165	-.043	.129	.089
	P value	.058	.	.075	.075	.833	.125	.259	.963	.551	.207	.747	.325	.497
Change in Algometer (1)	Pearson Correlation	.003	-.232	1	.484(**)	-.031	-.196	.073	.133	.133	.030	-.121	-.168	-.319(*)
	P value	.981	.075	.	.001	.815	.134	.577	.312	.309	.821	.359	.200	.013
Change in Algometer (2)	Pearson Correlation	.047	-.262	.484(**)	1	-.067	.021	.241	.093	.171	.157	.019	-.323(*)	-.092
	P value	.755	.075	.001	.	.656	.891	.102	.536	.249	.291	.901	.027	.541
Change in Flexion	Pearson Correlation	.103	.028	-.031	-.067	1	.189	-.016	-.134	-.087	-.088	-.019	.178	.140
	P value	.434	.833	.815	.656	.	.149	.905	.308	.507	.504	.884	.174	.287
Change in Extension	Pearson Correlation	-.040	.200	-.196	.021	.189	1	.103	-.017	.131	.097	-.019	-.110	.342(**)
	P value	.763	.125	.134	.891	.149	.	.434	.898	.319	.459	.883	.404	.007
Change in Right lateral flexion	Pearson Correlation	-.133	-.148	.073	.241	-.016	.103	1	.643(**)	.174	-.189	-.022	-.002	.004
	P value	.312	.259	.577	.102	.905	.434	.	.000	.184	.148	.868	.986	.974
Change in Left lateral flexion	Pearson Correlation	-.118	.006	.133	.093	-.134	-.017	.643(**)	1	.182	-.033	-.017	-.202	-.129
	P value	.370	.963	.312	.536	.308	.898	.000	.	.164	.802	.895	.121	.327
Change in Right rotation	Pearson Correlation	.041	-.079	.133	.171	-.087	.131	.174	.182	1	.439(**)	-.154	-.145	.037
	P value	.758	.551	.309	.249	.507	.319	.184	.164	.	.000	.241	.269	.778
Change in left rotation	Pearson Correlation	.158	-.165	.030	.157	-.088	.097	-.189	-.033	.439(**)	1	-.113	-.176	.083
	P value	.228	.207	.821	.291	.504	.459	.148	.802	.000	.	.389	.178	.526
Change in Prone	Pearson Correlation	-.038	-.043	-.121	.019	-.019	-.019	-.022	-.017	-.154	-.113	1	.034	.016
	P value	.771	.747	.359	.901	.884	.883	.868	.895	.241	.389	.	.797	.902
Change in Time prone	Pearson Correlation	-.060	.129	-.168	-.323(*)	.178	-.110	-.002	-.202	-.145	-.176	.034	1	.467(**)
	P value	.651	.325	.200	.027	.174	.404	.986	.121	.269	.178	.797	.	.000
Change in Time supine	Pearson Correlation	-.097	.089	-.319(*)	-.092	.140	.342(**)	.004	-.129	.037	.083	.016	.467(**)	1
	P value	.459	.497	.013	.541	.287	.007	.974	.327	.778	.526	.902	.000	.

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

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

Change 1	Change 2	Relationship	Significant or not	Reason
NRS	Time supine	negative	No significance	Therefore as the NRS goes down the time supine increases as a result of decreased contractile ability of the muscle (Multifidi), hypertonicity of the core muscle, decrease contractile ability of the muscle (Transverse), hypertonicity of the core muscle. inflammation, hypertonicity of the muscle and ligamentious strain, after the intervention was applied.
	Time prone	Negative	No significance	Therefore as the NRS goes down the time prone increases as a result of decreased contractile ability of the muscle (Multifidi), hypertonicity of the core muscle, decrease contractile ability of the muscle (Transverse), hypertonicity of the core muscle.
	Prone strength	Negative	No significance	As the NRS decreases so the strength measure increases (i.e. the difference in pressure cuff measures increase) NRS reading from 1 to 3 will give a positive result and looking at the stabilizer the amount that the patient was able to contract during the third reading needed to be subtracted to the first reading therefore putting the strength prone in a negative, therefore it makes sense why it is a negative. Therefore when the patient's pain decreases their strength should increase.
	Left lateral flexion	negative	No significance	As the NRS decreases the left lateral flexion increases as a result of decreased inflammation, hypertonicity of the muscle and ligamentious strain, after the intervention was applied.
	Right lateral flexion	negative	No significance	As the NRS decreases the right lateral flexion increases as a result of decreased inflammation, hypertonicity of the muscle and ligamentious strain, after the intervention was applied.
	Extension	negative	No significance	As the NRS decreases the extension increases as a result of decreased inflammation, hypertonicity of the muscle and the protective ability of the patient, after the restriction was removed.

RMQ	Prone strength	negative	No significance	As the RMQ decreases the prone strength increases. A patient that has weak core muscles will find it more difficult to do these activities found in the questionnaire. Furthermore a patient is also more protective over their painful back and will contract less than a painless patient.
	Left rotation	negative	No significance	As the RMQ decreases the left and right rotations increase. Repetitive use of a muscle could cause muscle strain that leads to pain. Pain causes the muscle to go into a muscle spasm that leads to vasoconstriction ischemia. As a result of this the muscle will sustain contraction and therefore there leads to decreased ROM. Furthermore rotation is a combination of coronal and horizontal movement that requires more muscle activity.
	Right rotation	negative	No significance	
	Right lateral flexion	negative	No significance	As the RMQ decreases the right lateral flexion increases. Most fixations were found on the left, therefore making the left sided quadratus lumborum muscle shorter and less able to stretch over to allow right lateral flexion to occur. Another reason for this negative relationship could be trauma to the facet or sacroiliac joint and inflammation that restricts this movement from occurring.
	Algometer (2)	negative	Significant	As the RMQ decreases the algometer increases. The reasons for this negative relationship could be that the patient would be more sensitive to the algometer due to: - periosteal sensitivity - muscle hypertonicity over the facet or sacroiliac joints - increased skin sensitivity over the fixated area and - the gate control theory where a mechanical stimulation leads to less pain.
	Algometer (1)	negative	Significant	

Algometer (1)	Time Supine	negative	Significant	As the algometer over 1 decreases the time supine increase. The patients got worse with repeated algometer measures and therefore an overall decrease was noted. Even thought the time supine increase the algometer decreased.
	Time Prone	negative	No significance	As the algometer over 1 decreases the time prone increases. The patients got worse with repeated algometer measures and therefore an overall decrease was noted. Even thought the time prone increase the algometer decreased.
	Prone Strength	negative	No significance	As the algometer over 1 decreases the prone strength increases. The patients got worse with repeated algometer measures and therefore an overall decrease was noted. Even thought the time supine increase the algometer decreased..
	Extension	negative	No significance	As the algometer over 1 decreases the extension increases. The patients got worse with repeated algometer measures and therefore an overall decrease was noted. Therefore even thought the time supine increase the algometer decreased.
	Flexion	negative	No significance	As the algometer over 1 decreases the flexion increases. The patients got worse with repeated algometer measures and therefore an overall decrease was noted. Even thought the time supine increase the algometer decreased.
	Algometer (2)	positive	Significant	A change in algometer one is related to the same change in algometer two The changes in the algometer where similar between 1 and 2 !!
Algometer (2)	Time Supine	negative	No significance	As the algometer over b decreases the time supine increases The patients got worse with repeated algometer measures and therefore an overall decrease was noted, therefore even thought the time supine increase the algometer decreased. This could however be an aggravation of the underlying myofascial component which may take longer to resolve.
	Time Prone	negative	Significant	As the algometer over b decreases the time prone increases The patients got worse with repeated algometer measures and therefore an overall decrease was noted. Therefore even thought the time prone increase the algometer decreased. This could however be an aggravation of the underlying myofascial component which may take longer to resolve.
	Flexion	negative	No significance	As the algometer over 1 decreases the flexion increases The patients got worse with repeated algometer measures and therefore an overall decrease was noted. Therefore even thought the time increase the algometer decreased. This could however be an aggravation of the underlying myofascial component which may take longer to resolve.

Flexion	Prone strength	negative	No significance	As flexion range of motion (ROM) increases, the prone strength decrease. The increase in flexion causes an increased stress and toning on the multifidus. However, this is not the case for rectus abdominis (RA) which becomes weaker and detoned RA.
	Left rotation	negative	No significance	As flexion ROM increases, the left and right rotation decreases
	Right rotation	negative	No significance	
	Left lateral flexion	negative	No significance	As flexion ROM increases, the left and right lateral flexion decreases
	Right lateral flexion	negative	No significance	
Extension	Time supine	positive	Significant	As extension increases the time supine increases. Multifidus needs to contract bilaterally to extend the lower back and during the Time supine test the multifidus needs to maintain the spine in a neutral position. In both stages the multifidus function and therefore it is understandable that both it would have a significant positive effect.
	Time prone	negative	No significance	As extension increases the time prone decreases. This could be do the patient extending the lower back in this position and jamming the already inflamed facets and aggravating the pain and therefore have a decreased prone time.
	Prone strength	negative	No significance	As extension increases – prone strength decreases. Algometer reading from 1 to 3 will give a positive result and looking at the stabilizer the amount that the patient was able to contract during the third reading needed to be subtracted to the first reading therefore putting the strength prone in a negative, therefore it makes sense why it is a negative. Therefore, as the patient is able to do more flexion he/she would be able to do a stronger muscle contraction.
	Left lateral flexion	negative	No significance	As extension increases the left lateral flexion decreases.

Right lateral flexion	Time prone	negative	No significance	As right lateral flexion increases the time prone decreases.
	Prone strength	negative	No significance	As right lateral flexion increases the prone strength decreases Algometer reading from 1 to 3 will give a positive result and looking at the stabilizer the amount that the patient was able to contract during the third reading needed to be subtracted to the first reading therefore putting the strength prone in a negative, therefore it makes sense why it is a negative. Therefore, as the patient is able to do more flexion he/she would be able to do a stronger muscle contraction.
	Left rotation	negative	No significance	As RLF increases – left rotation decreases
	Left lateral flexion	Positive	Significant	As right lateral flexion increases the left lateral flexion decreases. Orientation of the facet: when left rotating the facets on the left opens and on the right closes. Therefore the extent of left rotation could be to a greater degree than left lateral flexion that could have stayed the same or got worse.
Left lateral flexion	Time supine	negative	No significance	As left lateral flexion increases the time supine decreases. According to the statistics the difference between there two variables are so small that the result could not be plotted on a linear graph that was used in this research, however could be plotted better on a u-graph. Therefore it can't for certain be stated that this is a negative relationship.
	Time prone	negative	No significance	As left lateral flexion increases the time prone decreases. According to the statistics the difference between there two variables are so small that the result could not be plotted on a linear graph that was used in this research, however could be plotted better on a u-graph. Therefore it can't for certain be stated that this is a negative relationship.
	Prone strength	negative	No significance	As left lateral flexion increases the prone strength decreases. Algometer reading from 1 to 3 will give a positive result and looking at the stabilizer the amount that the patient was able to contract during the third reading needed to be subtracted to the first reading therefore putting the strength prone in a negative, therefore it makes sense why it is a negative. Therefore, as the patient is able to do more lateral flexion he/she would be able to do a stronger muscle contraction.
	Left rotation	negative	No significance	As left lateral flexion increases, the left rotation decreases. Orientation of the facet: when left rotating the facets on the left opens and on the right closes. Therefore the extent of left rotation could be to a greater degree than left lateral flexion which could have stayed the same or got worse.

Right rotation	Time prone	negative	No significance	Right rotation decreases with time prone increasing.
	Prone strength	Negative	No significance	Right rotation decreases with prone strength increasing. Algometer reading from 1 to 3 will give a positive result and looking at the stabilizer the amount that the patient was able to contract during the third reading needed to be subtracted to the first reading therefore putting the strength prone in a negative, therefore it makes sense why it is a negative. Therefore, as the patient is able to do more rotation he/she would be able to do a stronger muscle contraction.
	Left rotation	Positive	Significant	Right rotation decreases with left rotation increasing. If patient is able to do increased right rotation they improved in left rotation as well The reason for this could be two fold: ☑ muscle balance after manipulation ☑ decrease inflammation decrease hypertonicity
Left rotation	Time prone	Negative	No significance	Left rotation decreases with time prone increasing.
	Prone strength	Negative	No significance	Left rotation decreases with prone strength increasing. Algometer reading from 1 to 3 will give a positive result and looking at the stabilizer the amount that the patient was able to contract during the third reading needed to be subtracted to the first reading therefore putting the strength prone in a negative, therefore it makes sense why it is a negative. Therefore, as the patient is able to do more rotation he/she would be able to do a stronger muscle contraction.
Prone time	Time Supine	Positive	Significant	Prone time increase with supine time increasing. As patient is able to maintain a prone contraction he/she should hold a supine contraction for more or less same ratio due to the co-contracting ability of the multifidi and the transversus abdominus.

4.9 Summary and conclusion

The manipulation was statistically significantly effective for all demographic outcomes measured. For certain outcomes the effect was greater in particular groups compared with others, for example, the effect on flexion and left lateral flexion was greater in the shortest height group.

Strength improved but not significantly and endurance improved significantly due to the manipulation intervention.

Endurance in the prone position was significantly better if the side at which the first motion palpation finding was that of a sacroiliac restriction (left) and the second motion palpation reading (i.e. restriction) was located was the right side (facet restriction).

Improvement in time in the supine position due to the manipulation was affected significantly by the level of restriction, with L3 restrictions showing a faster rate of improvement.

There were many non-significant trends observed which could have been statistically significant if the sample size was higher.

4.10 Discussion of the objectives

Based on the results discussed above the following can be stated about the hypotheses:

Objective 1: To evaluate whether manipulation has an effect on the core stabilizer muscles strength.

Hypothesis 1

Manipulation had an effect on the core stabilizer muscles strength.

This hypothesis is ***not accepted*** as the outcomes do not support this hypothesis.

Objective 2: To evaluate whether manipulation has an effect on the core stabilizer muscles endurance.

Hypothesis 2

Manipulation had an effect on the core stabilizer muscle endurance.

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

Objective 3: To evaluate whether changes in the core stabilizer muscle strength and core stabilizer muscle endurance correlate with the clinical indicators with respect to mechanical lower back pain.

Hypothesis 3

Improvement in core stabilizer muscle strength and core stabilizer muscle endurance will correlate with the clinical indicators (decrease in NRS and RMQ, and increase in Algometer and inclinometer readings) with respect to mechanical lower back pain.

This hypothesis is ***accepted*** as the outcomes support this hypothesis, although caution needs to be taken with respect to the strength measures, where no statistical significance was found over time even through significant relationships where found with the clinical indicators.

CHAPTER FIVE

Conclusions and Recommendations

5.1) Introduction

In summary, this study comprised of sixty participants suffering from chronic mechanical low back pain. The patients were allocated into one group who underwent a treatment protocol as delineated.

VISIT	TREATMENT
1	Evaluation for inclusion and exclusion criteria Assessment of the lower back Reading 1 Treatment Reading 2
2	Reading 3

Subjective and objective findings were recorded using the NRS, RMQ, Inclinometer, Algometer and Stabilizer Biofeedback Device.

5.2) CONCLUSIONS

Patient diagnosis

When assessing the motion palpation findings, the most common areas of fixation were noted as at L4 and the sacroiliac joint, with the sacroiliac joint restrictions being the predominant restriction found when all motion palpation findings were compared. For the most part fixations were found on the left hand side with fewer restrictions on the right.

Numerical pain rating scale (NRS)

NRS was evaluated at three time points (i.e. pre and post the intervention with a third reading within 48 hours of the intervention), thus the immediate and short terms effects were evaluated. NRS values decreased over this treatment period and it was found that there was a statistically significant and therefore beneficial treatment effect with respect to the NRS.

Roland Morris Questionnaire score (RMQ)

RMQ score was evaluated at three time points (i.e. pre and post to the initial session and the third reading within 48 hours in the second session), thus the immediate and short terms effects were evaluated. It was noted that there was no decrease in the readings of the RMQ from reading 1 to reading 2 as the patients did not have the ability to re-evaluate actions pertinent to the questionnaire between these time point. Notwithstanding this, the mean score decreased over time between reading 2 and reading 3. Furthermore, it was shown that there was a significant beneficial treatment effect for RMQ score.

Non-Digital Algometer

The algometer measurements were also taken at three time points (i.e. pre and post to the initial session and the third reading within 48 hours in the second session), thus the immediate and short terms effects were also evaluated, giving an objective recording of pain. It was found that there was a highly significant beneficial immediate and short-term treatment effect over time ($p<0.001$) for the algometer measurements. However, this change was dependant on gender and weight when assess using the Pearson's correlation statistics.

Inclinometer

Inclinometer measurements was evaluated at three time points, (i.e. pre and post to the initial session and the third reading within 48 hours in the second session), thus the immediate and short terms effects were evaluated. There was a highly significant change in flexion, extension, right and left rotation, right and left lateral flexion, as expected for the outcomes of the intervention in this study, where manipulation is hypothesised to increase range of motion in all directions (Sandoz, 1975 and Vernon and Mrozek, 2005)

Stabilizer Biofeedback Device

Strength increased, but not significantly over the time period when measured in the prone position.

Endurance showed increases as follows:

- ☑ Supine – time period a (first set of motion palpation readings) with a p value of 0.011 and
- ☑ Prone – time period b (second set of motion palpation readings) with a p value of 0.013.

These results imply the following:

	Neurological	**Physiological**	**Muscle**	**Facet involvement**	**Sacroiliac involvement**
Prone	Neurological reflexes negated by pain stimuli (based on position*). Transversus abdominis being a peripheral muscle is not as greatly affected by neurological stimuli.	Improvement seen with time, irrespective of the degree of neurological stimulus negation.	Little activation of multifidi, greater reliance on transversus abdominis	*Position induces facet jamming	Limited and not seen based on the results.
Implication : Prone seems to be a more accurate measure of the rate of physiological change to the facet / sacroiliac syndrome.					
Supine	Neurological reflexes 2 fold – large sacroiliac joint stimulation associated with decreased muscle spasm (multifidi affected directly by manipulative stimulus).	Improvement significance not manifested after 48 hours as the bulk of improvement is seen from a neurological response.	Greater activation of multifidi, similar activation of transversus abdominis	Position does not induce facet jamming	Greater than for the prone position.
Implication : Supine seems to be a more accurate measure of the rate of neurological change to the facet / sacroiliac syndrome.					

Thus it would seem that muscle activation and endurance is affected by the manipulation, whereas the strength of the muscle is affected to a limited extent by the manipulation. Thus it would seem that the manipulation restores normal neurological and physiological parameters in order for muscular strength to improve over time. It therefore stands to reason that the limit of 48 hours on the re-assessment of the patient would not have allowed strength to develop.

In support of the above conclusions the correlations between the algometer readings and the changes indicated over the same periods, showed that the degree of pressure that the patient could sustain was increased immediately after the intervention with a slight decrease over time. Thus a neurological reflex is initiated (to varying degrees) and associated with a physiological response over time.

5.3 Recommendations

Methodology:

Based on the methodology utilized it is recommended that more objective outcome measures be incorporated into future studies, examples of which would include EMG or diagnostic ultrasound. This would increase the ability to triangulate information and draw firmer conclusions in the study.

Sample:

Sample Size:

The sample size was sixty. A larger sample size would increase the validity of any study as the results generated would centre more readily on a given trend(s) and improve / highlight significance levels more clearly.

Although a study examining the short-term effects of manipulation on the core muscle strength and endurance followed along side this research, a study investigating the long-term effects of manipulation on peak torque should be conducted.

Age:

All the patients that took part in this study were under the age of 45. Future studies could include older patients to compare the results obtained in this study.

Homogeneity of the groups

In future research it is suggested that increased homogeneity within the sample with respect to manual / non – manual occupations as well as gender and level of participation in sports / gym activities would increase the reliability of data pertinent to each group and allow for a decrease in "background noise" that these variables introduce into the study.

Non-digital algometer:

This instrument is a useful tool but it is very difficult to be certain that this device is placed at the exact same spot at each consultation.

Measurements

The introduction of a blinded examiner to take the outcome measure readings could increase the stability of the information, as the blinded examiner would have no vested interests in the outcome of the study.

Future studies

It is recommended that future studies consider:

- ☑ The role of a single manipulation compared to multiple manipulations over the recommended time for low back pain resolution.

- ☑ The role of manipulative intervention on core muscle strength and endurance in asymptomatic patients.

- ☑ The role of height (tall vs short individuals) to be addressed in patients with lower back pain during the manipulative intervention.

- ☑ The role of rehabilitation be assessed in respect of
  - Whether core muscle strength be addressed prior to or after manipulative intervention.
  - Whether core muscle strength be addressed in conjunction with manipulative intervention.

  As both these interventions seem to act synergistically based on the outcomes of this research, however the effectiveness of one or the other may be limited by the experience of pain by the patient.

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Appendices:

Appendix A

DURBAN INSTITUTE OF TECHNOLOGY
CHIROPRACTIC DAY CLINIC
CASE HISTORY

Patient: ______________________ Date: __________

File # : __________ Age: __________

Sex : __________ Occupation: ______________________

Intern : ______________________ Signature ______________________

FOR CLINICIANS USE ONLY:

Initial visit

Clinician: Signature :

Case History:

Examination:

Previous:

Current:

X-Ray Studies:

Previous:

Current:

Clinical Path. lab:

Previous:

Current:

CASE STATUS:

PTT:	Signature:	Date:

CONDITIONAL: Reason for Conditional:

Signature: Date:

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

Intern's Case History:

1. Source of History:

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

3. Present Illness:

	Complaint 1	**Complaint 2**
▸ Location ▸ Onset : Initial: Recent: ▸ 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. xrays
- Environmental Hazards (Home, School, Work)
- Exercise and Leisure
- Sleep Patterns
- Diet
- Current Medication
  Analgesics/week:
- Tobacco
- Alcohol
- Social Drugs

7. Immediate Family Medical History:

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

8. Psychosocial history:

- Home Situation and daily life
- Important experiences

- Religious Beliefs

9. Review of Systems:

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

Appendix B

Durban Institute of Technology

PHYSICAL EXAMINATION: SENIOR

Patient Name : ______________________________ **File no :**__________ **Date :**________

Student : **Signature :**

VITALS:

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

GENERAL EXAMINATION:

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

SYSTEM SPECIFIC EXAMINATION:

CARDIOVASCULAR EXAMINATION

RESPIRATORY EXAMINATION

ABDOMINAL EXAMINATION

NEUROLOGICAL EXAMINATION

COMMENTS

Clinician: **Signature :**

Appendix C

DURBAN INSTITUTE of TECHNOLOGY

REGIONAL EXAMINATION - LUMBAR SPINE AND PELVIS

*Patient:*___________________________________ *File#:*_______________ *Date:*_________

Intern\Resident:______________________________ Clinician:__________________________

STANDING:

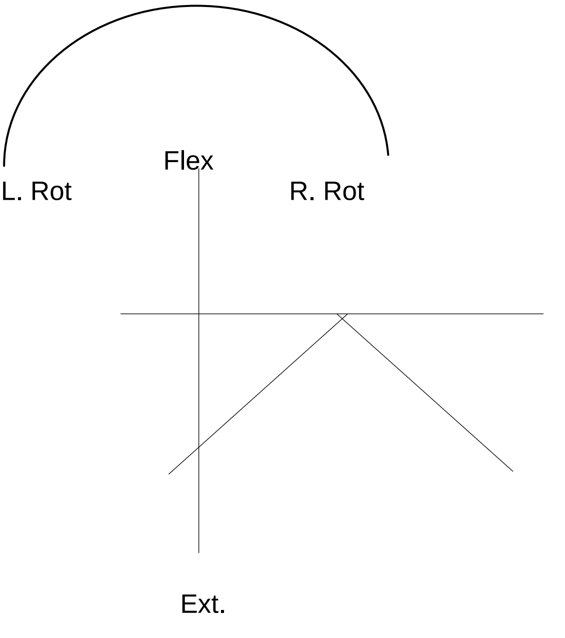
Posture– scoliosis, antalgia, kyphosis
Body Type
Skin
Scars
Discolouration

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

GAIT:

Normal walking
Toe walking
Heel walking
Half squat

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

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

	L	**R**
Bowstring		
Sciatic notch		
Circumference (thigh and calf)		
Leg length: actual -		
apparent -		
Patrick FABERE: pos\neg – location of pain?		
Gaenslen's Test		

Gluteus max stretch		
Piriformis test (hypertonicity?)		
Thomas test: hip \ psoas? \ rectus femoris?		
Psoas Test		

SITTING:

Spinous Percussion
Valsalva
Lhermitte

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

<u>NON ORGANIC SIGNS:</u> Pin point pain

Flip Test

Axial compression

Hoover's test

Trunk rotation

Ankle dorsiflexion test

Burn's Bench 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						

Action	Muscles	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

Appendix D

DURBAN INSTITUTE OF TECHNOLOGY

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

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

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

0: ***P:***

E:

Special attention to: ***Next appointment:***

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

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

O: ***P:***

E:

Special attention to: ***Next appointment:***

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

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

O: ***P:***

E:

Special attention to: ***Next appointment:***

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*** ***Least 0 1 2 3 4 5 6 7 8 9 10 Worst***	***A:***
O:	***P:*** ***E:***
Special attention to:	***Next appointment:***

APPENDIX E

LETTER OF INFORMATION:

Dear Participant.

Welcome to my research project.

Title of the research:

An investigation into the effect of a high velocity low amplitude manipulation on core muscle strength in patients with chronic mechanical lower back pain.

Name of Research student:
Lizette Uys Contact number: 031 2042205 / 083 4075362

Name of Research Supervisor:
Dr. Tarryn Macdougle Contact number: 031 2025991

Name of Research Co-supervisor:
Dr. Charmaine Korporaal Contact number: 031 301 2042611 / 0832463562

Institution: Durban Institute of Technology (DIT).
You have been selected to take part in a research study investigating the effect of lumbar and sacroiliac manipulation on core muscle strength in patients with chronic mechanical lower back pain. Sixty people will be required to complete this study. Each individual will have a standard clinical treatment, which include manipulation for the purpose of the study.

Research process:

The first consultation will take place at the DIT Chiropractic Day Clinic. Here patients will be screened for suitability for this study, which will be determined by a case history, physical examination and a lumbar spine regional examination. You will be asked to complete questionnaires, and specific measurements of your low back pain and your core stability will be measured.

All treatments will be performed, under the supervision of a qualified chiropractor, by the research student and will be free of charge.

Risk / discomfort:
The research study is safe and unlikely to cause any adverse side effects.

Remuneration and costs:

- All treatments will be free of charge and subjects taking part in the study will not be offered any other form of remuneration for taking part in the study.
- On completion of your participation in this study you are eligible for two free treatments at the Durban Institute of Technology Chiropractic Day Clinic.
- All patient information is confidential and the results of the study will be made available in the Durban Institute of Technology library in the form of a mini- dissertation.

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

Benefits of the study:
Your participation and co-operation will assist the Chiropractic profession in expanding its knowledge and the treatment protocol for chronic mechanical lower back pain, and thus making future rehabilitation of patients suffering from this condition more successful.

Confidentiality:
All patient information is confidential and the results will be used for research purposes only. It will be stored in the Chiropractic Day Clinic for 5 years, after which it will be shredded. Supervisors and senior clinic staff may however be required to inspect the records.

Persons to contact with problems or questions:
Should you have any further queries and you would like them answered by an independent source, you can contact my supervisor on the number above or alternatively you could contact the Faculty of Health Sciences Research and Ethics Committee as per Mr. Vikesh Singh at (031) 2042701.

Thank you for your participation.

Yours sincerely,

____________________________ ____________________________

Lizette Uys (Research Student) **Dr. T. MacDougall (Supervisor)**

Dr. C. Korporaal (Co-supervisor)

APPENDIX F

INFORMED CONSENT FORM

(To be completed by patient / subject)

Date :

Title of research project :

Name of supervisor :

Tel :

Name of research student :

Tel :

Please circle the appropriate answer **YES /NO**

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

9. Who have you spoken to? ______________________________

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

<u>Please Print in block letters:</u>

Patient /Subject Name:____________________________Signature: _________________

Parent/ Guardian:________________________________Signature:_________________

Witness Name:__________________________________Signature:_________________

Research Student Name:___________________________Signature:_________________

APPENDIX G

Are you between

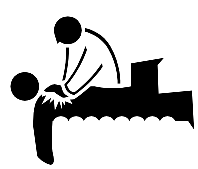
18 – 45 years of age?

and

SUFFER FROM

LOW BACK PAIN

of more than 3 months?



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

Chiropractic Day Clinic

FREE TREATMENT

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

For more information contact Lizette on 031 2042205 / 2512 or 083 4075362

Appendix H

NRS Pain Rating Scale

Patient Name:

Date:

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

0	1	2	3	4	5	6	7	8	9	10

No pain **Excruciating pain**

Adapted from Hsieh et al 1992

Appendix I

Inclinometer Readings

Patients name:
File no:

	Reading 1	Reading 2	Reading 3
Flexion			
Extension			
Right lateral flexion			
Left lateral flexion			
Right rotation			
Left rotation			

Appendix J
ALGOMETER READINGS

Patient's Name:

Date:

File No:

		Readings		
Site Description	**Site**	**First**	**Second**	**Third**

Appendix K

LOW BACK PAIN AND DISABILITY QUESTIONNAIRE
NAME:____________________________ DATE:________ AGE:____ SCORE:_______

When your back hurts, you may find it difficult to do some of the things you normally do. Mark only the sentences that describe you today by circling the corresponding number:

1. I stay at home most of the time because of my back.
2. I change position frequently to try and get my back comfortable.
3. I walk more slowly than usual because of my back.
4. Because of my back, I am not doing any jobs that I usually do around the house.
5. Because of my back, I use a handrail to get up stairs.
6. Because of my back, I lie down to rest more often.
7. Because of my back, I have to hold onto something to get out of an easy chair.
8. Because of my back, I try to get other people to do things for me.
9. I get dressed more slowly than usual because of my back.
10. I stand up for only short periods of time because of my back.
11. Because of my back, I try not to bend or kneel down.
12. I find it difficult to get out of a chair because of my back.
13. My back is painful almost all the time.
14. I find it difficult to turn over in bed because of my back.
15. My appetite is not very good because of my back.
16. I have trouble putting on my socks (or stockings) because of pain in my back.
17. I walk only short distances because of my back.
18. I sleep less well because of my back.
19. Because of back pain, I get dressed with help from someone else.
20. I sit down for most of the day because of my back.
21. I avoid heavy jobs around the house because of my back.
22. Because of my back I am more irritable and bad tempered with people than usual.
23. Because of my back, I go up stairs more slowly than usual.
24. I stay in bed most of the time because of my back.

From Roland M, Morris R. A study of the natural history of back pain: Part I: Development of a reliable and sensitive measure of disability in low back pain. 1983; 8:141-144.

The original 24 item Roland-Morris Questionnaire is displayed. The RM-18 deletes 2, 15, 17, 19, 20 and 24 without affecting it quality.

Appendix L: DATA COLLECTION SHEET

Patient's Name:	**Date:**
File No:	**Treatment No:**

Prone test for transversus abdominus and internal oblique:

Reading	Visit	Time	mmHg
1	1		
2	1		
3	2		

Supine position for training transverses abdominus:

Reading	Visit	Time	mmHg
1	1		
2	1		
3	2		

Roland Morris Oswestry LBP Questionnaire **NRS Pain Rating Scale**

Reading	***Value***	***Reading***	***Value***
1		1	
2		2	
3		3	

Motion Palpation Findings:

Visit	RUF	LUF	RUE	LUE	RLF	LLF	RLE	LLE	L1	L2	L3	L4	L5
1													
2													
3													