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THE EFFECT OF BRUEGGER'S EXERCISE ON CHRONIC LOW BACK PAIN IN ASSOCIATION WITH LOWER CROSSED SYNDROME

A research dissertation submitted to the Faculty of Health Sciences, University of Johannesburg, as partial fulfilment for the Masters Degree in Technology: Chiropractic by

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Supervisor: ____________________________ Date: _____________________

Dr C. Yelverton

DECLARATION

I, Tyron Waters, declare that this dissertation is my own, unaided work. It is being submitted as partial fulfilment for the Masters Degree in Technology, in the programme of Chiropractic, at the University of Johannesburg. It has not been submitted before any degree or examination in any other University or Technikon.

______________________________.

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ABSTRACT

Purpose: This study aims to determine the effect of Bruegger's exercise on chronic low back pain in association with lower crossed syndrome and compare it to spinal manipulation alone or a combination of Bruegger's exercise and spinal manipulation with regards to pain and disability, hip and lumbar range of motion as well as degree of lumbar lordosis.

Method: Thirty participants who met the inclusion criteria were randomly allocated to one of three different groups of ten participants each. Group one was only instructed on how to perform Bruegger's exercise. Group two only received a spinal manipulation/s over the restricted joint/s in the lumbar spine. Group three received a spinal manipulation/s over the restricted joint/s in the lumbar spine in conjunction to being instructed on how to perform Bruegger's exercise. All participants were assessed over a four week period. All groups attended six treatment sessions over three weeks of which Bruegger's exercise and/or spinal manipulation were performed. The participants who needed to perform Bruegger's exercise were also advised to continue doing the exercise out of the treatment session where applicable. In the fourth week only measurements were taken and no treatment was administered.

Procedure: Subjective data was collected at the first and fourth consultations prior to treatment, as well as on the seventh consultation by means of a Numerical Pain Rating Scale and Oswestry Low Back Pain Disability Questionnaire to assess pain and disability. Objective data was collected at the first and fourth consultations prior to treatment, as well as on the seventh consultation by means of a universal goniometer for assessing passive hip flexion and extension, a digital inclinometer for assessing active lumbar range of motion and a flexible ruler for measuring the degree of lumbar lordosis. Analysis of collected data was performed by a statician.

Results: Clinically significant improvements in group 1, group 2 and group 3 were noted over the duration of the study with regards to pain, disability, hip and lumbar range of motion as well as degree of lumbar lordosis. Statistically significant changes were noted in group 1 and group 2 with regards to pain, disability, hip and lumbar range of motion as well as degree of lumbar lordosis, and in group 3 with regards to hip and lumbar range of motion as well as degree of lumbar lordosis.

Conclusion: The results show that Bruegger's exercise, spinal manipulation and the combination of Bruegger's exercise and spinal manipulation are effective treatment protocols both clinically and significantly in decreasing pain and disability (not statistically for the combination of Bruegger's exercise and spinal manipulation), increasing hip and lumbar range of motion as well as decreasing the degree of lumbar lordosis. However, there was no treatment protocol that proved to be preferential over the other. Because spinal manipulation alone showed the greatest overall clinical improvements, it may be suggested that spinal manipulation alone is the most effective in the treatment of chronic low back pain associated with lower crossed syndrome with regards to pain and disability, hip and lumbar range of motion as well as degree of lumbar lordosis. Also, the addition of Bruegger's exercise may help in some instances to further assist in treatment once the full effects of the spinal manipulation has occurred and allowed for the muscles to be in their optimum state for exercise.

DEDICATIONS

To my Creator, I have always felt Your love and closeness towards me. I know that You have guided me and only done what is right for me throughout my life.

I would like to dedicate this research dissertation to my family, especially to my mom, dad and brother. I could not have asked for a better support system throughout my studies. Your kindness for helping me to be able to study Chiropractic and all the love and patience you have given me along the way. I can't thank you enough and I love you!

To my girlfriend, Inbal (Bali) Maman, thank you for your all encouragement and love that has carried me through the tough times of this research process. I love you so much!

To my friends, those that have supported me and allowed me to use them to practise my knowledge on, I really am lucky to have friends like you!

ACKNOWLEDGMENTS

To my supervisor, Dr Chris Yelverton, thank you for all your advice and support throughout this research process. I am sincerely grateful!

To Statkon, thanks for assisting me with all the stats.

To all those people that participated in this study, without you this research would not have been possible.

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CHAPTER ONE

INTRODUCTION

1.1 Problem Statement

According to Louw, Morris, Grimmer-Somers (2007), low back pain is the most prevalent musculoskeletal condition and one of the most common causes of disability in developed nations. The findings of Louw et al. (2007), revealed that the prevalence of low back pain in Africa is rising and therefore further research must be explored to identify, prevent and find the best treatment for low back pain. Currently, there is still inadequate biomechanical understanding about the pathogenesis of low back pain. Billions of dollars are spent each year to treat low back pain, which is one of the major causes of time lost at work (Renkawitz, Boluki, Grifka, 2006). Chronic low back pain can be defined as pain that lasts for more than three months and the pain may progress or at times flare up and then return back to a lower level of pain (Ulrich, 2007). In order for a structure to be a source of pain, that structure must be associated with the nervous system (Twomey and Taylor, 1994). Therefore, there are several causes of low back pain (Ulrich, 2007). Possible sources of pain may include the lumbar facet joints, various back muscles and ligaments amongst others (Twomey and Taylor, 1994).

Muscle imbalance is defined by Liebenson (2007), as a systemic change in the quality of muscle dysfunction that results in altered joint mechanics leading to pain, dysfunction and eventually degeneration. A specific type of muscle imbalance called distal (lower, hip-pelvic) crossed syndrome is inclined to over-stress the hip joints in addition to the low back (Liebenson, 2007).

According to Liebenson (1996), combining spinal manipulation and exercise gives chiropractors a vital role in the process of spinal rehabilitation.

There is evidence from high-quality trials that spinal manipulation is as good as or better than a wide variety of treatments for low back pain (Haas, Bronfort, Evans, 2006). Existing research also found that the use of exercise in combination with manipulation is expected to hasten and improve outcomes in addition to minimising episodic recurrence of low back pain (Lawrence, Meeker, Branson, Bronfort, Cates, Haas, Haneline, Micozzi, Updyke, Mootz, Triano, Hawk, 2008).

Bruegger's exercise is a routine designed to stretch tightened muscles and activate weakened ones that occur as a result of lower crossed syndrome from a poor prolonged sitting posture (Vizniak, 2010). Little research has been undertaken to study the effects of Bruegger's exercise and its effect on low back pain associated with lower crossed syndrome alone and in combination with spinal manipulation.

1.2 Aim of the study

The aim of this study was to determine the effect of Bruegger's exercise on chronic low back pain in association with lower crossed syndrome and compare it to spinal manipulation alone or a combination of Bruegger's exercise and spinal manipulation with regards to pain and disability, hip and lumbar range of motion as well as degree of lumbar lordosis.

1.3 Benefits of the study

The benefits of this study may include a reduction or resolution of symptoms and a better functioning spine, to establish a treatment protocol in which the patient can have an active role together with the doctor to treat their diagnosis, as well as for the community to recognize how muscle dysfunction can be directly related to low back pain.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Low back pain can be defined as pain located between the last rib and the interior gluteal folds with or without leg pan (Krismer and van Tulder, 2007). It is estimated that approximately 80% of people will experience an episode of low back pain within their lifetime (Hills, 2011).

Many forms of therapy are used in the treatment of low back pain with exercise forming a major part of the conservative approach (van Middelkoop, Rubinstein, Verhagen, Ostelo, Koes, van Tulder, 2010). Another treatment protocol for low back pain is spinal manipulation which has been found to be both safe and effective (Cooperstein, Perle, Gatterman, Lantz, Schneider, 2001).

The literature review that follows will discuss the relevant lumbar spine anatomy and biomechanics. It will then define low back pain and its causes and also investigate the use of spinal manipulation and exercise in the treatment of low back pain.

2.2 Anatomy of the lumbar spine

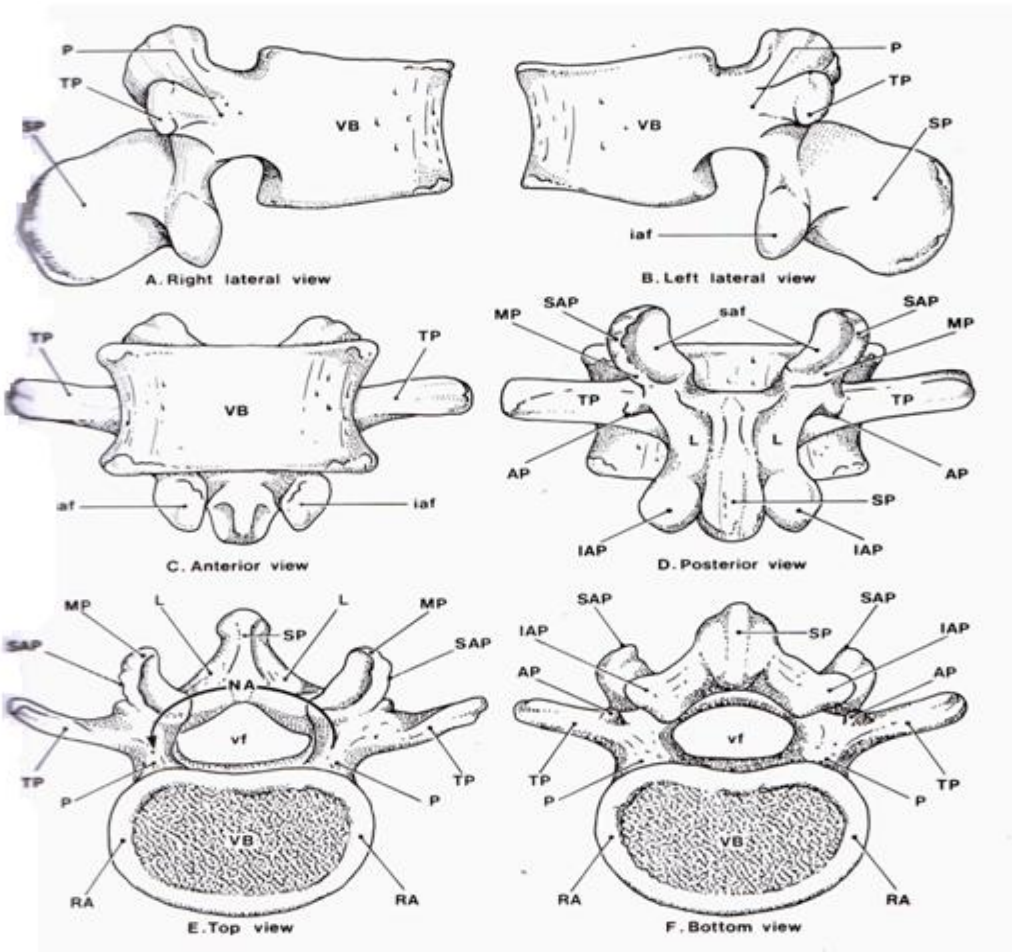
The lumbar spine is composed of five vertebrae which are named from superior to inferior (Bogduk and Twomey, 1996). The first four (L1-L4) are typical vertebrae and the fifth (L5) is an atypical vertebra. These vertebrae also increase in size from L1 down to L5 and they function to support the weight of the head, neck, upper limbs and trunk (Martini, 2004).

2.2.1 Typical lumbar vertebrae

Typical lumbar vertebrae (L1-L4) see figure 2.1, are large and kidney-shaped made to carry heavy loads imposed on it by an upright posture. The vertebral body is wider side to side than it is anterior to posterior. Its anterior surface is convex side to side and its posterior surface is concave from side to side in addition to superior and inferior. The superior and inferior surfaces of the vertebral body vary from flat to slightly concave in shape (Peterson and Bergmann, 2002).

The lumbar pedicles are found on the upper aspect of the vertebra and extend posteriorly in a horizontal direction. The superior vertebral notch is shallow while the inferior vertebral notch is deep. The lumbar laminae which run in a vertical plane are broad, short and also strong. The hatchet-shaped spinous processes are thick and broad, and are directed posteriorly. The transverse process which originate from the lamina-pedicle junction, are long, slender and become flattened on their anterior and posterior surfaces. The articular processes are thick, large and strong. The superior articular surfaces are concave in shape and they face medially and posteriorly whilst the inferior articular processes are convex in shape and they face laterally and anteriorly. The superior articular surfaces are wider apart and articulate with the outer aspect of the inferior articular processes. The mammillary processes are found on the posterosuperior rim of the superior articular process (Peterson and Bergmann, 2002).

The lumbar spinal canal (vertebral foramen) is found posterior to the vertebral body. It is formed by the vertebral arch (composed of two pedicles and two laminae) and the posterior aspect of the vertebral body. This spinal canal protects the conus medullaris (distal portion of the lumbar enlargement of the spinal cord) proximally and the cauda equina with spinal nerves distally. The spinal cord ends at the level of the second lumbar vertebra in adults, and the spinal nerves traverse the spinal canal as the cauda equina (Levangie and Norkin, 2005).



The parts of a typical lumbar vertebra: VB – vertebral body, P – pedicle, TP – transverse process, SP – spinous process, L – lamina, SAP – superior articular process, IAP – inferior articular process, saf – superior articular facet, iaf, inferior articular facet, MP – mamillary process, AP – accessory process, vf – vertebral foramen, RA – ring apophysis, NA – neural arch.

Figure 2.1: Anatomy of the Lumbar Vertebrae (Bogduk and Twomey, 1996).

2.1.3 The atypical lumbar vertebra

The only atypical vertebra (L5) has the largest circumference of all vertebrae, with the anterior aspect of its vertebral body being thicker than its posterior aspect. The transverse processes are thick and short while the spinous process is more rounded and shorter than the other lumbar vertebrae. The superior articular processes are oriented more posteriorly and less medially while the inferior articular processes are wider apart and face in a more coronal plane in comparison to the normal sagittal orientation of the other typical lumbar vertebrae (Peterson and Bergmann, 2002).

2.1.4 The intervertebral disc

Found between two vertebral bodies is the intervertebral disc (IVD). The IVD allows movement to occur between the adjacent vertebrae as well as act as shock absorbers. Each IVD consists of an outer fibrous part called the annulus fibrosis and a gelatinous central part called the nucleus pulposus. The annulus fibrosis, consisting of concentric lamellae of fibrocartilage, originates on the epiphysial rims found on the articular processes of the vertebral bodies formed by the annular epiphysis. The nucleus pulposus is composed of water and is cartilaginous allowing the IVD to be flexible and resilient (Moore and Dalley, 2004). The vertebral end-plates are layers of cartilage that each covers the superior and inferior aspects of each disc (Bogduk and Twomey, 1996).

The lumbar IVDs are well developed with the nucleus pulposus positioned more posteriorly in the disc. The ratio for disc height to body height is 1:3 which allows for more movement than the thoracic region and yet also sustaining a significant preloaded state that gives the disc a higher resistance to axial compressive forces (Peterson and Bergmann, 2002).

2.1.5 Lumbar facet joints

The facet joints are the joints of the vertebral arches. The lumbar facet joints are plane-type synovial joints which are located between the superior and inferior articular processes of the adjacent vertebrae. Surrounding each joint is a thin loose articular capsule which attaches to the margins of the articular processes of adjacent vertebrae. The articular capsules found in the lumbar spine are tighter compared to those found in the cervical and thoracic spine thus resulting in a greater degree of restriction in forward flexion. The plane-type synovial joints allow gliding movements between articular surfaces. Movement is determined by the shape and disposition of the articular surfaces (Moore and Dalley, 2006). The lumbar facet joints are primarily vertically orientated allowing flexion and extension to occur the most with rotation and lateral flexion being restricted to a large degree. Rotation can lead to damage to the annulus fibrosis of the IVD resulting in micro tears within the annulus (Cailliet, 1991).

The facet joints are innervated by articular branches that arise from the medial branches of the posterior rami of spinal nerves and each articular branch supplies two adjacent joints. Thus, each joint is supplied by two nerves (Moore and Dalley, 2006).

2.1.6 The lumbar lordosis

The lumbar vertebrae together form a curve known as the lumbar lordosis. This curve occurs as a result of the lumbo-sacral disc and the shape of the L5 vertebra being wedge-shaped and also by the inclination of the lumbar vertebra superior to L5. Each vertebra is inclined slightly backwards compared to the vertebra below it. The precise shape of the lumbar lordosis at rest varies from one person to another and it is difficult to define what the ‘normal’ lumbar lordosis might be, yet a value greater than 68 degrees is considered to indicate a hyperlordotic curve (Bogduk and Twomey, 1996).

2.2 Biomechanics of the lumbar spine

2.2.1 Introduction

The principal movements of the lumbar spine include: flexion, extension, lateral flexion and rotation (Gatterman, 2005). Restricted movement in the lumbar spine from anatomic variations may contribute to stresses and distribute this additional motion to other spinal segments. This results in abnormal strain on the soft tissues that work to prevent hypermobility of the neighbouring segments. Postural faults such as an anterior pelvic tilt may cause abnormal static loading in the lumbar spine (Gatterman, 2004).

2.2.2 Flexion

During flexion (Figure 2.2), the upper vertebral body tilts and slides anteriorly on the lower vertebral body. The thickness of the intervertebral disc (IVD) is reduced anteriorly and increased posteriorly. Thus, the IVD becomes wedge-shaped with the base facing posteriorly. The nucleus pulposus drives posteriorly causing the posterior fibres of the annulus fibrosis to be stretched. Simultaneously, the inferior articular processes of the upper vertebrae slide superiorly, moving away from the superior articular process of the lower vertebrae. This results in maximal stretching of the ligaments of the joints between the articular processes including the ligaments of the vertebral arch (ligamentum flavum, interspinous ligament, supraspinous ligament and posterior longitudinal ligament). Flexion is finally limited by the stretched ligaments (Kapandji, 1974).

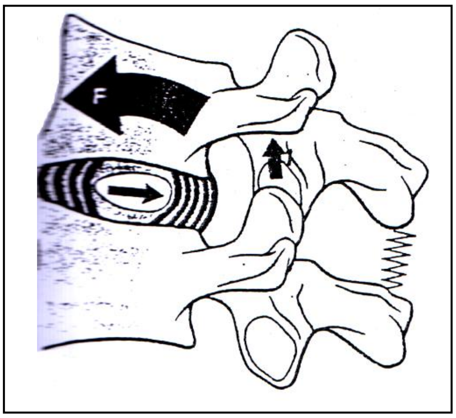


Figure 2.2: Flexion of the Lumbar Spine (Kapandji, 1974).

2.2.3 Extension

During extension (Figure 2.3), the upper vertebral body tilts and slides posteriorly on the lower vertebral body. The thickness of the IVD is reduced posteriorly and increased anteriorly. Thus, the IVD becomes wedge-shaped with the base facing anteriorly. The nucleus pulposus drives anteriorly causing the anterior fibres of the annulus fibrosis and anterior longitudinal ligament to be stretched while the posterior longitudinal ligament is relaxed. The articular processes of the upper and lower vertebrae become tightly interlocked with the spinous processes touching each other. Extension is therefore limited by the tension in the anterior longitudinal ligament and the bony structures of the vertebral arch (Kapandji, 1974).

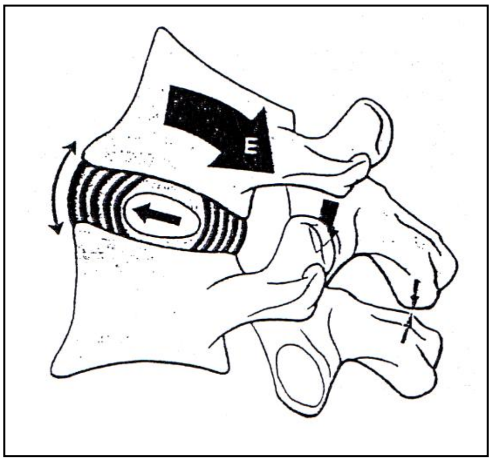


Figure 2.3: Extension of the Lumbar Spine (Kapandji, 1974).

2.2.4 Lateral flexion

During lateral flexion (Figure 2.4), the upper vertebral body tilts ipsilaterally whereas the IVD becomes wedge-shaped and its base faces contralaterally. The nucleus pulposus is slightly displaced contralaterally. The ipsilateral transverse ligament is relaxed while the contralateral transverse ligament is stretched. The articular processes slide in relation to one another causing the ipsilateral process of the upper vertebrae to be lowered while the contralateral process of the upper vertebrae to be raised. This results in the relaxation of both the ipsilateral ligamentum flavum and the capsular ligament of the joint between the articular processes whilst these structures are stretched on the contralateral side (Kapandji, 1974).

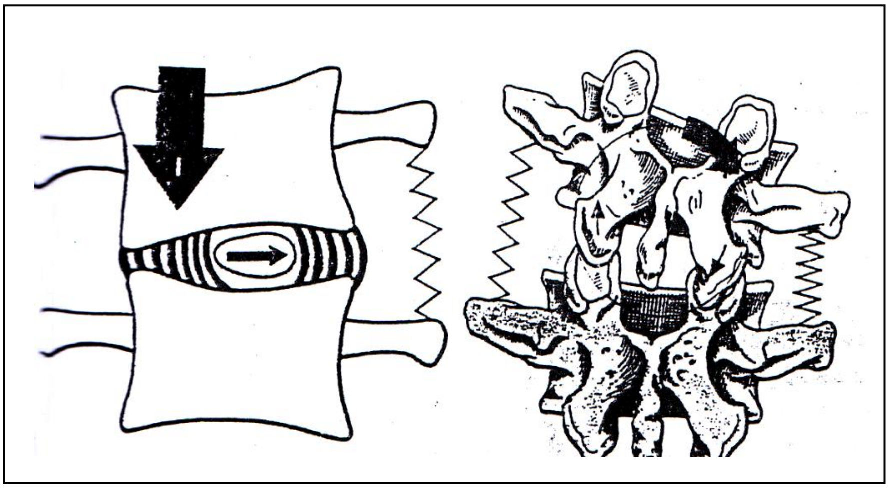


Figure 2.4: Lateral Flexion of the Lumbar Spine (Kapandji, 1974).

2.2.5 Rotation

During rotation (Figure 2.5), the upper vertebrae rotates on the lower vertebrae which takes place around the centre of the upper vertebrae and causes the upper vertebrae to slide over the lower vertebrae. During axial rotation, the IVD is not called into action. Rotation is limited by the orientation of the articular processes of the vertebrae causing the lumbar spine to have minimal rotation (Kapandji, 1974).

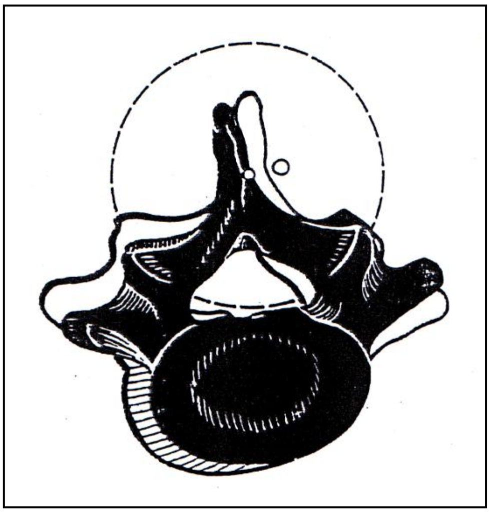


Figure 2.5: Rotation of the Lumbar Spine (Kapandji, 1974).

2.3 Low back pain

Low back pain can be defined as pain that is perceived as originating from the posterior region of the trunk which is bounded by the lateral borders of the erector spinae muscles, a horizontal plane through the T12 spinous process superiorly and through the posterior iliac spines inferiorly (Jayson, 1992).

Low back pain brought on by mechanical factors is far more frequent than those brought on by other non-mechanical disorders. From those mechanical factors, facet dysfunctions and muscle conditions are the most common causes of low back pain (Hooper, 1992).

There are three criteria which need to be considered in order for any structure to be deemed a cause of low back pain. They are: a structure that has a nerve supply to connect with the nervous system, a structure that is capable of eliciting pain similar to that seen clinically, and a structure that is susceptible to injury or disease which is known to be painful (Jayson, 1992).

Spinal manipulation and exercise are two methods that have become the paradigm of care, especially within the costly affair of low back pain (Liebenson, 1996).

There is evidence from high-quality trials that spinal manipulation is as good as or better than a wide variety of treatments for low back pain (Haas, Bronfort, Evans, 2006).

A great number of well-controlled studies have shown that exercise is effective for treatment of chronic low back pain. A Cochrane Collaboration exercise review found that for chronic low back pain, exercise therapy is more effective than usual care by a general practitioner for chronic low back pain (Liebenson, 2007).

2.4 The Vertebral Subluxation Complex

A chiropractic subluxation is defined as a motion segment in which alignment, movement integrity and/or physiologic function has been altered although contacts between the joint surfaces remain intact (Peterson and Bergmann, 2002). This alteration in function can result in pain and dysfunction with the chiropractic adjustment being able to restore normal join motion, thereby restoring physiologic function (Gatterman, 2005). This definition differs from an orthopaedic subluxation which is described as a partial or incomplete dislocation (Peterson and Bergmann, 2002).

The chiropractic subluxation is frequently presented as a complex multifaceted pathologic body known as the vertebral subluxation complex (VSC), (Peterson and Bergmann, 2002). The VSC, see Figure 2.6, is thus a model of spinal dysfunction which describes the common and essential elements of spinal dysfunction and degeneration (Gatterman, 2005).

The inter-linking components of this model include:

- Kinesiopathology
- Neuropathology
- Myopathology
- Connective tissue pathology
- Vascular abnormalities
- Inflammatory response

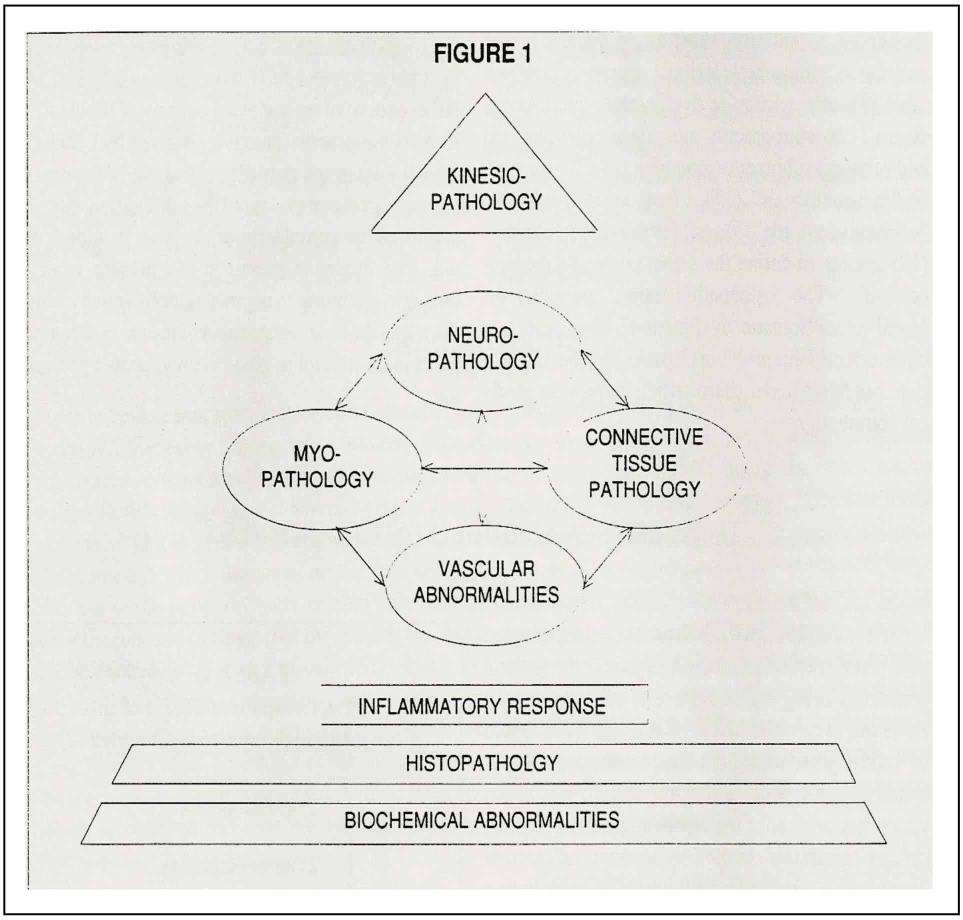


Figure 2.6: Vertebral Subluxation Model (Lantz, 1989).

2.4.1 Kinesiopathology

This component consists of capsules, ligaments and musculotendinous systems together with the spine, dural sac and all its contents. The spine is an essential entity in which restriction at one level could result in compensatory changes in other surrounding areas. Accordingly, no single aspect of a motion segment can persist without having an effect on other components of the same entity (Gatterman, 2005).

The spinal motion segment is composed of a three joint complex, usually consisting of two adjacent vertebrae that are joined by an IVD, two posterior facet joints with their capsules as well as several intrinsic ligaments. All situations that lead to immobilization of these motion segments cause some level of degeneration. Chiropractic techniques are designed to restore motion to a joint that was previously immobilized resulting in normal joint function and physiology (Gatterman, 2005).

2.4.2 Neuropathology

This component has been found to be the cornerstone of chiropractic theory. The nervous system has been shown to be the mediator of health and vitality of the individual's organs and tissues. Compression of the spinal cord, nerve roots or segmental roots plays an integral role in this component. Sensory receptors and internuncial cells also play a major role. During diagnostic assessment, reflexes, motor function, altered sensation and pain responses are central indicators of neurological function. Spinal nerves can be impinged by herniated discs or spurs and osteophytes around the joints of Luschka. Nerve impingement from hypertrophy of facet joints can also occur (Gatterman, 2005).

The dorsal root ganglia (DRG), which lie within the intervertebral canal, hold the cell bodies of all sensory neurons besides for those found in the cranial nerves. Their location makes them key targets in the process of subluxation and dysfunction. DRG are highly sensitive and when inflamed from minute acute compression or chronic irritation that lead to prolonged periods of repetitive firing lasting no longer than the stimulus itself. Abnormal impulses could bring about clinical and pathological signs and symptoms. The DRG are also highly prone to infection by viruses and bacteria due to them being richly vascularised with no blood barrier (Gatterman, 2005).

Articular pathology is central to the theory of chiropractic. The spinal joint receptor was classified by Wyke into four types, namely three types of mechanoreceptors and one nociceptor. The spinal joints can produce patterns of pain referral yet neurological mechanisms are not well understood. The afferent discharges derived from articular mechanoreceptors have a threefold effect when they go through the spinal cord: reflexogenic effects, perceptual effects and pain suppression. Joint inflammation sensitizes articular nociceptors to fire at rest and during normally non-painful joint movements (Gatterman, 2005).

Pain is the most significant factor for a patient seeking chiropractic care and is an important aspect of degeneration of the lumbar and pelvic areas. The pain that is felt is created by the miss-firing, mechanical and chemical irritation. The gate control theory is the most commonly discussed theory of pain which consists of specific internuncial neurons of the spinal cord that control pain perception. The stimulation of large A-beta and small A-delta and C fibres will control whether the transmission of pain sensations will occur through the gate. This mechanism helps explain how chiropractic techniques relieve pain (Gatterman, 2005).

2.4.3 Myopathology

Muscles maintain an osseous functional relationship to ensure the movement of bones. When a joint is immobilised, its muscles undergo a degenerative process referred to as disuse atrophy. Time of recovery depends on duration of immobility. Muscle changes can occur secondary to joint degeneration or primary due to trauma, congenital abnormalities or specific diseases that affect muscle. Muscle tension may cause excessive degeneration of cartilage through joint compression which can contribute to osteoarthritis (Gatterman, 2005).

Muscle spindles are adversely affected by immobilization which displays significant physiologic, morphologic and biomechanical changes. Increase in muscle spindle activity from physiologic alterations would lead to excessive stimuli into the central reflex pathways thereby altering efferent activity. This can lead to overstimulation of muscle groups which respond to the stretch reflex resulting in the end to muscle spasm as well as tender and active myofascial trigger points. On the other hand, such input can lead to reflex inhibition or the failure of joint musculature on challenge. Chiropractic techniques are used to maintain the muscle's function via gentle mobilization, eliminating muscle disuse atrophy (Gatterman, 2005).

2.4.4 Connective tissue pathology

Joint immobilization affects all connective tissues which each have their own unique pattern of change. Synovial fluids undergoes fibro-fatty consolidation leading to more adherent fibrous tissue providing a matrix for bone salts to be deposited in the final stages of ankylosis. Articular cartilage shrinks as a result of loss of proteoglycans after joint immobilization. Their cellular elements reorganize themselves, with the surface developing ulcerations, thereby connecting the synovial space with subchondral bone and ultimately undergo ossification (Gatterman, 2005).

Adhesions between any adjacent connective tissues that come into contact with each other form once joints are immobilised. Ligamentous contracture can be a mechanism for joint stiffness. This can occur in later stages of immobilization, with earlier stages resulting in more pliable and compliant ligaments referred to as ligamentous laxity. When muscle contraction is not involved in motion restriction, connective tissue is most likely involved. Chiropractic techniques can break down these adhesions allowing normal motion to re-occur (Gatterman, 2005).

2.4.5 Vascular abnormalities

Each motion segment is supplied by a segmental artery. Sometimes, one may carry more blood than the other for a specific segment which may contribute to radicular type symptoms, perhaps through insignificant anastomoses. These arteries are susceptible to the same forces as nerve roots and can thus be compressed as well via osseous impingement (Gatterman, 2005).

Each motion segment also contains a segmental vein that functions as the exit port for the venous plexus of Batson which have no valves to control blood flow direction and are rather controlled by posture and gravity allowing retrograde flow. A route can therefore be provided whereby toxins and inflammatory agents can spread from one area to another. Immobilization can cause venous stasis resulting in decreased toxic and metabolic removal causing inflammation and increased degeneration. Chiropractic techniques can help restore motion to the segments leading to possible restoration of normal vascular integrity (Gatterman, 2005).

2.4.6 Inflammatory response

This component is a combination of both cellular and biomechanical processes which are mainly mediated by the vascular system, although initiated by local events with the tissues themselves. Joint immobilization leads to an inflammatory response with ossification being the final point. It is important to monitor inflammatory spill over into surrounding tissue as in chemical radiculitis. This is one way which represents spinal joint degeneration affecting neurological components. Pain is the most obvious clinical manifestation of inflammation.

Inflamed nerves become hyperexcitable and exhibit abnormal behaviour. When the DRG are inflamed, they discharge action potentials which only stop long after mechanical stimulation has ceased. Nerves also become inflamed when stasis and oedema occur after venous obstruction. Therefore, compressive forces in the intervertebral canal do not need to directly affect nerves to have an impact on neurological functioning. Chiropractic techniques can thus reduce inflammation by removing joint immobilization (Gatterman, 2005).

2.5 Spinal Manipulation

There is evidence from high-quality trials that spinal manipulation is as good as or better than a wide variety of treatments for lower back pain (Haas et al*.,* 2006). There is moderate evidence that spinal manipulation together with strengthening exercise is similar in effect to prescription non-steroidal anti-inflammatory drugs (NSAIDS) with exercise in both the short and long term (Souza, 2009).

2.5.1 Definition of spinal manipulation

Spinal manipulation is a manual treatment technique where a force is applied to a vertebral joint creating a passive movement between the normal range of motion of the joint and the limits of its normal integrity (Ernest, 2007). The adjustment is a specific form of joint manipulation that uses either long or short leverage techniques with precise anatomic contacts. It is characterised by a low-amplitude dynamic thrust that uses controlled velocity, direction and amplitude (Peterson and Bergmann, 2002). An adjustment affects the inflow of sensory information to the central nervous system and restores the neurological integrity of the facet joint, physiological processes and muscle receptors by re-establishing the function and standard articular connection of the facet joint, thereby relieving pain (Pickar, 2002).

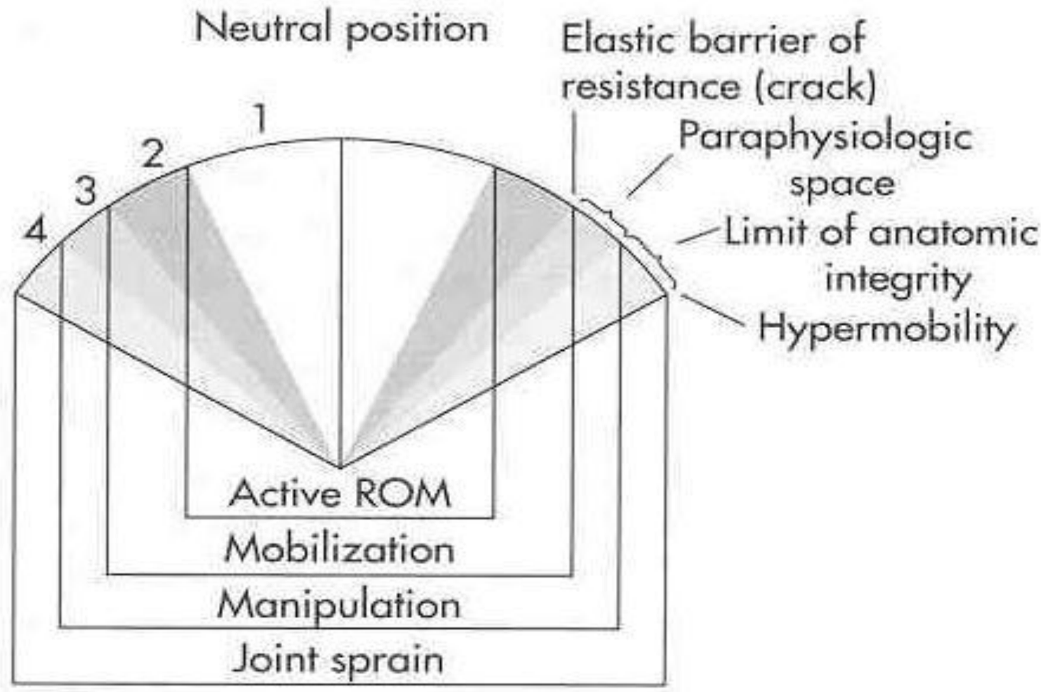


Figure 2.7: Four Stages of Range of Movement in Diarthrodial Joints: 1, Active Range of Movement. 2, Passive Range of Movement. 3, Paraphysiological Range of Movement. 4, Pathologic Movement (Gatterman, 2004).

It is important from figure 2.7 to see that the spinal manipulation involves a thrust procedure that moves a joint beyond the elastic barrier, into the paraphysiological space but not passing beyond the limit of anatomical integrity (Gatterman, 2004).

There are three events that occur while passing through the elastic barrier and paraphysiological space. These include: a sudden separation of joint surfaces, an audible cracking sound and the appearance of a radiolucent space in the joint (Esposito and Philipson, 2005). This allows greater joint separation and increases the passive range of motion into the paraphysiological space (Thiel and Cassidy, 1994). The audible articular crack or cavitation is a release of built up carbon dioxide gas within the joint capsule (Peterson and Bergmann, 2002).

2.5.2 Effects of spinal manipulation

According to Esposito and Philipson (2005), the clinical effects of spinal manipulation include:

- Increase in active and passive range of motion
- Reduction of pain
- Increase in skin pain tolerance level
- Increase in paraspinal muscles pressure pain tolerance
- Consistent and reliable reflex responses from muscles in the limb and spine
- Reduction in muscle electrical activity and tension
- Release of entrapped meniscoid, hyperplastic synovial tissue or synovial folds
- Breaking of contractile and collagen adhesions in local soft tissues and supporting structures
- Effects upon the intervertebral disc either in the form of intradiscal block or generalised effects on the process of disc protrusion
- Various autonomic responses including vasomotor changes, sudomotor activity and changes in visceral regulation control

Hyde and Gengenbach (2007), state that the goals of spinal manipulation include a combination of mechanical, soft tissue, neurologic and psychological effects:

a) Mechanical effects

This includes changes in alignment, dysfunction of motion and spinal curvature dynamics. The use of spinal manipulation for separating joint surfaces may release entrapped or extrapped synovial folds.

b) Soft tissue effects

This includes changes in tone and strength of supporting musculature as well as influences in the dynamics of supporting capsule-ligamentous connective tissue. It is believed that spinal manipulation can break the cross-linking and any intra-articular capsular fibro-fatty adhesions, and therefore allowing more freedom of movement and permitting water inhibition.

c) Neurological effects

This includes reduction in pain, influencing spinal and peripheral nerve conduction, causing altered sensory and motor function and effecting regulation of the autonomic nervous system. Spinal manipulation may stimulate the mechanoreceptors associated with synovial joints, thereby affecting joint pain. The structures most sensitive to noxious stimulation include the joint capsule and periosteum. Research has also shown that spinal manipulation also plays a role in increasing range of motion, increasing pain tolerance of the skin and deeper muscles, raising the levels of beta-endorphins in the blood plasma and it can have an effect on the nerve pathways between the viscera and soma that regulate general health.

d) Psychological effects

The power of touch cannot be overlooked or denied. When the patient sees how the clinician is very precise in his/her evaluation, the patient becomes convinced of the concerns, interests and manual skills of the clinician. Some patients may report an instant and total relief of symptoms with a second or two of an adjustment, which is far too short a time for any maximal benefit to occur. Although the mechanism of injury may have been mechanical in nature, it may result in a cascade of biomechanical and physiologic events.

2.6 Muscle Imbalance

Muscle imbalance is defined by Liebenson (2007), as a systemic change in the quality of muscle dysfunction that results in altered joint mechanics leading to low back pain, dysfunction and eventually degeneration. Furthermore, it is an altered state of balance and a relationship that occurs between muscles that are prone to tightness and muscles that are prone to weakness or inhibition.

Moderately tight muscles are typically stronger than usual yet, when there is pronounced tightness, there is a degree of decreased muscle strength. This weakness can be referred to as ‘tightness weakness’ to illustrate the closed association between altered viscoelasticity of the muscle and the muscle weakness. Treatment of tightness weakness by strengthening would therefore not be in the best interest as this would result in more pronounced weakness. Thus, stretching would rather be the treatment of choice in order to address the viscoelastic property of the muscle. Stretching tight muscles also leads to improved strength of inhibited antagonistic muscles by means of Sherrington’s law of reciprocal inhibition which states that when one muscle is contracted, its agonist muscle becomes automatically inhibited. Muscle imbalance needs to be considered as a systemic reaction of the whole muscle system and not just an isolated effect of one muscle. Muscle imbalance occurs mostly between major “tonic” muscles, which are muscles that are prone to developing tightness and major “phasic” muscles that are prone to inhibition (Liebenson, 2007). The active mechanism of muscles is part of the normal stabilising system of the lumbar spine and is thus crucial to the normal functioning of the spine (Norris, 1995).

2.7 Lower Crossed Syndrome

2.7.1 Definition of lower crossed syndrome

Janda was a physiatrist and neurologist from the Czech Republic who worked extensively on the patterns of muscle imbalance (Page, 2006). Janda proposed the concept of lower crossed syndrome as a fundamental factor in the genesis and perpetuation of several low back pain syndromes. Lower crossed syndrome (Figure 2.8), can be defined as a muscle imbalance where the hip flexors and low back extensors are tight and overactive (tonic muscles) whilst the abdominals and gluteus maximus are underactive and weak (phasic muscles), thus creating a ‘crossed pattern’ of disturbed sagittal lumbopelvic posturo-movement alignment and control (Key, 2010). The hamstrings are also often tight in this syndrome to try lesson the pelvic tilt or compensate for the weak glutei (Hammer, 1999).

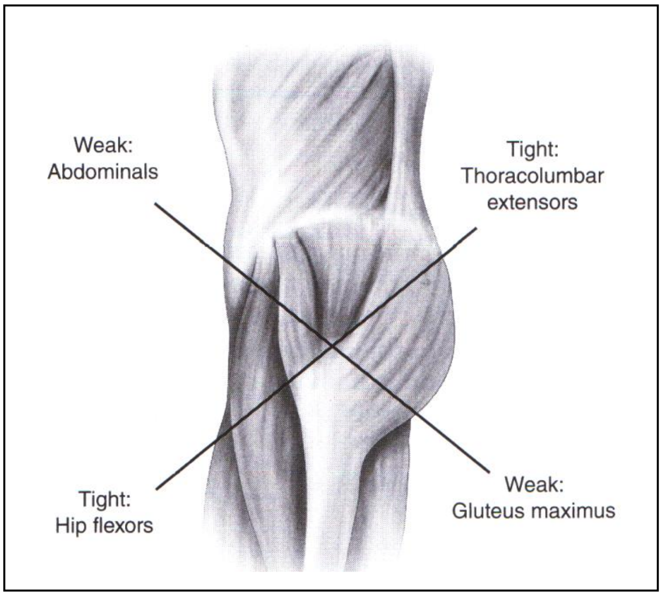


Figure 2.8: Lower Crossed Syndrome (Page, 2010).

This pattern of muscle imbalance causes joint dysfunction especially at the L4-L5 and L5-S1 segments, the sacroiliac joint and the hip joint. Specific changes in posture seen with lower crossed syndrome include an anterior pelvic tilt, increased lumbar lordosis, lateral lumbar shift, lateral leg rotation and knee hyperextension. If the lumbar lordosis is shallow and reaches into the thoracic region, the muscle imbalance predominates in the trunk muscles but if the lumbar lordosis is short and deep, then the muscle imbalance predominates in the pelvic muscles (Page et al., 2010). This would then lead to a concentration of pressure on the posterior aspect of the IVD and decreased pressure on its anterior aspect resulting in jamming of the lumbar facets, increasing the distribution of pressure on the posterior IVD and eventual degeneration of the area. All of this can cause irritability and pain (Hammer, 1999).

There are two subtypes of lower crossed syndrome (Figure 2.9): Type A and B. Patients that present with type A utilize more hip flexion and extension for mobility with their standing posture displaying an anterior pelvic tilt with slight hip flexion and knee flexion. In order to compensate for this, these people have a hyperlordosis limited to the lumbar spine together with a hyperkyphosis in the upper lumbar and thoracolumbar segments. Patients that present with type B utilize more movement of the abdominal and low back region. In order to compensate for this, these people have a hypolordosis that extends into the thoracolumbar segments, a thoracic hyperkyphosis and protracted head. The centre of gravity is displaced backwards with the shoulders behind the axis of the body and the knees are recurvated (Page et al., 2010).

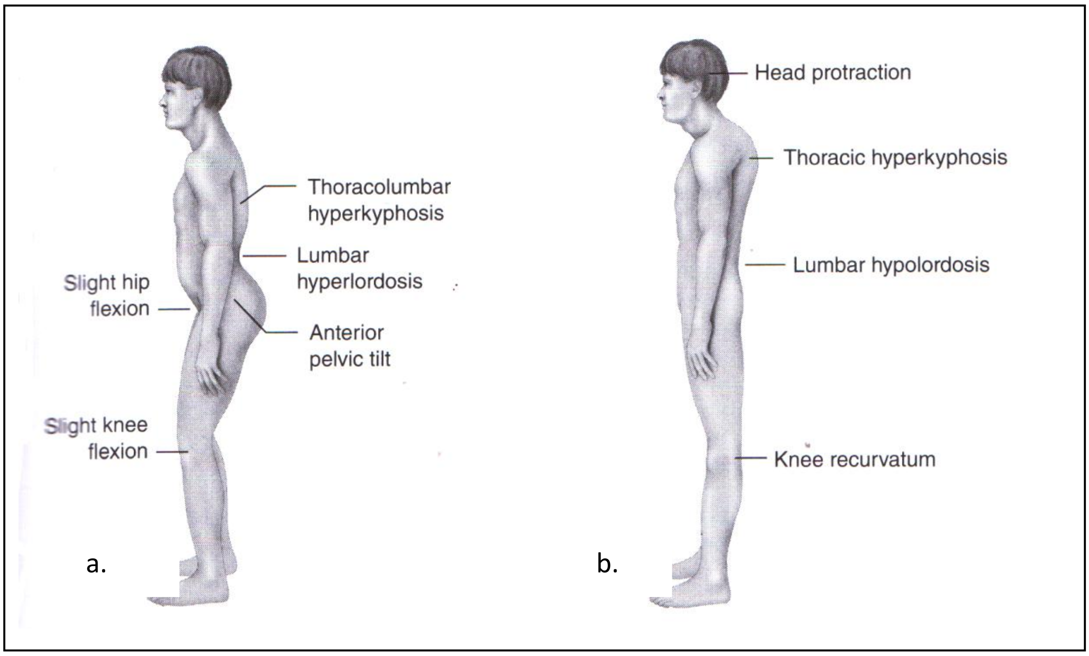


Figure 2.9: Two Types of Posture in Lower Crossed Syndrome: (a) Type A Posture and (b) Type B Posture (Page et al., 2010).

2.7.2 Anatomy of the muscles affected by lower crossed syndrome

The following Table 2.1, represents the anatomy of the muscles affected by lower crossed syndrome. The tonic muscles represent those muscles that are tight and overactive whilst the phasic muscles represent those muscles which are weak and underactive (Key, 2010).

Tonic muscles	Origin	Insertion	Innervation	Main Action
Iliopsoas: Psoas Major	Sides of T12-L5 vertebrae and IVD between them. Transverse processes of all lumbar vertebrae.	Lesser trochanter of femur.	Anterior rami of lumbar nerves (L1, L2 and L3).	

Psoas Minor	Sides of T12-L1 and IVD.	Pectineal line, iliopectineal eminence via iliopectineal arch.	Anterior rami of lumbar nerves (L1 and L2).	Act together to flex the thigh at the hip joint and stabilize this joint
Iliacus	iliac fossa, iliac crest, ala of sacrum and anterior sacroiliac ligaments.	Tendon of psoas major, lesser trochanter and femur distal to it.	Femoral nerve (L2, L3 and L4).	
Erector spinae: Iliocostalis	Arises by a broad tendon from the posterior aspect	Cervicis, thoracis and lumborum fibres pass superiorly to angles of lower ribs and cervical transverse processes.	Posterior rami of the spinal nerves.	Bilaterally: extend the vertebral column and head: as back is flexed, control movement by slowly lengthening
Longissimus		Capitis, cervicis and thoracis fibres' pass superiorly to ribs between tubercles and angles to		

	of iliac crest, posterior surface of sacrum, sacroiliac joint, sacral and inferior lumbar spinous processes and supraspinous ligament	transverse processes in thoracic and cervical regions and to mastoid process.		their fibres. Unilaterally: laterally flex the vertebral column.
Spinalis		Capitis, cervicis and thoracis fibres pass superiorly to spinous processes in upper thoracic region and to cranium.		
Hamstrings: Semitendinosus	Ischial tuberosity.	Medial surface of superior part of tibia.	Tibial division of sciatic nerve (L5, S1 and S2).	Extends thigh, flexes leg and medially rotates it when knee flexed. When thigh and leg are flexed it can
Semimembranosus		Medial condyle of tibia on posterior		

		aspect.		extend the trunk.
Biceps femoris	Long head: ischial tuberosity Short head: linea aspera and lateral supracondylar line of femur	Lateral aspect of head of fibula.	Long head: Tibial division of sciatic nerve (L5, S1 and S2). Short head: common peroneal division of sciatic nerve (L5, S1 and S2).	Extends thigh, flexes and laterally rotates leg when knee is flexed

Phasic muscles:	Origin	Insertion	Innervation	Main action
Abdominals: Rectus abdominis	Pubic symphysis and pubic crest.	Xiphoid process and 5th-7th costal cartilages.	Thoracoabdominal nerves (anterior rami of inferior 6 thoracic nerves).	Flexes lumbar spine and compresses abdominal viscera. It stabilizes and controls tilt of pelvis.
Transverse abdominis	Internal surfaces of 7th-12th costal cartilages, thoracolumbar	Linea alba with aponeurosis of internal oblique, pubic	Thoracoabdominal nerves (anterior	Supports and compresses abdominal viscera.

	fascia, iliac crest and lateral third of inguinal ligament	crest and pectin pubis by conjoint tendon.	rami of inferior 6 thoracic nerves) and 1^{st} lumbar nerves.	
Internal oblique	Thoracolumbar fascia, anterior two thirds of iliac crest and lateral half of inguinal ligament.	Inferior borders of 10^{th}-12^{th} ribs, linea alba and pectin pubis by conjoint tendon.		Supports and compresses abdominal viscera. Flex and rotates trunk.
External oblique	External surfaces of 5^{th}-12^{th} ribs.	Linea alba, pubic tubercle and anterior half of iliac crest.	Thoracoabdominal nerves (T7-T11) and subcostal nerve	Supports and compresses abdominal viscera.
Gluteus maximus	Ilium posterior to the posterior gluteal line, sacrotuberous ligament and dorsal surface of the sacrum and coccyx.	Majority of fibres attach onto the iliotibial band which inserts into the lateral condyle of the tibia, a few fibres insert on the gluteal tuberosity.	Inferior gluteal nerve (L5, S1 and S2)	Extends the thigh (particularly from the flexed position) and assists in its lateral rotation. Steadies the thigh and helps in rising from the seated position

Table 2.1: Anatomy of the muscles affected by lower crossed syndrome (Moore and Dalley, 2006).

2.8 Bruegger's exercise

Bruegger, a Swiss neurologist, whose work was focused on repetitive strain injuries, was the founder of Bruegger's exercise (Hill, 2011). Bruegger analysed and described posture as well as projected a strategy in order to improve it. He stressed on the point that functional impairment always included the whole body (Liebenson, 2007). Common postural faults that occur whilst in the seated position include an anterior head carriage and a poking chin (head which is pushed forward and chin poking) as well as an upper thoracic kyphosis causing the back to round and the shoulders to fall forward, which can result in chest breathing overriding good abdominal breathing. This causes a pattern of tight and weak muscles known as upper and lower crossed syndrome. Bruegger's exercise is a routine designed to stretch those tightened muscles (low back extensors and hip flexors) and activate those weakened muscles (abdominals and gluteus maximus) that occur as a result of being in a poor prolonged sitting posture (Vizniak, 2010). Bruegger's exercise, see Figure 2.10, involves the following; the patient sits on the edge of a chair with the hips abducted, feet externally rotated, the shoulders are back, head is up, forearms are supinated and the wrists and fingers are extended. The patient is to slowly exhale by breathing out through their lips while actively externally rotating their arms and spreading their fingers (Oliver, 2010). The patient is to perform this exercise once or twice every 20-30 minutes of prolonged sitting and held in this position for 30-60 seconds (Vizniak, 2010).

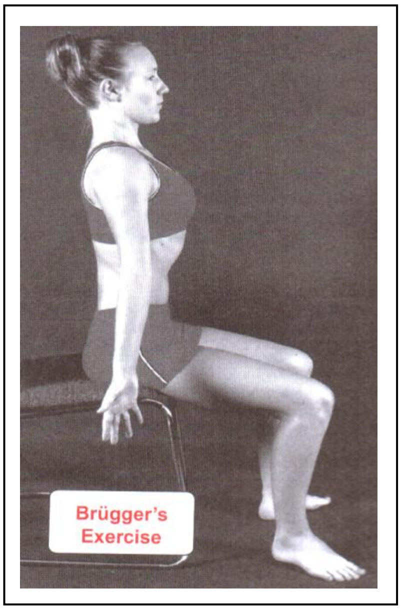


Figure 2.10: Bruegger's Exercise (Vizniak, 2010).

2.9 Conclusion

There is no consensus on the standard care for chronic low back pain, even though several conservative treatments have displayed benefits, including spinal manipulation and supervised exercise. Home exercises have been shown effective for acute and sub-acute low back pain but their effect on chronic low back pain is inconclusive (Bronfort, Maiers, Evans, Schulz, Bracha, Svendsen, Grimm, Owens, Garvey, Transfeldt, 2011).

Therefore given the indecisiveness of the matter and associating lower crossed syndrome with chronic low back pain, this study was conducted to establish what the best treatment protocol for this would be.

CHAPTER THREE

METHODOLOGY

3.1 Study Design

The study was a randomised controlled trial with a sample of convenience.

3.2 Participant Recruitment

Participants were recruited by word of mouth as well as advertisements (Appendix A) which were strategically placed around the University of Johannesburg Day Clinic.

3.3 Sample selection and size

Thirty participants were randomly divided into three groups of ten participants each. Group 1 was only instructed on how to perform Bruegger's exercise. Group 2 only received a spinal manipulation/s over the restricted joint/s in the lumbar spine. Group 3 received a spinal manipulation/s over the restricted joint/s in the lumbar spine in conjunction to being instructed how to perform Bruegger's exercise.

3.4 Patient Criteria

The participants for the research study were accepted based on inclusion and exclusion criteria.

3.4.1 Inclusion Criteria

- Participants had to be from the ages of 18 - 65 years old.
- Participants had to present with chronic low back pain that had presented for a three month duration or longer (Ulrich, 2007).
- Participants had to meet the criteria for lower crossed syndrome indicating tight hip flexors and erector spinae together with weak glutei and abdominals. The following tests were used to assess whether the patient displayed the criteria for lower crossed syndrome:
  i. Tight hip flexors via the Modified Thomas Test (Figure 3.1) (Travell and Simons, 1999).
     This test was performed with the patient supine and the thighs positioned over the edge of the examining table. The patient was told to grasp the thigh of the untested limb and pull it toward the chest to flatten the back and stabilise the pelvis, preventing an increase in lumbar lordosis. A

standard stretch position for the iliopsoas muscle is demonstrated with the hip extended and the leg hanging freely with normal knee flexion. A positive test was indicated if the hip remained flexed against gravity on tested limb. Additionally, if there was also knee extension on the tested limb then further testing was needed to decide between a tight iliopsoas or rectus femoris muscle. This was done by passively extending the knee of the tested limb to neutralise the effect of the rectus femoris and find if there was still no change in hip flexion.

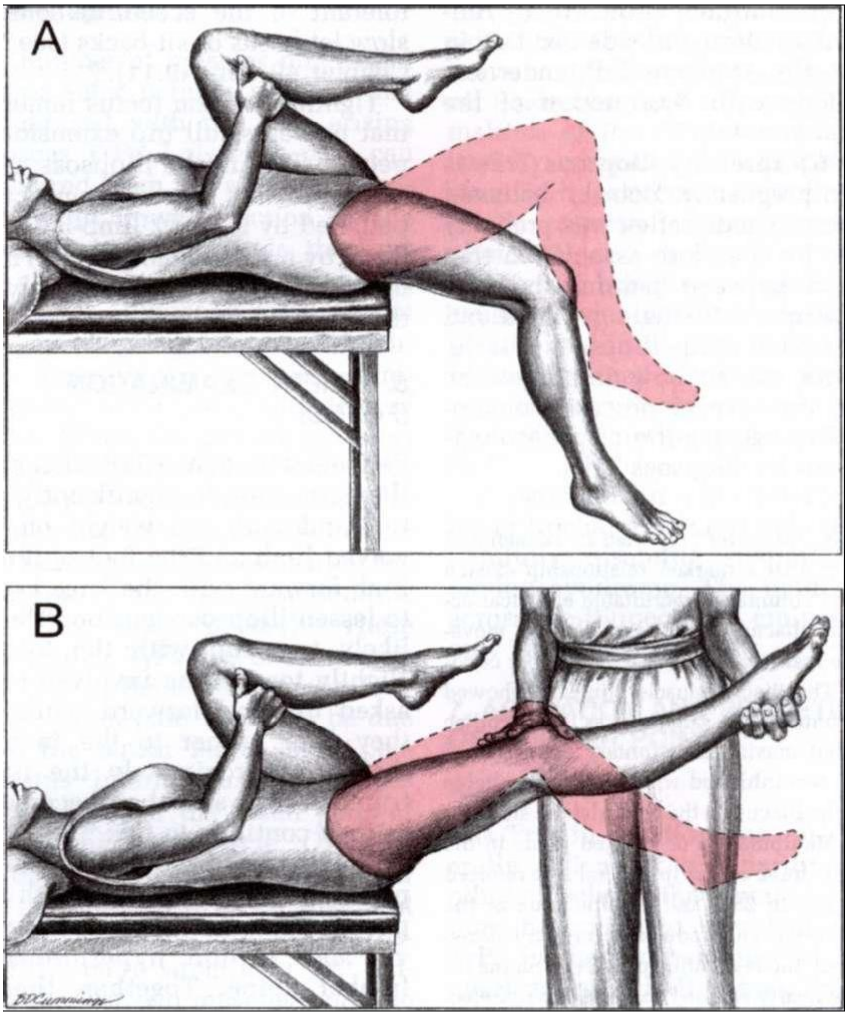
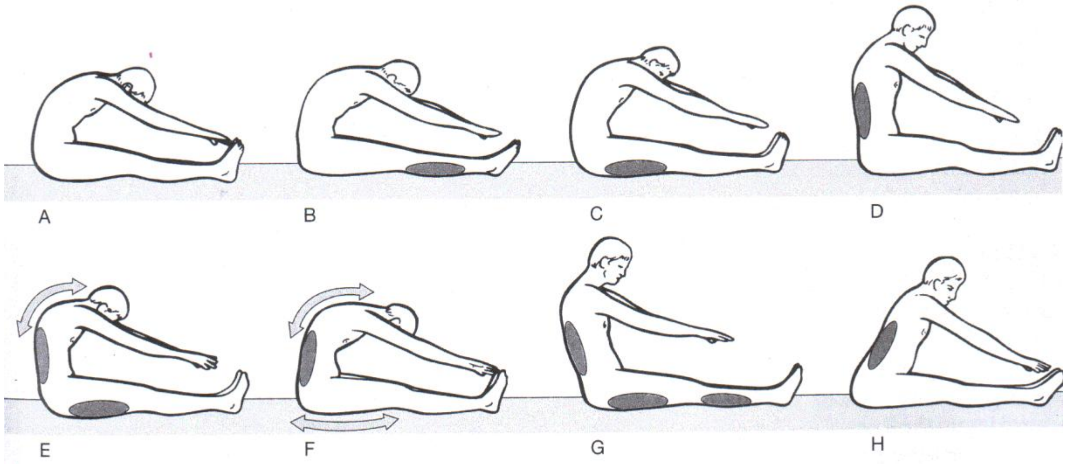


Figure 3.1: Modified Thomas' Test (Travell & Simons, 1999).

ii. Tight erector spinae by means of the visual assessment of shortness in lumbar erector spinae muscles (Figure 3.2.) (Chaitow, 2008).

The patient was seated on the examining table with the pelvis in a vertical position and the legs extended. The patient was asked to actively flex foreword in order to bring the forehead to the knees. The normal functioning of the erector spinae should display an even 'C' shaped curve and a distance of 10cm from the knees to the forehead. There should be also no knee flexion and involve no pelvic tilting. Any deviation from these norms indicates shortness of the erector spinae muscles.



<u>Figure: 3.2: Tests for shortness of the erector spinae muscles and related postural muscles (Chaitow, 2008)</u>

A: Normal length of erector spinae and posterior thigh muscles.

B: Tight gastrocnemius and soleus; the inability to dorsiflex the feet indicates tightness of the plantar-flexor group.

C: Tight hamstrings which cause the pelvis to tilt posteriorly.

D: Tight low back erector spinae.

E: Tight hamstrings; slightly tight low back muscles and overstretched upper back muscles.

F: Slightly shortened lower back muscles stretched upper back muscles and slightly stretched hamstrings.

G: Tight low back muscles, hamstrings and gastrocnemius/soleus.

H: Very tight low back muscles with lordosis maintained even in flexion.

iii. Weak gluteus maximus by way of the prone hip extension coordination/strength test (Figure 3.3) (Liebenson, 1996).

The patient lay prone and raised the tested thigh into extension with the knee held in an extended position. The researcher then palpated the lumbar erector spinae and gluteus maximus muscles. A normal activation sequence was then observed and palpated which involved first the hamstring and gluteus maximus muscles, then the contralateral lumbar erector spinae muscles and lastly the ipsilateral lumbar erector spinae muscles. A positive test result occurred if the lumbar erector spinae contracted before the gluteus maximus muscles did.

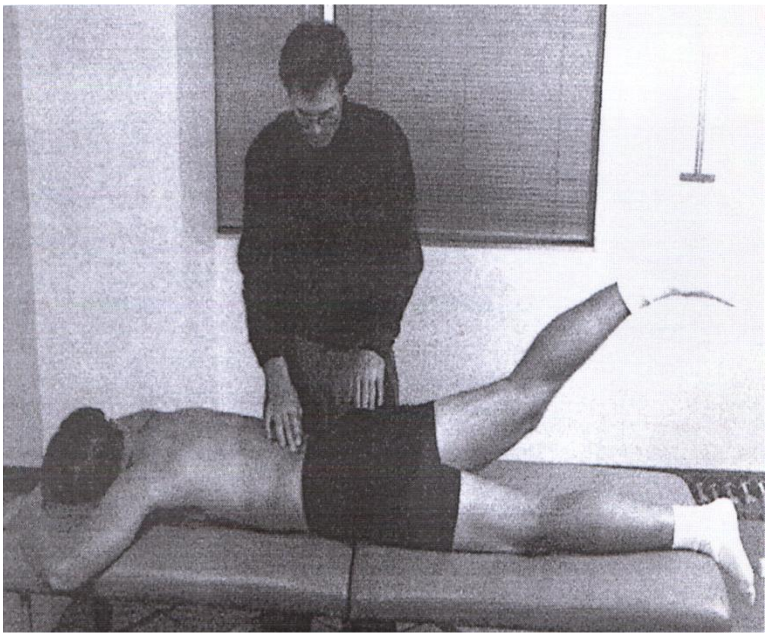


Figure 3.3: Hip Extension Coordination/Strength Test (Liebenson, 1996).

iv. Weak abdominals using the trunk flexion coordination and strength test (Figure 3.4) (Liebenson, 1996).

The patient lay supine with the arms either behind the neck or forward across the body and knees bent. The researcher then contacted the patient's heels or positioned a hand under the patient's lumbar spine. The patient was then asked to complete a posterior pelvic tilt and raise the trunk up until the scapulae cleared the table. This position was maintained for 2 seconds. The patient then held the pelvic tilt while lowering their back to the table. The patient was then instructed to perform 10 repetitions while holding the last repetition for 30 seconds. A positive test result occurred if the patient could not perform 10 repetitions without the lumbar spine or heels rising off the table.

Figure 3.4: Trunk Flexion Coordination and Strength Test (Liebenson, 1996).

- Confirmation of low back facet joint pain by a local positive result on Kemp's orthopaedic test (Souza, 2009). The seated patient was taken passively into extension and rotation on each side to establish if any local or radiating pain was reproduced. A positive test occurred if there was local pain indicating a facet cause.

3.4.2 Exclusion Criteria

- Contra-indications to spinal manipulation (Appendix B).

- Participants who would be undergoing other forms of treatment that may interfere with the study, for the duration of the study, including other manipulative and physical therapies or medication specific to back pain.
- Presence of other conditions that may mimic low back pain, e.g. nerve entrapment. This was determined by means of a case history, physical and lumbar regional examination.

3.5 Randomisation

Participants that met the inclusion criteria and had no exclusion criteria were randomly divided into three groups of ten participants each. Each participant was asked to draw one folded card out of a hat. There were thirty folded cards with ten of each card having the words “Group 1”, “Group 2” or “Group 3” written on it. The card the participant drew out determined which group they were in.

3.6 Treatment Approach

Participants were assessed over a four week period. This was in respect to a research study conducted where two proprioceptive neuromuscular facilitation programmes were evaluated to determine their effects on muscle endurance, flexibility and functional performance in women with chronic low back pain over four weeks. The results revealed an increase in muscle endurance and a significant reduction in functional disability and back pain (Kofotolis and Kellis, 2006).

3.6.1 First visit

This visit involved the following:

- Signing an informed consent form (Appendix C).
- Completing a thorough case history (Appendix D), full physical examination (Appendix E) and lumbar spine regional examination (Appendix F).
- Completing a Numerical Pain Rating Scale (Appendix G) and Oswestry Low Back Pain Disability Questionnaire (Appendix H).
- Active lumbar spine range of motion was measured with the digital inclinometer (Appendix I).

- Passive hip range of motion was measured with a universal goniometer (Appendix J).
- Measurement of lumbar lordosis via use of the flexible ruler (Appendix K).
- Participants in Group 1 and 3 performed and then were instructed when and how to perform Bruegger's exercise when they were out of the treatment sessions.
- Participants in Group 2 and 3 received spinal manipulation/s to the restricted lumbar spine segment/s.

3.6.2 Follow-up visits

All groups had to attend six follow-up sessions over a three week period. During their fourth and seventh follow-up, readings of subjective and objective data were taken in conjunction to the applicable treatment. During their fourth week which consisted of the seventh follow-up, no treatment was administered, and only readings of subjective and objective data were taken. However, the participants in Group 1 and 3 were advised to continue doing the Bruegger's exercise outside of treatment sessions where indicated.

These visits thus involved the following:

- Participants were re-assessed before each treatment.
- Before the fourth treatment and at the seventh follow-up, participants were requested to complete the Numerical Pain Rating Scale as well as the Oswestry Low Back Pain Disability Questionnaire.
- Before the fourth treatment and at the seventh follow-up, active lumbar spine range of motion was assessed using the digital inclinometer as well as passive hip flexion and extension using the universal goniometer.
- Before the fourth treatment and at the seventh follow-up measurement of lumbar lordosis via use of the flexible ruler was performed.
- Participants in Group 1 and 3 will perform Bruegger's exercise and be requested for feedback on usage of Bruegger's exercise outside follow-ups at each treatment session.
- Participants in Group 2 and 3 will receive spinal manipulation/s to the restricted lumbar spine segment/s at each treatment session.

3.7 Data Gathering

3.7.1 Subjective Data

a. Numerical (Pain) Rating Scale

The Numerical Rating Scale (Appendix G) is one of the most commonly used tools to measure pain intensity in both clinical and research settings. The Numerical Rating Scale is an 11-point scale that consists of numbers from 0 to 10, 0 signifies "no pain" and 10 signifies "worst imaginable pain". The participants were asked to select which number best corresponds to their pain intensity (Ferreira-Valente, Pais-Ribeiro, Jensen, 2011) by making a mark in the corresponding box and number. The Numerical Rating Scale is both reliable and valid (Williamson and Hoggart, 2005).

b. Oswestry Low Back Pain Disability Questionaire

The Oswestry Low Back Pain Disability Questionnaire (Appendix H) is an adequate apparatus used to measure disability caused by low back pain in the general population. It is a reliable, valid and responsive condition-specific assessment tool that has lasted despite time and scrutiny (Vianin, 2008). The Oswestry Low Back Pain Disability Questionnaire consists of 10 questions each consisting of six alternatives. Every question is scored from 0–5 and a percentage is formulated as a result of the sum of the scores (Niskanen, 2002).

According to Souza (2009), the key points to scoring of the Oswestry Low Back Pain Disability Questionnaire involve the following:

- The patient fills out the questionnaire in about 5 minutes and then the doctor scores it in about 1 minute.
- The patient marks the most relevant answer for each question as accurately as they can.
- Scoring is done on a scale of 0-5, starting with the first possible answer in the sequence being '0' and the last answer '5'.

- The maximum possible score for each section is 5. All the scores are added together and divided by the total number of possible points in order to calculate the total score.

For example, if all the sections were answered (i.e. 10 x 5 = 50) and the total points were 20 then the following calculation would be undertaken: 20/50 x 100 = 40 points. If a section was not answered then the patient's total points would be only divided by the number of sections answered times 10.

A commonly used reference for interpretation of results includes:

0-20% points	Minimal disability
21-40% points	Moderate disability
41-60% points	Severe disability
Over 60% points	Patient is severely disabled due to pain in several aspects of life

An improvement in the Oswestry Low Back Pain Disability Questionnaire indicates an improvement in the perception of the function for the patient and may display changes that might not be indicated in objective testing.

3.7.2 Objective data

a. Digital inclinometer

The digital inclinometer (Appendix I) is an easy and useful instrument to use (Venturni, Andre, Aguilar, Giacomelli, 2006). It was used to measure active lumbar range of motion. Measuring lumbar range of motion is a regular method used to examine patients with low back pain and to determine the functional limits of the spinal column. The inclinometer was found to be highly reliable and valid (Saur, Ensink, Frese, Seeger, Hildebrandt, 1996).

Measurements of all ranges of motion were taken at the L5-S1 interspace (point A) and at the T12-L1 interspace (point B) according to the AMA Guidelines method (Saunders, 1997).

Extension:

- The inclinometer was zeroed before each range was taken.
- The inclinometer was positioned at point A and the patient was asked to complete full extension where a reading was taken, making sure that the patient did not bend their knees which would affect the apparent extension mobility.
- This was repeated at point B.
- In order to calculate each range of motion, the readings at point A was subtracted from the readings at point B (Saunders, 1997).

Forward Flexion:

- The inclinometer was zeroed before each range was taken.
- The inclinometer was positioned at point A and the patient was asked to complete full forward flexion where a reading was taken.
- This was repeated at point B.
- In order to calculate each range of motion, the readings at point A was subtracted from the readings at point B (Saunders, 1997).

Lateral Flexion:

- The inclinometer was zeroed before each range was taken
- The patient stood in the same position and the inclinometer was zeroed at point A.
- The patient flexed laterally to their full range by running their respective arm down their leg while keeping their legs straight.
- Recordings were taken at point A and point B for both left and right sides.
- The range was calculated by subtracting the readings at point A from the readings at point B from each side (Saunders, 1997).

Rotation:

- The inclinometer was zeroed before each range was taken.
- The patient stood in 90 degrees of forward flexion and the inclinometer was zeroed at point A.
- The patient rotated their left shoulder maximally forward for left rotation and a recording was taken.
- This was repeated on the opposite side and again at point B.

- Ranges were calculated by subtracting readings at point A from readings at point B for each side (Saunders, 1997).

b. Universal Goniometer

In a clinical environment, the universal goniometer (Appendix J) is the most common assessment tool used for measuring range of motion or joint angles. It was used to measure passive hip flexion and extension. The universal goniometer was found to be valid and reliable when the same therapist uses the goniometer each time using a strict standard measurement protocol (Clarkson, 2000).

Measurement of passive hip flexion according to (Clarkson, 2000), involved the following:

- The patient was supine with the hip and knee of the tested side in neutral position and the contralateral hip flexed or extended.
- The trunk was stabilized through body positioning and the researcher stabilized the pelvis.
- The axis of the goniometer was placed over the greater trochanter of the femur on the tested side.
- The stationery arm of the goniometer was parallel to the midaxillary line of the trunk.
- The moveable arm of the goniometer was parallel to the longitudinal axis of the femur and pointed toward the lateral epicondyle.
- The tested hip was passively flexed to the limit of motion while the knee maintained a flexed position
- The end position was identified and measured.

Measurement of passive hip extension according to (Clarkson, 2000), involved the following:

- The patient was prone with the hips and knees in a neutral position and the feet over the edge of the examining table.
- The pelvis was stabilized with strapping.
- The axis of the goniometer was placed over the greater trochanter of the femur on the tested side.

- The stationery arm of the goniometer was parallel to the midaxillary line of the trunk.
- The moveable arm of the goniometer was parallel to the longitudinal axis of the femur and pointed toward the lateral epicondyle.
- The tested hip was passively extended to the limit of motion while the knee maintained an extended position.
- The end position was identified and measured.

c. Flexible Ruler

Lower crossed syndrome promotes an increase in the lumbar lordosis due to an anterior pelvic tilt and hip flexion hypertonicity (Magee, 2008). The flexible ruler (flexicurve) (Appendix K) is commonly used to measure the degree of spinal curvature of the lumbar lordosis in the sagittal plane. The flexible ruler was placed according to the Youdas method, over spinous processes from T12 to S2 vertebrae. The ruler was then cautiously removed from the spine and traced onto a plain piece of white paper. A vertical line was drawn to connect the T12 and S2 landmarks (L line) and together with the maximum width of the lumbar curvature (H line), they was measured to calculate in the equation: [theta] = 4*Arc*tan(2H/L) where [theta] symbolizes the magnitude of the lordotic curve (Rajabi, Seidi, Mohamadi, 2008). The flexible ruler is shown to be both valid and reliable (Seidi, Rajabi, Ebrahimi, Tavanai, Moussavi, 2009).

3.8 Data Analysis

Both the subjective and objective data was collected by the researcher during the study period. The data was then analysed by the statisticians of Statkon. The results were based on the subjective data (Numerical Pain Rating Scale and Oswestry Low Back Pain Disability Questionnaire) and objective data (hip flexion and extension, lumbar range of motion and lumbar lordosis readings) obtained during the study.

Tests for normality were analysed by the Shapiro Wilk test. Intragroup analysis involved the use of the Friedman test to determine if there were any statistically significant changes in the recorded data over time, from the first visit to the seventh visit. The Wilcoxon Signed Rank test was then used to establish at which visit the statistically significant changes occurred by comparing visit one with visit four and seven as well as visit four with visit seven. Intergroup analysis involved the use of the Kruskal-Wallis test to determine if there were any statistically significant changes in the recorded data between group one, group two and group three recorded on the first visit, fourth visit and seventh visit. The Mann-Whitney U test was then used to establish between which specific groups a statistically significant difference was found.

3.9 Ethical Considerations

All participants that partook in this particular study were requested to read and sign the information and consent form specific to this study on their first visit. The information and consent form outlined the names of the researcher, purpose of the study and benefits of partaking in the study, participant assessment and treatment procedure. Any risks, benefits and discomforts pertaining to the treatments involved were also explained and the participant's safety was ensured (prevention of harm). The information and consent also explained that the participant's privacy will be protected as only the doctor, patient and clinician will be in the treatment room and that anonymity will be ensured as the patient information will be converted into data and therefore cannot be traced back to the individual. The form also stated that standard doctor/patient confidentiality will be adhered to at all times when compiling the research dissertation. The participants were informed that their participation was on a voluntary basis and that they were free to withdraw from the study at any stage and no harm would come to them if they did so. If the participant had any further questions, these were explained by the researcher; whose contact details were made available. The participants were then required to sign the information and consent form, signifying that they understood all that was required of them for this particular study. Results of the study were made available on request. With regards to this particular study, the following possible discomforts were post treatment soreness from the spinal manipulation that may have been present for a few days and should resolve as well as possibly some minor pain or discomfort from the Bruegger's exercise routine. The participants would have been referred if it was necessary.

CHAPTER FOUR

RESULTS

4.1 Introduction

This chapter presents the results obtained during the clinical trial of this study. The sample group consisted of 3 groups of 10 participants in each. Group 1 performed Bruegger's exercise only, group 2 received a spinal manipulation/s only and Group 3 received a combined treatment of a spinal manipulation/s and performing Bruegger's exercise. The statistical results therefore represent a small group of subjects and no assumption can be made with respect to the general population. The probability level (p-value) for statistical significant analysis was set at 0.05. Thus, results are statistically significant if $p \leq 0.05$.

The analysis included:

1. Demographic date: analysis of age and gender.
2. Subjective measurements: Numerical Pain Rating Scale and Oswestry Low Back Pain Disability Questionnaire.
3. Objective measurements: left and right passive hip flexion and extension, active lumbar range of motion which includes flexion, extension, left and right lateral flexion and rotation as well as degree of lumbar lordosis.

4.2 Demographic data analysis

The participants used in this research had to be between the ages of 18 and 65. There did not have to be an equal ratio of females to males however, the ratio of females to males for this study was found to be 1.14:1.

4.2.1. Age distribution

Participants in group 1 were between the ages of 18 and 50 with a mean age of 26.30 years. Participants in group 2 were between the ages of 22 and 27 with a mean age of 24.40 years. Participants in group 3 were between the ages of 20 and 40 with a mean age of 25.50 years. The youngest participant was 18 years old and the eldest participant was 50 years old, resulting in a mean age of combined participants being 25.40 years, (Refer to table 4.1).

4.2.2 Gender distribution

Group 1 and group 3 consisted of 5 males and 5 females, and group 2 consisted of 4 males and 6 females. There were a total of 14 males and 16 females, (Refer to table 4.1).

	Mean Age	Male	Female
Group 1	26.30	5	5
Group 2	24.40	4	6
Group 3	25.50	5	5
Groups Combined	25,40	14	16

Table 4.1: Demographic data within the sample of 30 participants

4.3 Subjective data analysis

4.3.1 Numerical Pain Rating Scale

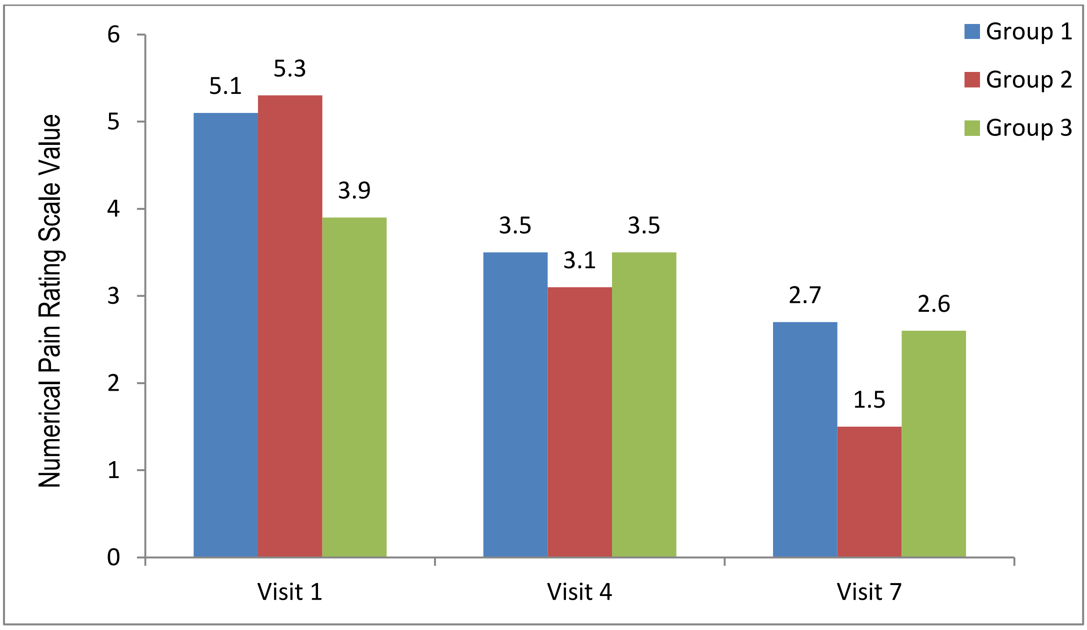


Figure 4.1: Bar graph comparing mean Numerical Pain Rating Scale values

Clinical Analysis

Figure 4.1 shows a bar graph comparing mean Numerical Pain Rating Scale values of all the groups measured at the first, fourth and seventh visits. From the bar graph it may be seen that the mean Numerical Pain Rating Scale value for group 1 was 5.10 at the first visit, 3.50 at the fourth visit and 2.70 and the seventh visit. This indicated an overall decrease in Numerical Pain Rating Scale values of 47%. The mean Numerical Pain Rating Scale value for group 2 was 5.30 at the first visit, 3.10 at the fourth visit and 1.50 and the seventh visit. This indicated an overall decrease in Numerical Pain Rating Scale values of 71.7%. The mean Numerical Pain Rating Scale value for group 3 was 3.90 at the first visit, 3.50 at the fourth visit and 2.60 at the seventh visit. This indicated an overall decrease in Numerical Pain Rating Scale values of 33.34%.

Intragroup analysis

The non-parametric Friedman test was used to compare the Numerical Pain Rating Scale values at visit 1 and 7 within each group. A statistically significant difference (p=0.001) was found in group 1 and a statistically significant difference (p=0.000) was found in group 2. However, no statistically significant difference (p=0.207) was found in group 3.

The non-parametric Wilcoxon Signed Rank test was then used to establish at which visit the Numerical Pain Rating Scale values had a statistically significant difference. Group 1 had a statistically significant difference between visit 1 and 4 (p=0.004) as well as between visit 1 and 7 (p=0.006). However, there was no statistically significant difference between visit 4 and 7 (p=0.075). Group 2 had a statistically significant difference between visit 1 and 4 (p=0.004), visit 4 and 7 (p=0.045) as well as visit 1 and 7 (p=0.005). Group 3 showed no statistically significant differences between any visits.

Intergroup analysis

The non-parametric Kruskal-Wallis test was used to compare the Numerical Pain Rating Scale values between all groups at visit 1, 4 and 7. No statistically significant difference was found at visit 1 (p=0.060), visit 4 (p=0.794) as well as visit 7 (p=0.133) between all groups. No further testing was completed since no statistically significant difference was found at any visit and therefore no statistically significant difference would be found between any groups.

4.3.2 Oswestry Low Back Pain Disability Questionnaire

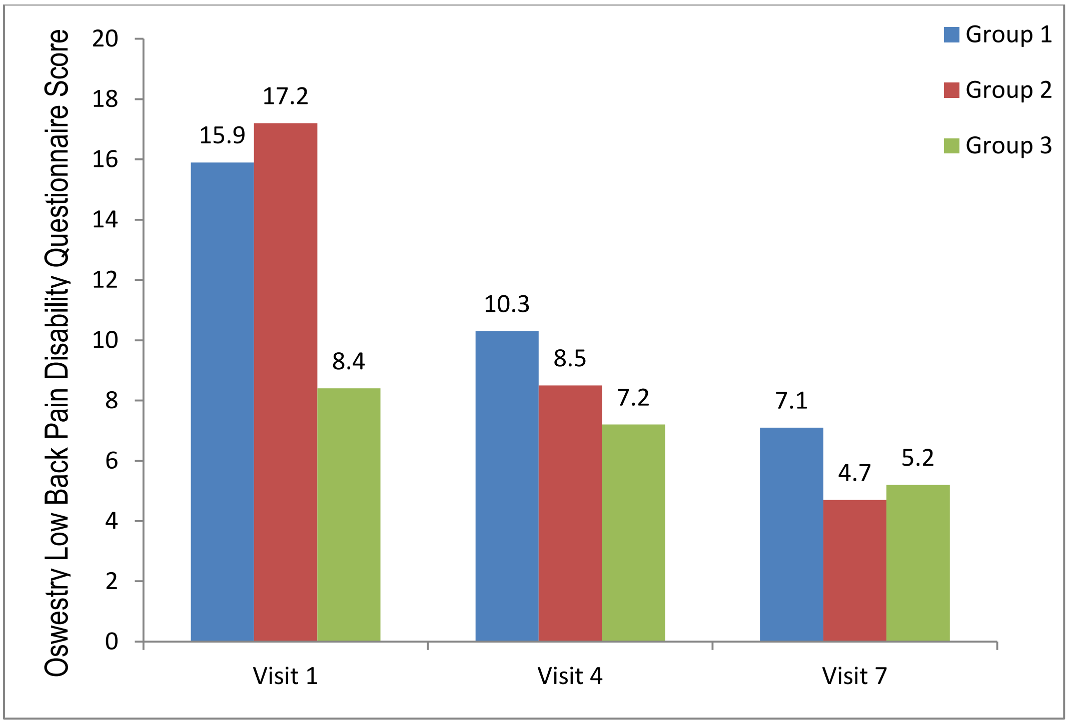


Figure 4.2: Bar graph comparing mean Oswestry Low Back Pain Disability Questionnaire scores

Clinical Analysis

Figure 4.2 shows a bar graph comparing mean Oswestry Low Back Pain Disability Questionnaire scores of all the groups measured at the first, fourth and seventh visits. From the bar graph it may be seen that the mean Oswestry Low Back Pain Disability Questionnaire score for group 1 was 15.90 at the first visit, 10.30 at the fourth visit and 7.10 and the seventh visit. This indicated an overall decrease Oswestry Low Back Pain Disability Questionnaire scores of 55.35%. The mean Oswestry Low Back Pain Disability Questionnaire score for group 2 was 17.20 at the first visit, 8.50 at the fourth visit and 4.70 and the seventh visit. This indicated an overall decrease in Oswestry Low Back Pain Disability Questionnaire scores of 72.67%. The mean Oswestry Low Back Pain Disability Questionnaire score for group 3 was 8.40 at the first visit, 7.20 at the fourth visit and 5.20 and the seventh visit. This indicated an overall decrease in Oswestry Low Back Pain Disability Questionnaire scores of 38.10%.

Intragroup analysis

The non-parametric Friedman test was used to compare Oswestry Low Back Pain Disability Questionnaire scores at visit 1 and 7 within each group. A statistically significant difference (p=0.000) was found in group 1 and statistically significant difference (p=0.000) was found in group 2. However, no statistically significant difference (p=0.282) was found in group 3.

The non-parametric Wilcoxon Signed Rank test was then used to establish at what visit the Oswestry Low Back Pain Disability Questionnaire scores had a statistically significant difference. Group 1 had a statistically significant difference between visit 1 and 4 (p=0.007) as well as between visit 1 and 7 (p=0.024). However, there was no statistically significant difference between visit 4 and 7 (p=0.007). Group 2 had a statistically significant difference between visit 1 and 4 (p=0.005), visit 4 and 7 (p=0.017) as well as visit 1 and 7 (p=0.005). Group 3 showed no statistically significant differences between any visits.

Intergroup analysis

The non-parametric Kruskal-Wallis test was used to compare the Oswestry Low Back Pain Disability Questionnaire scores between all groups at visit 1, 4 and 7. A statistically significant difference was found at visit 1 between the groups (p=0.025). However, no statistical significant difference was found at visit 4 (p=0.310) and visit 7 (p=0.473) between all groups.

The non-parametric Mann-Whitney U test was further used to establish between which groups a statistically significant difference was found. There was a statistically significant difference between groups 1 and 3 (p=0.019) as well as groups 2 and 3 (p=0.019). However, there was no statistically significant difference between groups 1 and 2 (p=0.676).

4.4 Objective data analysis

4.4.1 Passive hip range of motion

a) Left hip flexion

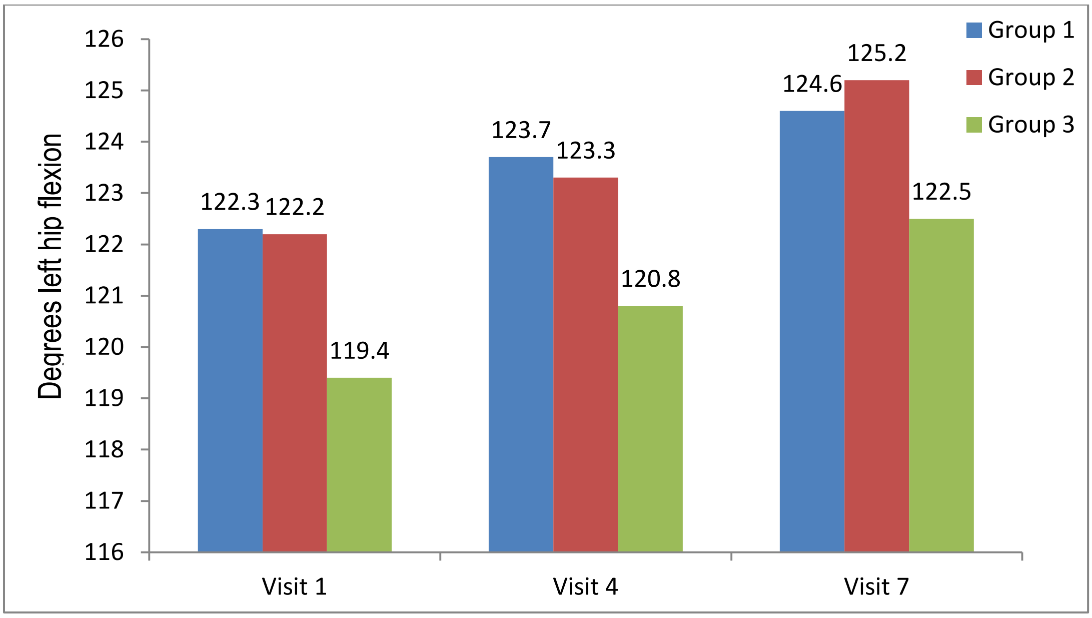


Figure 4.3: Bar graph comparing mean left hip flexion values

Clinical Analysis

Figure 4.3 shows a bar graph comparing mean left hip flexion values of all the groups measured at the first, fourth and seventh visits. From the bar graph it may be seen that the mean left hip flexion for group 1 was 122.30 ° at the first visit, 123.70 ° at the fourth visit and 124.60 ° and the seventh visit. This indicated an overall increase in left hip flexion values of 1.85%. The mean left hip flexion for group 2 was 122.20 ° at the first visit, 123.30° at the fourth visit and 125.20 ° and the seventh visit. This indicated an overall increase in left hip flexion values of 2.40%. The mean left hip flexion for group 3 was 119.40 ° at the first visit, 120.80 ° at the fourth visit and 122.50 ° and the seventh visit. This indicated an overall increase in left hip flexion values of 2.53%.

Intragroup analysis

The non-parametric Friedman test was used to compare the degree of left hip flexion at visit 1 and 7 within each group. A statistically significant difference was found in group 1 (p=0.000), group 2 (p=0.001) as well as group 3 (p=0.005).

The non-parametric Wilcoxon Signed Rank test was then used to establish at which visit the degree of left hip flexion had a statistically significant difference. Group 1 had a statistically significant difference between visit 1 and 4 (p=0.016), between visit 1 and 7 (p=0.030) as well as between visit 4 and 7 (p=0.004). Group 2 had a statistically significant difference between visit 1 and 4 (p=0.031), between visit 1 and 7 (p=0.012) as well as between visit 4 and 7 (p=0.005). Group 3 had a statistically significant difference between visit 1 and 4 (p=0.041), between visit 1 and 7 (p=0.024) as well as between visit 4 and 7 (p=0.011).

Intergroup analysis

The non-parametric Kruskal-Wallis test was used to compare the degree of left hip flexion between all groups at visit 1, 4 and 7. No statistically significant difference was found between all the groups at any visit.

b) Right hip flexion

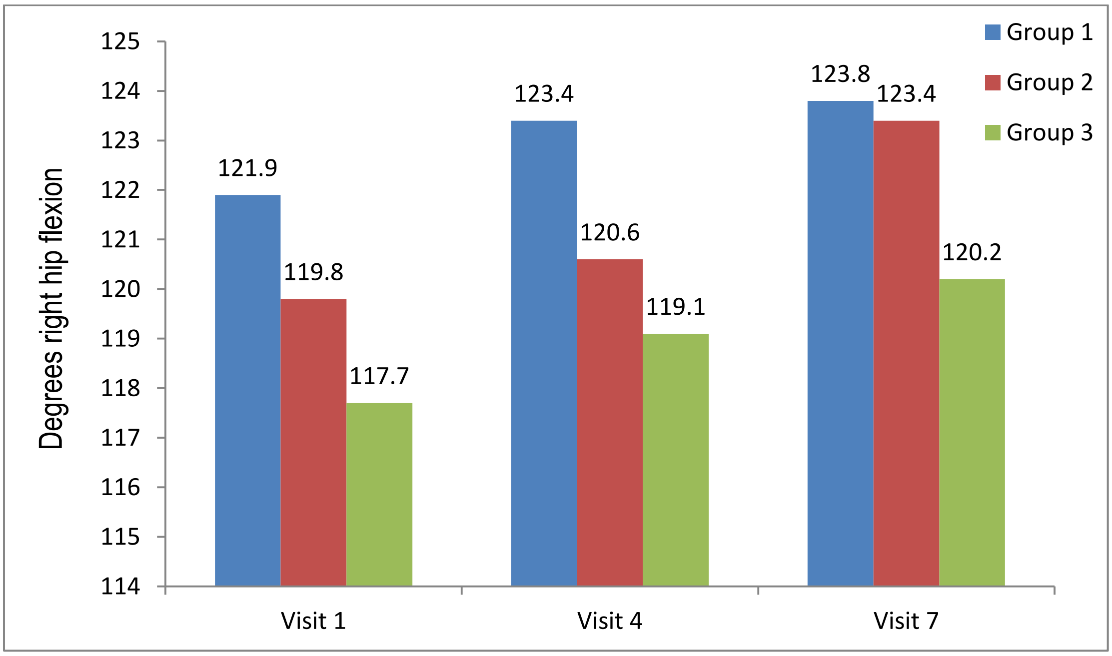


Figure 4.4: Bar graph comparing mean right hip flexion values

Clinical Analysis

Figure 4.4 shows a bar graph comparing mean right hip flexion values of all the groups measured at the first, fourth and seventh visits. From the bar graph it may be seen that the mean right hip flexion for group 1 was 121.90 º at the first visit, 123.40 º at the fourth visit and 123.80 º and the seventh visit. This indicated an overall increase in right hip flexion values of 1.53%. The mean right hip flexion for group 2 was 119.80 º at the first visit, 120.60º at the fourth visit and 123.40 º and the seventh visit. This indicated an overall increase in right hip flexion values of 2.92%. The mean right hip flexion for group 3 was 117.70 º at the first visit, 119.10 º at the fourth visit and 120.20 º and the seventh visit. This indicated an overall increase in right hip flexion values of 2.08%.

Intragroup analysis

The non-parametric Friedman test was used to compare the degree of right hip flexion at visit 1 and 7 within each group. A statistically significant difference was found in group 1 (p=0.002), group 2 (p=0.000) as well as group 3 (p=0.004).

The non-parametric Wilcoxon Signed Rank test was then used to establish at which visit the degree of right hip flexion had a statistically significant difference. Group 1 had a statistically significant difference between visit 1 and 4 (p=0.016) as well as between visit 4 and 7 (p=0.011) however, between visit 1 and 7 there was no statistically significant difference (p=0.334). Group 2 had a statistically significant difference between visit 4 and 7 (p=0.007) as well as between visit 1 and 7 (p=0.005) however, there was no statistically significant difference between visit 1 and 4 (p=0.268). Group 3 had a statistically significant difference between visit 1 and 4 (p=0.034) as well as between visit 4 and 7 (p=0.011). However, there was no statistically significant difference between visit 1 and 7 (p=0.188).

Intergroup analysis

The non-parametric Kruskal-Wallis test was used to compare the degree of right hip flexion between all groups at visit 1, 4 and 7. No statistically significant difference was found between all the groups at any visit.

c) Left hip extension

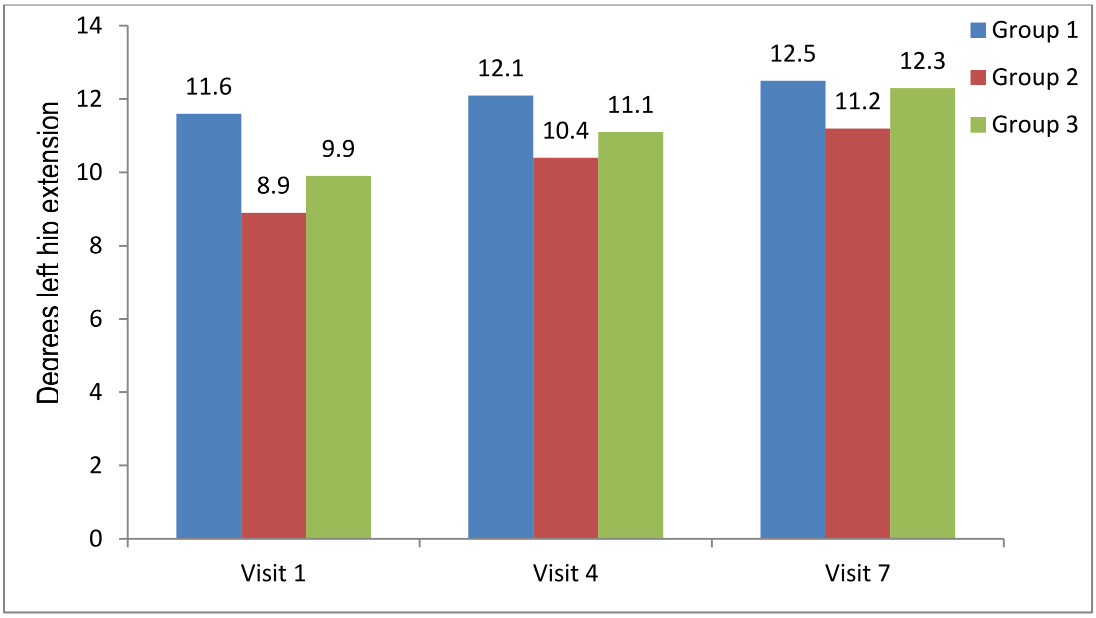


Figure 4.5: Bar graph comparing mean left hip extension values

Clinical Analysis

Figure 4.5 shows a bar graph comparing mean left hip extension values of all the groups measured at the first, fourth and seventh visits. From the bar graph it may be seen that the mean left hip extension for group 1 was 11.60 ° at the first visit, 12.10 ° at the fourth visit and 12.50 ° and the seventh visit. This indicated an overall increase in left hip extension values of 7.2%. The mean left hip extension for group 2 was 8.90 ° at the first visit, 10.40° at the fourth visit and 11.20 ° and the seventh visit. This indicated an overall increase in left hip extension values of 20.54%. The mean left hip extension for group 3 was 9.90 ° at the first visit, 11.10 ° at the fourth visit and 12.30 ° and the seventh visit. This indicated an overall increase in left t hip extension values of 19.51%.

Intragroup analysis

The non-parametric Friedman test was used to compare the degree of left hip extension at visit 1 and 7 within each group. A statistically significant difference was found in group 2 (p=0.005) and group 3 (p=0.000) but no statistically significant difference was found in group 1 (p=0.81).

The non-parametric Wilcoxon Signed Rank test was then used to establish at which visit the degree of left hip extension had a statistically significant difference. Group 1 had no statistically significant difference between any of the visits. Group 2 had a statistically significant difference between visit 1 and 4 (p=0.041) as well as between visit 1 and 7 (p=0.012) however, there was no statistically significant difference between visit 4 and 7 (p=0.054). Group 3 had a statistically significant difference between visit 1 and 4 (p=0.024), between visit 4 and 7 (p=0.010) as well as between visit 1 and 7 (p=0.005).

Intergroup analysis

The Kruskal-Wallis test was used to compare the degree of left hip flexion between all groups at visit 1, 4 and 7. A statistically significant difference was found between the groups at visit 1 (p=0.040) but no statistically significant difference was found between all the groups at visit 4 (p=0.436) and 7 (p=0.503).

The non-parametric Mann-Whitney U test was further used to establish between which groups a statistically significant difference was found. There was a statistically significant difference between groups 1 and 2 (p=0.016). However, there was no statistically significant difference between groups 1 and 3 (p=0.358) as well as groups 2 and 3 (p=0.105).

d) Right hip extension

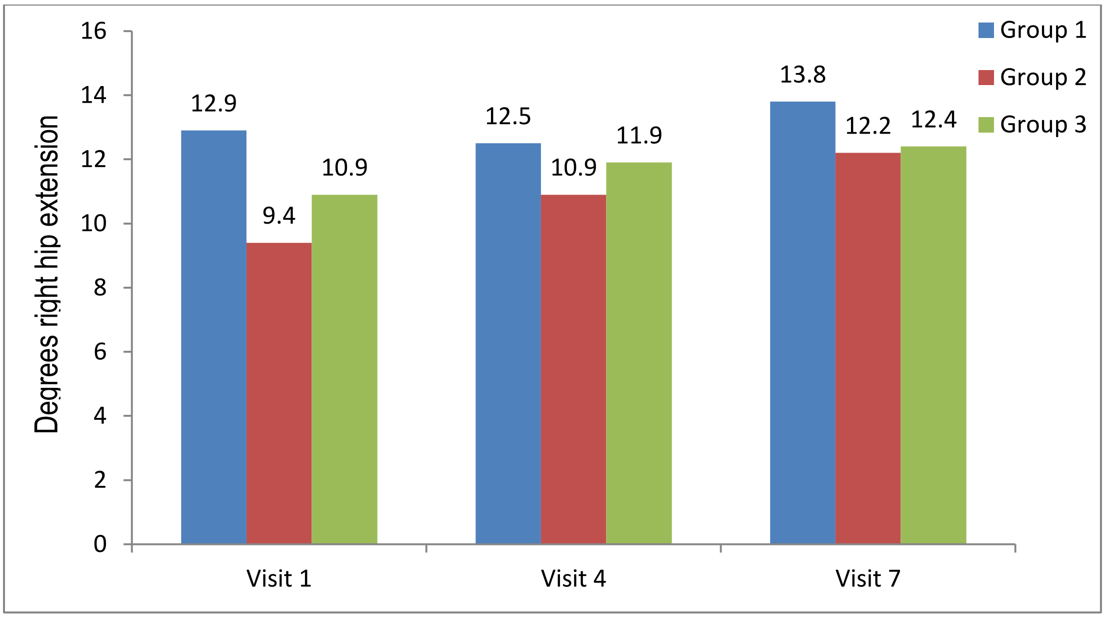


Figure 4.6: Bar graph comparing mean right hip extension values

Clinical Analysis

Figure 4.6 shows a bar graph comparing mean right hip extension values of all the groups measured at the first, fourth and seventh visits. From the bar graph it may be seen that the mean right hip extension for group 1 was 12.90 º at the first visit, 12.50 º at the fourth visit and 13.80 º and the seventh visit. This indicated an overall increase in right hip extension values of 6.5%. The mean right hip extension for group 2 was 9.40 º at the first visit, 10.90º at the fourth visit and 12.20 º and the seventh visit. This indicated an overall increase in right hip extension values of 23.0%. The mean right hip extension for group 3 was 10.90 º at the first visit, 11.90 º at the fourth visit and 12.40 º and the seventh visit. This indicated an overall increase in right hip extension values of 12.1%.

Intragroup analysis

The non-parametric Friedman test was used to compare the degree of right hip extension at visit 1 and 7 within each group. A statistically significant difference was found in group 2 (p=0.000) and group 3 (p=0.003) but no statistically significant difference was found in group 1 (p=0.112).

The non-parametric Wilcoxon Signed Rank test was then used to establish at which visit the degree of right hip extension had a statistically significant difference. Group 1 had no statistically significant difference between any of the visits. Group 2 had a statistically significant difference between visit 1 and 4 (p=0.026), between visit 4 and 7 (p=0.010) as well as between visit 1 and 7 (p=0.004). Group 3 had a statistically significant difference between visit 1 and 4 (p=0.020) as well as between visit 1 and 7 (p=0.011) however, there was no statistically significant difference between visits 4 and 7 (p=0.336).

Intergroup analysis

The non-parametric Kruskal-Wallis test was used to compare the degree of right hip flexion between all groups at visit 1, 4 and 7. A statistically significant difference was found between the groups at visit 1 (p=0.040) but no statistically significant difference was found between all the groups at visit 4 (p=0.384) and 7 (p=0.315).

The non-parametric Mann-Whitney U test was further used to establish between which groups a statistically significant difference was found. There was a statistically significant difference between groups 1 and 2 (p=0.018). However, there was no statistically significant difference between groups 1 and 3 (p=0.125) as well as groups 2 and 3 (p=0.206).

4.4.2 Active lumbar range of motion

a) Flexion

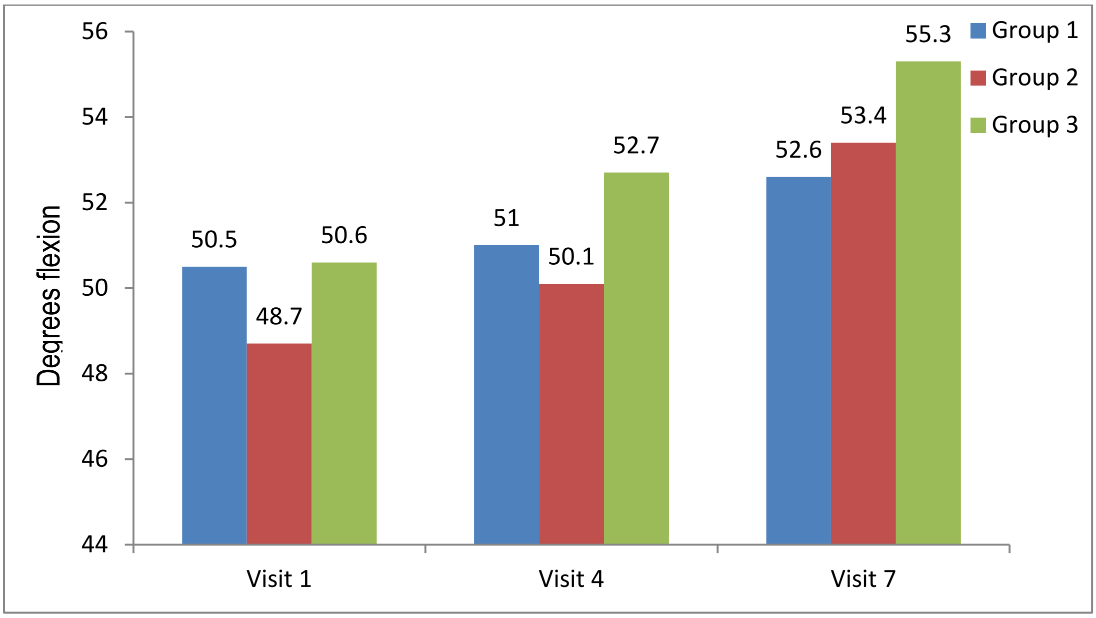


Figure 4.7: Bar graph comparing mean lumbar spine flexion values

Clinical Analysis

Figure 4.8 shows a bar graph comparing mean flexion values of all the groups measured at the first, fourth and seventh visits. From the bar graph it may be seen that the mean flexion for group 1 was 50.50 ° at the first visit, 51.00 ° at the fourth visit and 52.60 ° and the seventh visit. This indicated an overall increase in flexion values of 4.0%. The mean flexion for group 2 was 48.70 ° at the first visit, 50.10° at the fourth visit and 53.40 ° and the seventh visit. This indicated an overall increase in flexion values of 8.8%. The mean flexion for group 3 was 50.60 ° at the first visit, 52.70 ° at the fourth visit and 55.30 ° and the seventh visit. This indicated an overall increase in flexion values of 8.5%.

Intragroup analysis

The non-parametric Friedman test was used to compare the degree of flexion at visit 1 and 7 within each group. A statistically significant difference was found in group 1 ($p=0.000$), group 2 ($p=0.001$) and group 3 ($p=0.000$).

The non-parametric Wilcoxon Signed Rank test was then used to establish at which visit the degree of flexion had a statistically significant difference. Group 1 had a statistically significant difference between visit 4 and 7 (p=0.011) as well as 1 and 7 (p=0.006) however there was no statistically significant difference between visits 1 and 4 (p=0.238). Group 2 had a statistically significant difference between visit 1 and 4 (p=0.016), between visit 4 and 7 (p=0.007) as well as between visit 1 and 7 (p=0.005). Group 3 had a statistically significant difference between visit 1 and 4 (p=0.031), between visit 1 and 7 (p=0.005) as well as between visits 4 and 7 (p=0.005).

Intergroup analysis

The non-parametric Kruskal-Wallis test was used to compare the degree of right hip flexion between all groups at visit 1, 4 and 7. No statistically significant difference was found between all the groups at any visit.

b) Extension

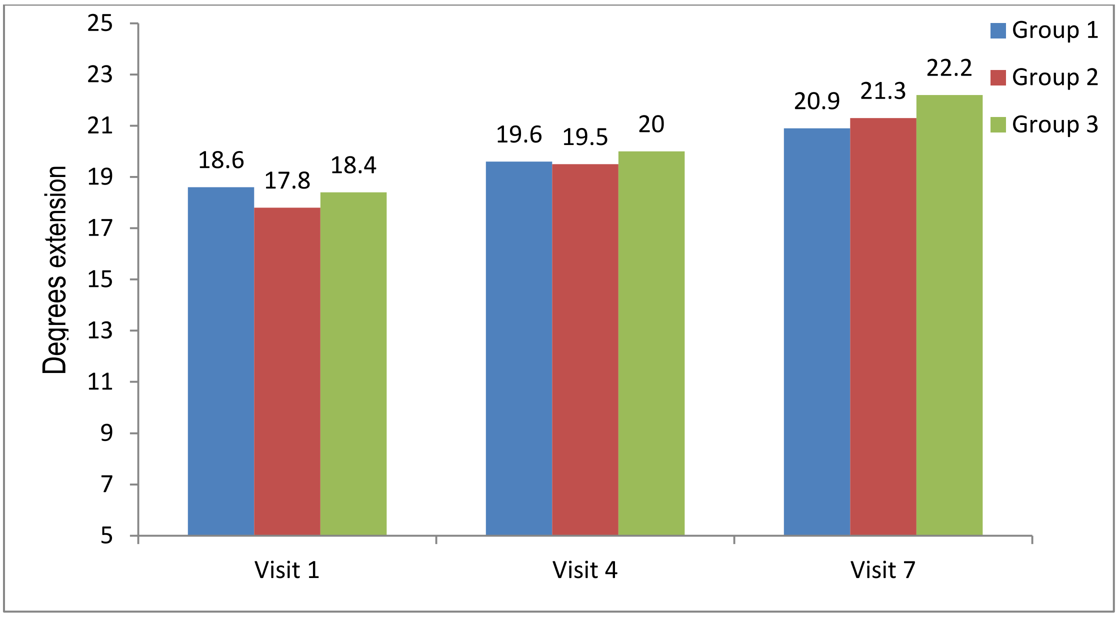


Figure 4.8: Bar graph comparing mean lumbar spine extension values

Clinical Analysis

Figure 4.8 shows a bar graph comparing mean extension values of all the groups measured at the first, fourth and seventh visits. From the bar graph it may be seen that the mean extension for group 1 was 18.60 ° at the first visit, 19.60 ° at the fourth visit and

20.90 º and the seventh visit. This indicated an overall increase in extension values of 11.0%. The mean extension for group 2 was 17.80 º at the first visit, 19.50º at the fourth visit and 21.30 º and the seventh visit. This indicated an overall increase in extension values of 16.43%. The mean extension for group 3 was 18.40 º at the first visit, 20.00 º at the fourth visit and 22.20 º and the seventh visit. This indicated an overall increase in extension values of 17.12%.

Intragroup analysis

The non-parametric Friedman test was used to compare the degree of extension at visit 1 and 7 within each group. A statistically significant difference was found in group 1 (p=0.00), group 2 (p=0.001) and group 3 (p=0.000).

The non-parametric Wilcoxon Signed Rank test was then used to establish at which visit the degree of extension had a statistically significant difference. Group 1 had a statistically significant difference between visit 1 and 4 (p=0.047), 4 and 7 (p=0.016) as well as visits 1 and 7 (p=0.004). Group 2 had a statistically significant difference between visit 1 and 4 (p=0.011), visit 4 and 7 (p=0.007) as well as between visit 1 and 7 (p=0.006). Group 3 had a statistically significant difference between visit 1 and 4 (p=0.011), visit 4 and 7 (p=0.005) as well as between visit 1 and 7 (p=0.004).

Intergroup analysis

The non-parametric Kruskal-Wallis test was used to compare the degree of extension between all groups at visit 1, 4 and 7. No statistically significant difference was found between all the groups at any visit.

c) Right rotation

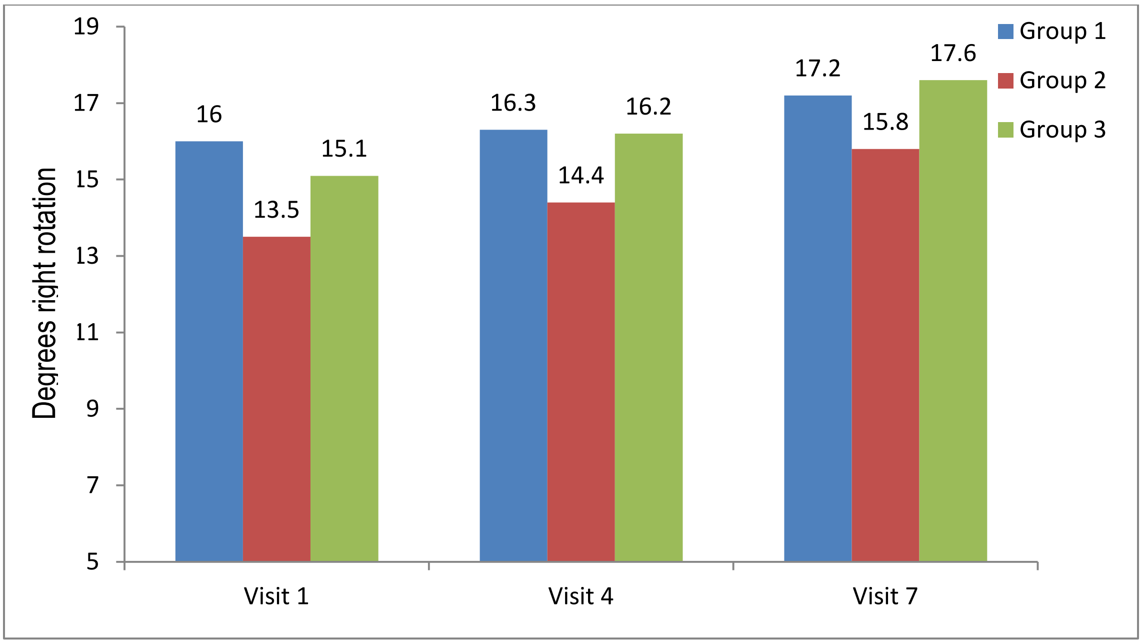


Figure 4.9: Bar graph comparing mean lumbar spine right rotation values

Clinical Analysis

Figure 4.9 shows a bar graph comparing mean right rotation values of all the groups measured at the first, fourth and seventh visits. From the bar graph it may be seen that the mean right rotation for group 1 was 16.00 ° at the first visit, 16.30 ° at the fourth visit and 17.20 ° and the seventh visit. This indicated an overall increase in right rotation values of 7.4%. The mean right rotation for group 2 was 13.50 ° at the first visit, 14.40° at the fourth visit and 15.80 ° and the seventh visit. This indicated an overall increase in right rotation values of 14.56%. The mean right rotation for group 3 was 15.10 ° at the first visit, 16.20 ° at the fourth visit and 17.60 ° and the seventh visit. This indicated an overall increase in right rotation values of 14.20%.

Intragroup analysis

The non-parametric Friedman test was used to compare the degree of right rotation at visit 1 and 7 within each group. A statistically significant difference was found in group 1 (p=0.003), group 2 (p=0.000) and group 3 (p=0.000).

The non-parametric Wilcoxon Signed Rank test was then used to establish at which visit the degree of right rotation had a statistically significant difference. Group 1 had a statistically significant difference between visit 1 and 7 (p=0.010), however there was no statistically significant difference at visits 1 and 4 (p=0.180) and 4 and 7 (p=0.083). Group 2 had a statistically significant difference between visit 1 and 4 (p=0.047), visit 4 and 7 (p=0.006) as well as between visit 1 and 7 (p=0.010). Group 3 had a statistically significant difference between visit 1 and 4 (p=0.008), visit 4 and 7 (p=0.004) as well as between visit 1 and 7 (p=0.004).

Intergroup analysis

The non-parametric Kruskal-Wallis test was used to compare the degree of right rotation between all groups at visit 1, 4 and 7. No statistically significant difference was found between all the groups at any visit.

d) Left rotation

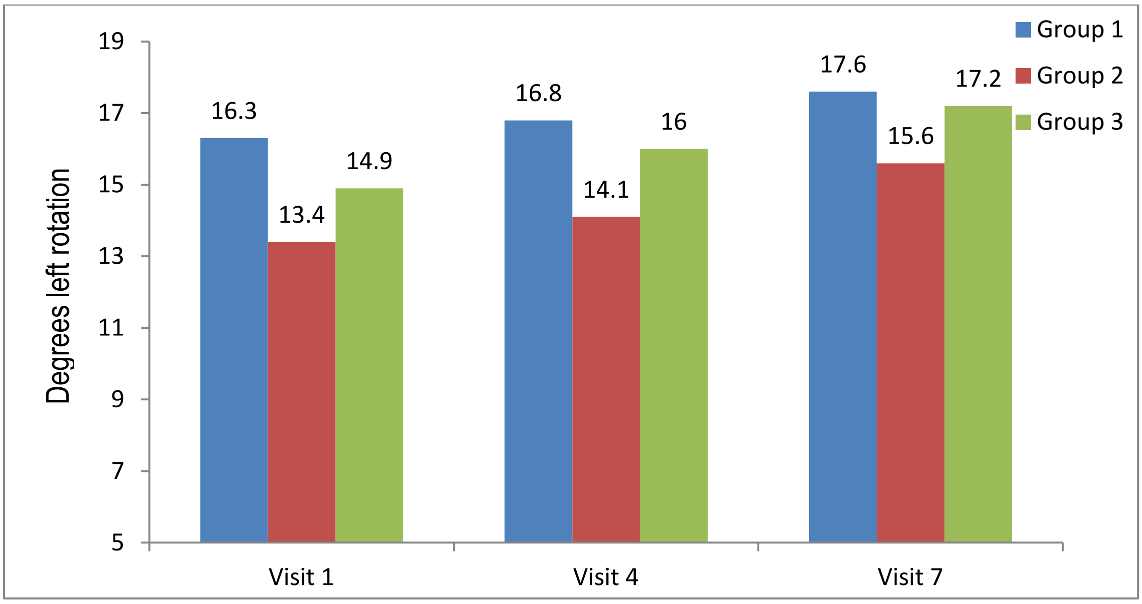


Figure 4.10: Bar graph comparing mean lumbar spine left rotation values

Clinical Analysis

Figure 4.10 shows a bar graph comparing mean left rotation values of all the groups measured at the first, fourth and seventh visits. From the bar graph it may be seen that the mean left rotation for group 1 was 16.30 ° at the first visit, 16.80 ° at the fourth visit and

17.60 º and the seventh visit. This indicated an overall increase in left rotation values of 7.39%. The mean left rotation for group 2 was 13.40 º at the first visit, 14.10º at the fourth visit and 15.60 º and the seventh visit. This indicated an overall increase in left rotation values of 14.10%. The mean left rotation for group 3 was 14.90 º at the first visit, 16.00 º at the fourth visit and 17.20 º and the seventh visit. This indicated an overall increase in left rotation values of 13.37%.

Intragroup analysis

The non-parametric Friedman test was used to compare the degree of left rotation at visit 1 and 7 within each group. A statistically significant difference was found in group 1 (p=0.001), group 2 (p=0.002) and group 3 (p=0.000).

The non-parametric Wilcoxon Signed Rank test was then used to establish at which visit the degree of left rotation had a statistically significant difference. Group 1 had a statistically significant difference between visits 4 and 7 (p=0.011) and 1 and 7 (p=0.006), however there was no statistically significant difference between visit 1 and 4 (p=0.059). Group 2 had a statistically significant difference between visits 4 and 7 (p=0.016) and 1 and 7 (p=0.006), however there was no statistically significant difference between visit 1 and 4 (p=0.216). Group 3 had a statistically significant difference between visit 1 and 4 (p=0.027), visit 4 and 7 (p=0.016) as well as between visit 1 and 7 (p=0.005).

Intergroup analysis

The non-parametric Kruskal-Wallis test was used to compare the degree of left rotation between all groups at visit 1, 4 and 7. No statistically significant difference was found between all the groups at any visit.

e) Right lateral flexion

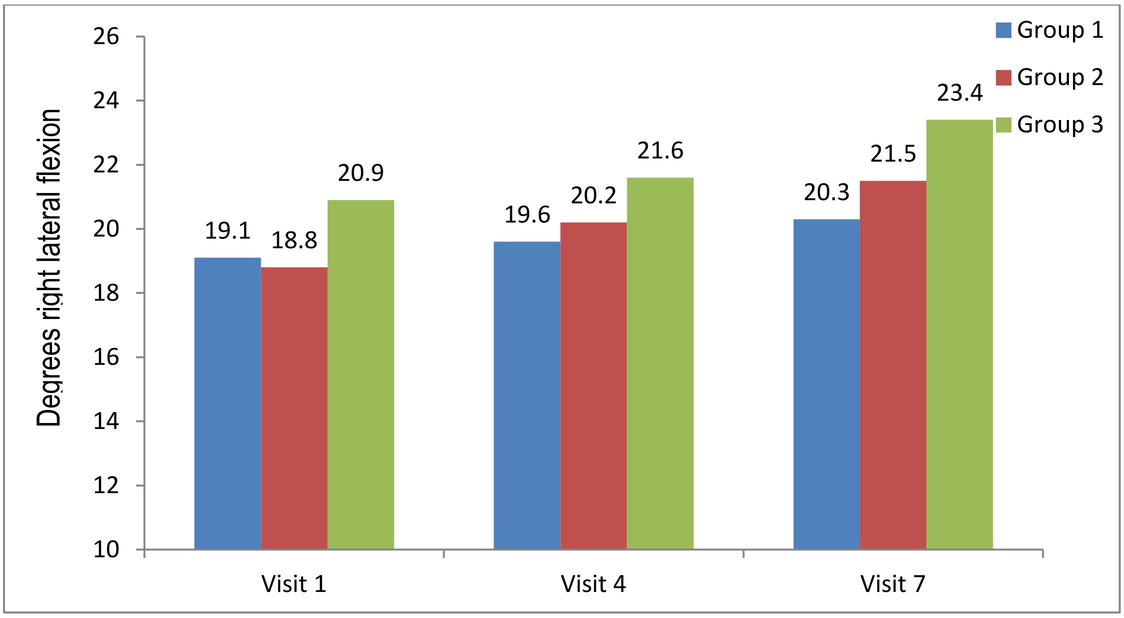


Figure 4.11: Bar graph comparing mean lumbar spine right lateral flexion values

Clinical Analysis

Figure 4.11 shows a bar graph comparing mean right lateral flexion values of all the groups measured at the first, fourth and seventh visits. From the bar graph it may be seen that the mean right lateral flexion for group 1 was 19.10 º at the first visit, 19.60 º at the fourth visit and 20.30 º and the seventh visit. This indicated an overall increase in right lateral flexion values of 4.5%. The mean right lateral flexion for group 2 was 18.80 º at the first visit, 20.20º at the fourth visit and 21.50 º and the seventh visit. This indicated an overall increase in right lateral flexion values of 12.56%. The mean right lateral flexion for group 3 was 20.90 º at the first visit, 21.60 º at the fourth visit and 23.40 º and the seventh visit. This indicated an overall increase in right lateral flexion values of 10.68%.

Intragroup analysis

The non-parametric Friedman test was used to compare the degree of right lateral flexion at visit 1 and 7 within each group. A statistically significant difference was found in group 1 (p=0.005), group 2 (p=0.001) and group 3 (p=0.000).

The non-parametric Wilcoxon Signed Rank test was then used to establish at which visit the degree of right lateral flexion had a statistically significant difference. Group 1 had a statistically significant difference between visits 4 and 7 (p=0.007) and 1 and 7 (p=0.001), however there was no statistically significant difference between visit 1 and 4 (p=0.059). Group 2 had a statistically significant difference between visits 1 and 4 (p=0.001) and 1 and 7 (p=0.004), however there was no statistically significant difference between visit 4 and 7 (p=0.095). Group 3 had a statistically significant difference between visit 1 and 4 (p=0.038), visit 4 and 7 (p=0.007) as well as between visit 1 and 7 (p=0.004).

Intergroup analysis

The non-parametric Kruskal-Wallis test was used to compare the degree of right lateral flexion between all groups at visit 1, 4 and 7. No statistically significant difference was found between all the groups at any visit.

f) Left lateral flexion

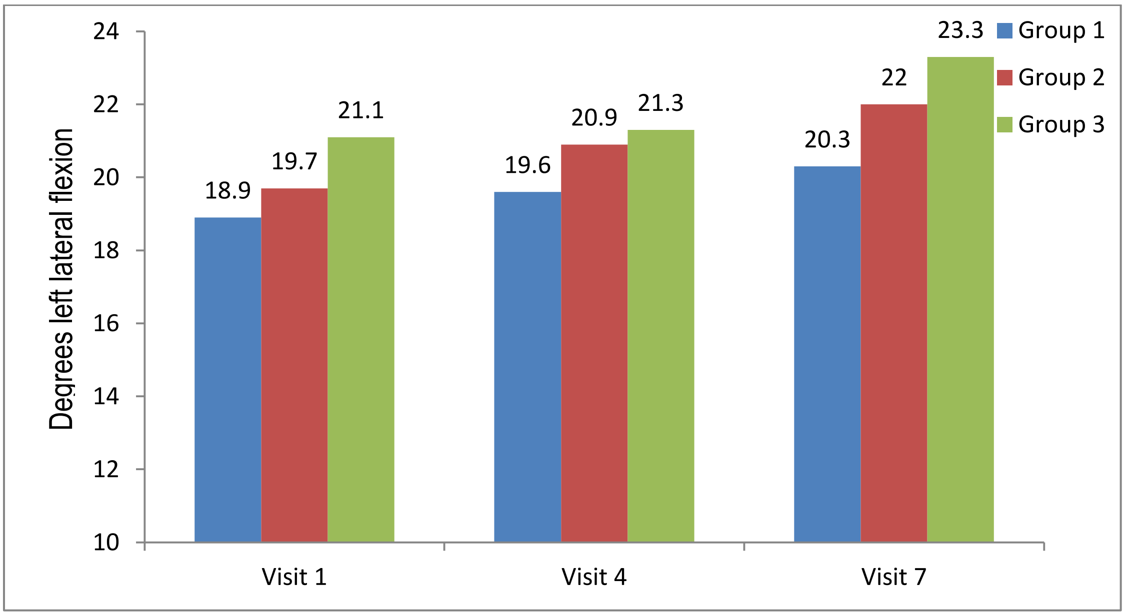


Figure 4.12: Bar graph comparing mean lumbar spine left lateral flexion values

Clinical Analysis

Figure 4.12 shows a bar graph comparing mean left lateral flexion values of all the groups measured at the first, fourth and seventh visits. From the bar graph it may be seen that the mean left lateral flexion for group 1 was 18.90 ° at the first visit, 19.60 ° at the fourth visit and 20.30 ° and the seventh visit. This indicated an overall increase in left lateral flexion values of 6.9%. The mean left lateral flexion for group 2 was 19.70 ° at the first visit, 20.90°

at the fourth visit and 22.00 º and the seventh visit. This indicated an overall increase in left lateral flexion values of 10.45%. The mean left lateral flexion for group 3 was 21.10 º at the first visit, 21.30 º at the fourth visit and 23.30 º and the seventh visit. This indicated an overall increase in left lateral flexion values of 9.44%.

Intragroup analysis

The non-parametric Friedman test was used to compare the degree of left lateral flexion at visit 1 and 7 within each group. A statistically significant difference was found in group 1 (p=0.008), group 2 (p=0.001) and group 3 (p=0.000).

The non-parametric Wilcoxon Signed Rank test was then used to establish at which visit the degree of left lateral flexion had a statistically significant difference. Group 1 had a statistically significant difference between visits 1 and 4 (p=0.038) and 1 and 7 (p=0.013), however there was no statistically significant difference between visit 4 and 7 (p=0.140). Group 2 had a statistically significant difference between visit 1 and 4 (p=0.026), visit 4 and 7 (p=0.016) as well as between visit 1 and 7 (p=0.011). Group 3 had a statistically significant difference between visits 4 and 7 (p=0.007) and 1 and 7 (p=0.005), however there was no statistically significant difference between visit 1 and 4 (p=0.589).

Intergroup analysis

The non-parametric Kruskal-Wallis test was used to compare the degree of left lateral flexion between all groups at visit 1, 4 and 7. No statistically significant difference was found between all the groups at any visit.

4.4.3 Lumbar lordosis

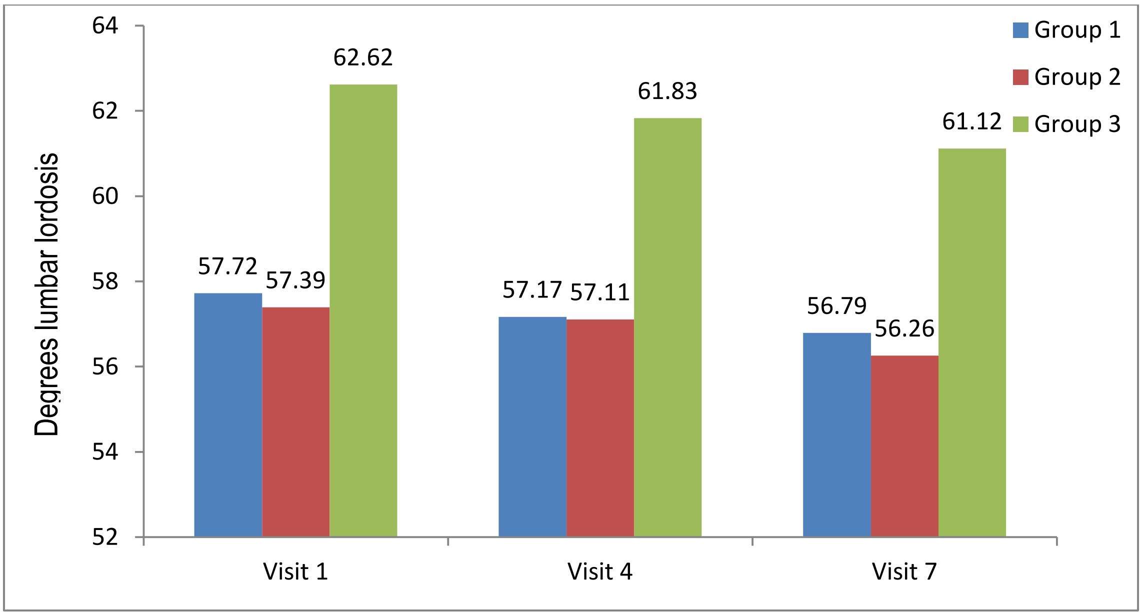


Figure 4.13: Bar graph comparing mean lumbar lordosis values

Clinical Analysis

Figure 4.13 shows a bar graph comparing mean lumbar lordosis values of all the groups measured at the first, fourth and seventh visits. From the bar graph it may be seen that the mean lumbar lordosis for group 1 was 57.52 ° at the first visit, 57.17 ° at the fourth visit and 56.79 ° and the seventh visit. This indicated an overall decrease in lumbar lordosis values of 1.27%. The mean lumbar lordosis for group 2 was 57.39 ° at the first visit, 57.11° at the fourth visit and 56.26 ° and the seventh visit. This indicated an overall decrease in lumbar lordosis values of 2.00%. The mean lumbar lordosis for group 3 was 62.62 ° at the first visit, 61.83 ° at the fourth visit and 61.12 ° and the seventh visit. This indicated an overall decrease in lumbar lordosis values of 2.4%.

Intragroup analysis

The non-parametric Friedman test was used to compare the degree of lumbar lordosis at visit 1 and 7 within each group. A statistically significant difference was found in group 1 (p=0.016), group 2 (p=0.002) and group 3 (p=0.001).

The non-parametric Wilcoxon Signed Rank test was then used to establish at which visit the degree of flexion had a statistically significant difference. Group 1 had a statistically significant difference between visit 1 and 7 ($p=0.028$) however there was no statistically significant difference between visits 1 and 4 ($p=0.059$) and 4 and 7 ($p=0.078$). Group 2 had a statistically significant difference between visit 1 and 7 ($p=0.036$) however there was no statistically significant difference between visits 1 and 4 ($p=0.109$) and 4 and 7 ($p=0.059$) Group 3 had a statistically significant difference between visit 1 and 4 ($p=0.012$) and between visit 1 and 7 ($p=0.011$), however there was no statistically significant difference between visits 4 and 7 ($p=0.051$).

Intergroup analysis

The non-parametric Kruskal-Wallis test was used to compare the degree of lumbar lordosis between all groups at visit 1, 4 and 7. No statistically significant difference was found between all the groups at any visit.

CHAPTER FIVE

DISCUSSION

5.1 Introduction

This chapter will discuss the subjective and objective data results of the clinical trial as described in the previous chapter and will outline possible explanations for these results by referring to previous literature.

5.2 Results of demographic data

Group 1 and group 3 consisted of 5 males and 5 females, and group 2 consisted of 4 males and 6 females. There were a total of 14 males and 16 females.

Participants in group 1 were between the ages of 18 and 50 with a mean age of 26.30 years. Participants in group 2 were between the ages of 22 and 27 with a mean age of 24.40 years. Participants in group 3 were between the ages of 20 and 40 with a mean age of 25.50 years.

The mean age of combined participants was 25.40 years. This can be comparable to a systemic review of 27 epidemiological studies conducted by Louw et al. (2007), which showed that the average lifetime prevalence of low back pain among adults (over 20 years of age) was 62%.

Degeneration of the spine which includes disc degeneration, facet joint osteoarthritis in addition to vertebral body and ligament degeneration usually advances with age (Niosi and Oxland, 2004). This could result in more statistical variations due to other factors that may have caused a participant to have low back pain and therefore affect the results of this study. However the mean age of participants in this study was 25.4 years and therefore mechanical factors rather than degenerative changes would contribute more significantly to the low back pain experienced by participants in this particular study.

5.3 Statistical analysis of subjective data

5.3.1 Numerical Pain Rating Scale (NPRS)

Intragroup analysis

The non-parametric Friedman test was used to determine whether there were any statistically significant changes in the NPRS values over time. There was a statistically significant difference in group 1 (p=0.001) and group 2 (p=0.000), but not in group 3 (p=0.207).

The non-parametric Wilcoxon Signed Rank test was then used to determine and reveal at what point in the treatment protocol any statistically significant changes in the NPRS values occurred. Group 1 had a statistically significant difference between visit 1 and 4 (p=0.004) as well as between visit 1 and 7 (p=0.006). Group 2 had a statistically significant difference between visit 1 and 4 (p=0.004), visit 4 and 7 (p=0.045) as well as visit 1 and 7 (p=0.005).

Intergroup analysis

The non-parametric Kruskal-Wallis test was used to determine whether there were any statistically significant changes in the NPRS values between group 1, group 2 and group 3 at the first visit, fourth visit and seventh visit. There was no statistically significant difference found between all the groups at any visit.

Clinical analysis

It can be seen from Figure 4.2 that the mean NPRS value from the first visit to the seventh visit for group 1 decreased by 47%, for group 2 by 71.17%, and for group 3 by 33.34%. These results indicate that spinal manipulation alone was the most effective in decreasing the perception of pain

5.3.2 Oswestry Low Back Pain Disability Questionnaire

Intragroup analysis

The non-parametric Friedman test was used to determine whether there were any statistically significant changes in the Oswestry Low Back Pain Disability Questionnaire scores over time. There was a statistically significant difference in group 1 (p=0.000) and group 2 (p=0.000) but not in group 3 (p=0.282).

The non-parametric Wilcoxon Signed Rank test was then used to determine and reveal at what point in the treatment protocol any statistically significant changes in the Oswestry Low Back Pain Disability Questionnaire scores occurred. Group 1 had a statistically significant difference between visit 1 and 4 (p=0.007) as well as between visit 1 and 7 (p=0.024). Group 2 had a statistically significant difference between visit 1 and 4 (p=0.005), visit 4 and 7 (p=0.017) as well as visit 1 and 7 (p=0.005).

Intergroup analysis

The non-parametric Kruskal-Wallis test was used to determine whether there were any statistically significant changes in the Oswestry Low Back Pain Disability Questionnaire scores between group 1, group 2 and group 3 at the first visit, fourth visit and seventh visit. A statistically significant difference was found between the groups at visit 1 (p=0.025) but not at visit 4 (p=0.310) or visit 7 (p=0.0473).

The non-parametric Mann-Whitney test was then used to establish between which groups a statistically significant difference in the Oswestry Low Back Pain Disability Questionnaire scores was found. A statistically significant difference was found between group 1 and group 3 (p=0.019) as well as group 2 and group 3 (p=0.019). However, no statistically significant difference was found between group 1 and group 2 (p=0.676).

Clinical analysis

It can be seen from Figure 4.3 that the mean Oswestry Low Back Pain Disability Questionnaire score from the first visit to the seventh visit for group 1 decreased by 55.35%, for group 2 by 72.67%, and for group 3 by 38.10%. These results indicate that spinal manipulation alone was the most effective in decreasing the perception of pain.

5.3.3 Outcomes of subjective data

The Numerical Pain Rating Scale values of the Bruegger's exercise and spinal manipulation only groups indicate a clinically and statistically significant decrease in the participants' perception of pain over the course of the study with the combined group of Bruegger's exercise and spinal manipulation showing no statistically significant decrease yet still a clinically significant decrease. This could be due to the participants in the combination group starting the trial at a lower (although not statistically significant) value than compared to the Bruegger's exercise and spinal manipulation only groups. There was also no statistically significant difference found between any of the groups when comparing the Numerical Pain Rating Scale values and therefore no treatment was found to more preferential over another.

The Oswestry Low Back Pain Disability Questionnaire scores of the Bruegger's exercise and spinal manipulation only groups indicate a clinically and statistically significant decrease in the participants' perception of disability due to pain over the course of the study with the combination group displaying no statistically significant decrease yet still a clinically significant decrease. It is important to note that in the intergroup analysis of the Oswestry Low Back Pain Disability Questionnaire there was a statistically significant difference found between the Bruegger's exercise only and combination groups as well as the spinal manipulation and combination groups at the first visit. This may have affected the trial in a negative way as according to the participants in the combination group they started this trial with pain that was statistically lower than the participants who were in the Bruegger's exercise and spinal manipulation only groups. Thus the benefits of the treatment that participants in the combination group received may not be as comparable as those between the Bruegger's exercise and spinal manipulation only groups who started the study with a more similar perception of pain.

Bronfort et al. (2011), conducted a study to assess the relative efficacy of supervised exercise, spinal manipulation, and home exercise for the treatment of chronic low back pain. The results showed a reduction in terms of patient-rated pain (which included an ordinal 11-box scale similar to that of the NPRS) and disability for all groups. Supervised exercise was shown to be the most favourable although the differences were small and not statistically significant. This study is in accordance with the results which showed a reduction in the patients' perception of pain in the Bruegger's exercise and spinal manipulation only groups.

Mohseni-Bandpei, Critchley, Staunton and Richardson (2006) performed a randomised controlled trial to compare spinal manipulation and exercise treatment with ultrasound and exercise treatment in patients with chronic low back pain. An inter-group analysis found that patients in the spinal manipulation and exercise group displayed a significantly greater reduction in pain intensity and functional disability (with the use of the Oswestry Low Back Pain Disability Questionnaire) than compared to the ultrasound and exercise group in the short term treatment plan and also a greater improvement in the long term (6 month follow-up). These results were not in accordance with this study which showed no statistically significant reduction in the perception of pain and disability of patients in the spinal manipulation and Bruegger's exercise combination group.

A study to assess the efficacy of spinal manipulation in the treatment of mechanical low back pain was conducted by Bronfort, Haas, Evans, Kawchuk and Dagenais (2007). Nine trials addressed mixed populations that had primarily chronic low back pain. Strong evidence existed regarding the efficacy of spinal manipulation for mixed (but predominately chronic) low back pain in terms of participant-rated pain and disability. Considerable evidence was found by Haldeman (2000) that patients who are treated with spinal manipulation experience pain relief which exceeds that achieved by other treatment methods. This is in accordance with the results which showed that patients in the spinal manipulation only group showed the greatest reduction in the perception of pain and disability.

The mechanisms by which spinal manipulation decrease pain and disability are still a matter of speculation. It is suggested that spinal manipulation may remove the source of mechanical pain and induce stimulus-produced analgesia (Peterson and Bergmann, 2002). Experimental evidence suggests that spinal manipulation stimulates superficial and deep mechanoreceptors, proprioceptors and nociceptors. The resultant afferent segmental stimulus of spinal cord sensory neurons inhibits the central transmission of pain (Roberts, Gillette and Kramis, 1989). Research has also shown that spinal manipulation also plays a role in increasing range of motion, increasing pain tolerance of the skin and deeper muscles, raising the levels of beta-endorphins in the blood plasma and it can have an effect on the nerve pathways between the viscera and soma that regulate general health (Hyde and Gengenbach, 2007).

Waddell (1999) determined that on a psychological level, therapist-patient interaction might alter emotional responses in patients resulting in pain modulation in spite of the treatment administered. Thus, taking nothing away from the neurophysiologic effects of spinal manipulation, it is possible by establishing a rapport with the participants over the course of the trial, there could have been a subconscious effect on the subjective perception of pain.

5.4 Statistical analysis of objective data

5.4.1 Passive hip range of motion

a. Left hip flexion

Intragroup analysis

The non-parametric Friedman test was used to determine whether there were any statistically significant changes in the left hip flexion values over time. A statistically significant difference was found in group 1 (p=0.000), group 2 (p=0.001) as well as group 3 (p=0.005).

The non-parametric Wilcoxon Signed Rank test was then used to determine and reveal at what point in the treatment protocol any statistically significant changes in the left hip flexion values occurred. Group 1 had a statistically significant difference between visit 1 and 4 (p=0.016), between visit 1 and 7 (p=0.030) as well as between visit 4 and 7 (p=0.004). Group 2 had a statistically significant difference between visit 1 and 4 (p=0.031), between visit 1 and 7 (p=0.012) as well as between visit 4 and 7 (p=0.005). Group 3 had a statistically significant difference between visit 1 and 4 (p=0.041), between visit 1 and 7 (p=0.024) as well as between visit 4 and 7 (p=0.011).

Intergroup analysis

The non-parametric Kruskal-Wallis test was used to determine whether there were any statistically significant changes in the left hip flexion values between group 1, group 2 and group 3 at the first visit, fourth visit and seventh visit. There was no statistically significant difference found between all the groups at any visit.

Clinical analysis

It can be seen from Figure 4.4 that the mean left hip flexion value from the first visit to the seventh visit for group 1 increased by 1.85%, for group 2 by 2.40%, and for group 3 by 2.53%. These results indicate that spinal manipulation with a combination of Bruegger's exercise was the most effective in increasing left hip flexion range of motion.

b. Right hip flexion

Intragroup analysis

The non-parametric Friedman test was used to determine whether there were any statistically significant changes in the right hip flexion values over time. A statistically significant difference was found in group 1 (p=0.002), group 2 (p=0.000) as well as group 3 (p=0.004).

The non-parametric Wilcoxon Signed Rank test was then used to determine and reveal at what point in the treatment protocol any statistically significant changes in the right hip flexion values occurred. Group 1 had a statistically significant difference between visit 1 and 4 (p=0.016) as well as between visit 4 and 7 (p=0.011) however, between visit 1 and 7 there was no statistically significant difference (p=0.334). Group 2 had a statistically significant difference between visit 4 and 7 (p=0.007) as well as between visit 1 and 7 (p=0.005) however, there was no statistically significant difference between visit 1 and 4 (p=0.268). Group 3 had a statistically significant difference between visit 1 and 4 (p=0.034) as well as between visit 4 and 7 (p=0.011). However, there was no statistically significant difference between visit 1 and 7 (p=0.188).

Intergroup analysis

The non-parametric Kruskal-Wallis test was used to determine whether there were any statistically significant changes in the right hip flexion values between group 1, group 2 and group 3 at the first visit, fourth visit and seventh visit. There was no statistically significant difference found between all the groups at any visit.

Clinical analysis

It can be seen from Figure 4.5 that the mean right hip flexion value from the first visit to the seventh visit for group 1 increased by 1.53%, for group 2 by 2.92%, and for group 3 by 2.08%. These results indicate that spinal manipulation alone was the most effective in increasing right hip flexion range of motion.

c. Left hip extension

Intragroup analysis

The non-parametric Friedman test was used to determine whether there were any statistically significant changes in the left hip extension values over time. A statistically significant difference was found in group 2 (p=0.005) and group 3 (p=0.000) but no statistically significant difference was found in group 1 (p=0.81).

The non-parametric Wilcoxon Signed Rank test was then used to determine and reveal at what point in the treatment protocol any statistically significant changes in the left hip extension values occurred. Group 1 had no statistically significant difference between any of the visits. Group 2 had a statistically significant difference between visit 1 and 4 (p=0.041) as well as between visit 1 and 7 (p=0.012) however, there was no statistically significant difference between visit 4 and 7 (p=0.054). Group 3 had a statistically significant difference between visit 1 and 4 (p=0.024), between visit 4 and 7 (p=0.010) as well as between visit 1 and 7 (p=0.005).

Intergroup analysis

The non-parametric Kruskal-Wallis test was used to determine whether there were any statistically significant changes in the left hip extension values between group 1, group 2 and group 3 at the first visit, fourth visit and seventh visit. A statistically significant difference was found between the groups at visit 1 (p=0.040) but no statistically significant difference was found between all the groups at visit 4 (p=0.436) and 7 (p=0.503).

The non-parametric Mann-Whitney U test was then used to establish between which groups a statistically significant difference in the right hip extension values was found. There was a statistically significant difference between groups 1 and 2 (p=0.016). However, there was no statistically significant difference between groups 1 and 3 (p=0.358) as well as groups 2 and 3 (p=0.105).

Clinical analysis

It can be seen from Figure 4.6 that the mean left hip extension value from the first visit to the seventh visit for group 1 increased by 7.2%, for group 2 by 20.54%, and for group 3 by 19.51%. These results indicate that spinal manipulation alone was the most effective in increasing left hip extension range of motion.

d. Right hip extension

Intragroup analysis

The non-parametric Friedman test was used to determine whether there were any statistically significant changes in the right hip extension values over time. A statistically significant difference was found in group 2 (p=0.000) and group 3 (p=0.003) but no statistically significant difference was found in group 1 (p=0.112).

The non-parametric Wilcoxon Signed Rank test was then used to determine and reveal at what point in the treatment protocol any statistically significant changes in the right hip extension values occurred. Group 1 had no statistically significant difference between any of the visits. Group 2 had a statistically significant difference between visit 1 and 4 (p=0.026), between visit 4 and 7 (p=0.010) as well as between visit 1 and 7 (p=0.004). Group 3 had a statistically significant difference between visit 1 and 4 (p=0.020) as well as between visit 1 and 7 (p=0.011) however, there was no statistically significant difference between visits 4 and 7 (p=0.336).

Intergroup analysis

The non-parametric Kruskal-Wallis test was used to determine whether there were any statistically significant changes in the right hip extension values between group 1, group 2 and group 3 at the first visit, fourth visit and seventh visit. A statistically significant difference was found between the groups at visit 1 (p=0.040) but no statistically significant difference was found between all the groups at visit 4 (p=0.384) and 7 (p=0.315).

The non-parametric Mann-Whitney U test was then used to establish between which groups a statistically significant difference in the right hip extension values was found There was a statistically significant difference between groups 1 and 2 (p=0.018). However, there was no statistically significant difference between groups 1 and 3 (p=0.125) as well as groups 2 and 3 (p=0.206).

Clinical analysis

It can be seen from Figure 4.7 that the mean right hip extension value from the first visit to the seventh visit for group 1 increased by 6.5%, for group 2 by 23.00%, and for group 3 by 12.10%. These results indicate that spinal manipulation alone was the most effective in increasing right hip extension range of motion.

5.4.2 Active lumbar range of motion

a. Flexion

Intragroup analysis

The non-parametric Friedman test was used to determine whether there were any statistically significant changes in the flexion values over time. A statistically significant difference was found in group 1 (p=0.000), group 2 (p=0.001) and group 3 (p=0.000).

The non-parametric Wilcoxon Signed Rank test was then used to determine and reveal at what point in the treatment protocol any statistically significant changes in the flexion values occurred. Group 1 had a statistically significant difference between visit 4 and 7 (p=0.011) as well as 1 and 7 (p=0.006) however there was no statistically significant difference between visits 1 and 4 (p=0.238). Group 2 had a statistically significant difference between visit 1 and 4 (p=0.016), between visit 4 and 7 (p=0.007) as well as between visit 1 and 7 (p=0.005). Group 3 had a statistically significant difference between visit 1 and 4 (p=0.031), between visit 1 and 7 (p=0.005) as well as between visits 4 and 7 (p=0.005).

Intergroup analysis

The non-parametric Kruskal-Wallis test was used to determine whether there were any statistically significant changes in the flexion values between group 1, group 2 and group 3 at the first visit, fourth visit and seventh visit. There was no statistically significant difference found between all the groups at any visit.

Clinical analysis

It can be seen from Figure 4.8 that the mean flexion value from the first visit to the seventh visit for group 1 increased by 4.0%, for group 2 by 8.8%, and for group 3 by 8.5%. These results indicate that spinal manipulation alone was the most effective in increasing lumbar flexion range of motion.

b. Extension

Intragroup analysis

The non-parametric Friedman test was used to determine whether there were any statistically significant changes in the extension values over time. A statistically significant difference was found in group 1 (p=0.00), group 2 (p=0.001) and group 3 (p=0.000).

The non-parametric Wilcoxon Signed Rank test was then used to determine and reveal at what point in the treatment protocol any statistically significant changes in the extension values occurred. Group 1 had a statistically significant difference between visit 1 and 4 (p=0.047), 4 and 7 (p=0.016) as well as visits 1 and 7 (p=0.004). Group 2 had a statistically significant difference between visit 1 and 4 (p=0.011), visit 4 and 7 (p=0.007) as well as between visit 1 and 7 (p=0.006). Group 3 had a statistically significant difference between visit 1 and 4 (p=0.011), visit 4 and 7 (p=0.005) as well as between visit 1 and 7 (p=0.004).

Intergroup analysis

The non-parametric Kruskal-Wallis test was used to determine whether there were any statistically significant changes in the extension values between group 1, group 2 and group 3 at the first visit, fourth visit and seventh visit. There was no statistically significant difference found between all the groups at any visit.

Clinical analysis

It can be seen from Figure 4.9 that the mean extension value from the first visit to the seventh visit for group 1 increased by 11.0%, for group 2 by 16.43%, and for group 3 by 17.12%. These results indicate that spinal manipulation in combination with Bruegger's exercise was the most effective in increasing lumbar extension range of motion.

c. Right rotation

Intragroup analysis

The non-parametric Friedman test was used to determine whether there were any statistically significant changes in the right rotation values over time. A statistically significant difference was found in group 1 (p=0.003), group 2 (p=0.000) and group 3 (p=0.000).

The non-parametric Wilcoxon Signed Rank test was then used to determine and reveal at what point in the treatment protocol any statistically significant changes in the right rotation values occurred. Group 1 had a statistically significant difference between visit 1 and 7 (p=0.010), however there was no statistically significant difference at visits 1 and 4 (p=0.180) and 4 and 7 (p=0.083). Group 2 had a statistically significant difference between visit 1 and 4 (p=0.047), visit 4 and 7 (p=0.006) as well as between visit 1 and 7 (p=0.010). Group 3 had a statistically significant difference between visit 1 and 4 (p=0.008), visit 4 and 7 (p=0.004) as well as between visit 1 and 7 (p=0.004).

Intergroup analysis

The non-parametric Kruskal-Wallis test was used to determine whether there were any statistically significant changes in the right rotation values between group 1, group 2 and group 3 at the first visit, fourth visit and seventh visit. There was no statistically significant difference found between all the groups at any visit.

Clinical analysis

It can be seen from Figure 4.10 that the mean right rotation value from the first visit to the seventh visit for group 1 increased by 7.4%, for group 2 by 14.56%, and for group 3 by 14.20%. These results indicate that spinal manipulation alone was the most effective in increasing right lumbar rotation range of motion.

d. Left rotation

Intragroup analysis

The non-parametric Friedman test was used to determine whether there were any statistically significant changes in the left rotation values over time. A statistically significant difference was found in group 1 (p=0.001), group 2 (p=0.002) and group 3 (p=0.000).

The non-parametric Wilcoxon Signed Rank test was then used to determine and reveal at what point in the treatment protocol any statistically significant changes in the left rotation values occurred. Group 1 had a statistically significant difference between visits 4 and 7 (p=0.011) and 1 and 7 (p=0.006), however there was no statistically significant difference between visit 1 and 4 (p=0.059). Group 2 had a statistically significant difference between visits 4 and 7 (p=0.016) and 1 and 7 (p=0.006), however there was no statistically significant difference between visit 1 and 4 (p=0.216). Group 3 had a statistically significant difference between visit 1 and 4 (p=0.027), visit 4 and 7 (p=0.016) as well as between visit 1 and 7 (p=0.005).

Intergroup analysis

The non-parametric Kruskal-Wallis test was used to determine whether there were any statistically significant changes in the left rotation values between group 1, group 2 and group 3 at the first visit, fourth visit and seventh visit. There was no statistically significant difference found between all the groups at any visit.

Clinical analysis

It can be seen from Figure 4.11 that the mean left rotation value from the first visit to the seventh visit for group 1 increased by 7.39%, for group 2 by 14.10%, and for group 3 by 13.37%. These results indicate that spinal manipulation alone was the most effective in increasing left lumbar rotation range of motion.

e. Right lateral flexion

Intragroup analysis

The non-parametric Friedman test was used to determine whether there were any statistically significant changes in the right lateral flexion values over time. A statistically significant difference was found in group 1 (p=0.005), group 2 (p=0.001) and group 3 (p=0.000).

The non-parametric Wilcoxon Signed Rank test was then used to determine and reveal at what point in the treatment protocol any statistically significant changes in the right lateral flexion values occurred. Group 1 had a statistically significant difference between visits 4 and 7 (p=0.007) and 1 and 7 (p=0.001), however there was no statistically significant difference between visit 1 and 4 (p=0.059). Group 2 had a statistically significant difference between visits 1 and 4 (p=0.001) and 1 and 7 (p=0.004), however there was no statistically significant difference between visit 4 and 7 (p=0.095). Group 3 had a statistically significant difference between visit 1 and 4 (p=0.038), visit 4 and 7 (p=0.007) as well as between visit 1 and 7 (p=0.004).

Intergroup analysis

The non-parametric Kruskal-Wallis test was used to determine whether there were any statistically significant changes in the right lateral flexion values between group 1, group 2 and group 3 at the first visit, fourth visit and seventh visit. There was no statistically significant difference found between all the groups at any visit.

Clinical analysis

It can be seen from Figure 4.12 that the mean right lateral flexion value from the first visit to the seventh visit for group 1 increased by 4.5%, for group 2 by 12.56%, and for group 3 by 10.68%. These results indicate that spinal manipulation alone was the most effective in increasing right lumbar lateral flexion range of motion.

f. Left lateral flexion

Intragroup analysis

The non-parametric Friedman test was used to determine whether there were any statistically significant changes in the left lateral flexion values over time. A statistically significant difference was found in group 1 (p=0.008), group 2 (p=0.001) and group 3 (p=0.000).

The non-parametric Wilcoxon Signed Rank test was then used to determine and reveal at what point in the treatment protocol any statistically significant changes in the left lateral flexion values occurred. Group 1 had a statistically significant difference between visits 1 and 4 (p=0.038) and 1 and 7 (p=0.013), however there was no statistically significant difference between visit 4 and 7 (p=0.140). Group 2 had a statistically significant difference between visit 1 and 4 (p=0.026), visit 4 and 7 (p=0.016) as well as between visit 1 and 7 (p=0.011). Group 3 had a statistically significant difference between visits 4 and 7 (p=0.007) and 1 and 7 (p=0.005), however there was no statistically significant difference between visit 1 and 4 (p=0.589).

Intergroup analysis

The non-parametric Kruskal-Wallis test was used to determine whether there were any statistically significant changes in the left lateral flexion values between group 1, group 2 and group 3 at the first visit, fourth visit and seventh visit. There was no statistically significant difference found between all the groups at any visit.

Clinical analysis

It can be seen from Figure 4.13 that the mean left lateral flexion value from the first visit to the seventh visit for group 1 increased by 6.9%, for group 2 by 10.45%, and for group 3 by 9.44%. These results indicate that spinal manipulation alone was the most effective in increasing left lumbar lateral flexion range of motion.

5.4.3 Lumbar lordosis

Intragroup analysis

The non-parametric Friedman test was used to determine whether there were any statistically significant changes in the lumbar lordosis values over time. There was a statistically significant difference in group 1 (p=0.016), group 2 (p=0.002) as well as in group 3 (p=0.001).

The non-parametric Wilcoxon Signed Rank test was then used to determine and reveal at what point in the treatment protocol any statistically significant changes in the lumbar lordosis values occurred. Group 1 had a statistically significant difference between visit 1 and 7 (p=0.028), however there was no statistically significant difference between visit 1 and 4 (p=0.059) as well as between visit 4 and 7 (p=0.078). Group 2 had a statistically significant difference between visit 1 and 7 (p=0.036), however there was no statistically significant difference between visit 1 and 4 (p=0.109) as well as between visit 4 and 7 (p=0.059). Group 3 had a statistically significant difference between visit 1 and 4 (p=0.012) as well as between visit 1 and 7 (p=0.011), however there was no statistically significant difference between visit 4 and 7 (p=0.051).

Intergroup analysis

The non-parametric Kruskal-Wallis test was used to determine whether there were any statistically significant changes in the lumbar lordosis values between group 1, group 2 and group 3 at the first visit, fourth visit and seventh visit. There was no statistically significant difference found between all the groups at any visit.

Clinical analysis

It can be seen from Figure 4.14 that the mean lumbar lordosis value from the first visit to the seventh visit for group 1 decreased by 1.27%, for group 2 by 2.00%, and for group 3 by

2.40%. These results indicate that spinal manipulation in combination with Bruegger's exercise was the most effective in decreasing the lumbar lordosis angle.

5.4.4 Outcomes of objective data

A statistically significant increase in passive hip range of motion and active lumbar range of motion was found over the course of the study in the spinal manipulation only and combination groups in hip flexion, hip extension, lumbar spine flexion, extension, rotation and lateral flexion; and in the Bruegger's exercise only group in hip flexion as well as lumbar spine flexion, extension, rotation and lateral flexion. In addition, passive hip range of motion and active lumbar range of motion values for all the groups indicate a clinically significant increase in hip flexion and extension and also lumbar spine flexion, extension, rotation and lateral flexion. Results indicate that the spinal manipulation only group generally experienced a greater clinical improvement compared to the Bruegger's exercise only and combination groups.

It is possible that hip extension in the Bruegger's exercise only group did not have a statistically significant increase due to incompliance with Bruegger's exercise and that the exercise was not performed correctly. Chapman-Smith (1999) reported that exercise will only have a lasting effect if they are continued and become a lifetime habit. Surprisingly the precise form of exercise does not seem to be vital but rather that the patient is compliant with the exercise (actually does the exercise on a continual basis).

The participants were instructed to perform Bruegger's exercise once or twice every 20-30 minutes of prolonged sitting and held in this position for 30-60 seconds (Vizniak, 2010) and is thus a home-based exercise routine. Yet, every time the participant came in for their visit, the researcher made sure to ask if they were being compliant with the exercise routine and to perform the exercise to ensure it was being completed correctly. A study by Liddle, Baxter and Gracey (2004), to investigate the existing evidence for the quality and type of exercise being offered to chronic low back patients within randomised control trials suggested that, supervised exercise is thought to play a part in enhancing the compliance of exercise and improving chronic low back pain prognosis, thus playing a pivotal role in enhancing successful treatment.

The only statistically significant difference found between any of the groups when comparing the hip and lumbar range of motion measurements was for left and right hip extension between the Bruegger's exercise and spinal manipulation only groups at visit 1. This may have occurred due to random sampling variability, however, every effort was made to ensure that all range of motion measurements were taken consistently and accurately over the course of the study.

A clinically and statistically significant decrease in the degree of lumbar lordosis angle was found over the course of the study for all the groups. When comparing the degree of lumbar lordosis angle between the groups, the results showed that there was no preferred treatment protocol.

According to Hammer (1999), specific changes in posture seen with lower crossed syndrome include an anterior pelvic tilt and an increased lumbar lordosis which is as a result of muscle imbalances within the pelvic region, and therefore it can be assumed that the lumbar lordosis has been created as a result of functional muscle imbalances with resultant joint dysfunction. The lumbar lordosis can thus be seen to be on one side part structural and on the other side part functional. It was not possible to determine what percentage of the lordosis was functional and structural. However it can be assumed that because there was a statistically significant reduction in the lumbar lordosis angle as a result of treatment that was intended to correct functional pathology, the lumbar lordosis of the participants was part functional.

Mohseni-Bandpei, Critchley, Staunton and Richardson (2006), conducted a randomised controlled trial to compare spinal manipulation and exercise treatment with ultrasound and exercise treatment in patients with chronic low back pain. The results concluded that the combination of spinal manipulation and exercise treatment had a statistically significant improvement in lumbar spine flexion and extension which was also greater than that of treatment with ultrasound and exercise. This study was in accordance with the results of this research which displayed statistically significant changes in lumbar spine flexion and extension in patients who were in the combined group of spinal manipulation and Bruegger's exercise. A previous study by Meade, Dyer, Browne, Townsend and Frank (1990), compared the effectiveness of spinal manipulative therapy with hospital outpatient treatment on a large population of patients suffering with low back pain. The patients that received spinal manipulation established significant improvements in pain and lumbar spine range of motion compared to the medical care group. Mead et al. (1990), concluded that spinal manipulative therapy was more effective in short- and long –term, especially for patients with chronic or severe low back pain.

Postural patterns are maintained by proprioceptive input that can be changed by habits, psychogenic factors and muscle pathology. Deviation from ideal posture may result in chronic pain syndromes. Sustained misalignments can result in certain muscles becoming shortened and others undergoing constant stretch and associated weakness (Watson and Trott, 1993).

Altered biomechanical function results in changes in the normal axis of motion creating a neural receptor irritation and altered muscle function. Therefore the basic loop of dysfunction is perpetuated. Spinal manipulation is defined by Peterson and Bergmann (2002), as a manual procedure that consists of a directed thrust in order to move a joint past its physiological range of motion without exceeding its anatomical limit. Spinal manipulation can influence and restore the biomechanics of affected joint and surrounding soft tissue. Moreover, it stimulates nociceptors and mechanoreceptors, thereby reducing pain (Esposito and Philipson, 2005). According to Esposito and Philipson (2005), the clinical effects of spinal manipulation include a reduction in pain, increase in active and passive range of motion as well as a reduction in muscle electrical activity and tension. A review article by Pickar (2001), to observe the neurophysiological basis for the effects of spinal manipulation found that spinal manipulation is capable of improving muscle function through either disinhibition or facilitation of neural pathways by evoking muscle reflexes and altering motorneuron excitability. Pickar (2001) also found that spinal manipulation can increase the excitability of motor pathways and at the same time decrease the inflow of sensory information from muscle spindles.

In this research study it may have been thought that the combination of spinal manipulation and Bruegger's exercise should have had the most superior results, however it was found that spinal manipulation alone overall showed the greatest results. Besides for the fact that patients in the combination group were found to have a lower perception of pain from the start of this trial, It may be hypothesised that spinal manipulation should first be administered alone until its full effects of restoring the neurophysiological effects of the affected joint and surrounding tissue have been reached, and thereafter exercise can be incorporated to stretch and strengthen the muscles in a optimal state where other factors have been corrected.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The aim of this study was to determine the effects of Bruegger's exercise on chronic low back pain in association with lower crossed syndrome and compare it to spinal manipulation alone or a combination of the Bruegger's exercise and spinal manipulation. These effects were based on results obtained from the Numerical Pain Rating Scale and Oswestry Low Back Pain Disability Questionnaire questionnaires, together with passive hip flexion and extension readings taken using a universal goniometer, active lumbar range of motion measurements using a digital inclinometer and also lumbar lordosis angle readings using a flexible ruler.

As spinal manipulation alone showed the greatest overall clinical improvements, it may be suggested that spinal manipulation alone is the most effective in the treatment of chronic low back pain in association with lower crossed syndrome with regards to pain and disability, hip and lumbar range of motion as well as degree of lumbar lordosis. However, Bruegger's exercise alone in addition to the combination of spinal manipulation and Bruegger's exercise also had a positive effect on treating chronic low back associated with lower crossed syndrome.

The possible outcome for the chiropractic profession is that spinal manipulation alone is sufficient to treat chronic low back associated with lower crossed syndrome, but the addition of Bruegger's exercise may help in some instances to further assist in treatment once the full effects of the spinal manipulation has occurred and allowed for the muscles to be in their optimum state for exercise. This is important to the chiropractic profession as it enables chiropractors to have other options for treating patients in case spinal manipulation alone is not fully sufficient. This could allow for cost effective and time saving treatment.

6.2 Recommendations

The following recommendations are suggested ways to possibly improve further related research:

- A supervised exercise protocol could allow for more patient compliance and lead to better results.
- A larger sample group size would provide more statistically representative information which would more accurately represent the general population.

- Increasing the trial period especially for Bruegger's exercise could help determine whether the exercise would have greater effects if it is implemented over a longer time.
- A one month follow-up consultation after treatment consultations could be implemented to determine long term benefits of treatment with regards to pain, disability and lumbar spine and hip range of motion.
- Spinal manipulation was limited to the lumbar spine. Pelvic, cervical and/or thoracic spinal manipulation can be included for complete correction of dysfunction which can spread beyond a specific motion segment to other spinal levels within the locomotor system.
- Limiting the participant's activity over the treatment period may help eliminate any unnecessary effects such as muscle fatigue or trauma on the collected data; one could instruct that the participants refrain from physical activities during the trial.

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APPENDICES

Appendix A: Advertisement

FREE

CHIROPRACTIC

TREATMENT!

DO YOU HAVE LOW BACK PAIN?

Have you had low back pain for 3 months or longer?

Are you from the ages of 18 and 65 years old?

Take part in a research study aimed to treat chronic low back pain!

Treatment is conducted in the supervised UJ Clinic at Gate 7, Sherwell Road, Doornfontein.

Contact Tyron Waters if you are interested in treatment of no charge!!

Appendix B: Contra-indications to Spinal Manipulation (Gatterman, 2004)

1. Vascular complications

- Vertebral artery syndrome
- Aneurysms

2. Tumours

- Primary to the bone
- Secondary (metastasised to the bone)

3. Bone infections

- Tuberculosis of the spine
- Osteomyelitis of the spine

4. Traumatic injuries

- Fractures
- Joint instabilities
- Severe sprains or strains
- Unstable spondylolisthesis

5. Arthritis

- Ankylosing spondylitis
- Rheumatoid arthritis
- Psoriatic arthritis
- Uncoarthritis
- Osteoarthritis

6. Psychological considerations

- Malingering
- Hysteria
- Hypochondriasis
- Pain intolerance

7. Neurological complications

- Sacral nerve root involvement from medial or massive disc protrusion
- Disc lesions (advanced neurological deficits)
- Space-occupying lesions

8. Metabolic Disorders

- Clotting Disorders
- Osteopenia (osteoporosis, osteomalacia)

Appendix C: Subject Information and Consent Form

Date: ___________________.

DEPARTMENT OF CHIROPRACTIC

Dear prospective participant, I, Tyron Waters, hereby invite you to participate in my research study which includes a signed consent from you to be in my study. I am currently a Chiropractic student, completing my Masters Degree at the University of Johannesburg.

The aim of this study is to determine the effects of Bruegger's exercise alone and compare it to spinal manipulation alone or in combination with Bruegger's exercise for low back pain in association with lower crossed syndrome.

All participants will attend seven sessions in total over four weeks at the University of Johannesburg Chiropractic Day Clinic over four weeks. Participants for my research study will be accepted based on inclusion and exclusion criteria. Participants will be randomly divided into three groups of ten each. Depending on the group, the participant will either perform Bruegger's exercise, receive a spinal manipulation or a combination of the two. Objective and subjective measurements will be taken during the first and fourth visit in addition to any treatment. On the seventh visit only the measurements will be taken and no treatment will be performed. The participants who need to perform the Bruegger's exercise will also be advised to continue doing the exercise out of the treatment session where applicable.

Data will be collected by the researcher and analysed by Statkon. Results of this study will be made available to you on request.

Spinal manipulation involves the restoration of normal joint motion. Abnormal joint motion will be detected by the researcher via motion palpation. Spinal manipulation and Bruegger's exercise are both safe, non-invasive treatment techniques.

Your privacy will be protected as only the doctor, patient (you) and clinician will be in the treatment room. Your anonymity will be ensured as your personal information will be converted into data and therefore cannot be traced back to you. Standard doctor/patient confidentiality will be adhered to at all times when compiling the research dissertation.

All procedures will be explained to you and all participation is entirely on a voluntary basis and you may withdraw at any stage of the study. No harm will be caused to you. Discomfort experienced may include post manipulation soreness and mild stretching pain or discomfort which are both normal and should resolve within a few days. Should this not resolve you will be further assessed for any unforeseen circumstances. The benefits of this study include a reduction or resolution of symptoms and a better functioning spine.

I have fully explained the procedures and their purpose. I have asked whether or not any questions have arisen regarding the procedures and have answered them to the best of my ability.

Date: ________________________ Researcher: ________________________________

I have been fully informed as to the procedures to be followed and have been given a description of the discomfort risks and benefits expected from the treatment. In signing this consent form I agree to this form of treatment and understand my rights and that I am free to withdraw my consent and participation in this study at any time. I understand that if I have any questions at any time, they will be answered.

Date: ________________________ Participant: _________________________________

Should you have any concerns or queries regarding the current study, the following persons may be contacted.

Researcher:	Tyron Waters	0832646413
Supervisor:	Dr C. Yelverton	0115596218

Appendix D: Case History

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UNIVERSITY OF JOHANNESBURG
CHIROPRACTIC DAY CLINIC

CASE HISTORY

Date: ______________

Patient: ______________________ File No: __________

Age: ______ Sex: __________ Occupation: ______________

Student: ______________________ Signature: ______________

FOR CLINICIAN'S USE ONLY

Initial visit clinician: ______________ Signature: ______________

Case History: ____

____

____

____

____

Examination:
Previous: UJ
Other
Current: UJ
Other

X-ray Studies:
Previous: UJ
Other
Current: UJ
Other

Clinical Path. Lab:
Previous: UJ
Other
Current: UJ
Other

Case status:
PTT: Conditional: Signed off: Final sign out:

Recommendations:

1

Students case history

1. *Source of history:*
2. *Chief complaint: (patient's own words)*

3. *Present illness:*

Location

Onset

Duration

Frequency

Pain (character)

Progression

Aggravating factors

Relieving factors

Associated Sx's and Sg's

Previous occurrences

Past treatment and outcome

4. *Other complaints:*

5. *Past history*

General health status

Childhood illnesses

Adult illnesses

Psychiatric illnesses

Accidents/injuries

Surgery

Hospitalisation

6. *Current health status and lifestyle*

Allergies

Immunizations

Screening tests

Environmental hazards

Safety measures

Exercise and leisure

Sleep patterns

Diet

Current medication

Tobacco

Alcohol

Social drugs

7. *Family history:*
Immediate family:

Cause of death

DM

Heart disease

TB

HBP

Stroke

Kidney disease

CA

Arthritis

Anaemia

Headaches

Thyroid disease

Epilepsy

Mental illness

Alcoholism

Drug addiction

Other

8. *Psychosocial history:*

Home situation
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 E: Physical Examination

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CHIROPRACTIC DAY CLINIC

PHYSICAL EXAMINATION

Underline abnormal findings in **RED.** **Date:** ____________________

Patient: ________________________ **File No:** ______________

Clinician: ________________________ **Signature:** ______________

Student: ________________________ **Signature:** ______________

Height: _________ **Weight:** _______ **Temp:** __________

Rates: **Heart:**__________ **Pulse:** ________ **Respiration:**_________

Blood pressure:	**Arms:**	L	R
	Legs:	L	R

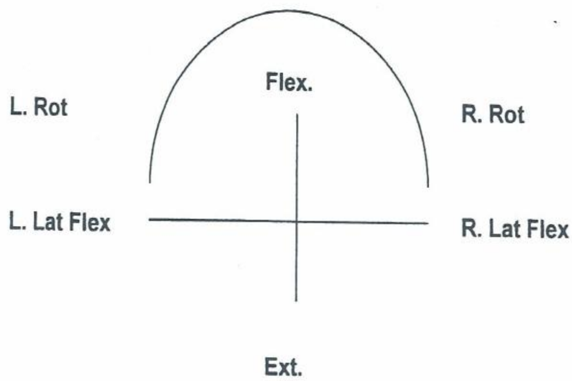
General Appearance:

____
____
____
____
____
____

1

STANDING EXAMINATION

1. Minor's sign
2. Skin changes
3. Posture:Erect
   Adam's
4. Ranges of motion (Thoracolumbar Spine)
   T/L spine: Flexion: 90º (fingers to floor)
   Extension: 50º
   R. lat. flex: 30º (fingers down leg)
   L. lat. flex: 30º (fingers down leg)
   Rot. to R: 35º
   Rot. to L: 35º



/ = pain-free limitation **// = painful limitation**

5. Romberg's sign
6. Pronator drift
7. Trendelenburg's sign
8. Gait:
   - rhythm
   - balance
   - pendulousness
   - on toes
   - on heels
   - tandem
9. Half squat
10. Scapular winging
11. Muscle tone
12. Spasticity/Rigidity
13. Shoulder: skin
    symmetry
    ROM
    - glenohumeral
    - scapulo-thoracic
    - acromioclavicular
    - elbow
    - wrist

14. Chest measurement:

	L	R
- inspiration	cm	cm
- expiration	cm	cm

15. Visual acuity

16. Breast examination:
    Inspection:
    - skin
    - size
    - contour
    - nipples
    - arms overhead
    - hands against hips
    - leaning forward

    Palpation
    - axillary lymph nodes
    - breast incl. tail

SEATED EXAMINATION

1. Spinal posture
2. Head
   - hair
   - scalp
   - skull
   - face
   - skin
3. Eyes:
   Observation
   - conjunctiva
   - sclera
   - eyebrows
   - eyelids
   - lacrimal glands
   - nasolacrimal duct
   - position and alignment
   - corneas and lenses

- corneal reflex

- ocular movement

L			R		
III	IV	VI	III	IV	VI

- visual fields
- accommodation
- Opthalmoscopic
- Examination
  - iris
  - pupils
  - red reflex
  - optic disc
  - vessels
  - general background

- macula
- vitreous
- lens

4. Ears:
- Inspection
  - auricle
  - ear canal
  - drum
- auditory acuity
- Weber test
- Rinne test

5. Nose:

- External
- Internal
  - septum
  - turbinates
  - olfaction

6. Sinuses (frontal & maxillary):
  - tenderness
  - transillumination

7. Mouth and pharynx:

- lips
- buccal mucosa
- gums and teeth
- roof
- tongue
  - inspection
  - movement
  - taste
  - palpation
- pharynx
  - CN X
  - inspection

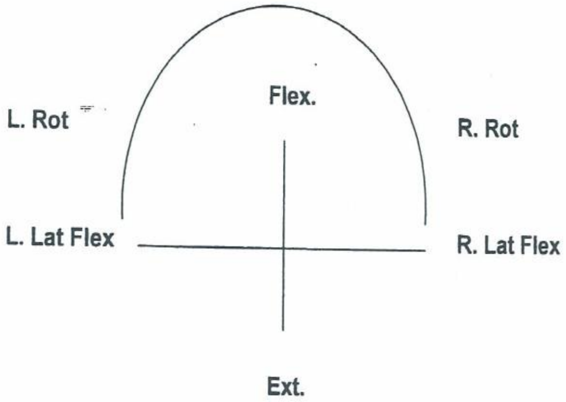
9. Neck

- posture
- size
- swelling
- scars
- discolouration
- hair line

Ranges of motion (cervical spine)

The following are normal ranges of motion

Forward flexion	=	45 ° chin to larynx or sternum
Extension	=	55 ° forehead parallel to ground
L/R Rotation	=	70 °
L/R Lat Flexion	=	40 °



- lymph nodes
- trachea
- thyroid
- carotid arteries (thrills, bruit)
- Cranial Nerves
  - CN V
  - CN VII
  - CN VIII (nystagmus)
  - CN IX
  - CN XI
  - CN X11

9. NEUROLOGICAL EXAMINATION (CERVICAL SPINE)

DERMATOMES	Left	Right	MYOTOMES	Left	Right	REFLEXES	Left	Right
C2			**Neck Flexion C1/2**			Biceps C5		
C3			**Lat. Neck Flexion C3**			Brachio – radialis C6		
C4			**Shoulder Elevation C4**			Triceps C7		
C5			**Shoulder Abduction C5**					
C6			**Elbow Flexion C5**					
C7			**Elbow Extension C7**					

C8			**Elbow Flexion at 90 ° C6**	
T1			**Forearm Pronation C6**	
			Forearm Supination C6	
			Wrist Extension C6	
			Wrist Flexion C7	
			Finger Flexion C8	
			Finger Abduction T1	
			Finger Adduction T1	

9. Peripheral vasculature:

- Inspection
  - skin
  - nail beds
  - pigmentation
  - hair loss

- Palpation
  - pulses:
    - femoral
    - popliteal
    - post. Tibial
    - dorsalis pedis
    - radial
    - brachial
  - lymph nodes
    - epitrochlear
    - femoral (horizontal & vertical)
  - temperature (feet and legs)

- Manual compression test
- Retrograde filling (Tredelenburg) test
- Arterial insufficiency test

10. Musculoskeletal:

(i) ROM

- hip

		L	R
flex.	90/120		
ext.	15		
abd.	45		
add.	30		
int rot	40		
ext rot	45		
		L	R
flex.	130		
ext.	0/15		

	L	R
plantar Flex 45		
dorsiflex 20		
inversion 30		
eversion 20		
	L	R
Apparent		
Actual		

- knee
- ankle

(ii) leg length

- Co-ordination
  - point to point
  - dysdiachokinesia

10. TMJ

- Inspection
  - ROM
  - deviation
- Palpation
  - crepitus
  - tenderness

11. Thorax

- Inspection
  - skin
  - shape
  - respiratory distress
  - rhythm (respiratory)
  - depth (respiratory)
  - effort (respiratory)
  - intercostals/supraclavicular retraction
- Palpation
  - tenderness
  - masses
  - respiratory expansion
  - tactile fremitus
- Percussion
  - lungs (posterior)
  - diaphgragmatic excursion
  - kidney punch
- Auscultation

  (i) breath sounds
  - vesicular
  - bronchial

  (ii) adventitious sounds
  - crackles (rales)
  - wheezes (rhonchi)
  - rubs

  (iii) voice sounds
  - broncophony
  - whispered pectoriloquey

	- egophony
• Cardiovascular	- auscultation (aortic murmurs) - Allen's test

SUPINE EXAMINATION

1. JVP
2. PMI
3. Auscultation heart (L. lat. Recumbent)
4. respiratory excursion
5. percussion chest (anterior)
6. breast palpation
7. Abdominal Examination

• Inspection	- skin - umbilicus - contour - peristalsis - pulsations - hernias (umbilical/incisional)
• Auscultation	- bowel sound - bruit
• Percussion	- general - liver - spleen
• Palpation	- superficial reflexes - cough - light - rebound tenderness - deep - liver - spleen - kidneys - aorta - intra-/retro-abdominal wall mass - shifting dullness - fluid wave
• Acute abdomen	- where pain began and now - cough - tenderness - guarding/rigidity - rebound tenderness - rovsing's sign - psoas sign - obturator sign - cutaneous hyperaesthesia

- rectal exam
- Murphy's sign

MENTAL STATUS

(i) Appearance and behaviour
- level of consciousness
- posture and motor behaviour
- dress, grooming, personal hygiene
- facial expression
- affect

(ii) Speed and language
- quantity
- rate
- volume
- fluency
- aphasia (pm)

(ii) Mood

(v) Memory and attention

- orientation (time, place, person)
- remote memory
- recent memory
- new learning ability

(vi) Higher cognitive functions

- information and vocabulary
- (general and specialised knowledge)
- abstract thinking

NEUROLOGICAL EXAMINATION (LUMBAR SPINE)

DERMATOMES	Left	Right	MYOTOMES	Left	Right	REFLEXES	Left	Right
T12			**Hip Flexion (L1/L2)**			Patellar (L3, 4)		
L1			**Knee Extension (L2, 3, 4)**			Medial Hamstring (L5)		
L2			**Knee Flexion (L5/S1)**			Lateral Hamstring (S1)		
L3			**Hip Int. Rot (L4/L5)**					
L4			**Hip Ext. Rot (L5/S1)**					
L5			**Hip Adduction (L2, 3, 4)**					
S1			**Hip Abduction (L4/5)**					
S2			**Ankle Dorsiflexion**					

			(L4/L5)	
S3			Hallux Extension (L5)	
			Ankle Plantar Flexion (S1/S2)	
			Eversion (S1)	
			Inversion (L4)	
			Hip Extension (L5/S1)	

Appendix F: Lumbar Spine and Pelvis Regional Examination

UNIVERSITY OF JOHANNESBURG

UNIVERSITY OF JOHANNESBURG
CHIROPRACTIC DAY CLINIC

REGIONAL EXAMINATION
LUMBAR SPINE AND PELVIS

Date: ____________________

Patient: _________________________ **File No:** _______________

Clinician: _________________________ **Signature:** _______________

Student: _________________________ **Signature:** _______________

A. STANDING

1. BODY TYPE
2. POSTURE
3. OBSERVATION: -

- Muscle Tone
- Bony + Soft Tissue Contours
- Skin
- Scars
- Discolouration
- Step deformity

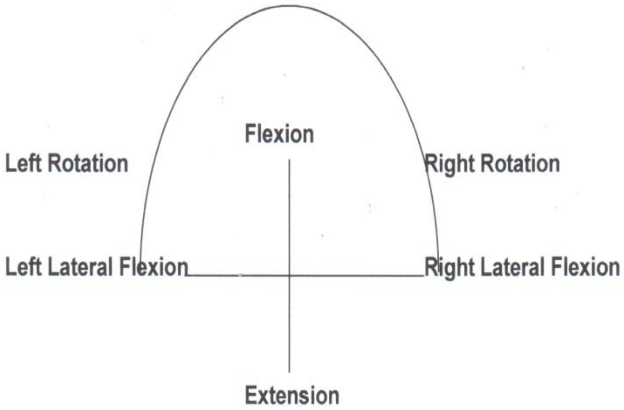
4. SPECIAL TESTS

- Schober's Test
- Spinous Percussion
- Treadmill
- Minor's Sign
- Quick Test
- Trendelenburg Test

1

5. RANGE OF MOTION

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



/ = Pain free limitation **// = Painful limitation**

6. GAIT

- Rhythm, pendulousness
- On Toes (S1)
- On Heels (L4, 5)
- Halt Squat on one leg (L2, 3, 4)
- Tandem Walking

7. MOTION PALPATION – sacroiliac joints

B. SITTING

01. SPECIAL TESTS

- Tripod Test
- Kemp's Test
- Valsalva Manoeuvre

2. MOTION PALPATION

Jt. Play			Left					Right				Jt. Play		
P/A	Lat	Fle	Ext	LF	AR	PR		Fle	Ext	LF	AR	PR	P/A	Lat
							T10							
							T11							
							T12							
							L1							
							L2							
							L3							
							L4							
							L5							
					U	L	S1	U	L					

C. SUPINE

01. OBSERVATION

- Hair, Skin, Nails
- Fasciculations

2. PULSES

- Femoral
- Popliteal
- Dorsalis Pedis
- Posterior Tibial

3. MUSCLE CIRCUMFERENCE

	LEFT	RIGHT
THIGH	cm	cm
CALF	cm	cm

4. LEG LENGTH

	LEFT	RIGHT
ACTUAL	cm	cm
APPARENT	cm	cm

5. ABDOMINAL EXAMINATION

- Observation
- Abdominal Reflexes
- Auscultation Abdomen and Groin
- Palpation Abdomen and Groin

Comments: ____

____

____

____

NEUROLOGICAL EXAMINATION

DERMATOMES	Left	Right	MYOTOMES	Left	Right	REFLEXES	Left	Right
T12			**Hip Flexion (L1/L2)**			Patellar (L3, 4)		
L1			**Knee Extension (L2, 3, 4)**			Medial Hamstring (L5)		
L2			**Knee Flexion (L5/S1)**			Lateral Hamstring (S1)		
L3			**Hip Int. Rot (L4/L5)**			Tibialis Posterior (L4, 5)		
L4			**Hip Ext. Rot (L5/S1)**			Archilles (S1/S2)		
L5			**Hip Adduction (L2, 3, 4)**			Plantar Reflex		
S1			**Hip Abduction (L4/5)**					
S2			**Ankle Dorsiflexion (L4/L5)**					
S3			**Hallux Extension (L5)**					
			Ankle Plantar Flexion (S1/S2)					
			Eversion (S1)					
			Inversion (L4)					
			Hip Extension (L5/S1)					

7. SPECIAL TESTS

- SLR
- WLR
- Braggard's
- Bowstring
- Sciatic Notch Pressure
- Sign of the Buttock
- Bilateral SLR
- Patrick Faber
- Gaenslen's Test
- Gapping Test
- "Squish" Test
- Gluteus Maximus Stretch
- Thomas' Test
- Rectus Femoris Contracture Test
- Hip Medial Rotation
- Psoas Test

<u>LATERAL RECUMBENT</u>

- Sacroiliac Compression
- Ober's Test
- Femoral Nerve Stretch Test
- Myotomes:
  - Quadratus Lumborum Strength
  - Gluteus Medius Strength

PRONE

- Facet joint challenge
- Myofascial Trigger points:
  * Quadratus Lumborum
  * Gluteus Medius
  * Gluteus Maximus
  * Piriformis
  * Tensor Fascia Lata
  * Hamstrings
- Skin Rolling
- Erichsen's Test
- Sacroiliac Tenderness
- Pheasant's Test
- Gluteal Skyline
- Myotomes:
  * Gluteus Maximus strength

NON-ORGANIC SIGNS

- Pin-point pain
- Axial Compression
- Trunk Rotation
- Burn's Bench Test
- Flip Test
- Hoover's Test
- Ankle Dorsiflexion Test
- Pin-point pain

Appendix G: Numerical Pain Rating Scale

Name: ____

How much pain have you had today because of your condition?

Please mark in one of the boxes to indicate how severe your pain is today:

Visit 1 - Date:

No pain   Worst Pain

Imaginable

0	1	2	3	4	5	6	7	8	9	10

Visit 4 - Date:

No pain   Worst Pain

Imaginable

0	1	2	3	4	5	6	7	8	9	10

Visit 7 - Date:

No pain   Worst Pain

Imaginable

0	1	2	3	4	5	6	7	8	9	10

Appendix H: Oswestry Low Back Pain Disability Questionnaire

Name: ____________________________ Visit/Date:_______________________

This questionnaire has been designed to give us information as to how your back pain is affecting your ability to manage in everyday life. Please answer by checking one box in each section for the statement which best applies to you. We realize you may consider that two or more statements in any one section apply, but please just shade out the spot that indicates the statement which most clearly describes your problem.

Section 1: Pain Intensity ○ I have no pain at the moment ○ The pain is very mild at the moment ○ The pain is moderate at the moment ○ The pain is fairly severe at the moment ○ The pain is very severe at the moment ○ The pain is the worst imaginable at the moment	**Section 6: Standing** ○ I can stand as long as I want without extra pain ○ I can stand as long as I want but it gives me extra pain ○ Pain prevents me from standing for more than 1 hour ○ Pain prevents me from standing for more than 30 minutes ○ Pain prevents me from standing for more than 10 minutes Pain prevents me from standing at all
Section 2: Personal Care (e.g. washing, dressing) ○ I can look after myself normally without causing extra pain ○ I can look after myself normally but it causes extra pain ○ It is painful to look after myself and I am slow and careful ○ I need some help but can manage most of my personal care ○ I need help every day in most aspects of self-care ○ I do not get dressed, wash with difficulty and stay in bed	**Section 7: Sleeping** ○ My sleep is never disturbed by pain ○ My sleep is occasionally disturbed by pain ○ Because of pain I have less than 6 hours sleep ○ Because of pain I have less than 4 hours sleep ○ Because of pain I have less than 2 hours sleep ○ Pain prevents me from sleeping at all

Section 3: Lifting ○ I can lift heavy weights without extra pain ○ I can lift heavy weights but it gives me extra pain ○ Pain prevents me lifting heavy weights off the floor but I can manage if they are conveniently placed (eg. on a table) ○ Pain prevents me lifting heavy weights but I can manage light to medium weights if they are conveniently positioned ○ I can only lift very light weights ○ I cannot lift or carry anything	**Section 8: Sex Life (if applicable)** ○ My sex life is normal and causes no extra pain ○ My sex life is normal but causes some extra pain ○ My sex life is nearly normal but is very painful ○ My sex life is severely restricted by pain ○ My sex life is nearly absent because of pain ○ Pain prevents any sex life at all
Section 4: Walking ○ Pain does not prevent me walking any distance ○ Pain prevents me from walking more than 1 mile ○ Pain prevents me from walking more than ½ mile ○ Pain prevents me from walking more than 100 yards ○ I can only walk using a stick or crutches ○ I am in bed most of the time	**Section 9: Social Life** ○ My social life is normal and gives me no extra pain ○ My social life is normal but increases the degree of pain ○ Pain has no significant effect on my social life apart from limiting my more energetic interests e.g. sport ○ Pain has restricted my social life and I do not go out as often ○ Pain has restricted my social life to my home ○ I have no social life because of pain
Section 5: Sitting ○ I can sit in any chair as long as I like ○ I can only sit in my favourite chair as long as I like ○ Pain prevents me sitting more than one hour ○ Pain prevents me from sitting more than 30 minutes ○ Pain prevents me from sitting more than 10 minutes ○ Pain prevents me from sitting at all	**Section 10: Travelling** ○ I can travel anywhere without pain ○ I can travel anywhere but it gives me extra pain ○ Pain is bad but I manage journeys over two hours ○ Pain restricts me to journeys of less than one hour ○ Pain restricts me to short necessary journeys under 30 minutes ○ Pain prevents me from travelling except to receive treatment

Appendix I: Inclinometer Lumbar Range of Motion Readings

Name: ____________________________________

Visit 1 Date: ________________________________

Flexion	Extension	R Rotation	L Rotation	R Lat Flex	L Lat Flex

Visit 4 Date: ________________________________

Flexion	Extension	R Rotation	L Rotation	R Lat Flex	L Lat Flex

Visit 7 Date: ________________________________

Flexion	Extension	R Rotation	L Rotation	R Lat Flex	L Lat Flex

Appendix J: Goniometer Hip Range of Motion Readings

Name: ___________________________________

Visit 1 Date: _______________________________

Left Flexion	Right Flexion	Left Extension	Right Extension

Visit 4 Date: _______________________________

Left Flexion	Right Flexion	Left Extension	Right Extension

Visit 7 Date: _______________________________

Left Flexion	Right Flexion	Left Extension	Right Extension

Appendix K: Flexible Ruler Lumbar Lordosis Readings

Name: ___________________________________

Visit 1 Date: _______________________________

Degree of lumbar lordosis: ____________________

Visit 4 Date: ________________________

Degree of lumbar lordosis: ____________________

Visit 7 Date: _________________________

Degree of lumbar lordosis: _____________________