THE EFFECT OF SPINAL MANIPULATION AS COMPARED TO PASSIVE OSCILLATORY MOBILIZATION ON THORACIC SPINE RANGE OF MOTION AND PAIN, IN PATIENTS WITH CHRONIC MECHANICAL THORACIC SPINE DYSFUNCTION.

By

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Dissertation submitted in partial compliance with the requirements for the Masters Degree in Technology: Chiropractic, in the faculty of Health at the Durban Institute of Technology, South Africa.

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ABSTRACT

Chronic thoracic spine dysfunction can be defined as pain of greater than 50 day duration, caused by a posterior facet syndrome in the thoracic spine arising primarily from the zygapophyseal (facet) joints, and their immediately adjacent soft tissues, namely paraspinal muscles. Thoracic complaints are a common occurrence in modern society, and various epidemiological studies have shown their prevalence to be notable (averaging 26% of presenting complaints in South African practice). Recent studies investigating the use of conservative treatment in the management of acute, subacute and chronic thoracic spine dysfunction have been performed, but none have compared passive oscillatory mobilization to spinal manipulation, using range of motion as a clinical experiment.

This study was in the form of a randomized controlled clinical trial consisting of a population of forty patients, randomly allocated into two groups of twenty patients each. One group received spinal manipulation as treatment for their chronic thoracic spine dysfunction, while the other group received passive oscillatory mobilization. Both groups received four treatments and one follow-up consultation over a two-week period. Subjective and objective measurements were taken before the first and third consultations, and at the fifth consultations.

The intra-group analysis revealed that both treatment protocols showed significant improvement between the consultations. Both interventions were successful in significantly reducing the patients' subjective pain perception within two treatments, whilst the mobilization group demonstrated greater efficacy in improving the objective pressure threshold readings. In terms of the range of motion data, the mobilization group improved thoracic flexion, left lateral flexion and left rotation range of motion, whilst the spinal manipulation group improved thoracic extension, right lateral flexion and right rotation range of motion. For inter-group analysis, the results demonstrated no significant difference between the two groups, indicating that

both spinal manipulation and passive oscillatory mobilization were effective in treating chronic mechanical thoracic spine dysfunction.

This study demonstrated both spinal manipulation and passive oscillatory mobilization to be effective and efficient interventions, in terms of reducing pain and stiffness (increased range of motion) experienced by patients suffering from chronic mechanical thoracic spine dysfunction. The findings will contribute to the current body of knowledge on thoracic spine dysfunction and hopefully lay the foundations upon which future studies on the thoracic spine can be built.

DEFINITION OF TERMS

Thoracic Spine

This is a transitional zone between the cervical and lumbar regions. Anatomically, the thoracic spine is from T1 to T12 (Flynn 1996: 3,87).

Mechanical Thoracic Spine Dysfunction

Joint dysfunction is known as a mechanical cause of pain from zygapophyseal synovial joints (Mennel 1990: 7). For the purpose of this study, it is pain caused by a posterior facet syndrome in the thoracic spine.

Manual Therapy

Manual therapy is the therapeutic application of manual force. Spinal manual therapy broadly defined, includes all procedures in which the hands are used to mobilize, adjust, manipulate, apply traction, massage, stimulate or otherwise influence the spine and paraspinal tissues with the aim of influencing the patient's health (Gatterman 1990: 410).

Manipulation

Manipulation is defined as a passive dynamic maneuver in which specifically directed manual forces are applied to the vertebral and extravertebral articulations of the body, with the object of restoring mobility to restricted area and increasing a restricted joints range of motion (Gatterman 1990: 410). This is accompanied by cavitation or gapping of the joint, which is thought to involve gas separating from fluid. Usually accompanied by an audible pop or click, manipulation has been shown to result in increased joint motion compared to mobilization alone. This increase in motion lasts for a 20-30 minute refractory period during which an additional cavitation of the same joint will not occur (Gatterman 1990: 410 and Haldeman et al. 1993: 103).

Passive Oscillatory Mobilization

Mobilization is defined as a passive movement within the paraphysiological joint space administered by a clinician for the purpose of increasing overall range of motion (Haldeman et al. 1993: 103).

Passive oscillatory mobilizations are movements performed slowly or quickly, smooth or staccato, with small or large amplitude, and applied in any part of the total range of movement. These movements may be performed while the joint surfaces are distracted or compressed (Maitland 2001: 3).

Chronic

The duration of symptoms experienced by the patient must be greater than 50 days. This refers to chronic mechanical thoracic spine pain as defined by the Quebec study (Leblanc 1987).

Articulation

The place of union or junction between 2 or more bones of the skeleton (Gatterman 1990: 405).

Contra-indication

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

Motion Palpation

Palpatory diagnosis of passive and active segmental joint ranges of motion (Gatterman 1990: 412).

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CHAPTER ONE

1.0 INTRODUCTION

1.1 THE PROBLEM AND ITS SETTING

Schafer and Faye (1990:143), state that the thoracic spine is the most frequently manipulated region of the spine, yet its fixations are the least efficiently corrected. They attribute this to the primary dorsal curvature, restricting costal articulations, thin discs and decreased mobility when compared to the cervical and lumbar regions of the spine.

In comparison to literature on the cervical and lumbar regions, the thoracic spine has been largely neglected, especially in terms of epidemiological and range of motion studies, due to the technical difficulties associated with movement analysis of this region as a result of coupled motions and the articulating rib cage, and the belief that the thoracic spine is less commonly implicated in clinical pain syndromes (Edmondston and Singer, 1997).

Recent chiropractic studies on mechanical thoracic spine pain included an investigation into the efficacy of spinal manipulative therapy (Schiller 1999) and another to evaluate the effectiveness of interferential current therapy versus spinal manipulative therapy (Tsolakis 2001). Both studies recommended that the duration of patients' symptoms be taken into account to improve on homogeneity and allow for greater accuracy and reliability of results. Drews (1994), in a study of demographic and epidemiological factors of private chiropractic practices and a teaching clinic in South Africa, found that chronic mechanical thoracic complaints (greater than 50 days), as opposed to acute and sub-acute complaints, were commonest in both.

According to Gavin (1999), no research specifically shows that range of motion in the thoracic spine increases after spinal manipulation. The author conducted a controlled study to determine the effect of joint manipulation on active range of motion, specifically forward and lateral flexion left and right, in the mid-thoracic spinal restrictions of seventy-eight asymptomatic subjects. In a comparison of pre-treatment versus post-treatment active range of motion, a statistically significant difference was seen in left lateral flexion only. Gavin concluded that one session of joint manipulation could increase active range of motion in left lateral flexion only, and recommended that the study be replicated using symptomatic patients.

The term "manual therapy" has been used to encompass both spinal manipulation and mobilization, and spinal manual therapy has become one of the most widely used methods of treating vertebral column pain, mainly in Western societies (Twomey and Taylor 1995: 617). The Canadian Orthopractic Manual Therapy Association, which includes professional groups such as chiropractors and osteopaths, defines mobilization as a gentle, rhythmic, repetitive passive movement of graded amplitude aimed at restoring mobility and function and reducing pain in a joint and surrounding tissue. Manipulation is described as a skilled, passive, rapid movement aimed at restoring mobility and function and reducing pain in a stiff joint and associated tissue (Canadian Orthopractic Manual Therapy Association 2002).

In a controlled study of thirty asymptomatic subjects, Lee et al. (1993) investigated the proposal that thoracic posteroanterior spinal stiffness is altered by manipulation. . The manipulation studied was a one-off posteroanterior thrust applied to the T4-T5 spinal level, and was deemed successful if the thrust was followed by an audible click. The effect of the manipulation was compared to a controlled intervention of supine lying, using a simulator to perform stiffness testing at each level, before and after the intervention. Analysis of the results revealed no statistically significant differences between the 2 interventions, manipulation or control ($p = 0.58$ at T4, $p = 0.54$ at T5).

Pillay (2001) investigated the effectiveness of spinal manipulation compared to passive oscillatory mobilization in a randomized controlled clinical trial, in order to evaluate the more effective treatment in the management of chronic mechanical thoracic pain. It was concluded that whilst both treatment protocols are effective interventions in the treatment of chronic mechanical thoracic pain with regard to the

Short-Form McGill Pain questionnaire and the Numerical Pain Rating Scale-101 questionnaire (subjective data), manipulation appeared to be more beneficial than passive oscillatory mobilization in terms of the algometer reading used to measure pain threshold (objective data) ($p = 0.38$).

Pillay recommended that future studies on the thoracic spine include the assessment of range of motion, as it is a basic evaluation technique used during a neuromuscular examination of the spine, and the use of more sensitive instrumentation to increase the accuracy of readings.

This study intends to demonstrate the effect of thoracic spinal manipulations on thoracic spine range of motion and pain in symptomatic subjects, as compared to passive oscillatory mobilization. It aims to improve on past studies, Gavin (1999), Tsolakis (2001) and Pillay (2001), involving the thoracic spine, by using symptomatic subjects, a homogenous sample, and digital equipment to assess range of motion and pain threshold respectively, thus allowing for more sensitive readings. This will contribute to the current body of knowledge accessed by clinicians in their role in effectively managing thoracic spine dysfunction.

1.2 <u>THE STATEMENT OF THE PROBLEM</u>

The purpose of this study was to determine the effect of spinal manipulation as compared to passive oscillatory mobilization, on thoracic spine range of motion, pain threshold and subjective pain experience, in patients with chronic mechanical thoracic spine dysfunction.

1.2.1 <u>SUBPROBLEM ONE</u>

The first sub problem of this study was to evaluate the effect of spinal manipulation as compared to passive oscillatory mobilization, on thoracic spine range of motion and pain threshold, in patients with chronic mechanical thoracic spine dysfunction.

1.2.2 <u>SUBPROBLEM TWO</u>

The second sub problem of this study was to evaluate the effect of spinal manipulation as compared to passive oscillatory mobilization, on thoracic spine subjective pain experience, in patients with chronic mechanical thoracic spine dysfunction.

1.3 THE HYPOTHESIS

1.3.1 HYPOTHESIS ONE

It was hypothesized that spinal manipulation will be more effective than passive oscillatory mobilization on thoracic spine range of motion and pain, in patients with chronic mechanical thoracic spine dysfunction.

1.3.2 HYPOTHESIS TWO

It was hypothesized that passive oscillatory mobilization will be more effective than spinal manipulation on thoracic spine range of motion and pain, in patients with chronic mechanical thoracic spine dysfunction.

CHAPTER TWO

2.0 REVIEW OF THE RELATED LITERATURE

2.1 INTRODUCTION

This chapter gives a comprehensive review of the available information on the thoracic spine in terms of chronic mechanical dysfunction, spinal manipulation and passive oscillatory mobilization.

2.2 INCIDENCE AND PREVALENCE OF THORACIC SPINE DYSFUNCTION

Bechgaard (1981:87) investigated the thoracic spine as cause for chest pain in 1097 patients admitted to a medical department and a coronary unit, by specifically examining the thoracic vertebrae and paravertebral muscles using palpation. It was found that segmental thoracic pain, that is pain arising from the vertebrae and associated paraspinal muscles, accounted for 13% of chest pains in a medical department, making it the third most common chest pain (behind coronary thrombosis 39% and angina pectoris 20%). Women made up 54.5% of the 13% whilst men accounted for the remaining 45.5%. Bechgaard concluded that thoracic segmental pain is often found when looked for, with minimal risk to possible coronary patients, minimizing the risk of false diagnoses and insufficient treatment.

In a study conducted by Bruckner (1987: 286-289), 73 patients with mid-dorsal and/or unilateral chest pain were seen in a rheumatology clinic over a 3-year period, after exclusion of visceral disease. The patients' ages ranged from 15 to 63 years, with the highest incidence being in the third decade. The female to male ratio was 5:1 for the group as a whole, but 94.6% of the patients under 30 years of age were female.

Housewives accounted for 30% of the patients, secretaries 21%, nurses 11% and manual labourers only 8%. These statistics predispose women under the age of 30 years to thoracic complaints.

Mior and Diakow (1987: 306) conducted an epidemiological survey of the prevalence of back pain in a sample of 320 Canadian chiropractors. They determined it to be 87%, the highest among the health professions yet studied for the prevalence of back pain (dentists 57% and nurses 52%), and at the upper end of the scale reported for the general population. This means that chiropractors as a profession are at greater risk than the majority of the population of developing back pain. The combined frequencies of regional back complaints were 59% in the lumbar spine, 50% in the thoracic spine and 30% in the cervical spine, with thoracic pain being more common among female chiropractors (79%).

Dreiser et al. (1997: 26-34) published an epidemiological study involving 132 subacute to chronic mechanical thoracic back pain patients in France. They found that 62% of the patients were women, strengthening previous findings that thoracic spine problems are more common in females, while 38% were men, with a mean age of 47.7 years. The mean duration of pain was 3.8 months, with 94% of the patients having a history of conservatively or non-surgically treated thoracic spine pain. Non-steroidal anti-inflammatory drugs or analgesics were given to 63% of the patients as treatment.

A cross-sectional survey was conducted by Drews (1995) in order to identify and compare the epidemiology of chiropractic patients at the chiropractic-teaching clinic at the Technikon Natal and private chiropractic practices in South Africa. Female patients outnumbered male patients in both the clinic group (52,5%) and the private practitioner group (59.3%). The patients' ages ranged from 10 to 70 years old, with the highest incidence being in the third decade once again. The most commonly used medications in both groups by those who used it (40.1% clinic and 39.5% private) were analgesics and anti-inflammatory drugs. Thoracic complaints were found to be more prevalent at the teaching clinic (29.6%) than in private practices (23.5%). Private practitioners treated more acute and subacute conditions than did the students at the teaching clinic, while chronic complaints were the commonest in both groups. Drews noted that a major limitation of the study was the 13% response rate from the private chiropractic practitioners.

In a similar study in Australia, Walsh and Jamison (1992) reported on the patient profile of a private practitioner in each of the 3 geographical areas served by the student clinics of the Philip Institute of Technology. The sample consisted of 422 new patients, the data being taken from the previous 12 months new patient files. The patients' ages ranged from 1 to 81 years, with the highest incidence being in the third and fourth decades for all of the groups. They also found that thoracic problems were more commonly found in teaching clinics (16.5%) as compared to the private clinics (10.2%, 11.4% and 7.4%). Drews (1995) had similar results. The greatest proportion of patient complaints were again of a chronic nature (2-3 months or more), whilst acute conditions were 2-3 times more prevalent in the private clinics than in the teaching clinics.

In a clinical trial to investigate the efficacy of spinal manipulative therapy (SMT) in the management of acute, subacute and chronic mechanical thoracic pain on a sample of 30 patients, Schiller (1999) found that the 47% of the patients were in the 16 to 24 age group, with a gender distribution of 53% female and 47% male. Duration of patient's symptoms was not taken into account.

Tsolakis (2001) compared the efficacy of spinal manipulation to interferential current therapy, in the management of mechanical thoracic back pain. The study population of 60 patients had a dominance of patients within the 16 to 34 age group (58%), with females being more predominant than males (65%). Duration of complaint was not accounted for in this study.

Bhoola (2001) conducted a clinical trial to determine the relative effectiveness of the combination of spinal manipulative therapy (SMT) and non-steroidal anti-inflammatory drugs (NSAIDS) versus SMT with the administration of a placebo medication, in the treatment of chronic mechanical thoracic facet syndrome. In her population of 60 patients, the gender distribution was 73% female, 27% male. The age distribution was from 16 to 64 years, with the highest incidence of thoracic complaints being in the 45 to 54 age group (30%), followed closely by the 25 to 34 age group (28%). The average age for both groups was 36.2 years.

It can be concluded that thoracic spine pain, although not as common as lumbar spine pain, presents itself often enough in various guises to warrant investigation. Chronic complaints of thoracic spine dysfunction appear to be more common than those of an acute or a sub-acute nature, with women being at greater risk than men and with the second and third decades having the highest incidence.

2.3 CONTRIBUTING AND RISK FACTORS OF THORACIC SPINE DYSFUNCTION

Harms-Ringdahl and Ekholm (1986: 117-126) conducted a pilot study on 10 healthy subjects to identify a possible cause for thoracic spine pain. It was found that extreme flexion positions of the lower-cervical-upper-thoracic spine, resembling the sitting posture in some common working conditions, caused pain in all experimental subjects within 15 minutes. This pain disappeared within 15 minutes of cessation of provocation, but was experienced again by 90% of subjects that same evening or the next morning and lasted up to 4 days. The recorded electromyographic levels from the splenius, thoracic spinae, rhomboid and lower trapezius muscles also demonstrated increased activity during provocation, with activity levels being higher during arm movement mimicking a work situation such as writing or typing, as compared to when the arms were at rest. It was concluded that thoracic pain does occur in healthy persons in common sitting work postures, such as keeping the lower cervical and upper thoracic spine in a maintained extreme flexion position when bending over a desk or drawing board.

Milogrom et al. (1993:187-193), conducted a prospective study of risk factors and treatment regimes for overexertional back pain, among 395 male infantry recruits. The thoracic kyphosis angle (inclination angle in reference to the horizontal plane), body mass index and waist circumference were found to have no statistically significant in relation to thoracic spine pain, however the lumbar lordosis (inclination angle) was found to have a statistically significant relationship with the incidence of overexertional thoracic pain ($p = 0.005$).

2.4 CLINICALLY RELEVANT ANATOMY OF THE THORACIC SPINE

The thoracic spine has a markedly different mechanical role within the vertebral column, designed for stability while accommodating a limited mobility (Giles and Singer 2000: 17). This central region of the human spine, in concert with the trunk musculature, provides a supporting role to sustain all postures and fascilitate motion, be it during gait or more dynamic activities like throwing. The relevant anatomy of the thoracic spine and rib cage pertaining to this study, will be discussed in this section.

The osteocartilaginous thoracic cage is formed by part of the vertebral column (12 thoracic vertebrae and intervertebral discs), 12 pairs of ribs and costal cartilages, and the sternum. The ribs and costal cartilages form the largest part of the thoracic cage (Moore 1992: 33).

Within the thoracic spine there are 12 vertebrae, which diminish in size from T1 to T3, and then increase progressively in size from T3 to T12 (Magee 1992: 332). Thoracic vertebrae are generally classified as typical or atypical, according to their rib attachments. The typical thoracic vertebrae are the 2nd through the 8th, and are heart shaped when viewed from above or below.

The thoracic vertebrae consists of two components, a body ventrally and an arch dorsally (Giles and Singer 2000: 19). The body of the vertebrae functions primarily, but not exclusively, to support the weight of the trunk due to the anterior concavity of the thoracic kyphosis. The vertebral body is deeper posteriorly compared to anteriorly (wedge shaped), and is slightly concave on its superior and inferior end-plate surfaces. The arch of the vertebra, with the body, encloses the vertebral foramen and serves to protect the spinal cord and the roots of the spinal nerves. Each thoracic vertebra is distinguished by costal facets on the sides of the body, and in all but the last two or three segments, by articular facets on the transverse process, articulating respectively with the heads and tubercles of the ribs. The laminae are short, thick and broad, overlapping one another like roof-tiles from above downwards. The articular processes (zygapophyses) arise from the junction of the pedicle and lamina on each thoracic vertebrae. The spinous processes are long and slender, and directed obliquely downward, with the greatest spinous process angulation at T7 (Giles and Singer 2000: 20 and Magee 1992: 332).

The movable thoracic vertebrae are connected by resilient intervertebral discs, which play an important role in movement between the vertebrae, and in absorbing shock transmitted up or down the vertebral column (Magee 1992: 332). The thoracic intervertebral discs, being narrower than those of the cervical and lumber regions, account for approximately one-sixth of the length of the thoracic column, the ratio of disc to vertebral column height being 1:5 (Giles and Singer 2000: 23). As with the vertebral bodies, thoracic discs demonstrate an anteriorly-wedged configuration, a trend most evident in the mid-thoracic region. According to Edmondston and Singer (1997: 133) thoracic disc height relative to vertebral body height, is less than that in the cervical and lumbar regions, and the ratio of disc diameter to height is 2-3 times higher in the thoracic than the lumbar segments. This enhances the stability and rotational mobility of the thoracic spine while restricting movement in the sagittal plane.

The thoracic vertebrae are unique in that they have facets on their bodies and transverse processes for articulation with the ribs, with the exception of T11 and T12 (Moore 1992: 33). Two demifacets are located laterally on the bodies of T2 to T9. The superior demifacet articulates with the head of its own rib and the inferior demifacet articulates with the head of the rib inferior to it. T1 has a single costal facet for the head of the first rib and a small demifacet for the superior part of the second rib. T10 has only one costal facet, which is partly on its body and partly on its pedicle. T11 and T12 have only a single costal facet on their pedicles. There are usually 12 ribs on each side of the thorax, elongated flat bones, which curve anteriorly and inferiorly from the thoracic vertebrae (Moore 1992: 34). Ribs 1, 10, 11 and 12 thus articulate with a single vertebra, while ribs 2 through 9 articulate with 2 adjacent vertebrae and the intervening intervertebral disc (Magee 1992: 331).

Three joints are located posteriorly in the thoracic region that are of relevance to this study. These are the facet (zygapophyseal) joints, the costotransverse joints and the costovertebral joints.

The ribs articulate posteriorly with the bodies and transverse processes of the thoracic vertebra at the costovertebral and costotransverse joints respectively (Fam 1988: 767). These are synovial-lined diarthrodial joints. The costovertebral joints are synovial plane joints, located between the ribs and the vertebral bodies (Magee 1992: 331). The costotransverse joints are synovial joints found between the ribs and the transverse processes of the corresponding vertebra of ribs 1 through 10. Ribs 11 and 12 do not articulate with the transverse processes, hence this joint does not exist for these two levels.

The facet joints are made up of the articular processes of two vertebrae. The articular processes (zygapophyses) of adjoining thoracic vertebrae form synovial joints, which allow a limited degree of movement, primarily facilitating axial rotation (Giles and Singer 2000: 23). The superior articulating processes of each vertebral body project upwards, backward and laterally from the junction of the laminae and the pedicles, while the inferior articular processes project downwards from the laminae, facing forwards and slightly medially. Each process has an articular facet. The articulation between the superior and inferior articular facets at the facet joint (zygapophyseal) helps to prevent anterior movement of a superior vertebra on an inferior one. The articular facets allow some flexion and extension as well as varying degrees of lateral flexion and rotation.

Panjabi et al. (1990: 888-901) described the quantitative three-dimensional surface anatomy of thoracic vertebrae, based on a mapping survey of 12 thoracic spines. The thoracic spine was found to have three distinct regions, by comparing the width to depth ratio of vertebral bodies to end plates. These were the upper (T1-T2), middle (T3-T9) and lower (T10-T12) segments. The upper region was characterized best by the narrowing of the end plate and spinal canal width from T2 to T4, while depths remained relatively constant. As a result the width-to-depth ratios decreased from T1 to T4, thus identifying this upper transition zone. The middle thoracic region was found to be clinically significant, due to a relatively narrow end plate and spinal canal from T4 through to T9 or T10. A small spinal canal makes this region more susceptible to cord impingement, although rib articulations add significant stiffness to this region. The middle region has also been called the critical vascular zone for the spinal cord, as the blood supply is least profuse in this region. The final transition zone, from thoracic to lumbar, was most evident through a distinct enlarging of the spinal canal from T10 to T12, and rib articulations changing from a complete unit at T10, to floating ribs at T11 and T12, thus providing less stiffness to the vertebral column in this region.

The thoracic spine, being one of the primary curves, exhibits a mild kyphosis or posterior curvature (Magee 1992: 331). In the thoracic spine, the apex of the kyphotic curve, or the region of greatest curvature, typically lies between T6 and T8 (Giles and Singer 2000: 31). Numerous factors contribute to the kyphosis, with the shape of the vertebral bodies being the major contributor. Other factors include the thoracic discs, reduced muscle tone, occupational and habitual posture, and ostopenia. Edmondston and Singer (1997: 133) write that the thoracic kyphosis is determined more by the osseous symmetry of the vertebral bodies, than muscle activation. Panjabi et al. (1990: 898) found the thoracic vertebral wedge angle to be 3.8° per vertebra, giving a kyphotic curve of approximately 45.6° for the entire thoracic spine (the bony angle).

Interactions between thoracic spine posture and mobility are believed to play a role in the development of spinal pain syndromes (Edmondston and Singer 1997:132). According to these authors, thoracic curvature will almost certainly influence patterns of load bearing and movement, and the greater stiffness of the thoracic spine may produce compensatory changes in the more mobile lumbar and cervical regions. It is the mechanical consequences of the changes in thoracic morphology and posture, which are likely to be important in the development of spinal pain.

2.5 CLINICALLY RELEVANT BIOMECHANICS OF THE THORACIC SPINE AND RIB CAGE

Adequate mobility of the spine is a prerequisite for the activities of daily living, and mobility of the spine affects physical performance (Schenkman and Shipp 1996). Movement analysis is an integral part of the clinical examination of patients presenting with thoracic spine dysfunction (Willems et al. 1996: 311).

The stability of the thoracic spine is substantially enhanced by the rib cage and its articulations (Edmondston and Singer 1997: 133). The thoracic spine has some unique characteristics that distinguish it from the cervical and lumbar spine regions (Giles and Singer 2000: 45). Morphologically, it is a region that is predominantly kyphotic. The ribs attach to the thoracic vertebrae, and the form of the zygapophyseal joint is such that they lie predominantly in a coronal plane orientation. These morphological factors have an implication for biomechanical function. For instance, the range of motion for flexion is less in the thoracic region than in other regions, whereas axial rotation is greater than in the lumbar region and almost as great as in the cervical region.

Normal biomechanical movement is complex with intervertebral, facet as well as costovertebral and costotransverse articulations (Gavin 1999). The components of forward bending (flexion) involve both facets sliding up and the disc stretching posteriorly and compressing anteriorly, while backward bending (extension) involves the facets sliding down. In general, during side bending, the facet on the ipsilateral side slides down while the opposite side slides up. From this it becomes evident that any unnatural or severe movement of the thoracic spine predisposes its facet joints to injury.

The mobility of a functional spinal unit is dependant on the relationship between the height and cross-sectional area of the intervertebral disc, and the morphology and orientation of the zygapophyseal joints (Edmondston and Singer 1997: 133). Thoracic disc height, relative to vertebral body height, is less than in the cervical and lumbar regions and the ratio of disc diameter to height is 2-3 times higher in the thoracic than the lumbar segments. Movement is further restricted by the acute angular orientation of the lamellae of the annulus, and the relatively small nucleus pulposis. The thoracic zygapophyseal joints limit the range of flexion and anterior translation, have little influence on the range of lateral flexion, and fascilitate rotation.

An in vivo study by Willems et al. (1996) was conducted on 60 normal subjects in order to provide preliminary data on three-dimensional thoracic spine kinematics. The study found axial rotation to be the dominant motion of the thoracic region, followed by sagittal and coronal plane motion. The middle thoracic region (T4-T8) accounted for half of the total thoracic rotation range, with the lower thoracic region exhibiting least axial rotation. Sagittal and coronal plane motion was found to be increased in a cephalocaudad direction, and all primary planes of motion were accompanied by motion in other planes. Sagittal plane motion showed the least associated motion whilst coupling was found to be most evident between lateral flexion and axial rotation. An ipsilateral pattern predominated in the middle and lower thoracic regions, when either lateral flexion or axial rotation was the primary motion.

As with other areas of the spine, the amount and type of motion of the thoracic vertebral motion segment is determined by the angulation and spatial orientation of the facet joints (Edmondston and Singer 1997: 132). Orientation of the facet joints in the coronal plane decreases from approximately 20% in the upper thoracic region to 15% in the lower segments, with the superior facets orientated backwards and slightly outwards and upwards, with an angle of approximately 60% to the medial sagittal plane. This angulation facilitates rotation of the vertebral motion segments, which decreases from approximately 14° at the T1-T2 vertebral motion segment to less than 5° at the T11-T12 vertebral motion segment. The average rotation at the T5-T6 and T7-T8 vertebral motion segments is 10°.

Coupled with rotation is lateral bending, which is greatest at the T11-T12 motion segment, averaging between 13° and 14°, and least at T5-T6, averaging 5°. It is generally 2-3° greater in the other vertebral motion segments. Flexion and extension is the least from T1-T2 through T5-T6, averaging less than 5°. It approaches 8° at

T7-T8 through T9-T10, reaching nearly 19° at the T11-T12 vertebral motion segment with the facets orientated more in the sagittal plane (Gatterman 1990: 182).

In summary, a number of anatomical features enhance the stability and rotational mobility of the thoracic spine while restricting movement in the sagittal plane, compared to the cervical and lumbar regions (Edmondston and Singer 1997: 133).

2.6 MECHANICAL THORACIC SPINE DYSFUNCTION

Kirkaldy-Willis (1992: 105), states that the term dysfunction implies that at one level, the components of the joint are not functioning normally. Joint dysfunction is known as a mechanical cause of pain from zygapophyseal synovial joints according to Mennel (1990: 7). Joint dysfunction presupposes the presence of mechanical play, which is a prerequisite for normal efficient motion in any joint. When joint play is lost, joint function becomes impaired and painful.

Gatterman (1990: 415) states that mechanical thoracic spine pain refers to pain caused by a posterior facet syndrome in the thoracic spine, with a facet syndrome being broadly defined as pain or dysfunction arising primarily from the zygapophyseal joints and their immediately adjacent soft tissues i.e. paraspinal muscles.

2.6.1 SIGN AND SYMPTOMS

The most common symptom of vertebral and costovertebral joint dysfunction is unilateral pain in the thoracic spine. Patients often describe the pain as sharp and stabbing, increased by deep inspiration, coughing or sneezing. Lesions of the rib heads commonly occur in unison with thoracic vertebral problems with characteristic associated spasm of the intercostal muscles (Gatterman 1990: 186).

2.6.2 DIAGNOSTIC CRITERIA

Triano et al. (1992: 26) detailed the following forced descriptive classification criteria for a patient to be diagnosed with mechanical spine pain:

1) Midline back pain.

2) Nondermatomal referred pain that is difficult to localize.

3) No signs of nerve root tension.

4) No major neurological deficit.

5) Pain with compression into spine extension.

6) Reduced range of motion.

Orthopedic test, such as the facet joint challenge (Gatterman 1990: 84) and Kemps test (Schafer and Faye 1990: 217) are usually positive, and contiguous paraspinal tenderness may also be present (Taylor et al. 1990).

Bergmann et al. (1993: 63), modified the acronym PARTS from Bourdillon and Day (1987), to identify the five diagnostic criteria for the identification of joint dysfunction. The physical signs indicative of joint dysfunction/subluxation are pain, abnormalities in alignment, joint mobility, and tissue texture:

P: Pain and Tenderness

The perception of pain and tenderness is evaluated in terms of location, quality and intensity. Firstly, the patients' description of pain and its location is obtained. Next, the location and intensity of tenderness produced by palpation of osseous and soft tissue is identified. These findings are noted though observation, percussion and palpation.

A: Asymmetry

This is noted on a segmental level, and includes observation of posture and gait, as well as palpation for misalignment of vertebral segments and extremity joint structures.

R: Range of Motion Abnormality

Changes in active, passive and accessory joint motions, reflected by increased, decreased or aberrant motion, are noted. Decrease in joint motion is thought to be a common component of joint dysfunction. Abnormalities are identified through motion palpation and stress radiography.

T: Tone, Texture and Temperature abnormality

Tissue tone, texture and/or temperature changes of skin, fascia, muscles and ligaments, are identified through observation, palpation, instrumentation, and tests for length and strength.

S: Special Tests

These include tests such as the slump test, passive scapular approximation and first thoracic nerve root stretch.

2.7 DIFFERENTIAL DIAGNOSIS OF THORACIC SPINE PAIN

The thoracic spine and rib joints, together with immediately adjacent cervical and lumbar segments, can give rise to a wide variety of common, benign musculoskeletal conditions (Grieve 1988: 401). Thoracic pain can be caused by a wide variety of disorders, with visceral disease within the chest or abdomen usually the first diagnoses to be considered and investigated (Bruckner et al. 1987: 286).

The differential diagnosis of thoracic pain must consider coronary, pulmonary and other origins of viscerosomatic pain. Referred pain from the viscera can mimic musculoskeletal disorders and should be ruled out before the chiropractor proceeds with manipulative therapy. Cardio-vascular causes may include coronary artery disease, myocardial infarction, angina pectoris, pericarditis and a dissecting aortic aneurysm. Pulmonary embolism may also give rise to thoracic pain. Visceral conditions that must be ruled out include a diaphragmatic hernia, peptic ulcers, pancreatitis and gall bladder disease (Gatterman 1990: 182-186).

In addition to vertebral and costovertebral dysfunction, a number of other conditions should be considered, and ruled out during the case history and physical examination when diagnosing mechanical thoracic spine disorder. These include tumors or their metastases, thoracic disc herniation, Scheuermann's disease, osteoporosis, diffuse idiopathic skeletal hyperostosis, Tietze syndrome, ankylosing spondylitis and thoracic myofascial pain syndromes (Gatterman 1990: 199-203).

Tuberculosis (TB) kills 2 million people each year according to the World Health Organization (WHO 2002). More than 100 000 South Africans are infected with the disease every year (Jordan 2002). TB forms one of the biggest health problems in South Africa according to Nzimande (1997), with pulmonary TB being one of the most common presentation of the disease. Caseation and destructive TB can also occur in bones however, particularly of the spine and distal joints. Recurrence of previously treated TB can be quite rapid under adverse conditions e.g. within 2-3 months, particularly if default occurred during early treatment (Nzimande 1997). This condition must be excluded completely when making a diagnosis of mechanical thoracic dysfunction.

2.8 SPINAL MANIPULATION

Spinal manipulative treatments have been used for the past century to heal musculoskeletal disorders, particularly chronic problems of the spine (Herzog et al. 1995: 233).

Spinal manipulation has been defined as a passive maneuver in which specifically directed manual forces are applied to vertebral or extravertebral articulations of the body, with the object of restoring mobility to specific areas (Gatterman 1990: 42).

The successful manipulation restores restricted mobility while avoiding areas of hypermobility and instability. The Canadian Orthopractic Manual Therapy Association (2002) defines manipulation as a skilled, passive, rapid movement aimed at restoring mobility and function, and reducing pain in a stiff joint and associated tissue.

Sandoz (1976) describes a classic adjustment as a passive maneuver during which an articular element is suddenly carried beyond the usual physiological limit of movement without exceeding the boundaries of anatomical integrity. The usual but not obligatory characteristic of an adjustment is the thrust, which is a brief, sudden, carefully dosed force delivered at the end of the normal passive range of movement, and is usually accompanied by a cracking noise.

Panzer (1995: 424) outlined the following specific proposed effects of spinal manipulation on a patient suffering from facet syndrome, based on the results of various research studies (Rahlmann 1987, Jones et al. 1989, Cox 1990, Giles 1992 and Bergmann 1993):

- Reduced weight bearing on the posterior facets.
- Unlocking of osseous restrictions.
- Reduction of local vascular stasis.
- Freeing of capsular adhesions.
- Breaking of post-immobilization links.
- Pain relief by stimulation of certain mechano-receptors.
- Release of entrapped meniscoids.

The primary indication for spinal manipulation is a reversible mechanical impediment of the intervertebral joint, which prevents normal physiological motion from occurring. This movement restriction has been referred to as joint fixation, joint locking or joint blockage, and can be determined clinically by motion palpation and stress radiographs (Gatterman 1990: 50).

2.8.1 STUDIES INVOLVING SPINAL MANIPULATION OF THE THORACIC SPINE

Schiller (1999) conducted a single blind, placebo-controlled clinical trial on 30 patients to investigate the efficacy of spinal manipulative therapy (SMT) in the management of acute, subacute and chronic mechanical thoracic pain. Each group consisted of 15 patients between the ages of 16 and 60 years. The first group received thoracic spinal manipulation, whilst the second group received placebo treatment in the form of de-tuned ultrasound only. Both groups received a maximum of 6 treatments over a period of 2 weeks. The subjective measurements were collected using the Oswestry Back Pain Disability Index, the Short Form McGill Pain Questionnaire and the Numerical Pain Rating Scale-101 questionnaire. The objective measurements were recorded using the manual BROM 11 goniometer to assess thoracic spine range of motion, and a manual algometer to assess pain threshold respectively. All measurements were taken before the first and final treatment, and a follow-up appointment was scheduled 1 month after the final treatment to assess the long-term benefits of the 2 treatments.

Analysis of the data revealed statistically significant differences ($p \leq 0.025$) between the SMT group and the placebo group in terms of subjective median percentage pain values extrapolated from the NRS-101, and right and left lateral flexion after the treatment period, but these differences were not evident after the one-month follow-up. This lead to the conclusion that the SMT group responded more favorably in terms of subjective and objective measures for a short period after the treatment period.

Schiller concluded that SMT has greater benefits than placebo treatment in the management of mechanical thoracic pain. Schillers' study incorporated both acute and chronic thoracic spine patients', a very broad age limit (16 to 60 years) and manual equipment to measure objective data. The study can be improved upon in terms of narrowing the age group, hence improving the homogeneity of the study, and the use of more sensitive instrumentation. Chronic thoracic complaints present more commonly according to Drews (1995) and Walsh and Jamison (1992) and require longer treatment periods than acute complaints, thus isolating the duration of the patients' symptoms to either acute or chronic, will improve the study's reliability. The use of more sensitive digital equipment would also help to reduce observer bias.

Gavin (1999) conducted a controlled study to determine the immediate effect of joint manipulation on active range of motion (AROM) in the mid-thoracic spine restrictions of 78 asymptomatic subjects. The subjects were divided into 3 categories: Group 1 was the control, Group 2 received mobility testing only and Group 3 received mobility testing and joint manipulation to a restricted segment.

The subjects were pre-tested for AROM in flexion and lateral bending of T3-T8. They were then either rested, received mobility tests or manipulated, after which post-test measurements were performed. In a comparison pre- versus post-treatment AROM, a significant difference was found in left lateral flexion only ($p = 0.12$). The author concluded that one session of manipulation techniques could influence AROM in the thoracic spine in side bending only. Weaknesses of the study include the fact that it made use of asymptomatic subjects, and in clinical situations, patients are symptomatic, as well as the fact that it utilized only one treatment session. In order to be clinically applicable in the management of thoracic spine dysfunction, symptomatic patients and a treatment protocol should be implemented.

Bhoola (2001) conducted a double blind randomized clinical trial, to determine the relative effectiveness of the combination of spinal manipulative therapy (SMT) and non-steroidal anti-inflammatory drugs (NSAIDS) versus SMT with the administration of a placebo medication, in the treatment of chronic mechanical thoracic facet syndrome. Sixty patients were randomly assigned to the manipulation and NSAID group or the manipulation and placebo medication group. Each patient in the NSAID group received 139mg of diclofenac free acid per day over 5 days, while the placebo group received the same dosage of a lactose powder with similar appearance to that of diclofenac free acid over the same period. Each group of thirty patients received six treatments of SMT over a three-week period. Subjective measurements included the McGill Short-Form Pain questionnaire, The Numerical Pain Rating Scale-101 and the Oswestry Pain Disability Index, and were collected at the 1st and 6th treatments.

Objective data was gathered from manual goniometric measurements to assess range of motion, at the commencement of the 1st, 3rd and 6th treatments.

Analysis of the data revealed no statistical difference between either group in terms of treatment efficacy, and Bhoola concluded that both treatment protocols were effective in treating chronic thoracic facet syndrome. Shortfalls of this study included a broad age limit (16 to 60 years), manual goniometric measurement decreasing the accuracy of readings, and the possibility of patients not being compliant in terms of medication dosage in both groups, interfering with the results.

In a controlled study of 30 asymptomatic patients, Lee et al. (1993) investigated the proposal that thoracic spinal stiffness is altered by manipulation. The manipulation studied was a posteroanterior thrust applied to the T4-T5 spinal level, considered a safe distance from the more mobile cervical spine not to be influenced by it. The effect of the manipulation was compared objectively, using a simulator for stiffness testing, to a controlled intervention of supine lying. A t-test comparing the changed scores between interventions revealed no significant difference. However, the posteroanterior stiffness at T5 was found to be significantly greater than at T4. It was concluded that these results do not provide support for the hypothesis that posteroanterior stiffness is altered by manipulation in asymptomatic subjects, indicating the need for further experiments of this type using symptomatic subjects who have thoracic spine pain.

Triano et al. (1992) conducted a study to determine the differences in treatment history with spinal manipulative therapy for acute, subacute, chronic and recurrent spine pain, by quantifying clinical characteristics in a population of 241 patients. 180 Patients were diagnosed with mechanical spine pain, 42 for muscular and 17 for nerve root entrapment. Seven questionnaires were administered, including the Oswestry questionnaire and the Visual Analogue Scale, at the beginning of the clinic visit, after the clinical evaluation, prior to any treatment and again after 6 weeks. The predominant mode of treatment was by manual manipulation, supported as needed by exercise and modalities of physical therapy. The differences in treatment were based upon chronicity, clinical categorization and location of complaint. Patients were also commonly given home care recommendations to assist in their recovery. The authors determined that complaints of the thoracic spine responded twice as quickly to manipulation as did complaints of the naturally lordotic areas of the spine, namely the cervical, lumbar and lumbosacral areas. Thoracic spine regions required about 3 treatments, while cervical regions required about 5.9 and the lumbar region 6.7. The study described here does not represent a controlled clinical trial, but the information it supplies is useful, as it describes the chronicity of complaints, to examine for differences in the relative amounts of treatment given and gives an overview of case management, as it would occur in a clinical setting.

In a single blind comparative pilot study, Tsolakis (2001) compared the efficacy of spinal manipulation to interferential current therapy, in the management of mechanical thoracic back pain. Sixty patients were randomly assigned to 2 groups of 30 each, one group receiving SMT and the other interferential current therapy, for a minimum of 3 or up to a maximum of 6 treatments over a 2 week period. Subjective data was collected from the McGill Short-Form Pain Questionnaire, Numerical Pain Rating Scale-101 and the Oswestry Back pain Disability Index. Objective data consisted of thoracic range of motion readings collected using the manual BROM II goniometer. Both subjective and objective measurements were collected before the 1^{st}, 2^{nd} and final treatment.

Statistical analysis of the data indicated a statistical difference between treatment groups in favour of spinal manipulation, in terms of the subjective Oswestry Back Pain Disability Index questionnaire only ($p = 0.017$). Tsolakis concluded that both spinal manipulation and interferential current therapy are effective in the treatment of mechanical thoracic spine pain, but that manipulation was more effective in restoring patients' function and decreasing their subjective pain disability by the end of the trial, than interferential current therapy. Limitations of the study included the fact that no restriction was placed on age, weakening the validity of the study in terms of homogeneity. Both sub-acute and chronic patients were accepted into the study, requiring different treatment periods to resolution, and manual goniometric measures were used, which could be improved upon with more sensitive digital equipment.

Mohseni-Bandpei <u>et al.</u> (1998) reviewed 25 randomized controlled clinical trials on spinal manipulation in the treatment of low back pain. The authors concluded that the efficacy of manipulation for patients with acute or chronic low back pain has not been convincingly demonstrated through the literature. They stated that studies with a better research methodology are clearly needed, with special attention being paid to factors such as duration of complaints, age and occupation (which modify the effect of manipulation, exclusion, and inclusion criteria), an explicit definition of therapeutic procedure, blinding the patients, therapist and assessor, placebo group trusted by patients, and prevention of co-intervention during treatment and follow-up.

In comparison to the above study, Manga <u>et al.</u> (1993), conducted a study funded by the Ontario Ministry of Health, to examine the efficacy and cost effectiveness of chiropractic management of low back pain. They concluded that based on the evidence of numerous scientifically valid studies, spinal manipulation applied by chiropractors is safer and more effective than alternative medical treatments of low back pain, such as bed rest, prescription drugs and surgical intervention, with many medical therapies being of questionable validity, or clearly inadequate.

2.9 MOBILIZATION

Mobilization is passive movement performed in such a manner (particularly in relation to the speed of the movement) that it is, at all times, within the ability of the patient to prevent the movement if he so chooses (Maitland 1986: 4). Refshauge and Gass (1995: 176) state that clinically, mobilization involves moving a joint passively but slowly, within its immediate available range of motion or slightly beyond the limit of that range.

The Canadian Orthopractic Manual Therapy Association (2002) defines mobilization as a gentle, rhythmic, repetitive passive movement of graded amplitude aimed at restoring mobility and function and reducing pain in a joint and surrounding tissue.

Mobilization may be perceived to stretch fibrous tissue in or around the joint, and on the grounds that stretching fibrous tissue may cause it to creep, it is sound in principle if the objective is to increase the range of motion (Refshauge and Gass 1995: 176). It is contested however that any gains achieved by this means are sustained. With respect to relief of pain, it has been postulated that mobilization promotes adaptation of capsular nerve endings, essentially decreasing their threshold for mechanical activation.

Flynn (1996:173) indicates that mobilization be used for restoring passive accessory motion, reducing pain and increasing segmental and total spinal range of motion

Palastanga (1994: 646) postulates the effects of mobilization as follows:

- It affects the hydrostatics of the vertebral bodies and discs.
- It activates the Type I and Type II mechanoreceptors in the capsule of the facet joint influencing the spinal gating mechanism.
- It alters the activity of the neuromuscular spindle in the intrinsic muscles of the segment subsequently affecting bias in the gray matter cells.
- It assists the pumping effect on the venous plexus of the vertebral segment.

Twomey and Taylor (1995) believe that the repetitive, low stress and small amplitude movements of mobilization allow effective synovial fluid distribution over and through articular cartilage and disc, and partial stretching of the ligamentous joint structures, events that are necessary on a regular basis for the efficient functioning and repair of the structures involved.

Emphasis is placed on the study of Maitland’s techniques in the undergraduate years of physiotherapy study here in South Africa and around the world, and post-graduate courses are offered to further educate physiotherapists in the art and skill of Maitland’s techniques (Morton 2001). Maitland is regarded as one of the leaders in the field of manual therapy, being a co-founder of the International Federation of Orthopedic Manipulative Therapists (IFOMT), as well as Inaugural President of the Australian College of Physiotherapist, and his techniques are widely used by the physiotherapy profession throughout the world (Banks et al. 2001). After taking the above into account, the Maitland technique of mobilization was selected to be used in this study.

2.9.1 STUDIES INVOLVING MOBILIZATION

Brodin (1984) conducted a randomized control trial on a sample population of 63 patients suffering from mechanical neck pain. Three groups were created within the study, namely a control group receiving no treatment, an experimental group receiving passive mobilization without thrusting and a third group receiving massage, gentle traction and electrical stimulation. All treatments were performed 3 times a week for 3 weeks, and all 3 groups were advised to take a salicyclate preparation during this period. Cervical ranges of motion using a goniometer, and pain intensity using an algometer were measured before the treatment, weekly during the treatment period and after a one-week follow-up period. Results indicated that one week after the treatment had ended, 48% of the mobilization group, 22% of the control group and 12% of the massage group were symptom free. Overall, 78% of the mobilization group experienced a decrease in pain as compared to 39% of the control group and 35% in the massage group ($p < 0.05$).

Cervical ranges of motion were found to be significantly increased in the mobilization group as compared to the other groups after week 3 of treatment ($p < 0.001$), but this difference was not as significant after the 4^{th} week ($p < 0.1$).

The author concluded that mobilization was an effective form of treatment for mechanical neck pain, but remarked that a statistically relevant relationship between increased mobility of the cervical spine and a decrease in pain could not be made in the outcome of patients suffering from mechanical neck pain.

Goodsell et al. (2000) conducted a crossover study to establish the short-term effects of lumbar posteroanterior mobilization, similar to Maitland's technique, in 26 patients with low back pain, compared to a controlled intervention of prone lying for 3 minutes. Patients with non-specific low back pain were randomly divided into 2 groups. Both groups received both interventions, which were in an order that was randomly allocated. An observer who was blinded to the order of intervention assessed the outcome measures before and after each intervention. Subjective measures included the McGill Short-Form Pain questionnaire and the Visual Analogue Scale. The objective measures consisted of an analogue inclinometer to assess range of motion, and a custom made stiffness measurement device linked to a laptop computer to quantify the posteroanterior responses.

Analysis of the results revealed no significant differences between the mobilization and control interventions in relation to posteroanterior response or range of movement. The score for pain on the worst movement showed significantly greater improvement for the mobilization than for the control procedure ($F = 6.37$).

The authors concluded that lumbar posteroanterior mobilization did not produce an objectively measurable change in the mechanical behavior of the lumbar spine, but that subjective pain experience did improve in patients with low back pain. They further attributed the improvement in some pain variables (in comparison with the control group) to the placebo effect. No restrictions were placed on the patients' ages, or duration of symptoms, adding to the weakness of the study. The custom made stiffness measuring device was not independently tested for reliability and validity, and an oil-filled pendulum inclinometer with a shortened base modified by the research team, was used to measure lumbar range of motion, highlighting the poor research design further.

2.10 MANIPULATION VERSUS MOBILIZATION

Gatterman (1990: 50) describes 3 physical events that occur during manipulation, that differentiate it from mobilization:

- As the elastic barrier of the joint is passed, the articular surfaces separate suddenly
- A cracking noise is heard

- A radioluscent space appears within the joint.

2.10.1 STUDIES INVOLVING MANIPULATION AND MOBILIZATION

Mead et al. (1990) conducted a randomized, multicentre trial to compare chiropractic care with conventional hospital outpatient management (physiotherapy mobilization, manipulation or both) of 741 patients with mechanical low back pain. Patients aged 18-65 years with no contra-indications to manipulation and who had not been treated within the past month were accepted into the study.

Treatment was left to the discretion of the chiropractors, who used spinal manipulation on most patients, or of the hospital staff, who most commonly used Maitland's technique of mobilization or manipulation or both. The main outcome measures included percentage changes in the score on the Oswestry Pain Disability Index and in the results of straight leg raising and lumbar flexion. The results indicated that chiropractic treatment (high velocity, low-amplitude adjustments in virtually all of the cases) was more effective than hospital outpatient management (Maitland's technique of mobilization, manipulation or both), mainly for patients with chronic or severe back pain. The benefits of chiropractic treatment became more evident through out the 6-month follow-up period, and at a 3-year follow-up.

The authors concluded that for patients with low back pain in whom manipulation is not contra-indicated, spinal manipulation as practiced by chiropractors confers worthwhile, long-term benefits in comparison with hospital outpatient management. The benefit is seen mainly in those with chronic or severe pain. It was further stated that consideration should be given to introducing chiropractic into the National Health Service, either in hospitals, or by purchasing chiropractic treatment in existing clinics.

Assendelft et al. (1992), in a later review of randomized clinical trials to determine the efficacy of chiropractic manipulation for back pain, stated that the study conducted by Meade et al. (1990) was the "best" randomized clinical trial ever planned with regard to the methodology, which was scored according to very stringent criteria by a panel of blinded independent reviewers, on the topic of spinal manipulation as a treatment of low back pain. Twomey and Taylor (1995) however, state that the study has received criticism due to the fact that those patients who received chiropractic had 44% more treatments than the hospital outpatients, and that the hospital treatment was not consistent in its form or structure.

Cassidy et al. (1992) conducted a randomized, controlled clinical trial in order to compare the immediate results of manipulation versus mobilization, on pain and range of motion in the cervical spine. The study involved 100 consecutive outpatients suffering from unilateral neck pain with referral into the trapezius muscle. The manipulation group contained 52 subjects whilst the mobilization group contained 48 subjects. The authors reported no significant differences between the 2 treatment groups, with respect to history of neck pain or level of disability, as measured by the Pain Disability index. The objective and subjective measurements were taken prior to and immediately after the treatments, and included cervical spine range of motion using an analogue goniometer, and the Numerical Pain Rating Scale-101 questionnaire respectively. The results showed that both treatments increased range of motion, but that manipulation had a significantly greater effect on pain intensity ($p = 0.05$). 85% of the manipulated patients, as compared to 69% of the mobilized patients reported pain improvements immediately after the treatments, however the decrease in pain intensity was more than 1.5 times greater in the manipulated group.

The authors concluded that a single manipulation was more effective than mobilization in decreasing pain in patients with mechanical neck pain, whilst both treatments increased cervical spine range of motion to a similar degree.

Myburgh (1998) conducted a randomized clinical trial to evaluate the relative effectiveness of spinal manipulation versus specific passive mobilization (Maitland's Technique) in the treatment of mechanical low back pain. A sample population of 30 patients, diagnosed as suffering from facet syndrome of the lumbar spine, a sacro-iliac syndrome or a combination of the 2 conditions, was divided into 2 groups of 15 each. Each group received the appropriate spinal manipulation or mobilization, with a frequency of 3 treatments per week for 2 weeks, and a one-month follow-up consultation.

Subjective measurements were recorded using the Numerical Pain Rating Scale-101 questionnaire and the Oswestry Back Disability Index. Objective measurements were recorded using an analogue goniometer to assess range of motion and an analogue algometer to assess pain threshold. Both subjective and objective data was collected before the 1^{st} and 6^{th} visits and at the one-month follow-up consultation. Analysis of the data revealed that for the intra-group comparison, with respect to the subjective data only the manipulation group showed a significant improvement between the initial visit and the one-month follow-up ($p < 0.025$). For the objective data the mobilization group showed significant changes in flexion and right rotation values, as well as in pain threshold measurements, over the same period. The manipulation group showed significant changes in all ranges of motion tested ($p = 0.005$) as well as pain intensity measurements ($p = 0.0003$). The inter-group comparison revealed no statistically significant results.

The author concluded that both treatment groups responded equally well to the treatment protocol given but due to the low power of the study, the chance of a Type 11 error was high, indicating that even if significant changes were present, they would not have been detected due to the small samples size, thus making the incorrect acceptance of the null hypothesis a possibility.

Pillay (2001) conducted a randomized controlled clinical trial to investigate the effectiveness of spinal manipulation compared to passive oscillatory mobilization in the management of chronic mechanical thoracic spine pain. The study population consisted of 60 patients, obtained by convenience sampling, who were randomly allocated to 2 groups of 30 each, one group receiving spinal manipulation and the other group receiving Maitland's passive oscillatory mobilization. Both groups of patients received 5 treatments over a 2-week period. Subjective data was obtained using the Short-Form McGill Pain questionnaire and the Numerical Pain Rating Scale-101 questionnaire. Objective data was captured using an analogue algometer to measure pain threshold. Subjective measurements were taken before the 1^{st}, 3^{rd} and

5th consults, whilst objective measurements were taken before and after the 1st, 3rd and 5th consults.

Analysis of the data for intra-group comparison revealed a significant improvement in both the manipulation and mobilization groups in terms of subjective data for the period between treatments 1 & 3, 3& 5 and 1 & 5. This indicated that both groups were successful in significantly reducing the pain intensity measurements and quality of the patients' pain responses. Inter-group analysis revealed spinal manipulation to be more effective than mobilization for the subjective data on quality of patients' pain responses in terms of the NRS-101 ($p = 0.034$) and the McGill Short-form ($p = 0.013$), and objective pain intensity measurements after treatment 1 ($p = 0.038$).

Pillay concluded that both spinal manipulation and passive oscillatory mobilization are effective manual interventions in the treatment of chronic mechanical thoracic spine pain, but that the spinal manipulation group appeared to achieve better results over all, as compared to the mobilization group. The author recommended that future studies improve on homogeneity in terms of severity of patients' symptoms, more sensitive instrumentation be used to increase the accuracy of readings, and consideration be given to assessment of range of motion, as it is a basic evaluation technique used during a neuromuscular spinal examination.

2.11 CONCLUSION

There has been a resurgence of interest in the thoracic spine from a clinical perspective according to Edmondston and Singer (1997), that may be explained by: the recognition of the thoracic spine as an important source of local and referred pain, the role of the thoracic curvature in determining overall spinal posture, and the influence of thoracic mobility on movement patterns in other regions of the spine and the shoulder girdle.

Dreyfuss et al. (1994), a group of medical researchers, believe that thoracic pain, although less common, can be as disabling as cervical and lumbar pain, due to the acceptance of the zygapophyseal joints as being potential pain generators in the cervical and lumbar regions, and receiving little attention in the thoracic region.

Di Fabio (1992) conducted an analysis of the literature in order to determine the efficacy of manual therapy in the treatment of patients who have somatic pain syndromes. Of 146 titles, 105 studies were not deemed primary studies of manual therapy. Of the remaining 41 studies, 18 did not utilize statistical comparison or report blinded assessment of outcome measures, and 9 controlled studies yielded negative results without describing the statistical power or minimum sample size required to detect potential differences. Thus only 14 studies were judged to be valid demonstrations of the efficacy of manual therapy. The author concluded that the review provided some evidence that manual therapy can be an effective modality when used to treat patients who have somatic pain syndromes, but that there may be a difference in efficacy, however, between manipulation and mobilization.

Anderson et al. (1992) conducted a literature review to assess the efficacy of spinal manipulative therapy in the treatment of back pain using meta-analytical techniques. One purpose of the analysis was to attempt to distinguish the efficacy of spinal manipulation from that of spinal mobilization, and in an analysis of the pooled results of 23 different studies, it appeared that manipulation may be more effective than mobilization in the treatment of the lumbar spine. The authors noted that this finding was based upon very limited data at that time.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 INTRODUCTION

This chapter includes a detailed description of the research methodology and is presented in the following sub-sections:

- Subjects
- Procedures
- Materials
- Statistical Analysis

3.2 SUBJECTS

3.2.1 SAMPLING PROCEDURE

This study utilized convenience sampling, as a specific diagnosis of chronic thoracic spine dysfunction was required. The study was advertised in the local newspapers, via pamphlets distribution, word of mouth and on notice boards around the Chiropractic Day Clinic, the Technikon Natal campus, tertiary institutions and at various gymnasiums and sports clubs in the greater Durban area.

Patients then either presented to the Chiropractic Day Clinic with chronic thoracic spine dysfunction or phoned in enquiring about the study, after which patients were interviewed either telephonically or one-on-one. The interview was conducted to determine if they met the inclusion criteria, in terms of age, and location and chronicity of their complaint, necessary to participate in the study.

3.2.2 INCLUSION CRITERIA

The following inclusion criteria were adhered to in order to increase homogeneity in the study, and ensure that all patients accepted to the study suffered from chronic mechanical thoracic spine dysfunction:

a) The patient had to be between the ages of 18 and 45 years. Based on the findings of Schenkman and Shipp (1996) and Sullivan and Dickinson (1994), the age limit imposed was below the age where significant restrictions in spine motion occurs secondary to the aging process.

b) Only patients' with chronic mechanical thoracic spine pain as defined by the Quebec study were included, i.e. the duration of symptoms experienced by the patient must be greater than 50 days (Leblanc 1987). Such a categorization contributed towards selection of a homogenous sample as recommended by Schiller (1999) and Pillay (2001). Based on the demographics supplied by Schiller (1999) and Drews (1995) mechanical thoracic spine pain of a chronic nature appears to be more common (as compared to acute, subacute or recurrent).

c) Only patients diagnosed as having mechanical thoracic spine dysfunction were included in the study. This can be diagnosed by the following symptoms and signs:
   - Midline thoracic pain.
   - Non-dermatomal referred thoracic pain difficult to localize.
   - Pain with compression into thoracic spine extension.
   - No major neurological deficit.
   - No sign of nerve root tension.
   - Reduced range of motion (Triano et al. 1992).
   - Positive Kemps test (Schafer and Faye 1990: 217).
   - Positive facet joint challenge (Gatterman 1990: 84).

d) Patients with active or latent myofascial trigger points were not excluded from the study, unless myofascial pain and dysfunction syndrome was found to be the primary cause of the patients signs and symptoms. Travell and Simons (1983: 645-646) state that myofascial trigger points in the paraspinal muscles can cause pain similar to that of zygapophyseal joint sprain.

3.2.3 EXCLUSION CRITERIA

The exclusion criteria were:

a) Patients' receiving workers compensation, disability insurance or involved in litigation related to their thoracic spine, were excluded from the study to avoid any legal complications.
b) Patients who received any other treatment for their condition or a co-existing condition. This was done to limit the amount of variables in the study and ensure the validity of the results.
c) Patients with contraindications to spinal adjustment (Haldeman 1992: 557-572) or mobilization (Thomson et al. 1991: 445).
d) Patients who were on short-term non-steroidal anti-inflammatory drug (NSAID) medication at the time of the study, or altered their dosage regularly.
e) If radiographs were deemed necessary to confirm a diagnosis or rule out pathology. Mennel (1992: 29) states that there are no characteristic radiological changes associated with joint dysfunction.
f) Patients who were unable to understand the Patient Information Letter or the Informed Consent Form (patients who could not speak or read English). Failure to do this would have necessitated the presence of an interpreter during all appointments, which was not possible in the context of this study, thus making it unethical to accept patients who could not understand the informed consent form.

3.2.4 SUBJECT ACCEPTANCE

Those patients considered suitable for the study after the interview by the researcher were informed, and an initial consultation was then scheduled for the patient. At the initial consultation, the purpose of the study was explained to the patient and a case history, physical examination and regional examination of the thoracic spine performed (Appendices A, B and C). Patients meeting the inclusion criteria in terms of the clinical history and physical findings were then accepted into the study, and asked to read a patient information letter (Appendix D) and sign an informed consent form (Appendix E).

3.3 PROCEDURES

A population of 40 patients meeting the research criteria were accepted into the study, and randomly allocated into two groups of 20 each. Each patient was required to draw a folded piece of paper from an envelope, with his or her eyes closed. There were 40 pieces of paper in the envelope, 20 marked 'A' and 20 marked 'B'. Those patients in Group A received spinal manipulation as treatment for their thoracic spine dysfunction, whilst those in Group B received passive oscillatory mobilization (Maitland's technique).

At the initial consultation, after the informed consent form was signed and witnessed, the patient completed the Numerical Pain Rating Scale-101 questionnaire (NRS-101) (Appendix F). The subjective and objective measurements were assessed before the treatment of the 1^{st} and 3rd consultations, and at the 5^{th} consultation.

Motion palpation technique was carried out during the regional examination of the thoracic spine, as is referenced in Haldeman (1992: 304-314) in order to determine the level (T1-T12), the side (right or left) and the direction (flexion, extension, right or left rotation, or right or left lateral flexion) of the loss of motion of the fixated joint.

In a randomized, controlled study to determine the construct validity of motion palpation of the thoracic spine, Haas et al. 1995 found that inter-examiner reliability was poor overall (k = 0.140), while intra-examiner reliability revealed moderate self-consistency. The subjects were 73 chiropractic students, both symptomatic and asymptomatic, and a blind repeated measures design was used in the laboratory setting in order to evaluate inter and intra-examiner reliability. The restriction rate was found to be unaffected by examiner, symptomology or repetition of palpatory examination, and the authors concluded the results to be consistent with the reliability reported for other spinal regions in the peer-reviewed chiropractic literature.

Other factors taken into account during identification of the affected joints were those described by Triano et al. (1992), Gatterman (1990: 84), Schafer and Faye (1990: 217) and Bergmann et al. (1993: 63), as is outlined in the inclusion criteria.

After the area of joint dysfunction had been identified and recorded on the patients' data sheet (Appendix G), the initial digital algometer and dual-inclinometer readings were taken. The patients' were then treated according to the randomly selected intervention for their group.

3.3.1 GROUP A: SPINAL MANIPULATION

Patients in Group A received spinal manipulative therapy as treatment for their chronic thoracic spine dysfunction.

Adjustive or spinal manipulative therapy is contra-indicated when the therapy may produce an injury, worsen an associated disorder, or delay appropriate curative or life-saving treatment (Bergmann 1993: 132).

Specific contra-indications to spinal manipulation include the following:

- Rheumatoid arthritis and instability or acute inflammation.
- Acute inflammatory state of ankylosing spondylitis.
- Severe degenerative joint disease.
- Thoracic disc protrusion or herniation.
- Neoplasms.
- Osteoporosis.

- Progressive spondylolisthesis with clinical signs and symptoms indicating radicular compression.
- In the acute phase after trauma.
- Psychogenic disturbances (Haldeman 1992: 557-572).

According to Gatterman (1990: 187), the most common conditions contra-indicating manipulation of the thoracic region are rib fractures and sprains of the costochondral, costosternal and interchondral joints. In view of the above, prospective patients for the study were carefully screened during the physical and thoracic regional examination for any contraindications to spinal manipulative therapy.

The adjustment to be used was determined by the level and the direction of loss of motion, i.e. the joint was adjusted with the force directed into the restriction and in line with the articular plane (Schafer and Faye 1989: 37).

The spinal manipulation group was positioned for their adjustment according to the diversified method of spinal manipulative therapy. The skin slack was taken up and the researcher then gently sprung the joint to its end position. A thrust from this end position was then delivered using a high-velocity, low-amplitude, specifically directed force (Haldeman 1992: 485).

The adjustment techniques used, included those performed in the seated, standing, supine, or prone positions as described by Bergmann et al. (1993: 329-387):

- For restricted flexion and/or extension at segments between T1-T4, the bilateral thenar transverse (prone) and/or hypothenar spinous occiput (prone) were used.
- For restricted rotation and/or lateral flexion at segments between T1-T3, the thumb spinous prone/sitting or side posture were used. The hypothenar transverse (combination move and modified combination move) was used for segments between T1-T4.
- For restrictions of flexion, extension, lateral flexion or rotation at segments between T4-T12, the bilateral thenar transverse (prone) or supine thoracic

fist transverse, or standing thoracic at segments between T3-T12 were employed.

- For restrictions of lateral flexion and/or rotation at segments between T4-T12, the unilateral hypothenar transverse (prone) or hypothenar spinous transverse (prone) were used. The hypothenar transverse sitting thoracic was used at segments between T3-T12.

If one technique was unsuccessful, another was employed given that more than one technique is available to adjust a particular fixation. The success of an adjustment was based on the accompaniment of an audible cracking sound with the application of the above techniques and post manipulative manual thoracic endplay assessment.

The cracking sound accompanying an adjustment has been associated with the cavitation of an intra-articular gas bubble within the spinal zygapophyseal joints (Sandoz 1969 and Herzog et al. 1993). Herzog et al. (1993) conducted a study of the cavitation sounds during spinal manipulative treatments, using accelerometry recordings to confirm a practitioners' perception of cavitation during SMT of 28 patients. The authors state cavitation to be an important aspect of spinal manipulative therapy, so much so that many clinicians rely on this sound to judge the effectiveness of their treatment, even repeating the manipulation if they did not hear or feel the cavitation occur. The authors concluded that cavitation may be measured during spinal manipulative therapy using accelerometry and that a practitioners perception of the occurrence of cavitation during spinal manipulative therapy is very accurate.

Endplay response is defined as the change from restricted to normal endplay immediately after intervention (Haas et al. 1995). In a study conducted on 60 volunteers, the authors found a moderate short-term responsiveness of rotatory thoracic end-play restriction to spinal manipulation, and concluded that it has utility as a post-treatment evaluative test.

3.3.2 GROUP B: PASSIVE OSCILLATORY MOBILIZATION

Patients in Group B received passive oscillatory mobilization according to Maitland's technique, as treatment for their chronic mechanical thoracic spine dysfunction. Prior to the study commencing, the assistance of two physiotherapists, Mrs. J. Morton and Mr. T. Kolbe was sought, the former of which trained directly under Maitland, to ensure the correct application of the technique.

Maitland (1986: 4) classifies mobilization into 2 types:

1. Passive oscillatory movements.
2. Sustained stretching.

Passive oscillatory movements may be performed slowly (one in 2 seconds), or quickly (3 per second), smooth or staccato, with small or large amplitude, and applied in any part of the total range of movement. These movements may be performed while the joint surfaces are distracted or compressed. Sustained stretching passive movements may be performed with or without tiny amplitude oscillations at the limit of the range.

The Maitland technique grades mobilization procedures as follows:

Grade 1 A small-amplitude movement or oscillation at or near the beginning of range of motion.

Grade 2 A large-amplitude movement or oscillation that is into the restricted range of motion but does not engage the barrier.

Grade 3 A large-amplitude movement or oscillation that is into the restricted range of motion and engages the barrier.

Grade 4 A small-amplitude movement or oscillation at the restrictive barrier (Maitland 1986: 96 and Flynn 1996: 174).

Certain conditions may be contra-indicated for spinal manipulative therapy, but not for mobilization, e.g., active arthritic, vascular and metabolic conditions (Maitland

1986: 110). The reason for this being that mobilization is considered to be the gentle cousin of manipulation (Refshauge and Gass 1995: 176). Its attraction is that by intention and by experience it carries less risk of morbidity than manipulation, with the advantage of the patient being able to stop the treatment if desired.

The patients were briefly educated on the mobilization technique prior to their first treatment, and told what to expect in terms of sensation during the procedure i.e. pressure over the painful area, with a possibility of mild discomfort during the mobilization. Patients were also requested to inform the researcher of the occurrence of any pain or discomfort experienced during the treatment, as subjective feedback was important in determining the grade of mobilization used.

The patients were mobilized in the prone position, as this is the classic system of mobilization utilized by Maitland (2001), Flynn (1996: 174) and Pillay (2001). Movement of each joint was produced by thumb pressure against the vertebrae (spine or transverse process), and the direction chosen was that in which movement was stiff (i.e. loss of motion) (Maitland 1986: 95). The rhythm and grades of mobilization used for each patient was dictated by clinical findings and subjective feedback from the patient during the treatment in terms of pain or discomfort.

When pain was localized to the joint, the mobilization was done in the range that was relatively pain-free, but movement was carried up to the point were pain began. If pain was felt very early in the range of movement, mobilization was performed with very small rhythmical oscillations (grade 1). If a larger range of pain-free movement was possible into the restricted range of motion, larger amplitude oscillations further into the range, without engaging the barrier were performed (grade 2). Once a resistance to movement was felt at the end of range, either large amplitude oscillations through out the range and engaging the barrier (grade 3), or smaller amplitude oscillation at the restrictive barrier were used (grade 4), depending on the severity of end of range pain. Patients with very little subjective pain and predominantly restriction of movement were treated with grade 4 oscillations.

Each treatment consisted of 3 or 4 mobilization sequences of the affected joint, with each sequence consisting of 20 to 30 oscillations at a rate of 1 oscillation every 1-2 seconds. After the initial treatment, patients were informed of possible post-treatment stiffness occurring briefly within the first 24hrs.

After the initial treatment (spinal manipulative therapy or passive oscillatory mobilization), the remaining 4 consultations were scheduled.

Triano et al. (1992), in a study on differences in treatment history with manipulation for spinal pain, reported that thoracic spine disorders needed an average of three treatments for clinical resolution. In her study on mechanical thoracic spine pain, Schiller (1999) found that most patients showed clinical improvement after the fourth treatment, and noted that most conditions were chronic in nature, thus possibly requiring more treatment to reach resolution. The patients in the study conducted by Pillay (2001), received a maximum of five treatments over a 2-week period, for their chronic mechanical thoracic spine pain, but no follow up consultation was scheduled, allowing only the immediate effects of treatment 5 to be measured. After taking the above into consideration, it was decided to utilize a treatment frequency of 4 treatment consultations and 1 follow-up consultation with no treatment over a 2-week period.

3.3.3 FLOWCHART (CRITICAL PATH)

Convenience sampling: The research project was advertised on noticeboards and the intranet at the Chiropractic Day Clinic, Technikon Natal, local tertiary institutions, gyms, sports clubs and in local and area newspapers, prior to and through out the duration of the research study.

Applicants were interviewed telephonically or one-on-one, to determine whether or not they met the inclusion and exclusion criteria as potential patients for the study.

Applicant accepted as a potential patient.

Applicant rejected as a potential patient.

The potential patients meeting the inclusion criteria had the study explained to them, and an initial consultation was scheduled during which prospective patients underwent a case history, physical examination and thoracic regional examination.

Patient accepted

Patient rejected

Patients were given a patient information letter and signed an Informed Consent Form, prior to being randomly allocated into one of the two treatment groups, 20 patients in each group.

Group A
Spinal Manipulation.

Group B
Passive Oscillatory Mobilization

Patients received a total of 4 treatments with 1 follow-up consultation, over a 2-week period. Subjective and objective data was collected before consultation 1and 3 and at consultation 5.

3.4 MATERIALS

3.4.1 OBJECTIVE MEASUREMENTS

The objective measurements for the study were gathered using a digital algometer to assess pain threshold, and a digital inclinometer to assess range of motion of the thoracic spine.

3.4.1.1 THE DIGITAL ALGOMETER

A digital algometer was utilized to determine and qualify localized tenderness by measurement of the pressure threshold of each patient.

Pressure threshold is referred to as the minimum pressure (force) that induces pain or discomfort (Fisher 1987). Pressure threshold has been shown to be useful for the evaluation of immediate effects of physiotherapy, and the adequateness of the intensity of treatment. After conducting his study on 50 volunteers, Fisher concluded that changes in pressure threshold, obtained under standard clinical conditions, can be regarded as reliable data and also correlates well with changes in clinical status.

Vernon et al. (1990) in their study on a group of 9 patients found the pressure pain threshold meter to be very useful in assessing the effect of a single manipulation, as opposed to a single rotational mobilization, in the cervical spines of subjects suffering from chronic mechanical neck pain.

Pillay (2001) recommended the use of the more sensitive digital algometer as compared to the manual version, which measures in increments of 2°, to reduce observer bias as well as detect small but possibly statistically significant changes within treatments, and hence increase the accuracy of the readings.

Prior to measurements being taken using the digital algometer, patients were first informed of the intentions of the researcher, and educated on the workings of the algometer and what to expect in terms of sensation. A test run was conducted on the patients forearm initially, so as to familiarize the patient with the sensation and the procedure.

The maximum area of pain over the relevant facet joint diagnosed with joint dysfunction was then identified by the researcher using palpation, noted on the patients' data capture form (Appendix G) and marked with a washable skin marker. The tip of the digital algometer was then placed over this mark, with the researcher ensuring that the instrument was perpendicular to the skin surface, to prevent possible false positive readings from soft tissue structures. Steady, gentle pressure was applied until the patient first felt the sensation of pain, in which case he/she responded by saying "now", after which the pressure was removed as quickly as possible. A total of three readings were taken each time and the average measurement recorded on the patients' data capture form.

The digital algometer used was: The Algometer Commander: Pain Threshold Meter, PTH-AFT. Manufacturer: JTech Medical Industries, 357 West 910 South, Heber City, Utah, USA.

3.4.1.2 THE DIGITAL INCLINOMETER

The digital dual-inclinometer was used to measure each patient's active thoracic ranges of motion in flexion, extension, bilateral lateral flexion, and bilateral rotation.

Newton and Waddell (1991) conducted a study to test the validity and reliability of three methods of measuring lumbar spine mobility: digital inclinometer, khyphometer and finger to floor, as these were considered to be most suitable for routine clinical use, on a total of 60 subjects: 50 patients with low back pain and 10 normal people. The authors concluded that inter-test reliability for the inclinometer method was good, with an intra-class correlation value of 0.76, and validity was confirmed by X-ray measurements. It was noted that the inclinometer was quick and easy to use, and had the advantage of being able to measure a comprehensive group of tests of lumbar mobility.

Saur et al. (1996) conducted a study on 54 patients to measure the reliability and validity of measuring lumbar range of motion with an inclinometer. By correlating measurements based on anatomic reference points determined by radiographs and those taken using the inclinometer alone, the noninvasive inclinometer technique was concluded to be highly reliable and valid ($p < 0.001$), and a useful clinical tool for measuring lumbar range of motion.

In a study conducted by Lantz et al. (1999) on 62 asymptomatic subjects, the dual-inclinometer showed high clinical reliability for inter- and intra-examiner studies of total active motion of the cervical spine ($p < 0.0001$), except for extension ($p = 0.014$). No reason was given for this. For validity, simultaneous digital dual inclinometry and electrogoniometry were performed twice over a one-week interval, and both were concluded to be valid instruments, with mean between-instrument discrepancies close to zero.

Tsolakis (2001) recommended that more sensitive instrumentation than the manual BROM II goniometer be introduced in the measuring of thoracic spine range of motion, in order to reduce observer bias and increase the accuracy of readings. By utilizing the digital dual-inclinometer in the measurement of active thoracic spine range of motion, this study hopes to be a stepping-stone for more studies on the thoracic spine.

Prior to measurements being taken, the patient was educated on the use of the inclinometer and demonstrated the various movements required during measurement of active range of motion, by the researcher. All measurements were taken with the patient seated on a firm surface, with feet also supported on a firm surface. The patients maximum active range of motions from an erect neutral spine position in flexion, extension, bilateral lateral flexion and bilateral rotation were then measured in degrees, according to the protocol laid out in the manufacturers procedure manual and instructional video, and recorded on the patients' data capture form (Appendix G).

The dual inclinometer used was: The Dualer Lite. Manufacturer: JTech Medical Industries, 357 West 910 South, Heber City, Utah, USA.

3.4.2 SUBJECTIVE MEASUREMENTS

The study employed the Numerical Pain Rating Scale-101 questionnaire (NRS-101), to measure subjective pain intensity.

3.4.2.1 THE NUMERICAL PAIN RATING SCALE-101 QUESTIONAIRE (NRS-101).

In a comparative study of 6 pain intensity measures, Jensen et al. (1986) found the NRS-101 to be the most practical index. It is simple to administer and score and can be measured either in written and verbal form (Jensen et al. 1986).

Bolton and Wilkinson (1998) conducted a study to compare the responsiveness of three pain scales, and concluded that given the relative ease of use of the NRS, the scale is recommended for pain intensity measures in most types of outcome studies.

The NRS-101 required the patient to rate their level of pain intensity on a numerical scale from 0 to 100, with 0 representing "no pain at all", and 100 representing "pain as bad as it could be". The responses for least and worst pain were then added together and divided by 2 to obtain an average. This average was then used for statistical analysis.

3.5 STATISTICAL ANALYSIS

3.5.1 INTRODUCTION

A random sample of 40 patients were utilized in this study, with $n_1 = 20$ and $n_2 = 20$. The Technikon Natal research statistician was consulted with regards to the manner in which the research data was to be analyzed. Due to the sample size of 20 patients per group, non-parametric tests were used.

Eight clinical experiments were carried out: thoracic spinal flexion, extension, left and right lateral flexion, left and right rotation, digital algometer readings and the NRS-101 questionnaire. Readings were taken 3 times for all of the experiments, before the 1st and 3rd consultation and at the 5th consultation.

The statistical package SPSS was used to analyze the data obtained from the NRS-101 questionnaire, the digital algometer and the digital inclinometer.

3.5.2 INTER-GROUP COMPARISON (MANIPULATION GROUP VERSUS MOBILIZATION GROUP)

The Mann-Whitney U test, a non-parametric test was used to compare the manipulation and mobilization groups with regard to the NRS-101 questionnaire, the digital algometer and digital inclinometer readings.

This test was used to determine whether any significant difference existed between the 2 groups at the 1st, 3rd and 5th consultations for each of the variables, at the $\alpha = 0.05$ level of significance.

Hypothesis Testing

For the above test, the null hypothesis (H_0) stated that there was no difference between the thoracic spinal manipulation group and the mobilization group with respect to each of the variables.

The alternative hypothesis (H_1) stated that there was a significant difference.

α was set at a 0.05 level of significance.

- H_0: There was no difference between the groups.
- H_1: There was a difference between the groups.
- $\alpha = 0.05$ = level of significance of the test.

DECISION RULE

The null hypothesis (H_0) is rejected at the α level of significance if $p < \alpha/2$ where p is the observed level of significance or p-value. Failing this, the null hypothesis (H_0) is accepted at the same level of significance ($p \geq \alpha/2$).

3.5.3 INTRA-GROUP COMPARISON (MANIPULATION GROUP AND MOBILIZATION GROUP)

The Friedman's T-test coupled with the Multiple Comparison Procedure was used to determine whether any significant improvement occurred within each group with regards to the NRS-101 questionnaire, the digital algometer and digital inclinometer readings, between the first, third and fifth consultations. The Multiple Comparison Procedure called the Dunn Procedure (Daniel 1978) was used as a post-hoc test to determine which group differed from which other group, if the p value was small.

Hypothesis Testing:

For the above test, the null hypothesis (H_0) stated that there was no difference between the consultations with regards to the variable of interest.

The alternative hypothesis (H_1) stated that there was a significant difference between the consultations with regards to the variable of interest.

α was set at 0.05 level of significance.

DECISION RULE

For a one-tailed test:

- p = reported p – value/2 $< \alpha$ — -if H_1 is of form > and Z is positive; -if H_1 is of form < and Z is negative

- $p = 1$ – (reported p value)/2 $< \alpha$ — -if H_1 is of form > and Z is negative; -if H_1 is of form < and Z is positive

- $\alpha = 0.05$

p was the observed significance level of the test.
(Thomas 2001)

The Dunn Procedure:

If the null hypothesis (H_0) was rejected for the Friedman's T test, then this multiple comparison procedure had to be applied to determine which of the treatments were significantly different (Daniel, 1978).

CHAPTER FOUR

4.0 THE RESULTS

4.1 INTRODUCTION

This chapter represents the data collected during the study. It begins with a comparison of demographic data between the two groups. The results attained from statistical analysis of the raw data, as outlined in chapter 3, are then reported in tabular form with relevant interpretations in narrative text. Visual representation of the mean value changes of the 2 groups are then presented in the form of bar graphs, indicating trends within the 2 groups over the period of evaluation.

Key for abbreviations used in the following tables:

Group A:	Spinal Manipulation Group
Group B:	Passive Oscillatory Mobilization Group
S.D.:	Standard Deviation
C_j:	Consultation $_j$
NRS-101:	Numerical Pain Rating Scale-101 Questionnaire
Alg:	Algometer Reading
ROM:	Range Of Motion

4.2 DEMOGRAPHIC DATA

4.2.1 AGE DISTRIBUTION

Table 1: Age distribution within the sample of 40 patients.

AGE	GROUP A	GROUP B	TOTAL (N=40)
18 - 24	10	8	18 (45%)
25 - 34	9	7	16 (40%)
35 – 45	1	5	6 (15%)

4.2.2 GENDER DISTRIBUTION

Table 2: Gender distribution within the sample of 40 patients.

GENDER	GROUP A	GROUP B	TOTAL (N = 40)
MALE	9	12	21 (52.5%)
FEMALE	11	8	19 (47.5%)

4.2.3 RACE DISTRIBUTION

Table 3: Race distribution within the sample of 40 patients.

RACE	GROUP A	GROUP B	TOTAL (N = 40)
BLACK	0	2	2 (5%)
COLOURED	1	3	4 (10%)
ASIAN	4	7	11 (27.5%)
WHITE	15	8	23 (57.5%)

4.2.4 SIDE DISTRIBUTION OF PRESENTING COMPLAINT

Table 4: Side distribution of presenting thoracic dysfunction complaint within sample of 40 patients.

SIDE	GROUP A	GROUP B	TOTAL (N = 40)
Left-sided pain	6	4	10 (25%)
Right-sided pain	11	12	23 (57%)
Central pain	3	4	7 (18%)

4.2.5 REGION DISTRIBUTION OF THORACIC PRIMARY FIXATION

Table 5: Region distribution of primary fixation within the sample of 40 patients.

REGION	GROUP A	GROUP B	TOTAL (N = 40)
T1 – T4	10	4	14 (35%)
T5 – T9	9	14	23 (57.5%)
T10 – T12	1	2	3 (7.5%)

4.2.6 TYPE AND DIRECTION DISTRIBUTION OF THORACIC FIXATIONS

Table 6: Type and direction distribution of thoracic fixations in the sample of 40 patients (percentage).

FIXATION	GROUP A (%)	GROUP B (%)
Flexion	5	6
Extension	29	31
Left Lateral Flexion	10	11
Right Lateral Flexion	18	11
Left Rotation	8	12
Right Rotation	30	29

4.2.7 OCCUPATION DISTRIBUTION

Table 7: Occupation distribution within the sample of 40 patients.

OCCUPATION	TOTAL (N = 40)		OCCUPATION	TOTAL (N = 40)
CHIRO STUDENT	11		UNEMPLOYED	1
STUDENT	5		DRAUGHTSMAN	1
BUSINESSMAN	1		SECRETARY	1
WAITRON	3		TECHNICIAN	3
POLICEMAN	2		TEACHER	1
LECTURER	2		NURSE	1
DIRECTOR	1		MANAGER	2
SHIPS AGENT	1		SELF-EMPLOYED	4

4.3 RESULTS OF DATA ANALYSIS

4.3.1 INTER-GROUP COMPARISON (Group A versus Group B)

4.3.1.1 SUBJECTIVE MEASURE

NRS-101 QUESTIONNAIRE

Table 8: Comparison of Group A and Group B using the Mann-Whitney U test to analyze results obtained from the NRS-101 Questionnaire at consultations 1, 3 and 5.

	GROUP A		GROUP B
	MEAN	p-value	MEAN
CONSULT 1	18.35	0.242	22.65
CONSULT 3	18.70	0.327	22.30
CONSULT 5	18.20	0.211	22.80

The values that are shown for consultation 1 are the values that were obtained before the first treatment, indicating that both Group A and Group B started off similarly ($p \geq 0.05$).

The null hypothesis is accepted for the Numerical Pain Rating Scale-101, indicating that at the $\alpha = 0.05$ level of significance, there was no difference in pain perception between the groups.

4.3.1.2 OBJECTIVE MEASURES

DIGITAL ALGOMETER READINGS

Table 9: Comparison of Group A and Group B using the Mann-Whitney U test to analyze the results obtained from the digital algometer readings at consultations 1, 3 and 5.

	GROUP A		GROUP B
	MEAN	p-value	MEAN
CONSULT 1	20.77	0.882	20.23
CONSULT 3	19.77	0.695	21.23
CONSULT 5	18.40	0.256	22.60

The values that are shown for consultation 1 are the values that were obtained before the first treatment, indicating that both Group A and Group B started off similarly ($p \geq 0.05$).

The null hypothesis is accepted for the digital algometer readings, indicating that at the $\alpha = 0.05$ level of significance, there was no difference in pressure threshold between the groups.

THORACIC FLEXION RANGE OF MOTION READINGS

Table 10: Comparison of Group A and Group B using the Mann-Whitney U test to analyze the results obtained from the digital inclinometer thoracic flexion readings at consultations 1, 3 and 5.

	GROUP A		GROUP B
	MEAN	p-value	MEAN
CONSULT 1	20.02	0.797	20.98
CONSULT 3	19.55	0.606	21.45
CONSULT 5	20.15	0.850	20.85

The values that are shown for consultation 1 are the values that were obtained before the first treatment, indicating that both Group A and Group B started off similarly ($p \geq 0.05$).

The null hypothesis is accepted for the digital inclinometer thoracic flexion readings, indicating that at the $\alpha = 0.05$ level of significance, there was no difference in thoracic flexion readings between the groups.

THORACIC EXTENSION RANGE OF MOTION READINGS

Table 11: Comparison of Group A and Group B using the Mann-Whitney U test to analyze the results obtained from the digital inclinometer thoracic extension readings at consultations 1, 3 and 5.

	GROUP A		GROUP B
	MEAN	p-value	MEAN
CONSULT 1	17.38	0.090	23.63
CONSULT 3	18.08	0.188	22.92
CONSULT 5	18.65	0.316	22.35

The values that are shown for consultation 1 are the values that were obtained before the first treatment, indicating that both Group A and Group B started off similarly ($p \geq 0.05$).

The null hypothesis is accepted for the digital inclinometer thoracic extension readings, indicating that at the $\alpha = 0.05$ level of significance, there was no difference in thoracic extension readings between the groups.

THORACIC LEFT LATERAL FLEXION RANGE OF MOTION READINGS

Table 12: Comparison of Group A and Group B using the Mann-Whitney U test to analyze the results obtained from the digital inclinometer thoracic left lateral flexion readings at consultations 1, 3 and 5.

	GROUP A		GROUP B
	MEAN	p-value	MEAN
CONSULT 1	19.75	0.685	21.25
CONSULT 3	19.63	0.636	21.38
CONSULT 5	18.5	0.279	22.50

The values that are shown for consultation 1 are the values that were obtained before the first treatment, indicating that both Group A and Group B started off similarly ($p \geq 0.05$).

The null hypothesis is accepted for the digital inclinometer thoracic left lateral flexion readings, indicating that at the $\alpha = 0.05$ level of significance, there was no difference in thoracic left lateral flexion readings between the groups.

THORACIC RIGHT LATERAL FLEXION RANGE OF MOTION READINGS

Table 13: Comparison of Group A and Group B using the Mann-Whitney U test to analyze the results obtained from the digital inclinometer thoracic right lateral flexion readings at consultations 1, 3 and 5.

	GROUP A		GROUP B
	MEAN	p-value	MEAN
CONSULT 1	19.05	0.432	21.95
CONSULT 3	19.17	0.473	21.83
CONSULT 5	18.17	0.207	22.83

The values that are shown for consultation 1 are the values that were obtained before the first treatment, indicating that both Group A and Group B started off similarly ($p \geq 0.05$).

The null hypothesis is accepted for the digital inclinometer thoracic right lateral flexion readings, indicating that at the $\alpha = 0.05$ level of significance, there was no difference in thoracic right lateral flexion readings between the groups.

THORACIC LEFT ROTATION RANGE OF MOTION READINGS

Table 14: Comparison of Group A and Group B using the Mann-Whitney U test to analyze the results obtained from the digital inclinometer thoracic left rotation readings at consultations 1, 3 and 5.

	GROUP A		GROUP B
	MEAN	p-value	MEAN
CONSULT 1	17.13	0.068	23.88
CONSULT 3	17.02	0.060	23.98
CONSULT 5	17.25	0.078	23.75

The values that are shown for consultation 1 are the values that were obtained before the first treatment, indicating that both Group A and Group B started off similarly ($p \geq 0.05$).

The null hypothesis is accepted for the digital inclinometer thoracic left rotation readings, indicating that at the $\alpha = 0.05$ level of significance, there was no difference in thoracic left rotation readings between the groups.

THORACIC RIGHT ROTATION RANGE OF MOTION READINGS

Table 15: Comparison of Group A and Group B using the Mann-Whitney U test to analyze the results obtained from the digital inclinometer thoracic right rotation readings at consultations 1, 3 and 5.

	GROUP A		GROUP B
	MEAN	p-value	MEAN
CONSULT 1	17.40	0.093	23.60
CONSULT 3	17.65	0.122	23.35
CONSULT 5	17.92	0.163	23.08

The values that are shown for consultation 1 are the values that were obtained before the first treatment, indicating that both Group A and Group B started off similarly ($p \geq 0.05$).

The null hypothesis is accepted for the digital inclinometer thoracic right rotation readings, indicating that at the $\alpha = 0.05$ level of significance, there was no difference in thoracic right rotation readings between the groups.

4.3.2 INTRA-GROUP COMPARISON

4.3.2.1 SUBJECTIVE MEASURE

NRS-101 QUESTIONNAIRE

Table 16: Comparison of Group A and Group B using the Friedman's T test to analyze results obtained from the NRS-101 within the groups, at consultations 1, 3 and 5.

	NUMERICAL PAIN RATING SCALE (NRS-101)					
	GROUP A			GROUP B		
	Consult 1	Consult 3	Consult 5	Consult 1	Consult 3	Consult 5
MEAN	41.83	29.33	18.13	46.38	34.38	24.25
S.D.	12.59	13.94	14.62	12.63	14.53	16.39
p-value	**0.000 (<0.001)**			**0.000 (<0.001)**		

The null hypothesis is rejected for both Groups A and B, for the Numerical Pain Rating Scale-101, indicating that at the $\alpha = 0.05$ level of significance there was a statistically significant improvement in pain perception between the three consultations, in each group.

4.3.2.2 OBJECTIVE MEASURES

DIGITAL ALGOMETER READINGS

Table 17: Comparison of Group A and Group B using the Friedman's T test to analyze results obtained from the digital algometer readings within the groups, at consultations 1, 3 and 5.

	DIGITAL ALGOMETER READINGS					
	GROUP A			GROUP B		
	Consult 1	Consult 3	Consult 5	Consult 1	Consult 3	Consult 5
MEAN	25.46	29.02	32.24	26.01	31.98	35.91
S.D.	7.03	8.43	9.83	7.80	11.20	10.01
p-value	**0.000 (<0.001)**			**0.000 (<0.001)**		

The null hypothesis is rejected for both Groups A and B, for the digital algometer readings, indicating that at the $\alpha = 0.05$ level of significance there was a statistically significant improvement in pressure threshold between the three consultations, in each group.

THORACIC FLEXION RANGE OF MOTION READINGS

Table 18: Comparison of Group A and Group B using the Friedman's T test to analyze results obtained from the digital inclinometer thoracic flexion readings within the groups, at consultations 1, 3 and 5.

	THORACIC FLEXION READINGS					
	GROUP A			GROUP B		
	Consult 1	Consult 3	Consult 5	Consult 1	Consult 3	Consult 5
MEAN	30.30	32.65	35.00	30.75	33.40	35.15
S.D.	9.60	9.00	10.23	10.94	10.39	10.01
p-value	0.000 (<0.001)			0.000 (<0.001)		

The null hypothesis is rejected for both Groups A and B, for the digital inclinometer thoracic flexion readings, indicating that at the $\alpha = 0.05$ level of significance there was a statistically significant improvement in thoracic flexion range of motion between the three consultations, in each group.

THORACIC EXTENSION RANGE OF MOTION READINGS

Table 19: Comparison of Group A and Group B using the Friedman's T test to analyze results obtained from the digital inclinometer thoracic extension readings within the groups, at consultations 1, 3 and 5.

	THORACIC EXTENSION READINGS					
	GROUP A			GROUP B		
	Consult 1	Consult 3	Consult 5	Consult 1	Consult 3	Consult 5
MEAN	25.50	28.30	30.30	30.10	32.95	33.90
S.D.	9.97	9.94	9.97	9.62	9.68	9.59
p-value	**0.000 (<0.001)**			**0.000 (<0.001)**		

The null hypothesis is rejected for both Groups A and B, for the digital inclinometer thoracic extension readings, indicating that at the $\alpha = 0.05$ level of significance there was a statistically significant improvement in thoracic extension range of motion between the three consultations, in each group.

THORACIC LEFT LATERAL FLEXION RANGE OF MOTION READINGS

Table 20: Comparison of Group A and Group B using the Friedman's T test to analyze results obtained from the digital inclinometer thoracic left lateral flexion readings within the groups, at consultations 1, 3 and 5.

	THORACIC LEFT LATERAL FLEXION READINGS					
	GROUP A			**GROUP B**		
	Consult 1	**Consult 3**	**Consult 5**	**Consult 1**	**Consult 3**	**Consult 5**
MEAN	30.05	30.60	31.7	31.8	32.45	34.7
S.D.	10.63	9.42	8.21	8.64	8.54	7.91
p-value	**0.006**			**0.002**		

The null hypothesis is rejected for both Groups A and B, for the digital inclinometer thoracic left lateral flexion readings, indicating that at the $\alpha = 0.05$ level of significance there was a statistically significant improvement in thoracic left lateral flexion range of motion between the three consultations, in each group.

THORACIC RIGHT LATERAL FLEXION RANGE OF MOTION READINGS

Table 21: Comparison of Group A and Group B using the Friedman's T test to analyze results obtained from the digital inclinometer thoracic right lateral flexion readings within the groups, at consultations 1, 3 and 5.

	THORACIC RIGHT LATERAL FLEXION READINGS					
	GROUP A			**GROUP B**		
	Consult 1	**Consult 3**	**Consult 5**	**Consult 1**	**Consult 3**	**Consult 5**
MEAN	29.80	32.00	33.25	31.30	32.70	35.60
S.D.	7.74	6.90	6.90	7.85	6.70	7.03
p-value	**0.000 (<0.001)**			**0.000 (<0.001)**		

The null hypothesis is rejected for both Groups A and B, for the digital inclinometer thoracic right lateral flexion readings, indicating that at the α = 0.05 level of significance there was a statistically significant improvement in thoracic right lateral flexion range of motion between the three consultations, in each group.

THORACIC LEFT ROTATION RANGE OF MOTION READINGS

Table 22: Comparison of Group A and Group B using the Friedman's T test to analyze results obtained from the digital inclinometer thoracic left rotation readings within the groups, at consultations 1, 3 and 5.

	THORACIC LEFT ROTATION READINGS					
	GROUP A			GROUP B		
	Consult 1	Consult 3	Consult 5	Consult 1	Consult 3	Consult 5
MEAN	28.90	30.85	32.15	35.25	38.05	38.50
S.D.	10.04	9.72	9.95	11.11	9.82	9.46
p-value	**0.000 (<0.001)**			**0.000 (<0.001)**		

The null hypothesis is rejected for both Groups A and B, for the digital inclinometer thoracic left rotation readings, indicating that at the α = 0.05 level of significance there was a statistically significant improvement in thoracic left rotation range of motion between the three consultations, in each group.

THORACIC RIGHT ROTATION RANGE OF MOTION READINGS

Table 23: Comparison of Group A and Group B using the Friedman's T test to analyze results obtained from the digital inclinometer thoracic right rotation readings within the groups, at consultations 1, 3 and 5.

	THORACIC RIGHT ROTATION READINGS					
	GROUP A			GROUP B		
	Consult 1	Consult 3	Consult 5	Consult 1	Consult 3	Consult 5
MEAN	29.05	32.65	33.65	34.05	36.65	37.55
S.D.	9.18	9.29	9.64	9.50	8.86	8.57
p-value	**0.000 (<0.001)**			**0.000 (<0.001)**		

The null hypothesis is rejected for both Groups A and B, for the digital inclinometer thoracic right rotation readings, indicating that at the $\alpha = 0.05$ level of significance there was a statistically significant improvement in thoracic right rotation range of motion between the three consultations, in each group.

4.3.2.3 <u>THE DUNN'S PROCEDURE (MULTIPLE COMPARISON TEST)</u>

If the null hypothesis (H_0) is rejected for the Friedman's T test, then this multiple comparison procedure will have to be applied to determine between which treatments a significant improvement occurred (Daniel 1978).

The null hypothesis (H_0) was rejected for the subjective and objective findings of Group A (SMT) and Group B (Mobilization), making it necessary to apply the Dunn's procedure to the Numerical Pain Rating Scale-101 questionnaire, the digital algometer and digital inclinometer readings, to determine which of the treatments were significantly different.

The Dunn's procedure is as follows:

Let C_i and C_i^1 be the j^{th} and j^{1th} treatment rank totals.
Let α be the experiment-wise error rate. Usually α = 0.10

If $|C_j - C_j^1| \geq Z \sqrt{\frac{bk(k+1)}{6}}$, then C_j and C_j^1 are declared significant.

In the above formula:

b = the number of blocks

k = the number of consultations

Z = value in inverse normal distribution corresponding to $(1 - [\alpha/k\,(k\text{-}1)\,])$.

In this case, k = 3, b = 20, α = 0.10 and z = 2.12

i.e. If the difference of rank totals ≥ 13.408, then C_i and C_i^1 are declared significant.

For the purpose of this study, C_1 is the 1st consultation, C_3 is the 3rd consultation and C_5 is the 5th consultation.

SUBJECTIVE MEASURE

NRS-101 QUESTIONNAIRE IN GROUP A

Table 24: Dunn's procedure for the NRS-101 (GROUP A)

	Rank Total	Difference	Rank Total	
C_1	57.6	18.0	39.6	C_3
C_1	57.6	34.6	23.0	C_5
C_3	39.6	16.6	23.0	C_5

$C_1 - C_3 = 18.0 \geq 13.408$, therefore between consultation 1 and 3, the result is declared statistically significant.

$C_1 - C_5 = 34.6 \geq 13.408$, therefore between consultations 1 and 5, the result is declared statistically significant.

$C_3 - C_5 = 16.6 \geq 13.408$, therefore between consultations 3 and 5, the result is declared statistically significant.

This implies that an improvement exists between consultations 1 and 3, 1 and 5 and 3 and 5, with regards to the subjective data on pain perception for Group A.

NRS-101 QUESTIONNAIRE IN GROUP B

Table 25: Dunn's procedure for the NRS-101 (GROUP B)

	Rank Total	Difference	Rank Total	
C_1	57.6	18.6	39.0	**C_3**
C_1	57.6	34.2	23.4	**C_5**
C_3	39.0	15.6	23.4	**C_5**

$C_1 - C_3 = 18.6 \geq 13.408$, therefore between consultation 1 and 3, the result is declared statistically significant.

$C_1 - C_5 = 34.2 \geq 13.408$, therefore between consultations 1 and 5, the result is declared statistically significant.

$C_3 - C_5 = 15.6 \geq 13.408$, therefore between consultations 3 and 5, the result is declared statistically significant.

This implies that an improvement exists between consultations 1 and 3, 1 and 5 and 3 and 5, with regards to the subjective data on pain perception for Group B.

OBJECTIVE DATA

DIGITAL ALGOMETER READINGS IN GROUP A

Table 26: Dunn's procedure for the digital algometer readings (GROUP A)

	Rank Total	Difference	Rank Total	
C_1	25.4	12.6	38.0	C_3
C_1	25.4	31.2	56.6	C_5
C_3	38.0	18.6	56.6	C_5

$C_1 - C_3 = 12.6 < 13.408$, therefore between consultation 1 and 3, the result is declared insignificant.

$C_1 - C_5 = 31.2 \geq 13.408$, therefore between consultations 1 and 5, the result is declared statistically significant.

$C_3 - C_5 = 18.6 \geq 13.408$, therefore between consultations 3 and 5, the result is declared statistically significant.

This implies that an improvement exists between consultations 1 and 5 and 3 and 5, but that no improvement can be demonstrated between consultation 1 and 3 with regards to the digital algometer pressure threshold reading for Group A.

DIGITAL ALGOMETER READINGS IN GROUP B

Table 27: Dunn's procedure for the digital algometer readings (GROUP B)

	Rank Total	Difference	Rank Total	
C_1	24.0	14.0	38.0	**C_3**
C_1	24.0	34.0	58.0	**C_5**
C_3	38.0	20.0	58.0	**C_5**

$C_1 - C_3 = 14.0 \geq 13.408$, therefore between consultation 1 and 3, the result is declared statistically significant.

$C_1 - C_5 = 34.0 \geq 13.408$, therefore between consultations 1 and 5, the result is declared statistically significant.

$C_3 - C_5 = 20.0 \geq 13.408$, therefore between consultations 3 and 5, the result is declared statistically significant.

This implies that an improvement exists between consultations 1 and 3, 1 and 5 and 3 and 5, with regards to the digital algometer pressure threshold readings for Group B.

THORACIC FLEXION READINGS IN GROUP A

Table 28: Dunn's procedure for the digital inclinometer thoracic flexion readings (GROUP A)

	Rank Total	Difference	Rank Total	
C_1	26.6	13.4	40.0	C_3
C_1	26.6	26.8	53.4	C_5
C_3	40.0	13.4	53.4	C_5

$C_1 - C_3 = 13.4 < 13.408$, therefore between consultation 1 and 3, the result is declared insignificant.

$C_1 - C_5 = 26.8 \geq 13.408$, therefore between consultations 1 and 5, the result is declared statistically significant.

$C_3 - C_5 = 13.4 < 13.408$, therefore between consultations 3 and 5, the result is declared insignificant.

This implies that an improvement exists between consultations 1 and 5, but no improvement can be demonstrated between consultations 1 and 3,and 3 and 5 respectively, with regards to the thoracic flexion range of motion readings for Group A.

THORACIC FLEXION READINGS IN GROUP B

Table 29: **Dunn's procedure for the digital inclinometer thoracic flexion readings (GROUP B)**

	Rank Total	Difference	Rank Total	
C_1	25.4	15.6	41.0	C_3
C_1	25.4	28.0	53.4	C_5
C_3	41.0	12.4	53.4	C_5

$C_1 - C_3 = 15.6 \geq 13.408$, therefore between consultation 1 and 3, the result is declared statistically significant.

$C_1 - C_5 = 28.0 \geq 13.408$, therefore between consultations 1 and 5, the result is declared statistically significant.

$C_3 - C_5 = 12.4 < 13.408$, therefore between consultations 3 and 5, the result is declared insignificant.

This implies that an improvement exists between consultations 1 and 3, and 1 and 5, but no improvement can be demonstrated between consultations 3and 5, with regards to the thoracic flexion range of motion readings for Group B.

THORACIC EXTENSION READINGS IN GROUP A

Table 30: Dunn's procedure for the digital inclinometer thoracic extension readings (GROUP A)

	Rank Total	Difference	Rank Total	
C_1	20.0	21.6	41.6	**C_3**
C_1	20.0	38.4	58.4	**C_5**
C_3	41.6	16.8	58.4	**C_5**

$C_1 - C_3 = 21.6 \geq 13.408$, therefore between consultation 1 and 3, the result is declared statistically significant.

$C_1 - C_5 = 38.4 \geq 13.408$, therefore between consultations 1 and 5, the result is declared statistically significant.

$C_3 - C_5 = 16.8 \geq 13.408$, therefore between consultations 3 and 5, the result is declared statistically significant.

This implies that an improvement exists between consultations 1 and 3, 1 and 5 and 3 and 5, with regards to the thoracic extension range of motion readings for Group A..

THORACIC EXTENSION READINGS IN GROUP B

Table 31: Dunn's procedure for the digital inclinometer thoracic extension readings (GROUP B)

	Rank Total	Difference	Rank Total	
C_1	23.4	18.6	42.0	**C_3**
C_1	23.4	31.0	54.4	**C_5**
C_3	42.0	12.4	54.4	**C_5**

$C_1 - C_3 = 18.6 \geq 13.408$, therefore between consultation 1 and 3, the result is declared statistically significant.

$C_1 - C_5 = 31.0 \geq 13.408$, therefore between consultations 1 and 5, the result is declared statistically significant.

$C_3 - C_5 = 12.4 < 13.408$, therefore between consultations 3 and 5, the result is declared insignificant.

This implies that an improvement exists between consultations 1 and 3, and 1 and 5, but no improvement can be demonstrated between consultations 3 and 5, with regards to the thoracic extension range of motion readings for Group B.

THORACIC LEFT LATERAL FLEXION READINGS IN GROUP A

Table 32: Dunn's procedure for the digital inclinometer thoracic left lateral flexion readings (GROUP A)

	Rank Total	Difference	Rank Total	
C_1	30.4	10.2	40.6	C_3
C_1	30.4	18.6	49.0	C_5
C_3	40.6	8.4	49.0	C_5

$C_1 – C_3 = 10.2 < 13.408$, therefore between consultation 1 and 3, the result is declared insignificant.

$C_1 – C_5 = 18.6 \geq 13.408$, therefore between consultations 1 and 5, the result is declared statistically significant.

$C_3 – C_5 = 8.4 < 13.408$, therefore between consultations 3 and 5, the result is declared insignificant.

This implies that an improvement exists between consultations 1 and 5, but no improvement can be demonstrated between consultations 1 and 3, and 3 and 5, with regards to the thoracic left lateral flexion range of motion readings for Group A.

THORACIC LEFT LATERAL FLEXION READINGS IN GROUP B

Table 33: Dunn's procedure for the digital inclinometer thoracic left lateral flexion readings (GROUP B)

	Rank Total	Difference	Rank Total	
C_1	33.4	2.6	36.0	C_3
C_1	33.4	17.2	50.6	C_5
C_3	36.0	14.6	50.6	C_5

$C_1 - C_3 = 2.6 < 13.408$, therefore between consultation 1 and 3, the result is declared insignificant.

$C_1 - C_5 = 17.2 \geq 13.408$, therefore between consultations 1 and 5, the result is declared statistically significant.

$C_3 - C_5 = 14.6 \geq 13.408$, therefore between consultations 3 and 5, the result is declared statistically significant.

This implies that an improvement exists between consultations 1 and 5, and 3 and 5, but no improvement can be demonstrated between consultations 1 and 3, with regards to the thoracic left lateral flexion range of motion reading for Group B.

THORACIC RIGHT LATERAL FLEXION READING IN GROUP A

Table 34: Dunn's procedure for the digital inclinometer thoracic right lateral flexion readings (GROUP A)

	Rank Total	Difference	Rank Total	
C_1	26.6	14.4	41.0	**C_3**
C_1	26.6	26.0	52.6	**C_5**
C_3	41.0	11.6	52.6	**C_5**

$C_1 - C_3 = 14.4 \geq 13.408$, therefore between consultation 1 and 3, the result is declared statistically significant.

$C_1 - C_5 = 26.0 \geq 13.408$, therefore between consultations 1 and 5, the result is declared statistically significant.

$C_3 - C_5 = 11.6 < 13.408$, therefore between consultations 3 and 5, the result is declared insignificant.

This implies that an improvement exists between consultations 1 and 3, and 1 and 5, but no improvement can be demonstrated between consultations 3 and 5, with regards to the thoracic right lateral flexion range of motion reading for Group A.

THORACIC RIGHT LATERAL FLEXION READING IN GROUP B

Table 35: Dunn's procedure for the digital inclinometer thoracic right lateral flexion readings (GROUP B)

	Rank Total	Difference	Rank Total	
C_1	26.0	12.0	38.0	C_3
C_1	26.0	30.0	56.0	C_5
C_3	38.0	18.0	56.0	C_5

$C_1 - C_3 = 12.0 < 13.408$, therefore between consultation 1 and 3, the result is declared insignificant.

$C_1 - C_5 = 30.0 \geq 13.408$, therefore between consultations 1 and 5, the result is declared statistically significant.

$C_3 - C_5 = 18.0 \geq 13.408$, therefore between consultations 3 and 5, the result is declared statistically significant.

This implies that an improvement exists between consultations 1 and 5 and 3 and 5, but no improvement can be demonstrated between consultations 1 and 3, with regards to the thoracic right lateral flexion range of motion reading for Group B.

THORACIC LEFT ROTATION READINGS IN GROUP A

Table 36: Dunn's procedure for the digital inclinometer thoracic left rotation readings (GROUP A)

	Rank Total	Difference	Rank Total	
C_1	26.0	13.0	39.0	**C_3**
C_1	26.0	29.0	55.0	**C_5**
C_3	39.0	16.0	55.0	**C_5**

$C_1 - C_3 = 13.0 < 13.408$, therefore between consultation 1 and 3, the result is declared insignificant.

$C_1 - C_5 = 29.0 \geq 13.408$, therefore between consultations 1 and 5, the result is declared statistically significant.

$C_3 - C_5 = 16.0 \geq 13.408$, therefore between consultations 3 and 5, the result is declared statistically significant.

This implies that an improvement exists between consultations 1 and 5 and 3 and 5, but no improvement can be demonstrated between consultations 1 and 3, with regards to the thoracic left rotation range of motion reading for Group A.

THORACIC LEFT ROTATION READING IN GROUP B

Table 37: Dunn's procedure for the digital inclinometer thoracic left rotation readings (GROUP B)

	Rank Total	Difference	Rank Total	
C_1	27.6	15.0	42.6	C_3
C_1	27.6	22.4	50.0	C_5
C_3	42.6	7.4	50.0	C_5

$C_1 - C_3 = 15.0 \geq 13.408$, therefore between consultation 1 and 3, the result is declared statistically significant.

$C_1 - C_5 = 22.4 \geq 13.408$, therefore between consultations 1 and 5, the result is declared statistically significant.

$C_3 - C_5 = 7.4 < 13.408$, therefore between consultations 3 and 5, the result is declared insignificant.

This implies that an improvement exists between consultations 1 and 3, and 1 and 5, but no improvement can be demonstrated between consultations 3 and 5, with regards to the thoracic left rotation range of motion reading for Group B.

THORACIC RIGHT ROTATION READING IN GROUP A

Table 38: Dunn's procedure for the digital inclinometer thoracic right rotation readings (GROUP A)

	Rank Total	Difference	Rank Total	
C_1	23.0	19.0	42.0	C_3
C_1	23.0	22.0	55.0	C_5
C_3	42.0	13.0	55.0	C_5

$C_1 - C_3 = 19.0 \geq 13.408$, therefore between consultation 1 and 3, the result is declared statistically significant.

$C_1 - C_5 = 22.0 \geq 13.408$, therefore between consultations 1 and 5, the result is declared statistically significant.

$C_3 - C_5 = 13.0 < 13.408$, therefore between consultations 3 and 5, the result is declared insignificant.

This implies that an improvement exists between consultations 1 and 3,and 1 and 5, but no improvement can be demonstrated between consultations 3 and 5, with regards to the thoracic right rotation range of motion reading for Group A.

THORACIC RIGHT ROTATION READING IN GROUP B

Table 39: Dunn's procedure for the digital inclinometer thoracic right rotation readings (GROUP B)

	Rank Total	Difference	Rank Total	
C_1	25.4	14.6	40.0	C_3
C_1	25.4	29.0	54.4	C_5
C_3	40.0	14.4	54.4	C_5

$C_1 - C_3 = 14.6 \geq 13.408$, therefore between consultation 1 and 3, the result is declared statistically significant.

$C_1 - C_5 = 29.0 \geq 13.408$, therefore between consultations 1 and 5, the result is declared statistically significant.

$C_3 - C_5 = 14.4 \geq 13.408$, therefore between consultations 3 and 5, the result is declared statistically significant.

This implies that an improvement exists between consultations 1 and 3, 1 and 5 and 3 and 5, with regards to the thoracic right rotation range of motion readings for Group B.

4.4 COMPARISON OF TRENDS

Figures 1 – 8 are visual representations of the mean value changes of Group A and B found within the 1st, 3rd and 5th consultation. These graphs serve to indicate trends within the 2 groups over the evaluation period.

4.4.1 MEAN NRS-101 VALUES

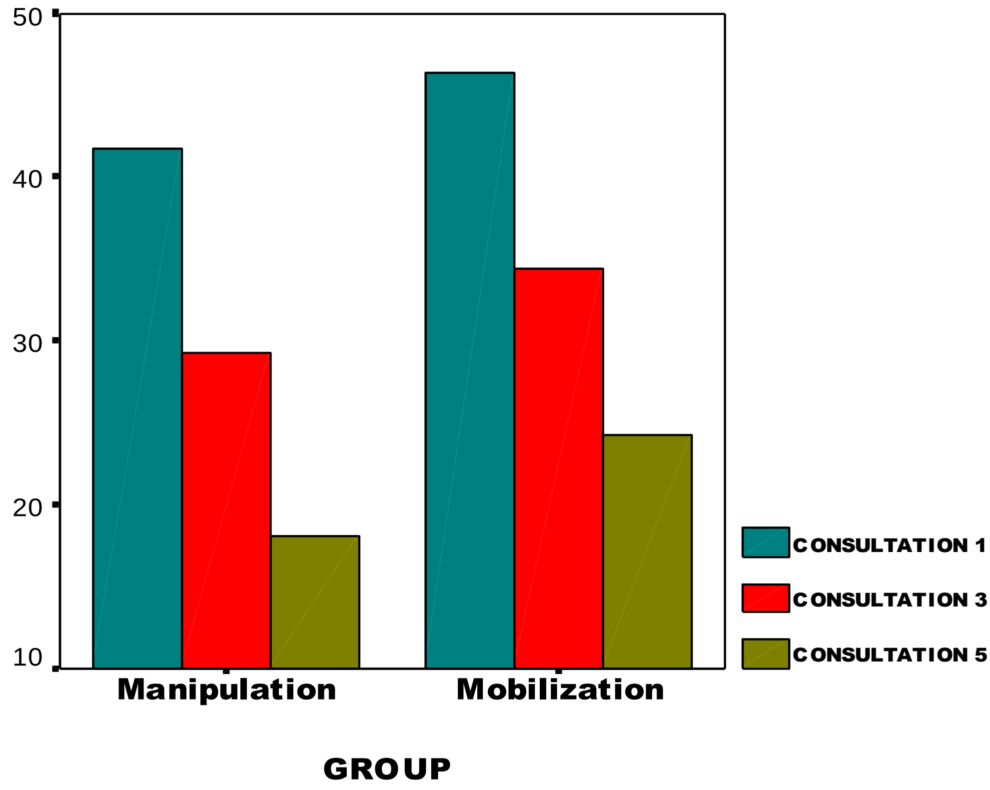

Figure 1: Changes in mean percentage of pain perception over the period of the evaluation.

4.4.2 MEAN DIGITAL ALGOMETER VALUES

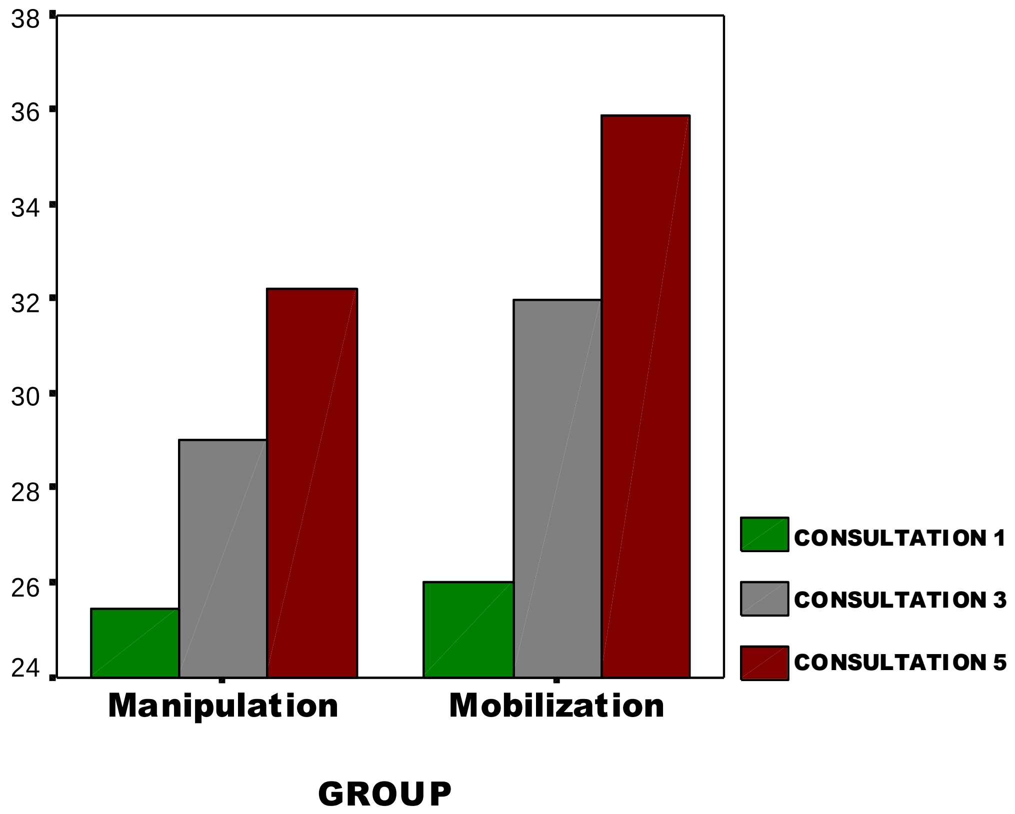

Figure 2: Changes in mean algometer values over the period of the evaluation.

4.4.3 MEAN THORACIC FLEXION VALUES

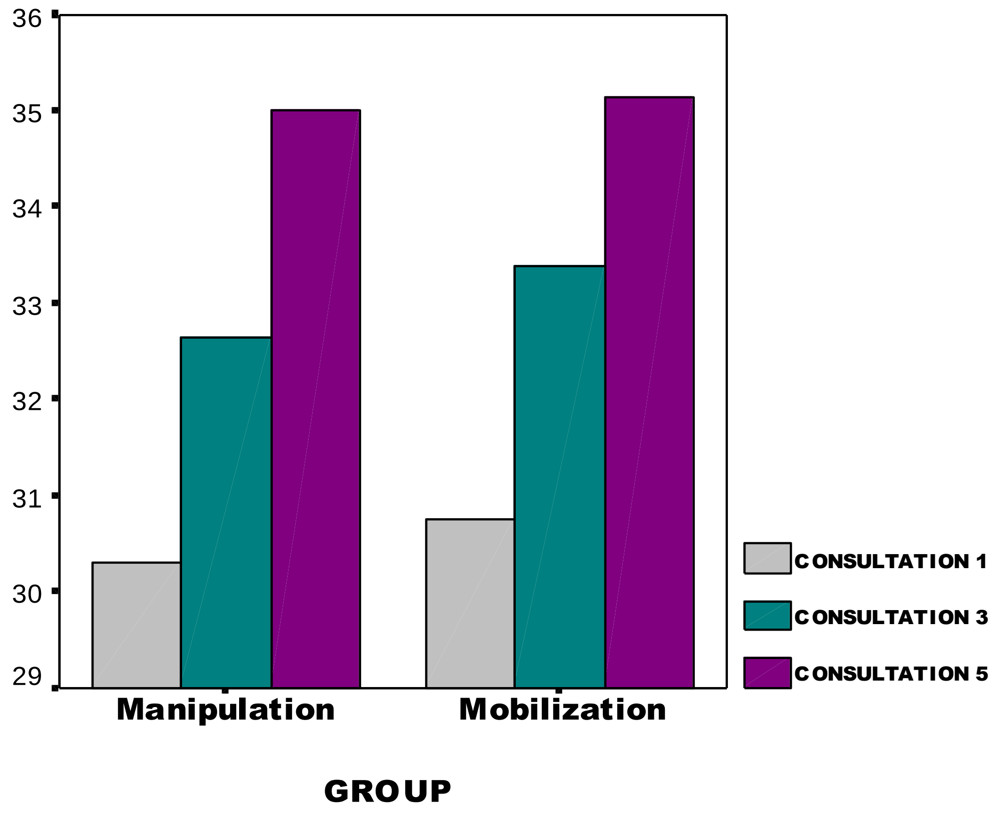

Figure 3: Changes in mean flexion values over the period of the evaluation.

4.4.4 MEAN THORACIC EXTENSION VALUES

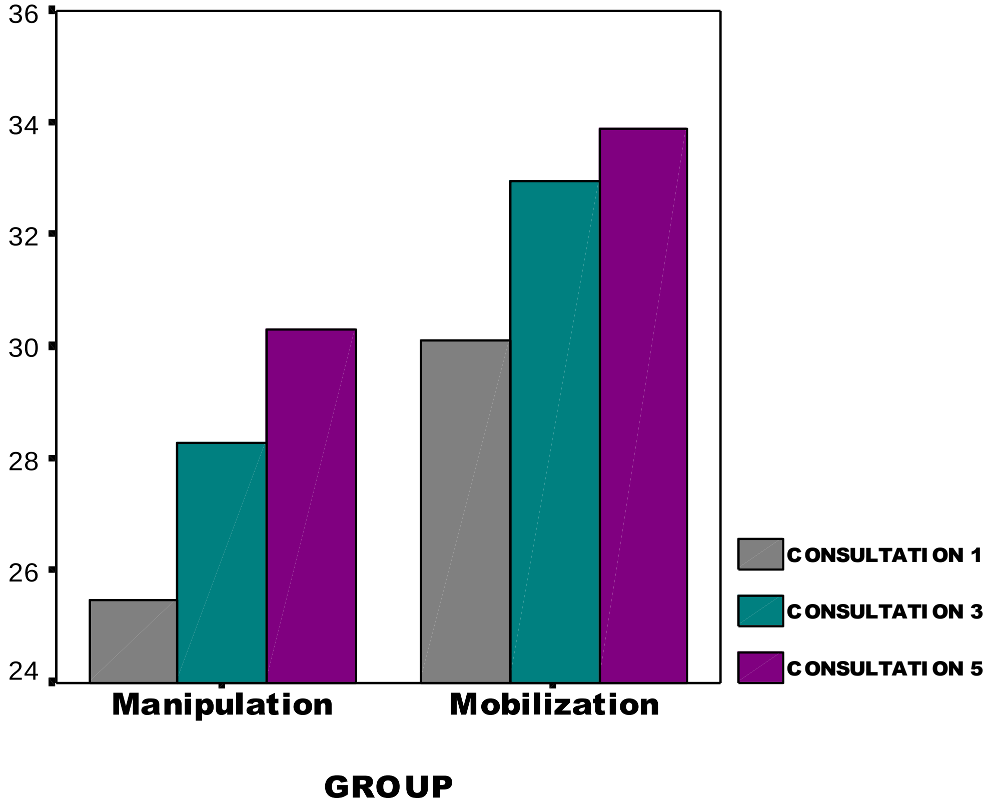

Figure 4: Changes in mean extension values over the period of the evaluation.

4.4.5 MEAN THORACIC LEFT LATERAL FLEXION VALUES

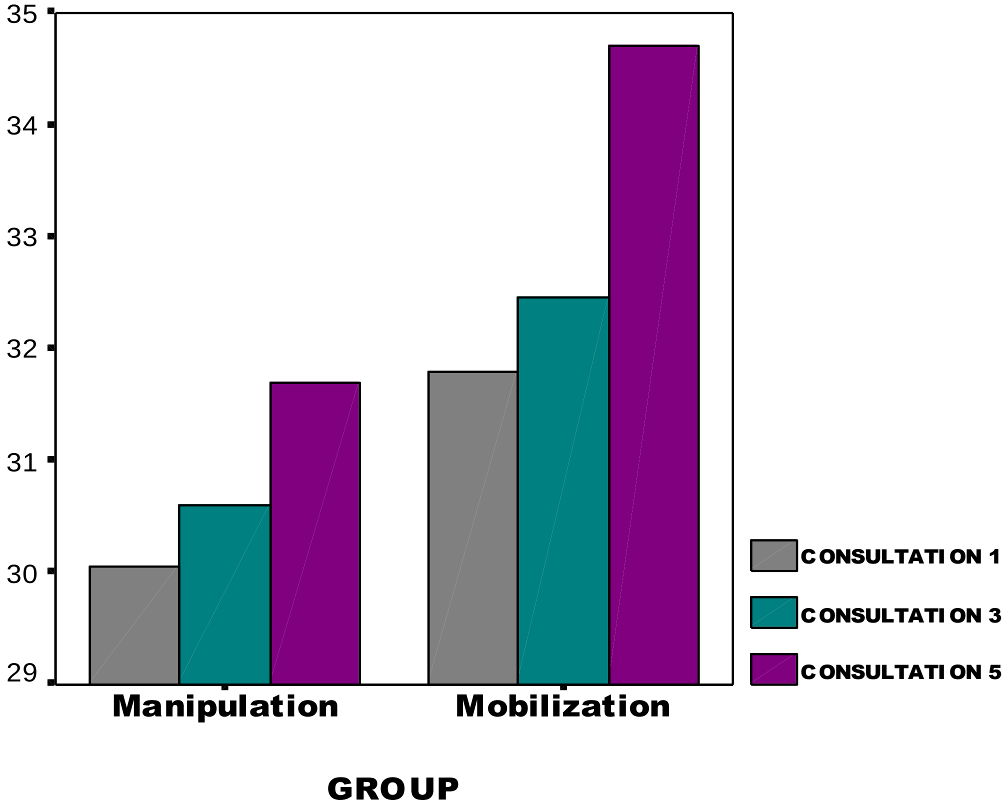

Figure 5: Changes in mean left lateral flexion values over the period of the evaluation.

4.4.6 MEAN THORACIC RIGHT LATERAL FLEXION VALUES

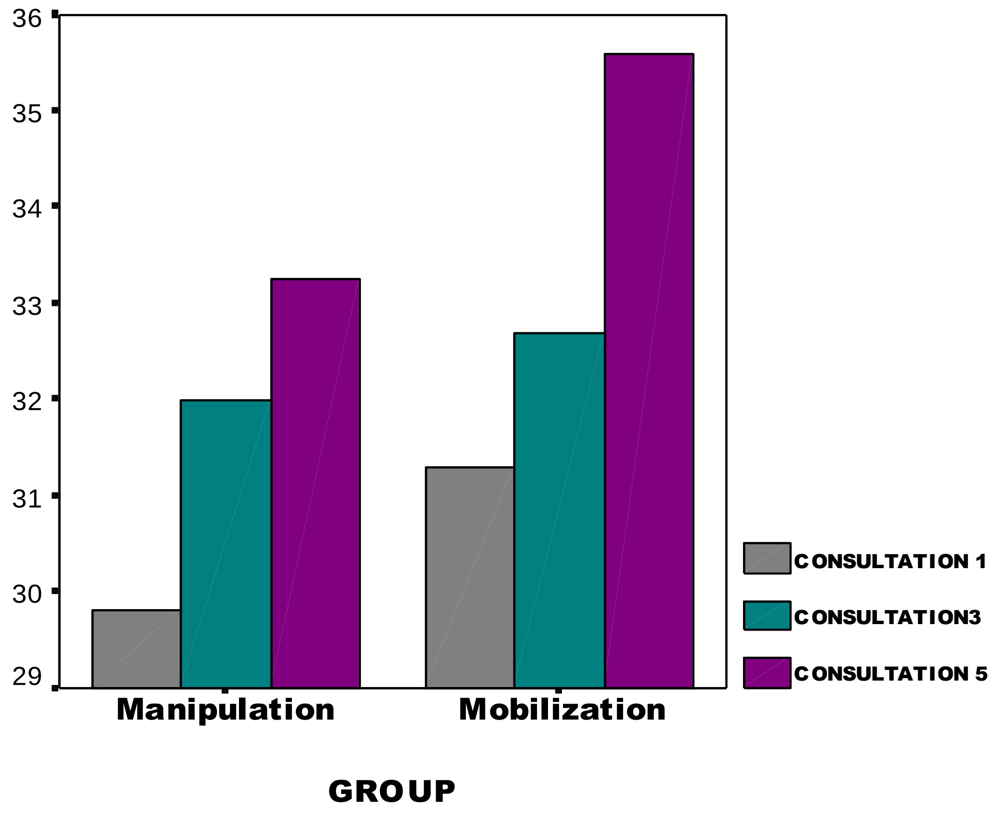

Figure 6: Changes in mean right lateral flexion values over the period of the evaluation.

4.4.7 MEAN THORACIC LEFT ROTATION VALUES

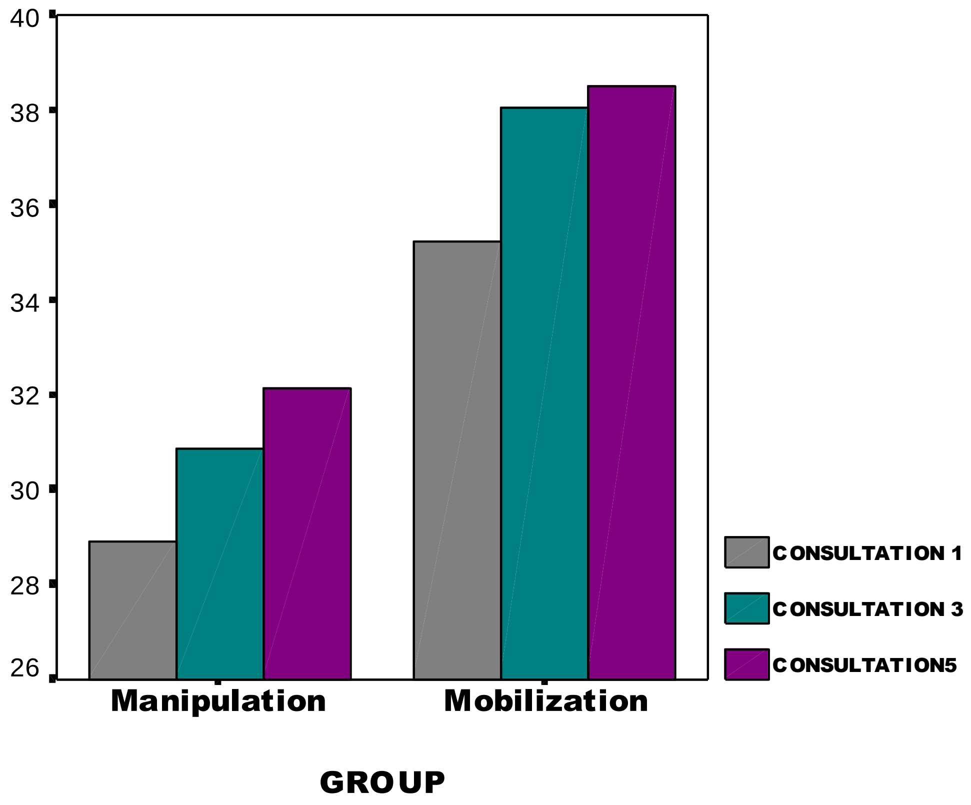

Figure 7: Changes in mean left rotation values over the period of the evaluation.

4.4.8 MEAN THORACIC RIGHT ROTATION VALUES

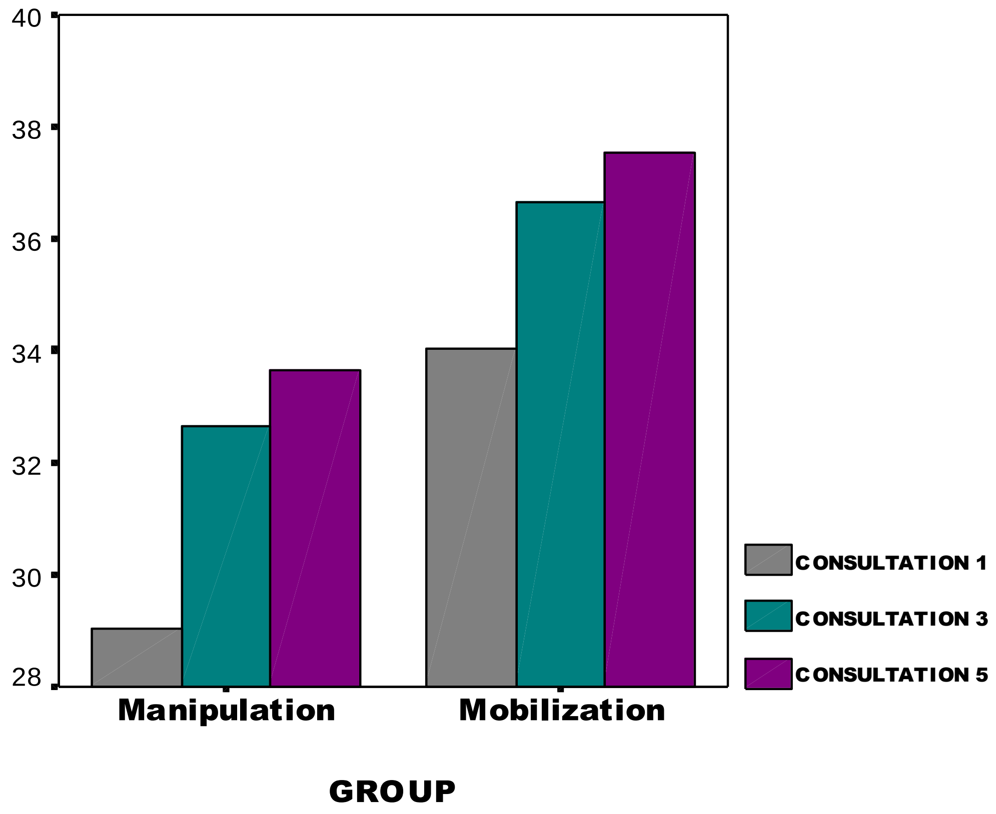

Figure 8: Changes in mean right rotation values over the period of the evaluation.

CHAPTER FIVE

5.0 DISCUSSION

5.1 INTRODUCTION

This chapter deals with the discussion of the demographic data, and the results after statistical analysis of the subjective and objective data, with regards to inter-group and intra-group comparison, as presented in Chapter 4.

5.2 THE DEMOGRAPHIC DATA

The demographic data collected from this study is located in tables 1 to 7.

From a review of the demographic data, it can be seen that the 2 groups were very similar in terms of age and gender distribution. They were also very similar in terms of the presenting side of thoracic dysfunction complaint, and the type and direction of thoracic fixations distribution. The two groups were not that similar in terms of race, occupation or the region of primary fixation distribution.

The age distribution within the sample of 40 patients (table 1), demonstrated that the majority of patients fell into the 18 – 24 age group (45%), closely followed by the 25 – 34 age group (40%). The following reason could account for this:

The study was conducted at the Technikon Natal campus, which is easily accessible to young students. This factor possibly affected both the age and occupation distribution of the sample. Students are susceptible to thoracic spine pain due to their maintained postural disturbances experienced whilst studying, as confirmed by Harms-Ringdahl and Ekholm (1986). They identified the maintained extreme flexion positions of the lower-cervical-upper-thoracic spine, as practiced by students studying, to be a causative factor of thoracic spine pain in healthy individuals.

The male to female ratio was fairly similar for both groups, with males (52.5%) being marginally more prominent than females (47.5%) in the sample (table 2). This finding is in contrast to the epidemiological findings of Bruckner (1987), Mior and Diakow (1987), and Dreiser (1997), which concluded thoracic spinal complaints to be more common in females.

An uneven racial distribution within the sample of 40 patients was also evident (table 3). The greatest proportion of the sample was White (57.5%), followed by Asian (27.5%). Reasons for this discrepancy could include the fact that chiropractic is still fairly new to the majority of South Africans, with chiropractic possibly being more familiar to some race groups as opposed to others due to socio-economic factors, literacy levels and the belief systems of different cultures.

The presenting complaints of thoracic dysfunction were found to be very similar for both groups in terms of central, or left or right-sided pain (table 4). The majority of complaints were of right-sided pain (57%), followed by left-sided pain (25%).

The primary fixation presented more commonly within the T5 – T9 region of the thoracic spine (57.5%), with fewer primary fixations occurring within the upper (35%) and lower (7.5%) thoracic regions (table 5). These findings are in keeping with those of Schiller (1999) and Tsolakis (2001). It is evident from table 4 however, that the mobilization group had a greater proportion of mid-thoracic (14) as compared to upper-thoracic (4) primary fixations. In contrast, the manipulation group had a more even distribution of mid-thoracic (9) to upper-thoracic (10) primary fixations

The type and direction of thoracic fixations treated during the study were similar for both groups (table 6). The greatest incidence of fixation occurred in extension, followed by right rotation, followed by right lateral flexion, for both groups. The higher incidence of right-sided fixations as compared to left-sided, may be due to the majority of the population being right handed.

Chiropractic students made up a large proportion of the sample group (27.5%), as the study was conducted at the Chiropractic Day Clinic, making it accessible for chiropractic students to take part. Bhoola (2001), Tsolakis (2001) and Pillay (2001) also reported a large proportion of chiropractic students, presenting for treatment. This finding concurred with that of Mior and Diakow (1987: 306), who stated that the highest incidence of thoracic back pain occurs in health care workers, especially chiropractors.

5.3 INTER-GROUP COMPARISON

5.3.1 THE SUBJECTIVE DATA

The statistical data for the Numerical Pain Rating Scale-101 questionnaire is located in table 8.

Statistical analysis revealed that no statistically significant difference could be noted between Group A and Group B at the 1st, 3rd and 5th consultations, with regards to the Numerical Pain Rating Scale-101 questionnaire.

A comparison of the 1st consultation for both groups revealed no significant difference (p = 0.242), indicating that both started off at a similar point in pain perception, suggesting that the symptomlogy caused by mechanical thoracic spine dysfunction was the same for both groups initially. A comparison of the 3rd and 5th consultations also revealed no significant difference between the 2 groups. The median values for the groups (figure 1) tend to indicate a similar response to their respective treatments over the period of evaluation.

This suggests that both spinal manipulation and mobilization were equally effective in reducing the patients' perception of pain.

The overall finding for the subjective data on inter-group comparison is in contrast to that of Pillay (2001), who found manipulation to be more effective than mobilization.

Possible reasons for the difference could be due to the significant difference between the 2 groups before consultation 1 in Pillays' study, and greater mean values for the mobilization group suggesting that symptoms experienced by patients in that group were more severe, thus effecting the outcome. Cassidy et al. (1992) however, in their study on manipulation versus mobilization of the cervical spine, reported no significant difference between the two treatment groups, but found cervical manipulation to have a significantly greater effect on pain perception than mobilization. Myburgh's (1998) study, comparing spinal manipulation to passive oscillatory mobilization in the treatment of mechanical low back pain, is in contrast to the above, and consolidates the findings of this study, having found no statistically significant difference between the spinal manipulation and mobilization groups in terms of pain perception. Myburgh (1998) did note that the power of his study was low however, indicating a greater possibility of a Type I I error occurring.

5.3.2 THE OBJECTIVE DATA

The statistical data for the digital algometer and the digital inclinometer range of motion readings are located in tables 9-15.

Statistical analysis revealed no significant difference between Group A and Group B with regard to the digital algometer and the digital inclinometer readings.

A comparison of the 1st consultations for both groups for the objective data revealed no significant difference, indicating that both started off at a similar point in terms of pain threshold and range of motion. A comparison of the 3rd and 5th consultations also revealed no significant difference between the 2 groups. The median values for the groups (figures 2-8) tend to indicate a similar response to their respective treatments over the period of evaluation.

This suggests that both spinal manipulation and mobilization had an equal effect on pain threshold as measured by the digital algometer, and range of motion readings as measured by the digital inclinometer, and are effective interventions in the clinical management of chronic mechanical thoracic spine dysfunction.

The overall finding for the digital algometer on inter-group comparison is supported by the findings of Pillay (2001) and Myburgh (1998). The inter-group digital algometer range of motion finding is in keeping with that of Cassidy et al. (1992), who found that both cervical manipulation and mobilization increased range of motion of the cervical spine to a similar degree.

5.4 INTRA-GROUP COMPARISON

5.4.1 THE SUBJECTIVE DATA

The statistical data for the Numerical Pain Rating Scale-101 questionnaire are located in tables 16, 24 and 25.

Analysis of the results, revealed a statistically significant improvement for both the spinal manipulation group and the mobilization group for the Numerical Pain Rating Scale-101 questionnaire at consultations 1, 3 and 5 (table 16). The null hypothesis was then rejected for Group A and Group B for the subjective NRS-101 questionnaire, and a multiple comparison procedure (Dunn's Procedure) was therefore used to determine at which point the treatment made a significant difference, and demonstrate the efficacy of each intervention.

For both Group A and Group B, a significant improvement was demonstrated between the 1st and 3rd, 1st and 5th, and 3rd and 5th consultations, with regards to the subjective data on pain perception (tables 24 and 25). This indicates that both groups were successful in significantly reducing the subjective pain perception experienced by the patients. These findings are in agreement with those of Pillay (2001), and imply that both spinal manipulation and passive oscillatory mobilization are effective and efficient interventions, which significantly reduce pain perception over a course of 4 treatments, in the management of chronic mechanical thoracic spine dysfunction.

Clinically, one would thus expect significant improvement in pain perception within one to three treatments when utilizing spinal manipulation or mobilization to treat patients suffering from chronic thoracic pain.

5.4.2 THE OBJECTIVE DATA

The statistical data for the digital algometer pressure threshold readings are located in tables 17, 26 and 27. The statistical data for the digital inclinometer range of motion readings are located in tables 18-23 and tables 28-39.

Analysis of the results, revealed a statistically significant improvement for both the spinal manipulation group and the mobilization group, for both the digital algometer and digital inclinometer measurements at consultations 1, 3 and 5 (tables 17-23). The null hypothesis was then rejected for the objective measurements for both Group A and Group B. A multiple comparison procedure (Dunn's Procedure) was therefore used for each of the objective measurements, to determine at which point in the treatment a significant difference was made, to determine the efficiency of each group.

Digital Algometer Readings (Tables 17, 26 and 27)

Analysis of the results between the 1st, 3rd and 5th consultations revealed a statistically significant difference in Group A ($p < 0.001$) and Group B ($p < 0.001$), indicating an increase in the pressure threshold readings (table 17). Dunn's procedure was then applied.

In Group A, no improvement could be demonstrated between consultation 1 and 3 but a significant improvement was demonstrated between consultations 1 and 5, and 3 and 5, with regards to the digital algometer pressure threshold readings (table 26).

In Group B, a significant improvement was demonstrated between consultations 1 and 3, 1 and 5, and 3 and 5 with regards to the digital algometer pressure threshold readings (table 27).

This suggests that the mobilization group experienced a faster response to treatment, showing a significant improvement within 2 treatments, and continuing to significantly improve over the course of 4 treatments, in contrast to the spinal manipulation group, which only demonstrated a significant improvement after 3 to 4 treatments. This implies mobilization to be a more efficient treatment in terms of pain threshold.

Pillay (2001) found contrasting results. In her study, a significant improvement for algometer measurements for the mobilization group only existed during the period between the 3rd and 5th consultations, with the manipulation group showing no significant intra-group improvement. However, in a study conducted by Mead et al. (1990), the benefits of chiropractic spinal manipulation in the management of low back pain became more evident throughout a follow-up period of 6 months, and at a 3-year follow-up, as compared to mobilization.

Digital Inclinometer Readings (tables 18-23 and tables 28-39)

Thoracic Flexion Readings

Analysis of the results between the 1st, 3rd and 5th consultations revealed a statistically significant difference in Group A ($p < 0.001$) and Group B ($p < 0.001$), indicating an increase in the thoracic flexion readings (table 18). Dunn's procedure was then applied.

In Group A, a significant improvement was demonstrated between consultations 1 and 5, but no improvement could be demonstrated between consultations 1 and 3, and 3 and 5 with regards to the thoracic flexion range of motion readings (table 28).

In Group B, a significant improvement was demonstrated between consultations 1 and 3, and 1 and 5, but no improvement could be demonstrated between consultation 3 and 5 with regards to the thoracic flexion range of motion readings (table 29).

This suggests that thoracic flexion range of motion increased significantly within 1 to 2 treatments for the mobilization group, whilst 3 to 4 treatments were necessary for the manipulation group to demonstrate a significant improvement, implying that in a clinical setting, mobilization would be a more efficient intervention in terms of thoracic flexion range of motion.

Thoracic Extension Readings

Analysis of the results between the 1st, 3rd and 5th consultations revealed a statistically significant difference in Group A ($p < 0.001$) and Group B ($p < 0.001$), indicating an increase in the thoracic extension readings (table 19). Dunn's procedure was then applied.

In Group A, a significant improvement was demonstrated between consultations 1 and 3, 1 and 5, and 3 and 5 with regards to the thoracic extension range of motion readings (table 30).

In Group B, a significant improvement was demonstrated between consultations 1 and 3, and 1 and 5, but no improvement could be demonstrated between consultation 3 and 5 with regards to the thoracic extension range of motion readings (table 31).

These findings demonstrate that thoracic extension improved significantly within 1 to 2 treatments for both groups, and continued to improve for the manipulation group over the course of 4 treatments, as compared to the mobilization group which only showed a significant improvement within 2 treatments and no improvement with a further 2 treatments thereafter. These findings suggest that spinal manipulative treatment may improve thoracic extension range of motion significantly over 4 treatments, whilst mobilization has a limited significant effect over 2 treatments.

Thoracic Left Lateral Flexion Readings

Analysis of the results between the 1^{st}, 3^{rd} and 5^{th} consultations revealed a statistically significant difference in Group A ($p = 0.006$) and Group B ($p = 0.002$), indicating an increase in the thoracic left lateral flexion readings (table 20). Dunn's procedure was then applied.

In Group A, a significant improvement was demonstrated between consultations 1 and 5, but no improvement could be demonstrated between consultations 1 and 3, and 3 and 5 with regards to the thoracic left lateral flexion range of motion readings (table 32).

In Group B, a significant improvement was demonstrated between consultations 1 and 5, and 3 and 5, but no improvement could be demonstrated between consultation 1 and 3 with regards to the thoracic left lateral flexion range of motion readings (table 33).

Thoracic left lateral flexion thus improved significantly between 3 and 4 treatments for the mobilization group, and after 4 treatments for the manipulation groups, suggesting mobilization to be mildly more efficient than manipulation in improving this range of motion in the thoracic spine.

Thoracic Right Lateral Flexion Readings

Analysis of the results between the 1^{st}, 3^{rd} and 5^{th} consultations revealed a statistically significant difference in Group A ($p < 0.001$) and Group B ($p < 0.001$), indicating an increase in the thoracic right lateral flexion readings (table 21). Dunn's procedure was then applied.

In Group A, a significant improvement was demonstrated between consultations 1 and 3, and 1 and 5, but no improvement could be demonstrated between consultations 3 and 5 with regards to the thoracic right lateral flexion range of motion readings (table 34).

In Group B, a significant improvement was demonstrated between consultations 1 and 5, and 3 and 5, but no improvement could be demonstrated between consultation 1 and 3 with regards to the thoracic right lateral flexion range of motion readings (table 35).

These findings suggest the manipulation group to more efficient, experiencing a significant improvement in thoracic right lateral flexion within 2 treatments, as compared to the mobilization group, which only exhibited a significant improvement after 3 to 4 treatments.

Thoracic Left Rotation readings

Analysis of the results between the 1st, 3rd and 5th consultations revealed a statistically significant difference in Group A ($p < 0.001$) and Group B ($p < 0.001$), indicating an increase in the thoracic left rotation readings (table 22). Dunn's procedure was then applied.

In Group A, a significant improvement was demonstrated between consultations 1 and 5, and 3 and 5, but no improvement could be demonstrated between consultations 1 and 3 with regards to the thoracic left rotation range of motion readings (table 36).

In Group B, a significant improvement was demonstrated between consultations 1 and 3, and 1 and 5, but no improvement could be demonstrated between consultation 3 and 5 with regards to the thoracic left rotation range of motion readings (table 37).

These findings, suggest that a minimum of 3 treatments were required to significantly improve the manipulation group for thoracic left rotation, whilst the mobilization group demonstrated greater efficacy, yielding a significant improvement within 2 treatments.

Thoracic Right Rotation Readings

Analysis of the results between the 1st, 3rd and 5th consultations revealed a statistically significant difference in Group A ($p < 0.001$) and Group B ($p < 0.001$), indicating an increase in the thoracic right rotation readings (table 23). Dunn's procedure was then applied.

In Group A, a significant improvement was demonstrated between consultations 1 and 3, and 1 and 5, but no improvement could be demonstrated between consultations 3 and 5 with regards to the thoracic right rotation range of motion readings (table 38).

In Group B, a significant improvement was demonstrated between consultations 1 and 3, 1 and 5, and 3 and 5 with regards to the thoracic right rotation range of motion readings (table 39).

Both the manipulation and the mobilization groups demonstrated a significant improvement in thoracic right rotation within 2 treatments, with the mobilization group improving significantly over the course of the 4 treatments.

5.5 CONCLUSION OF RESULTS

From the above data it can be concluded that both spinal manipulation and passive oscillatory mobilization are equally effective in treating chronic mechanical thoracic spine dysfunction. Inter-group comparison revealed that both treatments improved the patients' subjective pain perception with no significant difference between the 2 groups. Pressure threshold and thoracic range of motion in flexion, extension, bilateral lateral flexion and bilateral rotation were also improved effectively, with no significant difference between the 2 groups.

Intra-group analysis revealed that both treatment protocols showed significant improvement between the consultations. Both groups were successful in significantly reducing the patients' subjective pain perception within 2 treatments, whilst the mobilization group demonstrated greater efficacy in improving the objective pressure threshold readings, making a significant difference within 2 treatments as compared to the manipulation groups' 3-4 treatments. In terms of the range of motion data, the mobilization group showed faster improvements in thoracic flexion, left lateral flexion and left rotation, whilst the spinal manipulation group demonstrated greater efficacy in thoracic extension, right lateral flexion and right rotation.

Drews (1995) cross-sectional survey, found that analgesics and anti-inflammatory drugs were commonly used by up to 40% of patients in an effort to relieve symptoms of uncomplicated back pain, whilst Dreiser et al. (1997) reported 63% of patients in their epidemiological survey being given analgesics or non-steroidal drugs as treatment for their subacute to chronic mechanical thoracic spine pain.

The findings of this study demonstrate that in the clinical setting, both spinal manipulation and passive oscillatory mobilization can successfully and efficiently improve signs and symptoms of pain and restricted range of motion, as experienced by symptomatic patients suffering from chronic thoracic spinal dysfunction, within a course of 4 treatments. This will hopefully have an impact on future treatment protocols, and result in a decline in the use of analgesic and anti-inflammatory drugs.

5.6 LIMITATIONS OF THE STUDY

The following factors should be considered for future studies of this nature.

5.6.1 HOMOGENEITY

In any randomized clinical trial the goal is that the study groups should be similar in relevant patient characteristics. A higher degree of comparability between the two groups allows for more valid trial conclusions (Haldeman 1992: 418). According to Mohseni–Bandpei et al. (1998) special attention should be paid to factors such as duration of complaints, age and occupation in order to produce studies of higher quality. Similarity of relevant baseline characteristics was one of the criteria they used to assess the methodological quality of randomized controlled trials reviewed.

Only patients with chronic mechanical thoracic spine dysfunction were treated in this study, as recommended by Schiller (1999) and Pillay (2001). Based on the findings of Schenkman and Shipp (1996) and Sullivan and Dickinson (1994), the age limit of 18 to 45 years imposed, was below the age where significant restrictions in spine motion occurs secondary to the aging process. These categorizations helped to ensure a more homogenous study population, which would therefore allow for greater accuracy and reliability of results.

The demographic results from tables 1 to 7, showed the 2 groups to be very similar in terms of age and gender distribution. They were also very similar in terms of side of presenting thoracic dysfunction complaint, and type and direction of thoracic fixations distribution. The two groups were however not that similar in terms of race, occupation or region of primary fixation distribution.

The discrepancies in the study population with regard to race, region of primary fixation and occupation distribution, could possibly influence the interpretation of the results.

5.6.2 STUDY SIZE

This study utilized a sample of 20 patients in each group. Mohseni-Bandpei et al. (1998) state in their review of randomized controlled trials that one of the most important flaws seen in the trials reviewed included the sample size of the study population. Although the sample size of this study was statistically acceptable, an even larger study population would have lent additional strength to the study. It was not practically possible however, in the context of this study, to use a larger study population, due to the restrictions of the budget and time.

5.6.3 BLINDING

To reduce the possibility of bias occurring in any trial, particularly controlled trials, it is essential to eliminate observer, therapist, investigator and subject bias (Haldeman 1992: 48).

The possibility of practitioner bias exists in this study, as it was conducted solely by the author. The inclusion of an independent observer to assess the outcome measures was not practically possible, hence the validity of the study may be reduced due to the lack of double blinding.

5.6.4 SIGNIFICANCE

Significance may not be revealed by statistical analysis of the subjective and objective data, if outcome measures are not valid, precise and sensitive for measuring small but clinically relevant changes (Koes et al. 1995). It is not absolutely certain that the outcome measures employed in this study best fulfill the above characteristics. It has been demonstrated in chapter 3 that the subjective measurement (NRS-101 questionnaire), and objective measurements (digital algometer and digital inclinometer) used in this study are valid and reliable tools for assessing changes within patients. However, the possibility does exist that precise clinical changes of dysfunctional thoracic joints undergoing spinal manipulation or mobilization, have been incompletely measured.

The subjective NRS-101 questionnaire was explained to each of the patients during the study, but whether it was completed as requested or as honestly as possible, remains uncertain. It was noted that a number of patients seemed uncertain of their answers, and many did not appear to take the questionnaire seriously enough. The possibility of incorrect completion of the NRS-101 questionnaire by the patients due to any of the above reasons, does exist.

The objective measurements were taken using the latest digital equipment, as was recommended by Schiller (1999), Tsolakis (2001), Bhoola (2001) and Pillay (2001), in an effort to reduce observer bias and increase the accuracy of readings, due to enhanced sensitivity when compared to analogue instruments. There is a possibility however, that these instruments may have presented new difficulties.

The digital algometer is a highly sensitive instrument, and although great care was utilized when taking readings, measurement may have been affected by the speed with which the algometer-head was removed from the measurement point, when the patient said "now". Every effort was made to locate the exact same spot when taking measurements at subsequent consultations, using palpation and bony landmarks, but as a semi-permanent marker was not used in this study, the possibility does exist that the digital algometer was not placed on the exact same spot at each measurement consultation.

The digital inclinometer measurements were taken after all of the movements required for active range of motion measurement were carefully explained and demonstrated to each patient. Due to the complexity of rotation measurements, and the nature of the equipment relying upon the examiner placing the sensors on the exact landmark at each measuring consultation, a possibility of precise measures being compromised, does exist however. Measurements of active range of motion were all taken from a neutral starting position, but whether this position was the same for individual patients at each measurement consultation, cannot be confirmed. The above factors may have biased both the subjective and objective results, bringing about error.

5.6.5 COMPLIANCE

Patients were requested upon joining the study, to avoid all other forms of treatment for their condition and avoid altering medication dosages, during the course of the study. It was noted however, that the majority of participants in the study were familiar with chiropractic and many patients knew of stretches and soft tissue techniques that “sometimes helped their thoracic spine pain.” Whether the patient complied with the researchers’ request, remains uncertain.

5.6.6 CROSS-OVER STUDY DESIGN

An enhancement of this study would have been to introduce a cross-over aspect to the treatment protocol, which would have allowed for a more effective analysis of the therapies. One patient in the mobilization group left the study after one treatment, due to a desire to be in the manipulation group, but the lack of a cross-over study design did not allow for this. Two patients in the spinal manipulation group became asymptomatic before the final treatment and left the study, hence their data could not be included into the statistical analysis of the results. A cross-over design may have possibly strengthened the study and increased the validity of the results.

CHAPTER SIX

6.0 RECOMMENDATIONS AND CONCLUSIONS

6.1 RECOMMENDATIONS

Should this study be repeated, the author recommends the following improvements.

1. Homogeneity

A stratified randomization procedure should be utilized, possibly taking into account racial, occupation and the region of primary fixation distribution. This would enable greater similarity in baseline characteristics, and allow for greater accuracy and reliability of results.

2. Sample size

A larger sample size should be selected. There is a close connection between sample size and the power of statistical tests. A smaller sample size allows for the greater likelihood of a Type II error occurring (i.e. accepting the null hypothesis). This results from the low power of the study size to detect small but clinically relevant treatment differences (Koes et al. 1995: 233). Utilizing a larger sample size would aid in obtaining more valid trial conclusions, and increase the accuracy of statistical analysis.

3. Blinding

Bias can be eliminated, by utilizing an independent observer with no knowledge of the groups the patients fall into, to assess the digital algometer and digital inclinometer readings, and collect the subjective data.

4. Accuracy of Measurements

A permanent marker should be used for the duration of the study, and the relevant landmarks used for the digital algometer and the digital inclinometer marked with non-washable ink, so as to ensure that the exact same spot is utilized at each data capture consultation. An effort should be made to ensure that each patient is in a constant neutral position when examining range of motion of the thoracic spine. This should allow for more accurate readings and greater detection of small but significant differences in effects of treatment.

5. Cross-Over Design

A cross-over study design should be considered within the 2 groups, to limit the possibility of drop-outs during the course of the study. Those patients not showing adequate signs and symptoms of improvement can be changed over to the opposite group to see if ant improvement occurs.

6. Follow-Up Period

Mohseni-Bandpei et al. (1998) state that more effort should be made to establish long-term follow-up, as lasting improvement will be the most convincing estimate of cost-effectiveness. A follow-up period of 6 months or more is recommended, so as to establish the long-term treatment benefits of both treatment protocols.

7. Experience

A more experienced manual therapist, with at least 5 years clinical experience, should repeat this study. Limited experience of any undergraduate researcher may bias the results of a study, and since the Maitland technique of mobilization is utilized more extensively by physiotherapists, it is suggested that a similar trial be conducted utilizing an experienced physiotherapist to perform the mobilization and an experienced chiropractor to perform the spinal manipulation. An independent researcher to collect and analyze the data would further strengthen the study.

8. Other Studies on the Thoracic Spine

Future studies on the thoracic spine should include the costotransverse and costovertebral joints, either alone or in conjunction with the thoracic facet joints.

The study should also be repeated on a population suffering from acute or subacute thoracic spine dysfunction, so as to determine whether the duration of complaints plays any role in the efficacy of treatment.

The long term effect of spinal manipulation on thoracic spine range of motion, and extensor muscle reflex inhibition using EMG, in symptomatic subjects, should also be considered for future studies.

Updated studies on the incidence, prevalence and risk factors for thoracic spine dysfunction in South Africa, are also required.

6.2 CONCLUSION

This was a prospective, randomized controlled clinical study, consisting of a study population of 40 patients. All patients had to be diagnosed with chronic mechanical thoracic spine dysfunction according to certain criteria. These patients were randomly allocated to 2 groups of 20 each. Group A received spinal manipulative therapy, and Group B received passive oscillatory mobilization over the area of dysfunction. Both groups received 4 treatments with one follow up consultation, over a 2 week period.

Statistical analysis of the data for intra-group comparison revealed a significant improvement in both the spinal manipulation group and the mobilization group for the subjective Numerical Pain Rating Scale-101 questionnaire between consultations 1 & 3, 3 & 5 and 1 & 5. This indicated that both groups were successful in significantly reducing the patients' pain perception.

With regards to the objective digital algometer readings, the mobilization group showed a significant improvement between consultations 1 & 3, 3 & 5 and 1 & 5, whereas the spinal manipulation group only showed a significant improvement for the period between the 3rd and 5th consultations.

The objective digital inclinometer readings for range of motion showed significant improvements for both the spinal manipulation and the mobilization groups, for all ranges of motion. The spinal manipulation group showed significant improvements more rapidly than the mobilization group in terms of thoracic extension (between consultations 1&3, 3&5 and 1&5), right lateral flexion (between consultations 1&3) and right rotation (between consultations 1&3). The mobilization group however, showed significant improvement more rapidly than the spinal manipulation group in terms of thoracic flexion (between consultations 1&3), left lateral flexion (between consultations 3 and 5) and left rotation (between consultation 1&3). As is evident from table 6 in chapter 4, thoracic fixations were most common in extension, right rotation and right lateral flexion for both groups, which suggests that the spinal manipulative group proved to have more beneficial effects than the mobilization group in increasing the relevant thoracic ranges of motion.

Inter-group comparison revealed no statistically significant difference between Group A and Group B at the 1st, 3rd and 5th consultations, with regards to the subjective Numerical Pain Rating Scale-101 questionnaire, suggesting that both spinal manipulation and mobilization were equally effective in reducing the patients' perception of pain.

Statistical analysis revealed no significant difference between Group A and Group B with regard to the objective data, namely the digital algometer and the digital inclinometer readings. Spinal manipulation and mobilization proved to have an equal effect on pain threshold as measured by the digital algometer, and range of motion readings as measured by the digital inclinometer.

The results of this study indicate that both spinal manipulation and passive oscillatory mobilization are effective manual interventions for reduction of quality of patients' pain response, pain intensity and range of motion measurements, however further studies are needed to determine the more efficient of the two treatments.

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