The effectiveness of first rib adjustment as an adjunct to the treatment of mechanical neck pain.

By

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I, Colin Douglas Brown, do hereby declare that this dissertation represents my own work in both concept and execution.

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DEDICATION

To my parents, thank you for your contribution towards my studies.

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ABSTRACT

Objective: The purpose of this investigation was to evaluate the efficacy of the adjustment of the first rib as an adjunct to the manipulative treatment of mechanical neck pain, according to subjective and objective clinical findings.

The results of this study would indicate to Chiropractors which specific types of adjustments, used for the treatment of mechanical neck pain, would potentially increase the cervical range of motion and / or decrease pain experienced by the patient and thus lead to a more effective treatment protocol. The outcome of the study will help clinicians select the more appropriate treatment for patients based on the subjective and objective outcomes.

Method: This was achieved by selecting sixty participants by means of convenience sampling. One group of fifteen received a first rib manipulation (Group A), the second group received cervical manipulation (Group B), and Group C received both a first rib manipulation and cervical spine manipulation. All patients received treatment of the related scalene muscles using detuned ultrasound therapy. This included a fourth group, (Group D) which received detuned ultrasound therapy alone. Each group was given two treatments within a two-day period with an additional consultation scheduled on the third day to complete the assessment of subjective and objective findings.

Subjective measurements were only taken once during each of the three consultations, this included the patient answering a Canadian Memorial Chiropractic College (CMCC) neck disability questionnaire, and completing a Numerical Pain Rating (NRS) pain rating scale.

Objective measurements were obtained using a CROM to measure cervical range of motion, and the use of an algometer positioned over the most tender part of the

patients' symptomatic first rib. The objective measurements were taken before and after treatment during the first two consultations and only once during the third consultation.

All tests were measured at a 95% level of confidence, and the results from all four groups were statistically analysed. The SPSS version 11.5 (SPSS Inc, Chicago, Ill, USA) was used for analysis of data.
Demographics were compared between treatment groups using Pearson's chi square tests for categorical variables and one way ANOVA with Bonferroni post hoc tests for quantitative variables. Treatment effects for quantitative outcomes were analysed using repeated measures ANOVA. A significant time by group interaction ($p<0.05$) indicated a significant treatment effect. Profile plots were examined in order to assess in which direction the treatment effect was found. Subsets of the data were used to examine comparisons between specific treatment groups.

Results: What could be deduced from the results of the demographics was that the randomisation had provided the research with four groups of participants in which homogeneity was present. This allowed for the comparison of one group to another without there been pre-existing differences.

There was limited evidence for any difference in treatment effects between the three treatment groups. Only CMCC score showed significant treatment differences between the first rib group and cervical spine group (first rib was better), and between the cervical spine group and first rib plus cervical spine group (first rib plus cervical spine group was better). Thus, it appeared that first rib manipulation without cervical spine manipulation was more beneficial for CMCC score than cervical spine manipulation alone in patients suffering from mechanical neck pain.

In comparison with the placebo treatment, there were many significant treatment effects. NRS was significantly improved in all treatment groups compared with placebo. Where the p value was not significant, trends were demonstrated, these could however, only be further elucidated with larger sample sizes in future studies. Thus, it would seem that any treatment was better than placebo for most outcomes but particularly so for the NRS.

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GLOSSARY

Adjustment: Specific form of direct articular manipulation (see manipulation) utilizing either long or short leverage techniques with specific contacts, characterized by a dynamic thrust of controlled velocity, amplitude and direction (Gatterman, 1995:405).

Biomechanics: Application of mechanical laws to living structures. The study and knowledge of biological function from an application of mechanical principles (Gatterman, 1990: 406).

Chronic: Long standing (weeks, months or years) but not necessarily incurable. Symptoms may range from mild to severe (Gatterman, 1990: 406).

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

Degenerative: Deterioration or breaking down of a part or parts of the body (Gatterman, 1990: 407).

Diagnosis: Art of distinguishing one disease from another, the determination of the nature of a cause of a disease (Gatterman, 1990: 407).

Dysfunction: Refers to the inability of a joint to function within its normal parameters (Gatterman, 1990: 407).

Extension: Motion in a limb, a digit or the spine that tends to straighten the involved body segment or in the case of the shoulder and hip, to move the limb posterior to the trunk (Reider, 1999:373).

Fascia: Tissue layers under the skin or between muscles, which form the sheaths of muscles or invest other deep, definitive structures, as nerves and vessels (Gatterman, 1990: 408).

Fixation: 1. Absence of motion of a joint in a position of motion, usually at the extremity of such motion.
2. State whereby a vertebra or pelvic bone has become temporarily immobilized in a position that it may normally occupy during any phase of physiological spinal movement.
3. Immobilization of a vertebra in a position of movement when the spine is at rest, or in a position of rest when the spine is in movement (Gatterman, 1990: 408).

Fixation subluxation: Lack of movement of a joint, caused by muscular spasm, a shortened ligament or an intraarticular blocking (Gatterman, 1990: 408).

Flexion: Motion in a limb, digit or the spine that tends to bend the involved body segment or in the case of the shoulder and hip, to move the limb anterior to the trunk in the sagital plane (Reider, 1999: 373)

Incidence: A rate which refers to the number of persons with new back pain occurring over a given period among a known number of persons who were previously without back pain (Giles and Singer, 1997: 18).

Inhibition: Effect of one neuron upon another, tending to prevent it from initiating impulses (Gatterman, 1990: 409).

Innervation: Distribution of nerves to a part (Gatterman, 1990: 409).

Joint dysfunction: Joint mechanics showing area disturbances of function (Gatterman, 1990: 409).

Manipulation: Passive manoeuvre in which specifically directed manual forces are applied to vertebral and extravertebral articulations of the body, with the object of restoring mobility to restricted areas (Gatterman, 1990: 410).

Mechanical neck pain: A restriction of movement of the neck, which frequently refers pain to the occiput, shoulders, nuchal muscles, interscapular region and anterior chest wall, and is usually due to a history of trauma or awkward posture of the cervical spine. (Edwards *et al.* 1995:871).

Motion palpation: Palpatory diagnosis of passive and active segmental joint range of motion (Gatterman, 1990:412).

Prevalence: The number of persons who have experienced back pain ever, even if they are not affected at present (Giles and Singer, 1997: 18).

Prone: Lying with the ventral surface downwards (Gatterman, 1990: 413).

Proprioception: Sensing the motion and position of the body (Gatterman, 1990: 413).

Proprioceptors: Sensory nerve terminals that give information concerning movements and position of the body. They occur chiefly in the muscles, tendons, joints and labyrinths (Gatterman, 1990: 413).

Range of motion: The range of translation and rotation of a joint for each of its six ranges of freedom (Haldeman, 1992:623).

Reflex: Result of transforming an ingoing sensory impulse into an outgoing efferent impulse without the act of will (Gatterman, 1990: 414).

Spasm: Shortening of a muscle due to non-involuntary motor nerve activity. Spasm cannot be stopped by voluntary relaxation (Gatterman, 1990: 414).

Subluxation: A subluxation is a motion segment, in which alignment, movement integrity, and/or physiologic function are altered although contact between joint surfaces remains intact (Gatterman, 1995:475).

Supine: Lying with the ventral side upward (Gatterman, 1990: 415).

CHAPTER ONE - INTRODUCTION

1.1) THE PROBLEM AND ITS SETTING

According to Innes (1994), the first rib has significant motion and therefore is a cause, when dysfunctional, of the initiation of a manipulable lesion. When the first rib is found to be dysfunctional the following muscles have been implicated in the presentation and perpetuation of a manipulable lesion; anterior scalene, middle scalene, iliocostalis cervicis, and the levator costorum.

Anatomically the direct involvement of the scalenii muscles is due to the attachment of the scalenii to the first rib and upper cervical spine. In this position it is thought to cause the coupled motion of the cervical spine to become anomalous and painful as well as initiate atlanto-occiputal pathomechanics as a result of the presence of a dysfunction at the muscle's insertion into the first rib. This is thought to result in changes in the levator costorum that attach to the same cervical segments as the scalenii muscles, as a result of the levator costarum's compensation in response to the scalenii hypertonicity. This now places undue stress on the upper thoracic cage and the cervico-thoracic junction that has as part of its anatomical composition the first rib. Thus, we have a negative feed back loop where the anterior structures (ribs and scalenii) are responsible in initiating dysfunctions in the posterior structures (cervical spine and levator costarum), which in turn perpetuate lower cervical and upper thoracic dysfunctions and thus also dysfunctions of the first rib.

It is therefore conceivable that this negative feedback loop, which is of mechanical origin, results in multiple different types of patient signs and symptoms, including but not limited to, neck pain, headaches, postural changes with stiffness and / or pain between the shoulder blades and upper thoracic region. In addition there are also implications for the patient in terms of the development of thoracic outlet syndromes related to the first rib and / or the scalene muscles. However with the first rib being an anatomically difficult structure to access, it is often overlooked clinically.

Thus, the purpose of this investigation was to evaluate the efficacy of the manipulation of the first rib as an adjunct to the manipulative treatment of mechanical neck pain, according to subjective and objective clinical findings, in order to determine the extent to which the dysfunction of the first rib plays a role in mechanical neck pain.

1.2) THE OBJECTIVES AND HYPOTHESES OF THE STUDY

The effectiveness of first rib manipulation as an adjunct to cervical manipulation, versus cervical manipulation, versus first rib manipulation, in the treatment of mechanical neck pain, in comparison to a placebo group.

1.2.1) The first objective

The first objective was to determine the relative effectiveness of each different treatment in terms of objective clinical findings in the treatment of mechanical neck pain.

1.2.2) The first hypothesis

The treatment groups would be more effective than the placebo group in terms of *objective clinical findings*, in the treatment of mechanical neck pain.

1.2.3) The second objective

The second objective was to determine the relative effectiveness of each different treatment in terms of subjective clinical findings, in the treatment of mechanical neck pain.

1.2.4) The second hypothesis

The treatment groups would be more effective than the placebo group in terms of *subjective clinical findings*, in the treatment of mechanical neck pain.

1.2.5) The third objective

To compare the trends that are evident between the subjective and the objective findings in order to ascertain whether there was any relationship between these results.

1.2.6) The third hypothesis

Trends would not be evident between the objective and subjective clinical findings, demonstrating no relationship between these findings and no difference in terms of the outcomes for the treatment groups.

1.2.7) The fourth objective

To determine the relative effectiveness between each of the three different types of treatment, versus the placebo group, in terms of objective and subjective clinical findings, in the treatment of mechanical neck pain.

1.2.8) The fourth hypothesis

That each of the treatment groups would be more effective than the placebo group in terms of objective and subjective clinical findings, in the treatment of mechanical neck pain and a difference in terms of the outcomes for each of the three groups.

1.3) THE LIMITATIONS OF THE STUDY

This study aimed at addressing both objective and subjective clinical improvement and not to explain the mechanisms responsible. However, suggestions regarding the possible mechanisms are given in Chapter Five to allow for further discussion and / or research development in this field of study.

1.4) THE RATIONALE OF THE STUDY

The result of this study would allow Chiropractors to use specific types of adjustments for the treatment of mechanical neck pain that would potentially increase the cervical range of motion and / or decrease pain experienced by the patient and achieves a more effective treatment protocol. The outcome of the study could be of consideration for clinicians when treating patients, based on the subjective and objective outcomes.

1.5) THE BENEFITS OF THE STUDY

It was the purpose of the study to provide important information with regards to the benefit of the different treatment technique used in the treatment of mechanical neck pain.

1.6) CONCLUSION

This chapter therefore presented a preliminary literature review, with the argument supporting the aims and objects of this study. The rationale, benefits and limitations where also highlighted in order for you, the reader to have a conceptual understanding of the study. Chapter Two follows presenting a more detailed literature review, after which follows the materials and methods of the study in Chapter Three. Chapter Four then presents the results and the discussion of the results as found after execution of the discussed methodology, with Chapter Five summarising the final achievements of the study and highlighting areas of future research through recommendations stemming from the study.

CHAPTER TWO - REVIEW OF THE RELATED LITERATURE

2.1 INTRODUCTION

This chapter gives a review of all the literature related to mechanical neck pain and first rib dysfunction, describing incidence and prevalence, clinical features and diagnosis of the conditions. It gives an overview of the anatomy of the cervical spine and upper thorax, describing the muscles and innervations, and the relationship between the two regions.

2.2 INCIDENCES AND PREVALENCE OF MECHANICAL NECK PAIN AND FIRST RIB DYSFUNCTION

Cote *et al.,* (2000); indicate that the age-standardised lifetime prevalence of neck pain is approximately 67%. Thus, with neck pain being a common complaint and in most cases attributed to mechanical dysfunction, it has been identified as a significant health problem (Cassidy *et al.,* 1992). According to Dabbs and Lauretti (1995), many of the people suffering from a significant episode of musculoskeletal neck pain of a mechanical source will seek treatment, which, annually accounts for more than eight million visits to allopathic physicians and millions of visits to chiropractors. It is therefore important for chiropractors to recognise all the possible factors related to neck pain of a mechanical origin, and to be able to give the best possible treatment to the patients.

There are a number of factors that have been implicated in the cause of mechanical neck pain (Cote *et al.,* 2000), these include cervical spine trauma or repetitive strain to the neck, neck pain is more common in women, the prevalence of neck pain in both men and women increases with age, neck pain is associated with lower socio-economic status, and with occupational factors such as repetitive or static work tasks, awkward occupational postures, heavy lifting, or physically demanding work, finally adults with a previous injury to the neck, back, or shoulder may be more likely to experience chronic neck pain. This concurs with an earlier statement by Charschan (1998) who indicated that the spine does not exist by itself and that other forces act upon it resulting in the chronic mechanical dysfunctions.

2.3 ANATOMY

2.3.1 Anatomy of the cervical spine

The cervical spine consists of seven vertebrae, subdivided into two types with the first, second and seventh considered atypical vertebra, while the third to the sixth are typical vertebra (Gatterman 1990:205). The vertebral artery passes through the transverse foramina of C1 to C6 and sometimes through C7 (Moore 1992:331).

The typical vertebrae are made up anteriorly of the vertebral body, which consists of a thin cortical shell surrounding cancellous bone. The posterior aspect is composed of a neural arch that includes two pedicles and two laninae (Panjabi and White 1990:280). The posterior arches form the boundaries of the triangular vertebral foramen (Haldeman 1992:137). Both transverse processes as well as the spinous process arise from the laminae (White and Punjabi 1990:28). These processes act as levers to which various muscle groups attach to enable cervical spine motion (Foreman and Croft. 1995:262).

The articular processes on the superior and inferior surface are known as zygopophyseal joints or facet joints. The facet joints are orientated at approximately 45 degrees to the horizontal and 90 degrees to the sagital plane (Haldeman 1992:138). The superior facet joints point backward and upward while the inferior facets are directed forward and down, both are flat and oval in shape (Gatterman 1990:206). These joints are synovial and undergo degenerative changes (White and Punjabi 1990:28).

The muscles ligaments and joint capsules provide postural stability, while allowing adequate spinal motion, and it is these structures that are most commonly injured during trauma (Gatterman 1990:14,205).

2.3.2) Anatomy of the thorax

According to Moore (1992:33) the osteocartilagenous thoracic cage is formed by part of the vertebral column (12 thoracic vertebra and intervertibral discs); 12 pairs of ribs and costal cartilages, and the sternum.

The sternum is an elongated flat bone that forms the middle part of the anterior wall of the thorax, consisting of three parts: manubrium, body and xiphoid process. The manubrium makes up the superior aspect of the sternum; the first rib fuses with the lateral aspect, while the second rib articulates laterally to the sternal angle, which is the junction of the manubrium and the body of the sternum. The body of the sternum is longer, thinner and narrower than the manubrium, and found anterior to T5 to T9 vertebrae (Moore, 1992:41).

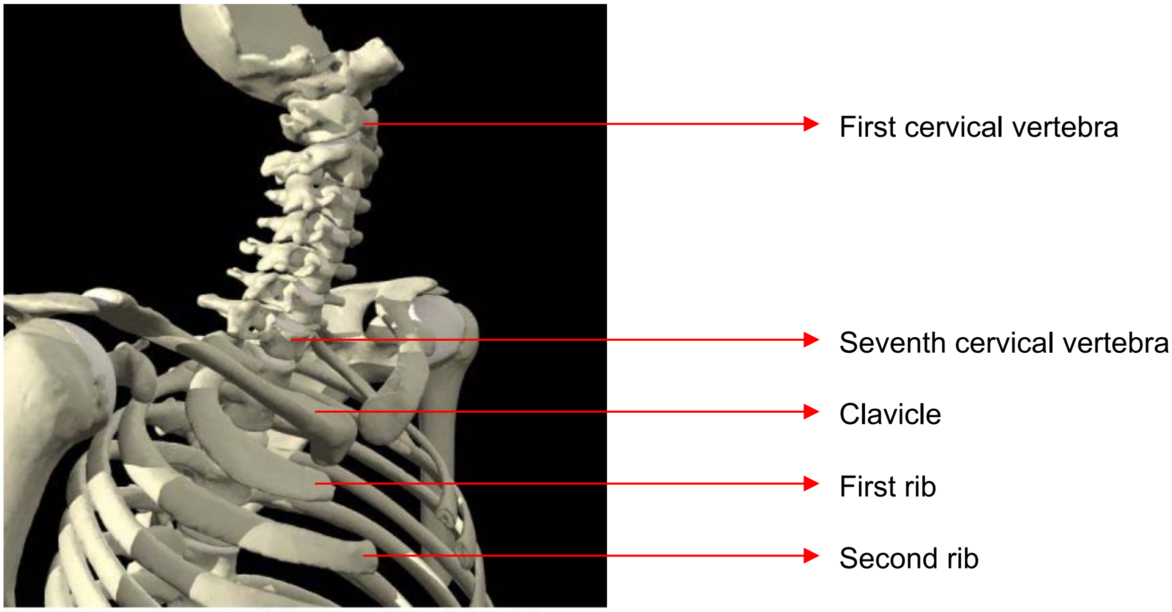
The ribs are narrow, curved, flat bones that form most of the thoracic wall and can be subdivided into three different categories, true, false and floating ribs.

- The first seven ribs are known as true or vertebrosternal ribs due to their individual attachment to the sternum through their costal cartilages.
- The eighth to tenth ribs are known as false or vertebrochondral ribs, as their cartilaginous attachment is to the rib immediately superior to it.
- The eleventh and twelfth ribs are known as floating or free ribs as their cartilages end in the anterior abdominal musculature (Moore, 1992:32).

2.3.3) Anatomy of the first rib

According to Moore (1992:353) this is the broadest and most curved of all ribs, and the shortest true rib. The first rib is clinically important as many structures cross or attach to it. A prominent scalene tubercle is found on the internal boarder of its superior surface for the attachment of the scalenus anterior muscle. The subclavian vein crosses the first rib anterior to the tubercle and the subclavian artery. The inferior trunk of the brachial plexus passes posterior to the scalene tubercle. Distinct grooves which the subclavian vessels and the brachial plexus on the flat, superior surface of the first rib form. Posteriorly the rib articulates only with the body of the first thoracic vertebra, and not with the intervertibral disc or the vertebra inferior to it, as is the case with the remaining true ribs. As a result, there are no intra-articular ligaments and the joint cavities are not divided. The first rib also has a prominent tubercle, which articulates with the transverse process of the first thoracic vertebra. Anteriorly the first rib is attached to the manubrium.

As a result of articulating with only one vertebral body, the first costovertibral capsule is considered to be thin and weak, but the joint is strengthened by the interosseous and radiate ligaments that originate from the head of the first rib and insert onto the first thoracic vertebral body. The anterior attachment of the costal cartilage is also strengthened by radiate ligaments (Haley, 1997:133).



2.3.4) Neuroanatomy

Posteriorly the synovial costovertibral joint of the first rib is considered to be highly innervated in comparison the other costovertibral joints (Haley, 1997:133).

The stellate or cervicothoracic ganglion lies between the base of the transverse process of C7 vertebra and the neck of the first rib posteriorly, lateral to the longus coli muscle and anteriorly to the subclavian artery and its associated veins (Amantro, 1994:48). The ganglion is formed by the fusion of the seventh and eighth cervical and first and second thoracic ganglia (Johnson, 1995:135).

2.3.5) Important muscles associated with the cervical spine and first rib

The following list was compiled using Moore (1992).

1. Scalenus anterior
   - Proximal attachment: Anterior tubercles on the transverse processes of C3 to C6 vertebrae.
   - Distal attachment: Scalene tubercle on the inner boarder of the first rib and on upper surface anterior to the groove for the subclavian artery.
   - Function: Stabilises the cervical spine against lateral movement as well as the first and second rib during inhalation.
   - Innervation: Motor branches of the anterior primary divisions of the spinal nerves of C2 to C7.

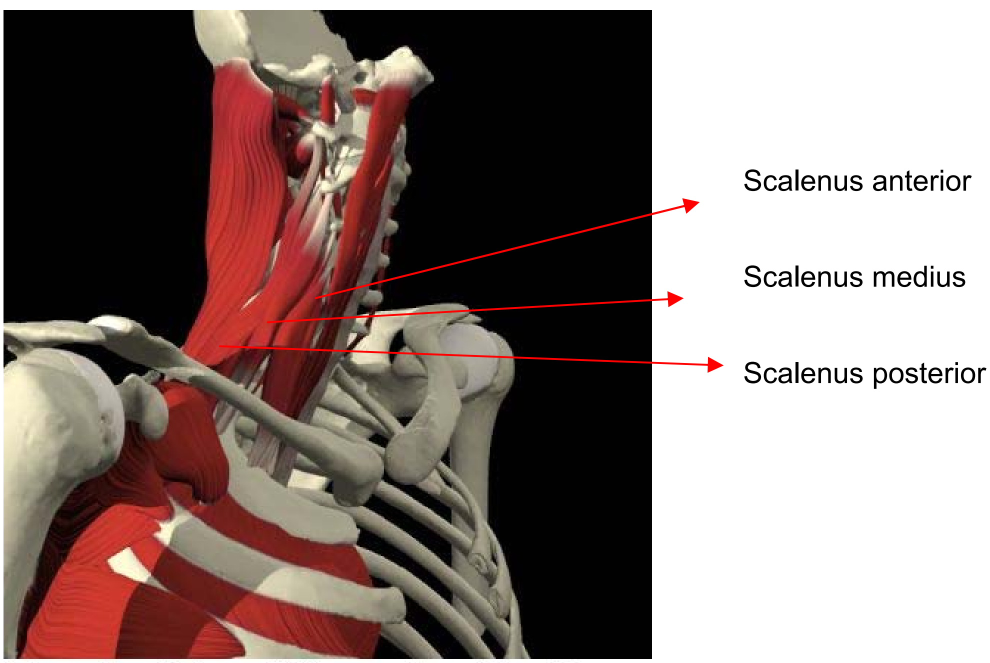
2. Scalenus medius
   - Proximal attachment: Posterior tubercles of the transverse processes of C2 to C7 vertebrae.
   - Distal attachment: Superior surface of the first rib, posterior aspect and deep to the groove of the subclavian artery.
   - Function: Stabilises the cervical spine against lateral movement as well as the first and second ribs during inhalation.
   - Innervation: Motor branches of the anterior primary divisions of the spinal nerves of C2 to C7.

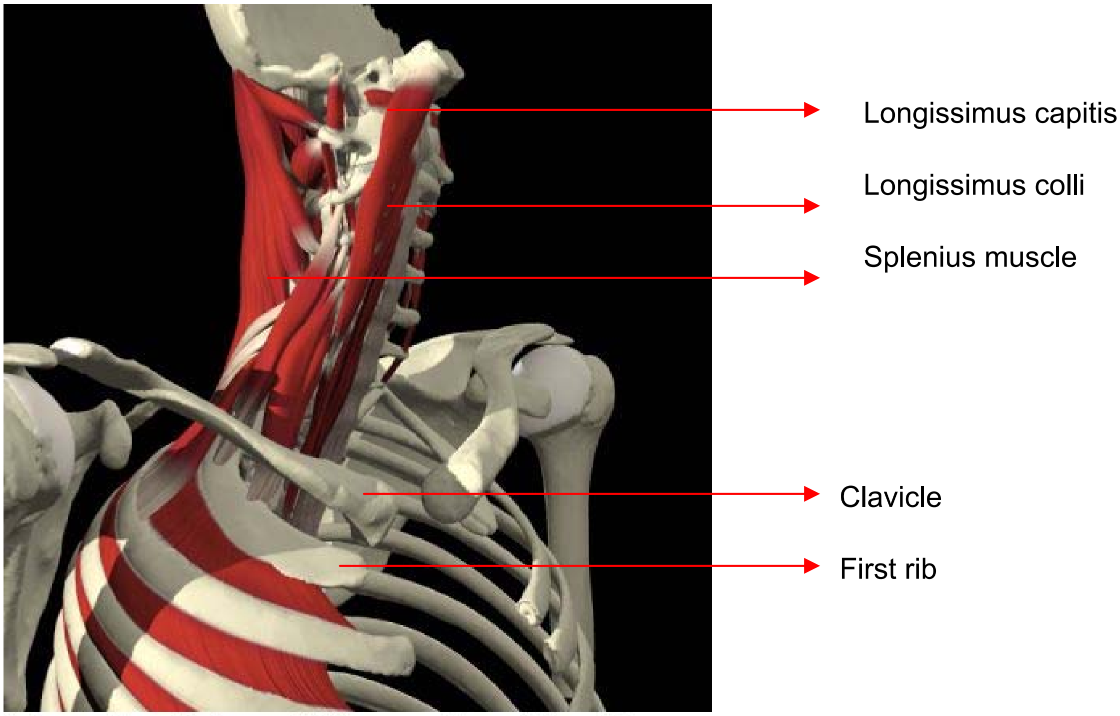
3. Scalenus posterior
   - Proximal attachment: Posterior tubercles on the transverse processes of the inferior two or three cervical vertebrae.
   - Distal attachment: Lateral surface of the second and sometimes third rib.

- Function: Stabilises the cervical spine against lateral movement as well as the first and second ribs during inhalation.
- Innervation: Motor branches of the anterior primary divisions of the spinal nerves of C2 to C7.

4. Scalenus minimus

- Proximal attachment: Posterior tubercles on the transverse processes of C7 and sometimes C6 vertebrae.
- Distal attachment: Fascia supporting the plural dome and the inner boarder of the first rib.
- Function: Stabilises the cervical spine against lateral movement as well as the first and second ribs during inhalation.
- Innervation: Motor branches of the anterior primary divisions of the spinal nerves C3 to C7.





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5. Longissimus capitis

- Proximal attachment: Posterior margins of the mastoid process.
- Distal attachment: Articular processes of the inferior three or four cervical vertebrae and to the transverse processes of the superior four or five thoracic vertebrae.
- Function: Extensor of the cervical spine, with lateral flexion to the ipsilateral side and rotation to the contra-lateral side.
- Innervation: Branches of the posterior primary division of the cervical spinal nerves.

6. Longissimus cervicis
    - Proximal attachment: Cervical transverse processes.
    - Distal attachment: Superior thoracic transverse processes.
    - Function: Extensor of the cervical spine; Lateral flexion to the ipsilateral side; Rotation to the contralateral side.
    - Innervation: Branches of the dorsal rami of the cervical spinal nerves.

7. Iliocastalis thoracis
    - Proximal attachment: All the superior ribs.
    - Distal attachment: All the inferior ribs.
    - Function: Extensor of the cervical spine; Lateral flexion to the ipsilateral side; Rotation to the contralateral side.
    - Innervation: Branches of the dorsal rami of the cervical spinal nerves.

8. Iliocastalis cervicis
    - Proximal attachment: Posterior tubercles of C4 to C6 vertebrae.
    - Distal attachment: Superior six ribs.
    - Function: Extensor of the cervical spine; Lateral flexion to the ipsilateral side; Rotation to the contralateral side.
    - Innervation: Branches of the dorsal rami of the cervical spinal nerves.

2.4) INTRODUCTION TO MECHANICAL NECK PAIN

2.4.1) Definition and cause of mechanical neck pain

Any condition or event (e.g. incorrect posture, acute injury, aging, congenital or developmental defects) leading to altered joint or muscle structure and function, can result in mechanical neck pain (Bergmann *et al.* 1993:35). Gatterman (1995:11) defines this condition as a combination of signs and symptoms that are involved in the pathophysiology of joints. Mechanical joint dysfunction is regarded as a frequent and significant cause of spinal pain (Bergmann *et al.* 1993: 58).

In this respect, a rib dysfunction can cause neck pain of mechanical origin (Haley, 1997). Innes (1994) indicates that the first rib has movement, therefore when dysfunctional, becomes significant in initiating a manipulable lesion. Bergmann *et al.* (1993:63) described five characteristics of any dysfunctional joint, which are: pain/tenderness (localised over the joint); asymmetry (of motion when the same motions are compared bilaterally); range of motion abnormality (degree or quality of motion compromise within the concerned joint); tissue tone, texture and/or temperature abnormality (as reflective of an inflammatory response and its concomitant consequences); and appropriate positive special tests (e.g. Kemps test). These five characteristics can be related to manipulable lesions relating to the first rib or the cervical spine.

Scalenii muscle involvement associated with a first rib dysfunction is associated with cervical spine pathomechanics (Innes, 1994). This argument was supported by the previous discussions by Lindgre and Leino (1988), who stated that the first costotransverse joint is the only level that lacks ligamentous support superiorly, making these joint susceptible to mechanical dysfunctions.

A first rib dysfunction with associated scalenii muscle involvement therefore also affects the lower cervical spine. It may therefore be common that patients with a first rib dysfunction will also report cervical involvement with a resultant decreased range of motion and pain radiating up the trapezius and scalenus muscles (Johnson, 1995).

2.5) MANIPULATION

2.5.1) Introduction and definition

The chiropractic profession has been around for a century, but records of manipulation date back as far back as 4000 years ago (Bergmann *et al.* 1993:1). This modality is perceived as the most significant and most specialised therapy employed by chiropractors (Bergmann *et al.* 1993:125).

In this respect, spinal manipulative therapy broadly defined includes all procedures where hands are used to mobilize, adjust, manipulate, apply traction, massage, stimulate, or otherwise influence the spine or the paraspinal tissues with the aim of influencing the patient's health (Haldeman, 1992:624).

According to Foreman and Croft (1995:458) in the arena of musculoskeletal medicine there is no single manipulation or technique that is likely to be ideal (or even suitable) for all conditions, and that a practitioner with a firm grounding in several techniques will generally have more to offer their patients than those who limit themselves to only one or two techniques.

2.5.2) Effects of manipulation

Cassidy *et al.* (1992) did a study on the immediate effect of manipulation on pain and range of motion in the cervical spine. Thirty-seven of the fifty patients reported a decrease in the pain, and all the patients had an increase in range of motion in all directions. The researcher however stated that this pilot study was not controlled, and that it only measured the short-term effects of manipulation. In addition, the statistical methods used were weak and that a greater sample size should have been used. The results were still clinically instructive and provided an outline for further research.

These results were confirmed by Parkin-Smith (1996) in his study on the efficacy of manipulation in the treatment of mechanical neck pain, where an increase in cervical range of motion and a decrease in neck pain were also recorded.

The causes of the effectiveness of chiropractic manipulation is described by Bergmann (1993:139) and included, amongst others, the following hypotheses:

- Mechanical

The cavitation is a rapid separation of two joint surfaces, which causes the stretching of periarticular tissue; this results in the release of intra-articular and extra-articular adhesions, and the stimulation of joint nociceptors and mechanoreceptors (which stimulate the golgi tendon organs and result in somatic afferent receptor activity). This all leads to a break down in the pain cycle and so a decrease in pain, muscle spasm, joint hypomobility and soft tissue inflexibility, and muscle fatigue.

A further mechanical effect of manipulation is the stimulation of the articular soft tissue and cartilage to repair its self, and the prevention of excessive fibrosis formation, atrophy and degeneration, which maintains the tissue inflexibility.

Leach (1994) discusses Korr's first theory relating to manipulative therapy resulting in the diminishing of muscle spasms in muscles related to the area of manipulative treatment, the effect was caused by forcefully stretching the muscle against its spindle-maintained resistance causing a barrage of afferent impulses intense enough to cause the CNS to reduce the gamma motorneuron discharge, secondly the Golgi tendon organs would be stimulated by forced stretch of the skeletal muscle to cause both gamma and alpha motor neuron inhibition.

- Analgesic

Manipulation causes the stimulation of superficial and deep mechanoreceptors, proprioceptors and nociceptors. This results in strong afferent segmental impulses to the spinal cord resulting in central pain transmission inhibition.

Korr (1986) suggested a number of factors that might affect the site, nature, and severity of a segmental dysfunction, which would lead to segmental facilitation. These were posture and attitude, neuroendocrine mechanisms, and endocoids (i.e., the peptides, mainly the endogenous opioids such as enkephalins and endorphins).

Korr (1986) also referred to theories crediting manipulation with the release of enkephalins and endorphins, which also caused a decrease in pain sensation. The placebo effect brought about by a consultation with a concerned and skilled practitioner is also thought to add to the analgesic effect.

- Neurobiologic

Restoring normal joint mechanics and altering neurological reflexes associated with joint dysfunction restores the normal functioning of the local and distant somatic tissue.

According to Korr (1975) the muscle spindle was the coordinator that could increase or decrease muscle contraction according to the direction of motion of the joint. This reflex muscle contraction could then produce joint motion by its action or prevent joint motion in an area of segmental dysfunction of the spine.

- Circulatory

A fixation complex can alter the segmental sympathetic tone resulting in a vasoconstriction affecting that segment. Manipulation would remove the irritation to that sympathetic segment and so lead to an improvement in circulation.

According to Leach (1994), besides the purely mechanical effect of joint manipulation, the greatest clinical effect of manipulative therapy may be due to increasing circulation within the joint itself.

2.5.3) Indication for rib manipulation

The first rib is commonly fixated in flexion, when the rib is palpated for motion it appears elevated and does not recede from the palpating finger. The restriction of movement is common following hyperextension injuries of the cervical spine, due to the attachments of the cervical spine (Gatterman, 1990:195).

2.5.4) Contra-indications to manipulation

Gatterman (1990:67) provides a comprehensive summary of the contra-indications to manipulation. Patients diagnosed with any contra-indications will be excluded from the study. This has been adapted into the following list.

- Vascular complication e.g. Vertebral-basilar insufficiency, arteriosclerosis of major blood vessels, aneurysm.
- Tumours e.g. Lung, thyroid, prostate, breast (known to metastasis to spine) and primary bone tumours
- Bone infections e.g. Tuberculosis, osteomyelitis
- Traumatic injuries e.g. Fractures, joint instability or hypermobility, severe sprains or strains and unstable spondylolisthesis.
- Arthritis e.g. Rheumatoid arthritis (transverse ligament rupture, increased inflammation), Ankylosing spondylitis (increased inflammation), Psoriatic arthritis (transverse ligament rupture), Osteoarthritis (first due to increased instability, later as a result of neurologic compromise), and uncoarthritis (vertebral compromise).
- Psychological considerations, which were noted during history taking (e.g. malingering, hysteria, hypochondriasis, and pain intolerance).
- Metabolic disorders e.g. Clotting disorders, osteoperosis, osteomalacia
- Neurological e.g. Disc protrusions, disc lesions and space-occupying lesions.

2.1 – 2.5 Summary

As a result of the first ribs involvement in cervical spine pathomechanics, it has been noted by Haley (1997) that first rib dysfunctions are under diagnosed or misdiagnosed due to a lack of assessment, or focus of assessment. However, it has been stated that a first rib dysfunction is one of the most common and over-looked dysarthrodial conditions to present to the Chiropractic Physician (Amitrano, 1994). The first rib is frequently subluxated superiorly when the lower cervical compression tests are positive (Amitrano, 1994).

As a result of his clinical experience Haley (1997) noticed immediate relief of his neck pain patients after the adjustment of a first rib dysfunction. When previous treatment has only brought temporary relief from neck pain, assessment of the first rib for joint dysfunctions is recommended, due to it being a possible source of pain (Haley, 1997). Lewit (1991:197) confirmed this observation (Haley, 1997) when his research showed that dysfunction of the first rib goes hand in hand with reflex spasm (increased tension) of the scalene muscles on the same side, which is abolished by treatment of the first rib.

According to Douglas (2004), first rib manipulation had a positive immediate and short-term effect on the following ranges of motion of the cervical spine, flexion, extension, right lateral flexion and left lateral flexion. The adjustment of the first rib caused no immediate or short-term relief from pain itself, and so is not an effective form of treatment for patients suffering from mechanical neck pain if used in isolation, Douglas (2004). This is supported by Johnson (1995:134) who found that the early detection and treatment of a first rib dysfunction often leads to significant and lasting relief from the condition for the patient.

Therefore, this research aims to investigate the effectiveness of first rib manipulation as an adjunct to the treatment of mechanical neck pain.

As a result of the paucity of literature this study focuses on a placebo-controlled trial of care, thus the following section will discuss the need for placebo and its application.

2.6) PLACEBO

2.6.1) Introduction and definition

The study involves the use of detuned ultrasounds as a placebo intervention in all four groups, with the fourth group been a placebo-controlled group as no other therapeutic intervention is employed in the treatment of the patients.

The placebo effect can be defined as a favourable response by patients to any intervention performed by a health professional regardless of whether the intervention has a direct effect on the condition (Jamison, 1994). Jamison (1994) continued that the response is unrelated to the physiological effects of the therapy applied.

2.6.2) Explanations for the placebo effect

Turner *et al.* (1994) gave three important reasons for clinical improvement in a patient suffering from a pain condition.

The first was attributed to natural history and regression to the mean, meaning that most acute and some chronic pain conditions resolve on their own irrespective of treatment.

Secondly, specific effects attributable to the characteristic content of the treatment.

Thirdly, the non-specific effects of the treatment, which are attributed to factors other than specific active components of the treatment. These would include the physicians attention, interest and concern in a healing setting; both patient and physician expectations of the treatment effects; the reputation, expense and impressiveness of the treatment: and finally the characteristics of the setting that influence patients to report improvement.

Levin and Solomon (1990) maintain that it is not possible to draw a boundary between the body of nature and the body of culture. The psychosomatic body of behavioural medicine, in which mind-body (psychological-physical) dualism restricted contemplation of psychophysiological interaction to particular conditions is been transformed by psychoneuroendoimmunology, in which the mind and body are seen as a single system of intercommunicating organized processes.

This is simply described instead of assuming that all interventions are of a physical or chemical nature; this model indirectly implies that all the individual's experiences affect his/her health status (Levin and Solomon, 1990:484).

2.6.3) Conclusion

The effect of the placebo phenomenon in clinical care has long been recognised. It is relatively recent that the legitimacy of actively promoting placebo benefits is being contemplated. Understanding of the multifactor interactive nature of health and disease has made such progress possible (Jamison, 1996).

CHAPTER THREE - MATERIALS AND METHODS

3.1) INTRODUCTION

In this chapter the following will be discussed:

a. A detailed description of the design of the study,
b. The interventions,
c. The methods employed in data collection,
d. A description of each treatment group is given, as well as the criteria for inclusion, exclusion and diagnosis of the patients, and
e. The statistical methods used for the analysis and interpretation of the data.

3.2) DESIGN

A prospective, comparative, randomised, placebo controlled clinical trial.

3.3) PATIENT RECRUITMENT

The public was informed about the nature of the research by way of pamphlets, newspaper advertisements, posters (Appendix A) and word of mouth at the Chiropractic Day Clinic and other public venues such as supermarkets, pharmacies, sports clubs, gyms, schools, libraries, places of business etc.

Only English-speaking patients were considered, as English is the researcher’s first language and so helped to reduce possible linguistic confusion between the research participants and the researcher.

3.4) SAMPLING

3.4.1) Sample size

The sample size consisted of sixty patients, which was further subdivided into four treatment groups each consisting of fifteen patients per group.

3.4.2) Sample allocation

Sixty participates with a diagnosis of mechanical neck pain with an associated first rib dysfunction were required for the study, and were obtained by means of a convenience sampling technique related to the advertising method.

Once accepted into the study, each patient was randomly assigned into either one of the four treatment groups. The process of randomisation included pre-selection by a randomly available third party, who assigned consecutive patients that presented to the clinic into either Group A, Group B, Group C, or Group D by means of drawing out of an envelope a slip of paper with a letter that represented one of the groups.

The possibility that the lower cervical spine might adjust while the first rib was been manipulated on the same side was considered. In order to minimise the possibility of cervical spine manipulation whilst manipulating the first rib, it was decided that all patients would be manipulated in the supine position. Nevertheless if this occurred, these participants would not be excluded from the study but put into a separate group for statistical purposes (see demographics 4.3.1).

3.5) PATIENT CONSULTATION

Where necessary, telephonic consultations were conducted with the prospective patients to ascertain whether they were eligible to participate in the study in accordance with the inclusion criteria, and to ensure that they had signs and symptoms indicating a strong possibility that they did indeed suffer from mechanical neck pain (see Appendix E1 for the questions that were posed in the telephonic interview).

When the patients presented to the Chiropractic Day Clinic, a face-to-face interview was conducted to determine if the patient fitted the rest of the diagnostic, inclusion and exclusion criteria. The questions asked were the same as for the telephonic interview (Appendix E1).

Thereafter a full history (Appendix H), senior physical (Appendix I), and a cervical examination (Appendix J) were conducted in order to assess the patient according to the diagnostic, inclusion and exclusion criteria.

3.6) INCLUSION, EXCLUSION AND DIAGNOSTIC CRITERIA

3.6.1) Inclusion criteria

- In order to increase group homogeneity, patients were required to have a neck pain, which was initially rated by the patient to be between 50 and 100 on the numerical pain rating scale, indicating a moderate to severe degree of discomfort, in order to be included in this trial (Mouton: 1996:137). This by virtue of the level of pain was deemed to indicate that the participants would have a greater tendency towards an acute presentation of neck pain as it is difficult to isolate independent cases of acute, acute on chronic or chronic neck pain between different patients with differing perceptions of these terms.

- Only participants between the ages of 18 and 50 years of age were included into the study, in an attempt to avoid including patients with significant degenerative changes that occur mostly over the age of fifty (Edwards, 1995). The age parameters are also in keeping with Douglas (2004) and allow for increased group homogeneity (Mouton: 1996:137).
- Only English-speaking patients were included, as English is the researcher's first language and helped to reduce possible linguistic confusion between participants and the researcher, when recording and reporting of data was completed.
- Patients were only accepted if they had read and signed the informed consent form, undergone a full history, physical examination, and cervical regional examination.
- After the initial consultation, patients were required to attend two follow-up visits and requested to participate in the entire protocol in order to avoid exclusion.

3.6.2) Exclusion criteria

- Any persons that at the time were currently taking either anti-inflammatory or analgesic medication were required to cease the intake 48 hours prior to consultation. According to Schafer and Faye (1990) and Poul *et al.* (1993) these particular drugs were able to provide pain relief and may thus confound the results obtained from the study.
- Participants with any contra-indications to manipulation (Forman and Croft 1995:469, Bergmann *et al.* 1993:133) were not included into the study as three of the four groups included manipulation. These contra-indications included but were not limited to: vertebrobasilar insufficiency, aneurysm, disc prolapse with neurological deficit, fracture, dislocation, and bone tumour and bone infection. Relative contra-indications included but were not limited to: atherosclerosis, anti-coagulant therapy, advanced osteoarthritis, inflammatory arthritis, joint instability, osteomyelitis, osteomalacia and space occupying lesions.

- Any individual who had a major whiplash injury more than 10 years previously was be excluded from the study, due to possible degenerative changes having occurred post injury (Foreman and Croft, 1995: 298).
- Any patient who did not sign the consent form (Appendix B) was excluded.
- Anyone who had indications that would necessitate further clinical testing, such as X-rays or blood tests, in order to confirm or refute the differential diagnoses was excluded from the study in order to maintain patient clinical homogeneity (Mouton, 1993:137)
- Participants were not to receive any other form of treatment for the entire duration of the study as this would result in them being excluded from the study.
- If any major lifestyle changes (e.g. rigorous exercise) were made while involved with the study, that participant was excluded from the study.
- Individuals who were pregnant or lactating, at the time of the study, were excluded.
- Patients presenting with any of the following unlimited contra-indications to ultrasound were excluded from the study: malignant tumours, pregnancy, and thrombophlebitis. Ultrasound shall also not be applied over the following: central nervous system tissue, joint cement, pacemaker, eyes, or reproductive organs. Precaution needs to be taken for the application of ultrasound in the following conditions: acute inflammation, epiphyseal plates, fractures, and breast implants (Cameron, 1999).
- Patients were excluded from the study if the allotted number of consultations or the clinical protocol were not adhered to.
- Patients found to have a positive Vertebral Artery/Wallenberg's Test were excluded from the study.

3.6.3) Diagnostic criteria

According to Bergmann *et al.* (1993:63) (Appendix E1) there are five diagnostic criteria for joint dysfunction in mechanical neck pain:

- **Pain/tenderness-** produced by palpation of osseous and soft tissue.
- **Asymmetry-** noted through observation of posture and gait as well as palpation for misalignment of vertebral segments.
- **Range of motion abnormality-** Changes in active, passive and accessory joint motions are noted through procedures of motion palpation.
- **Tissue tone, texture and/or temperature abnormality-** Changes in the characteristics of contiguous and associated soft tissue are noted through the procedures of observation, instrumentation and tests length and strength.
- **Special tests-** e.g. Kemps.

A positive motion palpation finding indicating a symptomatic joint shall be defined as meeting three criteria (Plaugher, 1993:87) (Appendix E2):

- Abnormal end feel.
- Abnormal quality of resistance to motion.
- Reproduction of pain (either local or referred) when passive accessory movements (end feel) are tested.

3.7) ORTHOPEDIC TESTS

3.7.1) Vertebral artery test

With the patient lying supine, the examiner passively places the patient's head into extension and lateral flexion, after which the head is then rotated to the same side, this position is held for 30 seconds. The patient reporting the following, but not limited to, the onset of dizziness or nausea, or the occurrence of nystagmus would indicate a positive result to the testing. The symptoms are as a result of compression of the opposite vertebral artery. This test must be done with care (Magee, 1997: 152). Patients that were found to have a positive vertebral artery test were excluded from the study.

3.7.2) Distraction test

The examiner places one hand beneath the patient's chin and the other around the occiput, and slowly lifts the patient's head, while the patient was in a seated position. The test is used for patients with radicular symptoms. The test is considered positive if the pain is relieved during the test indicating that pressure on the nerve roots has been relieved (Magee, 1997: 145). A positive test would be indicative of neck pain of a mechanical origin.

3.7.3) Foraminal compression test

The patient first laterally flexes their head to the unaffected side first, followed by the affected side. In the flexed position the examiner pushes straight down on the head. The test is positive if pain radiates into the arm, on the same side as to which the head is flexed, during compression, this is due to pressure on a nerve root. Neck pain with no radiation of pain is not considered to be a positive sign. If the pain occurs on the opposite side to which the head is bent it is indicative of muscle spasm in conditions such as tension myalgia and whiplash syndromes. (Magee, 1997: 145). The test was used to diagnose the patients condition and not as an exclusion criteria.

3.7.4) Shoulder depression test

The test is used to evaluate for brachial plexus lesions. The examiner laterally flexes the patient's head to one side while applying downward pressure to the opposite shoulder. If the pain increased the test was positive for irritation or compression of the nerve roots or foraminal encroachment due to osteophytes on the side being compressed. Adhesions around the dural sleeves of the nerve and adjacent capsule, or a hypermobile joint capsule on the side been stretched. Used to confirm neck pain of a mechanical origin.

3.8) RESEARCH METHODOLOGY/ PROCEDURE

After the completion of the initial evaluation and inclusion of the patient into the research, the patient was informed about the nature of the study and was provided with a letter of information (Appendix D). In order to ensure that the patient's completely understood the research and to protect their interests, the patients were required to read and sign the abovementioned letter of information. At any stage the patient had the opportunity to ask any questions pertaining to the research.

Fifteen randomly selected patients received first rib manipulation (GROUP A), fifteen randomly selected patients received cervical manipulation (GROUP B), fifteen randomly selected patients received both first rib manipulation and cervical spine manipulation (Group C), all patients received detuned ultrasound therapy over the related Scalene muscles, this included fifteen randomly selected patients that only received detuned ultrasound therapy (Group D). The ultrasound was applied over the scalene area for duration of two minutes.

In order to standardize the evaluations and treatments, the researcher did all evaluations and treatments.

3.8.1) Treatment Group A

The patients in Group A were treated using detuned ultrasound and the first rib was be manipulated. According to Schafer and Faye (1990) the first rib is located 4-5cm lateral to the first thoracic vertebra, anterior to the trapezius muscle, and postero-superior to the clavicle. A first rib that has been subluxed for any length of time would be very tender to palpation, Rollis (2003). The degree of tenderness would normally determine the type of contact and therefore the manipulative procedure.

The first rib was manipulated in the following manner: The manipulative procedure could be described as a fingertip or a knife-edge contact used to produce a superior to inferior force that will depress the motion of the first rib. Lateral flexion and rotation of the head of the patient towards the same side would further accentuate the movement of the first rib. The adjustment was performed in the supine position.

3.8.2) Treatment Group B

The patients of group B were treated using detuned ultrasound and the patients' cervical spine was manipulated. According to Schafer and Faye (1990) all cervical vertebrae from C2 to C7 move in flexion, extension, rotation, and lateral bending, with some regions been more active in certain movements than others. The occipitoatlantal joint allows for flexion, extension, slight lateral flexion, and rotation. Significant rotation, flexion, and extension, and slight lateral flexion occur at the atlanto-axial joint. During motion palpation, each motion segment will be assessed in the above planes of movement, assessing for normal and abnormal segmental movement, and for motion restrictions and abnormal motion quality.

The cervical spine was manipulated in the following manner: Any motion segment that, during palpation, exhibited a motion restriction was manipulated in order to regain normal function within that segment, in the direction of restriction. The motion segment was adjusted into the direction of decreased motion. As far as possible the patients were treated in a supine position, using an index contact, to standardize treatment procedure.

3.8.3) Treatment Group C

The first ribs of the patients were assessed and treated in the same manner as the patients in Group A. The patients also had their cervical spines assessed and treated in the same manner as the patients in Group B. The patients also received detuned ultrasound treatment.

With respect to manipulation (treatment groups A through C); the joint was deemed to have been manipulated when on re-assessment of the motion parameters (motion palpation), the joint showed evidence of improved movement. Therefore this research did not use the presence or absence of a cavitation in order to determine whether an applied manipulation was successful.

3.8.4) Treatment Group D

According to Grey *et al.* (1960:437), the scalenus anterior arises from the anterior tubercles of the transverse processes of the third, fourth, fifth, and sixth cervical vertebrae, and insert into the scalene tubercle on the inner border of the first rib, and into the ridge on the upper surface of the rib in front of the subclavian groove. The scalenus medius, the largest and longest of the three scalenii muscles, arises from the posterior tubercles of the lower six cervical vertebrae, and inserts into the upper surface of the first rib, between the tubercle and the subclavian groove. The scalenus posterior, the smallest and deepest of the three scalenii arises by two or three separate tendons, from the posterior tubercles of the transverse processes of the lower two or three cervical vertebrae, and inserts into the outer surface of the second rib, behind the attachment of the serratus anterior. It is occasionally blended with the scalenus medius.

Scalene muscle were treated in all four groups, groups A, B, C, and D using the following approach: to stretch the scalenus anterior, the head and neck of the seated patient is tilted towards the contralateral side and slightly extended. The head of the ultrasound applicator is then applied along the lines of the scalenus anterior muscle fibres, moving the applicator in small overlapping circles. The ultrasound shall be detuned and so the setting values are not applicable.

3.9) MEASUREMENTS

3.9.1) Objective measurements

To measure the objective outcomes the Cervical Range of Motion (CROM) Goniometer and the Pressure Algometer were used. These instruments are briefly discussed below:

- Cervical Range of Motion (CROM) Goniometer.

The Performance Attained Associates Mode (3600 Labore Rd, Suite 6, St. Paul, MN 55110-41144) was the CROM goniometer used in this study. The device had been shown to produce good intra and inter examiner reliability in the measurement of cervical spine range of motion (Youdas *et al.,* 1991).

To measure the cervical spine range of motion, the patient was asked to sit in a straight backed chair with their lower back pressed against the back of the chair. The CROM was then placed in position with the magnets around the patient's neck in the correctly aligned sequence. Measurement in degrees were taken and recorded for each range of motion. The patient's movements were carefully monitored during the procedure to ensure that each motion was pure in its intended direction. The results from each of the six ranges of motion were recorded onto Appendix F (before and after treatments 1 and 2, and at the beginning of the third consultation) and the transferred to spread sheets for analysis.

- Pressure Algometer.

The algometer is a gauge designed to measure forces (in kilograms per square centimetre) applied to a specific location (Livingston *et al.,* 1998). The validity of the algometer was confirmed by Fischer (1987), as a means to measure manipulation as an intervention, by quantifying the participant's response to manipulation due to the ability to measure the change in pressure threshold experienced by each patient. Prior to the measurements taken, the patients were informed as to what to expect. The algometer was placed over the most tender area of the fixated rib, which was near the insertion of the anterior scalene muscle. A slow steady pressure was applied in a superior to inferior direction, having given the patient instruction to inform the clinician immediately as to the onset of pain. The applied pressure was then released and the recording in kilograms per square centimetre was then recorded onto Appendix G. This was done during visits 1 and 2, before and after the treatment, and at the beginning of the third visit. Each patient regardless of the treatment the patient was receiving, was evaluated using the algometer. The same rib was assessed during each consultation to maintain consistency.

3.9.2) Subjective measurements

To measure the subjective outcomes, the patients were required to complete the CMCC Neck Disability Index (NDI) form (Appendix M) and the NRS Pain Rating Scale (NRS-101) form (Appendix C). These two forms of measurement are described below.

- CMCC Neck Disability Index (NDI)

The CMCC Neck Disability Index (Appendix M) questionnaire was used to assess subjective pain intensity; by measuring to what degree the participant's neck pain affects their daily life. Vernon and Mior (1991) showed that the questionnaire had a high degree of validity and internal consistency, and also that it is applicable to a wide age range and unaffected by gender. The questionnaire consists of ten questions, each having six options. The first option received a score of zero while the sixth receives the maximum score of five. The participant's final total score out of fifty was then calculated as a percentage, which was then recorded onto spreadsheets.

- NRS Pain Rating Scale (NRS-101)

The NRS-101 (Appendix C) was used to measure the subjective pain intensity at its worse and at its least. The validity and practicality of the NRS-101 was demonstrated by Jensen *et al.* (1986). The scale consists of two sections, in both the patient rates their pain on a scale of zero (no pain) to 100 (pain at its worst). In the first part the patient choose a number to indicate the pain at its worst, and in the second, a number to indicate when the pain is at its least. The two answers are added together and divided by two to give a percentage that was then recorded onto a spreadsheet.

<u>Summary of treatment and measurement intervals:</u>

Week	Visit	Group A	Group B	Group C	Group D
1*	1	Initial screen Treatment A Readings	Initial screen Treatment B Readings	Initial screen Treatment C Readings	Initial screen Treatment D Readings
	2	Readings Treatment A Readings	Readings Treatment B Readings	Readings Treatment C Readings	Readings Treatment D Readings
	3	Readings	Readings	Readings	Readings

* Within this week the patients were seen on 3 consecutive days.

Readings included: Range of Motion
Algometer
NRS
CMCC

Treatment:
- A — Ultrasound + first rib manipulation
- B — Ultrasound + cervical spine manipulation
- C — Ultrasound + first rib and cervical spine manipulation
- D — Ultrasound

3.10) STATISTICAL METHODOLOGY

The SPSS version 11.5 (SPSS Inc, Chicago, Ill, USA) was used for analysis of data. Demographics were compared between treatment groups using Pearson's chi square tests for categorical variables and one way ANOVA with Bonferroni post hoc tests for quantitative variables. Treatment effects for quantitative outcomes were analyzed using repeated measures ANOVA. A significant time by group interaction ($p<0.05$) indicated a significant treatment effect. Profile plots were examined in order to assess in which direction the treatment effect was found. Subsets of the data were used to examine comparisons between specific treatment groups.

CHAPTER FOUR - RESULTS AND DISCUSSION

4.1) INTRODUCTION

This chapter covers a detailed description of the statistical analysis of both the subjective and objective data obtained from the patients who participated in the study.

The research involved sixty patients suffering from mechanical neck pain being randomly subdivided into four groups, with fifteen patients in each group. The first group received a first rib manipulation and ultrasound placebo therapy, group two received cervical spine manipulation and placebo ultrasound therapy, group three received first rib manipulation, cervical spine manipulation and placebo ultrasound therapy, and group four received placebo ultrasound therapy only.

Subjective measurements were only taken once during each of the three consultations. This included the patient answering a CMCC neck disability questionnaire (Appendix M) which was shown by Vernon and Mior (1991) to have a high degree of validity and internal consistency, and to be unaffected by gender with a wide age range and an acceptable level of validity. The patient was also required to complete a NRS pain rating scale (NRS-101) (Appendix C). Jensen *et al.* (1986) demonstrated the validity and practicality of the NRS-101. The patient was asked to rate his/her pain on a scale of zero (no pain) to 100 (pain at its worse). The first recording was when pain was at its least and the second recording was of the pain at its worst, the two values were added together and divided by two resulting in a percentage which was then recorded onto a spreadsheet.

Objective measurements were obtained using a CROM (Youdas *et al*., 1991) (Appendix F) to measure cervical range of motion and the use of an algometer (Fischer, 1987) (Appendix G) positioned over the tenderest part of the patient's symptomatic first rib. The objective measurements were taken before and after treatment during the first two consultations and only once at the beginning of the third consultation.

The purpose of the analysis is to compare the effectiveness of first rib manipulation as an adjunct to the treatment of mechanical neck pain.

4.2) DATA

4.2.1) Primary and secondary data

This chapter tabulates the results obtained from the statistical analysis of the primary data collected. Demographic data consisting of age, race, gender, occupation and type of occupation (manual or non-manual) were analysed. Objective and subjective findings were also analysed, and the correlation between findings tabulated. The measurement criteria were:

- Algometer (Fischer, 1987) (Appendix G)
- CROM (Youdas *et al*., 1991) (Appendix F)
- NRS – 101 (Jensen *et al.*, 1986) (Appendix C)
- CMCC (Vernon and Mior, 1991) (Appendix M)

4.2.2) Key abbreviations

Demographics

patientno	–	patient number
groupno	–	treatment group subject was in
age	–	age of subject, in years
gender	–	1= male; 2 = female
race	–	1= white; 2 = black; 3 = Asian/Indian; 4 = other
occuptn	–	occupation – 1 = sedentary; 2 = active
height	–	measured in centimetres
weight	–	measured in kilograms

Inferential statistics

cmcc1	–	measurement from neck disability questionnaire during first consultation
cmcc2	–	measurement from neck disability questionnaire during second consultation
cmcc3	–	measurement from neck disability questionnaire during third consultation
nrs1	–	calculated from numerical pain rating scale, first consultation
nrs2	–	calculated from numerical pain rating scale, second consultation
nrs3	–	calculated from numerical pain rating scale, third consultation
ffpre1	–	forward flexion measured before first treatment
ffpost1	–	forward flexion measured after first treatment
ffpre2	–	forward flexion measured before second treatment
ffpost2	–	forward flexion measured after second treatment
ff3	–	forward flexion measured during third consultation, no treatment given
expre1	–	extension measured before first treatment
expost1	–	extension measured after first treatment
expre2	–	extension measured before second treatment
expost2	–	extension measured after second treatment
ex3	–	extension measured during third consultation, no treatment given
rrpre1	–	right rotation measured before first treatment
rrpost1	–	right rotation measured after first treatment
rrpre2	–	right rotation measured before second treatment
rrpost2	–	right rotation measured after second treatment
rr3	–	right rotation measured during third consultation, no treatment given
lrpre1	–	left rotation measured before first treatment
lrpost1	–	left rotation measured after first treatment

lrpre2	–	left rotation measured before second treatment
lrpost2	–	left rotation measured after second treatment
lr3	–	left rotation measured during third consultation, no treatment given
rlfpre1	–	right lateral flexion measured before first treatment
rlfpost1	–	right lateral flexion measured after first treatment
rlfpre2	–	right lateral flexion measured before second treatment
rlfpost2	–	right lateral flexion measured after second treatment
rlf3	–	right lateral flexion measured during third consultation, no treatment given
llfpre1	–	left lateral flexion measured before first treatment
llfposr1	–	left lateral flexion measured after first treatment
llfpre2	–	left lateral flexion measured before second treatment
llfposr2	–	left lateral flexion measured after second treatment
llf3	–	left lateral flexion measured during third consultation, no treatment given
algopre1	–	algometer reading taken before first treatment
algopost1	–	algometer reading taken after first treatment
algopre2	–	algometer reading taken before second treatment
algopost2	–	algometer reading taken after second treatment
algo3	–	algometer reading taken during third consultation, no treatment given

4.3) RESULTS

4.3.1) Demographics

Sixty participants between the ages of 19 and 50 years were randomised into 4 equal treatment groups. The mean age was 30.85 years (SD 7.7 years). Demographics were compared between the four groups to assess if randomisation had been complete.

The distribution of patients across each treatment group was found to be statistically similar (p=0.408). There was no statistically significant difference in the proportion of race groups by treatment group (p=0.269). Comparison between sedentary versus active occupations were made, and no statistically significant difference was found between each of the groups (p=0.849). The mean age of the patients in each group was compared and found to be statistically insignificant (p=0.546). The mean height and weight were compared between each treatment group and found to have no statistically significant difference between the groups (p=0.467 and p=0.838 respectively).

What can be deduced from the results of the demographics is that the randomisation has provided the research with four groups of participants in which homogeneity is present. Allowing for the comparison of one group to another without there been pre-existing differences.

Further it should be noted that from the methodology it was considered possible for the cervical spine to cavitate whilst the first rib was being manipulated. In order to accommodate for this the participants were to be grouped as either first rib manipulation with or without cervical spine cavitation. Based on the outcome of the study, none of the participants receiving the first rib only manipulation cavitated in the cervical spine and thus there was no need to subdivide this group (even though provision was made for this instance in the methodology).

4.3.1.1) Gender

Table 1 shows the cross-tabulation of gender with treatment group. There was no statistically significant difference (p=0.408); the proportion of males and females in each group was similar.

Table 1: Distribution of gender by treatment group

		Group				Total
		First rib manipulation	Cervical spine manipulation	First rib and cervical spine manipulation	Placebo	
GENDER	Male	4	8	8	7	27
		14.8%	29.6%	29.6%	25.9%	100.0%
	Female	11	7	7	8	33
		33.3%	21.2%	21.2%	24.2%	100.0%
Total		15	15	15	15	60
		25.0%	25.0%	25.0%	25.0%	100.0%

P=0.408

4.3.1.2) Race

Table 2 shows the distribution of race by treatment group. There was no significant difference in the proportions of the race groups by treatment group (p=0.269).

Table 2: Distribution of race by treatment group

		Group				Total
		First rib manipulation	Cervical spine manipulation	First rib and cervical spine manipulation	Placebo	
RACE	White	9	6	9	6	30
		30.0%	20.0%	30.0%	20.0%	100.0%
	Black	4	5	2	8	19
		21.1%	26.3%	10.5%	42.1%	100.0%
	Asian/Indian	2	4	4	1	11
		18.2%	36.4%	36.4%	9.1%	100.0%
Total		15	15	15	15	60
		25.0%	25.0%	25.0%	25.0%	100.0%

P=0.269

4.3.1.3) Occupation

There was no significant relationship between type of occupation and treatment group (p=0.849 – Table 3). Guidelines for sedentary versus active lifestyles were based on amount of time spent seated during the day while at the work place.

Table 3: Distribution of type of occupation by treatment group

		Group				Total
		First rib manipulation	Cervical spine manipulation	First rib and cervical spine manipulation	Placebo	
Occupation	Sedentary	8	8	8	6	30
		26.7%	26.7%	26.7%	20.0%	100.0%
	Active	7	7	7	9	30
		23.3%	23.3%	23.3%	30.0%	100.0%
Total		15	15	15	15	60
		25.0%	25.0%	25.0%	25.0%	100.0%

P=0.849

4.3.1.4) Age

Table 4 shows that the mean ages for each group were similar. Table 5 shows that there was no significant difference between the groups (p=0.546).

Table 4: Descriptive statistics for the comparison of mean age by group

Group	Mean	N	Std. Deviation
First rib	30.07	15	7.685
Cervical spine	30.87	15	7.855
First rib and cervical spine	29.27	15	8.004
Placebo	33.20	15	7.495
Total	30.85	60	7.706

Table 5: ANOVA table for the comparison of mean age by group

	Sum of Squares	df	Mean Square	F	p value
Between Groups	129.650	3	43.217	0.717	0.546
Within Groups	3374.000	56	60.250		
Total	3503.650	59			

4.3.1.5) Height and Weight

Height and weight were compared between the treatment groups in Tables 6 and 7. There was no statistically significant difference between the groups (p=0.467 and 0.838 respectively). Thus there were no confounding factors in the evaluation of the treatment effects.

Table 6: Descriptive statistics for the comparison of mean height and weight by group

Group		HEIGHT	WEIGHT
First rib	Mean	166.6000	65.27
	N	15	15
	Std. Deviation	9.46271	11.126
Cervical spine	Mean	170.6000	68.53
	N	15	15
	Std. Deviation	9.91247	22.248
First rib and cervical spine	Mean	170.5333	63.93
	N	15	15
	Std. Deviation	7.29840	11.010
Placebo	Mean	170.8667	66.80
	N	15	15
	Std. Deviation	6.96795	9.829
Total	Mean	169.6500	66.13
	N	60	60
	Std. Deviation	8.47894	14.195

Table 7: ANOVA table for the comparison of mean height and weight by group

		Sum of Squares	df	Mean Square	F	p value
HEIGHT	Between Groups	186.983	3	62.328	.861	0.467
	Within Groups	4054.667	56	72.405		
	Total	4241.650	59			
WEIGHT	Between Groups	176.933	3	58.978	.282	0.838
	Within Groups	11712.000	56	209.143		
	Total	11888.933	59			

4.4) ANALYSIS OF TREATMENT EFFECTS

4.4.1) First Rib versus Cervical Spine manipulation

4.4.1.1) Objective clinical findings

a) Flexion

Table 8: Between and within subjects effects for Flexion, first rib versus cervical spine manipulation

Effect	Statistic	p value
Time	Wilk's lambda=0.527	0.002
Time*group	Wilk's lambda=0.962	0.907
Group	F=0.360	0.554

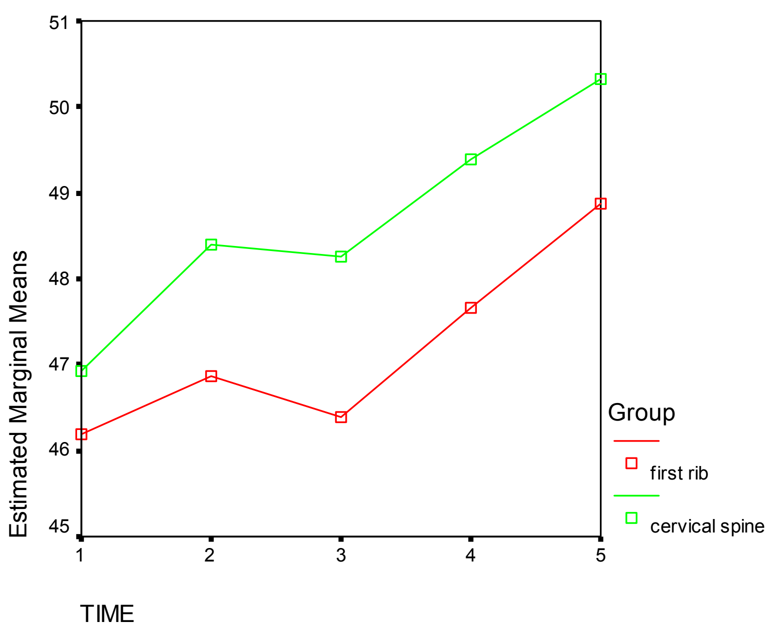

Figure 1: Profile plot of mean Flexion over time in first rib manipulation and cervical spine manipulation groups

The Null Hypothesis states that there is no difference in treatment effect between first rib manipulation and cervical spine manipulation in terms of flexion.

Table 8 shows that we cannot reject the null hypothesis. There was no treatment effect (p=0.907). Figure 1 shows that the profiles of the two groups were almost parallel. Both groups showed an increase at the same rate over time, and the overall improvement was statistically significant (p=0.002), but it was not dependant on the treatment group.

b) Extension

The Null Hypothesis states that there is no difference in treatment effect between first rib manipulation and cervical spine manipulation in terms of extension.

The null hypothesis could not be rejected for extension (p=0.115), although both groups showed a significant improvement over time (p=0.002). This is shown graphically in Figure 2, where the profiles of the two groups are almost parallel.

Table 9: Between and within subjects effects for Extension, first rib versus cervical spine manipulation

Effect	Statistic	p value
Time	Wilk's lambda=0.511	0.002
Time*group	Wilk's lambda=0.744	0.115
Group	F=3.809	0.061

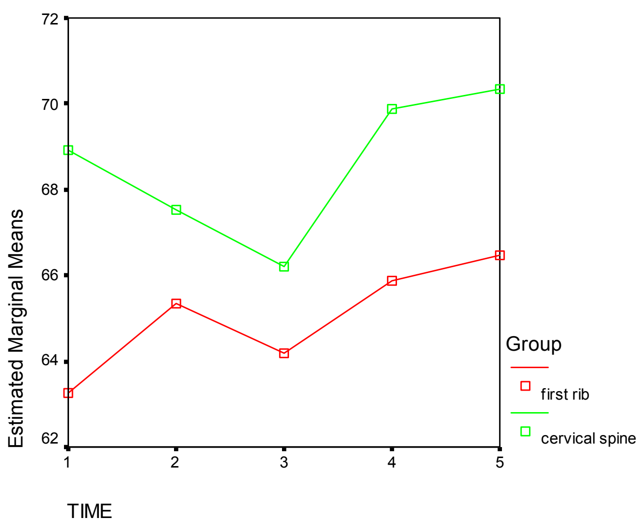

Figure 2: Profile plot of mean Extension over time in first rib manipulation and cervical spine manipulation groups

c) Right rotation

The Null Hypothesis states that there is no difference in treatment effect between first rib manipulation and cervical spine manipulation in terms of right rotation.

The null hypothesis is not rejected (p=0.607). Figure 3 shows similar treatment effects in both groups for right rotation.

Table 10: Between and within subjects effects for right rotation, first rib versus cervical spine manipulation

Effect	Statistic	p value
Time	Wilk's lambda=0.393	<0.001
Time*group	Wilk's lambda=0.901	0.607
Group	F=0.369	0.549

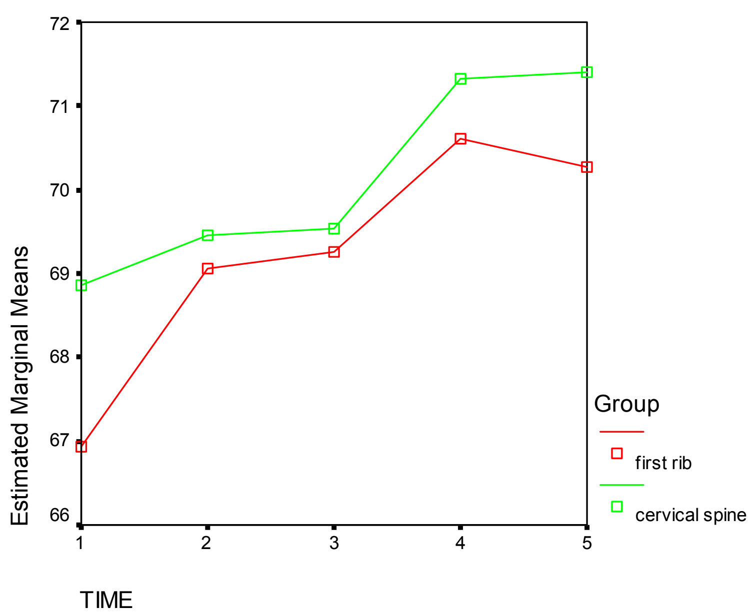

Figure 3: Profile plot of mean right rotation over time in first rib manipulation and cervical spine manipulation groups

d) Left rotation

The Null Hypothesis states that there is no difference in treatment effect between first rib manipulation and cervical spine manipulation in terms of left rotation.

The null hypothesis is not rejected (p=0.473) and both groups improved to the same extent over time (see Figure 4).

Table 11: Between and within subjects effects for left rotation, first rib versus cervical spine manipulation

Effect	Statistic	p value
Time	Wilk's lambda=0.418	<0.001
Time*group	Wilk's lambda=0.873	0.473
Group	F=0.046	0.831

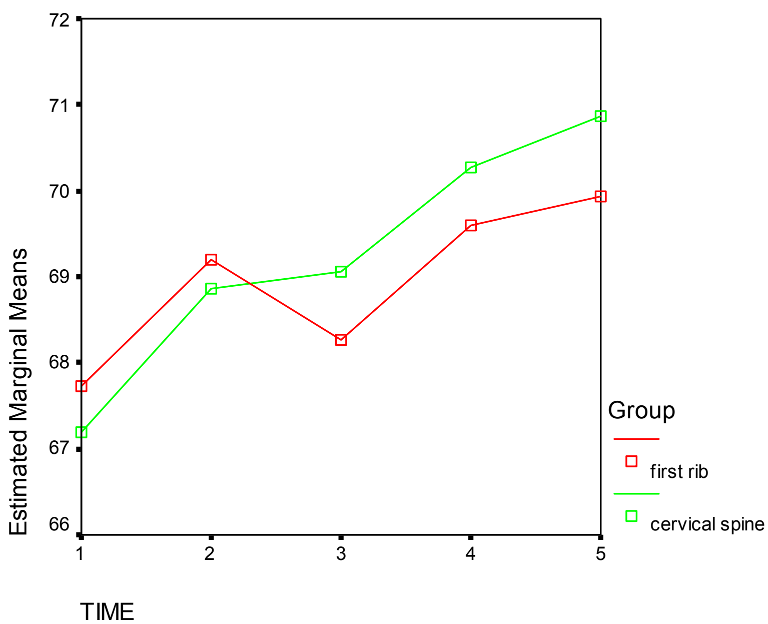

Figure 4: Profile plot of mean left rotation over time in first rib manipulation and cervical spine manipulation groups

e) Right lateral flexion

The Null Hypothesis states that there is no difference in treatment effect between first rib manipulation and cervical spine manipulation in terms of right lateral flexion.

We fail to reject the null hypothesis for this outcome (p=0.118). Figure 5 shows a possible non-significant trend between time 4 and 5. The cervical spine manipulation group continued to show improvement between these time points, while the first rib group decreased.

Table 12: Between and within subjects effects for right lateral flexion, first rib versus cervical spine manipulation

Effect	Statistic	p value
Time	Wilk's lambda=0.219	<0001
Time*group	Wilk's lambda=0.753	0.118
Group	F=0.299	0.589

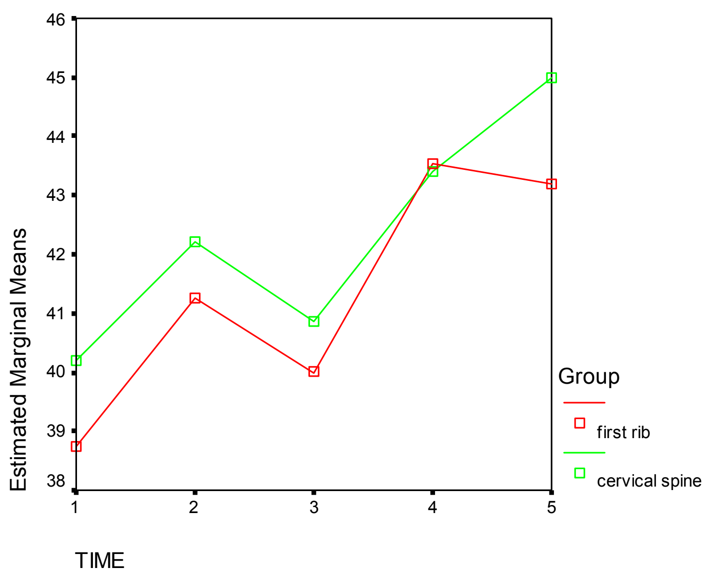

Figure 5: Profile plot of mean right lateral flexion over time in first rib manipulation and cervical spine manipulation groups

f) Left lateral flexion

The Null Hypothesis states that there is no difference in treatment effect between first rib manipulation and cervical spine manipulation in terms of left lateral flexion.

We do not reject the null hypothesis (p=0.241). Both groups showed significant improvement over time (Figure 6), although the first rib manipulation group appeared to improve at a faster rate after treatment 3.

Table 13: Between and within subjects effects for left lateral flexion, first rib versus cervical spine manipulation

Effect	Statistic	p value
Time	Wilk's lambda=0.399	<0.001
Time*group	Wilk's lambda=0.810	0.241
Group	F=0.258	0.615

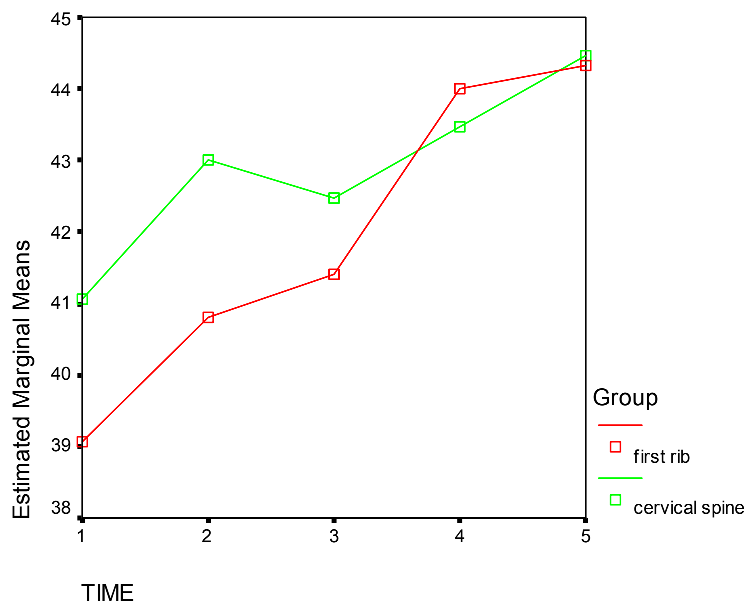

Figure 6: Profile plot of mean left lateral flexion over time in first rib manipulation and cervical spine manipulation groups

g) Algometer

The Null Hypothesis stated that there is no difference in treatment effect between first rib manipulation and cervical spine manipulation in terms of algometer.

The null hypothesis is not rejected for this outcome (p=0.502). Figure 7 shows almost parallel profiles over time.

Table 14: Between and within subjects effects for Algometer, first rib versus cervical spine manipulation

Effect	Statistic	p value
Time	Wilk's lambda=0.282	<0.001
Time*group	Wilk's lambda=0.879	0.502
Group	F=1.996	0.169

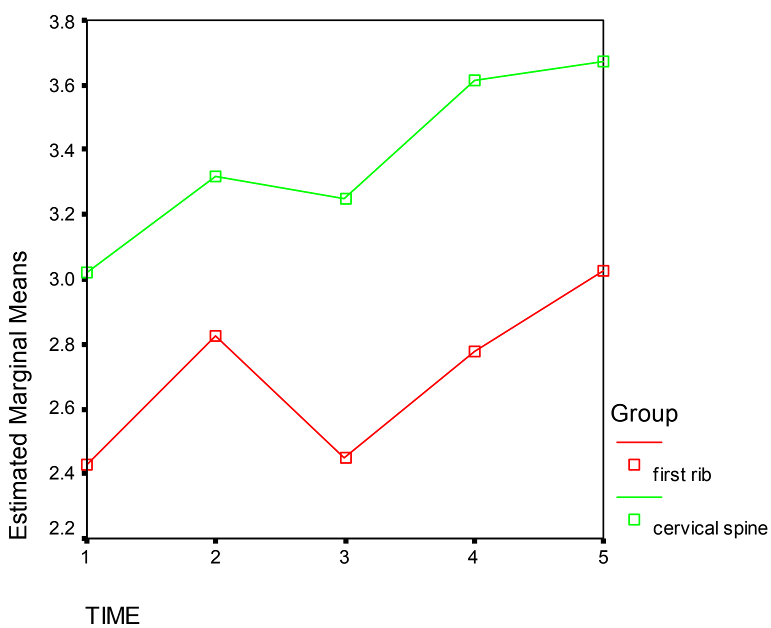

Figure 7: Profile plot of mean algometer over time in first rib manipulation and cervical spine manipulation groups

4.4.1.2) Subjective clinical findings

a) CMCC Score

The Null Hypothesis states that there is no difference in treatment effect between first rib manipulation and cervical spine manipulation in terms of CMCC score.

The null hypothesis is rejected (p=0.024). The treatment effect in the first rib manipulation group is significantly better than in the cervical spine group for CMCC scores. The interaction is shown in Figure 8. From time 2 onwards the first rib group continued to show a steep mean decrease while the cervical spine group started to show a more shallow decrease.

Table 15: Between and within subjects effects for CMCC, first rib versus cervical spine manipulation

Effect	Statistic	p value
Time	Wilk's lambda=0.131	<0.001
Time*group	Wilk's lambda=0.759	0.024
Group	F=0.003	0.956

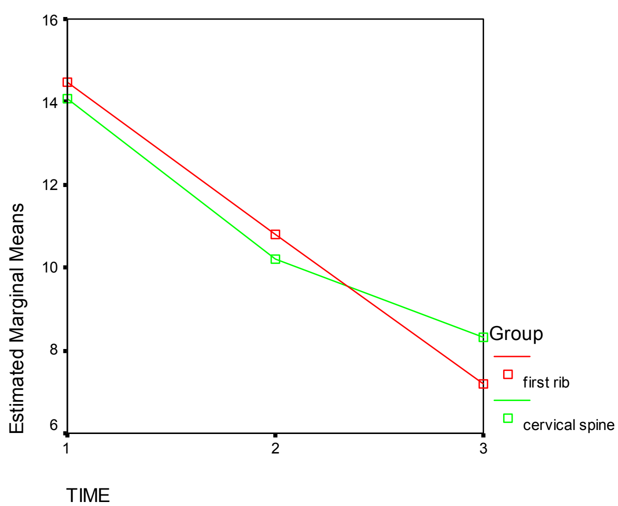

Figure 8: Profile plot of mean CMCC over time in first rib manipulation and cervical spine manipulation groups

b) NRS

The Null Hypothesis states that there is no difference in treatment effect between first rib manipulation and cervical spine manipulation in terms of NRS.

The null hypothesis is not rejected (p=0.909). Figure 9 shows that the profiles of the two groups were identical over time for NRS.

Table 16: Between and within subjects effects for NRS, first rib versus cervical spine manipulation

Effect	Statistic	p value
Time	Wilk's lambda=0.124	<0.001
Time*group	Wilk's lambda=0.993	0.909
Group	F=0.036	0.852

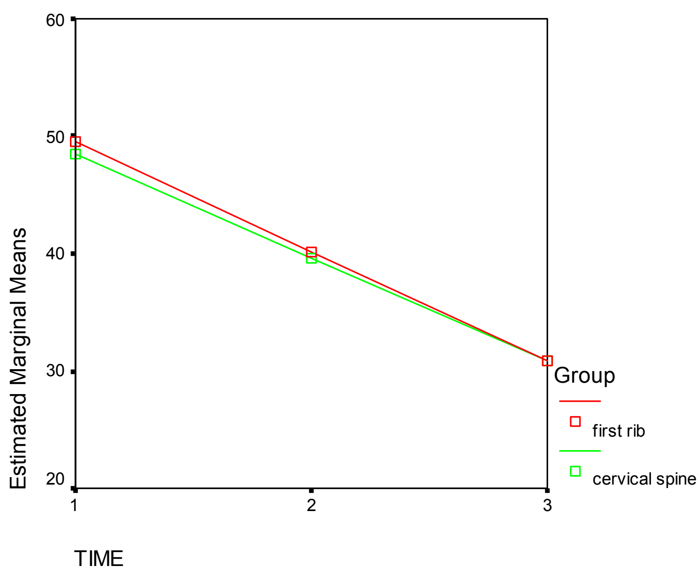

Figure 9: Profile plot of mean NRS over time in first rib manipulation and cervical spine manipulation groups

4.4.2) First Rib versus First rib plus Cervical Spine manipulation

4.4.2.1) Objective clinical findings

a) Flexion

Null Hypothesis: there is no difference in treatment effect between first rib manipulation and first rib plus cervical spine manipulation in terms of flexion.

Table 17 shows that the null hypothesis cannot be rejected for flexion (p=0.801). Figure 10 indicates parallel profiles over time.

Table 17: Between and within subjects effects for Flexion, first rib versus first rib plus cervical spine manipulation

Effect	Statistic	p value
Time	Wilk's lambda=0.428	<0.001
Time*group	Wilk's lambda=0.939	0.801
Group	F=2.024	0.166

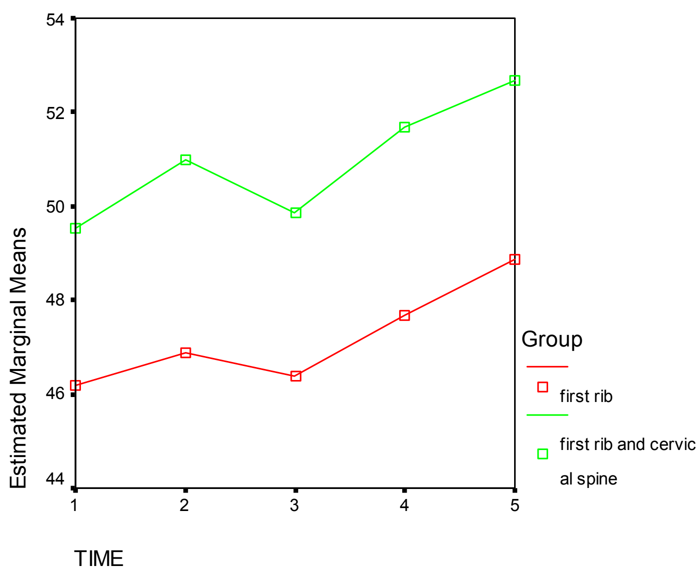

Figure 10: Profile plot of mean Flexion over time in first rib manipulation and first rib plus cervical spine manipulation groups

b) Extension

Null Hypothesis: there is no difference in treatment effect between first rib manipulation and first rib plus cervical spine manipulation in terms of extension.

The null hypothesis was not rejected (p=0.679). Overall both groups showed significant increases (p=0.001) in mean values over time but this was not dependent on the treatment group (see Figure 11).

Table 18: Between and within subjects effects for Extension, first rib versus first rib plus cervical spine manipulation

Effect	Statistic	p value
Time	Wilk's lambda=0.500	0.001
Time*group	Wilk's lambda=0.915	0.679
Group	F=0.594	0.447

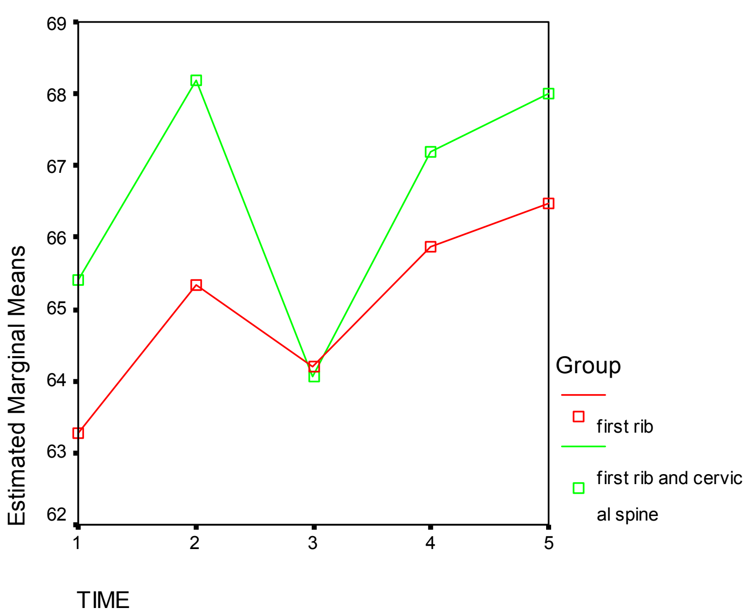

Figure 11: Profile plot of mean Extension over time in first rib manipulation and first rib plus cervical spine manipulation groups

c) Right rotation

Null Hypothesis: there is no difference in treatment effect between first rib manipulation and first rib plus cervical spine manipulation in terms of right rotation.

The null hypothesis was not rejected for this outcome (p=0.920). Figure 12 shows almost parallel profiles over time.

Table 19: Between and within subjects effects for right rotation, first rib versus first rib plus cervical spine manipulation

Effect	Statistic	p value
Time	Wilk's lambda=0.307	<0.001
Time*group	Wilk's lambda=0.965	0.920
Group	F=1.478	0.234

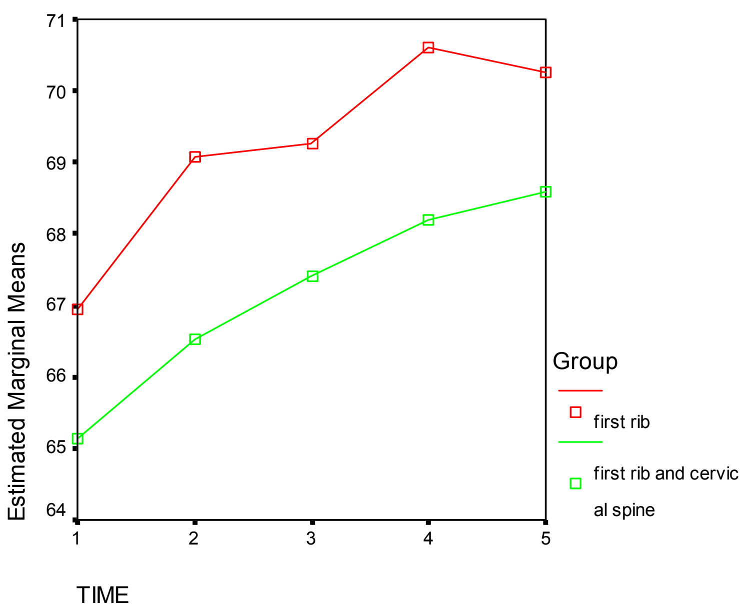

Figure 12: Profile plot of mean right rotation over time in first rib manipulation and first rib plus cervical spine manipulation groups

d) Left rotation

Null Hypothesis: there is no difference in treatment effect between first rib manipulation and first rib plus cervical spine manipulation in terms of left rotation.

The null hypothesis is not rejected (p=0.160). Figure 13 suggests some interaction between group and time, i.e. the group that received first rib plus cervical spine manipulation appeared to decrease between time 1 and 3 and then showed a steep increase.

Table 20: Between and within subjects effects for left rotation, first rib versus first rib plus cervical spine manipulation

Effect	Statistic	p value
Time	Wilk's lambda=0.395	<0.001
Time*group	Wilk's lambda=0.776	0.160
Group	F=0.361	0.553

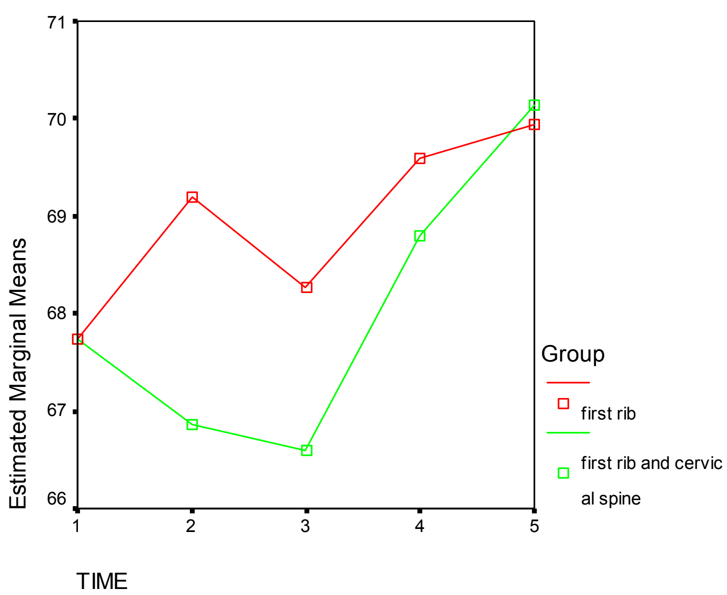

Figure 13: Profile plot of mean left rotation over time in first rib manipulation and first rib plus cervical spine manipulation groups

e) Right lateral flexion

Null Hypothesis: there is no difference in treatment effect between first rib manipulation and first rib plus cervical spine manipulation in terms of right lateral flexion.

The null hypothesis is not rejected (p=0.486). Figure 14 show that the two groups behaved very similar over time.

Table 21: Between and within subjects effects for right lateral flexion, first rib versus first rib plus cervical spine manipulation

Effect	Statistic	p value
Time	Wilk's lambda=0.176	<0001
Time*group	Wilk's lambda=0.876	0.486
Group	F=0.063	0.803

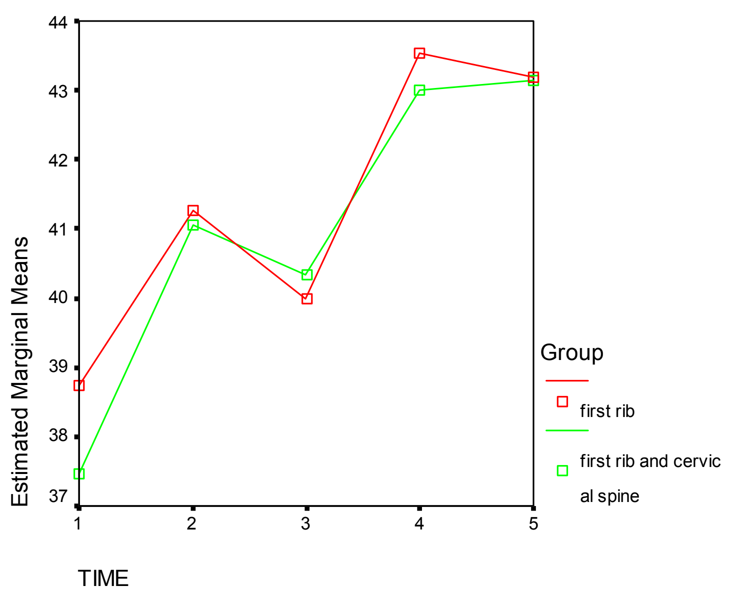

Figure 14: Profile plot of mean right lateral flexion over time in first rib manipulation and first rib plus cervical spine manipulation groups

f) Left lateral flexion

Null Hypothesis: there is no difference in treatment effect between first rib manipulation and first rib plus cervical spine manipulation in terms of left lateral flexion.

The null hypothesis is not rejected (p=0.528). The means over time were similar in both groups (see Figure 15).

Table 22: Between and within subjects effects for left lateral flexion, first rib versus first rib plus cervical spine manipulation

Effect	Statistic	p value
Time	Wilk's lambda=0.189	<0.001
Time*group	Wilk's lambda=0.885	0.528
Group	F=0.015	0.905

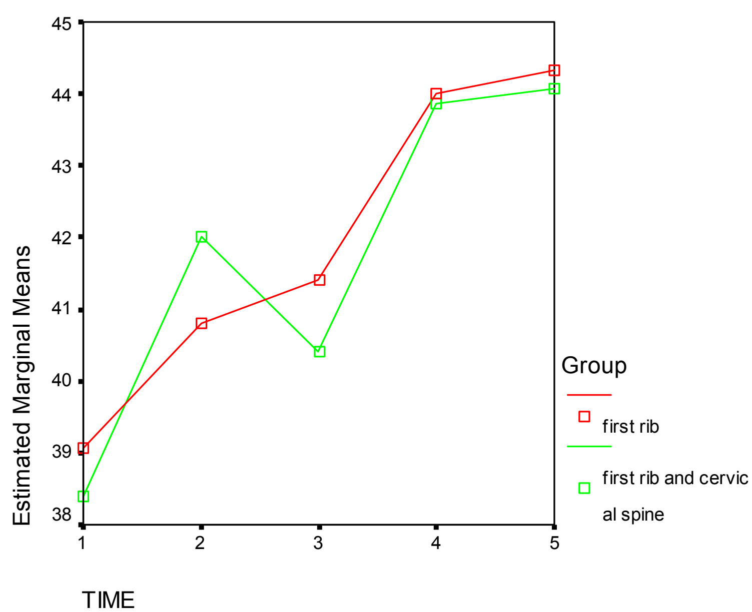

Figure 15: Profile plot of mean left lateral flexion over time in first rib manipulation and first rib plus cervical spine manipulation groups

g) Algometer

Null Hypothesis: there is no difference in treatment effect between first rib manipulation and first rib plus cervical spine manipulation in terms of algometer measurements.

There was no statistical evidence for a treatment effect (p=0.341), thus the null hypothesis was not rejected for algometer. Figure 16 shows parallel profiles over time, although the group means were significantly different at both all time points (p=0.038) that are not indicative of a treatment effect.

Table 23: Between and within subjects effects for Algometer, first rib versus first rib plus cervical spine manipulation

Effect	Statistic	p value
Time	Wilk's lambda=0.298	<0.001
Time*group	Wilk's lambda=0.840	0.341
Group	F=4.728	0.038

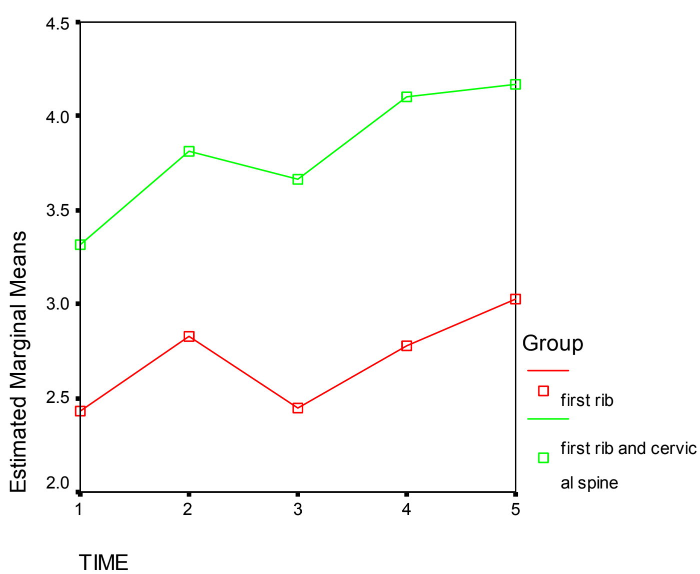

Figure 16: Profile plot of mean algometer over time in first rib manipulation and first rib plus cervical spine manipulation groups

4.4.2.2) Subjective clinical findings

a) CMCC Score

Null Hypothesis: there is no difference in treatment effect between first rib manipulation and first rib plus cervical spine manipulation in terms of CMCC score. There was no significant treatment effect (p=0.714) for CMCC score. Both groups decreased in parallel (Figure 17).

Table 24: Between and within subjects effects for CMCC, first rib versus cervical spine manipulation

Effect	Statistic	p value
Time	Wilk's lambda=0.119	<0.001
Time*group	Wilk's lambda=0.975	0.714
Group	F=1.085	0.306

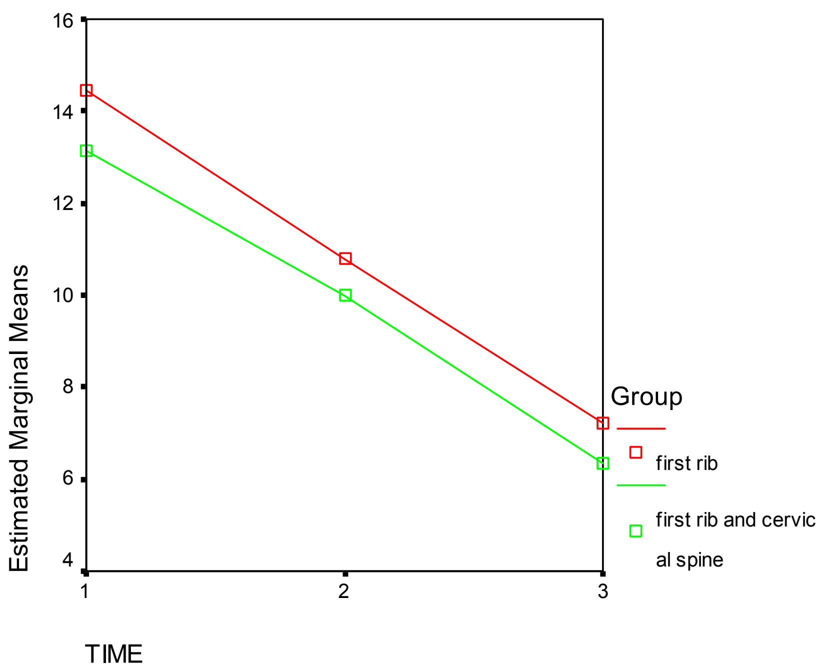

Figure 17: Profile plot of mean CMCC over time in first rib manipulation and first rib plus cervical spine manipulation groups

b) NRS

Null Hypothesis: there is no difference in treatment effect between first rib manipulation and first rib plus cervical spine manipulation in terms of NRS.

The null hypothesis was not rejected (p=0.959), thus the effect of the treatment on NRS was the same in both groups (Figure 18).

Table 25: Between and within subjects effects for NRS, first rib versus first rib plus cervical spine manipulation

Effect	Statistic	p value
Time	Wilk's lambda=0.106	<0.001
Time*group	Wilk's lambda=0.997	0.959
Group	F=2.529	0.123

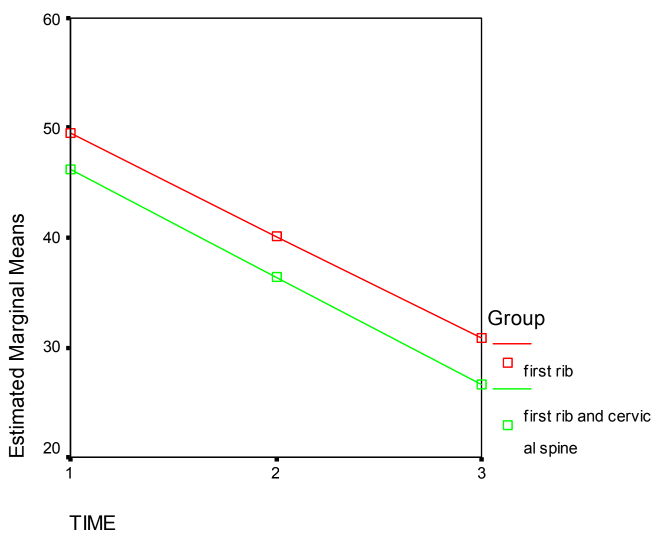

Figure 18: Profile plot of mean NRS over time in first rib manipulation and first rib plus cervical spine manipulation groups

4.4.3) Cervical Spine versus First Rib and Cervical Spine manipulation

4.4.3.1) Objective clinical findings

a) Flexion

Null Hypothesis: there is no difference in treatment effect between cervical spine manipulation and first rib plus cervical spine manipulation in terms of flexion.

The null hypothesis could not be rejected for this outcome (p=0.935), as there was a very similar rate of change over time in both groups (Figure 19).

Table 26: Between and within subjects effects for Flexion, cervical spine versus first rib plus cervical spine manipulation

Effect	Statistic	p value
Time	Wilk's lambda=0.359	<0.001
Time*group	Wilk's lambda=0.969	0.935
Group	F=0.524	0.475

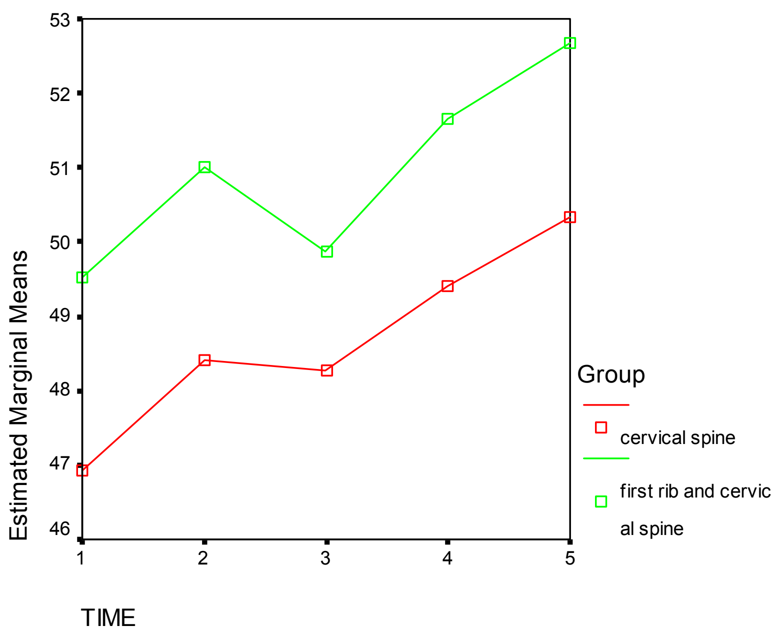

Figure 19: Profile plot of mean Flexion over time in cervical spine manipulation and first rib plus cervical spine manipulation groups

b) Extension

Null Hypothesis: there is no difference in treatment effect between cervical manipulation and first rib plus cervical spine manipulation in terms of extension.

The null hypothesis was not rejected (p=0.228). Figure 20 shows some interaction, which was non significant.

Table 27: Between and within subjects effects for Extension, cervical spine versus first rib plus cervical spine manipulation

Effect	Statistic	p value
Time	Wilk's lambda=0.576	0.006
Time*group	Wilk's lambda=0.805	0.228
Group	F=1.153	0.292

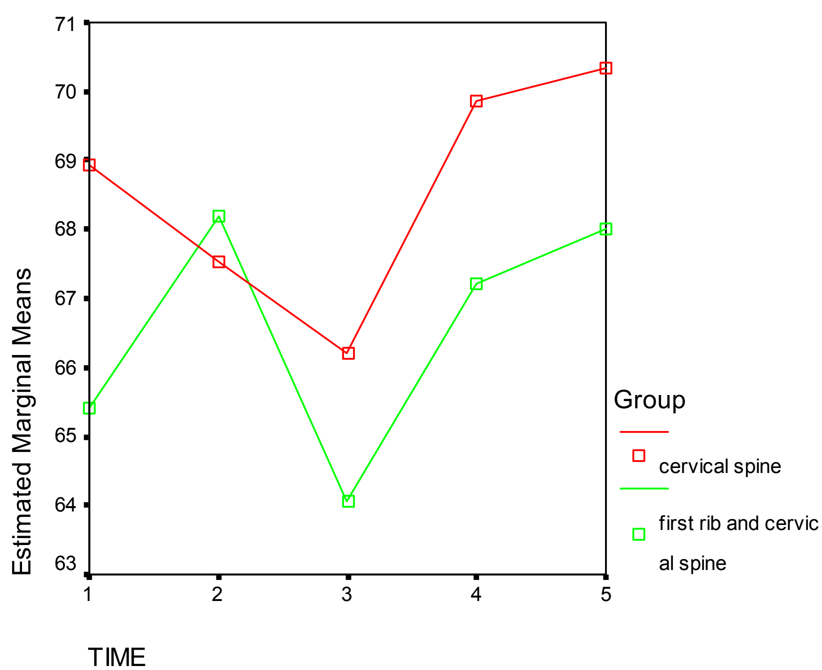

Figure 20: Profile plot of mean Extension over time in cervical spine manipulation and first rib plus cervical spine manipulation groups

c) Right rotation

Null Hypothesis: there is no difference in treatment effect between cervical spine manipulation and first rib plus cervical spine manipulation in terms of right rotation.

The null hypothesis is not rejected (p=0.880).

Table 28: Between and within subjects effects for right rotation, cervical spine versus first rib plus cervical spine manipulation

Effect	Statistic	p value
Time	Wilk's lambda=0.314	<0.001
Time*group	Wilk's lambda=0.955	0.880
Group	F=4.044	0.054

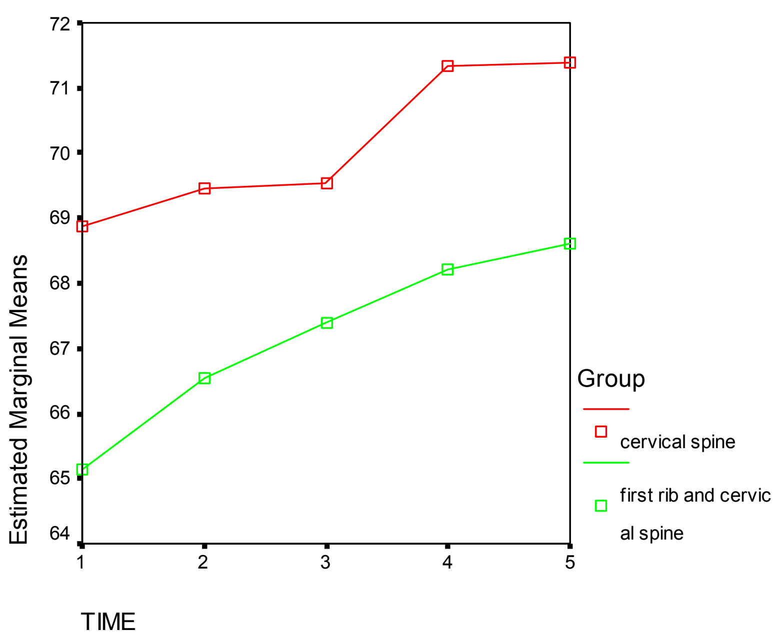

Figure 21: Profile plot of mean right rotation over time in cervical spine manipulation and first rib plus cervical spine manipulation groups

d) Left rotation

Null Hypothesis: there is no difference in treatment effect between cervical spine manipulation and first rib plus cervical spine manipulation in terms of left rotation.

The null hypothesis is not rejected (p=0.162).

Table 29: Between and within subjects effects for left rotation, cervical spine versus first rib plus cervical spine manipulation

Effect	Statistic	p value
Time	Wilk's lambda=0.387	<0.001
Time*group	Wilk's lambda=0.777	0.162
Group	F=0.651	0.427

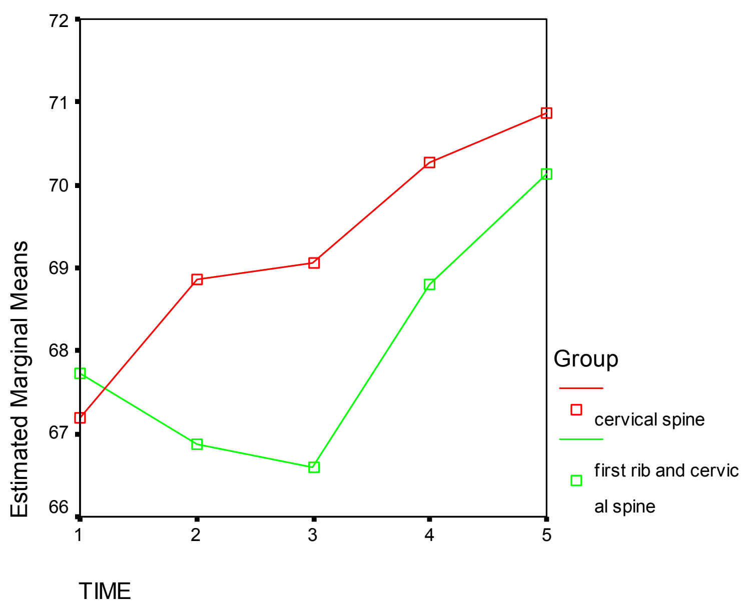

Figure 22: Profile plot of mean left rotation over time in cervical spine manipulation and first rib plus cervical spine manipulation groups

e) Right lateral flexion

Null Hypothesis: there is no difference in treatment effect between cervical spine manipulation and first rib plus cervical spine manipulation in terms of right lateral flexion.

The null hypothesis was not rejected (p=0.553).

Table 30: Between and within subjects effects for right lateral flexion, cervical spine versus first rib plus cervical spine manipulation

Effect	Statistic	p value
Time	Wilk's lambda=0.171	<0001
Time*group	Wilk's lambda=0.890	0.553
Group	F=0.579	0.453

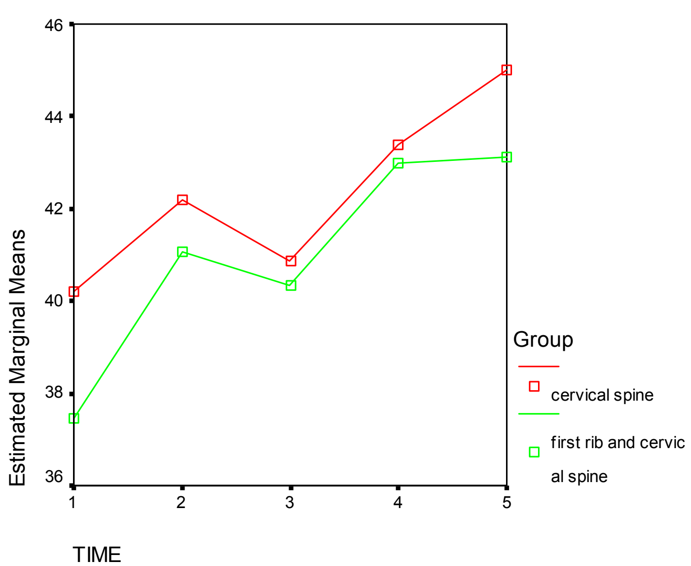

Figure 23: Profile plot of mean right lateral flexion over time in cervical spine manipulation and first rib plus cervical spine manipulation groups

f) Left lateral flexion

Null Hypothesis: there is no difference in treatment effect between cervical spine manipulation and first rib plus cervical spine manipulation in terms of left lateral flexion.

The null hypothesis was not rejected (p=0.206), although Figure 24 suggests that there was a trend towards a faster rate of improvement in the group that received both treatments.

Table 31: Between and within subjects effects for left lateral flexion, cervical spine versus first rib plus cervical spine manipulation

Effect	Statistic	p value
Time	Wilk's lambda=0.320	<0.001
Time*group	Wilk's lambda=0.796	0.206
Group	F=0.361	0.553

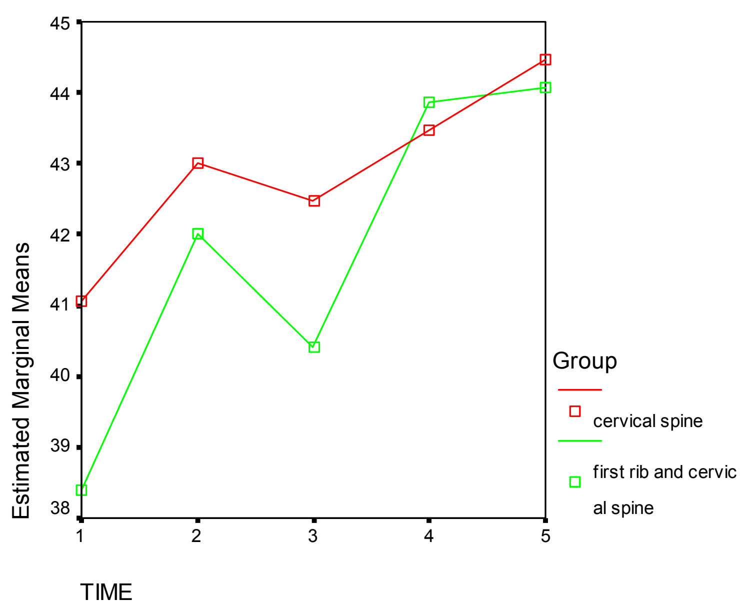

Figure 24: Profile plot of mean left lateral flexion over time in cervical spine manipulation and first rib plus cervical spine manipulation groups

g) Algometer

Null Hypothesis: there is no difference in treatment effect between cervical spine manipulation and first rib plus cervical spine manipulation in terms of algometer.

There was no evidence for a treatment effect for this outcome (p=0.780), thus the null hypothesis was not rejected.

Table 32: Between and within subjects effects for Algometer, cervical spine versus first rib plus cervical spine manipulation

Effect	Statistic	p value
Time	Wilk's lambda=0.211	<0.001
Time*group	Wilk's lambda=0.935	0.780
Group	F=0.589	0.449

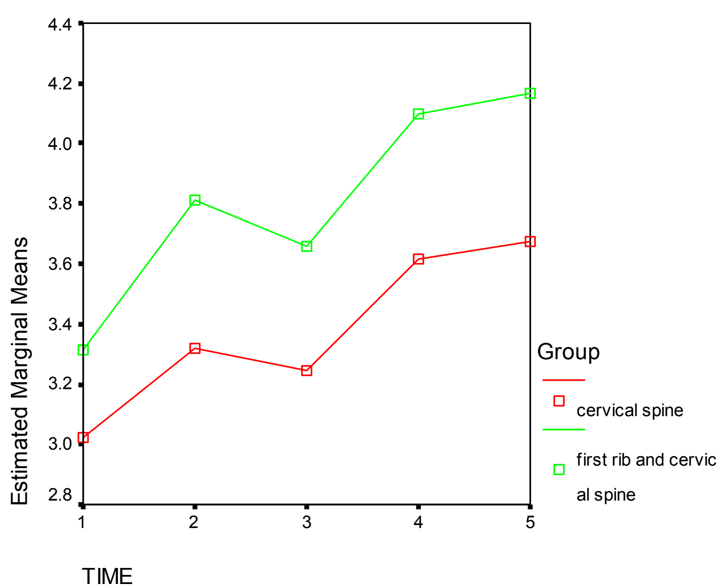

Figure 25: Profile plot of mean algometer over time in cervical spine manipulation and first rib plus cervical spine manipulation groups

4.4.3.2) Subjective clinical findings

a) CMCC score

Null Hypothesis: there is no difference in treatment effect between cervical spine manipulation and first rib plus cervical spine manipulation in terms of CMCC score.

The null hypothesis was rejected for this outcome (p=0.009). Figure 26 shows that the group that received both interventions decreased at a faster rate than the cervical spine group.

Table 33: Between and within subjects effects for CMCC, cervical spine versus first rib plus cervical spine manipulation

Effect	Statistic	p value
Time	Wilk's lambda=0.152	<0.001
Time*group	Wilk's lambda=0.705	0.009
Group	F=0.988	0.329

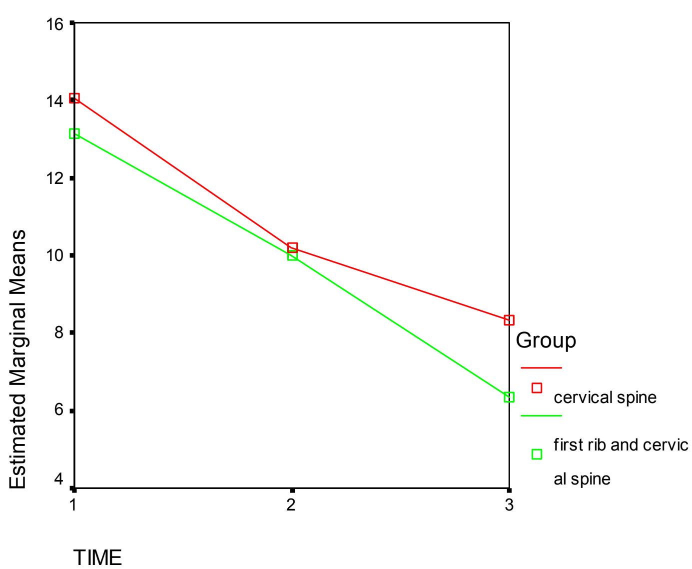

Figure 26: Profile plot of mean CMCC over time in cervical spine manipulation and first rib plus cervical spine manipulation groups

b) NRS

Null Hypothesis: there is no difference in treatment effect between cervical spine manipulation and first rib plus cervical spine manipulation in terms of NRS.

The null hypothesis was not rejected for NRS (p=0.631). The profiles of the two groups were parallel (Figure 27).

Table 34: Between and within subjects effects for NRS, cervical spine versus first rib plus cervical spine manipulation

Effect	Statistic	p value
Time	Wilk's lambda=0.067	<0.001
Time*group	Wilk's lambda=0.966	0.631
Group	F=1.602	0.216

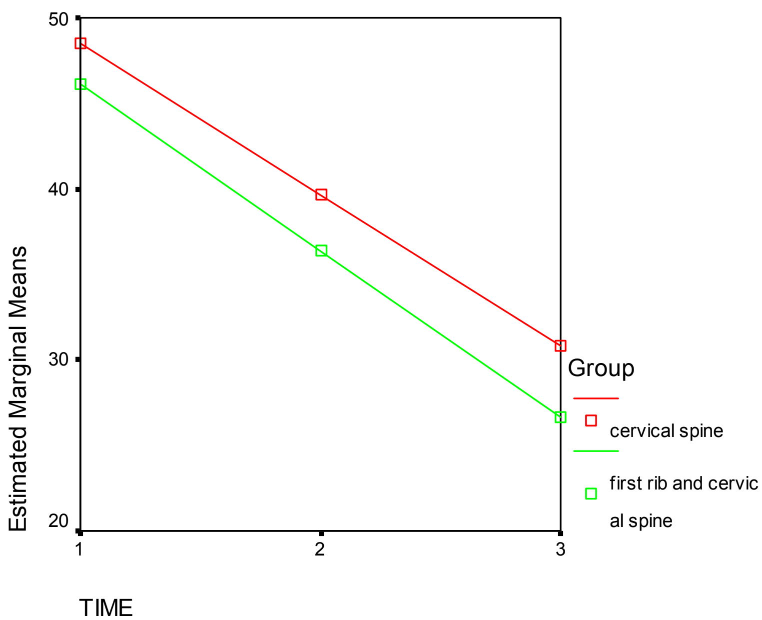

Figure 27: Profile plot of mean NRS over time in cervical spine manipulation and first rib plus cervical spine manipulation groups

4.4.4) All treatment groups versus placebo

4.4.4.1) Objective clinical findings

a) Flexion

Null Hypothesis: there is no difference in treatment effect between any treatment group and the placebo group in terms of flexion.

The null hypothesis was not rejected for any of the comparisons. For the comparison between first rib plus cervical rib manipulation vs. placebo the treatment effect was borderline non significant (p=0.052). Figure 28 shows a trend of all treatment groups showing a general increase over time but the placebo group showing no real change.

Table 35: Between and within subjects effects for Flexion, treatment groups versus placebo

Comparison	Effect	Statistic	p value
First rib vs. placebo	Time*group	Wilk's lambda=0.713	0.066
Cervical spine vs. placebo	Time*group	Wilk's lambda=0.747	0.109
First rib plus cervical spine vs. placebo	Time*group	Wilk's lambda=0.697	0.052

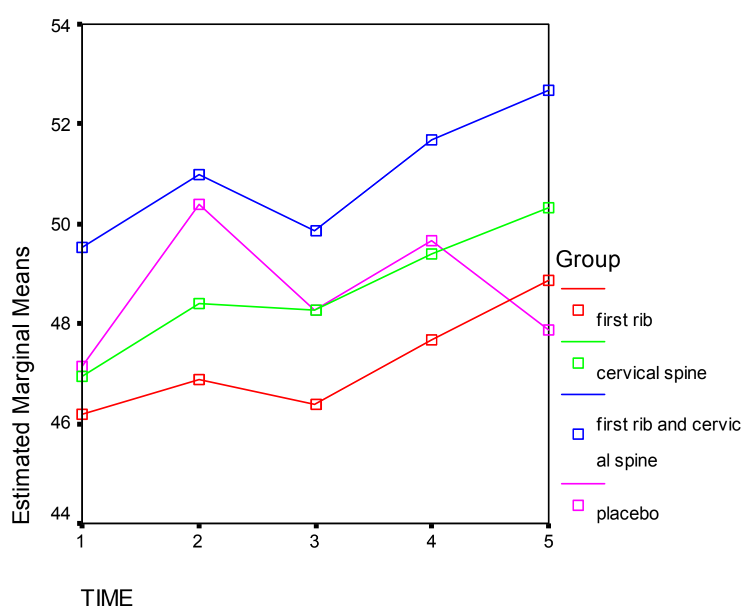

Figure 28: Profile plot of mean flexion over time by group

b) Extension

Null Hypothesis: there is no difference in treatment effect between any treatment group and the placebo group in terms of extension.

The null hypothesis was rejected for the comparison of cervical spine manipulation and placebo (p=0.038). Figure 29 shows that the cervical spine group decreased between time 1 and 3 while the placebo group increased. Thereafter the cervical spine group showed a sharp increase while the placebo group did not.

Table 36: Between and within subjects effects for Extension, treatment groups versus placebo

Comparison	Effect	Statistic	p value
First rib vs. placebo	Time*group	Wilk's lambda=0.824	0.286
Cervical spine vs. placebo	Time*group	Wilk's lambda=0.677	0.038
First rib plus cervical spine vs. placebo	Time*group	Wilk's lambda=0.770	0.147

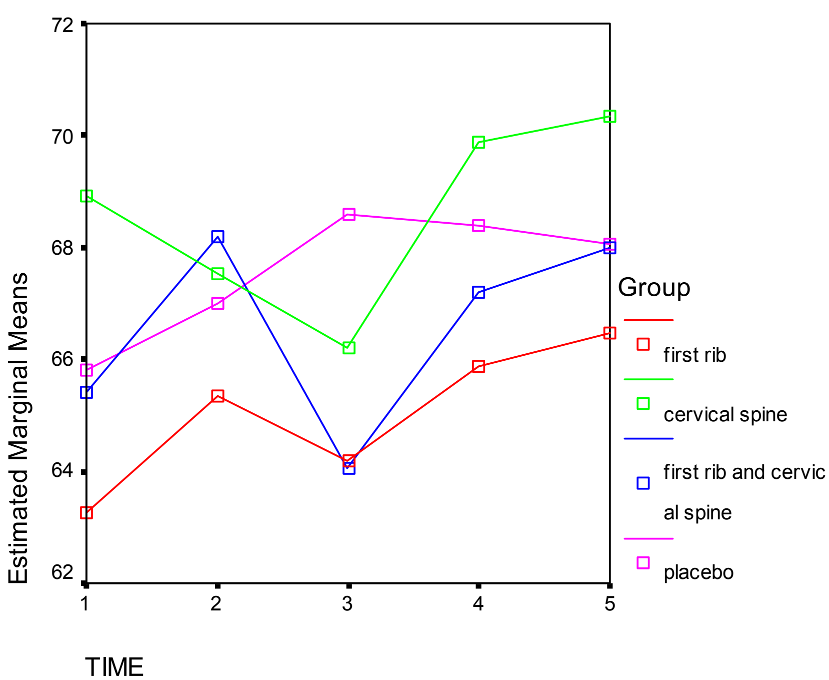

Figure 29: Profile plot of mean extension over time by group

c) Right rotation

Null Hypothesis: there is no difference in treatment effect between any treatment group and the placebo group in terms of right rotation.

This null hypothesis was not rejected. There was a borderline non-significant result for first rib versus placebo (p=0.053) and for first rib plus cervical spine versus placebo (p=0.054). Figure 30 shows that the treatment groups tended to show an increase over time while the placebo group was stable.

Table 37: Between and within subjects effects for right rotation, treatment groups versus placebo

Comparison	Effect	Statistic	p value
First rib vs. placebo	Time*group	Wilk's lambda=0.697	0.053
Cervical spine vs. placebo	Time*group	Wilk's lambda=0.769	0.146
First rib plus cervical spine vs. placebo	Time*group	Wilk's lambda=0.699	0.054

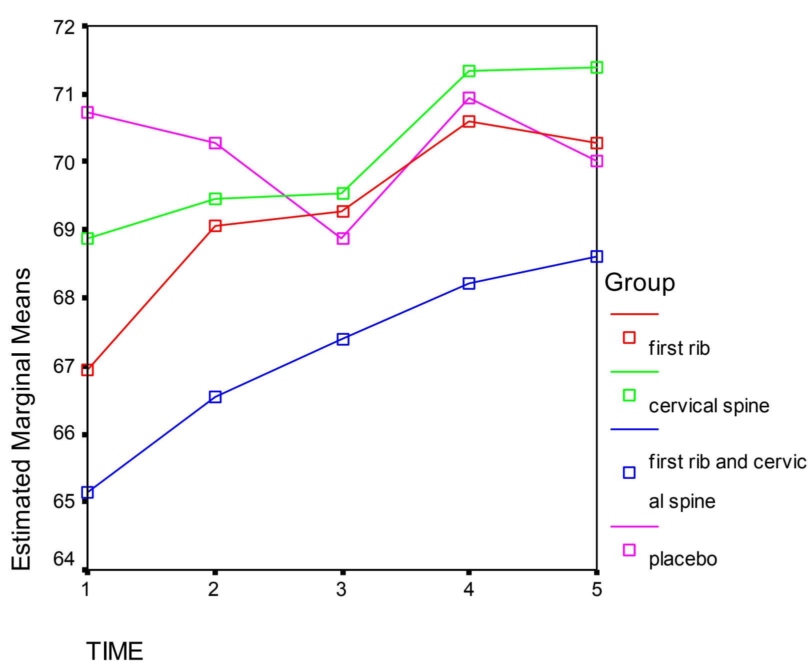

Figure 30: Profile plot of mean right rotation over time by group

d) Left rotation

Null Hypothesis: there is no difference in treatment effect between any treatment group and the placebo group in terms of left rotation.

The null hypothesis was not rejected for this outcome.

Table 38: Between and within subjects effects for left rotation, treatment groups versus placebo

Comparison	Effect	Statistic	p value
First rib vs. placebo	Time*group	Wilk's lambda=0.814	0.255
Cervical spine vs. placebo	Time*group	Wilk's lambda=0.756	0.122
First rib plus cervical spine vs. placebo	Time*group	Wilk's lambda=0.758	0.125

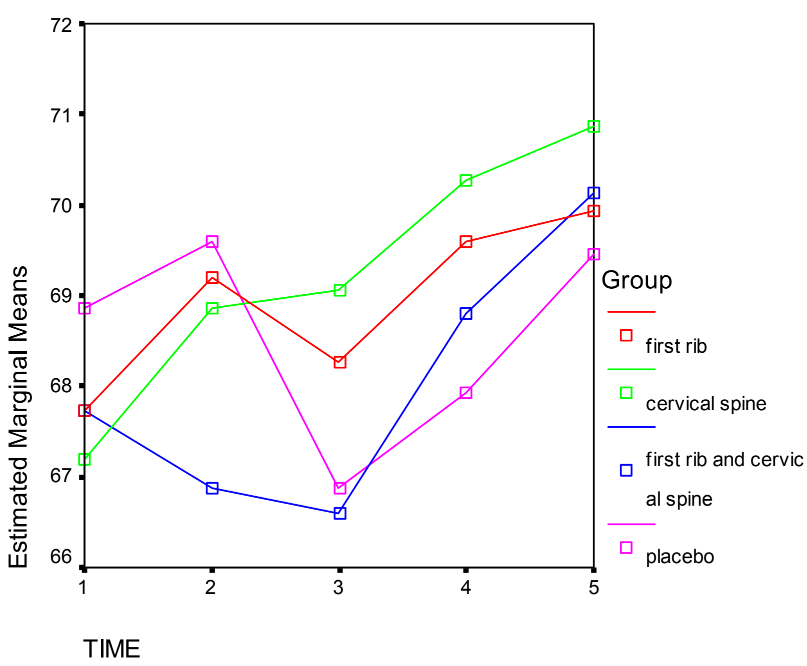

Figure 31: Profile plot of mean left rotation over time by group

e) Right lateral flexion

Null Hypothesis: there is no difference in treatment effect between any treatment group and the placebo group in terms of right lateral flexion.

The null hypothesis was not rejected for this outcome.

Table 39: Between and within subjects effects for right lateral flexion, treatment groups versus placebo

Comparison	**Effect**	**Statistic**	**p value**
First rib vs. placebo	Time*group	Wilk's lambda=0.820	0.271
Cervical spine vs. placebo	Time*group	Wilk's lambda=0.733	0.089
First rib plus cervical spine vs. placebo	Time*group	Wilk's lambda=0.724	0.079

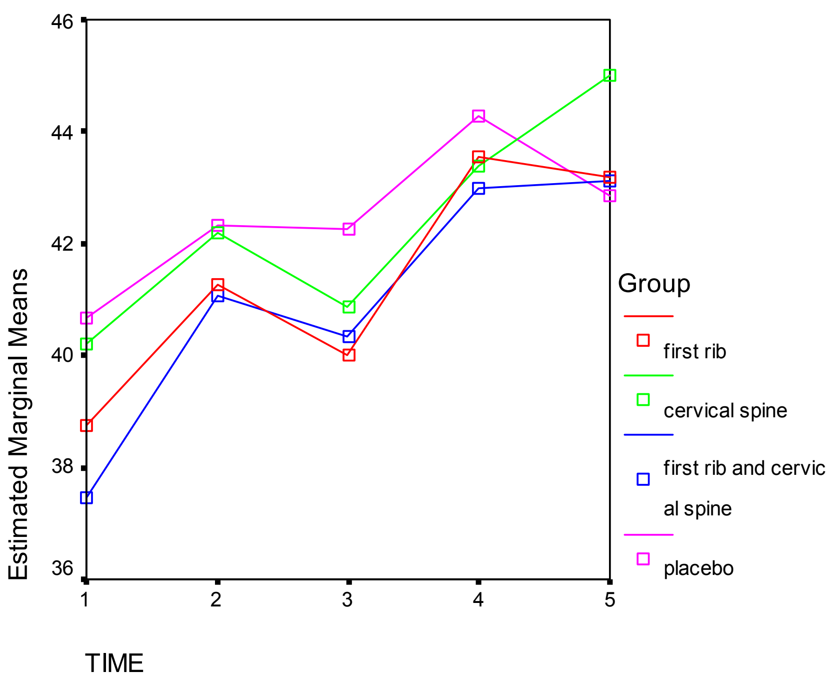

Figure 32: Profile plot of mean right lateral flexion over time by group

f) Left lateral flexion

Null Hypothesis: there is no difference in treatment effect between any treatment group and the placebo group in terms of left lateral flexion.

The null hypothesis was rejected for the comparison of first rib and placebo (p=0.013) and for the comparison of first rib plus cervical spine manipulation versus placebo (p=0.014). Figure 33 shows that the main treatment effect came into action between time 4 and 5, where the placebo group began to decrease, while the other groups increased.

Table 40: Between and within subjects effects for Left lateral flexion, treatment groups versus placebo

Comparison	Effect	Statistic	p value
First rib vs. placebo	Time*group	Wilk's lambda=0.615	0.013
Cervical spine vs. placebo	Time*group	Wilk's lambda=0.725	0.080
First rib plus cervical spine vs. placebo	Time*group	Wilk's lambda=0.616	0.014

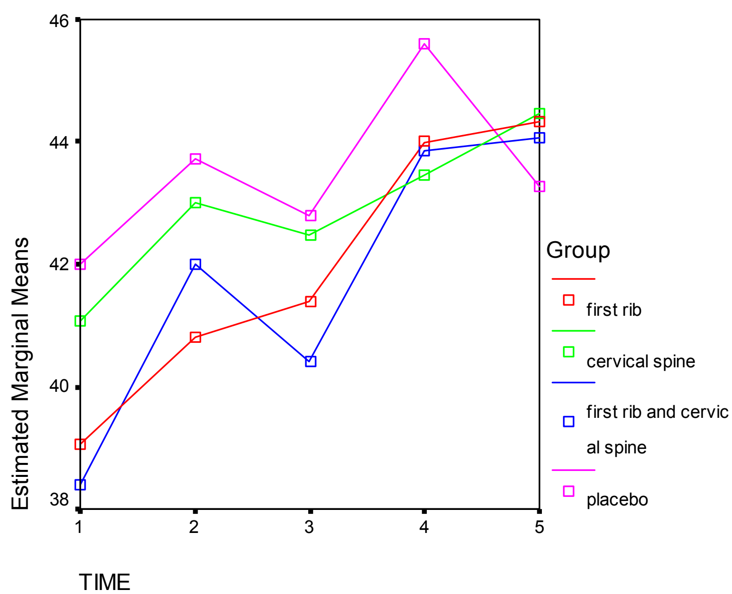

Figure 33: Profile plot of mean left lateral flexion over time by group

g) Algometer

Null Hypothesis: there is no difference in treatment effect between any treatment group and the placebo group in terms of algometer.

The null hypothesis was not rejected for this outcome.

Table 41: Between and within subjects effects for algometer, treatment groups versus placebo

Comparison	**Effect**	**Statistic**	**p value**
First rib vs. placebo	Time*group	Wilk's lambda=0.828	0.297
Cervical spine vs. placebo	Time*group	Wilk's lambda=0.846	0.361
First rib plus cervical spine vs. placebo	Time*group	Wilk's lambda=0.771	0.150

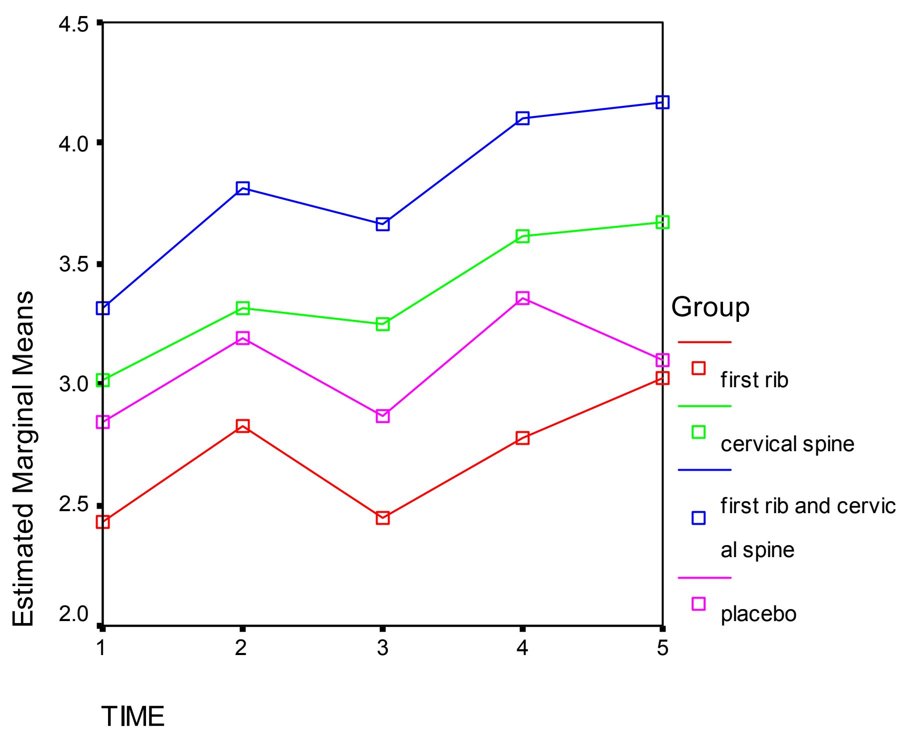

Figure 34: Profile plot of mean algometer over time by group

4.4.4.2) Subjective clinical findings

a) CMCC

Null Hypothesis: there is no difference in treatment effect between any treatment group and the placebo group in terms of CMCC score.

There was a significant treatment effect for the comparison of first rib vs. placebo (p=0.026). Thus, the null hypothesis is rejected for this comparison. Figure 35 shows that the profiles of the first rib group and placebo group intersected between time 2 and 3, when the placebo group started to decrease at a slower rate.

Table 42: Between and within subjects effects for CMCC, treatment groups versus placebo

Comparison	Effect	Statistic	p value
First rib vs. placebo	Time*group	Wilk's lambda=0.764	0.026
Cervical spine vs. placebo	Time*group	Wilk's lambda=0.941	0.422
First rib plus cervical spine vs. placebo	Time*group	Wilk's lambda=0.802	0.051

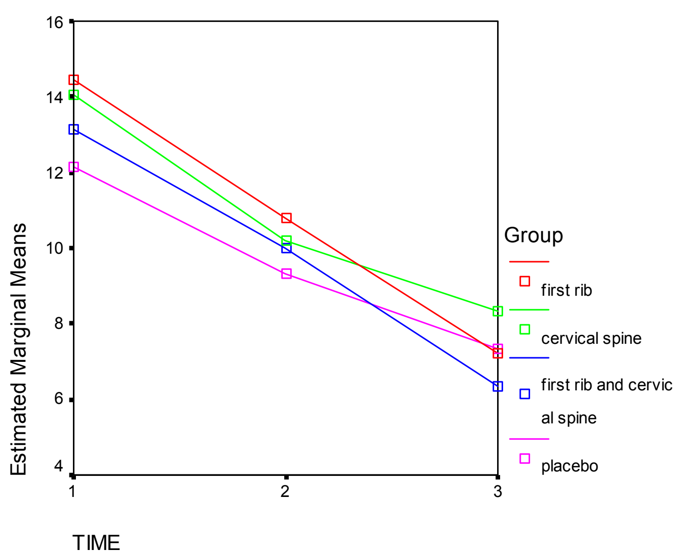

Figure 35: Profile plot of mean CMCC score over time by group

b) NRS

Null Hypothesis: there is no difference in treatment effect between any treatment group and the placebo group in terms of NRS.

The null hypothesis is rejected for all the comparisons. Each of the treatment groups were significantly better than the placebo group in terms of pain (see Figure 36).

Table 43: Between and within subjects effects for NRS, treatment groups versus placebo

Comparison	Effect	Statistic	p value
First rib vs. placebo	Time*group	Wilk's lambda=0.764	0.026
Cervical spine vs. placebo	Time*group	Wilk's lambda=0.690	0.007
First rib plus cervical spine vs. placebo	Time*group	Wilk's lambda=0.565	<0.001

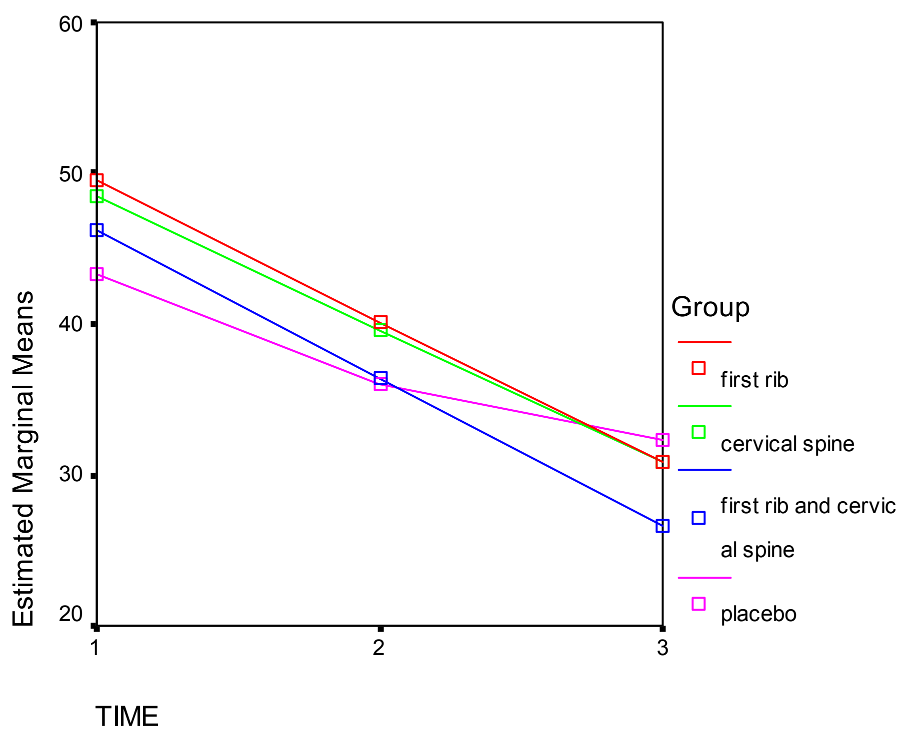

Figure 36: Profile plot of mean NRS over time by group

Table 44: Pearson's correlation between changes in outcome variables in the first rib manipulation group (n=15)

		Change in CMCC score	Change in NRS score	Change in Flexion	Change in Extension	Change in Right rotation	Change in left rotation	Change in right lateral flexion	Change in left lateral flexion	Change in algometer
Change in CMCC score	Pearson Correlation	1	.759(**)	-.446	.046	.267	.260	-.566(*)	-.616(*)	-.237
	Sig. (2-tailed)	.	.001	.096	.872	.336	.350	.028	.014	.396
Change in NRS score	Pearson Correlation	.759(**)	1	-.413	-.140	-.135	-.064	-.519(*)	-.700(**)	-.115
	Sig. (2-tailed)	.001	.	.126	.620	.631	.820	.048	.004	.683
Change in Flexion	Pearson Correlation	-.446	-.413	1	-.137	.252	.304	.344	.341	.220
	Sig. (2-tailed)	.096	.126	.	.626	.366	.270	.209	.214	.431
Change in Extension	Pearson Correlation	.046	-.140	-.137	1	-.055	.438	-.354	.065	.700(**)
	Sig. (2-tailed)	.872	.620	.626	.	.846	.102	.196	.818	.004
Change in Right rotation	Pearson Correlation	.267	-.135	.252	-.055	1	.510	.303	.338	-.412
	Sig. (2-tailed)	.336	.631	.366	.846	.	.052	.272	.218	.127
Change in left rotation	Pearson Correlation	.260	-.064	.304	.438	.510	1	-.068	.038	.218
	Sig. (2-tailed)	.350	.820	.270	.102	.052	.	.810	.894	.436
Change in right lateral flexion	Pearson Correlation	-.566(*)	-.519(*)	.344	-.354	.303	-.068	1	.729(**)	-.310
	Sig. (2-tailed)	.028	.048	.209	.196	.272	.810	.	.002	.260
Change in left lateral flexion	Pearson Correlation	-.616(*)	-.700(**)	.341	.065	.338	.038	.729(**)	1	.007
	Sig. (2-tailed)	.014	.004	.214	.818	.218	.894	.002	.	.980
Change in algometer	Pearson Correlation	-.237	-.115	.220	.700(**)	-.412	.218	-.310	.007	1
	Sig. (2-tailed)	.396	.683	.431	.004	.127	.436	.260	.980	.

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

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

Table 45: Pearson's correlation between changes in outcome variables in the cervical spine manipulation group (n=15)

		Change in CMCC score	Change in NRS score	Change in Flexion	Change in Extension	Change in Right rotation	Change in left rotation	Change in right lateral flexion	Change in left lateral flexion	Change in algometer
Change in CMCC score	Pearson Correlation	1	.128	-.142	-.448	-.237	-.271	-.474	-.311	-.479
	Sig. (2-tailed)	.	.650	.614	.094	.396	.328	.074	.259	.071
Change in NRS score	Pearson Correlation	.128	1	-.097	.211	-.310	.142	.385	.447	.345
	Sig. (2-tailed)	.650	.	.732	.450	.261	.615	.157	.095	.208
Change in Flexion	Pearson Correlation	-.142	-.097	1	.447	.195	.362	.361	.213	.559(*)
	Sig. (2-tailed)	.614	.732	.	.095	.486	.185	.186	.445	.030
Change in Extension	Pearson Correlation	-.448	.211	.447	1	-.250	.009	.762(**)	.453	.669(**)
	Sig. (2-tailed)	.094	.450	.095	.	.370	.975	.001	.090	.006
Change in Right rotation	Pearson Correlation	-.237	-.310	.195	-.250	1	.397	-.354	-.214	-.179
	Sig. (2-tailed)	.396	.261	.486	.370	.	.142	.196	.443	.522
Change in left rotation	Pearson Correlation	-.271	.142	.362	.009	.397	1	.000	-.022	.036
	Sig. (2-tailed)	.328	.615	.185	.975	.142	.	1.000	.939	.898
Change in right lateral flexion	Pearson Correlation	-.474	.385	.361	.762(**)	-.354	.000	1	.704(**)	.855(**)
	Sig. (2-tailed)	.074	.157	.186	.001	.196	1.000	.	.003	.000
Change in left lateral flexion	Pearson Correlation	-.311	.447	.213	.453	-.214	-.022	.704(**)	1	.567(*)
	Sig. (2-tailed)	.259	.095	.445	.090	.443	.939	.003	.	.028
Change in algometer	Pearson Correlation	-.479	.345	.559(*)	.669(**)	-.179	.036	.855(**)	.567(*)	1
	Sig. (2-tailed)	.071	.208	.030	.006	.522	.898	.000	.028	.

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

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

Table 46: Pearson's correlation between changes in outcome variables in the first rib plus cervical spine manipulation group (n=15)

		Change in CMCC score	Change in NRS score	Change in Flexion	Change in Extension	Change in Right rotation	Change in left rotation	Change in right lateral flexion	Change in left lateral flexion	Change in algometer
Change in CMCC score	Pearson Correlation	1	.433	-.152	-.169	.402	.088	-.064	-.170	-.035
	Sig. (2-tailed)	.	.107	.589	.547	.138	.756	.819	.545	.901
Change in NRS score	Pearson Correlation	.433	1	-.180	.419	.260	-.002	.622(*)	.378	-.109
	Sig. (2-tailed)	.107	.	.520	.120	.349	.993	.013	.165	.700
Change in Flexion	Pearson Correlation	-.152	-.180	1	-.071	.016	-.249	.150	.162	.272
	Sig. (2-tailed)	.589	.520	.	.801	.954	.371	.594	.565	.326
Change in Extension	Pearson Correlation	-.169	.419	-.071	1	.257	.146	.605(*)	.700(**)	-.343
	Sig. (2-tailed)	.547	.120	.801	.	.356	.604	.017	.004	.211
Change in Right rotation	Pearson Correlation	.402	.260	.016	.257	1	.507	-.078	.235	-.111
	Sig. (2-tailed)	.138	.349	.954	.356	.	.054	.783	.399	.694
Change in left rotation	Pearson Correlation	.088	-.002	-.249	.146	.507	1	-.275	.031	-.008
	Sig. (2-tailed)	.756	.993	.371	.604	.054	.	.321	.912	.978
Change in right lateral flexion	Pearson Correlation	-.064	.622(*)	.150	.605(*)	-.078	-.275	1	.804(**)	-.280
	Sig. (2-tailed)	.819	.013	.594	.017	.783	.321	.	.000	.311
Change in left lateral flexion	Pearson Correlation	-.170	.378	.162	.700(**)	.235	.031	.804(**)	1	-.320
	Sig. (2-tailed)	.545	.165	.565	.004	.399	.912	.000	.	.244
Change in algometer	Pearson Correlation	-.035	-.109	.272	-.343	-.111	-.008	-.280	-.320	1
	Sig. (2-tailed)	.901	.700	.326	.211	.694	.978	.311	.244	.

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

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

Table 47: Pearson's correlation between changes in outcome variables in placebo group (n=15)

		Change in CMCC score	Change in NRS score	Change in Flexion	Change in Extension	Change in Right rotation	Change in left rotation	Change in right lateral flexion	Change in left lateral flexion	Change in algometer
Change in CMCC score	Pearson Correlation	1	.527(*)	-.039	-.193	.411	-.007	-.183	-.016	-.199
	Sig. (2-tailed)	.	.044	.890	.491	.128	.982	.513	.954	.477
Change in NRS score	Pearson Correlation	.527(*)	1	-.323	.183	-.111	-.126	.114	.054	-.231
	Sig. (2-tailed)	.044	.	.240	.514	.694	.653	.686	.849	.407
Change in Flexion	Pearson Correlation	-.039	-.323	1	.303	.547(*)	.587(*)	.233	.588(*)	-.038
	Sig. (2-tailed)	.890	.240	.	.272	.035	.021	.404	.021	.894
Change in Extension	Pearson Correlation	-.193	.183	.303	1	-.138	-.203	.455	.188	.071
	Sig. (2-tailed)	.491	.514	.272	.	.625	.469	.088	.501	.802
Change in Right rotation	Pearson Correlation	.411	-.111	.547(*)	-.138	1	.453	-.139	.317	-.495
	Sig. (2-tailed)	.128	.694	.035	.625	.	.090	.622	.250	.061
Change in left rotation	Pearson Correlation	-.007	-.126	.587(*)	-.203	.453	1	-.218	.358	-.451
	Sig. (2-tailed)	.982	.653	.021	.469	.090	.	.434	.190	.091
Change in right lateral flexion	Pearson Correlation	-.183	.114	.233	.455	-.139	-.218	1	.534(*)	.348
	Sig. (2-tailed)	.513	.686	.404	.088	.622	.434	.	.040	.203
Change in left lateral flexion	Pearson Correlation	-.016	.054	.588(*)	.188	.317	.358	.534(*)	1	.151
	Sig. (2-tailed)	.954	.849	.021	.501	.250	.190	.040	.	.590
Change in algometer	Pearson Correlation	-.199	-.231	-.038	.071	-.495	-.451	.348	.151	1
	Sig. (2-tailed)	.477	.407	.894	.802	.061	.091	.203	.590	.

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

Tables 44 to 47 show intra-group correlations between changes in outcome variables. When examining correlations between objective and subjective changes, one can see that within the first rib manipulation group (Table 44), right lateral flexion as well as left lateral flexion was both significantly negatively correlated with CMCC score and NRS. Thus as one score decreased, the other increased. In the cervical spine manipulation group there were no significant correlations between objective and subjective changes, neither in the placebo group (Tables 45 and 47). In the group that received both interventions only NRS and right lateral flexion were significantly negatively correlated with each other.

4.5) DISCUSSION

4.5.1) Demographics

Sixty participants between the ages of 19 and 50 years were randomised into 4 equal treatment groups. The mean age was 30.85 years (SD 7.7 years). Demographics were compared between the four groups to assess if randomisation had been complete. The mean age of the patients in each group was compared and found to be statistically insignificant (p=0.546).

The distribution of patients across each treatment group was found to be statistically similar (p=0.408), with respect to the proportion of males and females in each group.

There was no significant difference in the proportion of race groups (4.3.1.2) by treatment group (p=0.269). The race groups did not reflect local demographics (statssa.gov.za), which could be attributed to the exclusion of non-English literate persons from the study.

Comparison between sedentary (patient was required to be stationary to perform their daily work) versus active occupations (patients work required that they were mobile to perform their required work) were made and no significant difference was found between each of the groups (p=0.849). Incorrect posture or postural overload can result in mechanical neck pain (Bergmann *et al.*, 1993).

The mean height and weight were compared between each treatment group and found to have no significant difference between the groups (p=0.467 and p=0.838 respectively). There were no differences between the groups in terms of demographics or anthropometry, thus the groups were comparable.

According to Mouton (2002) randomisation is the assignment of research subjects or participants to experimental and control groups on a random basis to control for the possible effects of individual differences. What can be deduced from the results of the demographics is that the randomisation has provided the research with four groups of participants in which homogeneity is present. Allowing for the comparison of one group to another without there been pre-existing differences at baseline. This ensured greater accuracy in the comparison of the results achieved.

4.5.2) Analysis of treatment effects

4.5.2.1) Objective clinical findings

a) CROM (ROM)

For all six ranges of motion measured the three treatment groups, the first rib treatment, the cervical spine treatment group, and the cervical spine and first rib treatment group, all showed signs of an increase in the recorded movements during the investigative period. This was as expected and could be attributed to either or both the neuromechanical and neurological effects of manipulation.

Bergmann (1993:139) describes the effect of the manipulation as the stretching of periarticular tissues, the release of intra-articular and extra-articular tissues, and the effect on joint nociceptors and mechanoreceptors due to the stimulation of golgi tendon organs and the somatic afferent receptor activity. These factors result in a decrease in muscle spasm, soft tissue inflexibility and muscle fatigue.

Curl (1994:297) states that stimulation of the autonomic nervous system due to manipulation results in the reflex inhibition of pain and muscle spasm.

Leach (1994:98-99) states that the Korr (1975) model, which is based on the muscle spindle been the coordinator that could increase or decrease muscle contraction according to the direction of motion of the joint, this reflex muscle contraction could then produce joint motion by its action or prevent joint motion in an area of segmental dysfunction.

According to Travell and Simons (1999) the scalene anterior and the scalene medius serve to stabilise the cervical spine against lateral movement during lateral flexion to the opposite side. Lewit (1991) reports that immobility or blockage of the first rib goes hand in hand with reflex spasm of the scalene muscles on the same side. Travell and Simons (1999:518) also mention that an articular dysfunction commonly observed with scalene muscle involvement is elevation of the first rib.

The longissimus capitis muscle functions as an extensor of the cervical spine (bilateral contraction) and also causes lateral flexion and rotation to the same side (unilateral contraction) (Moore, 1992). An apparent elevation of the first rib occurring simultaneous with first thoracic articular dysfunction may result from rotation of the vertebra by the longissimus capitis muscle that is shortened due to a reflex spasm. The longissimus capitis attaches to the transverse process and so may directly affect the first rib through its pull on the costotransverse junction (Travell and Simons, 1999). Lewit (1991) states that treatment of the first rib by manipulation relieves scalene muscle spasm, which may indirectly cause a relief in the longissimus muscle spasm at the same time.

Korr (1975) proposes two mechanisms whereby manipulation causes the relief of muscle spasm. The first is due to the intrafusal fibres being forcefully stretched against the spindle-maintained resistance resulting in a barrage of afferent impulses intense enough to signal the CNS to reduce the gamma motorneuron discharge. The second mechanism is suggested that as a result of the forced stretch of the skeletal muscle fibres the golgi tendon organ would be stimulated, causing both gamma and alpha motorneuron inhibition.

The range of motion of the placebo group displayed an increase in the left rotation and right lateral flexion, while flexion, extension, right rotation, and left lateral flexion remained unchanged.

b) Algometer

The improvement in the algometer readings in all of the three treatment groups was found to be greater than the improvement that took place in the placebo group, an indication of a favourable response to all the treatments and the placebo by the patients. The stimulation of the nervous system due to the manipulation, and so resulting in reflex inhibition of pain, could attribute to the increase in the algometer readings.

As the readings were taken by pressure being applied to the first rib, an increase in first rib joint mobility due to the effects of manipulation could also attribute to the improvement in algometer readings.

These possibilities are supported by Bergmann (1993:139) who attributes manipulation with the effect of stretching periarticular tissue, release of intra-articular and extra-articular adhesions, the stimulation of joint nociceptors and mechanoreceptor, and so resulting in a decrease in muscle spasm, soft tissue inflexibility and muscle fatigue.

4.5.2.2) Subjective clinical findings

a) CMCC Score

Cervical spine manipulation and first rib manipulation caused a decrease in CMCC score, indicating an improvement in the patients' perceived state of wellness (Vernon and Mior, 1991). This could be attributed to the neuromechanical and or the neurological effects of manipulation as discussed earlier (Bergmann).

The fact that the patient received treatment and care could also assist in the reported improvement of the patients' condition – “Hawthorne” or “ Observer” effects (Mouton, 1996:82).

b) NRS

The NRS was shown to decrease in all three of the treatment groups during the treatment period indicating a favourable response to the treatment by the patients in those groups. The treatment group were shown to respond significantly better to the treatment than the placebo group and this is in keeping with previous comparison between the treatment and placebo groups.

4.5.2.3 Final Hypotheses

The first hypothesis

The treatment groups would be more effective than the placebo group in terms of *objective clinical findings*, in the treatment of mechanical neck pain.

This hypothesis was accepted.

The second hypothesis

The treatment groups would be more effective than the placebo group in terms of *subjective clinical findings*, in the treatment of mechanical neck pain.

This hypothesis was accepted.

The third hypothesis

Trends would not be evident between the objective and subjective clinical findings, demonstrating no relationship between these findings and no difference in terms of the outcomes for the treatment groups.

This hypothesis was rejected.

The fourth hypothesis

That each of the treatment groups would be more effective than the placebo group in terms of objective and subjective clinical findings, in the treatment of mechanical neck pain and a difference in terms of the outcomes for each of the three groups.

This hypothesis was accepted for subjective clinical findings.
This hypothesis was rejected for objective clinical findings.

CHAPTER FIVE - CONCLUSION AND RECOMMENDATIONS

5.1) CONCLUSION

There was limited evidence for any difference in treatment effects between the three treatment groups. Only CMCC score showed significant treatment differences between the first rib group and cervical spine group (first rib was better) and between the cervical spine group and first rib plus cervical spine group (first rib plus cervical spine group was better). Thus it appeared that first rib manipulation was more beneficial for CMCC score than cervical spine manipulation, in terms of patients' perception.

In comparison with the placebo treatment, there were many significant treatment effects. Left lateral flexion was improved in the first rib group and the first rib plus cervical spine group compared with the placebo. Extension was improved in the cervical spine group compared with placebo. CMCC was improved in the first rib group relative to placebo, and NRS was significantly improved in all treatment groups compared with placebo. Where the p value was not significant, trends were demonstrated. Thus, any treatment was better than placebo for most outcomes.

5.2) RECOMMENDATIONS

The CMCC neck disability index questionnaire used in the study is designed to evaluate the change in the patient's condition over a longer period of time as that which occurred in this particular study. This was made relevant by the fact that certain tasks, such as patient's recreational activities, were not always performed on each of the consecutive days. A set of questions designed to evaluate a patient's response to treatment over a short term of evaluation would have been more appropriate.

The homogeneity of the study could be improved by including only male, or female participants in the study. The study included African, Asian and Caucasian participants, and this could be altered to include one race to also improve the homogeneity, but would then cause the results of the study to only be applicable to one single race. Altering the study to be applicable to only one type of occupation could be a further option to improve homogeneity.

The CROM and algometer measurements were taken by the researcher to allow for a uniformity of these objective measurements; in so doing the occurrence of researcher bias could be considered. In future research the assistance of an individual independent to the research to take the measurements would result in the research been more valid. The algometer measurements were taken over the first rib only and no readings were taken over the cervical spine region, this could have had an effect on the eventual outcome of the results.

The patients received all their adjustments in the supine position; further research could be done in order to compare the seated, prone and supine positions.

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APPENDICES

Appendix A

DO YOU SUFFER FROM…

NECK AND/OR UPPER BACK PAIN?

(AND/OR BETWEEN 18-50 YRS OLD)

RESEARCH IS BEING

CONDUCTED AT THE

CHIROPRACTIC DAY CLINIC

DURBAN INSTITUTE OF TECHNOLOGY

TREATMENT IS FREE,

SHOULD YOU QUALIFY FOR THIS STUDY!

PLEASE CONTACT COLIN BROWN AT THE CLINIC ON:

031 - 2042205 / 2042512

Appendix B

INFORMED CONSENT FORM

Date: ____________________

Title of research project:

"An investigation into the efficacy of a first rib manipulation in individuals experiencing mechanical neck pain – A pilot study."

Names of supervisor: Dr. C Korporaal (2042205 / 2512)

Name of research student: Colin Brown (2042205 / 2512)

Name of institution: Durban Institute of Technology

Sixty patients suffering from neck pain will be placed into four groups where they will undergo a specific treatment allocated. The immediate and short-term effectiveness of the treatment on neck pain will be investigated.

Please circle the appropriate answer:

1. Have you read the patient information sheet? YES/NO
2. Have you had the opportunity to ask questions regarding this study? YES/NO
3. Have you received satisfactory answers to your questions? YES/NO
4. Have you had the opportunity to discuss this study? YES/NO
5. Have you received enough information about this study? YES/NO
6. Who have you spoken to? …………………………… YES/NO
7. Do you understand the implications of your involvement in this study? YES/NO
8. Do you understand that you are free to withdraw from this study? YES/NO
    a. At any time
    b. Without having to give reason for withdrawing, and
    c. Without affecting your future health care.
9. Do you agree to voluntary participate in this study? YES/NO

PATIENT NAME: ……………………………SIGNATURE: ……………………….

WITNESS NAME: ……………………………SIGNATURE: ……………………….

RESEARCH STUDENT: ……………………SIGNATURE: ……………………….

IF YOU ANSWERED NO TO ANY OF THE ABOVE QUESTIONS, PLEASE DO NOT HESITATE TO CONTACT MY RESEARCH SUPERVISOR, WHO WILL BE ABLE TO ASSIST YOU.

Appendix C

NUMERICAL PAIN RATING SCALE 101

PATIENTNAME ______________________________________

FILE NUMBER: ____________________

DATE:_____________________

GROUP: ____________________

Please indicate on the line below the number between 0 and 100 that best describes the pain of your major problem at this point, when it is at its **WORST.** A zero (0) would mean "no pain at all" and one hundred (100) would mean, "Pain as bad as it could be."
Please write only one number.

0 ___________________________________ 100

Please indicate on the line below the number between 0 and 100 that best describes the pain of your major problem at this point, when it is at its **LEAST.** A zero (0) would mean "no pain at all" and one hundred (100) would mean, "Pain as bad as it could be."
Please write only one number.

0 ___________________________________ 100

Appendix D

Letter of Information

Dear Patient.

Welcome to my research study. My study is quite simple in that you will be randomly selected and put into one of four groups of fifteen. I will be concentrating mainly on an area at the junction of your neck and shoulder, just behind your collar bone (clavicle). This is where your first rib is located, a structure that could possibly be a relation to your neck pain. I will be performing three types of treatment to that area. Your treatment will depend on which group you are allocated.

Title of study:

"The effectiveness of first rib adjustment as an adjunct to the treatment of mechanical neck pain."

Supervisor: Dr. C. Korporaal (031) 2042205 /2512

Research Student: Colin Brown (031) 2042205 /2512
Institution: Durban Institute of Technology

Purpose of the study:

An investigation into the efficacy of the adjustment of the first rib as an adjunct for the treatment of individuals experiencing mechanical neck pain.

Procedures:

Participants shall have three visits in total. These will run over three consecutive days. The third visit is reserved for data collection and there will be no treatment intervention. It would be appreciated that participants involved in the study ensure they are able to attend these visits, as it is vital for the eventual outcome of the study.

The inclusion of a control group into this study is to make sure that the form of treatment we are investigating is as accurate as possible.

Risks/Discomfort:

Treatments are safe. There may be slight discomfort in the area that was treated after the first and second treatments.

Benefits:

Participants may or may not benefit from their treatments. This is a study and we are conducting this trial to see if this form of treatment is most beneficial for individuals suffering from mechanical neck pain. Your contribution however, by volunteering to partake in this study, will help us as Chiropractors to build on our knowledge. This will benefit you as a patient in the long run, as we will be able to provide you with more effective health care in the future.

New findings:

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

Reasons why you may be withdrawn from this study without your consent:

You may be removed from participating in this study without your consent for the following reasons:

- If you are unable to attend your follow–up appointment on the scheduled dates.
- If you have changed any lifestyle habits during your participation in this study that may effect the outcome of this research (e.g. medication, supplements or treatment).

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

Remuneration:

You will **NOT** be receiving a travel allowance in order to attend your appointment at the Chiropractic Day Clinic, Durban Institute of Technology.

Cost of the study:

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

Confidentiality:

All patient information is confidential. The results from this study will be used for research purposes only. Only individuals that are directly involved in this study (Dr. C. Korporaal and myself) will be allowed access to these records.

Persons to contact should you have any problems or questions:

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

Thank you for participating in my research study.

Colin Brown
(Chiropractic Intern)

Dr. C. Korporaal. M.Tech: Chiropractic. CCFC, CCSP, ICSSD
(Supervisor)

Appendix E1

According to Bergmann *et al.* (1993:63) there are five diagnostic criteria for joint dysfunction in mechanical neck pain:

-Pain/tenderness- **produced by palpation of osseous and soft tissue.**

-Asymmetry- **noted through observation of posture and gait as well as palpation**

for misalignment of vertebral segments.

-Range of Motion abnormality- Changes in active, passive and accessory joint motions are noted through procedures of motion palpation.

-Tissue tone, texture and/or temperature abnormality- Changes in the characteristics of contiguous and associated soft tissues are noted through the procedures of observation, palpation, instrumentation and tests length and strength.

-Special tests- e.g. Kemps

Appendix E2

A positive motion palpation finding indicating a symptomatic joint shall be defined as meeting the following 3 criteria:

1) Abnormal end-feel.
2) Abnormal quality of resistance to motion.
3) Reproduction of pain (either local or referred) when passive accessory movements (end feel) are tested. Plaugher (1993:87).

Appendix F

CROM Readings

Treatment	1	2	3	4	5
Flexion					
Extention					
Right rotation					
Left rotation					
Right lat flex					
Left lat flex					

Appendix G

Algometer Readings

Treatment	Before		After
Day 1			
Day 2			
Day 3			No reading

Appendix H

DURBAN INSTITUTE OF TECHNOLOGY
CHIROPRACTIC DAY CLINIC
CASE HISTORY

Patient: ____________________ Date: __________

File #: __________ Age: __________

Sex: __________ **Occupation:** ____________________

Intern: ____________________ Signature: ____________________

FOR CLINICIANS USE ONLY:
Initial visit
Clinician: Signature:

Case History:

Examination: Previous:
Current:

X-Ray Studies: Previous:
Current:

Clinical Path. Lab: Previous:
Current:

CASE STATUS:

PTT:	Signature:	Date:

CONDITIONAL:
Reason for Conditional:

Signature: Date:

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

Intern's Case History:

1. Source of History:

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

3. Present Illness:

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

4. Other Complaints:

5. Past Medical History:

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

6. Current health status and life-style:

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

7. Immediate Family Medical History:

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

8. Psychosocial history:

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

9. Review of Systems:

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

Appendix I

DURBAN INSTITUTE OF TECHNOLOGY
PHYSICAL EXAMINATION
SENIOR & RESEARCH

Patient:___________________________________ **File#:**____________ **Date:**________
Student: **Signature:**_______________________

VITALS

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

GENERAL EXAMINATION

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

SYSTEM SPECIFIC EXAMINATION

CARDIOVASCULAR EXAMINATION

RESPIRATORY EXAMINATION

ABDOMINAL EXAMINATION

Appendix J

DURBAN INSTITUTE OF TECHNOLOGY
REGIONAL EXAMINATION - CERVICAL SPINE

Patient: .... File No: ....

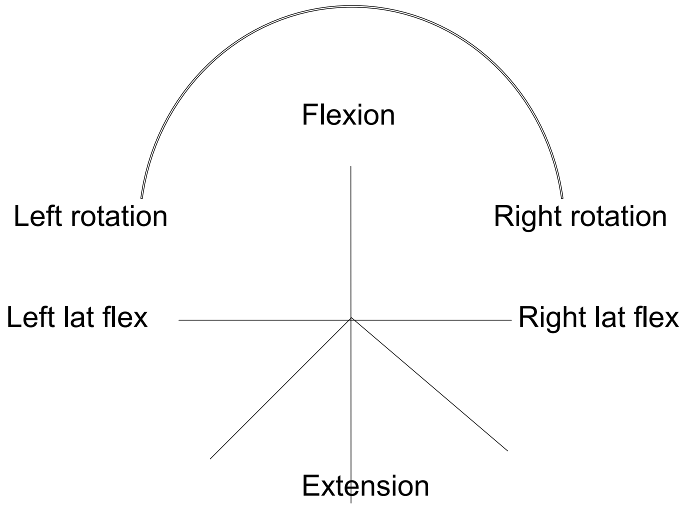
Date: .... Student: ....

Clinician: .... Sign: ....

OBSERVATION:
Posture
Swellings
Scars, discolouration
Hair line
Body and soft tissue contours

Shoulder position
Left :
Right :
Shoulder dominance (hand):
Facial expression:

RANGE OF MOTION:
Extension (70º):
L/R Rotation (70º):
L/R Lat flex (45º):
Flexion (45º):



PALPATION:
Lymph nodes
Thyroid Gland
Trachea

ORTHOPAEDIC EXAMINATION:

Tenderness		Right	Left
Trigger Points:	SCM		
	Scalenii		
	Post Cervicals		
	Trapezius		
	Lev scapular		

	Right	Left		Right	Left
Doorbell sign			Cervical compression		
Kemp's test			Lateral compression		
Cervical distraction			Adson's test		
Halstead's test			Costoclavicular test		
Hyper-abduction test			Eden's test		
Shoulder abduction test			Shoulder compression test		
Dizziness rotation test			Lhermitte's sign		

Brachial plexus test					

NEUROLOGICAL EXAMINATION:

Dermatomes	**Left**	**Right**	**Myotomes**	**Left**	**Right**	**Reflexes**	**Left**	**Right**
C2			C1			C5		
C3			C2			C6		
C4			C3			C7		
C5			C4					
C6			C5					
C7			C6					
C8			C7					
T1			C8					
			T1					

Cerebellar tests:	Left	Right
Disdiadochokinesis		

VASCULAR:	**Left**	**Right**		**Left**	**Right**
Blood pressure			Subclavian arts.		
Carotid arts.			Wallenberg's test		

MOTION PALPATION & JOINT PLAY:
Left: Motion Palpation:
Joint Play:
Right: Motion Palpation:
Joint Play:

Upper Thoracics:
Motion Palpation:
Joint Play:

BASIC EXAM: SHOULDER:
Case History:

ROM: Active:
Passive:
RIM:
Orthopaedic:
Neuro:
Vascular:
Observ/Palpation:

BASIC EXAM: THORACIC SPINE:
Case History:

ROM: Motion Palp:
Active:
Passive:
Orthopaedic:
Neuro:
Vascular:
Observ/Palpation:

Appendix K

DURBAN INSTITUTE OF TECHNOLOGY

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

Date: ***Visit:*** ***Intern:*** ***Attending Clinician:*** ***Signature:***	
S: *Numerical Pain Rating Scale (Patient)* *Intern Rating* *Least* ***0 1 2 3 4 5 6 7 8 9 10*** *Worst* ☐	***A:***
0:	***P:*** ***E:***
Special attention to:	***Next appointment:***
Date: ***Visit:*** ***Intern:*** ***Attending Clinician:*** ***Signature:***	
S: *Numerical Pain Rating Scale (Patient)* *Intern Rating* *Least* ***0 1 2 3 4 5 6 7 8 9 10*** *Worst* ☐	***A:***
O:	***P:*** ***E:***
Special attention to:	***Next appointment:***
Date: ***Visit:*** ***Intern:*** ***Attending Clinician:*** ***Signature***	
S: *Numerical Pain Rating Scale (Patient)* *Intern Rating* *Least* ***0 1 2 3 4 5 6 7 8 9 10*** *Worst* ☐	***A:***
O:	***P:*** ***E:***
Special attention to:	***Next appointment:***

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

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

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

0: **P:**

E:

Special attention to: **Next appointment:**

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

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

O: **P:**

E:

Special attention to: **Next appointment:**

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

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

O: **P:**

E:

Special attention to: **Next appointment:**

Appendix L

DURBAN INSTITUTE OF TECHNOLOGY

PATIENT NAME: ______________________ DATE: _________

FILE NO: ______ VISIT NO: ______ GROUP NO: ______

The effectiveness of first rib adjustment as an adjunct to the treatment of mechanical neck pain.

Research Student: **Colin Brown**

Research Supervisor: **Dr C. M. Korporaal**

Supervising Doctor/Chiropractor/Homoeopath: ______________________

DURBAN INSTITUTE OF TECHNOLOGY

PATIENT NAME: ______________________ DATE: _________

FILE NO: ______ VISIT NO: ______ GROUP NO: ______

The effectiveness of first rib adjustment as an adjunct to the treatment of mechanical neck pain.

Research Student: **Colin Brown**

Research Supervisor: **Dr C. M. Korporaal**

Supervising Doctor/Chiropractor/Homoeopath: ______________________

DURBAN INSTITUTE OF TECHNOLOGY

PATIENT NAME: ______________________ DATE: _________

FILE NO: ______ VISIT NO: ______ GROUP NO: ______

The effectiveness of first rib adjustment as an adjunct to the treatment of mechanical neck pain.

Research Student: **Colin Brown**

Research Supervisor: **Dr C. M. Korporaal**

Supervising Doctor/Chiropractor/Homoeopath: ______________________

Appendix M

CMCC NECK DISABILITY INDEX

Patient Name:____Fileno.:_________________Date:__________________

This questionnaire has been designed to give the doctor information as to how your back pain has affected your ability to manage everyday life. Please answer every section and mark in each section only ONE box as it applies to you. We realize you may consider that two of the statements in any one section could relate to you, but please just mark the box that most closely describes your problem.

Section 1 - Pain Intensity • I have no pain at the moment. • The pain is very mild at the moment. • The pain is moderate at the moment. • The pain is fairly severe at the moment. • The pain is very severe at the moment. • The pain is the worst imaginable at the moment.	**Section 6 - Concentration** • I can concentrate fully when I want to with no difficulty. • I can concentrate fully when I want to with slight difficulty. • I have fair degree of difficulty in concentrating when I want to. • I have a lot of difficulty in concentrating when I want to. • I have a great deal of difficulty in concentrating when I want to. • I cannot concentrate at all.
Section 2 - Personal Care (Washing, Dressing...) • I can look after myself normally without causing extra pain. • I can look after myself normally but it causes extra pain.. • It is painful to look after myself and I am slow and careful. • I need some help but manage most of my personal care. • I need help every day in most aspects of self-care. • I do not get dressed; I wash with difficulty and stay in bed.	**Section 7 - Work** • I can do as much work as I want to. • I can do only my usual work, but no more. • I can do most of my usual work, but no more. • I cannot do my usual work. • I can hardly do any work at all. • I cannot do any work at all.
Section 3 - Lifting • I can lift heavy weights without extra pain. • I can lift heavy weights but it gives extra pain. • Pain prevents me from lifting heavy weights off the floor, but I can manage if they are conveniently positioned, for example on a table. • Pain prevents me from lifting heavy weights, but I can manage light to medium weights if they are conveniently positioned. • I can lift only very light weights. • I cannot lift or carry anything at all.	**Section 8 - Driving** • I can drive my car without any neck pain. • I can drive my car as long as I want with slight pain in my neck. • I can drive my car as long as I like with moderate pain in my neck. • I cannot drive my car as long as I want because of moderate pain in my neck. • I can hardly drive at all because of severe pain in my neck.. • I cannot drive at all.
Section 4 - Reading • I can read as much as I want to without pain in my neck. • I can read as much as I want to with slight pain in my neck. • I can read as much as I want with moderate pain in my neck. • I cannot read as much as I want because of moderate pain in my neck. • I can hardly read at all because of severe pain in my neck. • I cannot read at all.	**Section 9 - Sleeping** • I have no trouble sleeping. • My sleep is slightly disturbed (<1 hour sleep loss). • My sleep is mildly disturbed (1-2 hours sleep loss). • My sleep is moderately disturbed (2-3 hours sleep loss). • My sleep is greatly disturbed (3-5 hours sleep loss). • My sleep is completely disturbed (5-7 hours sleep loss).

Section 5 - Headaches	**Section 10 - Recreation**
• I have no headaches at all. • I have slight headaches that come infrequently. • I have moderate headaches that come infrequently. • I have moderate headaches that come frequently. • I have severe headaches that come frequently. • I have headaches almost all the time.	• I am able to engage in all my recreation activities with no neck pain at all. • I am able to engage in all my recreation activities, with some pain in my neck. • I am able to engage in most, but not all of my usual recreation activities because of pain in my neck. • I am able to engage in a few of my usual recreation activities because of pain in my neck. • I can hardly do any recreation activities because of pain in my neck. • I cannot do any recreation activities at all.

Vernon/Hagino, modified from Foubister *et al*., Physiotherapy, 1980