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CERVICAL SPINE MANIPULATION AND MUSCLE ENERGY TECHNIQUE IN THE TREATMENT OF UPPER TRAPEZIUS MYOFASCIAL PAIN

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

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Supervisor: ____________________________ Date: ____________________________

Dr. D.M. Landman
DECLARATION

I, Vicki Ferreira, declare that this is my own, unassisted work. It is being submitted to the University of Johannesburg in partial fulfilment of my Master’s degree in Technology of Chiropractic. It has not been submitted before for any degree or examination to any other Technikon or University.

________________________________________
Vicki Ferreira

On the ______ day of the month of ________________ 2016

UNIVERSITY
OF
JOHANNESBURG
DEDICATION

This dissertation is dedicated to the Lord Almighty and the people I love and hold dearest to my heart:

To my mother. You have given everything to help me reach my dream. I am truly blessed to have you in my life. You mean the world to me. There is nothing I can repay you with for what you have done for me. You stood by me through the difficult times, motivated me when things felt overwhelming and supported me all the way. There are no words to express my gratitude towards you. All I can say from the bottom of my heart is thank you.

To my sister. Your love, compassion and friendship helped me through the toughest times. Thank you for always supporting me and being there for me.

To my dearest husband, best friend and soul mate. Thank you for being my pillar of strength, making me smile and for being my biggest fan. Thank you for your words of encouragement that always had a way of lifting me up. You have always believed in me and encouraged me to be the best I can be. I will love you forever.
ACKNOWLEDGEMENTS

I would like to say thank you and convey my sincere gratitude to Dr. Landman for all the assistance and support, without your guidance this dissertation would not have been possible.

Thank you to Juliana van Staden at Statkon for your assistance and time in the statistical analysis of my study.

A special thank you to everyone who participated in my research study. Without you the study would not have been possible.
ABSTRACT

Purpose: The aim of this study was to compare the effects of muscle energy technique (MET) to chiropractic manipulations and a combination thereof with regards to pain, disability and range of motion of the cervical spine in the treatment of upper trapezius myofascial and associated neck pain. This was done by comparing MET, chiropractic manipulation and combination treatment groups. Short term and long term effects were measured to determine an appropriate treatment protocol for upper trapezius and associated neck pain.

Method: Forty five (45) participants, between the ages of 18 and 55, with non-specific neck and muscle pain were invited to participate in the study. Once the cervical spine examination was performed and all the inclusion criteria were met with none of the exclusion criteria present, they were included in the study and randomly allocated into 3 groups. Group A received a chiropractic manipulation to the cervical spine, Group B received MET to the upper trapezius muscle and Group C received a combination treatment. Each participant was treated a total of six times over a two week period. The seventh visit served the purpose of obtaining the final measurements. The data was always collected before the treatment was administered. The objective data consisted of measuring the range of motion of the cervical spine with a CROM instrument as well as measuring the pain pressure threshold with a pressure algometer. The subjective data was collected using the Vernon-Mior neck pain and disability index. The objective data was gathered on the first, fourth and seventh visits and the subjective data on the first and seventh visits.

Results: The results were interpreted by STATKON at the University of Johannesburg. All three groups improved significantly in the subjective and objective measurements over the two week trial period with regards to pain, disability and cervical range of motion. This indicated that all three treatment interventions were effective in the treatment of upper trapezius myofascial pain. These results also indicated that Group C (combination treatment of MET and chiropractic manipulation) was statistically superior to Group A (chiropractic manipulation) and Group B (MET) when cervical range of motion was considered as a whole. There was no statistical superiority between the three treatment groups with regards to pain pressure threshold values obtained, even though Group B reported a greater improvement over time. With regards to the subjective measurements, all three groups were equally effective in reducing the patient’s perceived pain and disability.

Conclusion: The results of this study show that chiropractic manipulation, MET and a combination of chiropractic manipulation and MET are effective treatments in reducing pain and disability and have the ability to restore proper mechanical function by increasing cervical spine range of motion. There was no treatment protocol that was proven to be more effective than the other. Since a combination treatment of
chiropractic manipulation and MET showed the greatest overall clinical improvements, it may be suggested that a combination treatment is the most effective treatment in the treatment of upper trapezius myofascial pain with regards to cervical spine range of motion and neck pain and disability.
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<thead>
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<th>Acronym</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>MET:</td>
<td>Muscle Energy Technique</td>
</tr>
<tr>
<td>MFTP/s:</td>
<td>Myofascial Trigger Point/s</td>
</tr>
<tr>
<td>NMJ:</td>
<td>Neuromuscular Junction</td>
</tr>
<tr>
<td>RI:</td>
<td>Reciprocal Inhibition</td>
</tr>
<tr>
<td>ROM:</td>
<td>Range of Motion</td>
</tr>
<tr>
<td>PIR:</td>
<td>Post-Isometric Relaxation</td>
</tr>
<tr>
<td>VMNPDI:</td>
<td>Vernon-Mior Neck Pain and Disability Index</td>
</tr>
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</table>
CHAPTER ONE: INTRODUCTION

1.1 Introduction

Myofascial trigger points (MFTPs) are some of the most common causes of myofascial pain seen in medical practice; however it is poorly recognized and inadequately managed. The point of prevalence ranges from 10% to 18% (Kannan, 2012). Non-specific neck pain has an annual prevalence ranging between 30% and 50%. Within 1 to 5 years following the initial onset, 50% to 85% of patients continue to report constant or recurrent neck pain (Bryans et al., 2014).

Poor neck and shoulder posture are common observations associated with shoulder and back pain in repetitive computer users. The average person spends approximately 7 to 8 hours a day working in front of a visual display unit, usually with poor posture causing the neck to go into an increased flexion and resulting in an anterior head carriage. This could result in activation of the extensor muscles as well as the upper trapezius muscle (Yoo, 2013). Poor neck posture can be described as an anterior head carriage, which is the result of flexion in the lower cervical spine combined with extension in the upper cervical spine. Poor shoulder posture results from scapular abduction and elevation. A “hunched over” posture is seen when these two poor postures are combined. A study done by Gaffney, Maluf, Curran-Everette and Davidson (2014) to find the association between cervical and scapular posture on the muscle activity of the trapezius muscle revealed that the upper portion of the trapezius muscle gets activated with scapular elevation, but not with cervical extension. Thus, the trapezius muscle plays a core role in scapular stabilization. In order to reduce static loading on the upper trapezius when sitting for prolonged periods, scapular elevation should be avoided (Gaffney, Maluf, Curran-Everette and Davidson, 2014).

Soft tissues, such as muscles, ligaments, tendons and other connective tissues, may undergo certain changes in length (shortening or lengthening), contraction and strength (strengthening or weakening) or may become painful. The human body possesses the ability to compensate for these changes and the adaptive demands placed on it. These adaptive demands can include a combination of processes such as aging, daily activities, repetitive microtrauma and emotional states. Myofascial dysfunction can thus be demonstrated due to the body's adaptive capabilities. The bodily compensation will continue until the adaptive ability of the tissues is exhausted. At this stage, the main symptoms will present as an increase in pain and limited range of motion (ROM) (Chaitow, 2006).

Travell and Simons (1999) defined MFTPs as hyperirritable spots within a skeletal muscle that is coupled with a palpable and hypersensitive nodule within a taut band. According to Chaitow (2006), MFTPs can sometimes be the major contributor to the pain experienced by people with musculoskeletal dysfunction. Although the etiology of MFTPs are not completely understood, recent studies suggest that overloading or
injuring muscle fibers will result in the pathogenesis of MFTPs (Gerwin et al., 2004).

Fortunately, a range of treatments exist that can promote normal function and alter pain, depending on the nature and chronicity of the condition. Among some of the most effective treatments, capable of aiding in both functional and structural changes, are chiropractic manipulations and Muscle Energy Techniques.

Esposito and Philipson (2005) defined a chiropractic manipulation as any chiropractic therapeutic procedure that utilizes controlled force, leverage, direction, amplitude and velocity. These procedures are applied to specific joints or anatomical areas. Chiropractors regularly use these procedures to affect joint and neurophysiologic function (Esposito and Philipson, 2005). The World Federation of Chiropractic (2001) defines chiropractic as follows: A health care profession concerned with the diagnosis, treatment and prevention of mechanical disorders on the functions of the nervous system and general health. Emphasis is placed on manual therapies, including spinal manipulations over and above manipulations of other joint and soft tissue.

Muscle Energy Techniques (MET) is considered a form of soft tissue osteopathic manipulation methods aimed at reducing pain and restoring musculoskeletal function. It has been hypothesized that MET may restore musculoskeletal function to muscle groups by decreasing pain of antagonist and agonist muscle groups as well as restoring joint ROM, particularly in restricted joints. MET integrates precisely directed and controlled, isometric and/or isotonic muscle contractions initiated by the patient (Chaitow, 2006). The prognosis for the treatment of people with myofascial trigger points is very good, as the MFTPs typically respond quickly to manipulative techniques, like stretching. MET has proven to be a safe, simple and effective method to reduce MFTPs. MET is also particularly helpful in preventing the re-activation of MFTPs while normal muscle resting length is re-established. If a muscle is unable to reach its normal resting length, the MFTPs within that muscle will re-activate (Chaitow, 2006).

While research has been conducted to establish the effectiveness of chiropractic manipulations as opposed to MET in the treatment of cervical facet syndrome, to date there has not been any other research to determine, whether it is better to only use muscle energy technique or chiropractic manipulation in the treatment of upper trapezius and associated neck pain a combination thereof.

1.2 Aim

The aim of this study was to compare the effects of MET to chiropractic manipulations and a combination thereof with regards to perceived pain and disability as well as ROM of the cervical spine in the treatment of upper trapezius myofascial and associated neck pain. This was done by comparing MET, chiropractic
manipulation and combination treatment groups. Short term and long term effects were measured to
determine an appropriate treatment protocol for upper trapezius and associated neck pain.

1.3 Possible outcomes and benefits

The possible outcome of this study was to determine whether a combination of chiropractic manipulation
and MET can reduce trapezius myofascial and associated neck pain and increase cervical ROM. The
results of the study provide an additional treatment protocol to chiropractors when dealing with myofascial
and neck pain. Should a patient be contraindicated for chiropractic manipulations, MET can be used as an
alternative treatment to restore normal ROM and decrease pain. The dosage of application of MET can be
modified should a pathology such as osteoporosis and arthritis be present (Chaitow, 2006). This study
may provide a less invasive treatment approach in myofascial pain to patients who don’t like dry needling.
CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

The literature review will discuss relevant anatomy of the cervical spine and surrounding skeletal muscles, with special emphasis placed on the trapezius muscle. The aetiology of pain and myofascial trigger points (MFTPs) will be defined. The use of Muscle Energy Technique (MET) and chiropractic manipulation of the cervical spine will be investigated in the management of trigger points in the upper trapezius muscle.

2.2 Cervical Spine Anatomy

The upper segment of the spinal column, known as the cervical spine, is made up of of seven vertebrae and is situated between the base of the skull and the upper thorax (Moore and Dalley, 2006).

The cervical spine can be divided into two separate regions based on morphology and function: the upper and lower cervical spine. Structures included in the upper cervical spine region are the occipital condyles, the C1 (atlas) and C2 (axis) vertebrae and the joint formed between the second (C2) and third (C3) cervical vertebrae. The lower cervical spine region includes the rest of the cervical vertebra (C3 to C7) (Levangie and Norkin, 2005; Radcliff et al., 2010). The cervical spine vertebrae can be classified as atypical or typical vertebrae based on their structural characteristics. The atypical vertebrae are the atlas (C1), axis (C2) and C7. C3 to C6 are classified as typical vertebrae (Moore et al., 2010).

2.2.1 Atypical cervical vertebrae

Figure 2-1: The first and second cervical vertebrae (Netter, 2011)
a) Atlas

The atlas is often described as a washer placed between the occipital condyles and the axis. It is the first cervical vertebrae (C1). It is considered to be an atypical vertebra as it is a ring-like and kidney-shaped bone lacking a body and spinous process. The anterior and posterior arches connect the lateral masses. Superiorly the atlas articulates with the occipital condyles and inferiorly with the second cervical vertebra, the axis. The atlas is considered the widest cervical vertebra due to the more laterally placed transverse processes on the lateral masses. This in turn provides increased leverage for the attached muscles. The ventral surface of the anterior arch forms the anterior tubercle, and the dorsal surface provides the facet for articulation with the dens of the axis. The posterior arch is similar to the lamina of the typical vertebra. The vertebral artery and C1 nerve can be found in a groove on its superior surface. The foramina transversia are found in the transverse processes for the passage of vertebral veins and arteries (Moore et al., 2010).

b) Axis

The axis is considered to be an atypical vertebra due to the inferior orientation of the anterior part of the body and the presence of a vertical projection called the odontoid process (dens) that originates from the superior surface of the body (Levangie et al., 2005). This odontoid process functions as a pivot for the atlanto-axial joint. The axis has two lateral articular facets that are oriented superolaterally, convex anteroposteriorly and flat transversely (Kapandji, 2008).

The spinous process of C2 is large, elongated, bifid and easily palpated in the nuchal groove in the back of the neck (Moore et al., 2010). The vertebral artery passes through the vertical foramen of the transverse process (Kapandji, 2008).

c) Seventh cervical vertebra

A long spinous process, which is not bifid, is characteristic of the C7 vertebrae. This is called the vertebra prominens (Moore et al., 2010). The vertebral canal of C7 is usually smaller and the body bigger when compared to the other cervical vertebrae. The vertebral artery does not pass through the thick and prominent transverse process (Chaitow et al., 2008).

2.2.2 Typical cervical vertebrae

Vertebrae C3 to C7 are considered typical cervical vertebrae. There are two major parts in the structure of typical vertebrae: the anterior vertebral body and the posterior vertebral or neural arch. There is a further division of the neural arch to form the pedicles and the posterior elements. The laminae, articular processes, spinous processes and the transverse processes are all part of the posterior elements (Levangie et al., 2005).
Table 2-1 summarizes all the characteristics of typical cervical vertebrae.

**Table 2-1: Characteristics of a typical cervical vertebra (Moore et al., 2010)**

<table>
<thead>
<tr>
<th>Part</th>
<th>Characteristic</th>
</tr>
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<tbody>
<tr>
<td>Body</td>
<td>Small and narrower back to front diameter than side to side. The superior surface forms a concavity with the uncus of the body and the inferior surface is convex.</td>
</tr>
<tr>
<td>Vertebral foramen</td>
<td>Triangular and large.</td>
</tr>
<tr>
<td>Transverse foramen</td>
<td>End in two lateral projections: anterior and posterior tubercles which provide attachment for cervical muscles. This is the canal for the vertebral arteries, veins and nerves to pass through in all cervical vertebrae, except C7.</td>
</tr>
<tr>
<td>Articular processes</td>
<td>The superior facets are oriented superoposteriorly and the inferior facets are oriented inferoanteriorly.</td>
</tr>
<tr>
<td>Spinous processes</td>
<td>The spinous processes are short (C3-C5) and bifid (C3-C6).</td>
</tr>
</tbody>
</table>

2.3 Joints of the Cervical Spine

2.3.1 The atlanto-occipital joint

These are the two uppermost joints (Magee, 2005). It is formed by the articulation of the two concave superior articulating facets of the lateral masses of C1 and the convex occipital condyles of the skull (Levangie et al., 2005). The C0/C1 joints allow nodding of the head (flexion and extension) in addition to lateral flexion of the head and neck. They form part of the condyloid type of synovial joints (Moore et al., 2010).

2.3.2 The atlanto-axial joint

The atlanto-axial joints are considered to be the most mobile articulations of the spine (Magee, 2005). There are three synovial joints formed here: two lateral atlanto-axial joints and one central atlanto-axial joint. These synovial joints are between the inferior facets of the lateral masses of C1 and the superior facets of C2 and between the odontoid process of C2 and the anterior arch of C1. When movement occurs at all three joints it permits left and right rotation of the head (Moore et al., 2010).

2.3.3 Zygapophysial joints

These articulations are also known as facet joints. The superior and inferior articular processes of adjacent vertebrae form the facet joints. The shape and nature of the articular surfaces are key in the determination of range and direction of movement (Moore et al., 2010). The superior facets, of the vertebrae below, are
orientated superiorly, posteriorly and medially to articulate with the inferior facets, of the vertebrae below, that face inferiorly, anteriorly and laterally. These joints permit flexion, extension, rotation and lateral flexion (Magee, 2005).

These joints are true synovial joints and contain meniscoids (Levangie et al., 2005). The thin and lax joint capsule that surrounds every joint allows for a large ROM. The joint capsule connects the articular processes of adjacent vertebrae. The facet joints are stabilized by accessory ligaments that bond the laminae, transverse processes and spinous processes (Moore et al., 2010). These joints receive innervation from the medial branch of the posterior rami of spinal nerves (Levangie et al., 2005).

2.3.4 The uncovertebral joint

The uncovertebral joints are considered to be additional joints in the cervical spine as they are not found between the articular processes and the intervertebral discs (Kapandji, 1974). The uncovertebral joints (of Luschka) develop between the uncinate processes of C3 to C6 and the inferolateral surfaces of the superior vertebral bodies. These joints are found laterally and posterolaterally to the intervertebral discs. The articulating surfaces of these “joints” are covered with cartilage (Moore et al., 2010).

Although they are considered to be synovial joints by some, others believe they are just degenerative spaces in the discs full of extracellular fluid. Bony spurs commonly form at the uncovertebral “joints” and thus they may cause neck pain (Moore et al., 2010).

The uncovertebral “joints” are involved in the total ROM of the spine, except rotation, by guiding the movements (Kapandji, 2008).

2.3.5 The intervertebral disc

The intervertebral discs (IVD) connect the articulating surfaces of adjacent vertebrae by providing strong attachments between the vertebral bodies (Moore et al., 2010). No IVD are found between C0/C1 and C1/C2 (Magee, 2005).

The IVD consist of an annulus fibrosus and nucleus pulposus. The annulus fibrosus is a fibrous ring-like structure made up of concentric lamellae of fibrocartilage to form the border of the IVD. The fibers of the annulus fibrosus attach to the epiphyseal plate of each vertebra. The fibers forming each lamella run at a 30 degree angle from one vertebra to another, while the fibers of the adjacent lamellae cross each other obliquely at angles greater than 60 degrees. This strengthens the bond between them while providing limited rotation of adjacent vertebrae. The annulus fibrosus is avascular centrally and sensory innervations is only received from the outer third (Moore et al., 2010).
The nucleus pulposus is considered the centre of the IVD. At birth, the nucleus pulposus is almost entirely made up of water and more cartilaginous than fibrous. The flexibility and pliability of the IVD is mainly due to its semi-fluid nature. The nucleus pulposus is located between the centre and the posterior aspect of the IVD. This is due to the fibers of the annulus fibrosus being thinner and less abundant posteriorly. The nucleus pulposus is avascular and the blood vessels of the periphery of the annulus fibrosus and vertebral artery supply the necessary nourishment via diffusion (Moore et al., 2010).

![Figure 2-2: Structure and function of intervertebral discs (Moore et al., 2010)](image)

2.4 Biomechanics of the Cervical Vertebrae

Bergmann and Peterson (2011) define biomechanics as the application of mechanical laws to living organisms, with special emphasis on the locomotive system of the human body. Interrelations between the skeleton, muscles and joints are the main focus of biomechanics.

The vertebral column as a whole can flex, extend, rotate and laterally flex. These movements seem to occur independently, however, when looking at the motion segments, these movements are coupled movements (Levangie et al., 2005). Two adjacent articulating planes and the surrounding tissues binding them form the functional unit known as a motion segment (Esposito and Philipson, 2005).

Movement of a motion segment is affected by numerous factors, which include the width of the intervertebral discs, the conformity of its fibrocartilage and the measurements and shape of the adjacent vertebral endplates. The direction, type and amount of movement of a motion segment is decided by the orientation and shape of the articulating facets, the muscles and ligaments (Middleditch et al., 2005).
Table 2-2: Global range of motion for the cervical spine (Bergmann and Peterson, 2011)

<table>
<thead>
<tr>
<th>Movement</th>
<th>Normal Range (Degrees)</th>
<th>Range Without Impairment (Degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion</td>
<td>60 - 90</td>
<td>60</td>
</tr>
<tr>
<td>Extension</td>
<td>75 - 90</td>
<td>75</td>
</tr>
<tr>
<td>Rotation</td>
<td>80 – 90</td>
<td>45</td>
</tr>
<tr>
<td>Lateral Flexion</td>
<td>45 – 55</td>
<td>80</td>
</tr>
</tbody>
</table>

The biomechanics of the cervical spine can be separated into two regions: the superior (sub-occipital) segment consisting of the occiput, atlas (C1) and axis (C2) and the inferior segment consisting of vertebrae C3 to C7.

2.4.1 Biomechanics of the atlanto-occipital joint

Flexion and extension are the major movements that occur at the atlanto-occipital joint (Bergmann and Peterson, 2011). The initial 25° of flexion and extension occurs at the atlanto-occipital joint (Kapandji, 2008).

During normal flexion, the occipital bone moves away from the posterior arch as the occipital condyles glide posterosuperiorly on the lateral masses of C1 (Bergmann and Peterson, 2011). Flexion is limited by the tension developed in the articular capsule, the posterior atlanto-occipital membrane and the posterior cervical ligament (Kapandji, 2008).

During extension, the opposite occurs. The occipital condyles now slide anteriorly on the lateral masses of C1 as the occipital bone approximates the posterior arch of C1 (Bergmann and Peterson, 2011). Extension is limited by the bony approximation of the posterior arch of the atlas and the axis (Kapandji, 2008).

Secondary rotation takes place at the atlanto-occipital joint. With left rotation of the occiput, the right occipital condyle moves anteriorly on the right lateral mass of the atlas. During this movement, the left occipital condyle is pulled to the right by the tension in the lateral atlanto-occipital ligament. A linear displacement of 2-3mm of the occiput to the left and lateral flexion to the right occurs as a result of rotation of the atlanto-occipital joint complex. With right rotation, the opposite occurs (Kapandji, 2008).
2.4.2 Biomechanics of the atlanto-axial and atlanto-odontoid joints

The atlanto-axial joint segment is composed of three joints: two lateral atlanto-axial joints and one central atlanto-odontoid joint. These joints are linked mechanically due to the absence of an intervertebral disc.

During flexion, the lateral masses of the atlas simply roll on the superior surface of the axis, moving the contact points anteriorly and opening up the interspace between atlas and odontoid superiorly. During extension, the contact points are shifted posteriorly and the interspace between atlas and odontoid opens up inferiorly (Kapandji, 2008).

During right rotation, the odontoid process acts as the fixed pivot around which the osteoligamentous ring created by the atlas and transverse ligament rotates counter-clockwise. In the vertical plane, the axis corresponds to the odontoid process. The capsular ligament is relaxed on the right and stretched on the left. Anterior movement of the right lateral mass and posterior movement of the left lateral mass also occurs. The opposite occurs with left rotation (Kapandji, 2008).

2.4.3 Biomechanics of the lower cervical spine

Flexion and extension is the greatest in the lower cervical spine. Lateral flexion is greater than rotation, although both significantly decrease at the cervico-thoracic junction (Bergmann and Peterson, 2011).
During flexion, the superior vertebra tips and glides anteriorly. This results in stretching of the posterior disc and facet joints with anterior disc approximation and compression as the nucleus pulposus is moved slightly posteriorly. The intervertebral space is narrowed from anterior to posterior. The superior facet glides anterosuperiorly relative to the inferior facet, resulting in an opening posteriorly. Flexion is limited by soft tissue restraints such as the tension developed in the posterior longitudinal ligament, capsular ligaments, ligamentum flavum, interspinous ligaments and the luchal ligament (Kapandji, 2008; Bergmann and Peterson, 2011).

During extension, the superior vertebra tips and glides posteriorly. The anterior annulus fiber become taut as the nucleus pulposus is moved slightly anteriorly. The intervertebral space is narrowed from posterior to anterior. The superior facet glides posteroinferiorly relative to the inferior facet, resulting in an opening anteriorly. Extension is limited by the bony impact between the posterior arches and superior articulating processes of the inferior vertebra and the transverse processes of the upper vertebra in addition to the tension developed in the anterior longitudinal ligament (Kapandji, 2008).

Lateral flexion and rotation of the lower cervical spine does not occur separately, but rather as a coupled movement. This is due to the 45° posteroinferior orientation of the facets and the sharp elevations of the uncinate processes relative to the transverse plane (Kapandji, 2008).

During left rotation there is simultaneous left lateral flexion. The left inferior facet of the superior vertebra moves posteroinferiorly and the right inferior facet moves anterosuperiorly. The opposite occurs for right rotation (Bergmann and Peterson, 2011).

During left lateral flexion, all the inferior facets on the left move inferomedially due to the coupled movements. The inferior facets on the right move superiorly, resulting in facet joint distraction on the right (Bergmann and Peterson, 2011).

Figure 2-4: Coupled movements of the lower cervical spine (Neumann, 2010)
2.5 Anatomy

2.5.1 Skeletal muscle

Muscle tissue, one of the four primary tissue types found in the human body (others being epithelial, connective and neural tissues), consists mainly of cells highly specialized for contraction. The ability to change shape is a muscle's most important property. Muscle tissue can be divided into cardiac, smooth and skeletal muscle. Cardiac muscle is only located in the heart and plays a vital role in the circulatory system. Smooth muscle is located in the blood vessel walls and in the reproductive, urinary, digestive and respiratory organs. Skeletal muscle is mainly responsible for movement and locomotion as they are either directly or indirectly connected to the bones of the skeleton (Martini and Nath, 2009). According to Guyton and Hall (2011), skeletal muscle comprises 40 percent of the human body mass. These muscles are considered organs and consist largely of skeletal muscle tissue, but also contain connective tissue, nerves and blood vessels. Skeletal muscle is innervated by somatic motor neurons.

a) Functional organization of skeletal muscle

Skeletal muscle components are organised into layers of connective tissue. These layers and different components are illustrated in Figure 2-5. Fascia, a sheath of connective tissue, separates skeletal muscles from each other. Connected and beneath the fascia is a dense layer of collagen fibers called the epimysium. This layer parts the muscle from adjacent organs and tissues. The muscle is then further divided into a series of compartments called fascicles by the perimysium, a connective tissue membrane. Within this layer, blood vessels and nerves are found. The endomysium, a connective tissue membrane, surround each individual muscle fiber inside the fascicle (Martini and Nath, 2009).

A muscle fiber is the cellular unit of a muscle. They are long cylindrical structures that can vary in size and length. The sarcolemma surrounds the cytoplasm of a muscle fiber. Myofibrils are the contractile components found in muscle fibers and consist of protein filaments called myofilaments. Actin, myosin, troponin and tromyosin are the contractile proteins that myofilaments are composed of (Martini and Nath, 2009).
b) Structure of the sarcomere

The smallest functional unit of a muscle is called a sarcomere and is made up of thick filaments (myosin) and thin filaments (actin, troponin and tropomysin). The difference in size, density and distribution of these filaments are responsible for the light (‘I’ bands) and dark (‘A’ bands) banded appearance of each myofibril. The ‘A’ band is formed by the thick filaments and is found in the centre of the sarcomere. This band also contains parts of the thin filaments and is subdivided into the ‘M’ line, the ‘H’ band and the zone of overlap. The ‘M’ line runs through the exact middle of the sarcomere to connect it to the next sarcomere. The ‘H’ band is found on either side of the ‘M’ line and consists of only thick filaments and no thin filaments. In the zone of overlap, thin filaments are surrounded by thick filaments (Martini and Nath, 2009).

The ‘I’ band extends between the ‘A’ bands of two adjacent sarcomeres and contains only thin filaments. Sarcomeres are separated by the ‘Z’ line, which comprises of proteins called actinins that interconnect the thin filaments of two adjacent sarcomeres. The thick filaments are attached to the ‘Z’ line by elastic proteins called titin. Figure 2-6 shows the structure of a sarcomere (Martini and Nath, 2009).
c) The neuromuscular junction

The nervous system is responsible for skeletal muscle contraction. The communication occurs at the neuromuscular junction (NMJ), where the distal end of a motor nerve axon synapses onto skeletal muscle fibers (Figure 2-7). At this site, four types of specialized cells are present: motor neurons, Schwann cells, muscle fibers and newly discovered kranocytes. The synaptic cleft is the opening that separates the motor neuron from the muscle fiber (Hong and Etherington, 2011). The NMJ is dependent on Acetylcholine (Ach) as neurotransmitter, which is produced in the synaptic terminal using the energy supplied by the mitochondria (Travell and Simons, 1999).
Travell and Simons (1999) explain the initiation and maintenance of a muscle contraction in the following steps:

- An action potential is generated by an abrupt change in transmembrane potential and travels along a motor neuron to reach the synaptic terminal.
- The synaptic terminal responds by opening the voltage-gated calcium channels that allows ionized calcium to move from the synaptic cleft to the synaptic terminal.
- These channels can be found on both sides of the specialized portion of the nerve membrane that releases Ach in response to the influx of ionized calcium.
- Ach floods the barrier of acetylcholinesterase (AchE) in the synaptic cleft to reach the Ach receptors in the post-junctional membrane of the muscle fiber.
- The change in membrane permeability allows for an influx of sodium ions through the sodium channels and the action potential is transferred to the muscle fiber.
- Ach is broken down by AchE in the synaptic cleft to limit its action time.
- The synapse can now respond to other incoming action potentials.

**d) Muscle spindles**

Muscle spindles are spindle-shaped proprioceptive fibers that are found in the perimysium of a skeletal muscle. Their function is to send information regarding stretch and muscle length changes to the brain and spinal cord and to initiate a reflex that will prevent excessive stretching (Marieb and Hoehn, 2013).

A muscle spindle can be divided into intrafusal and extrafusal muscle fibers. The effector muscles are known as the extrafusal muscles and are innervated by alpha motor neurons. Each muscle spindle is made up of a connective tissue capsule that contains small muscle fibers called intrafusal fibers. The intrafusal fibers are adapted so that it has a contractile and non-contractile portion. Due to the lack of myofilaments, the central portion of the intrafusal fibers are non-contractile. The ends of the intrafusal fibers are the only areas where actin and myosin myofilaments can be found, making it the contractile portion. The central portion of the intrafusal fibers are innervated by sensory nerve fibers and the contractile ends by gamma motor neurons (Marieb and Hoehn, 2013).

A muscle spindle can be stretched when the entire muscle is lengthened by an external force or when the gamma motor neurons that innervate the intrafusal fibers are activated and thereby stretch the muscle internally. Excessive stretching that could cause damage to the muscle fibers is prevented by the stretch reflex (Marieb and Hoehn, 2013).
e) Golgi tendon organs

Golgi tendon organs can be described as encapsulated sensory receptors that can be found where muscle fibers and tendons connect (Gatterman, 2005; Guyton and Hall, 2010). They are responsible for the transmission of the degree of tension in a tendon during an isometric contraction, in order to limit extreme joint movement and to prevent injury to muscles, tendons and ligaments by the inhibition of the motor activity (Coetzee, Loots and Meiring, 2003; Bergmann and Peterson, 2011; Guyton and Hall, 2010; Silverthorn, 2004). This response is known as the relaxation reflex (Silverthorn, 2004). Functions include monitoring external muscle tension and the rate of change during muscle contraction (Martini, 2009).

Silverthorn (2004) explains that during an isometric muscle contraction, the collagen fibers inside the golgi tendon organ are tightened. This activates the sensory nerve endings to fire. In the spinal cord, the inhibitory interneurons are activated to inhibit the alpha motor neurons that supply innervations to the muscle. There is a marked reduction or complete cessation in muscle contraction. With an increase in the force of contraction of a muscle, this reflex just slows the muscle contraction down.

2.5.2 Physiology of skeletal muscle

Muscles perform vitally important functions in the human body. The main function of skeletal muscles is to provide movement and locomotion to the human body or any of its parts. The continuous contraction of skeletal muscles play a vital role in maintaining posture and body position as well as in stabilizing joints.
Skeletal muscle contractions increase the heat production within the body and contribute the most to the maintenance of body heat (Marieb and Hoehn, 2013).

Four special characteristics of skeletal muscles enable them to perform their functions. These include excitability or responsiveness (the ability to receive and react to a stimulus, usually from a nerve), contractility (the ability to contract or shorten powerfully when sufficiently stimulated), extensibility (the ability to extend or stretch beyond the normal resting length when they are relaxed) and elasticity (the ability of a muscle to return and recoil back to its normal resting length after stretching) (Marieb and Hoehn, 2013).

a) Types of muscle contractions

There are four types of skeletal muscle contractions: isotonic, isometric and eccentric contractions, which differ as follows:

- During isotonic contractions there is a change in muscle length without a change in force used to produce movement. There are two types of isotonic contractions: concentric and eccentric contractions (Moore et al., 2010). Pure isotonic contractions can only be obtained when the resistance throughout the ROM remains constant (Mense and Gerwin, 2010).
- During isometric contractions the muscle length remains unchanged but the force increases to oppose gravity or other antagonistic forces (Moore et al., 2010).
- During concentric contractions movement is produced due to shortening of the muscle (Moore et al., 2010). The simultaneous length and force changes are characteristic of this type of muscle (Mense and Gerwin, 2010).
- During eccentric contractions the contracted muscle lengthens due to external forces. The force that the muscle produce is not sufficient to resist the force causing it to lengthen, thus the muscle contraction slows down the lengthening (Mense and Gerwin, 2010).

Muscle energy technique requires voluntary contractions by the patient to be isometric, isotonic or isolytic, each resulting in a different therapeutic effect (Chaitow, 2006). These therapeutic effects will be discussed later in this chapter.

b) The mechanism of contraction

Marieb and Hoehn (2013) explain muscle contraction in two phases.

The process starts when a muscle fiber is stimulated by a motor neuron (Phase 1):

- A nerve impulse arrives at the axon terminal at the NMJ and Ach is released.
- The Ach binds to the receptors on the sarcolemma, altering its ion permeability and causing depolarization.
- The depolarization at the NMJ creates an impulse that spreads over the length of the entire sarcolemma and along the T-tubules and to the sarcoplasmic reticulum.
- The stimulation of the sarcoplasmic reticulum causes Ca²⁺ ions to be released into the cytosol.
- The Ca²⁺ ions attach to the troponin within the thin myofilaments.
- Tromyosin molecules in the thin filaments move away and expose actin’s binding sites.
- Myosin can now bind to the actin to form cross-bridges of the thick filaments and use their energy to pull the thin myofilaments towards the centre of the sarcomere (Figure 2-9).
- This cycle can occur multiple times per second if adenosine-triphosphate (ATP) is present (Thibodeau and Patton, 2003).

![Image](http://medicine.academic.ru/139269/sliding_filament_mechanism)

**Figure 2-9:** The sliding filament mechanism, showing myosin cross-bridges pulling the thin filaments toward the centre of each sarcomere

The process ends with relaxation (Phase 2) (Martini and Nath, 2009):

- The generation of an action potential comes to a stop when Ach is broken down by AchE.
- The Ca²⁺ ions are resorbed by the sarcoplasmic reticulum to normal resting levels.
- Tropomyosin returns to its normal position, covering the active sites of actin and preventing more cross-bridges from forming.
- Contraction ends without cross-bridge interactions and the muscle relaxes and returns to its normal resting length.
2.6 Cervical Muscles

The cervical region has the most mobility when compared to the rest of the spine. The functions of the cervical muscles include controlling the cervical spine movements and maintaining the cervical posture (Middleditch et al., 2005).

In Table 2-3 below, the cervical muscles are classified according to the movements they produce in the cervical spine at the intervertebral joints.

Table 2-3: Major muscles producing movement of the cervical intervertebral joints (Moore et al., 2010)

<table>
<thead>
<tr>
<th>Flexion</th>
<th>Extension</th>
<th>Lateral Flexion</th>
<th>Rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bilateral action of: Longus colli, Scalene, Sternocleidomastoid (SCM)</td>
<td>Semispinalis cervicis and capitus, Splenius cervicis and capitus, Iliocostalis cervicis, Levator scapulae, Trapezius, Multifidus and Longissimus capitus</td>
<td>Unilateral action of: Iliocostalis cervicis, Longissimus capitus and cervicis, Splenius cervicis and capitus, Intertransversarii and Scalene muscles</td>
<td>Unilateral action of: Rotatores, Semispinalis cervicis and capitus, Multifidus, Splenius cervicis</td>
</tr>
</tbody>
</table>

2.7 The Trapezius Muscle

2.7.1 Anatomy

a) Origin and insertion

The trapezius muscle is a large and flat diamond-shaped muscle found on the posterolateral portion of the neck and thorax (Moore et al., 2010). The proximal attachments include the external occipital protuberance, the superior nuchal line, nuchal ligament and the spinous processes of C7 to T12. The distal attachment is on the spine of scapula, acromion and lateral third of the clavicle (Vizniak, 2012). Figure 2-10 illustrates the trapezius muscle.

Travell and Simons (1999) describe the trapezius muscle as a tripartite muscle that is separated into an upper, middle and lower portion, each with different functions. The upper trapezius starts from the medial third of the superior nuchal line and in the midline from the nuchal ligament. The fibers unite laterally and forward and attach to the lateral third of the clavicle on the posterior border. The middle trapezius fibers attach to the spinous processes and interspinous ligaments of C7 to T12 vertebrae medially. It attaches to
the medial margin of the acromion and the superior lip of the spine of scapula laterally. The lower trapezius is considered to be the fan-shaped portion of the muscle. It attaches to the spinous processes and interspines ligaments of T4 to T12 vertebrae medially. This part of the muscle unites laterally and attaches to the spine of scapula medially and slightly lateral to the lower attachment of the levator scapulae muscle.

Figure 2-10: The different parts of the trapezius muscle
(http://www.mobilityondemand.cards/blog/2015/11/17/how-low-can-you-go)

b) Innervation

The trapezius muscle receives its sensory and motor innervation from different nerves. The sensory innervations for pain and proprioception is from the third (C3) and fourth (C4) cervical spinal nerves. The motor innervation is received from the spinal section of the accessory nerve (cranial nerve XI). The course of the trapezius portion of the motor nerve can be described as follows: from its origin within the spinal canal from the ventral roots of the cervical segments, it ascends through the foramen magnum to exit the skull via the jugular foramen. The nerve then anastomoses with a deep plexus, deep to the trapezius muscle, that is then linked to the spinal nerves C2, C3 and C4 (Travell and Simons, 1999).

c) Blood supply

The main blood supply to the trapezius muscle is from the tranverse cervical and dorsal scapular arteries (Vizniak, 2012).

d) Function

Each of the different parts of the trapezius muscle has a different function. When the trapezius muscle is acting bilaterally, it contributes to extension of the cervical and thoracic spine. Unilaterally, the upper part
of the muscle is responsible for ipsilateral extension and lateral flexion of the head and neck, and contributes to contralateral excessive rotation. When the muscle is acting bilaterally, the upper portion of the fibers only extends the head and neck in the presence of resistance. The middle trapezius allows for two different functions. The more superior fibers of the middle trapezius that attach to the acromion can assist with scapular adduction and contributes to the force couple that causes upward scapular rotation, only after upward rotation has been initiated, to assist the upper trapezius and serratus anterior portion. The lower more inferior fibers of the middle trapezius attach to the scapular spine and adduct the scapula more effectively (Travell and Simons, 1999). It also retracts the scapula at the scapulocostal joints (Muscolino, 2009). The lower part of the trapezius muscle is responsible for scapular adduction as well as rotating the glenoid fossa upwards. The middle trapezius along with the lower trapezius is responsible for scapular stabilization while other muscles rotate it (Travell and Simons, 1999).

2.8 Myofascial Trigger Points of the Upper Trapezius

Myofascial trigger points (MFTPs) are commonly found in the trapezius muscle. Throughout the entire trapezius muscle, seven trigger points can be found. The upper trapezius has two trigger points: trigger point 1 (TP1) and trigger point 2 (TP2). The most common MFTP location in the body has been identified as TP1 (Travell and Simons, 1999). For the purpose of this study, only the TP1 and TP2 of the upper trapezius muscle will be discussed.

2.8.1 Location and referral pattern of the trigger points in the upper trapezius muscle

TP1 is located in the mid-portion of the anterior border of the upper trapezius and involve the fibers that attach to the clavicle anteriorly. TP1 is known to unilaterally refer pain upwards all along the posterolateral aspect of the mastoid process. When the referred pain is intense, it can refer to the temples, the back of the eye and the angle of the jaw. TP1 occasionally refer occiput and lower molar teeth. When the referred pain from TP1 overlaps with the referred pain from other muscles, it can produce a tension-type headache (Travell and Simons, 1999).

TP2 is located in the almost horizontal fibers of the upper trapezius that are caudal and somewhat lateral to TP1. TP2 may be the cause of extra pain as it is able to activate satellite trigger points in other muscles. The referred pain can usually be felt posterior to the cervical reference zone of TP1, joining TP1’s distribution behind the ear (Travell and Simons, 1999).
Figure 2-11: Location and referred pain pattern of TP1 and TP2 in the upper trapezius muscle
(Travell and Simons, 1999)

2.8.2 Observation of active trigger points in the upper fibers of the trapezius muscle

A patient with active MFTPs in the upper trapezius muscle, either in TP1 or TP2, frequently presents with
their arms folded across their chest and holding the chin with one hand. Patients might be rubbing over the
trapezius muscle and constantly moving their head as if to stretch the trapezius muscle. When observing
the patient from the front, an elevated shoulder level along with slight lateral flexion of the neck on the
affected side may be seen. In the case where the trapezius muscle alone is involved, the lateral flexion
towards the unaffected side is the most limited movement. Active rotation of the head towards the affected
side may be painful at the end of ROM as the muscle is maximally contracted (Travell and Simons, 1999).

2.8.3 Symptoms of an active trapezius myofascial trigger point

Active MFTPs in the upper trapezius muscle may produce symptoms that are strongly associated with and
similar to articular dysfunction below C2, C3 and C4 vertebrae. When TP1 is active, the patient may report
severe constant posterolateral neck pain with an associated ipsilateral temporal headache and occasional
referred pain to the angle of the mandible. An active TP2 produces a similar neck pain, but no associated
headache. Pain is experienced with active and full rotation towards the opposite side. With activation of
both TP1 and TP2, wearing heavy clothing may be painful as the intolerance to the weight causes pain
(Travell and Simons, 1999).
2.8.4 Activation and perpetuation of the trigger points in the upper fibers

The activation of all the MFTPs of the trapezius muscle is largely attributed to trauma i.e. falling from a height or whiplash. The upper trapezius trigger points are more frequently activated by chronic injury due to overload or microtrauma. This can include pressure caused by tight narrow bra straps that needs to support large breasts or carrying a heavy back pack. Other factors that may add to the activation of trigger points include the presence of body asymmetry, such as leg length discrepancies or a small hemipelvis, causing a functional scoliotic curve that can overload the shoulder girdle. Walking with a cane that is too long or maintaining a position or posture where the trapezius muscle helps to bear the weight of the arm, like pressing a phone against your ear with your shoulder, also contributes to the activation of upper trapezius trigger points (Travell and Simons, 1999).

2.9 Myofascial Trigger Points

2.9.1 Introduction

Musculoskeletal pain in patients is commonly caused by MFTPs (Okhovatian et al., 2012). Everyone experiences these painful MFTPs at some stage in their lives. Although these MFTPs are not life-threatening, their painfullness affects a person's quality of life (Travell and Simons, 1999). Epidemiology studies propose that MFTPs play a vital role in musculoskeletal dysfunction (Fernandez-la-Penas et al., 2005).

MFTPs not only occur in skeletal muscle but are also commonly found in skeletal muscle tendons, joint capsules, ligaments surrounding a joint, periosteum and skin (Travell and Simons, 1999). There are numerous factors that contribute to the formation of MFTPs. They can include severe trauma, overuse and overstretch, psychological stress or joint dysfunction (Fernandez-la-Penas et al., 2005). It can also be caused by macrotrauma or increasing microtrauma such as abnormal postures, repetitive motion or psychological stresses (Okhovatian et al., 2012). Indirect activation of MFTPs can also occur via nutritional deficiencies, chronic infections and infestations or by other myofascial trigger points (Travell and Simons, 1999).

2.9.2 Definition of a myofascial trigger point

Travell and Simons (1999) describe MFTPs as hyperirritable spots within a skeletal muscle that is coupled with a palpable and hypersensitive nodule within a taut band. Compression, stretching and periods overload of this spot is usually painful. This can then cause characteristic motor dysfunction, referred pain and tenderness and autonomic phenomena. When defining a central MFTP etiologically, it is seen as a
It is important to differentiate between the different types of MFTPs. They include active, latent, associated, attachment, central, key, primary and satellite MFTPs (Travell and Simons, 1999).

An active MFTP can be described as a point that is painful without compression, tender on palpation, causes a distinctive pain referral pattern for that specific muscle with or without digital compression, causes muscle weakness, affects the muscle flexibility and may produce a twitch response when compressed or needled (Travell and Simons, 1999).

Latent MFTPs are clinically silent with regards to unprompted pain and only cause pain when palpated. There may be an increase in the muscle tension and shortening as well as energy consumption during the whole process. Latent MFTPs can limit ROM, cause muscle weakness and prevent full lengthening of the muscle in which it is found. Muscular imbalance, overuse and poor posture may convert a latent MFTP into an active MFTP (Travell and Simons, 1999).

Figure 2-12: A schematic version of a myofascial trigger point complex of a muscle in a longitudinal section. A central trigger point can be seen in the endplate zone and two trigger points are seen at the attachment sites (Travell and Simons, 1999)

2.9.3 Myofascial trigger point examination

When assessing MFTPs, patient comfort is of utmost importance in order to make an accurate assessment. This can be achieved by ensuring that the patient is comfortable, relaxed and warm during the assessment. It becomes difficult to distinguish between tense bands and surrounding relaxed muscle fibers when the patient is cold or tense. These tense bands feel like a tight ‘rope-like’ cord of muscle fibers surrounded by normal relaxed fibers. The point of maximal tenderness is identified as the examiner palpates along the
tense band. If pressure is firmly applied to this point, pain and referral patterns present (Travell and Simons, 1999).

Travell and Simons (1999) discuss three methods of MFTP palpation:

1. Flat palpation: This type of palpation works best for superficial muscles. A fingertip can be utilized to slide the subcutaneous tissue and the underlying muscle fibers over each other. Tight bands can be felt under the fingertip. Transverse snapping palpation can be used on the tense bands. This technique is similar to plucking a violin or guitar string.

2. Pincer palpation: This is used when the origin and insertion of a muscle can be palpated and the muscle belly can be pinched between two digits, usually between the thumb and the fingers. A back-and-forth rolling motion is applied while the muscle belly is being compressed in order to locate the taut bands. With the location of a taut band, the examiner explores the extent of it and locates the point of maximal tenderness.

3. Deep palpation: Also called probing palpation. This type of palpation is utilized to palpate deep muscles that cannot be accessed using flat or pincer palpation due to the amount of tissue and skin overlying it. This technique is performed by placing a fingertip over the region of skin that overlies the attachment or motor point region of a muscle with MFTPs.

![Figure 2-13: Cross-sectional schematic drawing demonstrating flat palpation and pincer palpation of a taut band and its myofascial trigger point (Travell and Simons, 1999)](image)

2.9.4 The local twitch response

The local twitch response is described as a brief involuntary contraction of the taut band of muscle fibers (Muscolino, 2009; Travell and Simons, 1999). This rapid transient contraction is produced when the MFTP
in the tight band is mechanically stimulated. The mechanical stimulation can be from needling or compressing the MFTP or by transverse snapping of the MFTP. When a local twitch response is elicited, it serves as a confirmatory sign for the identification of a MFTP (Travell and Simons, 1999).

2.9.5 Diagnostic criteria

Gerwin (2014) describes the characteristics of a MFTP as follows:

- Taut band within the muscle.
- Extreme tenderness at a point on the taut band.
- Reproduction of the patient’s pain.
- Eliciting a localized twitch response.
- Referred pain.
- Weakness.
- Limited ROM.
- Autonomic signs (erythema, tearing, pilo-erection)

The first three characteristics are vital in the diagnosis of MFTPs, while the last five are not necessary to make a diagnosis (Gerwin, 2014).

2.9.6 Pathogenesis

There are numerous theories regarding the pathogenesis of MFTPs which will be discussed below. Although the aetiology of MFTPs is unclear, a credible explanation was provided by Huguenin (2004) which is generally accepted. His theories include the energy crisis theory and the motor endplate hypothesis. Travell and Simons (1999) compiled the integrated hypothesis by combining information from the histopathological and electrophysiological sources.

Other theories that explain how MFTPs are formed include the muscle spindle hypothesis, the pain-spasm-pain cycle and the fibrotic scar tissue hypothesis (Travell and Simons, 1999). These theories were dismissed, as there was not sufficient experimental evidence to support them.

a) Energy crisis theory

The energy crisis theory is the most famous description of MFTP formation (Muscolino, 2009). It was based on the work done for the identification of a possible pathophysiological process that could explain the following findings with regards to MFTPs (Travell and Simons, 1999):

- The lack of motor unit action potentials in the palpable taut band of the MFTPs when the muscle was relaxed.
- The fact that muscle overload could activate MFTPs.
- The sensitization of the nociceptors found in the MFTPs.
- The efficiency of any therapeutic technique that returns the muscle to its full and normal stretch length.

In order to comprehend the energy crisis theory, it is vital to understand the role that Adenosine Tri-Phosphate (ATP), the energy source for cells to perform their functions, plays in the sliding filament mechanism (Muscolino, 2009). This theory hypothesises that a muscle will release calcium ions from the extracellular fluid or sarcoplasmic reticulum as a result of acute injury or chronic microtrauma (Rachlin, 2002). An increase in the amount of Acetylcholine (Ach) from the motor end plate may also cause an increase in calcium (Travell and Simons, 1983). When ATP is present, the free calcium ions cause the sarcomeres to experience a continuous and sustained contraction and there is an increase in the metabolic demands. The sustained muscle contraction affects the blood flow within the MFTP as there is now oxygen debt. This energy crisis is caused due to the combination of decreased blood flow and increased metabolic demand (Rachlin, 2002).

As previously discussed, ATP is necessary to inhibit Ach at the neuromuscular junction. With the reduction in available ATP, Ach is free to be released in the neuromuscular junction in large amounts. This in turn causes the disruption of action potentials across the sarcolemma, leading to a sustained contractile state. The oxygen debt interferes with the cells’ ability to normally produce ATP to allow for muscle relaxation. The energy dependant calcium pump is responsible for the return of calcium to the sarcoplasmic reticulum. This too is impaired as a result of the ischaemia and causes accumulation of intracellular calcium. The result is excessive binding between the thick and thin filaments of the sarcomere (Rachlin, 2002).

The local energy crisis is the stimulus for the production of vasoactive substances and ischaemic by-products of metabolism to sensitize the local nociceptors. These vasoactive substances, which include bradykinin, serotonin, histamine and prostaglandins, lead to MFTP tenderness and pain as well as perceived referred pain (Rachlin, 2002; Travell and Simons, 1999).
b) Motor endplate dysfunction hypothesis

The motor endplate dysfunction hypothesis proposes that MFTPs form due to dysfunction in the motor endplate area. The terms neuromuscular junction (NMJ) and endplate can be used interchangeably. The endplate refers to the actual structure while the NMJ applies to the structures functional importance (Travell and Simons, 1999).

With a dysfunctional motor endplate, many mechanisms can cause it to present as a MFTP. Firstly, the local sensory nerves are compressed by the sustained muscle contraction. This affects the axoplasmic transport of molecules that usually inhibit Ach release (Hohmann and Herkenham, 1999; Gessa et al., 1998). Secondly, the blood vessels are compressed by this muscle contraction, causing a reduction in the available oxygen to the muscles. The combination of decreased blood supply and raised metabolic demand leads to a swift depletion of ATP (Travell and Simons, 1999).

The energy crisis theory and motor endplate dysfunction hypothesis can occur simultaneously due to the presence of a synaptic junction between the motor endplate and the muscle cell (Huguenin, 2004).

c) Integrated hypothesis

The integrated hypothesis has developed a great deal since 1981 when it was introduced as the ‘energy crisis theory’. It is founded on the combination of electrodiagnostic and histopathological evidence (Dommerholt and Huibregts, 2011). According to Travell and Simons (1999), the integrated hypothesis can be used to indicate a MFTP. This is an area with numerous dysfunctional endplates and each
The dysfunctional endplate is linked to a portion of muscle fibers that are maximally contracted. This area is known as the contraction knot. The integrated hypothesis suggests a possible link between the dysfunctional endplates and the contraction knot (Travell and Simons, 1999).

When a motor neuron is continuously stimulated, it secretes excessive amounts of Ach into the NMJ, causing the motor endplate to generate excessive amounts of action potentials. In turn, a sustained partial depolarization of the motor endplate results, increasing the ATP demand by the muscle and depleting the ATP available at the motor endplate (Muscolino, 2009). The increased energy demand due to the increased amounts of Ach is indicated by abnormal mitochondria in the NMJ (Travell and Simons, 1999).

The release of calcium ions from the sarcoplasmic reticulum might be a result of the sustained depolarization of the post-synaptic membrane and produces local sarcoplasmic contractions in the contraction knots. The continuous release of calcium increases the energy demand of the calcium pumps in the sarcoplasmic membrane, which is responsible for the return of calcium into the sarcoplasmic reticulum. There is a depletion of the oxygen reserve and local energy supply within the contraction knot as the sarcomeres are continuously contracted (Travell and Simons, 1999).

A local energy crisis results and triggers the release of neuro-active substances which sensitise the sensory (nociceptive) and autonomic nerves in the area. The presence of these neuro-active substances may contribute to extra Ach to be released from the neuromuscular junction, which then causes a self-sustaining malicious cycle (Travell and Simons, 1999; Mense and Simons, 2010).

Figure 2-15: A schematic representation of the integrated hypothesis (Travell and Simons, 1999)
2.9.7 Referral pain from myofascial trigger points

The definition established by Travell and Simons (1999) for referred MFTP pain is “pain that arises in a MFTP, but is felt at a distance, often remote from its source. The pattern of referred pain is reproducibly related to its site of origin”. MFTPs are well recognised sources of referred pain in specific pain referral patterns for each muscle. There are seldom exceptions to these patterns (Mense and Gerwin, 2010).

2.10 Chiropractic Manipulation

A chiropractic manipulation can be described as any therapeutic process that utilizes precise force, leverage, direction, amplitude and velocity, directed at specific joints or anatomical regions to move a joint past the physiological ROM without passing the anatomical limit. A chiropractic manipulation reverses dysfunction and restores neurological dysfunction (Esposito and Philipson, 2005). Gatterman (2005) describes a motion restriction as a joint dysfunction, joint locking or joint blockage.

Bergmann and Peterson (2011) also provide a description for joint manipulation therapy as any technique that utilizes the hands to affect the joints of the body by mobilizing, adjusting, manipulating or apply traction to the joints with the main purpose to influence the patient’s well being. They propose that the chief goal of chiropractic manipulation is to better health and function by reducing musculoskeletal pain and correcting abnormal joint alignment and function. The chiropractic manipulation influences joint dysfunctions, muscle spasms, periarticular fibrosis and adhesions.

In order to understand how a chiropractic manipulation works, it is important to explain where exactly it occurs within the diarthrodial joint’s ROM. There are four zones (active ROM, passive ROM, paraphysiological space and pathological movement) and two barriers (the elastic barrier of resistance and the limit of anatomical integrity) found in a joint’s ROM (Esposito and Philipson, 2005).

![Figure 2-16: Joint range of motion (Esposito and Philipson, 2005)](image-url)
Sandoz (1970) provides the following description for the four zones and two barriers for joint ROM:

- Zone one corresponds to the active ROM produced by active muscles.
- Zone two corresponds to the passive ROM that extends to the elastic barrier of resistance. Joint play is examined here.
- Zone three corresponds to the paraphysiological space. This space spans from elastic barrier of resistance to the limit of anatomical integrity. A joint cavitation will occur with movement into this space.
- Zone four corresponds to pathological movement past the anatomical integrity limit (Esposito and Philipson, 2005).

Chiropractic manipulations are usually coupled with an audible articular crack or cavitation (Bergman and Peterson, 2011). This cavitation is a mechanical phenomenon described in biomechanics as the process when the elastic barrier of a joint is passed, causing a sudden separation in joint surfaces, the appearance of a radiolucent space in the joint as well as an audible cracking sound (Esposito and Philipson, 2005).

2.10.1 Clinical effectiveness of a chiropractic manipulation

Chiropractic manipulation is a recommended treatment for acute and chronic neck pain for short- as well as long-term benefit (Bryans et al., 2014).

The physical effects of a chiropractic manipulation include a cavitation, joint and muscle mechanoreceptor stimulation, better active and passive ROM and breaking articular adhesions. It is proposed to overcome the elastic barrier of resistance to result in the separation of the articular surfaces (Gatterman, 1990).

The neurophysiological effects of a chiropractic manipulation include pain inhibition, muscle relaxation as well as stimulation of the autonomic nervous system (Gatterman, 1990). The various autonomic nervous system reactions include vasomotor changes, pseudo motor activity and changes in visceral control. This occurs due to the stimulation of the spinal nerves as they exit the intervertebral foramen. This stimulation in turn inhibits the pain gate mechanism which causes pain inhibition and muscle relaxation of nerves related to the areas that have been manipulated (Bergman et al., 1993; Esposito and Philipson, 2005).

Various biomechanical changes have been suggested regarding the vertebral movement during a chiropractic manipulation. During a chiropractic manipulation, the mechanical force applied may influence segmental biomechanics in a number of ways including releasing trapped meniscoids and adhesions or reducing deformation in the annulus fibrosis of the vertebral column. The mechanical changes caused by a chiropractic manipulation can supply enough energy to restore a segment to a lower energy level. This
allows the joint play and joint mobility to be restored as the mechanical stresses or strain on the soft tissue surrounding and overlying the segment is now reduced (Pickar, 2002).

### 2.10.2 Reflexogenic effects of a chiropractic manipulation

Muscle hypertonicity has been identified by many authors as a potential cause for joint dysfunction and spinal pain. Numerous theories suggest that a high-velocity chiropractic manipulation may relieve muscle spasms and interrupt the self-perpetuating myofascial cycle of pain (Bergmann and Peterson, 2011).

Muscle spasm due to increased motor output is frequently associated with joint dysfunction. MFTP formation might be prevented as chiropractic manipulation decreases the motor output. It has also been thought that active MFTPs might change into latent MFTPs with chiropractic manipulations (Wyke, 1984).

According to Bergmann and Peterson (2011), a chiropractic manipulation can potentially restore normal joint biomechanics and eliminate the altered neurogenic reflexes linked to joint dysfunction. The results of a chiropractic manipulation may include a reduction on the strain the joint is experiencing, reduce muscle spasm and cause cessation of nociceptive inputs from these tissues to the spinal cord.

#### a) The reflex theory of chiropractic manipulations

This study places special emphasis on the reflex theory of chiropractic manipulation. The chiropractic manipulation is considered a biomechanical deviation in a vertebral motion segment. It is theorised that this dysrelationship leads to the stimulation of sensory receptors located in the spinal and paraspinal muscles, ligaments and joint capsules. The impulses from these receptors are most likely responsible for the activation of the neural reflex centres within the spinal cord or higher centres. Sensory receptors are sensitive to any mechanical (position, movement and tissue tension), inflammatory (pain) and temperature changes. The impulses from these receptors may lead to muscle spasm via somato-somatic responses or an autonomic phenomena via somato-visceral responses in the sympathetic and parasympathetic nerves (Haldeman, 2000).

An experimental study done on animals showed that these reflexes are responsible for the activation of central reflex pathways and specific somato-somatic reflexes. Chiropractic manipulation at spinal level has been proven to activate these reflexes (Haldeman, 2000). Chiropractors palpate for taut muscles and use it as a suggestion of where a manipulation is needed. This method is supported by Haldeman’s (2000) findings (De Vocht, Pickar and Wilder, 2005).

Schafer and Faye (1990) state that when muscles surrounding a segment are in a secondary or protective spasm, any high velocity chiropractic manipulation applied to that specific segment will result in muscle relaxation if the impulse is sufficient to eliminate the main stimulus for the reflex.
The theory of sudden stretching of hypertonic muscles resulting in reflex relaxation is of interest for this study. It has been thought that abnormal muscle tone could be normalised by chiropractic manipulations, which is frequently due to the activation of inhibitory afferents in the dorsal horn from mechanoreceptors (Evans, 2002).

Duquette and Kazemi (2016) propose that chiropractic manipulations appear to affect the muscle spindles surrounding the joint, producing the reflexogenic effects. During the application of a chiropractic manipulation the afferent output from the surrounding muscle spindles increases, similar to the pain gate theory. Immediately following a chiropractic manipulation, there is a short silent period during which the muscles do not fire. Relaxation of the surrounding muscles occurs after this silent period, as the muscle spindles now fire at the appropriate rate (Duquette and Kazemi, 2016).

Chiropractic may bring on a brief phasic response activated by the stimulation of both the superficial and deep mechanoreceptors. A more long term tonic response may also be started, which is activated by the noxious stimulation of nociceptive receptors (Gillette, 2004).

b) The pain relief theory of a chiropractic manipulation

It is well known that chiropractic manipulation results in the reduction of pain and disability. Research suggests that chiropractic manipulation induces enough force to result in the activation of nociceptors, proprioceptors and both superficial and deep mechanoreceptors, causing stimulus-induced analgesia. Central transmission of pain is inhibited as this stimulation generates a bombardment of strong sensory afferent impulses (Bergmann and Peterson, 2011). Evidence from Haldeman (2000) show that patients receiving chiropractic manipulation reported a greater pain relief than with other treatment methods. These findings however can also be explained by the psycho-physiological mechanism and might not only be due to the effects of chiropractic manipulation on pain relief.

A study done to investigate how the pain pressure threshold of latent MFTPs in the upper trapezius was affected by a single cervical spine manipulation found that there was an increase in the treatment group receiving chiropractic manipulation to the C3 and C4 spinal segments. The control group showed a decrease in the pain pressure threshold levels after receiving a sham manipulation (Ruiz-Saez et al., 2007).

In a case study, the average pain pressure threshold levels of six sensitive and tender areas in the neck increased after receiving chiropractic manipulation (Pickar, 2002). Many mechanisms have been suggested to explain the neurophysiological mechanism by which chiropractic manipulation may result in changes in the pain pressure threshold in myofascial trigger points. A reduction of chemical algogenic
mediators, activation of segmental inhibitory pathways and/or activation of central descending inhibitory pathways has been proposed (Ruiz-Saez et al., 2007).

2.10.3 Effects of chiropractic manipulations

Chiropractic manipulation techniques are used as tools, designed to attain a specific neuro-biomechanical effect. It is a general hypothesis that chiropractic manipulation results in an increase in quality and extent of joint motion (Broome, 2000). According to Licht et al. (1999), chiropractic manipulations are utilized to relieve the symptoms that are due to biomechanical dysfunction of the spine. The most important goal when manipulating a restricted segment is to induce and restore movement to that segment in a specific line of drive (Van Schalkwyk and Parkin-Smith, 2000).

a) Mechanical effects of chiropractic manipulations

The vertebral column is a malleable structure and chiropractic manipulations applied to it will facilitate physiological and mechanical deformations with the result of improved function and flexibility. The internal structural design of the body and spine comprises of many structures such as bones, articular cartilage, discs, muscles, ligaments, tendons etc. All of these structures are affected by chiropractic manipulations, either directly or indirectly (Herzog, 2000).

Derangement of soft tissue accounts for mechanical dysfunction. Contributing factors to this mechanical dysfunction can be trauma, postural decompensation, recurring motion injuries, congenital anomalies, immobilization and degenerative conditions (Bergmann and Peterson, 2011). Patients presenting with acute pain due to a whiplash injury or chronic neck pain have responded well to chiropractic manipulations that is aimed at improving joint function (Jordan et al., 1998).

The mechanical force applied to the spine during a chiropractic manipulation results in certain mechanical changes, altering segmental biomechanics by releasing trapped menicoids and adhesions as well as reducing the amount of distortion of the annulus fibrosis. The mobility and joint play of the zygapophyseal joint is suggested to be restored by these mechanical effects. The return of full, pain-free movement of the musculoskeletal system is the aim of chiropractic manipulations (Pickar and Wheeler, 2001).

Segmental muscle hypertonicity and joint dysfunction often occur concurrently. It is thus evident through this pattern that muscles play a central role in movement, either facilitating or hindering the movement. Antagonistic and agonistic muscles must maintain a synergistic equilibrium for articular mobility. An alteration to this synergistic equilibrium of any muscle causes compensatory changes in the kinematic chain, resulting in decreased ROM with linked joint restrictions. Chiropractic manipulations eradicate the
physiological musculoskeletal constraints by re-establishing normal joint function and movement and restoring correct kinematic function (Bergmann and Peterson, 2011).

b) Neurophysiological effects of chiropractic manipulations

The sensory innervations of joint capsules and paraspinal muscles offer adequate proprioception when it comes to the forces applied to the spine and its spatial orientation (Pickar, 2002). It has been hypothesised by Korr (1975) that joint mobility is enhanced by chiropractic manipulations as this stimulates the mechanoreceptors (type II and III) found in muscles, tendons and joint capsules. The peripheral receptors convey proprioceptive information that results in the restoration of articular alignment and resolution of joint dysfunction. An experimental study done by Pickar and Wheeler (2001) showed that the discharge of Group I and II afferents can be modified by chiropractic manipulations. When manipulative-like loads are applied to the lumbar spine vertebrae, muscle spindles and the golgi organ tendons of the lumbar paraspinal muscles are stimulated, thus the impulse conduction of the Group Ia and Ib afferents is altered.

Alteration of noxious impulses to the brain can also be altered by the pain gate theory. The pain gate theory states that dorsal horn can modulate and alter the incoming sensory information (Melzack and Wall, 1965). The nociceptive input from the unmyelinated Group IV/C fibers is inhibited when the type II and type III mechanoreceptors are stimulated by non-noxious mechanical stimuli. Thus, evidence proposes that chiropractic manipulation activates type II and III mechanoreceptors, resulting in a delay in the transmission of the noxious stimulus to the central nervous system and followed by reconciliation of the dysfunction causing the nociception (Melzack and Wall, 1965; Bergmann and Peterson, 2011; Pickar, 2002; Pickar and Wheeler, 2001).

Reflex responses are elicited by the high-velocity, low amplitude thrusting techniques applied during chiropractic manipulation. This can produce a range of effects including reflex inhibition of spastic muscles, a reduction in pain and temporary reflex activation of paraspinal and associated upper and lower limb musculature (Herzog, 2000). According to Pickar (2002), there is proof that supports the suggestion that chiropractic manipulation produces muscle reflexes and modifies the excitability of motor neurons.

An increase in muscle strength following a chiropractic manipulation has been found in numerous studies via the use of electromyographs on the paraspinal muscles (Herzog, 2000; Keller and Colloca, 2000; Pickar, 2002). Also, Suter et al. (2000) proved that chiropractic manipulations are also able to inhibit the motor neurons in spasmodic musculature, responsible for the nociception and hindering of normal biomechanics.
2.10.4 Clinical effects of a chiropractic manipulation

Esposito et al. (2005) compiled the following list of the clinical effects of a chiropractic manipulation:

- Active and passive ROM increase.
- Reduction in pain.
- Increase in skin pain tolerance.
- Raised paraspinal muscle pressure pain tolerance.
- Reduction in muscle electrical activity and tension.
- Consistent, reliable reflex responses in muscles in the spine and limbs.
- Release of entrapped meniscoids, synovial folds or hyperplastic synovial tissue.
- Breaking of contractile and collagen adhesions found in the local soft tissue and supporting structures.
- Effects upon the intervertebral disc either in the form of intradiscal block or generalised effects on the process of disc protrusion.
- Various autonomic responses such as vasomotor changes, sudomotor activity and changes in visceral regulation control.

2.11 Muscle Energy Technique

2.11.1 Introduction

T.J Reddy (1961) and Fred Mitchell Snr (1967) were the original founders of Muscle Energy Technique (MET). T.J Reddy developed the ‘rapid resistive duction’, a treatment method that involves patient-induced, rapid, pulsating contractions against resistance. This was used by Mitchell as the basis for the evolution of MET (Chaitow, 2006). The objective of MET is to re-establish normal joint function and position while having an influence on proper posture (Bergmann and Peterson, 2011). MET has developed due to contributions from many individuals and is now acknowledged by many mainstream therapists as an alternative treatment for joint dysfunction (Fryer, 2011; Day et al., 2010).

Greenman (1996) and Fryer (2011) identify the following clinical uses of MET:

- It can be utilized to stretch spastic, shortened or contracted.
- Strengthening of weak muscles.
- Reduce oedema and alleviate passive congestion.
- Lymphatic drainage.
- Mobilization of a restricted joint.
Chaitow (2006) explains that MET is a safe, easy and effective method to reduce MFTPs in a muscle, as these MFTPs respond well to stretching techniques. If a muscle cannot reach its normal length, MFTPs are likely to be re-activated within that muscle. MET requires active patient participation, resulting in patient empowerment. A qualitative study has shown the importance of patient empowerment during and outside of patient care (Day et al., 2010).

2.11.2 Definition of muscle energy technique

MET is a well-known osteopathic manipulative method usually used in the management of somatic dysfunctions of the spine as well as to restore musculoskeletal function and reduce pain (Burns and Wells, 2006; Chaitow, 2006).

MET is a type of soft tissue osteopathic manipulation method that requires voluntary contraction of a patient’s muscles in a specific and controlled direction, at alternating intensity levels, against a precise counterforce applied by the operator (Day et al., 2010; Chaitow, 2006). The voluntary contractions by the patient can be isometric, isotonic or isolytic, depending on the desired therapeutic effect. The contraction is initiated from or short of the resistance barrier, depending on the acuteness of the patient (Chaitow, 2006).

2.11.3 Physiological principles of muscle energy technique

Chaitow (2006) defines two physiological mechanisms that occur to cause a reduction in muscle tone within one muscle or a group of muscles. These include post-isometric relaxation and reciprocal inhibition.

a. Post-isometric relaxation

To achieve muscle relaxation is the main objective of post-isometric relaxation (PIR) (Ward, 2003). This term refers to the reduction in muscle tone of a muscle or a group of muscles following an isometric contraction. During this relaxed refractory period, passive stretching can be achieved. The golgi tendon organ apparatus detects an increase in tension during muscle contraction and a reflex neurological loop is activated, resulting in the inhibition or PIR effect in the specific muscle (Chaitow, 2006).
b. Reciprocal inhibition

Reciprocal inhibition (RI) entails the lengthening or reduction in muscle tone of an antagonist muscle or muscle group by isometrically contracting the agonistic muscle. This initiates the neurological reflex. The main objective of RI is to lengthen a muscle that was shortened due to a cramp or muscle spasm (Ward, 2003).
2.11.4 Neurological explanation of muscle energy technique

Isometric contraction of a muscle causes loading of the golgi tendon organ. When this contraction is terminated, PIR occurs. This phase of hypotonicity, lasting about 15 seconds, allows the tissues to stretch easier than before the contraction. RI of the antagonistic muscles during and following an isometric contraction of a muscle also allow for easier stretching (Chaitow, 2006).

The practitioner controls the forces by instructing the patient to only make light contractions. This gives the patient more comfort, reduces the pain usually associated with strong contractions and decreases the likelihood of cramping. Depending on the condition (acute or chronic), the force of contractions can range between fifteen and twenty percent of the total available strength of the patient. When more strength is used, the phasic muscles are activated rather than the postural muscles, which are the ones that have shortened and need to be stretched (Chaitow, 2006).

2.11.5 Mechanisms of therapeutic effects of muscle energy technique

a) Muscle energy technique and pain

MET may have an effect on pain mechanisms and promote hypoalgesia. The incorporation of PIR in techniques such as MET reduces pain and discomfort when applied to muscles. Central and peripheral modulatory mechanisms may be involved. Examples of these mechanisms can include mechanoreceptor activation involving centrally mediated pathways such as noradrenergic and non-opioid seratonergic descending inhibitory pathways or the periaquaductal grey matter in the midbrain (Fryer, 2011).

Hypoalgesia may also be induced as MET increases fluid drainage. The effects of mechanical forces are changes in interstitial pressure and a rise in capillary blood flow. Blood flow and lymphatic drainage is also affected by muscle contractions. MET could possibly lower pro inflammatory cytokines levels and cause the peripheral nociceptors to be desensitized (Fryer, 2011).

It has been suggested that lymphatic flow improves and a reduction in oedema occurs as a result of MET. Muscle contractions cause an increase in blood flow and lymphatic drainage, therefore physical activity results in increased lymphatic flow through the collecting ducts, thoracic duct and inside the muscle during isometric and concentric muscle contractions. Thus, hypoalgesia is achieved as MET results in better lymphatic flow and removal of excess tissue fluid (Fryer, 2011).

MET, as a treatment element, has been part of numerous clinical trials exploring the osteopathic management of spinal pain. These trials proved that MET is an effective method to significantly lower pain and disability (Fryer, 2011). Popa (2014) concluded that MET treatment shortens the rehabilitation period for patients with cervicalgias.
b) Myofascial extensibility

There is controversy about the physiological mechanisms responsible for myofascial extensibility caused by MET. The short and intermediate term alterations in myofascial extensibility can be explained by three mechanisms: reflex relaxation, changes to stretch intolerance and viscoelastic or tissue property change. The change to stretch intolerance is the most evidence-based mechanism (Chaitow, 2006).

MET techniques facilitate reflex relaxation. This reflex relaxation is produced by a neurological reflex following an isometric muscle contraction. It has been suggested that the muscle relaxation after an isometric contraction is either due to the activation of the golgi organ tendons exhibiting an inhibitory effect on the alpha-motor neuron pool or a result of RI caused by the contraction of an antagonistic muscle. There is proof that the alpha-motor neuron pool may be inhibited by MET, which is in line with numerous procedures that propose stretching following a five to ten second isometric muscle contraction. This hypothesis of MET induced neurological muscle relaxation is supported by numerous studies (Chaitow, 2006).

Connective tissues may exhibit mechanical properties relating to their gel or fluid components and their elastic properties. This is called viscoelasticity. A constant elongation force applied to a tissue will cause the tissue to undergo slow elongation or 'creep'. The tissue creep causes hysteresis (loss of energy) and greater deformation will occur with continuous repetitive loading prior to tissue recovery. Passive tension reduction can be obtained with muscle contractions and muscle stretching, however a combination of this (as used in MET) might produce more effective viscoelastic changes than passive stretching alone. This occurs as a result of the greater force leading to increased viscoelastic change and passive extensibility. The water content may be affected by isometric contractions and stretch, leading to alterations to the stiffness and length of the tissue (Chaitow, 2006).

A study to determine the effect of MET versus static stretching on pain and functional disability in patients presenting with mechanical neck pain, showed that MET resulted in a reduction in the pain perception by increasing the stretch tolerance. When stretching and isometric contractions occur simultaneously, there is stimulation of the muscle and joint mechanoreceptors and proprioceptors. This results in a reduction in the pain perception, allowing the stretch that follows to be more tolerable and to be done with greater ease. These results are consistent with previous studies that found a reduction in the pain intensity after MET techniques were applied to the neck and other regions of the body (Phadke et al., 2016).

c) Muscle energy technique and myofascial trigger points

According to Chaitow (2006), MFTPs respond well to manipulative techniques including stretching, making the prognosis excellent for patients presenting with MFTPs. MET has proven to be a safe, simple and
efficient technique to decrease MFTPs in a muscle. Many trigger point therapies only result in temporary relief; however this is not the case with MET. The goal of MET is to return the affected muscle to its original resting length to prevent re-activation of the MFTPs. Re-activation of MFTPs is hypothesised to occur if the muscle is unable to reach its normal resting length (Chaitow, 2006).

MFTPs are affected and de-activated by the alteration of the dynamics of the circulatory imbalance caused by treatment methods that involves stretching. MET utilizes active and passive stretching techniques to treat the muscle hypertonicity and MFTPs. This type of stretching is effective as it lessens the taut band and causes hyperaemia to the area. A reduction in pain, muscle tenderness and MFTPs can be achieved with the MET sequence (contraction-relax-stretch) (Chaitow, 2006).

Simons (2002) explains that the cornerstone of effective trigger point release techniques is post isometric relaxation. Gentle muscle contraction is likely to balance the sarcomere length in fibers affected by MFTPs. Sarcomeres in the contraction knots are maximally shortened, resulting in a limitation in its ability to exert any contractile forces. On the other hand, the sarcomeres between the MFTP and muscle fiber attachments find themselves in the ideal state for muscle contraction. Consequently, the sarcomeres are allowed to lengthen to produce an adequate elongation force on the MFTPs’ shortened sarcomeres with the application of gentle voluntary contractions.

d) Effects of muscle energy technique on range of motion

According to Chaitow (2006), spinal ROM can be increased and improved with MET. MET places special emphasis on repairing the dysfunctional soft tissues, which might have been the cause for the limited ROM. During the research trials of Burns et al. (2006) study, they noticed an inversely proportional relationship between neck pain and cervical spine ROM when MET was used.

Schenk, Adelman and Rousselle (1994) conducted a four-week study to investigate the effect of MET on cervical ROM. Multiple MET treatments were administered during this time, which lead to a considerable increase in cervical ROM.

The methodology of the study will be explained in the following chapter.
CHAPTER THREE: METHODOLOGY

3.1 Introduction

This chapter serves to explain and describe of the details of the research study. Study design, participant recruitment, sample size and selection, randomization and treatment protocol are included. The assessments, objective and subjective measurements, statistical analysis and data evaluation are also discussed in this chapter.

3.2 Study Design and Protocol

3.2.1 Study design

This was a comparative clinical study with random group allocation whereby it was determined whether a combination of chiropractic manipulation and muscle energy technique (MET) had an effect on pain and cervical spine range of motion (ROM) with regards to the upper trapezius muscle.

3.2.2 Participant recruitment

The recruitment of participants was mainly done using advertisements (Appendix A), which were placed around the University of Johannesburg’s Doornfontein Campus, in the gymnasium and in the Chiropractic Day Clinic. Word of mouth was also used. Any individuals, between the ages of 18 and 55, who presented to the Chiropractic Day Clinic with localized neck pain over the upper trapezius muscle, or other areas, of pain referred by an active MFTP in either upper trapezius muscle, were considered as a potential candidate for the study.

3.2.3 Sample selection and size

Forty five participants were used in the study. Once the participants were informed of the nature of the study and it was established that they met all of the inclusion criteria and none of the exclusion criteria, they were allocated to one of three groups by means of random group allocation. The group allocation was only done once the information form (Appendix B) was read and the informed consent form (Appendix C) was signed.

3.3 Participant Criteria

3.3.1 Inclusion criteria

In order to be included in the study, the participants were required to meet the following inclusion criteria:
• Participants could be male or female between 18 and 55 years of age. Up to 10% of the adult population may be affected by myofascial pain at any given time (Kalichman and Vulfsons, 2010).
• Participants who spend between 6 to 8 hours working behind a desk.
• Participants had to present with non-specific neck and muscle pains, as well as neck stiffness, specifically in and around the upper trapezius muscle.
• Using motion palpation, participants had to present with a minimum of one cervical spine restriction.

3.3.2 Exclusion criteria

Volunteers were excluded from the study if they presented with any of the following exclusion criteria:

• Contraindications to chiropractic manipulations (Appendix K).
• Contraindications to MET: The presence of pathology (osteoporosis, arthritis, etc.) does not contradict the use of MET, but its presence needs to be noted in order to modify the application dosage accordingly (Chaitow, 2006).
• Participants receiving treatment that could interfere with the results of the study, for the duration of the study, which include other manipulative or physical therapies, as well as medication.

3.3.3 Random group allocation

Participants meeting the inclusion criteria were allocated randomly into one of three groups. Each group consisted of fifteen participants. Group allocation was determined by the participants drawing one of forty five cards from a container with either Group A (15), Group B (15) or Group C (15) written on it. The group that was written on the card that the participants drew from the container represented the group that they were allocated to.

The participants in Group A received a chiropractic manipulation/s over the restricted joint/s of the cervical spine. The participants in Group B were treated with MET over the upper trapezius muscle. The participants in Group C received a combination treatment consisting of a chiropractic manipulation/s to the restricted joint/s of the cervical spine as well as MET to the upper trapezius muscle.

3.4 Treatment Approach

3.4.1 Initial and follow-up consultations

Once the participants met all the inclusion criteria and none of the exclusion criteria, they were asked to not participate in other forms of management that may meddle with the results of this study, including medication, manipulative and physical therapies.
Before commencement of the screening process, the participants were required to sign the participant information form (Appendix B) and the informed consent form (Appendix C). A complete case history (Appendix L), physical examination (Appendix M) and a cervical spine regional examination (Appendix N) were performed by the researcher. The participants were then asked to complete the Vernon-Mior Neck Pain and Disability Index questionnaire (Appendix D). Motion palpation and a myofascial examination were performed on the participant’s cervical spine to note the relevant restrictions and MFTPs, respectively.

All the participants received three treatments per week for two weeks, leading to a total of six treatments over a two-week period. A seventh visit was required to only take objective and subjective measurements to conclude the treatment. The treatment protocols explained below were followed for visits one to six. Objective measures were collected on the first, fourth and seventh visits. Subjective measures were collected on the first and seventh visits.

Group A received chiropractic manipulations to the cervical spine over the restricted joints. Group B received MET to the upper trapezius trigger points. Group C received a combination of chiropractic manipulation and MET over the restricted joints and MFTPs, respectively.
The following schematic representation provides a clear understanding of the methodology.

Figure 3-1: Flow diagram - methodology
3.5 Myofascial Trigger Point Location

Each participant underwent a MFTP examination of the upper trapezius muscle during the cervical spine regional examination. There are two MFTPs found in the upper trapezius muscle. Trigger point 1 is found in the midportion of the upper trapezius, near its attachment to the clavicle. When active, trigger point 1 may refer pain to the posterolateral neck, mastoid process, temples, back of the eye or to the angle of the jaw. Trigger point 2 is found just caudal and lateral to trigger point 1, in the middle of the horizontal fibers of the upper trapezius. When active, this trigger point may refer pain to the occiput or behind the ear.

![Figure 3-2: Location of the myofascial trigger points in the trapezius muscle (Travell and Simons, 1999)](image)

When locating trigger point 1 of the upper trapezius muscle, the participant is placed in a supine position and the ear is brought slightly towards the ipsilateral shoulder to place the muscle on moderate stretch. Using a pincer grasp, the free margin of the upper trapezius was lifted off the underlying apex of the lung and supraspinatus muscle. Rolling the muscle firmly between the fingers and thumb allows you to feel for nodules or firm bands as well as locating this MFTP (Travell and Simons, 1999).

Trigger point 2 of the upper trapezius muscle was identified with a similar pincer grasp, just inferior to trigger point 1. It is located approximately halfway between the acromion and spinous processes of C5/C6 (Travell and Simons, 1999).
3.6 Treatment Intervention

3.6.1 Cervical spine manipulation

The type of manipulation depends on the restriction found at a specific joint. For this study, the following manipulations were used:

- Posterior superior occiput (Appendix F)
- Cervical rotary thumb contact (Appendix G)
- Cervical break 1 (Appendix H)
- Cervical break 2 (Appendix I)

3.6.2 Muscle energy technique

Chatow (2006) describes the technique as follows:

A sequential application of MET is required to treat all the fibers of upper trapezius muscle. This clinical approach subdivides the upper trapezius into anterior, middle and posterior fibers. The flexed neck was placed in three different positions of rotation (full rotation away from the side being treated, half rotation away from side being treated and slight rotation towards side being treated) and coupled with full lateral flexion away from the side being treated.

The participant was placed in a supine position, with the arms at their side and with the head/neck laterally flexed away from the side being treated to just before the restriction barrier. The doctor stabilized the shoulder with the one hand and cupped the ear and mastoid with the other. With the neck fully laterally flexed and fully rotated contralaterally, the posterior fibers of the upper trapezius muscle are involved in the contraction and will facilitate stretching of that part of the muscle. With the neck fully laterally flexed and half rotated contralaterally, the middle fibers are involved in the contraction. With the neck fully laterally flexed and slightly rotated ipsilaterally, the anterior fibers of the upper trapezius are contracted.

With the participant placed in a specific position, they are then instructed to initiate a light resisted effort (20% of available strength) to bring the stabilized shoulder towards the ear in a shrug movement and to bring the ear towards the shoulder. This double movement caused contraction of both ends of the muscle simultaneously. The degree of effort should be mild and pain free. The contraction is held for 7 -10 seconds and upon complete and full relaxation, the doctor gently increases the degree of lateral flexion and rotation and the shoulder is stretched caudally.

The possibility of initiating a stretch response is reduced by asking the participant to initiate the stretch of the muscle on instruction (as you breathe out, please slide your ear and shoulder away from each other...
gently). Once the muscle reached the stretch position, the patient relaxes and the stretch is held for 30 seconds.

3.7 Data Collection

The data was collected using objective and subjective measures. The objective measures were collected at the commencement of the first, fourth and seventh visit. The subjective measures were taken at the beginning of the first and seventh visits.

3.7.1 Objective data

The participant’s available cervical ROM was measured using the Cervical Spine Range of Motion (CROM) instrument. Measurements were recorded on the first, fourth and seventh visits. The CROM readings were recorded on the data collection sheet (Appendix E).

3.7.1.1 Cervical range of motion inclinometer (CROM)

CROM is used to assess the total cervical spine ROM using three inclinometers. The apparatus is fitted to the participant’s head to allow the neck to be positioned in oder to allow the readings to be taken (Agarway, Allison and Singer, 2005). A recent article in the Journal of Manipulative and Physiological Therapeutics concludes that the CROM inclinometer can be used as a valid and reliable method to measure cervical spine ROM (Lachtman et al., 2015).

The CROM instrument was fitted over the nose bridge and ears, and was secured to the head by means of a Velcro strap. The measurements are read from the dial meters. Gravity meters are used to assess lateral flexion and movements in the sagittal plane. To measure rotation, a magnetic meter is used that responds to the shoulder mounted magnetic yoke after shoulder substitution was eliminated (Agarway, Allison and Singer, 2005). CROM readings can only be considered as valid if the inclinometers are positioned parallel to the ground due to the spirit inclinometers that it contains (Quek, Pua et al., 2013). All the movements were only done once to prevent accommodation and stretch that may increase ROM. The readings were recorded on the data collection sheet (Appendix E).
a. Cervical flexion and extension

To measure flexion, the participant was instructed to sit up straight on the chair with the sacrum touching the back of the chair, arms hanging on the side and both feet firmly on the ground. The CROM instrument was then fitted on their nose and against the forehead and fastened with the Velcro straps. To assess full cervical flexion, the participant was instructed to bring their chin to their chest as far as they can. This was only done once to prevent any accommodation by the muscle that may affect the reading. Using the sagittal plane meter, the reading was noted.

To measure extension, the participant was instructed to look up at the ceiling and tilt their head back as far as they can go. The reading was taken from the sagittal plane meter.

b. Cervical lateral flexion

To measure lateral flexion, the participant was instructed to sit up straight on the chair with the sacrum touching the back of the chair, arms hanging on the side and both feet firmly on the ground. The participant was instructed to find a focus point on the wall and keep their head still until the meter had a reading of zero. The participant then laterally flexed the head to one side and the reading was noted. This was repeated on the opposite side.

c. Cervical rotation

To measure rotation, the magnetic yoke and rotation arm needs to be added to the CROM instrument and the 'north' direction was determined. With the arms pointing north, the magnetic yoke was placed on the participant’s shoulders. The participant was then instructed to sit up straight on the chair with the sacrum touching the back of the chair, arms hanging on the side and both feet firmly on the ground. It was important to position the participant in such a way that the lateral flexion, sagittal plane and rotation meters had a reading of zero. The participant was instructed to imagine a line parallel to the ground to ensure
smooth and straight movement as the neck rotates to one side to take a reading. The same applied to the opposite side.

### 3.7.1.2 Pressure algometer

A hand held pressure algometer (Figure 3-4), also known as the pressure threshold meter, is a force measure, spring operated plunger calibrated in kg/cm². It is fitted with a rubber disc at one end and a scale on the other. The main function of an algometer is to provide a measurement of pressure threshold and tissue compliance (Fischer, 1987). The moment when pressure becomes uncomfortable or painful is called pressure pain threshold (Waller et al., 2015). The algometer is a practical and useful device in practice to determine the severity of a MFTP as well as to monitor the efficacy of treatment over time. The validity and intra-tester reliability of the pressure algometry was evaluated in a study done on women with pain in the neck and shoulder area and was found to be valid and reliable for use in clinical trials (Ylinen et al., 2007).

![Figure 3-4: A hand held pressure algometer used in this study](image)

The pressure algometry reading of the upper trapezius MFTP was measured. Initially, pinch palpation was used to locate the trigger point and reproduce the trapezius muscle referral pattern. The pressure algometer was then placed over the same trigger point in the upper trapezius muscle and a downwards force was applied. The algometer was removed as soon as the participant’s pain threshold was reached and the reading in kg/cm² was noted. The readings were taken before treatment on the first and fourth visits and on the final seventh data collection visit.

### 3.7.2 Subjective data

#### 3.7.2.1 Vernon-Mior neck pain and disability index (Appendix D)

When it comes to measuring the intensity and quality of pain, the Vernon-Mior neck pain and disability index is most commonly used. It is considered to be valid and reliable (Chan et al., 2009). The
The questionnaire is composed of ten self-report sections which include pain intensity, personal care, lifting, reading, headaches, concentration, work, driving, sleeping and recreation. This provides the practitioner with information about how the neck pain has affected the participant's everyday activities. The measurements were recorded at the first and seventh visit.

Each of the ten self-report sections of the neck disability index questionnaire has six possible options ranging from a 0 to 5 pain scale. A final total score will range between 0 and 50, where 0 means there is no pain or disability and 50 means there is severe pain and disability (Gay, Madson and Cieslak, 2007). The obtained score will be converted into a percentage score (0% to 100%) to represent the disability present. A high percentage indicates more disability.

1. All the sections are scored individually (0 to 5 points each) and then added up (max. Total = 50).

Example:

<table>
<thead>
<tr>
<th>Section 1: Pain Intensity</th>
<th>Point Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>I have pain at the moment.</td>
<td>0</td>
</tr>
<tr>
<td>The pain is very mild at the moment.</td>
<td>1</td>
</tr>
<tr>
<td>The pain is moderate at the moment.</td>
<td>2</td>
</tr>
<tr>
<td>The pain is fairly moderate at the moment.</td>
<td>3</td>
</tr>
<tr>
<td>The pain is very severe at the moment.</td>
<td>4</td>
</tr>
<tr>
<td>The pain is the worst imaginable at the moment.</td>
<td>5</td>
</tr>
</tbody>
</table>

2. If all the sections are answered, the participant's score is simply doubled.

3. If a section was left out, the participant's percentage is calculated by dividing the total score by the number of sections completed and multiplied by 100.

4. Disability interpretation:

<table>
<thead>
<tr>
<th>Percentage Range</th>
<th>Disability Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0% – 20%</td>
<td>Minimal Disability</td>
</tr>
<tr>
<td>20% - 40%</td>
<td>Moderate Disability</td>
</tr>
<tr>
<td>40% - 60%</td>
<td>Severe Disability</td>
</tr>
<tr>
<td>60% - 80%</td>
<td>Crippled</td>
</tr>
<tr>
<td>80% - 100%</td>
<td>Exaggerating or bed bound</td>
</tr>
</tbody>
</table>

3.8 Ethical Considerations

This study was approved by the Faculty of Health Sciences, Research Ethics Committee on 22 April 2015, UJ Ethics Clearance Number: REC-01-39-2016 (Appendix P). The information form (Appendix B) and
The consent form (Appendix C) outlined the names and contact information of the researchers, the purpose of the study and the benefits of partaking in the study, participant assessment and the treatment procedure. Any risks, benefits and discomfts pertaining to the treatments involved were also explained and the participants were reassured that all the necessary precautions were taken to ensure their safety. The information and consent form also emphasised that the participant's privacy would be protected as only the researcher, participant and clinician (alternatively the supervisor) were in the treatment room and that anonymity was ensured (all participant information was converted into data and therefore cannot be traced back to the individual). The form also stated that standard doctor/patient confidentiality would be adhered to at all times when compiling the research dissertation. The participants were also informed that their participation is on a voluntary basis and that they were free to withdraw from the study at any stage, without penalty. Additional questions from the participants were answered by the researcher and the researcher’s contact details were made available.

With regards to this particular study, the following risks and discomfts that could occur were: post treatment soreness from the spinal manipulation as well as some minor pain or discomfort from the MET may be experienced after the treatments. This is a normal response that may occur after chiropractic spinal manipulation and MET. Occasionally a slight headache may occur on the tested side as a result of working on the active trigger points and causing them to refer pain. This however, is also a normal response and should settle within 24 to 48 hours.

The participants were required to sign the consent form to show that they understood what was expected of them in this study. The results of this study were made available on request. Participants were notified that they would be referred to the relevant health care practitioner when necessary, should the assessment reveal anything of concern to the researcher.

3.9 Data Analysis

The objective and subjective data was collected by the researcher over the study period mentioned. The results were given to Juliana Van Staden, a STATKON statistician (located at the University of Johannesburg Kingsway Campus). STATKON used the objective readings from the CROM inclinometer and the pressure algometer and the subjective readings from the Vernon-Mior Neck Pain and Disability Index for the analysis.

The Shapiro-Wilks test was used to determine whether the subjective and objective data was distributed normally.
Analysis of the subjective measurements consisted of intragroup and intergroup analysis. The intragroup analysis was done using the Paired Sample T-test and the Wilcoxon Signed Rank Test. Intergroup analysis was done using the one way ANOVA test.

Analysis of the objective measurements also consisted of intragroup and intergroup analysis. The intragroup analysis was done using the Friedman test and the Wilcoxon Signed Rank Test. Intergroup analysis was done using the one way ANOVA test.

3.10 Originality check

Upon completion of the dissertation, an originality check was completed using Turnitin. A report (Appendix R) was generated, which compared the similarity of the work to other sources and revealed 21% similarity.

The following chapter will provide, in detail, the results of the study.
CHAPTER FOUR: RESULTS

4.1 Introduction

This chapter presents the results obtained during the study’s clinical trials. The sample group comprised of forty five (45) participants: fifteen (15) participants were representative of the group that received chiropractic manipulations to restricted segments of the upper cervical spine, 15 participants were representative of the group that received Muscle Energy Technique (MET) to the upper trapezius muscle and the last 15 participants were representative of the group that received a combination treatment of chiropractic manipulation and MET to the upper trapezius. The statistical results only represent a small group of participants and therefore no generalisations can be made with regard to the population as a whole.

In order to establish an overall baseline for the research group, frequencies and descriptive were used to analyse all forty-five participants. The analysis included:

1. Demographic analysis with regards to age and gender.
2. Normality analysis of the data distribution.
4. Objective data made up of the measurements taken with the CROM instrument and the pressure algometer readings.

Statistical significance in the results can be determined using the p-value. A p-value of \(0.05\) or less \((p \leq 0.05)\) indicates statistically significant results. If a p-value greater than \(0.05\) was obtained \((p > 0.05)\), the results were considered to be statistically insignificant.

Intragroup analysis for the objective measurements consisted of the Friedman test and the Paired Sample T-test to assess if there was any change over time within the groups between the first and seventh consultation. If a change was revealed over time, then the Wilcoxon Signed Ranked Test was used to determine where the difference could be found. Intergroup analysis of the objective measurements consisted of the one way ANOVA test.

4.2 Demographic Data Analysis

Group A represents Chiropractic manipulations, Group B represents MET and Group C represents the combination treatment group.
4.2.1 Age

Forty five participants were included in the analysis of the study. A minimum age of 19 years and a maximum age of 55 years were recorded. The mean age for this study was \(25.40\) years. The median for Group A, Group B and Group C was 25 years.

As shown in Figure 4-1, the participants recruited for this study were between the ages of 19 and 55. It also shows that Group A and Group B had a closely related distribution. The minimum and maximum age for Group A was 20 and 26 years respectively. The minimum age for Group B was 19 years and the maximum age was 26 years. Group C had a minimum age of 20 years and a maximum of 55 years. Group A participants had a mean age of \(24.13\) years, Group B participants had a mean age of \(23.73\) years and Group C had a mean age of \(28.33\) years. All three groups had a median value of 25 years.

4.2.2 Gender

Figure 4-2 displays the gender distribution between the groups. Across all three groups, there were more female than male participants. A total of 45 participants were recruited and included in this study. Group A consisted of 13 female and 2 male participants, Group B consisted of 12 female and 3 male participants and Group C consisted of 10 female and 5 male participants. In total there were 10 male and 35 female participants.
The Shapiro-Wilk Test was applied to the subjective and objective data in all three groups to test for normality. Normality can be described as the distribution of each of the variables. Normality testing is key in deciding which tests to use for further data analysis. The Shapiro-Wilk test was used to test for normality. Table 4-1 and Table 4-2 display the p-values for the subjective and objective data, respectively. A $p \geq 0.05$ indicates a normal distribution and allow parametric tests to be done. A $p \leq 0.05$ indicates that the data is not distributed normally and therefore allows non-parametric tests to be done.

**Table 4-1: Shapiro-Wilk Test subjective data p-values**

| Groups | Visit 1 | | | Visit 7 | |
|--------|--------| | |--------| |
| Group A | 0.08 | | | 0.05 | |
| Group B | 0.71 | | | 0.90 | |
| Group C | 0.10 | | | 0.00 | |
Table 4-2: Shapiro-Wilk Test objective data p-values

<table>
<thead>
<tr>
<th></th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Flexion</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visit 1</td>
<td>0.28</td>
<td>0.01</td>
<td>0.63</td>
</tr>
<tr>
<td>Visit 4</td>
<td>0.16</td>
<td>0.29</td>
<td>0.40</td>
</tr>
<tr>
<td>Visit 7</td>
<td>0.32</td>
<td>0.04</td>
<td>0.97</td>
</tr>
<tr>
<td><strong>Extension</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visit 1</td>
<td>0.02</td>
<td>0.89</td>
<td>0.04</td>
</tr>
<tr>
<td>Visit 4</td>
<td>0.58</td>
<td>0.55</td>
<td>0.12</td>
</tr>
<tr>
<td>Visit 7</td>
<td>0.09</td>
<td>0.19</td>
<td>0.91</td>
</tr>
<tr>
<td><strong>Right Rotation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visit 1</td>
<td>0.31</td>
<td>0.04</td>
<td>0.20</td>
</tr>
<tr>
<td>Visit 4</td>
<td>0.66</td>
<td>0.74</td>
<td>0.70</td>
</tr>
<tr>
<td>Visit 7</td>
<td>0.10</td>
<td>0.71</td>
<td>0.08</td>
</tr>
<tr>
<td><strong>Left Rotation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visit 1</td>
<td>0.08</td>
<td>0.48</td>
<td>0.33</td>
</tr>
<tr>
<td>Visit 4</td>
<td>0.69</td>
<td>0.02</td>
<td>0.66</td>
</tr>
<tr>
<td>Visit 7</td>
<td>0.74</td>
<td>0.47</td>
<td>0.22</td>
</tr>
<tr>
<td><strong>Right Lateral Flexion</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visit 1</td>
<td>0.00</td>
<td>0.75</td>
<td>0.13</td>
</tr>
<tr>
<td>Visit 4</td>
<td>0.00</td>
<td>0.05</td>
<td>0.18</td>
</tr>
<tr>
<td>Visit 7</td>
<td>0.00</td>
<td>0.02</td>
<td>0.67</td>
</tr>
<tr>
<td><strong>Left Lateral Flexion</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visit 1</td>
<td>0.03</td>
<td>0.03</td>
<td>0.797</td>
</tr>
<tr>
<td>Visit 4</td>
<td>0.19</td>
<td>0.14</td>
<td>0.98</td>
</tr>
<tr>
<td>Visit 7</td>
<td>0.42</td>
<td>0.17</td>
<td>0.21</td>
</tr>
<tr>
<td><strong>Pressure Algometer</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visit 1</td>
<td>0.41</td>
<td>0.33</td>
<td>0.28</td>
</tr>
<tr>
<td>Visit 4</td>
<td>0.63</td>
<td>0.70</td>
<td>0.02</td>
</tr>
<tr>
<td>Visit 7</td>
<td>0.58</td>
<td>0.08</td>
<td>0.69</td>
</tr>
</tbody>
</table>
4.4 Subjective Data Analysis

Intragroup analysis was performed using the Paired Sample T-Test. If statistically significant values were revealed, further intragroup analysis was performed using the Wilcoxon Signed Rank test.

Intergroup analysis was done using the one way ANOVA test.

The overall improvement can be calculated as follows:

\[
\% \text{ improvement} = \left( \frac{\text{reading at visit 7} - \text{reading at visit 1}}{\text{reading at visit 1}} \right) \times 100
\]

4.4.1 Vernon-Mior neck pain and disability index

The participants' total Vernon-Mior neck pain and disability index (VMNPDI) ranged from a maximum of 52% at visit one to a minimum of 0% at visit seven. When the mean of all three groups between visit one and visit seven was compared, the results indicated that Group B and Group C had the most positive response, as seen in Table 4-3.

There was an overall improvement in the VMNPDI in all three groups, with 59.53% for Group A, 70.44% for Group B and 67.28% for Group C. These results suggest that the treatment protocol specific to a group was clinically significant.

Table 4-3: Comparison of the total Vernon-Mior neck pain and disability index variables between groups and visits

<table>
<thead>
<tr>
<th></th>
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<th>Mean (%)</th>
<th>Median (%)</th>
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<tr>
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<table>
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<th>Median (%)</th>
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<td>Group B</td>
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<td>0</td>
<td>18</td>
<td>5.73</td>
<td>6</td>
</tr>
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<td>15</td>
<td>0</td>
<td>26</td>
<td>7.33</td>
<td>6</td>
</tr>
</tbody>
</table>
Figure 4-3 provides a summary of the total VMNPDI values. There was an overall reduction in the total VMNPDI values in all three groups over the three week treatment period.

Figure 4-3: Summary of the total Vernon-Mior neck pain and disability index values.

The mean VMNPDI values which indicated the signs and symptoms of all the participants in all three groups over the three week period can be seen in Figure 4.4.

Figure 4-4 show that all three groups experienced a decrease in the signs and symptoms from visit 1 to visit 7 at a similar rate.

Figure 4-4: Vernon-Mior neck pain and disability index mean values
a) Intragroup analysis

Comparative intragroup analysis was done by means of the Paired Sample T-test and the Wilcoxon Signed Rank test in order to determine whether one treatment protocol was more effective than another treatment protocol. The data used in these tests was gathered from Figure 4-3.

The Paired Sample T-test revealed a statistically significant change over time in Group A (p=0.00), Group B (p=0.00) and Group C (p=0.00).

The Wilcoxon Signed Ranks test compared the values recorded at the seventh visit with the values at the first visit. There was a statistically significant difference in Group A (p=0.00), Group B (p=0.00) and Group C (p=0.00).

This result means that there was in fact a difference in the effectiveness of each treatment protocol.

b) Intergroup analysis

The one way ANOVA test was used to compare Group A, Group B and Group C over time. The data used in this test was gathered from Figure 4-3. The one way ANOVA test revealed that the groups were not statistically significant at visit 1 (p=0.69) and visit 7 (p=0.20).

4.5 Objective Data Analysis

Intragroup analysis was performed using the Friedman test. If statistically significant values were revealed, further intragroup analysis was performed using the Wilcoxon Signed Rank Test.

Intergroup analysis was performed using the one way ANOVA test.

4.5.1 Cervical spine flexion

The participants’ total cervical spine flexion ranged from a minimum of 20° at visit one to a maximum of 96° at visit seven. The lowest mean at visit one was 56.87°, which occurred in Group B, and the highest mean at visit seven was 73.60°, which occurred in Group C. When the mean as well as the minimum and maximum values of all three groups were compared from visit to and visit seven, the results indicated that an increase in cervical spine flexion was seen to have occurred in all three groups over the seven visits, as shown in Table 4-4. These results indicate that the treatment protocol specific to a group was clinically significant.
There was an overall improvement in the cervical spine flexion readings in all three groups, with 15.68% for Group A, 16.77% for Group B and 19.40% for Group C. These results suggest that the treatment protocol specific to a group was clinically significant.

Table 4-4: Comparison of total cervical spine flexion readings between groups and visits

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<tbody>
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<td>40</td>
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<tr>
<td>Group B</td>
<td>15</td>
<td>20</td>
<td>72</td>
<td>56.87</td>
<td>60</td>
</tr>
<tr>
<td>Group C</td>
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<td>40</td>
<td>81</td>
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<tbody>
<tr>
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<td>15</td>
<td>50</td>
<td>82</td>
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<tr>
<td>Group B</td>
<td>15</td>
<td>30</td>
<td>78</td>
<td>60.27</td>
<td>62</td>
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<tr>
<td>Group C</td>
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<td>44</td>
<td>82</td>
<td>66.53</td>
<td>64</td>
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<table>
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<tbody>
<tr>
<td>Group A</td>
<td>15</td>
<td>50</td>
<td>84</td>
<td>67.73</td>
<td>70</td>
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<tr>
<td>Group B</td>
<td>15</td>
<td>36</td>
<td>76</td>
<td>64</td>
<td>67</td>
</tr>
<tr>
<td>Group C</td>
<td>15</td>
<td>48</td>
<td>96</td>
<td>73.60</td>
<td>76</td>
</tr>
</tbody>
</table>

Figure 4-5 provides a summary of the total cervical spine flexion values. There was an overall increase in the cervical spine flexion values in all three groups over the three week treatment period.
Figure 4-5: Summary of total cervical spine flexion values

Figure 4-6 show that all three groups experienced an increase in the cervical spine flexion ROM from visit 1 to visit 7 at a similar rate. There was a slight increase in Group C cervical spine flexion between visit four and visit seven.

Figure 4-6: Means of cervical spine flexion values
a) Intragroup analysis
Comparative intragroup analysis was done by means of the Friedman test and the Wilcoxon Signed Rank test.

The Friedman test revealed a statistically significant difference over time in Group A (**p=0.00**), Group B (**p=0.01**) and Group C (**p=0.00**).

The Wilcoxon Signed Ranks test compared the values recorded at the fourth visit with the values at the first visit. There was a statistical difference in Group A (**p=0.03**). Group B (**p=0.11**) and Group C (**p=0.13**) was not statistically significant when the first visit and fourth visit was compared. The values recorded at the seventh visit were then compared to the values measured at the fourth visit. A statistically significant difference was found in Group A (**p=0.01**), Group B (**p=0.02**) and Group C (**p=0.00**). Finally, the values of the seventh visit were compared to those of the first visit. A statistically significant difference was found in Group A (**p=0.00**), Group B (**p=0.01**) and Group C (**p=0.01**).

b) Intergroup analysis
The one way ANOVA test was used to compare Group A, Group B and Group C over time. The one way ANOVA test revealed that the groups were not statistically significant at visit 1 (**p=0.44**), visit 4 (**p=0.32**) and visit 7 (**p=0.07**).

4.5.2 Cervical spine extension
The participants’ total cervical spine extension ranged from a minimum of 30° at visit one to a maximum of 88° at visit seven. The lowest mean at visit one was 56.80°, which occurred in Group B, and the highest mean at visit seven was 64.67°, which occurred in Group C. When the mean as well as the minimum and maximum values of all three groups were compared from visit to and visit seven, the results indicated that an increase in cervical spine extension was seen to have occurred in all three groups over the seven visits, as shown in Table 4-5. These results indicate that the treatment protocol specific to a group was clinically significant.

There was an overall improvement in the cervical spine extension readings in all three groups, with 11.13% for Group A, 11.72% for Group B and 11.19% for Group C. These results suggest that the treatment protocol specific to a group was clinically significant.
Table 4-5: Comparison of total cervical spine extension readings between groups and visits

Visit 1

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
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<td>15</td>
<td>40</td>
<td>84</td>
<td>56.93</td>
<td>52</td>
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<tr>
<td>Group B</td>
<td>15</td>
<td>30</td>
<td>76</td>
<td>56.80</td>
<td>56</td>
</tr>
<tr>
<td>Group C</td>
<td>15</td>
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<td>76</td>
<td>59.40</td>
<td>60</td>
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Visit 4

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<tr>
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<td>78</td>
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<tr>
<td>Group C</td>
<td>15</td>
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<td>76</td>
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Visit 7

<table>
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<td>15</td>
<td>42</td>
<td>82</td>
<td>64.67</td>
<td>64</td>
</tr>
</tbody>
</table>

Figure 4-7 provides a summary of the total cervical spine extension values. There was an overall increase in the cervical spine extension values in all three groups over the three week treatment period.
Figure 4-8 show that Group A and Group C experienced an increase in the cervical spine extension ROM from visit 1 to visit 7 at a similar rate. The cervical spine extension for Group B increased at a slower rate than the other groups between visit one and visit four, but increased rapidly between visit four and visit seven.
a) Intragroup analysis

Comparative intragroup analysis was done by means of the Friedman test and the Wilcoxon Signed Rank test.

The Friedman test revealed a statistically significant difference over time in Group A \((p=0.00)\) and Group B \((p=0.02)\). Group C \((p=0.13)\) was statistically insignificant.

The Wilcoxon Signed Ranks test compared the values recorded at the fourth visit with the values at the first visit. Group A \((p=0.06)\), Group B \((p=0.41)\) and Group C \((p=0.20)\) was not statistically significant when the first visit and fourth visit was compared. The values recorded at the seventh visit were then compared to the values measured at the fourth visit. A statistically significant difference was found in Group A \((p=0.01)\), Group B \((p=0.02)\). Group C \((p=0.33)\) was statistically insignificant. Finally, the values of the seventh visit were compared to those of the first visit. A statistically significant difference was found in Group A \((p=0.00)\), Group B \((p=0.01)\) and Group C \((p=0.03)\).

b) Intergroup analysis

The one way ANOVA test was used to compare Group A, Group B and Group C over time. The one way ANOVA test revealed that the groups were not statistically significant at visit 1 \((p=0.79)\), visit 4 \((p=0.56)\) and visit 7 \((p=0.82)\).

4.5.3 Cervical spine right rotation

The participants’ total cervical spine right rotation ranged from a minimum of 40° at visit one to a maximum of 94° at visit seven. The lowest mean at visit one was 64.27°, which occurred in Group A, and the highest mean at visit seven was 72.53°, which occurred in Group A. When the mean as well as the minimum and maximum values of all three groups were compared from visit to and visit seven, the results indicated that an increase in cervical spine right rotation was seen to have occurred in all three groups over the seven visits, as shown in Table 4-6. These results indicate that the treatment protocol specific to a group was clinically significant.

There was an overall improvement in the cervical spine right rotation readings in all three groups, with 16.03% for Group A, 9.21% for Group B and 8.52% for Group C. These results suggest that the treatment protocol specific to a group was clinically significant.
Table 4-6: Comparison of total cervical spine right rotation readings between groups and visits

Visit 1

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<th>Max (°)</th>
<th>Mean (°)</th>
<th>Median (°)</th>
</tr>
</thead>
<tbody>
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<td>92</td>
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<td>78</td>
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<tr>
<td>Group C</td>
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Visit 4

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<th>Max (°)</th>
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<tbody>
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<td>58</td>
<td>84</td>
<td>68.93</td>
<td>70</td>
</tr>
<tr>
<td>Group B</td>
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<td>80</td>
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<tr>
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<td>84</td>
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Visit 7

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<td>94</td>
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<tr>
<td>Group B</td>
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<td>86</td>
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<tr>
<td>Group C</td>
<td>15</td>
<td>56</td>
<td>86</td>
<td>68.93</td>
<td>70</td>
</tr>
</tbody>
</table>

Figure 4-9 provides a summary of the total cervical spine right rotation values. There was an overall increase in the cervical spine right rotation values in all three groups over the three week treatment period.
Figure 4-9: Summary of total cervical spine right rotation values

Figure 4-10 show that all three groups experienced an increase in the cervical spine right rotation ROM from visit 1 to visit 7 at a similar rate. However, Group C had a lower right rotation ROM mean value when compared to the other groups at visit seven.
a) Intragroup analysis

Comparative intragroup analysis was done by means of the Friedman test and the Wilcoxon Signed Rank test.

The Friedman test revealed a statistically significant difference over time in Group A (p=0.00), Group B (p=0.00) and Group C (p=0.01).

The Wilcoxon Signed Ranks test compared the values recorded at the fourth visit with the values at the first visit. There was a statistical difference in Group A (p=0.03). Group B (p=0.13) and Group C (p=0.18) was not statistically significant when the first visit and fourth visit was compared. The values recorded at the seventh visit were then compared to the values measured at the fourth visit. A statistically significant difference was found in Group A (p=0.01). Group B (p=0.07) and Group C (p=0.38) was statistically insignificant. Finally, the values of the seventh visit were compared to those of the first visit. A statistically significant difference was found in Group A (p=0.00), Group B (p=0.00). No statistical significant difference was found in Group C (p=0.11).

b) Intergroup analysis

The one way ANOVA test was used to compare Group A, Group B and Group C over time. The one way ANOVA test revealed that the groups were not statistically significant at visit 1 (p=0.93), visit 4 (p=0.94) and visit 7 (p=0.52).

4.5.4 Cervical spine left rotation

The participants' total cervical spine left rotation ranged from a minimum of 38° at visit one to a maximum of 84° at visit seven. The lowest mean at visit one was 59.87°, which occurred in Group C, and the highest mean at visit seven was 71.60°, which occurred in Group A. When the mean as well as the minimum and maximum values of all three groups were compared from visit to and visit seven, the results indicated that an increase in cervical spine right rotation was seen to have occurred in all three groups over the seven visits, as shown in Table 4-7. These results indicate that the treatment protocol specific to a group was clinically significant.

There was an overall improvement in the cervical spine left rotation readings in all three groups, with 14.28% for Group A, 11.64% for Group B and 18% for Group C. These results suggest that the treatment protocol specific to a group was clinically significant.
Table 4-7: Comparison of total cervical spine left rotation readings between groups and visits

**Visit 1**

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<tr>
<td>Group B</td>
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<td>40</td>
<td>80</td>
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<tr>
<td>Group C</td>
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**Visit 4**

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**Visit 7**

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<td>15</td>
<td>58</td>
<td>80</td>
<td>69.33</td>
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</tbody>
</table>

Figure 4-11 provides a summary of the total cervical spine left rotation values. There was an overall increase in the cervical spine left rotation values in all three groups over the three week treatment period.
Figure 4-11: Summary of total cervical spine left rotation values

Figure 4-12 show that all three groups experienced an increase in the cervical spine left rotation ROM from visit 1 to visit 7 at a similar rate. There appears to be a greater increase between visit one and visit four for all three groups.

Figure 4-12: Means of cervical spine left rotation values
a) Intragroup analysis

Comparative intragroup analysis was done by means of the Friedman test and the Wilcoxon Signed Rank test.

The Friedman test revealed a statistically significant difference over time in Group A (p=0.00), Group B (p=0.01) and Group C (p=0.00).

The Wilcoxon Signed Ranks test compared the values recorded at the fourth visit with the values at the first visit. There was a statistical difference in Group A (p=0.01) and Group C (p=0.02). There was no statistically significant difference when the first visit and fourth visit was compared of Group B (p=0.12). The values recorded at the seventh visit were then compared to the values measured at the fourth visit. A statistically significant difference was found in Group C (p=0.03). Group A (p=0.40) and Group B (p=0.09) was statistically insignificant. Finally, the values of the seventh visit were compared to those of the first visit. A statistically significant difference was found in Group A (p=0.00), Group B (p=0.01) and Group C (p=0.00).

b) Intergroup analysis

The one way ANOVA test was used to compare Group A, Group B and Group C over time. The one way ANOVA test revealed that the groups were not statistically significant at visit 1 (p=0.44), visit 4 (p=0.44) and visit 7 (p=0.61).

4.5.5 Cervical spine right lateral flexion

The participants' total cervical spine right lateral flexion ranged from a minimum of 20° at visit one to a maximum of 60° at visit seven. The lowest mean at visit one was 37.60°, which occurred in Group B, and the highest mean at visit seven was 46.13°, which occurred in Group A. When the mean as well as the minimum and maximum values of all three groups were compared from visit to and visit seven, the results indicated that an increase in cervical spine right lateral flexion was seen to have occurred in all three groups over the seven visits, as shown in Table 4-8. These results indicate that the treatment protocol specific to a group was clinically significant.

There was an overall improvement in the cervical spine right lateral flexion readings in all three groups, with 7.42% for Group A, 16.52% for Group B and 19.17% for Group C. These results suggest that the treatment protocol specific to a group was clinically significant.
Table 4-8: Comparison of total cervical spine right lateral flexion readings between groups and visits

Visit 1

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Figure 4-13 provides a summary of the total cervical spine right lateral flexion values. There was an overall increase in the cervical spine right lateral flexion values in all three groups over the three week treatment period.
Figure 4-13: Summary of total cervical spine right lateral flexion values

Figure 4-14 show that all three groups experienced an increase in the cervical spine right lateral flexion ROM from visit 1 to visit 7 at a similar rate. Group A showed the least improvement over the seven visits.

Figure 4-14: Means of cervical spine right lateral flexion values
a) Intragroup analysis

Comparative intragroup analysis was done by means of the Friedman test and the Wilcoxon Signed Rank test.

The Friedman test revealed a statistically significant difference over time in Group B (p=0.00) and Group C (p=0.00). Group A (p=0.09) was statistically insignificant.

The Wilcoxon Signed Ranks test compared the values recorded at the fourth visit with the values at the first visit. There was a statistical difference in Group B (p=0.04) and Group C (p=0.01). Group A (p=0.40) was not statistically significant when the first visit and fourth visit was compared. The values recorded at the seventh visit were then compared to the values measured at the fourth visit. No statistically significant difference was found in Group A (p=0.11), Group B (p=0.09) and Group C (p=0.69). Finally, the values of the seventh visit were compared to those of the first visit. A statistically significant difference was found in Group B (p=0.00) and Group C (p=0.05). Group A (p=0.24) was statistically insignificant.

b) Intergroup analysis

The one way ANOVA test was used to compare Group A, Group B and Group C over time. The one way ANOVA test revealed that the groups were not statistically significant at visit 1 (p=0.16), visit 4 (p=0.41) and visit 7 (p=0.46).

4.5.6 Cervical spine left lateral flexion

The participants’ total cervical spine left lateral flexion ranged from a minimum of 20° at visit one to a maximum of 70° at visit seven. The lowest mean at visit one was 37.73°, which occurred in Group B, and the highest mean at visit seven was 45.07°, which occurred in Group A. When the mean as well as the minimum and maximum values of all three groups were compared from visit to and visit seven, the results indicated that an increase in cervical spine left lateral flexion was seen to have occurred in all three groups over the seven visits, as shown in Table 4-9. These results indicate that the treatment protocol specific to a group was clinically significant.

There was an overall improvement in the cervical spine left lateral flexion readings in all three groups, with 9.73% for Group A, 12.13% for Group B and 18.33% for Group C. These results suggest that the treatment protocol specific to a group was clinically significant.
Table 4-9: Comparison of total cervical spine left lateral flexion readings between groups and visits

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Figure 4-15 provides a summary of the total cervical spine left lateral flexion values. There was an overall increase in the cervical spine left lateral flexion values in all three groups over the three week treatment period.
Figure 4-15: Summary of total cervical spine left lateral flexion values

Figure 4-16 show that Group A and Group B experienced an increase in the cervical spine left lateral flexion ROM from visit 1 to visit 7 at a similar rate. However, Group C showed the most improvement between visits one and four when compared to visit four and visit seven.

Figure 4-16: Means of cervical spine left lateral flexion values
a) Intragroup analysis

Comparative intragroup analysis was done by means of the Friedman test and the Wilcoxon Signed Rank test.

The Friedman test revealed a statistically significant difference over time in Group A \( p=0.05 \), Group B \( p=0.02 \) and Group C \( p=0.02 \).

The Wilcoxon Signed Ranks test compared the values recorded at the fourth visit with the values at the first visit. There was a statistical difference in Group C \( p=0.01 \). Group A \( p=0.65 \) and Group B \( p=0.15 \) was not statistically significant when the first visit and fourth visit was compared. The values recorded at the seventh visit were then compared to the values measured at the fourth visit. A statistically significant difference was found in Group B \( p=0.01 \) and Group C \( p=0.04 \). Group A \( p=0.07 \) was statistically insignificant. Finally, the values of the seventh visit were compared to those of the first visit. A statistically significant difference was found in Group B \( p=0.01 \) and Group C \( p=0.01 \). No statistical significant difference was found in Group A \( p=0.10 \).

b) Intergroup analysis

The one way ANOVA test was used to compare Group A, Group B and Group C over time. The one way ANOVA test revealed that the groups were not statistically significant at visit 1 \( p=0.33 \), visit 4 \( p=0.53 \) and visit 7 \( p=0.65 \).

4.5.7 Pressure algometer measurements

The participants’ total pressure algometer readings ranged from a minimum of \( 1.43 \) kg.cm\(^{-2} \) at visit one to a maximum of \( 5 \) kg.cm\(^{-2} \) at visit seven. The lowest mean at visit one was \( 2.80 \) kg.cm\(^{-2} \), which occurred in Group B, and the highest mean at visit seven was \( 3.78 \) kg.cm\(^{-2} \), which occurred in Group B. When the mean as well as the minimum and maximum values of all three groups were compared from visit to and visit seven, the results indicated that an increase in pressure algometer readings was seen to have occurred in all three groups over the seven visits, as shown in Table 4-10. These results indicate that the treatment protocol specific to a group was clinically significant.

There was an overall improvement in the pressure algometer readings in all three groups, with 24.94% for Group A, 45.45% for Group B and 23.73% for Group C. These results suggest that the treatment protocol specific to a group was clinically significant.
Table 4-10: Comparison of total pressure algometer readings between groups and visits

Visit 1

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Visit 7

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Figure 4-17 provides a summary of the total pressure algometer readings. There was an overall increase in the pressure algometer readings in all three groups over the three week treatment period.
Figure 4-17: Summary of total pressure algometer readings

Figure 4-18 show that all three groups experienced an increase in the pressure algometer readings from visit 1 to visit 7 at a similar rate.

Figure 4-18: Means of pressure algometer readings
a) Intragroup analysis

Comparative intragroup analysis was done by means of the Friedman test and the Wilcoxon Signed Rank test.

The Friedman test revealed a statistically significant difference over time in Group A (p=0.01), Group B (p=0.00) and Group C (p=0.03).

The Wilcoxon Signed Ranks test compared the values recorded at the fourth visit with the values at the first visit. There was a statistical difference in Group B (p=0.01). Group A (p=0.36) and Group C (p=0.08) was not statistically significant when the first visit and fourth visit was compared. The values recorded at the seventh visit were then compared to the values measured at the fourth visit. A statistically significant difference was found in Group A (p=0.01) and Group B (p=0.01). Group C (p=0.10) was statistically insignificant. Finally, the values of the seventh visit were compared to those of the first visit. A statistically significant difference was found in Group A (p=0.02), Group B (p=0.00) and Group C (p=0.02).

b) Intergroup analysis

The one way ANOVA test was used to compare Group A, Group B and Group C over time. The one way ANOVA test revealed that the groups were not statistically significant at visit 1 (p=0.59), visit 4 (p=0.22) and visit 7 (p=0.43).
CHAPTER FIVE: DISCUSSION

5.1 Introduction

This chapter serves as a discussion of the objective and subjective results obtained, as presented in chapter four. Possible explanations for these results are delineated by referring to the literature review in chapter two and the results of previous studies.

The comparison of the subjective and objective results in the seventh visit determined which treatment protocol was more effective.

5.2 Demographic Data

A total of 45 participants (3 groups of 15 participants each) took part in the study. Group A comprised of 2 males and 13 females (1:6.5 ratio), Group B comprised of 3 males and 12 females (1:4 ratio) and Group C comprised of 5 males and 10 females (1:2 ratio).

The ages of Group A's participants ranged between 20 and 26 years of age, with a mean age of 24.13 years. The ages of participants in Group B ranged between 19 and 26 years of age, with a mean age of 23.73 years. The ages of Group C’s participants ranged between 20 and 55 years of age, with the majority of the sample between the ages of 20 and 33 years of age and only one 55 year old participant. The mean age of Group C’s participants was 28.33 years.

The entire participant sample had a mean age of 25.4 years of age. The average lifetime prevalence of neck pain in adults (over 18 years) ranged from 14.2% to 71% (Fejer et al., 2006). This is corroborated by the mean participant age in this study. According to Kalichman and Vulfsons (2010), up to ten percent of the adult population may be affected by myofascial pain at any given time.

5.3 Statistical Analysis of Subjective Data

5.3.1 Vernon-Mior neck pain and disability index

a) Clinical analysis

When the first visit was compared to the seventh visit with regards to the Vernon-Mior neck pain and disability index (VMNPDI), all the groups showed a clinically significant difference. Group A, Group B and Group C all resulted in a decrease in pain and disability over time, although Group B showed the most improvement of 70.44% when compared to the 59.53% of Group A and the 67.28% of Group C (refer to Figure 4-3).
These results indicate that all three interventions were successful in reducing neck pain and disability of the cervical spine.

b) Intragroup analysis

The Paired Sample T-Test was used to determine whether there statistically significant changes over time in the VMNPDI. All the groups demonstrated statistically significant changes over the course of the study.

The Wilcoxon Signed Ranks Test was used to compare the values recorded at the seventh visit with the recorded values of the first visit within each group. All the groups demonstrated a statistically significant difference.

c) Intergroup analysis

The one way ANOVA test was used to determine and reveal any statistically significant intergroup changes in the VMNPDI values between Group A, Group B and Group C at the first and seventh visits. No statistically significant difference was found between all the groups.

5.3.2 Outcomes of subjective data

Vernon-Mior neck pain and disability index: As previously stated, the VMNPDI values for Group A, Group B and Group C indicate a considerable decrease in the participants’ perception of pain as the study progressed. When comparing the VMNPDI values for Group A, Group B and Group C, Group B (MET) showed a much larger improvement over the duration of the study than Group A and Group C (70.44% as opposed to the 59.53% of Group A and the 67.28% of Group C). A statistically significant difference was found in the comparison between the mean VMNPDI values for Group A (p=0.00), Group B (p=0.00) and Group C (p=0.00) at the seventh visit.

All three groups revealed positive clinical and statistical changes over the course of the seven visits. However, comparative intragroup analysis revealed that the participants’ perceived lessening of the pain, or the disability due to pain, was not statistically significant at the seventh visit. This means that none of the groups demonstrated superiority with regards to the participants’ pain perception and disability due to pain. This result suggests that MET, chiropractic manipulations and a combination thereof are equally effective in reducing participant-rated pain and disability in the case of trapezius myofascial trigger points.

A study conducted by Lewit and Simons (1984) on 244 patients presenting with musculoskeletal pain to determine the effect of MET on myofascial pain, found that 94% of the muscles showed an immediate reduction in pain and tenderness. When MET and associated post-isometric techniques are applied to the
spine, several studies have suggested that it results in a reduction of pain, discomfort and disability (Wilson, Payton, Donegan-Shoaf and Dec, 2003).

Joint dysfunction can be caused by several factors. As a result of the tension in pain sensitive structures of the cervical spine and joints, reflexive muscle spasm develop and causes splinting of the joint. This finally causes a reduction in the ROM of that specific joint. The reduction in joint movement also affects the peri-articular structures and results in thickening of the joint capsule, increased capsular tension, shrinking of connective tissues, muscle atrophy and demineralization of bone. This emphasises the importance of why a restricted joint needs to be restored to its proper biomechanical function. A chiropractic manipulation results in the following neurological effects: pain reduction, affecting the conduction of spinal and peripheral nerves to modify sensory and motor function (Gatterman, 2005). According to Wyke (1985), the synovial joint mechanoreceptors can be stimulated by chiropractic manipulations, thus influencing the joint pain via closure of the pain gate.

According to Royah and Okhovatian (2012), MET could have an effect on pain mechanisms and may promote hypoalgesia. This can be explained by the therapeutic actions of MET. When MET is applied to stretch and enhance myofascial tissue extensibility, the viscoelastic and plastic tissue properties, fibroblast mechanotransduction and the extracellular fluid dynamics mediated autonomically appear to be affected. Hypoalgesia and fluid drainage within muscles may be increased with MET. The rhythmic muscle contraction results in an increase in muscle blood and lymph flow rates. The fibroblast within connective tissues experience mechanical forces acting on them, resulting in altered interstitial pressure and increased transcapillary blood flow. A reduction in pro-inflammatory cytokines and the desensitization of peripheral nociceptors may also occur as a result of MET. The application of MET may aid the removal of excess tissue fluid in order to promote hypoalgesia as well as to change the intramuscular pressure and passive tone of the muscle (Royah and Okhovatian, 2012).

Furthermore, MET has been included as a treatment component when dealing with spinal pain in several clinical trials. The results of these trials were a significant reduction in pain and disability. Thus, the effectiveness of MET is supported by these findings (Licciardone et al., 2003; Fryer et al., 2005 and Chrown et al., 2008).

A qualitative study done on the patient’s perspective on powerlessness demonstrated the importance of empowering the patient during and outside of patient care (Day et al., 2010; Aujoulet et al., 2007). MET incorporates active participation of the patient in the treatment technique, thus empowering the patient. This could provide an explanation as to why Group B showed the greatest improvement over the duration of the study.
There are various treatment options available for myofascial pain, however manual therapy is the most basic option available to orthopaedic manual physical therapists (Dommerholt, Bron and Franssen, 2006). Facet dysfunction is usually associated with pain and joint dysfunction, emphasizing the importance of administering treatment that not only decreases the pain but also corrects the underlying dysfunction. According to Gatterman (2005), people with joint dysfunction and muscle splinting experience pain relief mainly due to the co-activation of different mechanoreceptors consequently influencing the neurological input received by the nervous system.

This can provide an explanation for the perceived reduction in pain and disability demonstrated after MET in this study.

5.4 Statistical Analysis of Objective Data

5.4.1 Cervical range of motion

5.4.1.1 Cervical spine flexion

a) Clinical analysis

As shown by Figure 4-5, all three groups demonstrated a clinically significant increase in the mean cervical spine flexion ROM. As the study progressed, the mean flexion values for Group A improved by 15.68%, Group B improved by 16.77% and Group C improved by 19.40%. This therefore indicates that Group C demonstrated the most clinically significant improvement over the course of the study.

These results indicate that all three interventions were successful in increasing the flexion ROM of the cervical spine.

b) Intragroup analysis

The Friedman test was used to determine and expose any statistically significant intragroup changes in the cervical spine flexion over time. All three groups revealed a statistically significant change over the course of the study (Group A: p=0.00, Group B: p=0.01 and Group C: p=0.00).

The Wilcoxon Signed Ranks Test was used to compare the values recorded at the fourth visit with the first visit, the seventh visit with the fourth visit and the seventh visit with the first visit. Comparisons between the first and the fourth visit revealed that only Group A (p=0.03) demonstrated a statistically significant difference. When the seventh visit and the fourth visits were compared, Group A (p=0.01), Group B (p=0.02) and Group C (p=0.00) all showed a statistically significant difference. When the first and seventh
visits were compared, Group A \((p=0.00)\), Group B \((p=0.01)\) and Group C \((p=0.01)\) all showed a statistically significant difference.

c) Intergroup analysis

The one way ANOVA test was used to determine and reveal any statistically significant intergroup changes in the cervical spine flexion between Group A, Group B and Group C and the first, fourth and seventh visits. No statistically significant difference was found between the three groups for the first \((p=0.44)\), fourth \((p=0.32)\) and seventh \((p=0.07)\) visits. This could be due to the fact that all three groups showed a steady increase in the flexion ROM, even though Group C demonstrated a greater improvement from 62.87° to 73.60° when compared to Group A from 59.47° to 67.73° and Group B from 56.87° to 64.00°. This indicates that the treatment in Group C was more effective in improving flexion cervical ROM than it was in Group A and Group B.

The improvement in Group C's cervical flexion ROM could be attributed to the rehabilitation procedure, whereby MET may have caused an increase in the flexibility of the muscles, ligaments and joint capsules. According to Chaitow (2006), MET results in the following physiological effects: potential viscoelastic changes in connective tissues, increasing the stretch tolerance and post isometric relaxation of antagonistic muscles. This could provide an explanation for the resulting ability to stretch the tissues with greater ease and efficiency (Norris, 1999). A study done by Van Schalkwyk and Parkin-Smith (2000) examining how different manipulation techniques would affect mechanical neck pain demonstrated an increase in the mean cervical flexion ROM.

5.4.1.2 Cervical extension

a) Clinical analysis

As shown by Figure 4-7, all three groups demonstrated a clinically significant increase in the mean cervical spine extension ROM. As the study progressed, the mean flexion values for Group A improved by 11.13%, Group B improved by 11.72% and Group C improved by 11.19%. This therefore indicates that Group B demonstrated the most clinically significant improvement over the course of the study.

These results indicate that all three interventions were successful in increasing the extension ROM of the cervical spine.

b) Intragroup analysis

The Friedman test was used to determine and expose any statistically significant intragroup changes in the cervical spine extension over time. Group A \((p=0.00)\) and Group B \((p=0.02)\) revealed a statistically
significant change over the course of the study. No statistically significant difference was revealed by Group C \((p=0.13)\).

The Wilcoxon Signed Ranks Test was used to compare the values recorded at the fourth visit with the first visit, the seventh visit with the fourth visit and the seventh visit with the first visit. Comparisons between the first and the fourth visit revealed that none of the groups demonstrated a statistically significant difference (Group A: \(p=0.06\), Group B: \(p=0.41\) and Group C: \(p=0.20\)). Comparisons between the seventh visit and the fourth visits revealed that Group A \((p=0.01)\) and Group B \((p=0.02)\) showed a statistically significant difference. When the first and seventh visits were compared, all the groups showed a statistically significant difference (Group A: \(p=0.00\), Group B: \(p=0.01\) and Group C: \(p=0.03\)).

c) Intergroup analysis

The one way ANOVA test was used to determine and reveal any statistically significant intergroup changes in the cervical spine extension between Group A, Group B and Group C and the first, fourth and seventh visits. No statistically significant difference was found between the three groups for the first \((p=0.79)\), fourth \((p=0.56)\) and seventh \((p=0.82)\) visits. This could be due to the fact that all three groups showed a steady increase in the extension ROM, even though Group B demonstrated a greater improvement from 56.80° to 62.53° when compared to Group A from 56.93° to 62.67° and Group C from 59.40° to 64.67°. This indicates that the treatment in Group B was more effective in improving extension cervical ROM than it was in Group A and Group C.

The improvement in Group B’s cervical extension ROM could be attributed to the rehabilitation procedure, whereby MET may have caused an increase in the flexibility of the muscles, ligaments and joint capsules. According to Chaitow (2006), MET results in the following physiological effects: potential viscoelastic changes in connective tissues, increasing the stretch tolerance and post-isometric relaxation of antagonistic muscles. This could provide an explanation for the resulting ability to stretch the tissues with greater ease and efficiency (Norris, 1999).

5.4.1.3 Cervical spine right rotation

a) Clinical analysis

As shown by Figure 4-9, all three groups demonstrated a clinically significant increase in the mean cervical spine right rotation ROM. As the study progressed, the mean right rotation values for Group A improved by 16.03%, Group B improved by 9.21% and Group C improved by 8.52%. This therefore indicates that Group A demonstrated the most clinically significant improvement over the course of the study.
These results indicate that all three interventions were successful in increasing the right rotation ROM of the cervical spine.

b) Intragroup analysis

The Friedman test was used to determine and expose any statistically significant intragroup changes in the cervical spine right rotation over time. All three groups revealed a statistically significant change over the course of the study (Group A: \( p=0.00 \), Group B: \( p=0.00 \) and Group C: \( p=0.01 \)).

The Wilcoxon Signed Ranks Test was used to compare the values recorded at the fourth visit with the first visit, the seventh visit with the fourth visit and the seventh visit with the first visit. Comparisons between the first and the fourth visit revealed that only Group A \( (p=0.03) \) showed a statistically significant difference. Comparisons between the seventh visit and the fourth visits revealed that only Group A \( (p=0.01) \) showed a statistically significant difference. When the first and seventh visits were compared, Group A \( (p=0.00) \) and Group B \( (p=0.00) \) demonstrated a statistically significant difference.

c) Intergroup analysis

The one way ANOVA test was used to determine and reveal any statistically significant intergroup changes in the cervical spine right rotation between Group A, Group B and Group C and the first, fourth and seventh visits. No statistically significant difference was found between the three groups for the first \( (p=0.93) \), fourth \( (p=0.94) \) and seventh \( (p=0.52) \) visits. This could be due to the fact that all three groups showed a steady increase in the right rotation ROM, even though Group A demonstrated a greater improvement from \( 64.27^\circ \) to \( 72.53^\circ \) when compared to Group B from \( 65.73^\circ \) to \( 71.47^\circ \) and Group C from \( 64.93^\circ \) to \( 68.93^\circ \). This indicates that the treatment in Group A was more effective in improving right rotation cervical ROM than it was in Group B and Group C.

These results are supported by the study done by Palmgren, Sandstrom, Lundqvist and Heikkila (2006) to examine the effect of chiropractic manipulation on non-traumatic neck pain. This study concluded that chiropractic manipulations increase the cervical spine left and right rotation ROM. Furthermore, Parbhoo (2011) studies the effectiveness of MET and chiropractic manipulation on cervical facet syndrome. He also found that manipulation the neck resulted in increased right rotation of the cervical spine.

5.4.1.4 Cervical spine left rotation

a) Clinical analysis

As shown by Figure 4-11, all three groups demonstrated a clinically significant increase in the mean cervical spine left rotation ROM. As the study progressed, the mean left rotation values for Group A
improved by 14.28%, Group B improved by 11.64% and Group C improved by 18.00%. This therefore indicates that Group C demonstrated the most clinically significant improvement over the course of the study.

These results indicate that all three interventions were successful in increasing the left rotation ROM of the cervical spine.

b) Intragroup analysis

The Friedman test was used to determine and expose any statistically significant intragroup changes in the cervical spine left rotation over time. All three groups revealed a statistically significant change over the course of the study (Group A: p=0.00, Group B: p=0.01 and Group C: p=0.00).

The Wilcoxon Signed Ranks Test was used to compare the values recorded at the fourth visit with the first visit, the seventh visit with the fourth visit and the seventh visit with the first visit. Comparisons between the first and the fourth visit revealed that Group A (p=0.01) and Group C (p=0.02) showed a statistically significant difference. Comparisons between the seventh visit and the fourth visits revealed that only Group C (p=0.03) demonstrated a statistically significant difference. When the first and seventh visits were compared, all three groups demonstrated a statistically significant difference (Group A: p=0.00, Group B: p=0.01 and Group C: p=0.00).

c) Intergroup analysis

The one way ANOVA test was used to determine and reveal any statistically significant intergroup changes in the cervical spine left rotation between Group A, Group B and Group C and the first, fourth and seventh visits. No statistically significant difference was found between the three groups for the first (p=0.44), fourth (p=0.44) and seventh (p=0.61) visits. This could be due to the fact that all three groups showed a steady increase in the left rotation ROM, even though Group C demonstrated a greater improvement from 59.87° to 69.33° when compared to Group A from 64.00° to 71.60° and Group B from 63.87° to 69.73°. This indicates that the treatment in Group C was more effective in improving left rotation cervical ROM than it was in Group A and Group B.

These results are supported by the study done by Palmgren, Sandstrom, Lundqvist and Heikkila (2006) to examine the effect of chiropractic manipulation on non-traumatic neck pain. This study concluded that chiropractic manipulations increase the cervical spine left and right rotation ROM. Furthermore, Parbhoo (2011) studies the effectiveness of MET and chiropractic manipulation on cervical facet syndrome. He also found that manipulation the neck resulted in increased right rotation of the cervical spine.
5.4.1.5 Cervical spine right lateral flexion

a) Clinical analysis

As demonstrated by Figure 4-13, all three groups demonstrated a clinically significant increase in the mean cervical spine right lateral flexion ROM. As the study progressed, the mean right lateral flexion values for Group A improved by 7.42%, Group B improved by 16.52% and Group C improved by 19.17%. This therefore indicates that Group C demonstrated the most clinically significant improvement over the course of the study.

These results indicate that all three interventions were successful in increasing the right lateral flexion range of motion of the cervical spine.

b) Intragroup analysis

The Friedman test was used to determine and expose any statistically significant intragroup changes in the cervical spine right lateral flexion over time. Group B \( (p=0.00) \) and Group C \( (p=0.00) \) revealed a statistically significant change over the course of the study.

The Wilcoxon Signed Ranks Test was used to compare the values recorded at the fourth visit with the first visit, the seventh visit with the fourth visit and the seventh visit with the first visit. Comparisons between the first and the fourth visit revealed that Group B \( (p=0.04) \) and Group C \( (p=0.01) \) showed a statistically significant difference. Comparisons between the seventh visit and the fourth visits revealed that none of the groups demonstrated a statistically significant difference. When the first and seventh visits were compared, only Group B \( (p=0.00) \) demonstrated a statistically significant difference.

c) Intergroup analysis

The one way ANOVA test was used to determine and reveal any statistically significant intergroup changes in the cervical spine right lateral flexion between Group A, Group B and Group C and the first, fourth and seventh visits. No statistically significant difference was found between the three groups for the first \( (p=0.16) \), fourth \( (p=0.41) \) and seventh \( (p=0.46) \) visits. This could be due to the fact that all three groups showed a steady increase in the right lateral flexion ROM, even though Group C demonstrated a greater improvement from 38.80° to 44.27° when compared to Group A from 44.53° to 46.13° and Group B from 37.60° to 42.67°. This indicates that the treatment in Group C was more effective in improving right later flexion cervical ROM than it was in Group A and Group B.

Fryer and Ruszkowski (2004) concluded that using MET consisting of a 5 second contraction phase, resulted in a greater increase in the restricted direction of a restricted joint. Therefore, the mobility of
specific restricted joints is affected by MET significantly. The mechanical effects of manual therapy, i.e. MET and chiropractic manipulations consist of changes in: joint alignment, dysfunction and the dynamics of spinal curvatures. The derangement of the somatic structures of the body that have altered joint function respond well to the mechanical effects of the chiropractic manipulations (Gatterman, 2005), while MET aims to normalize muscular imbalances to a point of homeostatic function (Chaitow, 2006).

5.4.1.6 Cervical spine left lateral flexion

a) Clinical analysis

As demonstrated by Figure 4-15, all three groups demonstrated a clinically significant increase in the mean cervical spine left lateral flexion ROM. As the study progressed, the mean left lateral flexion values for Group A improved by 9.73%, Group B improved by 12.13% and Group C improved by 18.33%. This therefore indicates that Group C demonstrated the most clinically significant improvement over the course of the study.

These results indicate that all three interventions were successful in increasing the left lateral flexion ROM of the cervical spine.

b) Intragroup analysis

The Friedman test was used to determine and expose any statistically significant intragroup changes in the cervical spine left lateral flexion over time. All three groups revealed a statistically significant change over the course of the study (Group A: \( p=0.05 \), Group B: \( p=0.02 \) and Group C: \( p=0.02 \)).

The Wilcoxon Signed Ranks Test was used to compare the values recorded at the fourth visit with the first visit, the seventh visit with the fourth visit and the seventh visit with the first visit. Comparisons between the first and the fourth visit revealed that only Group C (\( p=0.01 \)) showed a statistically significant difference. Comparisons between the seventh visit and the fourth visits revealed that Group B (\( p=0.01 \)) and Group C (\( p=0.04 \)) showed a statistically significant difference. When the first and seventh visits were compared, Group B (\( p=0.01 \)) and Group C (\( p=0.01 \)) demonstrated a statistically significant difference.

c) Intergroup analysis

The one way ANOVA test was used to determine and reveal any statistically significant intergroup changes in the cervical spine left lateral flexion between Group A, Group B and Group C and the first, fourth and seventh visits. No statistically significant difference was found between the three groups for the first (\( p=0.33 \)), fourth (\( p=0.53 \)) and seventh (\( p=0.65 \)) visits. This could be due to the fact that all three groups showed a steady increase in the left lateral flexion ROM, even though Group C demonstrated a greater
improvement from 37.80° to 44.13° when compared to Group A from 42.53° to 45.07° and Group B from 37.73° to 42.00°. This indicates that the treatment in Group C was more effective in improving left lateral flexion cervical ROM than it was in Group A and Group B.

Fryer and Ruszkowski (2004) concluded that using MET consisting of a 5 second contraction phase, resulted in a greater increase in the restricted direction of a restricted joint. Therefore, the mobility of specific restricted joints is affected by MET significantly. The mechanical effects of manual therapy, i.e. MET and chiropractic manipulations consist of changes in: joint alignment, dysfunction and the dynamics of spinal curvatures. The derangement of the somatic structures of the body that have altered joint function respond well to the mechanical effects of the chiropractic manipulations (Gatterman, 2005), while MET aims to normalize muscular imbalances to a point of homeostatic function (Chaitow, 2006).

5.4.2 Pressure algometer

a) Clinical analysis

As shown in Figure 4-17, all three groups demonstrated a clinically significant increase in the mean pressure algometer values. As the study progressed, the mean pressure algometer values for Group A improved by 24.94%, Group B improved by 45.45% and Group C improved by 23.73%. This therefore indicates that Group B demonstrated the most clinically significant improvement over the course of the study.

These results indicate that all three interventions were successful in increasing the pain pressure threshold over the trapezius muscle.

b) Intragroup analysis

The Friedman test was used to determine and expose any statistically significant intragroup changes in the pain pressure threshold over time. All three groups revealed a statistically significant change over the course of the study (Group A: \( p=0.01 \), Group B: \( p=0.00 \) and Group C: \( p=0.03 \)).

The Wilcoxon Signed Ranks Test was used to compare the values recorded at the fourth visit with the first visit, the seventh visit with the fourth visit and the seventh visit with the first visit. Comparisons between the first and the fourth visit revealed that only Group B (\( p=0.01 \)) showed a statistically significant difference. Comparisons between the seventh visit and the fourth visits revealed that Group A (\( p=0.01 \)) and Group B (\( p=0.01 \)) showed a statistically significant difference. When the first and seventh visits were compared, all three groups demonstrated a statistically significant difference (Group A: \( p=0.02 \), Group B: \( p=0.00 \) and Group C: \( p=0.02 \)).
c) Intergroup analysis

The one way ANOVA test was used to determine and reveal any statistically significant intergroup changes in the pain pressure threshold between Group A, Group B and Group C and the first, fourth and seventh visits. No statistically significant difference was found between the three groups for the first (p=0.59), fourth (p=0.22) and seventh (p=0.43) visits. This could be due to the fact that all three groups showed a steady increase in the pain pressure threshold, even though Group B demonstrated a greater improvement from 2.80 kg.cm\(^{-2}\) to 3.78 kg.cm\(^{-2}\) when compared to Group A from 2.86 kg.cm\(^{-2}\) to 3.43 kg.cm\(^{-2}\) and Group C from 3.04 kg.cm\(^{-2}\) to 3.68 kg.cm\(^{-2}\). This indicates that the treatment in Group B was more effective in improving pain pressure threshold than it was in Group A and Group C.

5.4.3 Outcomes of objective data

Cervical spine range of motion: Analysis of the percentage change in the cervical spine ROM values revealed that all three groups demonstrated an increase in the ROM of the cervical spine over the course of the study. This suggests that MET, chiropractic manipulation and a combination treatment can be considered as an effective means to improve cervical spine ROM. Intragroup analysis showed that statistically significant differences were found in all ROM and all groups, except for extension of Group C and right lateral flexion of Group A. When the visits are compared over time, it becomes evident that the most improvement occurred when the fourth and seventh visits and first and seventh visits are compared. The results of which group improved the most with the different ranges of motion varies. However, when all ROM are considered, the combination treatment of Group C was superior to the treatment received by Group A and Group B with regards to cervical spine ROM. These results suggest that a combination treatment consisting of MET and chiropractic manipulation is more effective than MET and chiropractic manipulation alone in increasing cervical spine ROM in the case of upper trapezius MFTPs.

According to Baldy (2002), pain and the failure of a muscle containing active MFTPs to stretch fully could limit the ROM. A restriction in movement may be linked to muscle hypertonicity as joint dysfunction (Bergmann and Peterson, 2011). Inactivation of a MFTP and the release of the taut band will result in normal ROM (Travell and Simons, 1999). Fryer and Ruszkowski (2004) concluded that using MET consisting of a 5 second contraction phase, resulted in a greater increase in the restricted direction of a restricted joint. Therefore, the mobility of specific restricted joints is affected significantly by MET. The mechanical effects of manual therapy, i.e. MET and chiropractic manipulations consist of changes in: joint alignment, dysfunction and the dynamics of spinal curvatures. The derangement of the somatic structures of the body that have altered joint function respond well to the mechanical effects of the chiropractic manipulations (Gatterman, 2005), while MET aims to normalize muscular imbalances to a point of homeostatic function (Chaitow, 2006).
Hvid (1963) and Yeomans (1992) have been investigating changes in active ROM following a series of manipulations, using functional radiography. Both of them reported a significant increase in active flexion and extension after approximately 6 to 8 weeks of chiropractic manipulations. Whittingham and Nilsson (2001) also assessed the effect of chiropractic manipulation on active cervical spine ROM. They concluded that 3 weeks of treatment resulted in significant increases in cervical spine rotation and lateral flexion. Paton (2013) investigated the effect of chiropractic manipulation on the ROM of the cervical spine after a 24 hour period. He reported a statistically significant increase in all ROM of the cervical spine post-manipulation.

Muscles that cross more one joint are more likely to become tight and hypertonic. If the hypertonic musculature, containing MFTPs, is not resolved it could modify or limit the normal ROM. A few studies have demonstrated that MET can result in increased ROM in the cervical, thoracic and lumbar spines (Shenk, Adelman and Rouselle, 1994; Lenehan, Fryer and McLaughlin, 2003; Fryer and Ruszkowski, 2004). Provided that an increase was only reported with active spinal ROM, it could be suggested that this increase occurred as a result of a change in the stretch intolerance. Joint and muscle mechanoreceptors and proprioceptors are stimulated by stretching and isometric contractions. Pain inhibition at the level of the dorsal horn of the spinal cord results from the stimulation of large diameter mechanoreceptors. When MET is applied, the patients may experience a reduction in the perceived muscle pain as well as producing long-term changes in the stretch tolerance. This may account for the increase in cervical spine ROM seen in this study (Chaitow, 2006).

Another possible explanation for the increase in cervical ROM during MET treatment could be as a result of the post-isometric relaxation of the muscle. Ward (2003) explained that the main goal of post-isometric relaxation is to achieve muscle relaxation. When the muscle tone of a muscle or group of muscles decreases after an isometric contraction, it is referred to as post isometric relaxation. Passive stretching can be carried out during this relaxed refractory period. An increase in tension during muscle contraction is detected by the proprioceptors of the golgi organ tendon, which then activates a reflex neurological loop resulting in inhibition or a post isometric relaxation effect in that muscle (Chaitow, 2006). Post isometric relaxation is the cornerstone of numerous effective MFTP release techniques. Gentle muscle contraction seems to restore the sarcomere lengths in the fibers affected by MFTPs. Sarcomeres within the taut bands are maximally shortened, thus they cannot contract any more. Nevertheless, the sarcomeres found between the MFTP and the attachments of the muscle fibers are in the most favourable state for muscle contraction. Thus gentle voluntary contractions allow the sarcomeres that are lengthened to apply an effective elongation force on the shortened sarcomeres of the MFTP and result in alleviation of the MFTP (Simons, 2002).
Travell and Simons (1999) claim that it might be helpful to stretch a muscle with MFTPs seeing as stretching could release the contraction knot and cause the blood flow to the area to increase. Consequently, stretching of the MFTP and the increased blood flow might explain the therapeutic effects of post-isometric relaxation and thus the increase in cervical ROM seen in this study as the upper trapezius muscle was in a state of muscle relaxation.

Connective tissues can be described as being viscoelastic when they contain mechanical characteristics that relates to their fluid or gel components and elastic properties. When a tissue is continuously stretched, it responds with ‘creep’ or rather slow elongation. The tissue ‘creep’ causes a loss of energy (hysteresis), thus repetitive loads placed on the tissue will produce greater deformation. Similar reductions in tissue tensions have been produced by isometric muscle contractions and stretching. Passive stretching alone is not affective enough to produce the same viscoelastic change as that produced by contractions and stretching techniques (as used in MET). Combining the forces may result in greater viscoelastic change and passive extensibility. The length and stiffness of the involved tissue may also be altered as the stretch and isometric contractions also affect the water content. Consequently MET may aid in the realignment of maturing connective tissues along the lines of forces as well as breaking weakly aligned cross linkages (Chaitow, 2006). This could also provide a possible explanation for the increase in cervical spine range of motion seen in this study as MET of the upper trapezius muscle may have decreased the tissue tension within the muscle.

Increases in spinal ROM following MET have been demonstrated by a few studies (Chaitow, 2006). A study done by Shenk et al. (1994) that investigated the effects of multiple MET sessions on cervical spine ROM over a four week period found that there was a significant increase in the cervical ROM. MET was also applied to the thoracic spine in the direction of the restricted rotation and subsequently resulted in a significant increase in active trunk rotation range (Shenk et al., 1994). Lenahan et al. (2003) found that a single MET isometric contraction resulted in increased thoracic rotation. Fryer and Ruszkowski (2004) did a study to determine the effect of a single MET application to a rotational restriction of the atlanto-axial joint in the cervical spine. They concluded that MET treatment resulted in a significant increase in the restricted direction.

When looking at ROM as a whole, it appears that Group C improved the most overall. This could be due to the fact that the chiropractic manipulation restored the joint biomechanics and the MET treatment restored upper trapezius muscle length and elasticity. This may account for the statistical superiority of Group C when compared to Group A and Group B over the course of the study.

**Pressure algometer:** Analysis of the percentage change in the pain pressure threshold values revealed that all three groups responded positively to the administered treatment however, Group B showed a slight
clinical superiority over the duration of the study. Therefore, the results suggest that all three treatment methods were effective in increasing the pain pressure threshold values. Intragroup analysis showed statistically significant differences with regards to pain pressure threshold values in Group A, Group B and Group C. Intergroup analysis showed no statistically significant difference in the mean pain pressure threshold values of the three groups throughout the study. The results suggest that all three treatments are equally effective in increasing the pain pressure threshold values in the case of the upper trapezius MFTPs.

Chiropractic manipulation has shown to cause a reduction in pain and disability. Bergmann and Peterson (2011) suggested that enough force can be induced by a chiropractic manipulation to activate both superficial and deep mechanoreceptors, proprioceptors and nociceptors. This could result in stimulus-induced analgesia. Central transmission of pain is inhibited as this stimulation generates a bombardment of strong sensory afferent impulses. Evidence from Haldeman (2000) showed that patients receiving chiropractic manipulation reported a greater pain relief than with other treatment methods. These findings however can also be explained by the psycho-physiological mechanism and might not be due to the effects of chiropractic manipulation on pain relief.

A study done to investigate how the pain pressure threshold of latent MFTPs in the upper trapezius was affected by a single cervical spine manipulation found that there was an increase in the treatment group receiving chiropractic manipulation to the C3 and C4 spinal segments. The control group showed a decrease in the pain pressure threshold levels after receiving a sham manipulation (Ruiz-Saez et al., 2007).

In another case study, the average pain pressure threshold levels of six sensitive and tender areas in the neck increased after receiving chiropractic manipulation (Pickar, 2002). Many mechanisms have been suggested to explain the neurophysiological mechanism by which chiropractic manipulation may result in changes in the pain pressure threshold in MFTPs. A reduction of chemical algogenic mediators, activation of segmental inhibitory pathways and/or activation of central descending inhibitory pathways has been proposed (Ruiz-Saez et al., 2007).

Dearing and Hamilton (2007) investigated the effect of MET and ischaemic compression on pain pressure threshold of MFTPs. They concluded that both MET and ischaemic compression resulted in a reduction in pain sensitivity at the MFTPs found in the upper trapezius muscle.

The neurophysiological effects of a chiropractic manipulation include pain inhibition, muscle relaxation as well as stimulation of the autonomic nervous system (Gatterman, 1990). The various autonomic nervous system reactions include vasomotor changes, pseudo motor activity and changes in visceral control. This occurs as a result of the stimulation of the spinal nerves as they exit the intervertebral foramen. This
stimulation in turn inhibits the pain gate mechanism which causes pain inhibition and muscle relaxation of nerves related to the areas that have been manipulated (Bergman et al., 1993; Esposito and Philipson, 2005).

The precise mechanism by which MET causes an increase in the pain pressure threshold is still uncertain, and could possibly involve both mechanical and neurophysiological factors (i.e. plastic and viscoelastic changes) in the muscle’s connective tissue elements (Royah and Okhovatian, 2012). Dearing and Hamilton (2007) investigated the effect of MET and ischaemic compression on pain pressure threshold of MFTPs. They concluded that both MET and ischaemic compression resulted in a reduction in pain sensitivity at the MFTPs found in the upper trapezius muscle.

Passive stretching alone is not effective enough to produce the same viscoelastic change than that produced by contractions and stretching techniques (as used in MET). Combining the forces may result in greater viscoelastic change and passive extensibility. The length and stiffness of the involved tissue may also be altered as the stretch and isometric contractions also affect the water content. Consequently MET may aid in the realignment of maturing connective tissues along the lines of forces as well as breaking weakly aligned cross linkages (Chaitow, 2006).

When MET is applied, the patients may experience a reduction in the perceived muscle pain as well as producing long-term changes in the stretch tolerance. Pain inhibition at the level of the dorsal horn of the spinal cord results from the stimulation of large diameter mechanoreceptors (Chaitow, 2006).

When the muscle tone of a muscle or group of muscles decreases after an isometric contraction, it is referred to as post-isometric relaxation. Passive stretching can be carried out during this relaxed refractory period. An increase in tension during muscle contraction is detected by the proprioceptors of the golgi organ tendon, which then activates a reflex neurological loop resulting in inhibition or a post isometric relaxation effect in that muscle (Chaitow, 2006). Post isometric relaxation is the cornerstone of numerous effective MFTP release techniques. Gentle muscle contraction seems to restore the sarcomere lengths in the fibers affected by MFTPs. Sarcomeres within the taut bands are maximally shortened, thus they cannot contract any more. Nevertheless, the sarcomeres found between the MFTP and the attachments of the muscle fibers are in the most favourable state for muscle contraction. Thus gentle voluntary contractions allow the sarcomeres that are lengthened to apply an effective elongation force on the shortened sarcomeres of the MFTP and result in alleviation of the MFTP (Simons, 2002). MFTP deactivation will decrease pain and cause an increase in the pain pressure threshold (Hong, 1994). This may explain why Group B showed the greatest improvement in pain pressure threshold values. Group B was slightly clinically superior to Group A and Group C with regards to pain pressure threshold values.
5.5 Conclusion of results

It can be concluded, based on the results, that a combination treatment of chiropractic manipulation and MET was more effective than chiropractic manipulation and MET individually in the treatment of upper trapezius myofascial pain. This conclusion is based on the results showing that the combination treatment was more effective in the majority of the objective measurements. This, however, does not rule out MET and chiropractic manipulations individually as a treatment protocol for myofascial pain, as both treatments did demonstrate improvements in the ROM of the cervical spine and a reduction in pain, although not as efficiently as in the combination treatment. The results obtained also showed that this treatment approach requires a minimum of four sessions. Only then will a statistically significant improvement will occur. Patients should be made aware of the time-frame required to alleviate their symptoms and to show significant results.
6.1 Introduction

This chapter serves to summarise and conclude the outcomes of the study. A conclusion was made with regards to the data and results illustrated in chapter 4 and discussed in chapter 5. Recommendations have been made and may be helpful to the practitioner or person who intends to add to this study.

6.2 Conclusion

This study was performed on forty-five participants, all of which had to present with active MFTPs in the upper trapezius muscles after an extensive examination was performed. Random allocation divided the participants into three groups of fifteen each. Group A received chiropractic manipulations to the cervical spine, Group B received MET on the upper trapezius muscle and Group C received a combination treatment.

From the analysis of the data gathered in this trial, it is evident that the participants of all three groups responded well to their respective treatments.

Objective measurements consisted of cervical spine ROM measurements as well as the pressure algometer readings. With regards to cervical spine ROM: in the intragroup analysis, Group A displayed a statistically significant difference in flexion, extension, left and right rotation and left lateral flexion and did not show a statistically significant difference in right lateral flexion. Group B displayed a statistically significant difference in all ROM of the cervical spine. Group C displayed a statistically significant difference in flexion, left and right rotation and left and right lateral flexion and did not show a statistically significant difference in extension. With regards to the pain pressure threshold values: in the intragroup analysis, Group A, Group B and Group C displayed a statistically significant difference in the pressure algometer measurements.

In terms of the subjective measurements in the intragroup analysis, Group A, Group B and Group C all displayed a statistically significant difference in the Vernon-Mior neck pain and disability index.

In terms of the objective measurements with regards to cervical spine ROM, the intergroup analysis revealed that Group A, Group B and Group C all showed no statistically significant difference between the first and final visits in all of the cervical ROM measurements. However, Group C resulted in a greater increase in most of the ROM when compared to Group A and Group B. With regards to the pain pressure
threshold values, the intergroup analysis revealed that Group A, Group B and Group C all displayed no statistically significant difference in the pressure algometer measurements.

In terms of the subjective measurements in the intergroup analysis, Group A, Group B and Group C all showed no statistically significant difference between the first and final visits in the Vernon-Mior neck pain and disability index. However, Group B resulted in a greater increase in the average pain rating values.

The aim of the study was to determine whether Muscle Energy Technique (MET) of the upper trapezius muscle or chiropractic manipulation of the cervical spine is better used alone or in combination with each other for the treatment of upper trapezius myofascial pain. The combination group (Group C) showed statistically significant improvements at visit 7 with regards to cervical spine ROM, thus it can be stated that a combination of cervical spine chiropractic manipulation and MET is more effective in increasing the cervical spine ROM. These results, however, only apply to the CROM readings and not to the rest of the subjective and objective data. Thus it can be concluded that no group’s treatment protocol is more effective than the other at affecting the subjective data and the pain pressure threshold aspect of the objective data.

Although none of the groups showed a statistically significant difference with regards to the majority of the objective and subjective data, the results of this study have shown that the MET treatment only demonstrated a highly effective response in lowering the participant's perceived pain and pain pressure threshold values. This emphasises that MET alone is an effective means of treatment for patients expressing high pain levels. It will thus only make the participant feel better without providing objective evidence of improvement.

6.3 Recommendations

The following are some of the recommendations that could improve future related research:

- A much larger population sample to determine to what extent the combination group or the chiropractic group alone has an effect on the patients suffering with upper trapezius myofascial pain.

- The study can be repeated with equal male to female ratios to determine which sex responds better to the MET and chiropractic manipulation treatment.

- A study where MET is used post-needling on post-needling soreness.
• Repetition of the study for a longer duration with increased frequency of treatments. A minimum of 12 sessions would be required in order to gather sufficient data, which will give better insight into the use of MET and chiropractic manipulations in the treatment of upper trapezius myofascial pain.

• A study to determine how long the perceived reduction in pain lasts after MET treatment.

• Incorporating a flexicurve measurement of the cervical spine before the initial consultation and after the last consultation to assess the effect of MET and chiropractic manipulation on anterior head carriage associated with upper trapezius myofascial trigger points.

• A study where another treatment, such as Neuromuscular Technique (NMT), is used in comparison to chiropractic manipulations for the treatment of upper trapezius myofascial pain.
REFERENCES


APPENDICES

APPENDIX A: ADVERTISEMENT

RESEARCH

CERVICAL SPINE MANIPULATION AND MUSCLE ENERGY TECHNIQUE IN THE TREATMENT OF UPPER TRAPEZIUS MYOFASCIAL PAIN

Do you have lower neck pain?
Do you sit at a desk for long periods of time?

Are you between the ages of 18 and 55?

If you answered yes, you are invited to take part in my research study. (REC-01-39-2016)

WHERE: University of Johannesburg Doornfontein Campus
Gate 7, Sherwell Road

Please contact Vicki Ferreira on 083 288 0679 if you would like to be part of this study
DEPARTMENT OF CHIROPRACTIC

RESEARCH STUDY INFORMATION LETTER

Date: ____________________________

Good Day

My name is Vicki Ferreira I WOULD LIKE TO INVITE YOU TO PARTICIPATE in a research study on cervical spine manipulation and muscle energy technique in the treatment of upper trapezius myofascial pain.

Before you decide on whether to participate, I would like to explain to you why the research is being done and what it will involve for you. I will go through the information letter with you and answer any questions you have. This should take about 10 to 20 minutes. The study is part of a research project being completed as a requirement for a Master's Degree in Chiropractic through the University of Johannesburg.

THE PURPOSE OF THIS STUDY is to compare cervical spine manipulation and muscle energy technique in the treatment of upper trapezius pain.

Below, I have compiled a set of questions and answers that I believe will assist you in understanding the relevant details of participation in this research study. Please read through these. If you have any further questions I will be happy to answer them for you.

DO I HAVE TO TAKE PART? No, you don't have to. It is up to you to decide to participate in the study. I will describe the study and go through this information sheet. If you agree to take part, I will then ask you to sign a consent form.
WHAT EXACTLY WILL I BE EXPECTED TO DO IF I AGREE TO PARTICIPATE? If you agree to be part of this study, you will be required to be available for 7 consultations over a 2 week period. You will draw a card from a container that will have either Group A, Group B or Group C on it. Group A will receive chiropractic manipulation to the cervical spine, Group B will receive muscle energy technique to the upper trapezius and Group C will receive a combination treatment.

WHAT WILL HAPPEN IF I WANT TO WITHDRAW FROM THE STUDY? If you decide to participate, you are free to withdraw your consent at any time without giving a reason and without any consequences. If you wish to withdraw your consent, you must inform me as soon as possible.

IF I CHOOSE TO PARTICIPATE, WILL THERE BE ANY EXPENSES FOR ME, OR PAYMENT DUE TO ME: No. Participation in the study is completely voluntary and all the treatment administered will be free of charge.

RISKS INVOLVED IN PARTICIPATION: Chiropractic manipulations are part of routine chiropractic care, but there is a slight risk of discomfort such as post-adjustment stiffness.

BENEFITS INVOLVED IN PARTICIPATION: A reduction in pain as well as an increase in neck range of motion is the biggest benefits in this study. This study will also help to establish a more effective treatment protocol to treat patients with muscle-related neck pain and who is not comfortable with having dry needling.

WILL MY PARTICIPATION IN THIS STUDY BE KEPT CONFIDENTIAL? Yes. Names on the questionnaire/data sheet will be removed once analysis starts. All data and back-ups thereof will be kept in password protected folders and/or locked away as applicable. Only I or my research supervisor will be authorised to use and/or disclose your anonymised information in connection with this research study. Any other person wishing to work with your anonymised information as part of the research process (e.g. an independent data coder) will be required to sign a confidentiality agreement before being allowed to do so.

WHAT WILL HAPPEN TO THE RESULTS OF THE RESEARCH STUDY? The results will be written into a research report that will be assessed. In some cases, results may also be published in a scientific journal. In either case, you will not be identifiable in any documents, reports or publications. You will be given access to the study results if you would like to see them, by contacting me.

WHO IS ORGANISING AND FUNDING THE STUDY? The study is being organised by me, under the guidance of my research supervisor at the Department of Chiropractic in the University of Johannesburg. The cost involved in this study will be covered by the supervisor linked bursary from the University of Johannesburg.
WHO HAS REVIEWED AND APPROVED THIS STUDY? Before this study was allowed to start, it was reviewed in order to protect your interests. This review was done first by the Department of Chiropractic, and then secondly by the Faculty of Health Sciences Research Ethics Committee at the University of Johannesburg. In both cases, the study was approved.

WHAT IF THERE IS A PROBLEM? If you have any concerns or complaints about this research study, its procedures or risks and benefits, you should ask me. You should contact me at any time if you feel you have any concerns about being a part of this study. My contact details are:

Vicki Ferreira
083 288 0679
v.ferreir.chiro@gmail.com

You may also contact my research supervisor:

Dr. D.M Landman
dirkiel@uj.ca.za

If you feel that any questions or complaints regarding your participation in this study have not been dealt with adequately, you may contact the Chairperson of the Faculty of Health Sciences Research Ethics Committee at the University of Johannesburg:

Prof. Marie Poggenpoel
Tel: 011 559-6686
Email: mariep@uj.ac.za

FURTHER INFORMATION AND CONTACT DETAILS: Should you wish to have more specific information about this research project information, have any questions, concerns or complaints about this research study, its procedures, risks and benefits, you should communicate with me using any of the contact details given above.

Researcher: Vicki Ferreira

UJ Ethics Clearance number: REC-01-39-2016
APPENDIX C: CONSENT FORM

DEPARTMENT OF CHIROPRACTIC

RESEARCH CONSENT FORM

Cervical Spine Manipulation and Muscle Energy Technique in the Treatment of Upper Trapezius Myofascial Pain

Please initial each box below:

☐ I confirm that I have read and understand the information letter dated ______/_____/______ for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.

☐ I understand that my participation is voluntary and that I am free to withdraw from this study at any time without giving any reason and without any consequences to me.

☐ I agree to take part in the above study.

________________            _________________________
Name of Participant        Signature of Participant         Date

__________________  ____________________
Name of Researcher                 Signature of Researcher          Date
APPENDIX D: VERNON-MIOR NECK PAIN AND DISABILITY INDEX (Vernon and Mior, 1991)

Neck Disability Index

Participant number: ______________________ Date: ______________________

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

<table>
<thead>
<tr>
<th>Section 1: Pain Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ I have no pain at the moment</td>
</tr>
<tr>
<td>□ The pain is very mild at the moment</td>
</tr>
<tr>
<td>□ The pain is moderate at the moment</td>
</tr>
<tr>
<td>□ The pain is fairly severe at the moment</td>
</tr>
<tr>
<td>□ The pain is very severe at the moment</td>
</tr>
<tr>
<td>□ The pain is the worst imaginable at the moment</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section 2: Personal Care (Washing, Dressing, etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ I can look after myself normally without causing extra pain</td>
</tr>
<tr>
<td>□ I can look after myself normally but it causes extra pain</td>
</tr>
<tr>
<td>□ It is painful to look after myself and I am slow and careful</td>
</tr>
<tr>
<td>□ I need some help but can manage most of my personal care</td>
</tr>
<tr>
<td>□ I need help every day in most aspects of self care</td>
</tr>
<tr>
<td>□ I do not get dressed, I wash with difficulty</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section 3: Lifting</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ I can lift heavy weights without extra pain</td>
</tr>
<tr>
<td>□ I can lift heavy weights but it gives extra pain</td>
</tr>
<tr>
<td>□ Pain prevents me lifting heavy weights off the floor but I can manage if they are conveniently placed, for example on a table</td>
</tr>
<tr>
<td>□ Pain prevents me lifting heavy weights off the floor but I can manage light to medium weights if they are conveniently placed</td>
</tr>
<tr>
<td>□ I can only lift very light weights</td>
</tr>
<tr>
<td>□ I cannot lift or carry anything</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section 4: Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ I can read as much as I want to with no pain in my neck</td>
</tr>
<tr>
<td>□ I can read as much as I want to with slight pain in my neck</td>
</tr>
<tr>
<td>Section 5: Headaches</td>
</tr>
<tr>
<td>-------------------------------------</td>
</tr>
<tr>
<td>□ I have no headaches at all</td>
</tr>
<tr>
<td>□ I have slight headaches, which come infrequently</td>
</tr>
<tr>
<td>□ I have moderate headaches, which come infrequently</td>
</tr>
<tr>
<td>□ I have moderate headache, which come frequently</td>
</tr>
<tr>
<td>□ I have severe headaches, which come frequently</td>
</tr>
<tr>
<td>□ I have headaches almost all the time</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section 6: Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ I can concentrate fully when I want to with no difficulty</td>
</tr>
<tr>
<td>□ I can concentrate fully when I want to with slight difficulty</td>
</tr>
<tr>
<td>□ I have a fair degree of difficulty in concentrating when I want to</td>
</tr>
<tr>
<td>□ I have a lot of difficulty in concentrating when I want to</td>
</tr>
<tr>
<td>□ I have a great deal of difficulty in concentrating when I want to</td>
</tr>
<tr>
<td>□ I cannot concentrate at all</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section 7: Work</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ I can do as much work as I want to</td>
</tr>
<tr>
<td>□ I can only do my usual work, but no more</td>
</tr>
<tr>
<td>□ I can do most of my usual work, but no more</td>
</tr>
<tr>
<td>□ I cannot do my usual work</td>
</tr>
<tr>
<td>□ I can hardly do any work at all</td>
</tr>
<tr>
<td>□ I can’t do any work at all</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section 8: Driving</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ I can drive my car without any neck pain</td>
</tr>
<tr>
<td>□ I can drive my car as long as I want with slight pain in my neck</td>
</tr>
<tr>
<td>□ I can drive my car as long as I want with moderate pain in my neck</td>
</tr>
<tr>
<td>□ I can’t drive my car as long as I want because of moderate pain in my neck</td>
</tr>
<tr>
<td>□ I can hardly drive at all because of severe pain in my neck</td>
</tr>
<tr>
<td>□ I can’t drive my car at all</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section 9: Sleeping</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ I have no trouble sleeping</td>
</tr>
<tr>
<td>□ My sleep is slightly disturbed (less than 1 hr sleepless)</td>
</tr>
</tbody>
</table>
- My sleep is mildly disturbed (1-2 hrs sleepless)
- My sleep is moderately disturbed (2-3 hrs sleepless)
- My sleep is greatly disturbed (3-5 hrs sleepless)
- My sleep is completely disturbed (5-7 hrs sleepless)

**Section 10: Recreation**

- 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 can’t do any recreation activities at all

Total score:

<table>
<thead>
<tr>
<th>Section</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</tbody>
</table>
APPENDIX E: DATA COLLECTION FORM

Participant Number: ____________________________

Visit 1 – Date: ________________

CROM

<table>
<thead>
<tr>
<th>Flexion</th>
<th>Extension</th>
<th>(R) Rotation</th>
<th>(L) Rotation</th>
<th>(R) Lateral Flexion</th>
<th>(L) Lateral Flexion</th>
</tr>
</thead>
</table>

Algometer readings (kg/m²)

Reading 1:  
Reading 2:  
Reading 3:  
Average

Visit 4 – Date: ________________

CROM

<table>
<thead>
<tr>
<th>Flexion</th>
<th>Extension</th>
<th>(R) Rotation</th>
<th>(L) Rotation</th>
<th>(R) Lateral Flexion</th>
<th>(L) Lateral Flexion</th>
</tr>
</thead>
</table>

Algometer readings (kg/m²)

Reading 1:  
Reading 2:  
Reading 3:  
Average
APPENDIX F: CHIROPRACTIC MANIPULATION: POSTERIOR SUPERIOR OCCIPUT

(Esposito and Philipson, 2005)

Static Listing: RPS – LPS Occiput

Dynamic Listing: Right and Left Occiput Rotary restrictions


Doctor Position: Homolateral to the listing in a toggle stance, at right angles to the patient, facing towards the patient.

Contact Hand: Caudad hand. Rotate to 45° before taking contact. Thumb pad contacts on the posterior-inferior aspect of the mastoid. Palmar contact over cheek and mandible, 5th digit inferior to jaw.

Forearm parallel and close to the sternum.

Indifferent Hand: Cephalad hand. Patient’s ear between thumb and index with the palm and remaining fingers supporting the occiput. Index and middle fingers split the SCM.

Technique: Traction cephalad with contact and indifferent hands.

The indifferent hand flexes between occiput and atlas, homolateral to the listing. Contact hand then induces quick rotation to the occiput through the mastoid contact.
APPENDIX G: CHIROPRACTIC MANIPULATION: CERVICAL ROTARY THUMB CONTACT

(Esposito and Philipson, 2005)

Static Listing: RP – LP

Dynamic Listing: Right and Left anterior rotary restrictions (C2 – C7)

Patient Position: Supine. Head-piece in neutral and slightly elevated position.

Doctor Position: At head of patient and slightly towards the lesioned side, at a 45° angle.

Contact Hand: Caudad hand. Palmar aspect of thumb on the articular process of the involved segment. Palm is against the mandible with the fingers pointing cephalad.

Indifferent Hand: Cephalad hand. Cups the ear with the fingers supporting the occiput and slightly flexes the head.

Technique: Rotate the head slightly to get contact on the articular pillar, then bring it back to neutral. Skin slack is removed from posterior to anterior. Laterally flex the cervical spine and rotate the head between 45° - 60° to the point of articular locking.

Thrust is a pectoral impulse in an arc around the axis of the cervical spine.
APPENDIX H: CHIROPRACTIC MANIPULATION: CERVICAL BREAK 1 (Esposito and Philipson, 2005)

Static Listing: RP - LP

Dynamic Listings: Right and Left anterior rotary restrictions (C1 - C7)

Patient Position: Supine. Head-piece in the neutral position.
Head rotated to approximately 45° to the contralateral side.

Doctor Position: On homolateral side to the listing, in a square stance, at right angles to the patient.

Contact Hand: Caudad hand. Index contact on the articular process of involved vertebra.
Forearm parallel to the ground.
Skin slack removed from posterior to anterior.

Indifferent Hand: Cephalad hand. Cup ear with palm. Index and middle finger split the SCM.
Induces lateral flexion and only slight rotation of the patient’s head as well as cephalad traction.

Technique: Break straight across in line with the eyes.
Thrust is a high velocity, low amplitude impulse thrust.
APPENDIX I: CHIROPRACTIC MANIPULATION: CERVICAL BREAK 2 (Esposito and Philipson, 2005)

Static Listing: RI – LI

Dynamic Listing: Right and Left lateral flexion restrictions (C1 – C7)

Patient Position: Supine. Head-piece in the neutral position.

Doctor Position: On homolateral side to the listing, in a square stance, at right angles to the patient.

Contact Hand: Caudad hand. Index contact on the posterior articular process of involved vertebra.

Indifferent Hand: Cephalad hand. Palm cups the ear. Index and middle finger split the SCM. Induces lateral flexion and cephalad traction.

Technique: Break is across and slightly cephalad. Thrust is a high velocity, low amplitude, pectoral thrust.
APPENDIX J: MUSCLE ENERGY TECHNIQUE (Chaitow, 2006)

Method A: MET treatment of chronically shorted upper trapezius

In order to treat all the fibers of upper trapezius, MET needs to be applied sequentially. In this clinical approach upper trapezius is subdivided into anterior, middle and posterior fibers. The flexed neck should be placed into three different positions of rotation (full rotation away from side being treated, half rotation away from side being treated and slight rotation towards the side being treated), always coupled with full side-bending away from the side being assessed, for precise treatment of the posterior, middle and anterior fibers, respectively.

- The patient lies supine, arm on the side to be treated lying alongside the trunk, head / neck side-bent away from the side being treated to just short of the restriction barrier, while the practitioner stabilizes the shoulder with one hand and cups the ipsilateral ear / mastoid area, with the other.
- With the flexed neck fully side-bent, and fully rotated contralaterally, the posterior fibers of the upper trapezius are involved in the contraction (see below).
- This will facilitate subsequent stretching of this aspect of the muscle.
- With the flexed neck fully side-bent, and half rotated, the middle fibers of the upper trapezius are involved in the contraction.
- With the flexed neck fully side-bent and slightly rotated towards the side being treated, the anterior fibers of the upper trapezius are engaged.
- The various contractions and subsequent stretches can be performed with the practitioner’s arms crossed, hands stabilizing the mastoid and shoulder area (see figure 5.35).
- The patient introduces a light resisted effort (20% of the available strength) to take the stabilized shoulder towards the ear (a shrug movement) and the ear towards the shoulder.
- The double movement (or effort towards movement) is important in order to introduce a contraction of the muscle from both ends simultaneously.
- The degree of effort should be mild and no pain should be felt.
- The contraction is sustained for 7 – 10 seconds and, upon complete relaxation of effort, the practitioner gently eases the head / neck into an increased degree of side-bending and rotation, where it is stabilised, as the shoulder is stretched caudally.
- As stretching is introduced, the patient can usefully assist in this phase of the treatment by initiating, on instruction, the stretch of the muscle (‘as you breath out please slide your hand towards your feet’).
- Patient participation in the stretch reduces the chances of a stretch reflex being initiated.
- Once the muscle is in a stretched position, the patient relaxes and the stretch is held for 30 seconds.

CAUTION!!! : No stretch should be introduced from the cranial end of the muscle, as this could stress the neck. The head is stabilized at its side-flexion and rotation barrier.
APPENDIX K: CONTRA-INDICATIONS TO CHIROPRACTIC MANIPULATIONS (Gatterman, 2004)

1. Vascular complications
   - Vertebrobasilar insufficiency
   - Aneurysms

2. Tumours
   - Primary to the bone
   - Secondary (metastasised to the bone)

3. Bone infections
   - Tuberculosis of the spine
   - Osteomyelitis of the spine

4. Traumatic injuries
   - Fractures
   - Joint instabilities
   - Severe sprains or strains
   - Unstable spondylolisthesis

5. Arthritis
   - Ankylosing spondylitis
   - Rheumatoid arthritis
   - Psoriatic arthritis
   - Uncoarthritis
   - Osteoarthritis

6. Psychological considerations
   - Malingering
   - Hysteria
   - Hypochondriasis
   - Pain intolerance

7. Neurological complications
   - Space-occupying lesions
   - Advancing neurological deficit

8. Metabolic disorders
   - Clotting disorders
   - Osteopenia (osteoporosis, osteomalacia)
# APPENDIX L: CASE HISTORY

### CASE HISTORY

<table>
<thead>
<tr>
<th>Date:</th>
<th>File No:</th>
</tr>
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<tbody>
<tr>
<td>Patient:</td>
<td></td>
</tr>
<tr>
<td>Occupation:</td>
<td>Age:</td>
</tr>
<tr>
<td>Student:</td>
<td>Sex:</td>
</tr>
<tr>
<td></td>
<td>Signature:</td>
</tr>
</tbody>
</table>

**FOR CLINICAN USE ONLY:**

<table>
<thead>
<tr>
<th>Initial visit clinician:</th>
<th>Signature:</th>
</tr>
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<tbody>
<tr>
<td>Case History:</td>
<td></td>
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<td></td>
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<table>
<thead>
<tr>
<th>Examination:</th>
<th>Previous:</th>
<th>Current:</th>
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<tr>
<td></td>
<td>UJ</td>
<td>Other</td>
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<table>
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<th>X-ray Studies:</th>
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<tbody>
<tr>
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<td>UJ</td>
<td>Other</td>
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<th>Previous:</th>
<th>Current:</th>
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<td></td>
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<td>Other</td>
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<thead>
<tr>
<th>Case status:</th>
<th>PTT:</th>
<th>Signed off:</th>
<th>Final sign out:</th>
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<tbody>
<tr>
<td></td>
<td>Conditional:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Recommendations:**
**Students case history:**

1. Source of History: __________________________

2. Chief Complaint in patients own words:

   __________________________________________

   __________________________________________

   __________________________________________

   __________________________________________

3. **PRESENT ILLNESS/PRIMARY COMPLAINT**

<table>
<thead>
<tr>
<th>Location</th>
<th>Onset</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>Frequency</td>
</tr>
<tr>
<td>Pain Character</td>
<td>Progression</td>
</tr>
<tr>
<td>Aggravating Factors</td>
<td>Relieving Factors</td>
</tr>
<tr>
<td>Ass Signs &amp; Symptoms</td>
<td>Previous Occurrence</td>
</tr>
<tr>
<td>Past Tx and Outcomes</td>
<td></td>
</tr>
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</table>

4. **PAST HISTORY**

<table>
<thead>
<tr>
<th>General Health Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Childhood Illnesses</td>
</tr>
<tr>
<td>Adult Illnesses</td>
</tr>
<tr>
<td>Psychiatric Illnesses</td>
</tr>
<tr>
<td>Accidents</td>
</tr>
<tr>
<td>Traumatic Injuries</td>
</tr>
<tr>
<td>Surgeries</td>
</tr>
<tr>
<td>Hospitalizations</td>
</tr>
</tbody>
</table>

5. **ANY OTHER COMPLAINTS**

   __________________________________________
<table>
<thead>
<tr>
<th>9. REVIEW OF SYSTEMS</th>
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</thead>
<tbody>
<tr>
<td>General</td>
</tr>
<tr>
<td>Skin</td>
</tr>
<tr>
<td>Head</td>
</tr>
<tr>
<td>Eyes</td>
</tr>
<tr>
<td>Ears</td>
</tr>
<tr>
<td>Noses / Sinuses</td>
</tr>
<tr>
<td>Mouth / Throat</td>
</tr>
<tr>
<td>Neck</td>
</tr>
<tr>
<td>Breasts</td>
</tr>
<tr>
<td>Respiratory</td>
</tr>
<tr>
<td>Cardiac</td>
</tr>
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<td>Gastrointestinal</td>
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<tr>
<td>Urinary</td>
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<tr>
<td>Genital/Sexual Function</td>
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<tr>
<td>Hematological</td>
</tr>
<tr>
<td>Endocrine</td>
</tr>
<tr>
<td>Psychiatric</td>
</tr>
<tr>
<td>Other</td>
</tr>
</tbody>
</table>
APPENDIX M: PHYSICAL EXAMINATION

UNIVERSITY OF JOHANNESBURG
CHIROPRACTIC DAY CLINIC

PHYSICAL EXAMINATION

Underline abnormal findings in RED

Patient: ____________________________
Clinician: ____________________________
Student: ____________________________

Date: ____________________________
File No: ____________________________
Signature: ____________________________

<table>
<thead>
<tr>
<th><strong>VITAL SIGNS</strong></th>
<th><strong>STANDING EXAMINATION</strong></th>
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</thead>
<tbody>
<tr>
<td>Height</td>
<td>Minor’s Sign</td>
</tr>
<tr>
<td>Weight</td>
<td>Skin Changes</td>
</tr>
<tr>
<td>Temperature</td>
<td>Posture</td>
</tr>
<tr>
<td>Heart Rate</td>
<td>• Erect</td>
</tr>
<tr>
<td>Pulse</td>
<td>• Adams</td>
</tr>
<tr>
<td>Respiratory Rate</td>
<td>• Romberg’s Sign</td>
</tr>
<tr>
<td></td>
<td>• Pronator Drift</td>
</tr>
<tr>
<td></td>
<td>• Trendelenburg Sign</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>BLOOD PRESSURE</strong></th>
<th><strong>Gait</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Left</td>
<td>Right</td>
</tr>
<tr>
<td>Arms</td>
<td>Legs</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Half Squat</strong></th>
<th>Spasticity / Rigidity</th>
<th>Spine measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scapular Winging</td>
<td></td>
<td>Inspiration cm</td>
</tr>
<tr>
<td>Muscle Tone</td>
<td></td>
<td>Expiration cm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Visual Acuity</strong></th>
<th>Lumbar Spine ROM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Flexion (90°)</td>
</tr>
<tr>
<td></td>
<td>• Extension (50°)</td>
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<td>• Lat. Flexion (30°)</td>
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<td>• Rotation (35°)</td>
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### Seated Examination

#### Spinal Posture
- Head
  - Hair & Skin
  - Scalp
  - Skull
  - Face

#### Eyes
- Observation
  - Conjunctiva
  - Sclera
  - Eyebrows & Lids
  - Lacrimal Glands
  - Nasolacrimal Duct
  - Position
  - Alignment
  - Cornea / Lens
- Corneal Reflex
- Ocular Movements
- Visual Fields
- Accommodation
- Ophthalmoscopy
  - Iris
  - Pupils
  - Red Reflex
  - Optic Disc
  - Macula
  - Vitreous
  - Lens

#### Ears
- Inspection
  - Auricle
  - Ear Canal
  - Drum
- Auditory Acuity
- Weber Test
- Rinne Test

#### Nose
- External Inspection
- Internal Inspection
  - Septum
  - Turbinates
  - Olfaction

#### Sinuses
- Tenderness
- Transillumination

#### Mouth & Pharynx
- Lips
- Buccal Mucosa
- Gums & Teeth
- Roof
- Tongue
  - Inspection
  - Movements
  - Taste
  - Palpation
- Pharynx – CN X

#### TMJ
- Inspection
  - ROM
  - Deviation
- Palpation
  - Crepitus
  - Tenderness

#### Neck
- Posture
- Size / Swellings
- Scars
- Discissions
- Hairline
- Lymph Nodes
- Tracheal Alignment
- Thyroid & Carotids

#### Cervical Spine ROM
- Flexion (45°)
- Extension (55°)
- Lat. Flexion (40°)
- Rotation (70°)

#### Peripheral Vascular
- Inspection
  - Pulsation, Skin, Nailbeds, Hair loss
  - Palpation
    - Pulses, Lymph nodes, Skin Temp
- Manual Compression
- Retrograde Filing
- Arterial Insufficiency
- Allen’s Test
### BREAST
- Inspection
  - Skin
  - Size
  - Contour
  - Nipples
  - Arms Overhead
  - Hands Against Hips
  - Learning Forward
- Palpation
  - Axillary Lymph Nodes
  - Breast
  - Breast tail

### THORAX – HEART AND LUNGS
- Inspection
  - Skin
  - Shape
  - Respiratory Distress
  - Rhythm
  - Depth
  - Effort
  - Intercostal Retraction
- Palpation
  - Tenderness
  - Masses
  - Respiratory Expansion
  - Tactile Fremitus
  - JVP
  - PMI
- Percussion
  - Lungs (posterior)
  - Diaphragmatic excursion
  - Kidney Punch
- Auscultation
  - Breath Sounds
  - Adventitious Sounds
  - Voice Sounds
  - Heart Auscultation
  - Heart Murmurs

### ABDOMINAL
- Inspection
  - Skin
  - Umbilicus
  - Contour
  - Peristalsis
  - Pulsations
  - Hemias
- Auscultation
  - Bowel Sounds
  - Bruits
- Percussion
  - General
  - Liver
  - Spleen
- Palpation
  - Superficial Reflex
  - Cough
  - Light
  - Rebound Tenderness
  - Deep
  - Liver
  - Spleen
  - Kidneys
  - Aorta
  - Abdominal Masses
  - Shifting Dullness
  - Fluid Wave
- Acute Abdomen
  - Where pain began?
  - Moved to where?
  - Cough
  - Tenderness
  - Guarding / Rigidity
  - Rebound Tenderness
- Special Tests
  - Rovsing’s Sign
  - Psoas Sign
  - Obturator Sign
  - Cutaneous
  - Hyperesthesia
  - Murphy’s Sign
  - Rectal Examination
### Musculoskeletal

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### Coordination and Cerebellar Testing

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**DERMATOMES**

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**Lumbar**

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**REFLEXES**

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<tr>
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<td>Triceps</td>
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<tr>
<td>Patella</td>
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<td>Achilles</td>
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**MYOTOMES**

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<tr>
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<td>L1 / L2</td>
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### Range of Motion

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<td>Rotation (70° - 80°)</td>
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### Neurological Assessment

#### Dermatomes

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#### Discriminative Sensations

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### Neurological Assessment

#### Reflexes

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<tr>
<td>Triceps</td>
<td>C7</td>
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**Reflex Grading**
- 4+ Very brisk, hyperactive. Perform ankle clonus.
- 3+ brisk
- 2+ Average; normal.
- 1+ Somewhat diminished; low normal.
- 0 No reaction

### Neurological Assessment

#### Coordination

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<td>Point to Point Movements</td>
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### Neurological Assessment

#### Stance

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<tr>
<td>Romberg’s</td>
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<td>Pronator Drift</td>
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<td>Arm Tapping</td>
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### Cranial Nerves

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<tbody>
<tr>
<td>CN I</td>
<td>Smell</td>
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<td>CN II</td>
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<td></td>
<td>Visual fields by confrontation</td>
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<tr>
<td>CN III</td>
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<tr>
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<td>Reactions to light</td>
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<td>CN III, IV, and V</td>
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<td>CN IV</td>
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<td>CN VIII</td>
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<td>Rinse</td>
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<tr>
<td>CN IX and X</td>
<td>Voice</td>
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<td>Movements of soft palate and pharynx</td>
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<td></td>
<td>Gag reflex</td>
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<tr>
<td>CN XI</td>
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<td>Neck rotation</td>
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<td>CN XII</td>
<td>Asymmetry/deviation of tongue</td>
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<td>Fasciculation’s Strength</td>
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### Orthopaedic Tests

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<td>Spurling’s Manoeuvre</td>
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<td>Kemp’s Test</td>
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<td>Decortication Injection</td>
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<td>Shoulder Abduction Test</td>
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<td>Shoulder Depression Test</td>
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<td>Dizziness Rotation Test</td>
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<td>Lysholm’s Sign</td>
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<td>Costoclavicular Test</td>
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### Vascular Testing

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<td>Subclavian Pulse</td>
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<td>Auscultation of Subclavian</td>
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<td>Allen’s Test</td>
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<td>Dizziness / Disequilibrium</td>
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<th>P: Procedure Codes</th>
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<td>Student:</td>
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<td>Date:</td>
<td>Clinician:</td>
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<th>Comments:</th>
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APPENDIX P: ETHICS CLEARANCE LETTER

FACULTY OF HEALTH SCIENCES
RESEARCH ETHICS COMMITTEE
NHREC Registration no: REC-241112-035

REG-01-39-2016
20 May 2016

TO WHOM IT MAY CONCERN:

STUDENT: FERRERA, V
STUDENT NUMBER: 201111717

TITLE OF RESEARCH PROJECT: Cervical Spine Manipulation and Muscle Energy Technique in the Treatment of Upper Trapezius Myofascial Pain

DEPARTMENT OR PROGRAMME: CHIROPRACTIC
SUPERVISOR: Dr DM Landman
CO-SUPERVISOR: -

The Faculty Academic Ethics Committee has scrutinised your research proposal and confirm that it complies with the approved ethical standards of the Faculty of Health Sciences, University of Johannesburg.

The REC would like to extend their best wishes to you with your postgraduate studies.

Yours sincerely,

[Signature]
Prof M Poggenpoel
Chair: Faculty of Health Sciences REC
Tel: 011 559 6689
Email: marlen@uj.ac.za
APPENDIX Q: HIGHER DEGREES CLEARANCE LETTER

FACULTY OF HEALTH SCIENCES

HIGHER DEGREES COMMITTEE

HDC-01-14-2016

22 April 2016

TO WHOM IT MAY CONCERN:

STUDENT: FERREIRA, V
STUDENT NUMBER: 201117177

TITLE OF RESEARCH PROJECT: Cervical Spine Manipulation Versus Muscle Energy Technique and a Combination thereof in the Treatment of Upper Trapezius Myofascial Pain

DEPARTMENT OR PROGRAMME: CHIROPRACTIC
SUPERVISOR: Dr DM Landman CO-SUPERVISOR: 

The Faculty Higher Degrees Committee has scrutinised your research proposal and concluded that it complies with the approved research standards of the Faculty of Health Sciences; University of Johannesburg.

The HDC would like to extend their best wishes to you with your postgraduate studies.

Yours sincerely,

[Signature]

Prof Y Coopoo
Chair: Faculty of Health Sciences HDC
Tel: 011 559 6944
Email: yogac@uj.ac.za
APPENDIX R: ORIGINALITY CHECK

Digital Receipt

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The first page of your submissions is displayed below.

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Submission title: Cervical spine manipulation and mu..
File name: ATMENT_OF_UPPER_TRAPEZIUS..
File size: 2.82M
Page count: 108
Word count: 29,714
Character count: 163,995
Submission date: 14-Nov-2016 12:01PM
Submission ID: 733329410