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THE EFFECTIVENESS OF CERVICAL ADJUSTMENT THERAPY, DRY NEEDLING OF THE POSTERIOR CERVICAL MUSCULATURE AND THE COMBINATION OF THE TWO IN THE TREATMENT OF CHRONIC MECHANICAL NECK PAIN

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

Jacqui Cooper
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Supervisor: ________________________ Date: _________________________
Dr C. Yelverton
DECLARATION

I declare that this dissertation is my own, unaided work. It is being submitted for the Masters Degree in Technology in the program Chiropractic at the University of Johannesburg. It has not been submitted before for any degree of examination in any other Tertiary Institute.

________________________
Jacqui Cooper

On this_______ day of ________ 2013
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DEDICATION

To Wayne,

For all you did and all you gave.

Wish you were here to see this.

Until we meet again my love.
AKNOWLEDGEMENTS

Dr. Yelverton and Dr. Hay, thank you for the enormous amount of work and energy you spent on getting me through this process. You helped me in so many ways and I will always be grateful for all your support and understanding.

To all my chiropractic friends thank you for all your help and love. Without your encouragement and support this wouldn't have been possible.

To my family, thank you for your patience, understanding and support.
ABSTRACT

Mechanical neck pain is the general term that refers to any type of pain within the cervical spine caused by placing abnormal stress and strain on muscles of the vertebral column. This is a very common musculo-skeletal disorder within the population, with 45% to 54% reporting neck pain at any given time of their lives (Martinez-Segura, Fernandez-de-las-Penas, Ruiz-Saez, Lopez-Jimenez and Rodriguez-Blanco, 2006). A vast majority of individuals do not experience a complete resolution of symptoms and as such often becomes a chronic pain (Cote, Cassidy, Carol and Kristman, 2004). Chronic pain by definition is one which is present for a period longer than six weeks (Segen, 2002).

Accompanying the neck pain is often a limited or reduced range of motion within the cervical spine. Some studies suggest that hyper-tonicity and strain of the supporting muscles within this region due to an altered biomechanics also contributes to the pain and dysfunction (Armstrong, McNair and Williams, 2005 and Dall’Alba et al., 2001). One of the major muscle groups involved in this is the posterior cervical musculature. This is a general term used to describe the muscles located on the posterior aspect of the neck and includes longissimus capitis, semispinalis capitis, semispinalis cervicis, rotatores and multifidus (Dalley and Moore, 2006).

Chiropractic adjustment therapy has been shown to have many effects of the body and especially the cervical spine including a decrease in pain perception and muscle hypertonicity (Kirkaldy-Willis and Cassidy, 1985), an increase in cervical range of motion (Bergmann, Peterson and Lawrence, 1993) as well as an increased skin pain tolerance level (Terrett and Vernon, 1984). Dry needling therapy has also been proven to have similar effects, including, a reduction in pain perception, an increase in range in motion of the specific linked biomechanical section, and most importantly a reduction of muscle tension (Travell and Simons, 1993). The purpose of this study was to see if a synergistic
effect of the two above mentioned treatments would occur when combined under one treatment protocol.

The aim of this study was to determine how effectively cervical adjustment therapy, dry needling of the posterior cervical muscles and a combination of the two treatments was in treating chronic mechanical neck pain with regards to pain, disability and cervical spine range of motion over a three week period.

Participants were recruited from the University of Johannesburg Chiropractic Day Clinic. They were eligible to participate in the study once they met the inclusion and exclusion criteria. Participants were recruited by means of word of mouth as well as with the use of advertisements that were placed around the respective campuses of the University of Johannesburg.

Thirty participants who presented with chronic mechanical neck pain, volunteered for this comparative study. This trial is a randomised controlled clinical trial which used convenience sampling. Group A received a combination treatment of dry needling and cervical manipulation. Group B received cervical adjustment only while group C received dry needling of the posterior cervical musculature alone. participants were treated for a total of 6 visits. Subjective and objective measurements were done at visits 1, 4 and a final visit 7 during which only measurements were taken.

These effects are based on Vernon-Mior Pain and Disability Index, Numerical Pain Scale Rating, Pressure Algometer as well as Cervical Spine Range of Motion measuring instrument (CROM).

The results of this trial indicated that all three treatments were effective in treating chronic mechanic neck pain. While one treatment was not statistically more effective than the other the dry needling and cervical manipulation alone
produced a superior result. While combining these treatments was effective the synergistic effect one would expect was not as evident.
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CHAPTER ONE – INTRODUCTION

1.1 Problem statement

Mechanical neck pain is the general term that refers to any type of pain within the cervical spine caused by placing abnormal stress and strain on muscles of the vertebral column. This is a very common musculo-skeletal disorder within the population, with 45% to 54% reporting neck pain at any given time of their lives (Martinez-Segura, Fernandez-de-las-Penas, Ruiz-Saez, Lopez-Jimenez and Rodriguez-Blanco, 2006). A vast majority of individuals do not experience a complete resolution of symptoms and as such often becomes a chronic pain (Cote, Cassidy, Carol and Kristman, 2004). Chronic pain by definition is one which is present for a period longer than six weeks (Segen, 2002).

Accompanying the neck pain is often a limited or reduced range of motion within the cervical spine. Some studies suggest that hyper-tonicity and strain of the supporting muscles within this region due to an altered biomechanics also contributes to the pain and dysfunction (Armstrong, McNair and Williams, 2005 and Dall’Alba et al. 2001). One of the major muscle groups involved in this is the posterior cervical musculature. This is a general term used to describe the muscles located on the posterior aspect of the neck and includes longissimus capitis, semispinalis capitis, semispinalis cervicis, rotatores and multifidus (Dalley and Moore, 2006).

Chiropractic adjustment therapy has been shown to have many effects of the body and especially the cervical spine including a decrease in pain perception and muscle hypertonicity (Kirkaldy-Willis and Cassidy, 1985), an increase in cervical range of motion (Bergmann, Peterson and Lawrence, 1993) as well as an increased skin pain tolerance level (Terrett and Vernon, 1984). Dry needling therapy has also been proven to have similar effects, including, a reduction in pain perception, an increase in range in motion of the specific linked biomechanical section, and most importantly a reduction of muscle tension.
(Travell and Simons, 1993). The purpose of this study was to see if a synergistic effect of the two above mentioned treatments would occur when combined under one treatment protocol.

1.2 Aim

The aim of this study was to determine how effectively cervical adjustment therapy, dry needling of the posterior cervical muscles and a combination of the two treatments was in treating chronic mechanical neck pain with regards to pain, disability and cervical spine range of motion over a three week period. These effects are based on Vernon-Mior Pain and Disability Index, Numerical Pain Scale Rating, Pressure Algometer as well as Cervical Spine Range of Motion measuring instrument (CROM).

1.3 Benefits of study

The benefits of this study may help to determine if chiropractic adjustment of the cervical spine combined with dry needling of the posterior cervical musculature improves the presenting symptoms of participants suffering from chronic mechanical neck pain more than chiropractic adjustment or dry needling alone. This may be beneficial to the profession as it may help to better treat patients presenting with chronic mechanical neck pain, which as previously mentioned forms a large percentage of the population.
CHAPTER TWO - LITERATURE REVIEW

2.1 Introduction

According to Vizniak and Carnes (2009) 65% of all individuals who suffer from neck pain are experiencing a mechanical neck pain. The definition of a chronic mechanical neck pain is one which affects the articulating facets joints as well as muscle spasm for a period of six weeks or more. This musculoskeletal dysfunction offsets an inflammatory reaction and therefore there is pain associated with it due to the presence of pain producing substances such as histamines, prostaglandins and bradykinin (Gatterman, 1990). The pain associated with the inflammatory reaction is also a trigger to initiate a local reflex muscle spasm, which by causing localised ischaemia sets up a positive feedback mechanism of increased pain (Bergmann and Peterson, 2002).

The literature review will attempt to give an overview of the incidence and prevalence of chronic mechanical neck pain as well as the anatomy of the cervical spine. It will indicate mechanisms of injury and treatment as well as the physiological effects of dry needling therapy as a modality used by the chiropractic profession.

2.2 Incidence and prevalence of chronic neck pain

2.2.1 General population

Chronic mechanical neck pain is a common complaint in chiropractic practice and will affect close to one third of the adult population (Vernon and Hu, 1999).

2.2.2 Gender and age incidence
Roughly two thirds of the population will experience neck pain at some point of their lives, with a peak in prevalence in middle age and is more commonly found in women. According to Borgouts et al (1999), there is a lifetime prevalence of up to 43% in women, and this number increases in women who are between the ages of 40 – 60 years of age (Wilson and Boyle, 2002).

2.3 Aetiology and cause of chronic mechanical neck pain

Neck pain can originate from any of the pain sensitive structures in the area, including muscles, ligaments, soft tissue in or around the area, intervertebral discs, nerves or osseous structures (Moore and Dalley, 1999). Any stress, abnormal biomechanics or postural strains could result in these structures causing pain. In our society poor posture, poor ergonomics at work and in our daily lives contribute greatly to this dysfunction.

There are multiple causes for neck pain, and can include: mechanical abnormalities, inflammatory conditions, metabolic imbalances, neoplastic conditions as well as a pain referral pattern from a distant site.

The table below summarises the causes of neck pain:

Table 2.1 Causes of neck pain (Haslett et al., 2002)
<table>
<thead>
<tr>
<th>Category</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical</td>
<td>• Postural</td>
</tr>
<tr>
<td></td>
<td>• Whiplash injury</td>
</tr>
<tr>
<td></td>
<td>• Disc prolapsed</td>
</tr>
<tr>
<td></td>
<td>• Cervical spondylosis</td>
</tr>
<tr>
<td>Inflammatory</td>
<td>• Infections</td>
</tr>
<tr>
<td></td>
<td>• Spondylitis</td>
</tr>
<tr>
<td></td>
<td>• Juvenile idiopathic arthritis</td>
</tr>
<tr>
<td></td>
<td>• Rheumatoid arthritis</td>
</tr>
<tr>
<td></td>
<td>• Polymyalgia rheumatica</td>
</tr>
<tr>
<td>Metabolic</td>
<td>• Osteoporosis</td>
</tr>
<tr>
<td></td>
<td>• Osteomalacia</td>
</tr>
<tr>
<td></td>
<td>• Pagets disease</td>
</tr>
<tr>
<td>Neoplastic</td>
<td>• Metastases</td>
</tr>
<tr>
<td></td>
<td>• Myeloma</td>
</tr>
<tr>
<td></td>
<td>• Reticuloses</td>
</tr>
<tr>
<td></td>
<td>• Intrathecal tumours</td>
</tr>
<tr>
<td>Other</td>
<td>• Fibromyalgia</td>
</tr>
<tr>
<td></td>
<td>• Torticollis</td>
</tr>
<tr>
<td>Referred pain</td>
<td>• Pharynx</td>
</tr>
<tr>
<td></td>
<td>• Cervical lymph nodes</td>
</tr>
<tr>
<td></td>
<td>• Teeth</td>
</tr>
<tr>
<td></td>
<td>• Angina pectoris</td>
</tr>
</tbody>
</table>
2.4 Anatomy of the cervical spine

2.4.1 Introduction

The cervical spine is comprised of 7 cervical vertebrae which all work together as a biomechanical chain to bring about mobility of the head and neck, as well as positioning of the eyes on the relatively immobile thoracic spine (Windsor, 1999). There are two different categories of cervical vertebrae, namely typical and atypical.

2.4.2 Typical cervical spine vertebrae

Typical cervical vertebrae include C3-7. All typical cervical vertebrae have defining characteristics which make them typical. This is demonstrated in Figure 2.1

Figure 2.1 Superior view of a typical cervical vertebrae (Gray, 2002)
The body of all typical cervical vertebrae are relatively small when compared with other regions of the vertebrae and are also wider from side to side than they are in their anterior to posterior diameter. The shape of the body is slightly concave on its superior aspect while convex on the inferior aspect. The superior surface has a small projection on either side which is known as the uncinate process. The inferior plateau has a corresponding articular facet for the uncinate process and together these from the uncovertebral joints (Moore and Dalley, 1999). The function of these joints is to limit lateral flexion as well as to help guide anteroposterior movement during flexion and extension, hence enhancing stability within the cervical spine (Gatterman, 2004).

Typical cervical vertebrae also have a large and slightly triangular shaped vertebral foramen (Moore and Dalley, 1999).

The transverse processes have a very distinctive feature, namely the transverse foramina which may be small or absent in C7. The function of this transverse foramen is to allow the passage of the vertebral artery, vein and plexus of nerves. The vertebral artery is the first branch off the first part of the subclavian artery. However the vertebral artery does not pass through the transverse foramen of the seventh cervical vertebrae, only small accessory vertebral veins. Another distinctive feature of the transverse process of the cervical vertebrae is the anterior and posterior tubercles which are visible giving them a slightly bifid appearance (Moore and Dalley, 1999). There is a small groove present on the superior surface of the transverse process which allows for the passage of cervical nerves as they branch of the relevant levels of the spinal cord (Standring, 2008).
The articular processes in this region of the spine are as follows: superior facets are directed superoposteriorly, inferior facets are directed inferoanteriorly and obliquely placed facets are orientated in a nearly horizontal manner. This is evident in figure 2.2.

C3-5 spinous processes are short and bifid in the cervical spine. C6 is slightly longer but C7 has the longest spinous process and is referred to as the vertebra prominence (Moore and Dalley, 1999).

### 2.4.3 Atypical cervical spine vertebrae

The atypical cervical vertebrae include C1 (Atlas), C2 (Axis) and C7 (Vertebral Prominence).
The atlas is the first cervical vertebrae (refer to figure 2.3). This ring shaped bone is responsible for supporting the skull, therefore superiorly its articular surfaces are concave in order to receive and articulate with the occipital condyles. It is through these condyles that the weight of the head is transferred onto the vertebral column. Inferiorly the atlas articulates with the second cervical vertebrae (Moore and Dalley, 1999).

The atlas is considered atypical as it has no body or spinous process. It consists rather of an anterior and posterior arch. Each arch is comprised of a tubercle and a lateral mass. The posterior arch, which is essentially the equivalent of the lamina in a typical vertebrae has a groove on its surface whose purpose it is to transmit the vertebral artery as it makes its way to its entrance into the skull, the foramen magnum (Hiatt and Gartner, 2001). Accompanying the artery at this level is also the greater occipital nerve (Moore and Dalley, 1999).
b) C2 - Axis

The axis is considered the strongest bone of the vertebral column, purely because of its function. During rotation of the head, the skull which rests on the atlas, rotates as a unit on the axis (Moore and Dalley, 1999).

The second cervical vertebrae is considered as an atypical vertebrae due to the fact that the anterior portion of its body extends inferiorly and the superior surface has a projection arising from it which is know as the dens or odontoid process (Levangie et al., 2005). This is evident in figure 2.4. Anteriorly the dens articulates with the posterior aspect of the anterior arch of atlas via an oval articular facet (Middleditch et al, 2005). The dens is bordered anteriorly by the transverse ligament of the atlas which is essential in order to minimise horizontal displacement of the atlas (Moore and Dalley, 1999).

Figure 2.4: Superior view on the Axis (C2) vertebrae (Gray, 2002)
The spinous process of C2 is large and bifid (Moore and Dalley, 1999) while the transverse processes are small, projects off the sides of the vertebral body in a lateral direction (Palastanga, 1989).

![Figure 2.5: Lateral view on the Axis (C2) (Gray, 2002)](image)

**Figure 2.5: Lateral view on the Axis (C2) (Gray, 2002)**

c) Seventh Cervical Vertebrae

![Figure 2.6: Superior view of the C7 vertebrae (Gray, 2002)](image)

**Figure 2.6: Superior view of the C7 vertebrae (Gray, 2002)**

The seventh cervical vertebra is also considered atypical and is commonly called the vertebral prominence due to the elongated spinous process which is its key identifying feature. Not only is the spinous process elongated but it also lacks the typical feature of cervical spine spinous processes as it is not bifid. Therefore it
exhibits more identifying features of the region below it, the thoracic spine. For this reason C7 is considered a transitional region (Moore and Dalley, 1999).

The body is larger and the vertebral foramen more narrow than other cervical vertebra. And while it has a transverse foramen, the vertebral artery does not pass through it, only the vertebral vein (Chaitow and DeLany, 2008).

2.5 Joints of the cervical spine

2.5.1 Zygapophyseal joints

These joints are commonly referred to as “facet joints”. They are plain synovial joints which exist between the superior and inferior articular processes of corresponding vertebrae (Moore and Dalley, 1999). (Refer to figure 2.6)

As the zygapophyseal joints are synovial joints, there are a few typical features present. The articular surfaces are covered with hyaline cartilage between the superior and inferior articular facets of the corresponding vertebrae. There is a thin loose capsule surrounding the joint, which is lined by a synovial membrane.
This membrane is responsible for the production of synovial fluid, which is necessary for lubrication of the joint as well as nutrition. When a joint becomes immobile, the nutritional supply to that joint is compromised (Gatterman, 1990).

2.5.2 Uncovertebral joints

The uncovertebral joints are present from C3 – 6 and are located between the uncinate processes and adjacent vertebral bodies of the above mentioned levels. The location of these joints is at the lateral and posterolateral aspect of the intervertebral discs. Due to the presence of articular cartilage and capsule, containing a lubricating fluid, they are considered by some to be synovial joints (Moore and Dalley, 1999).

2.5.3 The atlanto-occipital joint

This is the joint between the concave lateral masses of the first cervical vertebra and the convex occipital condyles located on the occipital bone of the skull (Middleditch et al., 2005). This is a synovial joint with no intervertebral disc present between the articulating surfaces. This allows a greater range of motion and permits nodding of the head, which is flexion and extension. This joint also allows slight tilting of the head, however primary movement here is flexion (Moore and Dalley, 1999).

Occipital condyles and C1 are also connected by the anterior and posterior atlanto-occipital membranes. The anterior division of this membrane is made up of broad, dense fibres, while the posterior is broad but weak. These membranes help prevent excessive movement at this level (Moore and Dalley, 1999).
2.5.4 The atlanto-axial joint

This joint is composed of three separate articulations. Two lateral atlantoaxial joints, between the lateral mass of the first cervical vertebrae and the superior facets of the second. As well as one medial atlantoaxial joint this is located between the dens of the second cervical vertebrae and the anterior arch of atlas. Both above mentioned joints are synovial joints. Movement at these joints allow for the movement of the head from side to side. During this rotation the skull and first cervical vertebrae move as a unit on the second cervical vertebrae (Moore and Dalley, 1999).

2.5.5 Intervertebral discs

The intervertebral discs and ligaments aim to connect the articulating surfaces of the adjacent vertebral bodies. They also have a role in closing of the intervertebral foramen by forming the inferior half of the anterior body. Other functions of the discs include shock absorption and their shape helps contribute to the secondary curvatures of the spine (Moore and Dalley, 1999).

![Figure 2.8: The composition of the intervertebral disc (Gray, 2002)](image)

Each intervertebral disc is composed of an annulus fibrosis and nucleus palposis. The annulus fibrosis is the outer fibrous part of the disc and is composed of concentric lamellae of fibrocartilage. It insert into the articular surfaces of the adjacent vertebral bodies. The fibres which form each lamellae are arranged so that they run at an oblique angle from the vertebra above to the one below. This
composition allows a small degree of movement but more importantly provides a large amount of stability to be present between the articulating segments (Moore and Dalley, 1999).

The nucleus pulposis is a gelatinous central mass which is more cartilaginous in nature when compared to the fibrocartilage nature of the annulus fibrosis. Although described as being centrally located it lies slightly posteriorly due to the lamellae being fewer in number and thinner in the posterior aspect of the disc. It is composed primarily of water and is avascular, receiving its nutrition via diffusion from surrounding structures.

In the cervical spine, there is no disc present between C1 and C2 and they are thicker anteriorly than posteriorly.

2.5.6 Ligaments of the cervical spine

Figure 2.9: Diagram indicating the ligaments of the cervical spine (Gray, 2002)
The anterior longitudinal ligament connects the anterolateral aspects of the vertebral bodies and intervertebral discs. It extends from the pelvic surface of the sacrum to the anterior tubercle of C1 and occipital bones. It is broad and fibrous in nature and functions to stabilise the joints between the vertebral bodies and prevent any hyperextension (Moore and Dalley, 1999).

The posterior longitudinal ligament is narrower and weaker when compared to the anterior. It runs along the posterior aspect of the vertebral bodies, therefore within the vertebral canal. It runs from C2 to the sacrum, taking attachment at vertebral bodies and their intervertebral discs. The functions of this ligament include prevention of hyperflexion as well as protrusion of disc material into the vertebral column. It is also well innervated with nociceptors for the sensation of pain (Moore and Dalley, 1999).

The ligamentum flavum is located posteriorly to the above mentioned posterior longitudinal ligament. It is a vertically orientated ligament which connects lamina of adjacent vertebrae. It helps form the posterior boundary of the vertebral canal (Moore and Dalley, 1999). Due to its highly elastic nature it aids in protecting the spinal cord, without it causing any impingement itself during movement of the vertebral column (Radcliff, Ben-Gallim, Dreianeg, Martin, Reitman, Lin and Hipp, 2010).

The infraspinous ligament attaches the spinous process above to the one below, but is thin and weak. It is similar in nature to the supraspinous ligament, however this ligament is only present from the sacrum to C7. At C7 it fuses with the ligamentum nuchae which is a very strong, medially located ligament found in the cervical region (Agur and Dalley, 2005).

The transverse ligament of the atlas connects the medial aspect of the lateral masses of C1. Its function is to hold the dens against the anterior of C1. There are longitudinal bands running vertically from the transverse ligament to the
occipital bone superiorly and body of C2 inferiorly. Together these two ligaments form the cruciate ligament (Moore and Dalley, 1999).

The alar ligament has a function in checking rotation of the skull and so runs from the dens to the lateral margins of the foramen magnum (Moore and Dalley, 1999).

The tectorial membrane is a continuation of the posterior longitudinal ligament. It is located from the body of C2 to the internal surface of the occipital bone (Moore and Dalley, 1999).

2.5.7 Innervation of the cervical spine

The cervical zygapophyseal joints, which were discussed earlier, are innervated by four different types of neuroreceptors along multiple levels, due to the multi level ascending and descending afferent fibres. The four types include one nociceptor and three mechanoreceptors (Agur and Dalley, 2005).

Type 1 receptors are static and dynamic receptors which are highly sensitised and therefore fire continuously even when the joint is not moving. These are found primarily in the outer layers of the joints capsules (Clarke, 2005; Peterson and Bergmann, 2002).

Type 2 receptors are found in the deeper layers of the joint capsules and are therefore less sensitive. They do not fire unless there is movement within the joint however their threshold is low and can be stimulated by any minor changes of movement within the joint. They are able to adapt rapidly and will cease firing when movement desists (Clarke, 2005; Peterson and Bergmann, 2002).
Type 3 receptors are not as commonly found as the previously mentioned receptors. Initially they were thought to only be present in peripheral joints but are present within the cervical facet joints. They have an inhibitory effect on motor neurons (Clarke, 2005; Peterson and Bergmann, 2002).

Type 4 receptors are the nociceptors which are slow conducting. They are found throughout the joint capsule but not within the articulating surfaces or synovial membranes. These nociceptors may be activated by fracture or dislocation of the facet joints, chemical irritation, intervertebral disc injury or inflammation (Clarke, 2005; Peterson and Bergmann, 2002).

### 2.5.8 Blood supply of the cervical spine

Vertebral and ascending cervical arteries which are present within the neck send off segmental arteries to vertebrae to supply them with the necessary nutrition. They enter via the intervertebral foramina, divide into terminal radicular arteries which supply the roots of the spinal nerves. The spinal veins form plexuses namely the internal and external vertebral venous plexuses, relative to the spinal canal.

### 2.6 Muscles of the cervical spine

There are two groups of muscles within the cervical spine, namely the intrinsic and extrinsic. The extrinsic have been divided into superficial and intermediate and their function is mainly to produce or control limb movement as well as certain movement necessary for respiration (Moore and Dalley, 1999).

The intrinsic muscle group are the deep layer of muscles which function mainly to produce movement of and maintain posture of the vertebral column (Moore and
Dalley, 1999). The posterior cervical muscles are part of the intrinsic muscles group.

### 2.6.1 Posterior cervical musculature

The posterior cervical musculature is a term used to encompass five muscles (Travell and Simons, 1993):

- Semispinalis capitis
- Longissimus capitis
- Semispinalis cervicis
- Multifidi
- Rotators

These muscles are primarily responsible for the extension of the head and neck by the more superficial fibres, and rotation by the more deep fibres (Travell and Simons, 1993).

The anatomical attachments of these muscles are tabulated in table 2.3 below.
Table 2.2: Anatomical attachment of the posterior cervical muscles (Travell and Simons, 1993).

<table>
<thead>
<tr>
<th>Muscle:</th>
<th>Origin:</th>
<th>Insertion:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semispinalis Capitis</td>
<td>Articular process: C4-C6</td>
<td>Occiput between superior and inferior nuchal lines</td>
</tr>
<tr>
<td></td>
<td>TVP: T1-T6</td>
<td></td>
</tr>
<tr>
<td>Longissimus Capitis</td>
<td>Articular process: C4-C7</td>
<td>The skull at the posterior margin of mastoid process</td>
</tr>
<tr>
<td></td>
<td>TVP: T1-T4</td>
<td></td>
</tr>
<tr>
<td>Semispinalis cervicis</td>
<td>TVP: T1-T5</td>
<td>Spinous process: C2-C5</td>
</tr>
<tr>
<td>Cervical multifidi</td>
<td>Spinous process: C2-C3</td>
<td>Articular process: C4-C7</td>
</tr>
<tr>
<td>Cervical rotatores</td>
<td>Begin at the level of C2</td>
<td>Connect to adjacent or alternate vertebrae</td>
</tr>
</tbody>
</table>

2.7 Biomechanics of the cervical spine

2.7.1 Atlanto-occipital joint

This articulation occurs between the superior aspect of the articular facets of the lateral mass of atlas and the occipital condyles. The articular facets of the atlas are oval and obliquely orientated with their axes running medially and anteriorly. They are lined with articular cartilage and are concave giving these articular surfaces a spherical shape. The occipital condyles are shaped so that they fit perfectly within this sphere and for this reason this joint is considered an enarthrosis. The definition of an enarthrosis is a joint with spherical articular surfaces allowing three degrees of movement: axial rotation, flexion and extension and lateral flexion (Kapandji, 1974).

a) Rotation
The rotation of the occiput on the atlas is secondary to movement of the atlas on the axis around the vertical axis which passes through the centre of the odontoid process. During rotation to the left there is an anterior displacement of the right occipital condyle on the lateral mass of the atlas. This results in the lateral odontoid ligament being stretched quite considerably due to the fact that it becomes wrapped around the odontoid process. The tension which develops within this ligament is responsible for right occipital condyle being pulled slightly to the left. This results in rotation of the occiput being accompanied by a 2-3mm displacement to the left as well as slight lateral flexion to the right (Kapanji, 1974; Middleditch and Olivier, 2005).

b) Lateral flexion

During lateral flexion there is no movement occurring at the atlanto-axial joint, only at the segment above and below, that is between the atlas and occiput and between the axis and third cervical vertebra (Kapanji, 1974).

The movement which occurs at the atlanto-occipital joint is considered to be a ‘slipping’ movement of the occipital condyles to the right during lateral flexion to the left and vice versa. Due to the tension developed within the capsular ligament of the atlanto-occipital joint, it is only a small degree of movement which occurs. There is only about three degrees of movement occurring at this level (Kapanji, 1974; Middleditch and Olivier, 2005).

c) Flexion and extension
During flexion the occipital condyles slide slightly posteriorly on the lateral masses of the atlas and concurrently the occiput moves slightly away from the posterior arch of atlas. Widening between occiput and posterior arch of atlas is usually associated with flexion of the atlanto-axial joint and as a result the space between the atlas and axis also widens. This movement is limited or checked by tension present within the posterior atlanto-occipital membrane and posterior cervical ligament (Kapanji, 1974; Middleditch and Olivier, 2005).

During extension the occipital condyles slide in an anterior direction on the lateral masses of atlas. This results in an approximation of the occipital condyles and posterior arch of atlas as well as between the atlas and axis. It is the approximation and impact of these three bony prominences which limit extension in this segment. The total range of flexion and extension at this level is approximately fifteen degrees (Kapanji, 1974; Middleditch and Olivier, 2005).

2.7.2 The atlanto-axial joint
As previously discussed there are three joints present between the atlas and axis which are mechanically linked. There are two located laterally which are known as the atlanto-axial joints, which are located between the lateral masses of the atlas and the superior articular surfaces of the axis. The third centrally located joint is the atlanto-odontoid joint and it is here that the odontoid process, or dens acts as a pivot (Kapanji, 1974; Middleditch and Olivier, 2005).

**a) Flexion and extension**

During flexion the atlas slides on the superior surface of the axis and as a result the point of contact that exists between these two articular surfaces moves more forward, that is in a slightly more anterior direction. The resulting effect at the atlanto-odontoid joint is an opening up of the joint slightly. This opening up of the joint occurs superiorly due to the orientation of the joint (Kapanji, 1974; Middleditch and Olivier, 2005).

During extension the point of contact within the atlanto-axial joint moves slightly posteriorly from its normal resting position and the facet on the atlanto-odontoid joint would be a slight opening out of the joint space in the inferior aspect (Kapanji, 1974; Middleditch and Olivier, 2005).

On radiographic study however there is very little opening of the joint space between the atlanto-odontoid joint, and this is due to the presence of the alar ligament which keeps the two articulating surfaces in close proximity to one another. The central point around which this movement occurs is located roughly in the centre of the odontoid process when viewed from a lateral aspect and due to this there is a rolling and sliding movement which occurs as the inferior facet of the lateral mass of the atlas moves on the superior articular facet of the axis (Kapanji, 1974; Middleditch and Olivier, 2005).
b) Rotation

When viewing the atlanto-odontoid joint from a superior aspect, it becomes evident that the odontoid process is in fact cased in an osteoligamentous ring. The odontoid process itself is cylindrical in shape and has two articular facets, one on its anterior aspect, and one on its posterior aspect. The anterior facet articulates with the posterior aspect of the anterior arch of atlas. It is surrounded laterally by the lateral masses of the atlas, but posteriorly it is surrounded by the transverse ligament, which runs from lateral mass to lateral mass. Hence the odontoid process is surrounded by an osteoligamentous ring (Kapanji, 1974; Middleditch and Olivier, 2005).

Within this osteoligamentous ring the odontoid process forms two types of joints. Anteriorly we note the presence of a synovial joint, but posteriorly is a joint without a capsule which is embedded in fibro adipose tissue and occurs between the odontoid process and the osteoligamentous ring (Kapanji, 1974; Middleditch and Olivier, 2005).

During rotation to the left the osteoligamentous ring rotates in an anticlockwise around the stationary odontoid process. As a result the articular capsule on the left hand side is relaxed, while the one on the right becomes taught. There is also movement which occurs in the atlanto axial joint as these are a biomechanically linked chain. Therefore the left lateral mass of the atlas moves slightly anteriorly while the right moves slightly posteriorly. Due to the superior articular surface of the axis being slightly convex anteroposteriorly, the movement is not purely horizontal but slightly convex superiorly. Therefore there is a slight vertical drop of the atlas on the axis resulting in a more spiralled movement. All this occurs in reverse when there is rotation in a clockwise direction (Kapanji, 1974; Middleditch and Olivier, 2005).
2.8.3 Lower cervical vertebral column

Within the lower cervical vertebral column the adjacent vertebra are connected by the intervertebral discs with their fibres of the annulus fibrosis being evenly stretched as well as by their articular processes. The articular surfaces in this region are obliquely orientated inferiorly and posteriorly and are slightly concave anteriorly. The centre of curvature is located anteriorly and inferiorly resulting in the formation of the lumbar lordosis (Kapanji, 1974; Middleditch and Olivier, 2005).

a) Extension

The vertebral body will tilt and slide posteriorly resulting in compression of the intervertebral space posteriorly. This forces the nucleus pulposis to move anteriorly and the anterior fibres of the annulus fibrosis being stretched anteriorly as well. The space between the articular facets is widened anteriorly due to the fact that this movement is not occurring around the centre of curvature of the articular processes. The superior articular facet will slide inferiorly and posteriorly on the inferior articular process because of this. It also tilts posteriorly forming an angle of extension. This movement of extension is checked by tension which is built up within the anterior longitudinal ligament as well as by the approximation of the superior articular process of the vertebra below with the transverse process of vertebra above as well as by the impact of the posterior arches (Kapanji, 1974; Middleditch and Olivier, 2005).

b) Flexion

During flexion the vertebral body of the segment above will tilt and slide anteriorly, resulting in the intervertebral disc space being compressed on its anterior aspect. This forces the nucleus pulposis posteriorly which in turn stretches the anterior fibres of the annulus fibrosis. The anterior ledge which is present on superior plateau of the vertebra below allows the beak like projection
of the inferior surface of the vertebra above to move past. Flexion, like extension, does not occur around the centre of curvature of the articular facets therefore the inferior articular facet of the vertebra above moves superiorly and anteriorly resulting in an opening of the interspace posteriorly which is the angle of flexion. This movement is not checked by bony approximation but rather by tension within the posterior longitudinal ligament, capsular ligament of the joint, ligamentum flavum, ligamentum nuchae and posterior cervical ligament in other words all posterior ligamentous structures (Kapanji, 1974; Middleditch and Olivier, 2005).

c) Combined lateral flexion and rotation

This movement is governed by the oblique orientation of the articular facets in the lower cervical spine. This prevents pure rotation or pure lateral flexion from occurring (Kapandji, 1974). This motion occurs due to the coronal and oblique orientation of the cervical facet joints therefore this is known as coupled motion (Magee, 2008; Greenstein, 1997).

The superior and inferior surfaces of the articular facets are slightly convex posteriorly between C6 and C7, while at C3 and C4, they are slightly concave posteriorly. This increases the obliquity of the facet joints, from C7 to C3. Therefore, the plane of the C7/T1 facet joint articulation lies almost in line with the vertical axis. As a result, almost pure rotation will occur at this level. At the C2/C3 level the obliquity of the plane, through the articular surfaces forms an angle of forty to forty-five degrees with the vertical axis, therefore indicating almost equal rotation and lateral flexion occurring at this level. During lateral flexion, the inferior articular processes glide posteriorly and inferiorly on the concave side, while they glide superiorly and anteriorly on the convex side. Cervical rotation occurs in a transverse plane about a vertical axis between C2 and C7. Rotation occurs in the same direction as lateral flexion (Kapandji, 1974).
d) Movement at the uncovertebral joint

The unciform processes are located on the superior aspect of the vertebral body, they are lined by cartilage and are orientated in an medially and superiorly in order to articulate with the corresponding semilunar facets on the inferior plateau of the vertebra above. The uncovertebral joints are surrounding by a capsule and are continuous on their medial aspect with the intervertebral discs (Kapanji, 1974).

During flexion and extension the body of the upper vertebra will slide anteriorly or posteriorly and the uncovertebral joints will also slide relative to one another in such a way that the uncovertebral joints guide the vertebra into its anterior or posterior position (Kapanji, 1974).

During lateral flexion the joint space of the uncovertebral joint will be opened out slightly by an angle which is equal to the angle of lateral flexion Kapanji, 1974).

2.8.4 Range of motion of the cervical spine

According to Magee (2008), the range of motion present within the cervical spine is variable depending on the region. This is evident in table 2.2 below.
Table 2.3: Approximate range of motion for the three planes of movement for the joints of the cervical spine (Magee, 2008)

<table>
<thead>
<tr>
<th>Joint or region</th>
<th>Degrees of flexion and extension</th>
<th>Degrees of axial rotation</th>
<th>Degrees of lateral flexion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlanto-occipital joint</td>
<td>Flexion: 5</td>
<td>Negligible</td>
<td>Roughly 5</td>
</tr>
<tr>
<td></td>
<td>Extension: 10</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total: 15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Atlanto-axial joint</td>
<td>Flexion: 5</td>
<td>40-45</td>
<td>Negligible</td>
</tr>
<tr>
<td></td>
<td>Extension: 10</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total: 15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C2-7</td>
<td>Flexion: 35</td>
<td>45</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Extension: 70</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total: 105</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total cervical spine movement</td>
<td>Flexion: 45-50</td>
<td>90</td>
<td>Roughly 40</td>
</tr>
<tr>
<td></td>
<td>Extension: 85</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total: 130-135</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.9 Vertebral Subluxation Complex

The vertebral subluxation complex is a theoretical model seen from a clinical chiropractic perspective to view spinal dysfunction. This model indicates that dysfunction at a motion segment incorporates a complex interaction of pathological change in muscles, ligaments, nerves, vascular system or connective tissues. The model indicates that each facet of the hierarchy affect the other and eventually will start to affect other motion segments (Gatterman, 2004).
As seen in figure 2.10, a hypomobile segment would result in neuropathology. This neurological component is considered the cornerstone of chiropractic treatment as it is the mediator for health of all tissues and organs (Gatterman, 2004).
The next component is the connective tissue component, and this is vital in joint immobilisation due to the fact that if a joint becomes fixated or movement is compromised there are multiple changes which occur within the connective tissue. This includes fibro fatty changes of the synovial fluid resulting in an adherent fibrous tissue. This provides a matrix for the deposit of bone salts in the final stage of ankylosis. There is a loss of proteoglycans, which in turns cause the articular cartilage to shrink and reorganising resulting in the formation of ulcerations which are open between the synovial space and subchondral bone; this will ultimately lead to ossification (Gatterman, 2004).

The muscular component will also undergo degenerative changes in the form of disuse atrophy due to the immobilisation and general lack of movement in and around the segment (Gatterman, 2004).

Vascular components of a motion segment, like nerves, are susceptible to compression. The occlusion of these vessels can aggravate joint stiffness and may be associated with joint degeneration. If motion is restored, blood supply will be restored the ability for waste products to be removed and nutrition supplied will return to normal (Gatterman, 2004).

Finally the inflammatory component, inflammation is characterised by number of cellular features; including an increase in permeability and vasodilation of vessels and the migration of granulocytes and monocytes into the area. This results in localised swelling and the infiltration of macrophages into the area. The macrophages will not only engulf the damaged tissue, but the living tissue as well. The inflammation will slowly spread into surrounding areas leading to degeneration of the motion segment and adjacent segments as well (Gatterman, 2004).
Through the vertebral subluxation complex it is evident that treatment must be aimed at restoring normal homeostasis for a motion segment as all aspects of the VSC affect one another and result in degeneration of tissues.

2.10 Chronic mechanical neck pain

Chronic mechanical neck pain is a general term which refers to any type of pain occurring within the cervical spine which is caused due to abnormal stresses and strains being placed on the muscles, ligaments or subcutaneous tissue in the cervical spine. It may originate for intervertebral discs, nerves or bones (Maigne, 1996). Chronic pain refers to the fact that the pain has been present for more than a month beyond the usual course of an acute illness or injury, or if it is reoccurring in nature (Seaman and Cleveland, 1999).

2.10.1 Aetiology

Any structures receiving a nerve supply may become a source of pain, if it is affected by a disorder. The innervated structures in the cervical spine are the zygapophyseal joints and the posterior neck musculature, the cervical intervertebral discs, the vertebral bodies, the anterior and posterior ligaments, the dura mater of the cervical spinal cord, the prevertebral muscles and the vertebral artery which is innervated by cervical nerves (Bogduk et al, 2006).

Any stress or strain on the above mentioned structures may result in pain. The main causes of this are overuse in the form of poor posture, excessive computer work with improper ergonomics, poor rest protocol and poor exercise protocols. Trauma may also cause neck pain in the form of a whiplash injury. However if any of the above mentioned conditions are long standing or do not resolve in the expected time frame they will be considered as chronic.
2.10.2 Signs and symptoms of neck pain

When the upper cervical spine is affected there is typically a pain referral into the suboccipital region as well as the experience of headaches by the patient. If the middle cervical spine is affected pain is typically experienced in the supra-scapular region and when the inferior cervical spine is affected the pain typically radiates into the inter-scapular region. Therefore the symptoms that are present give us the ability to locate the source of the pain (Maigne, 1996).

The other less specific symptoms which are present in chronic mechanical neck pain includes dizziness, facet joint tenderness, headaches, pain over the superior aspects of the shoulder especially over the surface area of the trapezius muscles (Maigne, 1996).

2.11 Effects of the cervical spine adjustment

2.11.1 Introduction

The overall aim of a chiropractic adjustment is to remove the restriction of motion present within the motion segment and to restore normal function (Gatterman, 2005). By removing a restriction to the joint one provides local mechanical, neurological and vascular effects (Esposito and Philipson, 2005; Gatterman, 2005).

2.11.2 Mechanical effects of the adjustment
When there is a disorder of the neuromusculoskeletal system there will be soft tissue disorders as well as mechanical dysfunctions (Peterson and Bergmann, 2002). This can occur via the release of entrapped synovial or disc material when an adjustment is delivered. This will not only decrease pain but also increase mobility. The adjustment may also help reduce adhesions and dynamically stretch muscle tissue (Vernon, 1997).

### 2.11.3 Neurological effects of the adjustment

According to Cassidy, Lopes and Yong-Hing, (1992) adjustment therapy has a reflex effect on pain and muscle tension. This appears to work on the level of the primary afferent neurons of the paraspinal tissues, the motor control system as well as the pain processing centre (Pickar, 2002). The adjustment provides a new input into the nervous system and has the ability to remove any aberrant sensory information, this brings about a biomechanical change (Leach, 2004). Adjustment also has the ability stimulate mechanoreceptors of the synovial joints in order to bring about normal function (Gatterman, 2005). This mechanoreceptor stimulation is important as when the motion of a segment is affected type I, II and III mechano-receptors become dormant, therefore the receptors firing are the nociceptive type IV causing the perception of pain. Type I, II and III receptors have the ability to inhibit the perception of pain if they are functioning correctly. Increasing the motion will allow this normal function, decreasing the perception of pain (Gatterman, 2005).

### 2.11.7 Effects of the adjustment on the myofascial cycle

Adjustment of the cervical spine has a direct effect on the structures which surround the spine by causing a stretch of the surrounding muscles and therefore causing muscle spindle reflexes, this is due to manual therapy changing the tone of supporting musculature, which in turn may reduce the taut palpable bands present within the muscle which are known as trigger points. Cervical adjustment may also help decrease the presence of adhesions, and increase segmental motion (Plaugher, 1993).
Spinal structures are densely innervated by multiple sensory receptors in muscle, ligament, facet joints, paraspinal skin, the meninges and outer fibres of the IVD, all of which are affected by cervical adjustments. The receptors which are present within these spinal structures have different sensitivities and the stimulation of these receptors has the ability to activate a central reflex pathway and somato-somatic reflex, this assists in decreasing the present muscle spasm and increasing range of motion (Haldeman, 2000).

2.12 Myofascial trigger points

2.12.1 Introduction

The definition of a myofascial trigger point is a hyper-irritable zone inside a muscle which is characterised by the following features:

- Increased metabolism
- Poor vascularity
- Presence of a taut, palpable band
- Localised tenderness and pain
- Abnormal contraction
- Reproducible pain referral pattern specific to the muscle as well as to the involved trigger point
- Failure of normal relaxation
- Generalised weakness of the muscle
- Sometimes autonomic phenomena including:
  - Profuse tearing
- Visual disturbances
- Narrowed palpebral fissure
- Reddening of the conjunctiva
- Ptosis
- Maxillary sinus congestion

### 2.12.2 Trigger point agenesis

According to Gatterman (1990) mechanical stresses are responsible for the formation of trigger points. These mechanical stresses can be externally or internally induced due to microtrauma.

#### a) External trauma

An external trauma would typically be a form of muscle strain which would ultimately lead to tissue damage and the tearing of the sarcoplasmic reticulum. This results in the release of blood from the tissue and therefore platelets and mast cells being released. Mast cells are responsible for the release of histamine which ultimately leads to the sensitisation of nerve endings and the activation of pain circuits. Platelets trigger homeostasis, both primary and secondary. Primary homeostasis causes vessel constriction and activation and adherence of platelets due to the presence of arachidonic acid which is released from membrane lipids, which is converted by the enzymes cyclo-oxygenase and thromboxane synthetase into thromboxane B2 and prostaglandin. This results in the formation of the platelet plug and therefore haemorrhaging is ceased. However the by products which are formed, namely prostaglandins, serotonin and bradykinin all lead to sensitisation of nerve endings and activation of the pain circuits. Secondary homeostasis simply deposit fibrin in order to stabilise the platelet plug (Gatterman, 2004).
b) Internal trauma

Internal trauma would occur due to a chronic repetitive stress such as a poor rest protocol, bad posture or poor exercise protocol. This ultimately leads to a chronic muscle strain which causes the release of stored calcium which not only causes a sustained contraction and excessive fatigue, but also a decreased ability to remove the calcium from the injured site. This inability to remove the released calcium sets up a perpetuating chain of events as one has normal levels of Adenosine triphosphate (ATP) with excessive calcium; this will result in a localised sustained contraction which forms a taut band within the muscle. This taut band causes a lack of interaction between the actin and myosin of the affected muscle fibres and with the excess calcium due to the damaged sarcoplasmic reticulum causes a sustained and uncontrolled muscle contraction which has uncontrolled metabolism. This is a stimulus for reflex vasoconstriction. Due to this vasoconstriction the released metabolites (particularly prostaglandin) accumulates causing pain (Gatterman, 2004).

Other factors which may also result in the formation of trigger points include:

- Nutritional inadequacies including
  - Vitamin B1
  - Vitamin B6
  - Vitamin B12
  - Folic acid
  - Vitamin C

- Psychological factors

- Metabolic and endocrine inadequacies

- Chronic infection

- Other factors, such as:
Allergies

Impaired sleep

Radiculopathy

Chronic visceral disease

2.12.3 Location of trigger points

Semispinalis Capitis has three trigger points. Trigger point one is found 1-2cm from the midline of the base of the skull and trigger point two is found around the level of C1, while the third trigger point is found just lateral to C3-4. Due to the path of the vertebral artery along the posterior arch of C1 the upper two trigger points are not needled. Only the third trigger point receives dry needling therapy (Travell and Simons, 1993).

Longissimus capitis has one trigger point which is typically found around the level of C3-4 just lateral to the spinous processes. While trigger points may be present above or below this area, the muscle is too deep for any trigger point to be effectively localised (Travell and Simons, 1993).

Semispinalis capitis trigger points are also located just lateral to the spinous process around the C4-5 level (Travell and Simons, 1993).

Cervical multifidi have trigger points which are located between the spinous processes starting at about C3, but these are very deep and hard to identify as are the rotators trigger points (Travell and Simons, 1993).

It becomes evident when discussing the posterior cervical muscle trigger point location that due to the overlapping layered nature of these muscles, by inserting
a needle around the level of C3-5 into a taut band, one would be affecting multiple levels of muscles and essentially targeting multiple trigger points.

2.12.4 Trigger point pain referral

Semispinalis capitis referral pattern is a band like projection above the orbit with a concentration of the pain over the temporal region. It is also capable of producing a referral pattern over posterior occiput. It also causes local pain over the active trigger points (Travell and Simons, 1993).

Longissimus capitis concentrates on the region of the ear as well as just above or below the ear. The referral pattern may extend down the posterior neck and sometimes also pain present posterior to the orbit (Travell and Simons, 1993).

Semispinalis cervicis refers pain mainly to the suboccipital region only (Travell and Simons, 1993).

Cervical multifidi refers pain up into the suboccipital region and down to the vertebral border of the scapula (Travell and Simons, 1993).

The cervical rotators muscles cause pain over the midline and only to the segment where the trigger point is located (Travell and Simons, 1993).

2.12.5 Effects of dry needling therapy

Dry needling disrupts the integrity of the dysfunctional end plates within the trigger point. It has two main effects, the first is the mechanical and physiological resolution of the trigger point and the second is the activation of strong pain
inhibition by opioids released via activation of the A-Delta receptors (Travell and Simons, 1993).

a) Mechanical and physiological resolution of trigger points

During dry needling there are superficial effects that occur as well. This happens due to the needling passing through the skin and subcutaneous tissue overlying the active myofascial trigger point. This results in stimulation of the fast A-Delta fibres which are found within the skin. This essentially closes the dorsal horn of the spinal cord off to pain signal so they no longer move up to the higher brain functioning areas. To assist this function there is also activation of the descending inhibitory system of the central nervous system.

b) Opioid pain inhibitory system

Dry needling of the deep myofascial trigger points activates the pain suppressing endogenous opioid system. The activation of a local twitch response leads to the alteration of the length of the muscle fibre. This stimulates the large diameter mechanoreceptors in the dorsal horn of the spinal cord leading to blockage of nociceptive information and the release of opioids to assist in a reduction of pain.

2.13 Conclusion of literature review

As discussed in the above chapter it is clear that chiropractic adjustment is aimed at clearing disability and pain at a neuro-musculoskeletal level while dry needling is aimed at the resolution of symptoms via the treatment of muscle alone. Therefore one aims to see if there is a synergistic effect which occurs when both treatments are combined as both effects are desirable.
CHAPTER THREE – METHODOLOGY

3.1 Study design

This trial is a randomised controlled clinical trial which used convenience sampling.

3.2 Participant recruitment

The methodology included thirty participants who were diagnosed with chronic mechanical neck pain. The participants were recruited via advertisements placed around the University of Johannesburg as well as surrounding areas and campuses (Appendix A). Each participant underwent screening tests to ensure that they all met the inclusion criteria.

At the initial consultation the patient read and signed the information and consent form (Appendix B). They were screened via a full case history (Appendix C) as well as with a physical exam (Appendix D). A cervical spine regional was also carried out (Appendix E). All of the above mentioned screening tests ensure that the participants all have chronic mechanical neck pain due to an abnormality which is present at the cervical facet joints. It was also diagnosed as being chronic via the use of motion palpation, Kemps test and trigger point analysis as these are all increments of the inclusion criteria.

3.3 Sample selection and size

Thirty participants between the ages of eighteen and thirty were recruited to participate in the study. Suitable participants drew papers labelled A, B or C out of a container which randomly divided the participants into three groups of ten participants each. Equal male and female numbers were guaranteed by keeping only a limited amount of spaces open for each gender in all three groups.
3.3.1 Inclusion criteria

In order to eliminate any possible variables each participant is required to meet the following:

- Participants could be male or female.

- Participants were between the ages of 18 to 50 years as after 50 years of age there is an increased incidence of arthritic changes within the spine which could potentially affect the study.

- Participants presented with chronic mechanical neck pain. The diagnostic criteria for chronic mechanical neck pain includes (Seaman and Cleveland, 1999):
  - Pain which has been present for at least one month, beyond the usual course of an acute injury or illness, or if it reoccurring in nature for months or years.
  - The pain present within the cervical spine may be due to muscular, subcutaneous, ligamentous or osseous dysfunction.

- Participants presented with active trigger points of the posterior cervical musculature. This is a trigger point which has a specific, reproducible pain referral pattern (Travell and Simons, 1993).

Once selected participants were divided into three groups:

**Group one** received cervical adjustment therapy to restricted joint segments.

**Group two** received dry needling of the posterior cervical musculature.

**Group three** received a combination of the two above mentioned treatment protocols.
3.3.2 Exclusion criteria

Participants are excluded from the study if they suffer from:

- Participants who presented with any contraindications to chiropractic adjustment of the cervical spine (Appendix F).
- Participants that presented with any contraindications to dry needling (Appendix G).
- Any pre-existing condition that may have had an effect on the presence of Chronic Mechanical Neck Pain.
- Participants who were undergoing any other form of treatment outside of this study, which would have interfered with the results of the study.

3.3.3 Random group allocation

Suitable participants drew papers labelled A, B or C out of a container which randomly divided the participants into three groups of ten participants each. Equal male and female numbers were guaranteed by keeping only a limited amount of spaces open for each gender in all three groups.

3.4 Treatment approach

3.4.1 First visit

- Signing of an Information and consent form (Appendix B).
- Participants underwent a detailed case history (Appendix C).
- Participants underwent a physical examination (Appendix D).
- Participants underwent a cervical spine regional examination (Appendix E).
• Participants were requested, prior to treatment, to complete a Numerical Pain Rating Scale (NPRS) in order to evaluate pain or discomfort levels (Appendix H)

• Participants were requested, prior to treatment, to complete a Neck Pain and Disability Index: Vernon Mior in order to quantify pain and disability in the participants life (Appendix I)

• Before treatment, the full cervical spine range of motion was measured using a Cervical Range of Motion Measuring Instrument (CROM) (Appendix J)

• Before the treatment the sensitivity of the chronic cervical facet was assessed using a Pressure Algometer (Appendix K)

3.4.2 Follow up visits

• The objective and subjective data was collected at the beginning of the 4th and 7th sessions

• Participants went through a chiropractic assessment and completion of clinical assessment notes prior to the treatment

• Treatments were applied according to the participant’s allocated group. The final (7th) consultation was used for data collection alone

• A total of 6 treatments (including the first visit) took place over a three week period

3.4.3 Treatments

• Participants were treated five times over a three week period

• Group one was treated with cervical adjustment therapy to restricted joint segments between C1 and C5
• Group two was treated with dry needling to the posterior cervical musculature active trigger points

• Group three received a combination of the above mentioned treatments

• At onset of treatment all participants were asked to refrain from strenuous activity, exercise, analgesics as well as any other treatment for neck pain until the end of the treatment period

3.4.4 Discussion of treatment protocol

Participants in Group A received a Chiropractic cervical adjustment. Each participant in Group A was adjusted in a supine position using an index contact delivered as a high-velocity, low amplitude thrust to the restricted acute cervical facet joint/s. Participants in Group A were adjusted in a supine position using an index contact delivered as a high-velocity, low amplitude thrust to the restricted acute cervical facet joint/s.

A rotary chiropractic cervical technique was used, since it is the technique that is used for joint restrictions in a rotary direction, as determined by motion palpation.

The cervical Index technique was used (Vizniak et al, 2010):

The participants were positioned supine for right and left anterior rotary restrictions from C1-C7. The researcher was in a squatting position at the side of the restriction and applied an index contact on the posterior articular process of the involved vertebrae. The wrist of the contact hand was straight and relaxed, and the thumb of the contact hand may be placed on the patients chin for stability. The indifferent hand cups the patient’s ear with palm, with the index and middle fingers forming a split sternocleidomastoid contact and thus inducing rotation and slight lateral flexion of the participants head. The thrust is a high
velocity, low amplitude pectoral impulse which was delivered by the contact hand medially and superiorly in a line parallel to that of the eyes for rotary restrictions.

Group B received dry needling therapy only and was placed prone with the headpiece lowered slightly. Once the active trigger point had been identified the area was cleaned with an alcohol swab as well as the researcher’s gloved hands. The needle is inserted in a posterior to anterior direction one centimetre lateral to the spinous process of the involved vertebra. The needle was then left in the trigger point for ten minutes being stimulated and twisted every minute. After ten minutes the needle was removed and placed in a sharps bin immediately and the area that had been treated was swabbed with another clean alcohol swab and inspected for any adverse reactions to the treatment. A heat pack was then applied to the area after which the muscle was stretched according to proper needling techniques (Travell and Simons, 1993).

As group C was a combination group it received the full treatment protocol from both of the above mentioned groups.

3.5 Subjective data

3.5.1 Numerical Pain Rating Scale

The participants were subjectively evaluated by completing a Numerical Pain Rating Scale (Appendix H). This questionnaire was completed at the first, fourth and seventh visits. The participants were asked to indicate the level of pain experienced at that moment on a scale from 0 to 10. 0 indicates no pain whereas 10 indicate worst pain ever felt (Mc Dowell and Newell, 1996). According to Williamson and Hoggart (2004), the Numerical Pain Rating Scale is reliable, valid and appropriate for use in clinical practice. The Numerical Pain Rating Scale was answered by participants before the first, fourth and during the seventh visits. None of the participants were told his/her scores following completion of the questionnaire, nor were they shown the scores from previously completed questionnaires.
3.5.2 Vernon-Mior Neck Pain and Disability Index

The Vernon-Mior Neck Pain and Disability Index (Appendix I) is among one of the most commonly utilised questionnaires used to assess both the intensity and quality of pain experienced by the participant. It is considered valid and reliable according to Chan Ci En, Clair and Edmondston (2009). It is made up of ten categories, six answers to each category, making a total of sixty questions which provides information on how the patient’s ability to manage everyday life has been affected by neck pain (Vernon, 2008).

The Neck Pain and Disability Index provide the researcher with the ability to calculate a numeric figure to change the information gained into statistical information. The Neck Pain and Disability Index has become a standard instrument for measuring self-rated disability due to neck pain and are used by clinicians and researchers alike. Each of the 10 items is scored from 0-5. The maximum score is then converted to a percentage score (Vernon and Mior, 1991; McCarthy et al., 2007; MacDermid et al., 2009). In order to interpret the degree of pain and disability the participant is suffering, the researcher is required to calculate a score from the participant’s record of the index. The percentage scores obtained relate to the degree of disability as follows (Vernon and Mior, 1991):

- 0-8% represents no disability
- 10-28% represents minimal disability, where the participant is able to cope with the pain during most daily activities
- 30-48% represents moderate disability, where the participant experiences more pain or problems with daily activities. The participant may notice that travel and their social life is more difficult, and they may tend to take off work because of the disability
- 50-68% represents severe disability, where pain is the main problem, but travel, personal care, social life and sleep are also affected
• Above 68% represents complete disability, where the disability impinges on all aspects of daily life at home and work.

3.6 Objective data

3.6.1 Pressure Algometer

The Algometer is reliable, valid and measures the “pressure threshold” experienced by the participants (Ylinen, 2007). The Algometer is widely accepted for clinical use as a quantitative measure of pressure pain threshold (Charlton, 2005). Pressure threshold is a measure of the pressure pain sensitivity of tender areas and is considered the minimum pressure that causes pain (Rachlin, 1994).

The Algometer is a spring operated plunger calibrated in kg/cm² fitted with a rubber disc of 1cm² surfaces. Algometer readings were measured on the chronic side of the participant. The Algometer was placed over the chronic cervical facet at a 90 degree angle to the skin. Pressure was then applied downwards until the participant indicated that the pressure was causing pain. The Algometer was removed and a reading in kg/cm² was taken and recorded (Appendix K).

Measurements were taken with the Algometer before the first, fourth and during the seventh visits. None of the participants were told their measurements following completion, nor were they shown the measurements from previous visits.

3.6.2 Cervical Range of Motion measuring instrument (CROM)

The CROM device was used in this research study to assess cervical spine ranges of motion in active flexion, extension, lateral flexion and rotation (Appendix J). The CROM has been shown to have some of the best ratings on clinometric aspects such as reproducibility, responsiveness and validity (de Koning et al., 2008). The CROM is a reproducible method for assessing changes in mobility after treatment (Palmer and Epler, 1998). The CROM measures three planes of movement: flexion and extension are measured in the sagittal plane,
right and left lateral flexion are measured in the coronal plane and right and left rotation are measured in the transverse plane.

The CROM was strapped to the participant’s head. The participants were asked to place their head in a neutral position and the CROM dial was checked that the neutral position was at 0 degrees of movement. From the neutral position, the participants slowly flexed as far as possible then returned to neutral. The same procedure was repeated for extension, bilateral lateral flexion and bilateral rotation. At the end of each movement, the participant was asked to return to the neutral position. Three measurements were taken at the end range for each movement and averaged to obtain the mean measurement for that range of movement. Measurements of flexion, extension, right and left lateral flexion as well as rotation were taken with the CROM before the first, fourth and during the seventh visits. None of the participants were told their measurements following completion, nor were they shown the measurements from previous visits.

The average ranges of motion in each cervical spine movement are as follows (Plaugher and Lopes, 1993; Levangie and Norkin, 2005):

- Flexion 45-90 degrees
- Extension 55-90 degrees
- Lateral Flexion 20-45 degrees
- Rotation 70-90 degrees

### 3.7 Data Analysis

Objective and subjective data will be collected by the researcher throughout the study. Analysis of the data was then aided by a statistician at STATKON at the University of Johannesburg Kingsway campus. STATKON analysed these results using an Exploratory Data Analysis (EDA) for a comparison of the three above
mentioned groups. If the results of the EDA indicate that the distribution of results is not Normal or Bell-Shaped, the individual sample T-Test will be performed in order to compare the averages of the three groups datasets.

In the unlikely event that the individual sample T-Test’s assumptions do not hold, the Kruskall-Wallis test and Mann-Whitney U Test were performed as a non-parametric alternative to the T-Test for the inter-group analysis. The Friedman test and Wilcoxon Signed Rank test will be used in order to assess the intra-group analysis. This helped draw conclusions as to which group responded better overall to the particular treatment as well as which group responded faster over the treatment period.

It was concluded that the results were analysed using the Shapiro-Wilk test for normality and Levene’s test for equal variances. Parametric tests revealed that normality and equal variances were not present, due to the small sample size of the study. Subsequently, the non-parametric Wilcoxon Signed Ranks and Friedman tests were performed to compare intra-group results and the Mann-Whitney U test was done to compare inter-group results.

### 3.8 Ethical considerations

All participants that wished to partake in this particular study were requested to read and sign the information and consent form specific to this study. The information and consent form outlined the names of the researcher, purpose of the study and benefits of partaking in the study, participant assessment and treatment procedure. Any risks, benefits and discomforts pertaining to the treatments involved were explained and that the participant’s safety would be ensured (prevention of harm). The information and consent form were also explained that the participant’s privacy was protected as only the doctor, patient and clinician would be in the treatment room and that anonymity would be ensured as the patient information would be 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 informed that their participation was on a voluntary basis and that they were free to withdraw from the study at any stage without prejudice. Should the participant have had any further questions, those would have been explained by the researcher, whose contact details were made available. The participants were then required to sign the information and consent form, signifying that they understood all that was required of them for this particular study.

With regards to this particular study, possible post needling or post adjustment muscle stiffness could have occurred which should have settle within a few days at the most. If these symptoms persisted the treatment would have been stopped and the patient would have been referred to the appropriate health professional. Benefits from treatment may have involved complete or partial, permanent or temporary relief of pain and an increase in cervical range of motion.

Results of this study were made available on request.
CHAPTER FOUR-RESULTS

4.1 Introduction

The findings obtained from the study are presented in this chapter. The sample group consisted of thirty participants that were divided into group A, group B and group C. Group A represents the ten participants treated with both cervical adjustment as well as dry needling therapy (combination group). Group B represents the group of ten participants treated with dry needling only, and group C was the group of ten participants who were treated with only cervical adjustment. The statistical results only represent a small group of subjects and therefore no assumptions can be made with respect to the population as a whole.

The p-value for the tests was set at 0.05 and represented the level of significance of the results. If the p-value was less than or equal to 0.05 ($p \leq 0.05$) there was a statistically significant finding. If the p-value was greater than 0.05 ($p \geq 0.05$) there was no statistically significant finding. Statistical significance means that a given result is unlikely to have occurred by chance.

The analyses included:

- Demographic data analysis which consisted of the gender and age of the participants.

- Subjective measurements which consisted of the Numerical Pain Rating Scale and Vernon-Mior Disability Index.

- Objective measurements which consisted of Pressure Algometer readings and cervical range of motion measuring instrument (CROM), which included flexion, extension, left and right lateral flexion and left and right rotation.
4.2 Demographic Data Analysis

The population group of this study consisted of fifteen female and fifteen male participants (n=30). Group A consisted of ten participants (n=10); five females and five males. Group B also consisted of ten participants (n=10); also five females and five males. The final group, Group C consisted on ten participants (n=10); also five males and five females. The mean age of each group and for the demographic as a whole is demonstrated in table 4.1. The mean age of group A was 24.6 years and of group B was 25.6 years, and group C 25.2 years of age; making the total population mean 25.1 years.

Table 4.1: Comparison of Demographic Data Between Groups

<table>
<thead>
<tr>
<th>Data</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
<th>Combined total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age distribution (Years)</td>
<td>23-26</td>
<td>24-29</td>
<td>24-26</td>
<td>23-29</td>
</tr>
<tr>
<td>Mean age (Years)</td>
<td>24.6</td>
<td>25.6</td>
<td>25.2</td>
<td>25.1</td>
</tr>
<tr>
<td>Gender description</td>
<td>5 Males</td>
<td>5 Males</td>
<td>5 Males</td>
<td>5 Males</td>
</tr>
<tr>
<td></td>
<td>5 Females</td>
<td>5 Females</td>
<td>5 Females</td>
<td>5 Females</td>
</tr>
</tbody>
</table>

4.3 Subjective Data Analysis

4.3.1 Evaluation of Numerical Pain Rating Scale Readings (NPRS)

Intragroup Analysis

The Shapiro-Wilk test, that tests for normality was inconclusive. Therefore the non-parametric Friedman Test was used to determine intragroup results between the 1st and 7th treatment. The non-parametric Wilcoxon Signed Rank Test was used to determine intragroup results between the 1st and 4th and the 4th and the 7th treatment.

a) Group A
The Friedman test was used to compare group A’s 1st treatment to the 7th treatment. The results indicated that group A demonstrated a statistically significant improvement \((p \leq 0.05)\) over time \((p=0.01)\).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement \((p \leq 0.05)\) for the 1st treatment to the 4th treatment \((p=0.00)\) and for the 4th treatment to the 7th treatment \((p=0.01)\).

The NPRS results on the first visit for group A had a mean value of 5.60, on the fourth visit had a mean value of 3.10 and on the seventh visit had a mean value of 1.30. The mean difference between the 1st and 4th visit for group A was 2.50, this resulted in a median percentage improvement of 45%. The median difference between the 4th and 7th visit for group A was 1.8 and this resulted in a median percentage improvement of 39%. At the end of the study group A was 4.30, which resulted in a median percentage improvement of 77%. All results from the non-parametric intragroup analysis is demonstrated in table 4.2.

### Table 4.2: Intra-group analysis of \(p\) and mean values for Group A

<table>
<thead>
<tr>
<th>Visits Group A</th>
<th>(p) value</th>
<th>Mean difference</th>
<th>Percentage difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st-4th visit</td>
<td>0.00</td>
<td>2.50</td>
<td>45%</td>
</tr>
<tr>
<td>4th-7th visit</td>
<td>0.01</td>
<td>1.80</td>
<td>39%</td>
</tr>
<tr>
<td>1st-7th visit</td>
<td>0.01</td>
<td>4.30</td>
<td>77%</td>
</tr>
</tbody>
</table>

b) Group B
The Friedman test was used to compare group B’s 1st treatment to the 7th treatment. The results indicated that group B demonstrated a statistically significant improvement \((p\leq 0.05)\) over time \((p=0.01)\).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement \((p\leq 0.05)\) for the 1st treatment to the 4th treatment \((p=0.00)\) and for the 4th treatment to the 7th treatment \((p=0.01)\).

The NPRS results on the first visit for group B had a mean value of 5.60. On the fourth visit group B had a mean value of 3.50, and on the seventh visit group B had a mean value of 1.20. The mean difference between the 1st and 4th visit for group B was 2.10 and this resulted in a median percentage improvement of 38%. The median difference between the 4th and 7th visit for group B was 2.30, this resulted in a median percentage improvement of 66%. At the end of the study group B was 4.40 and this resulted in a median percentage improvement of 79%. All of the non-parametric intragroup analysis results are demonstrated in table 4.3.

<table>
<thead>
<tr>
<th>Group B</th>
<th>p value</th>
<th>Mean difference</th>
<th>Percentage difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st-4th visit</td>
<td>0.00</td>
<td>2.10</td>
<td>38%</td>
</tr>
<tr>
<td>4th-7th visit</td>
<td>0.01</td>
<td>2.30</td>
<td>66%</td>
</tr>
<tr>
<td>1st-7th visit</td>
<td>0.01</td>
<td>4.40</td>
<td>79%</td>
</tr>
</tbody>
</table>


c) Group C
The Friedman test was used to compare group C’s 1st treatment to the 7th treatment. The results indicated that group B demonstrated a statistically significant improvement \((p \leq 0.05)\) over time \((p = 0.01)\).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement \((p \leq 0.05)\) for the 1st treatment to the 4th treatment \((p = 0.01)\) and for the 4th treatment to the 7th treatment \((p = 0.00)\).

The NPRS results on the first visit for group C had a mean value of 5.10, on the fourth visit group C had a mean value of 3.10 and on the seventh visit group C had a mean value of 1.10. The mean difference between the 1st and 4th visit for group C was 2.00. This resulted in a median percentage improvement of 39%. The median difference between the 4th and 7th visit for group C was 2.30. This resulted in a median percentage improvement of 66%. At the end of the study group C was 4.00 which resulted in a median percentage improvement of 78%. All of the above mentioned intragroup analyses can be seen in table 4.4.

### Table 4.4: Intragroup analysis for p and mean values for Group C

<table>
<thead>
<tr>
<th>Group C</th>
<th>p value</th>
<th>Mean difference</th>
<th>Percentage difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st-4th visit</td>
<td>0.01</td>
<td>2.00</td>
<td>39%</td>
</tr>
<tr>
<td>4th-7th visit</td>
<td>0.00</td>
<td>2.30</td>
<td>66%</td>
</tr>
<tr>
<td>1st-7th visit</td>
<td>0.01</td>
<td>4.00</td>
<td>78%</td>
</tr>
</tbody>
</table>

**Intergroup Analysis**

The Independent T test, that tests for normality were inconclusive, therefore the Mann-Whitney U tests were used to determine if there is a statistical significance between group A, B and C on the numerical pain rating scale.

The Mann-Whitney U test revealed that there was no statistical significance \((p \geq 0.05)\) between group A, group B and group C at the 1st visit \((p = 0.65)\), the 4th visit \((p = 0.55)\) and the 7th visit \((p = 0.90)\). This means that the groups started
out comparable and that they remained like that throughout the study with no significant difference in improvement between them, and this is demonstrated in table 4.5.

<table>
<thead>
<tr>
<th></th>
<th>1st visit</th>
<th>4th visit</th>
<th>7th visit</th>
</tr>
</thead>
<tbody>
<tr>
<td>p value</td>
<td>0.65</td>
<td>0.55</td>
<td>0.90</td>
</tr>
</tbody>
</table>

**Table 4.5: Results of Intergroup analysis of NPRS**

4.3.2 Evaluation of Vernon-Mior Disability Index (VMDI)

**Intragroup Analysis**

The Shapiro-Wilk test, that tests for normality was inconclusive. Therefore the non-parametric Friedman Test was used to determine intragroup results between the 1st and 7th treatment. The non-parametric Wilcoxon Signed Rank Test was used to determine intragroup results between the 1st and 4th and the 4th and the 7th treatment.

a) **Group A**

The Friedman test was used to compare group A’s 1st treatment to the 7th treatment. The results indicated that group A demonstrated a statistically significant improvement \((p \leq 0.05)\) over time \((p=0.00)\).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement \((p \leq 0.05)\) for the 1st treatment to the 4th treatment \((p=0.00)\) and for the 4th treatment to the 7th treatment \((p=0.04)\).

With regards to the mean VMDI values the first visit for group A had a mean value of 9.30, on the fourth visit group A had a mean value of 5.60 and on the seventh visit group A had a mean value of 2.40. The mean difference between the 1st and 4th visit for group A was 3.70. This resulted in a median percentage improvement of 40%. The median difference between the 4th and
7th visit for group A was 3.20. This resulted in a median percentage improvement of 57%. At the end of the study group A was 6.90 which resulted in a median percentage improvement of 74%. All of the above mentioned data is visible in table 4.6.

Table 4.6: Intragroup analysis p and mean values for Group A

<table>
<thead>
<tr>
<th>Group A</th>
<th>p value</th>
<th>Mean difference</th>
<th>Percentage difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st-4th visit</td>
<td>0.00</td>
<td>3.70</td>
<td>40%</td>
</tr>
<tr>
<td>4th-7th visit</td>
<td>0.00</td>
<td>3.20</td>
<td>57%</td>
</tr>
<tr>
<td>1st-7th visit</td>
<td>0.00</td>
<td>6.90</td>
<td>74%</td>
</tr>
</tbody>
</table>

b) Group B

The Friedman test was used to compare group B’s 1st treatment to the 7th treatment. The results indicated that group B demonstrated a statistically significant improvement \( (p \leq 0.05) \) over time \( (p=0.01) \).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement \( (p \leq 0.05) \) for the 1st treatment to the 4th treatment \( (p=0.01) \) and for the 4th treatment to the 7th treatment \( (p=0.01) \).

The VMDI results on the first visit for group B had a mean value of 9.80, on the fourth visit group B had a mean value of 5.30 and on the seventh visit group B had a mean value of 2.00. The mean difference between the 1st and 4th visit for group B was 4.50. This resulted in a median percentage improvement of 46%. The median difference between the 4th and 7th visit for group B was 3.30. This resulted in a median percentage improvement of 62%. At the end of the study group B was 7.80 which resulted in a median percentage improvement of 80%. All of the above mentioned results are visible in table 4.7.

Table 4.7: Intragroup analysis of p and mean values for Group B
c) Group C

The Friedman test was used to compare group B’s 1st treatment to the 7th treatment. The results indicated that group B demonstrated a statistically significant improvement \((p \leq 0.05)\) over time \((p=0.01)\).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement \((p \leq 0.05)\) for the 1st treatment to the 4th treatment \((p=0.01)\) and for the 4th treatment to the 7th treatment \((p=0.01)\).

The VMDI results on the first visit for group C had a mean value of 8.20, on the fourth visit group C had a mean value of 4.80 and on the seventh visit group C had a mean value of 2.60. The mean difference between the 1st and 4th visit for group C was 3.40. This resulted in a median percentage improvement of 41%. The median difference between the 4th and 7th visit for group C was 2.20. This resulted in a median percentage improvement of 46%. At the end of the study group C was 5.60 which resulted in a median percentage improvement of 68%. This is evident in table 4.8 below.

<table>
<thead>
<tr>
<th>Group C</th>
<th>p value</th>
<th>Mean difference</th>
<th>Percentage difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st-7th visit</td>
<td>0.01</td>
<td>3.40</td>
<td>41%</td>
</tr>
</tbody>
</table>

Table 4.8: Intragroup analysis of p and mean values for Group C
Intergroup Analysis

The Independent T test, that tests for normality were inconclusive, therefore the Mann-Whitney U tests were used to determine if there is a statistical significance between group A, B and C on the Vernon-Mior Disability Index.

The Mann-Whitney U test revealed that there was no statistical significance (p≥0.05) between group A, group B and group C at the 1st visit (p=0.63), the 4th visit (p=0.61) and the 7th visit (p=0.51). This means that the groups started out comparable and that they remained like that throughout the study with no significant difference in improvement between them.

<table>
<thead>
<tr>
<th></th>
<th>1st visit</th>
<th>4th visit</th>
<th>7th visit</th>
</tr>
</thead>
<tbody>
<tr>
<td>p value</td>
<td>0.63</td>
<td>0.61</td>
<td>0.51</td>
</tr>
</tbody>
</table>

**Table 4.9: Intergroup analysis of Vernon-Mior Disability Index**

4.4 Objective Data Analysis

4.4.1 Evaluation of Pressure Algometer Reading
All pressure algometer readings were only taken on the side of the chronic facet.

**Intragroup Analysis of Algometer Readings**

The Shapiro-Wilk test, that tests for normality was inconclusive, therefore the Friedman Test was used to determine intragroup results between the 1st and 7th treatment. The Wilcoxon Signed Rank Test was used to determine intragroup results between the 1st and 4th and the 4th and the 7th treatment.

**a) Group A**

The Friedman test was used to compare group A’s 1st treatment to the 7th treatment. The results indicated that group A demonstrated a statistically significant improvement \((p \leq 0.05)\) over time \((p=0.01)\).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement \((p \leq 0.05)\) for the 1st treatment to the 4th treatment \((p=0.02)\) and for the 4th treatment to the 7th treatment \((p=0.01)\).

The Algometer results on the first visit for group A had a mean value of 5.57\(\text{kg/cm}^2\), on the fourth visit group A had a mean value of 5.78\(\text{kg/cm}^2\) and on the seventh visit group A had a mean value of 6.20\(\text{kg/cm}^2\). The mean difference between the 1st and 4th visit for group A was 0.21\(\text{kg/cm}^2\). This resulted in a median percentage improvement of 4%. The median difference between the 4th and 7th visit for group A was 0.42\(\text{kg/cm}^2\). This resulted in a median percentage improvement of 7%. At the end of the study group A was 0.63\(\text{kg/cm}^2\) which resulted in a median percentage improvement of 11%. This is evident in table 4.10 below.

<table>
<thead>
<tr>
<th>Table 4.10: Intragroup analysis of p and mean values for Group A</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group A</strong></td>
</tr>
<tr>
<td>1st-4th visit</td>
</tr>
</tbody>
</table>

60
b) Group B

The Friedman test was used to compare group B’s 1st treatment to the 7th treatment. The results indicated that group B demonstrated a statistically significant improvement \((p \leq 0.05)\) over time \((p=0.01)\).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement \((p \leq 0.05)\) for the 1st treatment to the 4th treatment \((p=0.01)\) and for the 4th treatment to the 7th treatment \((p=0.01)\).

The Algometer results on the first visit for group B had a mean value of 4.98kg/cm², on the fourth visit group B had a mean value of 5.49kg/cm² and on the seventh visit group B had a mean value of 6.04kg/cm². The mean difference between the 1st and 4th visit for group B was 0.51kg/cm². This resulted in a median percentage improvement of 10%. The median difference between the 4th and 7th visit for group B was 0.55kg/cm². This resulted in a median percentage improvement of 10%. At the end of the study group B was 1.06kg/cm² which resulted in a median percentage improvement of 21%. This is evident in table 4.11 below.

<table>
<thead>
<tr>
<th>4th-7th visit</th>
<th>0.01</th>
<th>0.42kg/cm²</th>
<th>7%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st-7th visit</td>
<td>0.01</td>
<td>0.63kg/cm²</td>
<td>11%</td>
</tr>
</tbody>
</table>

Table 4.11: Intragroup analysis of p and mean values for Group B

<table>
<thead>
<tr>
<th>Group B</th>
<th>p value</th>
<th>Mean difference</th>
<th>Percentage difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st-4th visit</td>
<td>0.01</td>
<td>0.51kg/cm²</td>
<td>10%</td>
</tr>
</tbody>
</table>
c) Group C

The Friedman test was used to compare group C’s 1st treatment to the 7th treatment. The results indicated that group B demonstrated a statistically significant improvement \((p \leq 0.05)\) over time \((p=0.01)\).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement \((p \leq 0.05)\) for the 1st treatment to the 4th treatment \((p=0.01)\) and for the 4th treatment to the 7th treatment \((p=0.01)\).

The Algometer results on the first visit for group C had a mean value of 4.63 kg/cm², on the fourth visit group C had a mean value of 5.21 kg/cm² and on the seventh visit group C had a mean value of 5.88 kg/cm². The mean difference between the 1st and 4th visit for group C was 0.58 kg/cm². This resulted in a median percentage improvement of 13%. The median difference between the 4th and 7th visit for group C was 0.67 kg/cm². This resulted in a median percentage improvement of 13%. At the end of the study group C was 1.25 kg/cm² which resulted in a median percentage improvement of 27%. All of the above mentioned intragroup analysis results are evident in table 4.12.

<table>
<thead>
<tr>
<th>Group C</th>
<th>p value</th>
<th>Mean difference</th>
<th>Percentage difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st-4th visit</td>
<td>0.01</td>
<td>0.58 kg/cm²</td>
<td>13%</td>
</tr>
</tbody>
</table>

Table 4.12: Results of Intragroup analysis of p and mean values for group C
Intergroup Analysis

The Independent T Test, that tests for normality was inconclusive, therefore the Mann-Whitney U tests were used to determine if there is a statistical significance between group A, B and C on the pressure algometer readings over the chronic facet.

The Between-Subject Effects test revealed that there was no statistical significance \((p \geq 0.05)\) between group A and group B at the 1st visit \((p=0.69)\), the 4th visit \((p=0.85)\) and the 7th visit \((p=0.95)\). This means that the groups started out comparable and that they remained like that throughout the study.

<table>
<thead>
<tr>
<th></th>
<th>1st visit</th>
<th>4th visit</th>
<th>7th visit</th>
</tr>
</thead>
<tbody>
<tr>
<td>p value</td>
<td>0.69</td>
<td>0.85</td>
<td>0.95</td>
</tr>
</tbody>
</table>

### 4.4.2 Evaluation of Cervical Spine range of Motion Readings

Intragroup Analysis of Cervical Forward Flexion Range of Motion
The Shapiro-Wilk test, which tests for normality within intragroup results, was inconclusive with all the cervical ranges of motion. Therefore the non-parametric Friedman Test was used to determine intragroup results between the 1st and 7th treatment. The non-parametric Wilcoxon Signed Rank Test was used to determine intragroup results between the 1st and 4th and the 4th and the 7th treatment.

a) Group A

The Friedman test was used to compare group A’s 1st treatment to the 7th treatment. The results indicated that group A demonstrated a statistically significant improvement \((p \leq 0.05)\) over time \((p=0.09)\).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement \((p \leq 0.05)\) for the 1st treatment to the 4th treatment \((p=0.01)\) and for the 4th treatment to the 7th treatment \((p=0.01)\).

The CROM forward flexion results on the first visit for group A had a mean value of 66.70°, on the fourth visit group A had a mean value of 68.20° and on the seventh visit group A had a mean value of 71.80°. The mean difference between the 1st and 4th visit for group A was 1.50°. This resulted in a median percentage improvement of 2%. The median difference between the 4th and 7th visit for group A was 3.60°. This resulted in a median percentage improvement of 5%. At the end of the study group A was 5.10° which resulted in a median percentage improvement of 8%. All of the above mentioned data is evident in table 4.14.

<table>
<thead>
<tr>
<th>Group A</th>
<th>p value</th>
<th>Mean difference</th>
<th>Percentage difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
b) Group B

The Friedman test was used to compare group B’s 1st treatment to the 7th treatment. The results indicated that group B demonstrated a statistically significant improvement \((p \leq 0.05)\) over time \((p=0.02)\).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement \((p \leq 0.05)\) for the 1st treatment to the 4th treatment \((p=0.01)\) and for the 4th treatment to the 7th treatment \((p=0.01)\).

The CROM forward flexion results on the first visit for group B had a mean value of 63.80°, on the fourth visit group B had a mean value of 66.90° and on the seventh visit group B had a mean value of 71.10°. The mean difference between the 1st and 4th visit for group B was 3.10°. This resulted in a median percentage improvement of 5%. The median difference between the 4th and 7th visit for group B was 4.20°. This resulted in a median percentage improvement of 6%. At the end of the study group B was 7.30° which resulted in a median percentage improvement of 11%. This is evident in table 4.15.

<table>
<thead>
<tr>
<th>1st-4th visit</th>
<th>p value</th>
<th>Mean difference</th>
<th>Percentage difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.09</td>
<td>1.50°</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td>4th-7th visit</td>
<td>0.01</td>
<td>3.60°</td>
<td>5%</td>
</tr>
<tr>
<td>1st-7th visit</td>
<td>0.01</td>
<td>5.10°</td>
<td>8%</td>
</tr>
</tbody>
</table>

Table 4.15: Intragroup analysis of p and mean values for Group B
c) Group C

The Friedman test was used to compare group B’s 1st treatment to the 7th treatment. The results indicated that group B demonstrated a statistically significant improvement (p≤0.05) over time (p=0.02).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement (p≤0.05) for the 1st treatment to the 4th treatment (p=0.01) and for the 4th treatment to the 7th treatment (p=0.01).

The CROM forward flexion results on the first visit for group C had a mean value of 67.70°, on the fourth visit group C had a mean value of 70.30° and on the seventh visit group C had a mean value of 74.00°. The mean difference between the 1st and 4th visit for group C was 2.60°. This resulted in a median percentage improvement of 4%. The median difference between the 4th and 7th visit for group C was 3.70°. This resulted in a median percentage improvement of 5%. At the end of the study group C was 6.30° which resulted in a median percentage improvement of 9%. This is evident in table 4.16 below.

<table>
<thead>
<tr>
<th>1st-4th visit</th>
<th>0.02</th>
<th>3.10°</th>
<th>2%</th>
</tr>
</thead>
<tbody>
<tr>
<td>4th-7th visit</td>
<td>0.01</td>
<td>4.20°</td>
<td>6%</td>
</tr>
<tr>
<td>1st-7th visit</td>
<td>0.01</td>
<td>7.30°</td>
<td>11%</td>
</tr>
</tbody>
</table>

Table 4.16: Intragroup analysis of p and mean values for Group C
Intergroup Analysis

The Independent T Test, that tests for normality was inconclusive, therefore the Mann-Whitney U tests were used to determine if there is a statistical significance between group A and B on cervical spine flexion range of motion.

The Between-Subject Effects test revealed that there was statistical significance \((p\geq0.05)\) between group A and group B at the 1st visit \((p=0.32)\), however this was not the case at the 4th visit \((p=0.60)\) and the 7th visit \((p=0.54)\). This means that the groups started out comparable and that they remained like that throughout the study. This is evident in table 4.17 below.

<table>
<thead>
<tr>
<th></th>
<th>1st-7th visit</th>
<th>1st-4th visit</th>
<th>4th-7th visit</th>
</tr>
</thead>
<tbody>
<tr>
<td>p value</td>
<td>0.02</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>2.60°</td>
<td>3.70°</td>
<td>6.30°</td>
</tr>
<tr>
<td></td>
<td>4%</td>
<td>5%</td>
<td>9%</td>
</tr>
</tbody>
</table>

**Table 4.17: Intergroup analysis of CROM forward flexion**

<table>
<thead>
<tr>
<th>p value</th>
<th>1st visit</th>
<th>4th visit</th>
<th>7th visit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.32</td>
<td>0.60</td>
<td>0.54</td>
</tr>
</tbody>
</table>

Intragroup analysis of Cervical Extension Range of Motion

a) Group A
The Friedman test was used to compare group A’s 1\textsuperscript{st} treatment to the 7\textsuperscript{th} treatment. The results indicated that group A demonstrated a statistically significant improvement \((p≤0.05)\) over time \((p=0.01)\).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement \((p≤0.05)\) for the 1\textsuperscript{st} treatment to the 4\textsuperscript{th} treatment \((p=0.46)\) and for the 4\textsuperscript{th} treatment to the 7\textsuperscript{th} treatment \((p=0.01)\).

The CROM extension results on the first visit for group A had a mean value of 63.60°, on the fourth visit group A had a mean value of 65.00° and on the seventh visit group A had a mean value of 69.20°. The mean difference between the 1\textsuperscript{st} and 4\textsuperscript{th} visit for group A was 1.40°. This resulted in a median percentage improvement of 2%. The median difference between the 4\textsuperscript{th} and 7\textsuperscript{th} visit for group A was 4.20°. This resulted in a median percentage improvement of 7%. At the end of the study group A was 5.60° which resulted in a median percentage improvement of 9%. This is evident in table 4.18 below.

<table>
<thead>
<tr>
<th>Group A</th>
<th>p value</th>
<th>Mean difference</th>
<th>Percentage difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st-4th visit</td>
<td>0.46</td>
<td>1.40°</td>
<td>2%</td>
</tr>
<tr>
<td>4th-7th visit</td>
<td>0.01</td>
<td>4.20°</td>
<td>7%</td>
</tr>
<tr>
<td>1st-7th visit</td>
<td>0.01</td>
<td>5.60°</td>
<td>9%</td>
</tr>
</tbody>
</table>

\[ Table 4.18: \text{Intragroup analysis of p and mean values for Group A} \]

b) Group B

The Friedman test was used to compare group B’s 1\textsuperscript{st} treatment to the 7\textsuperscript{th} treatment. The results indicated that group B demonstrated a statistically significant improvement \((p≤0.05)\) over time \((p=0.01)\).
The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement \( (p \leq 0.05) \) for the 1st treatment to the 4th treatment \( (p=0.01) \) and for the 4th treatment to the 7th treatment \( (p=0.01) \).

The CROM extension results on the first visit for group B had a mean value of 63.40°, on the fourth visit group B had a mean value of 66.70° and on the seventh visit group B had a mean value of 69.40°. The mean difference between the 1st and 4th visit for group B was 3.30°. This resulted in a median percentage improvement of 5%. The median difference between the 4th and 7th visit for group B was 2.70°. This resulted in a median percentage improvement of 4%. At the end of the study group B was 6.00° which resulted in a median percentage improvement of 10%. The above mentioned data is evident in table 4.19 below.

**Table 4.19: Intragroup analysis of p and mean values for Group B**

<table>
<thead>
<tr>
<th>Group B</th>
<th>p value</th>
<th>Mean difference</th>
<th>Percentage difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st-4th visit</td>
<td>0.007</td>
<td>3.30°</td>
<td>5%</td>
</tr>
<tr>
<td>4th-7th visit</td>
<td>0.011</td>
<td>2.70°</td>
<td>4%</td>
</tr>
<tr>
<td>1st-7th visit</td>
<td>0.005</td>
<td>6.00°</td>
<td>10%</td>
</tr>
</tbody>
</table>

c) Group C

The Friedman test was used to compare group C’s 1st treatment to the 7th treatment. The results indicated that group B demonstrated a statistically significant improvement \( (p \leq 0.05) \) over time \( (p=0.01) \).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement \( (p \leq 0.05) \) for the 1st treatment to the 4th treatment \( (p=0.01) \) and for the 4th treatment to the 7th treatment \( (p=0.02) \).

The CROM extension results on the first visit for group C had a mean value of 64.80°, on the fourth visit group C had a mean value of 69.10° and on the
seventh visit group C had a mean value of $74.10°$. The mean difference between the 1st and 4th visit for group C was $4.30°$. This resulted in a median percentage improvement of $7\%$. The median difference between the 4th and 7th visit for group C was $5.00°$. This resulted in a median percentage improvement of $7\%$. At the end of the study group C was $9.30°$ which resulted in a median percentage improvement of $14\%$. This can be seen in table 4.20 below.

**Table 4.20: Intragroup analysis of p and mean values for group C**

<table>
<thead>
<tr>
<th>Group C</th>
<th>p value</th>
<th>Mean difference</th>
<th>Percentage difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st-4th visit</td>
<td>0.01</td>
<td>4.30°</td>
<td>7%</td>
</tr>
<tr>
<td>4th-7th visit</td>
<td>0.02</td>
<td>5.00°</td>
<td>7%</td>
</tr>
<tr>
<td>1st-7th visit</td>
<td>0.01</td>
<td>9.30°</td>
<td>14%</td>
</tr>
</tbody>
</table>

**Intergroup Analysis**

The Independent T Test, that tests for normality was inconclusive, therefore the Mann-Whitney U tests were used to determine if there is a statistical significance between group A, B and C on cervical extension range of motion.

The Between-Subject Effects test revealed that there was no statistical significance ($p \geq 0.05$) between group A, B and C at the 1st visit ($p = 0.74$), the 4th visit ($p = 0.42$) and the 7th visit ($p = 0.38$). This means that the groups started out comparable and that they remained like that throughout the study, this is evident in table 4.21 below.

**Table 4.21: Intergroup analysis of Cervical Spine Extension**

<table>
<thead>
<tr>
<th>p value</th>
<th>1st visit</th>
<th>4th visit</th>
<th>7th visit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.74</td>
<td>0.42</td>
<td>0.38</td>
<td></td>
</tr>
</tbody>
</table>
Intragroup Analysis of Cervical Left Lateral Flexion Range of Motion

a) Group A

The Friedman test was used to compare group A’s 1st treatment to the 7th treatment. The results indicated that group A demonstrated a statistically significant improvement \((p \leq 0.05)\) over time \((p=0.01)\).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement \((p \leq 0.05)\) for the 1st treatment to the 4th treatment \((p=0.01)\) and for the 4th treatment to the 7th treatment \((p=0.01)\).

The CROM left lateral flexion results on the first visit for group A had a mean value of 60.10°, on the fourth visit group A had a mean value of 63.00° and on the seventh visit group A had a mean value of 66.50°. The mean difference between the 1st and 4th visit for group A was 2.90°. This resulted in a median percentage improvement of 5%. The median difference between the 4th and 7th visit for group A was 3.50°. This resulted in a median percentage improvement of 6%. At the end of the study group A was 6.40° which resulted in a median percentage improvement of 11%. The above mentioned is evident in table 4.22 below.

<table>
<thead>
<tr>
<th>Group A</th>
<th>p value</th>
<th>Mean difference</th>
<th>Percentage difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st-4th visit</td>
<td>0.01</td>
<td>2.90°</td>
<td>5%</td>
</tr>
<tr>
<td>4th-7th visit</td>
<td>0.01</td>
<td>3.50°</td>
<td>6%</td>
</tr>
</tbody>
</table>
b) Group B

The Friedman test was used to compare group B’s 1st treatment to the 7th treatment. The results indicated that group B demonstrated a statistically significant improvement (p≤0.05) over time (p=0.01).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement (p≤0.05) for the 1st treatment to the 4th treatment (p=0.01) and for the 4th treatment to the 7th treatment (p=0.06).

The CROM left lateral flexion results on the first visit for group B had a mean value of 53.80°, on the fourth visit group B had a mean value of 59.70° and on the seventh visit group B had a mean value of 63.60°. The mean difference between the 1st and 4th visit for group B was 5.90°. This resulted in a median percentage improvement of 11%. The median difference between the 4th and 7th visit for group B was 3.90°. This resulted in a median percentage improvement of 7%. At the end of the study group B was 9.80° which resulted in a median percentage improvement of 18%. This is evident in table 4.23 below.

<table>
<thead>
<tr>
<th>Table 4.23: Intragroup analysis of p and mean values for Group B</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group B</strong></td>
</tr>
<tr>
<td>1st-4th visit</td>
</tr>
<tr>
<td>4th-7th visit</td>
</tr>
</tbody>
</table>
c) Group C

The Friedman test was used to compare group C’s 1st treatment to the 7th treatment. The results indicated that group B demonstrated a statistically significant improvement \((p\leq0.05)\) over time \((p=0.01)\).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement \((p\leq0.05)\) for the 1st treatment to the 4th treatment \((p=0.01)\) and for the 4th treatment to the 7th treatment \((p=0.01)\).

The CROM left lateral flexion results on the first visit for group C had a mean value of 50.70°, on the fourth visit group C had a mean value of 54.50° and on the seventh visit group C had a mean value of 61.00°. The mean difference between the 1st and 4th visit for group C was 3.80°. This resulted in a median percentage improvement of 8%. The median difference between the 4th and 7th visit for group C was 6.50°. This resulted in a median percentage improvement of 12%. At the end of the study group C was 10.30° which resulted in a median percentage improvement of 20%. This is evident in table 2.24 below.

<table>
<thead>
<tr>
<th>Group C</th>
<th>p value</th>
<th>Mean difference</th>
<th>Percentage difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st-4th visit</td>
<td>0.01</td>
<td>3.80°</td>
<td>8%</td>
</tr>
<tr>
<td>4th-7th visit</td>
<td>0.01</td>
<td>6.50°</td>
<td>12%</td>
</tr>
</tbody>
</table>

Table 4.24: Intragroup analysis of p and mean values for Group C
1st-7th visit | 0.01 | 10.30° | 20%

Intergroup Analysis

The Independent T Test, that tests for normality was inconclusive, therefore the Mann-Whitney U tests were used to determine if there is a statistical significance between group A, B and C on cervical left lateral flexion range of motion.

The Between-Subject Effects test revealed that there was no statistical significance \((p\geq0.05)\) between group A and group B at the 1st visit \((p=0.03)\), the 4th visit \((p=0.05)\) and the 7th visit \((p=0.20)\). This means that the groups started out comparable and that they remained like that throughout the study, this is evident in table 4.25 below.

Table 4.25: Intergroup analysis of Cervical Spine Left Lateral Flexion

<table>
<thead>
<tr>
<th></th>
<th>1st visit</th>
<th>4th visit</th>
<th>7th visit</th>
</tr>
</thead>
<tbody>
<tr>
<td>p value</td>
<td>0.03</td>
<td>0.05</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Intragroup Analysis of Cervical Right Lateral Flexion Range of Motion

a) Group A

The Friedman test was used to compare group A’s 1st treatment to the 7th treatment. The results indicated that group A demonstrated a statistically significant improvement \((p\leq0.05)\) over time \((p=0.02)\).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement \((p\leq0.05)\) for the 1st treatment to the 4th treatment \((p=0.01)\) and for the 4th treatment to the 7th treatment \((p=0.01)\).
The CROM right lateral flexion results on the first visit for group A had a mean value of **62.20°**, on the fourth visit group A had a mean value of **65.90°** and on the seventh visit group A had a mean value of **70.00°**. The mean difference between the 1st and 4th visit for group A was **3.70°**. This resulted in a median percentage improvement of **6%**. The median difference between the 4th and 7th visit for group A was **4.10°**. This resulted in a median percentage improvement of **6%**. At the end of the study group A was **7.80°** which resulted in a median percentage improvement of **13%**. This is evident in table 4.26 below.

Table 4.26: Intragroup analysis of p and mean values for Group A

<table>
<thead>
<tr>
<th>Group A</th>
<th>p value</th>
<th>Mean difference</th>
<th>Percentage difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st-4th visit</td>
<td>0.02</td>
<td>3.70°</td>
<td>6%</td>
</tr>
<tr>
<td>4th-7th visit</td>
<td>0.01</td>
<td>4.10°</td>
<td>6%</td>
</tr>
<tr>
<td>1st-7th visit</td>
<td>0.01</td>
<td>7.80°</td>
<td>13%</td>
</tr>
</tbody>
</table>

b) Group B

The Friedman test was used to compare group B’s 1st treatment to the 7th treatment. The results indicated that group B demonstrated a statistically significant improvement (*p*≤0.05) over time (*p*=0.01).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement (*p*≤0.05) for the 1st treatment to the 4th treatment (*p*=0.01) and for the 4th treatment to the 7th treatment (*p*=0.01).

The CROM right lateral flexion results on the first visit for group B had a mean value of **49.10°**, on the fourth visit group B had a mean value of **56.50°** and on the seventh visit group B had a mean value of **63.30°**. The mean difference between the 1st and 4th visit for group B was **7.40°**. This resulted in a median percentage improvement of **15%**. The median difference between the 4th and 7th visit for group B was **6.80°**. This resulted in a median percentage improvement of **12%**. At the end of the study group B was **14.2°**
which resulted in a median percentage improvement of 29%. This is evident in table 4.27 below.

**Table 4.27: Intragroup analysis of p and mean values for Group B**

<table>
<thead>
<tr>
<th>Group B</th>
<th>p value</th>
<th>Mean difference</th>
<th>Percentage difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st-7th visit</td>
<td>0.01</td>
<td>7.40°</td>
<td>15%</td>
</tr>
<tr>
<td>1st-4th visit</td>
<td>0.01</td>
<td>6.80°</td>
<td>12%</td>
</tr>
<tr>
<td>4th-7th visit</td>
<td>0.01</td>
<td>14.20°</td>
<td>29%</td>
</tr>
</tbody>
</table>

**c) Group C**

The Friedman test was used to compare group C’s 1st treatment to the 7th treatment. The results indicated that group B demonstrated a statistically significant improvement \((p≤0.05)\) over time \((p=0.01)\).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement \((p≤0.05)\) for the 1st treatment to the 4th treatment \((p=0.01)\) and for the 4th treatment to the 7th treatment \((p=0.01)\).

The CROM right lateral flexion results on the first visit for group C had a mean value of 53.30°, on the fourth visit group C had a mean value of 56.90° and on the seventh visit group C had a mean value of 61.80°. The mean difference between the 1st and 4th visit for group C was 3.60°. This resulted in a median percentage improvement of 7%. The median difference between the 4th and 7th visit for group C was 4.90°. This resulted in a median percentage improvement of 9%. At the end of the study group C was 8.50° which resulted in a median percentage improvement of 16%. This is evident in table 4.28 below.

**Table 4.28: Intragroup analysis of p and mean values for Group C**

<table>
<thead>
<tr>
<th>Group C</th>
<th>p value</th>
<th>Mean difference</th>
<th>Percentage difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st-7th visit</td>
<td>0.01</td>
<td>3.60°</td>
<td>7%</td>
</tr>
</tbody>
</table>
Intergroup Analysis

The Independent T Test, that tests for normality were inconclusive, therefore the Mann-Whitney U tests were used to determine if there is a statistical significance between group A, B and C on cervical right lateral flexion range of motion.

The Between-Subject Effects test revealed that there was no statistical significance \((p \geq 0.05)\) between group A and group B at the 1\(^{st}\) visit \((p=0.01)\), the 4\(^{th}\) visit \((p=0.03)\) and the 7\(^{th}\) visit \((p=0.03)\). This means that the groups started out comparable and that they remained like that throughout the study.

Table 4.29: Intergroup analysis of Cervical Spine Right Lateral Flexion

<table>
<thead>
<tr>
<th></th>
<th>1st-4th visit</th>
<th>4th-7th visit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statistic</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Mean</td>
<td>4.90°</td>
<td>8.50°</td>
</tr>
<tr>
<td>Median</td>
<td>9%</td>
<td>16%</td>
</tr>
</tbody>
</table>

Intragroup Analysis of Cervical Left Rotation Range of Motion

The Friedman test was used to compare group A’s 1\(^{st}\) treatment to the 7\(^{th}\) treatment. The results indicated that group A demonstrated a statistically significant improvement \((p \leq 0.05)\) over time \((p=0.01)\).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement \((p \leq 0.05)\) for the 1\(^{st}\) treatment to the 4\(^{th}\) treatment \((p=0.01)\) and for the 4\(^{th}\) treatment to the 7\(^{th}\) treatment \((p=0.01)\).

The CROM left rotation results on the first visit for group A had a mean value of 69.90°, on the fourth visit group A had a mean value of 72.90° and on the seventh visit group A had a mean value of 75.60°. The mean difference between the 1\(^{st}\) and 4\(^{th}\) visit for group A was 3.00°. This resulted in a median percentage improvement of 4%. The median difference between the 4\(^{th}\) and 7\(^{th}\) visit for group A was 2.70°. This resulted in a median percentage improvement of 4%. At the end of the study group A was 5.70° which
resulted in a median percentage improvement of 8%. This is evident in table 4.30 below.

### Table 4.30: Intragroup analysis of p and mean values for Group A

<table>
<thead>
<tr>
<th>Group A</th>
<th>p value</th>
<th>Mean difference</th>
<th>Percentage difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st-4th visit</td>
<td>0.01</td>
<td>3.00°</td>
<td>4%</td>
</tr>
<tr>
<td>4th-7th visit</td>
<td>0.01</td>
<td>2.70°</td>
<td>4%</td>
</tr>
<tr>
<td>1st-7th visit</td>
<td>0.01</td>
<td>5.70°</td>
<td>8%</td>
</tr>
</tbody>
</table>

**b) Group B**

The Friedman test was used to compare group B’s 1st treatment to the 7th treatment. The results indicated that group B demonstrated a statistically significant improvement \((p \leq 0.05)\) over time \((p=0.01)\).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement \((p \leq 0.05)\) for the 1st treatment to the 4th treatment \((p=0.01)\) and for the 4th treatment to the 7th treatment \((p=0.02)\).

The CROM left rotation results on the first visit for group B had a mean value of 70.20°, on the fourth visit group B had a mean value of 74.40° and on the seventh visit group B had a mean value of 76.50°. The mean difference between the 1st and 4th visit for group B was 4.20°. This resulted in a median percentage improvement of 6%. The median difference between the 4th and 7th visit for group B was 2.10°. This resulted in a median percentage improvement of 3%. At the end of the study group B was 4.70° which resulted in a median percentage improvement of 7%. This is evident in table 4.31 below.

### Table 4.31: Intragroup analysis of p and mean values for Group B

<table>
<thead>
<tr>
<th>Group B</th>
<th>p value</th>
<th>Mean</th>
<th>Percentage</th>
</tr>
</thead>
</table>
c) Group C

The Friedman test was used to compare group C’s 1st treatment to the 7th treatment. The results indicated that group C demonstrated a statistically significant improvement \((p \leq 0.05)\) over time \((p=0.01)\).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement \((p \leq 0.05)\) for the 1st treatment to the 4th treatment \((p=0.01)\) and for the 4th treatment to the 7th treatment \((p=0.01)\).

The CROM left rotation results on the first visit for group C had a mean value of 75.00°, on the fourth visit group C had a mean value of 77.80° and on the seventh visit group C had a mean value of 81.30°. The mean difference between the 1st and 4th visit for group C was 2.80°. This resulted in a median percentage improvement of 4%. The median difference between the 4th and 7th visit for group C was 3.50°. This resulted in a median percentage improvement of 5%. At the end of the study group C was 6.30° which resulted in a median percentage improvement of 8%.

### Table 4.32: Intragroup analysis of p and mean values for Group C

<table>
<thead>
<tr>
<th>Group C</th>
<th>p value</th>
<th>Mean difference</th>
<th>Percentage difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st-4th visit</td>
<td>0.01</td>
<td>2.80°</td>
<td>4%</td>
</tr>
<tr>
<td>4th-7th visit</td>
<td>0.01</td>
<td>3.50°</td>
<td>5%</td>
</tr>
<tr>
<td>1st-7th visit</td>
<td>0.01</td>
<td>6.30°</td>
<td>8%</td>
</tr>
</tbody>
</table>

**Intergroup Analysis**
The Independent T Test, that tests for normality was inconclusive, therefore the Mann-Whitney U tests were used to determine if there is a statistical significance between group A and B on cervical left rotation range of motion.

The Between-Subject Effects test revealed that there was no statistical significance between \((p \geq 0.05)\) group A and group B at the 1\(^{st}\) visit \((p=0.23)\), the 4\(^{th}\) visit \((p=0.25)\) and the 7\(^{th}\) visit \((p=0.06)\). This means that the groups started out comparable and that they remained like that throughout the study, this is evident in table 4.33 below.

<table>
<thead>
<tr>
<th>Table 4.33: Intergroup analysis of Cervical Spine Left Rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st visit</td>
</tr>
<tr>
<td>p value</td>
</tr>
</tbody>
</table>

Intragroup Analysis of Cervical Right Rotation Range of Motion

a) Group A

The Friedman test was used to compare group A’s 1\(^{st}\) treatment to the 7\(^{th}\) treatment. The results indicated that group A demonstrated a statistically significant improvement \((p \leq 0.05)\) over time \((p=0.01)\).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement \((p \leq 0.05)\) for the 1\(^{st}\) treatment to the 4\(^{th}\) treatment \((p=0.01)\) and for the 4\(^{th}\) treatment to the 7\(^{th}\) treatment \((p=0.29)\).

The CROM right rotation results on the first visit for group A had a mean value of 69.30\(^{\circ}\), on the fourth visit group A had a mean value of 73.10\(^{\circ}\) and on the seventh visit group A had a mean value of 76.90\(^{\circ}\). The mean difference between the 1\(^{st}\) and 4\(^{th}\) visit for group A was 3.80\(^{\circ}\). This resulted in a median percentage improvement of 6\%. The median difference between the 4\(^{th}\) and 7\(^{th}\) visit for group A was 0.90\(^{\circ}\). This resulted in a median percentage improvement of 1\%. At the end of the study group A was 4.70\(^{\circ}\).
which resulted in a median percentage improvement of 7%. This is evident in table 4.34 below.

**Table 4.34: Intragroup analysis of p and mean values for Group A**

<table>
<thead>
<tr>
<th></th>
<th>p value</th>
<th>Mean differences</th>
<th>Percentage difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st-4th visit</td>
<td>0.01</td>
<td>3.80°</td>
<td>6%</td>
</tr>
<tr>
<td>4th-7th visit</td>
<td>0.29</td>
<td>0.90°</td>
<td>1%</td>
</tr>
<tr>
<td>1st-7th visit</td>
<td>0.01</td>
<td>4.70°</td>
<td>7%</td>
</tr>
</tbody>
</table>

**b) Group B**

The Friedman test was used to compare group B’s 1st treatment to the 7th treatment. The results indicated that group B demonstrated a statistically significant improvement \((p \leq 0.05)\) over time \((p=0.01)\).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement \((p \leq 0.05)\) for the 1st treatment to the 4th treatment \((p=0.03)\) and for the 4th treatment to the 7th treatment \((p=0.02)\).

The CROM right rotation results on the first visit for group B had a mean value of 68.60°, on the fourth visit group B had a mean value of 72.80° and on the seventh visit group B had a mean value of 74.80°. The mean difference between the 1st and 4th visit for group B was 4.20°. This resulted in a median percentage improvement of 6%. The median difference between the 4th and 7th visit for group B was 2.00°. This resulted in a median percentage improvement of 3%. At the end of the study group B was 6.20° which resulted in a median percentage improvement of 9%. This is evident in table 4.35 below.

**Table 4.35: Intragroup analysis of p and mean values of Group B**

<table>
<thead>
<tr>
<th></th>
<th>p value</th>
<th>Mean difference</th>
<th>Percentage difference</th>
</tr>
</thead>
</table>
Group C

The Friedman test was used to compare group C’s 1st treatment to the 7th treatment. The results indicated that group B demonstrated a statistically significant improvement ($p \leq 0.05$) over time ($p = 0.01$).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement ($p \leq 0.05$) for the 1st treatment to the 4th treatment ($p = 0.01$) and for the 4th treatment to the 7th treatment ($p = 0.01$).

The CROM right rotation results on the first visit for group C had a mean value of 69.30°, on the fourth visit group C had a mean value of 76.90° and on the seventh visit group C had a mean value of 81.30°. The mean difference between the 1st and 4th visit for group C was 4.40°. This resulted in a median percentage improvement of 6%. The median difference between the 4th and 7th visit for group C was 4.40°. This resulted in a median percentage improvement of 4%. At the end of the study group C was 8.80° which resulted in a median percentage improvement of 12%. This is evident in table 4.36 below.

### Table 4.36: Intragroup analysis of p and mean values for Group C

<table>
<thead>
<tr>
<th></th>
<th>p value</th>
<th>Mean difference</th>
<th>Percentage difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st-4th visit</td>
<td>0.01</td>
<td>4.40°</td>
<td>6%</td>
</tr>
<tr>
<td>4th-7th visit</td>
<td>0.01</td>
<td>4.40°</td>
<td>6%</td>
</tr>
<tr>
<td>1st-7th visit</td>
<td>0.01</td>
<td>8.80°</td>
<td>12%</td>
</tr>
</tbody>
</table>

Intergroup Analysis
The Independent T Test, that tests for normality was inconclusive, therefore the Mann-Whitney U tests were used to determine if there is a statistical significance between group A, B and C on cervical right rotation range of motion.

The Between-Subject Effects test revealed that there was no statistical significance \( p \geq 0.05 \) between group A and group B at the 1\textsuperscript{st} visit \( p=0.23 \), the 4\textsuperscript{th} visit \( p=0.33 \) and the 7\textsuperscript{th} visit \( p=0.06 \). This means that the groups started out comparable and that they remained like that throughout the study, this is evident in table 4.37 below.

**Table 4.37: Intergroup analysis of Cervical Spine Right Rotation**

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**CHAPTER 5 - DISCUSSION**

5.1 Introduction

The results of this study are discussed with reference to the previous results chapter. Any statistical significant results are highlighted in this chapter. Where it was possible, relevant results of previous studies and aspects of the above literature review are included.

5.2 Demographic Data Analysis

5.2.1 Age and Gender Distribution

Participants in this study had to meet the selection criteria of 18 to 30 years of age. This is due to the fact that within this age group the mechanical neck pain will be purely mechanical in nature with little influence from other factors.
such as degeneration and altered biomechanics due to degeneration within the cervical spine. Table 4.1 shows that the gender distribution was set at 15 females and 15 males. This was intentionally done in order to try minimise any deviations and also in order to try standardise the sample size making the results more statistically viable. A systematic review identified physical risk factors in some specific populations for developing neck pain; females appeared to have a greater chance of developing neck pain in comparison to males (Bourghouts, Koes, Vondeling and Bouter. 1999). Table 4.1 also shows that the average age was 25.13. This ensured that gender related variable were kept to a minimum.

5.3 Analysis of Subjective Data

5.3.1 Statistical and clinical results of NPRS and VMPDI

To discuss the findings of the NPRS and Vernon-Mior Neck Pain and Disability Index, the study was divided into two separate analyses. They were an intragroup analysis and an intergroup analysis. A direct comparison of three different treatment protocols may then be made.

a) Intra Group Analysis

Group A

With regards to the NPRS the Friedman test revealed that from the 1st treatment to the 7th, the combination group proved to have a statistical significance with regards to pain perception ($p=0.01$). The Wilcoxon Signed Rank test revealed a statistical significance from the 1st treatment to the 4th
and the 4\textsuperscript{th} treatment to the 7\textsuperscript{th} (\textit{p}=0.00). The subjective outcome measurements were favourable when combining cervical adjustment and dry needling therapy, with a decrease of pain perception of 77\%, when comparing the beginning of the study to the end. This is evident in table 4.2.

With regards to the Vernon-Mior Neck Pain and Disability Index the Friedman test revealed that from the 1\textsuperscript{st} treatment to the 7\textsuperscript{th}, the combination group proved to have a statistical significance with regards to disability and pain as the p-values were below 0.05 (\textit{p}=0.00). There was also a statistically significant improvement with regards to the Wilcoxon Signed Rank test, which revealed that from the 1\textsuperscript{st} treatment to the 4\textsuperscript{th} (\textit{p}=0.00) and the 4\textsuperscript{th} treatment to the 7\textsuperscript{th} (\textit{p}=0.00).

These results demonstrated that combining cervical adjustment and dry needling therapy had a positive effect over time, with a decrease of disability and pain of 74\%, when comparing the beginning of the study to the end. This is evident in table 4.6.

These results indicate that the combination therapy was effective in decreasing pain perception. These effects are due to the fact that adjustment increases the level of opioids (neurochemical pain inhibitors) within the brain this leads to inhibition of nociceptive input to the spinal cord. The stimulation and regulation of the mechanoreceptive, proprioceptive and nocioceptive input associated with spinal adjustments is believed to be the theory behind the effectiveness of spinal manipulation, therefore reducing the mechanical source of pain and disability (Bergmann and Peterson, 2002).

According to McMorland and Suter (2000), patients treated with chiropractic adjustment for mechanical neck pain or lower back pain, had statistically significant reductions in their pain-related disability after the treatment. Patients with neck pain had an average of 53.80\% reduction in their pain and disability (McMorland and Suter, 2006). This was also found to be the case in this study.

With regards to dry needling there is similarly provided pain relief, this may be due to an increased release of opioids. Opioids are responsible for
inhibiting the release of substance P (neurotransmitter) at synapses which are responsible for relaying of pain sensation to the spinal cord (Martini, 2001). According to Baldry (2001) there is a “gate-like” effect due to dry needling therapy which occurs by the stimulation of mechanoreceptors. The stimulation of the mechanoreceptors occurs due to the twitch response which occurs within the myofibrils. This twitch allows a lengthening of the muscle fibres to occur thereby increasing function of the muscle. This leads to inhibition of the intra dorsal horns ability to relay nociceptive information (via the descending inhibitory pathway) from the myofascial trigger points causing myofascial pain relief.

**Group B**

With regards to the NPRS the Friedman test revealed that from the 1\textsuperscript{st} treatment to the 7\textsuperscript{th}, the dry needling group proved to have a statistical significance with regards to pain perception ($p=0.01$). The Wilcoxon Signed Rank test revealed a statistical significance from the 1\textsuperscript{st} treatment to the 4\textsuperscript{th} ($p=0.00$) and the 4\textsuperscript{th} treatment to the 7\textsuperscript{th} ($p=0.01$). The subjective outcome measurements were favourable when performing dry needling therapy as it had a positive effect over time, with a decrease of pain perception of 79\%, when comparing the beginning of the study to the end. This is evident in table 4.3.

With regards to the Vernon-Mior Neck Pain and Disability Index the Friedman test revealed that from the 1\textsuperscript{st} treatment to the 7\textsuperscript{th}, the dry needling group proved to have a statistical significance with regards to disability and pain ($p=0.01$). The Wilcoxon Signed Rank test revealed that from the 1\textsuperscript{st} treatment to the 4\textsuperscript{th} ($p=0.01$) and the 4\textsuperscript{th} treatment to the 7\textsuperscript{th} ($p=0.01$). The subjective outcome measurements were favourable when performing dry needling therapy as it had a positive effect over time, with a decrease of disability and pain of 80\%, when comparing the beginning of the study to the end. This is evident in table 4.7.

Dry needling of myofascial trigger points lead to a decrease in pain perception due to the closing of the pain gate. When a MFTP is needled a
twitch response is elicited and accompanying it is a change in the length of the muscle fibre. This would lead to a change in the mechanoreceptive sensory afferent input into the A-delta fibres blocking the intra dorsal horn passage of nociceptive information which originated from the MFTP to the dorsal horn of the spinal cord (Travell and Simons, 1999). According to Baldry and Cummings (2006) endogenous opioids are released through needle stimulation of A-delta receptors, therefore dry needling has a pain-inhibitory action.

According to Travell and Simons (1999) dry needling also results in an increased blood flow to the trigger point area. This increased blood flow flushes the excess calcium from the area therefore causing a decrease in local muscle contraction in turn decreasing pain (Travell and Simons, 1999).

**Group C**

With regards to the NPRS the Friedman test revealed that from the 1st treatment to the 7th, the cervical adjustment group proved to have a statistical significance with regards to pain perception \((p=0.01)\). The Wilcoxon Signed Rank test revealed a statistical significance from the 1st treatment to the 4th \((p=0.01)\) and the 4th treatment to the 7th \((p=0.00)\). The subjective outcome measurements were favourable when using cervical adjustment as it had a positive effect over time, with a decrease of pain perception of 78%, when comparing the beginning of the study to the end. This is evident in table 4.4.

With regards to the Vernon-Mior Neck Pain and Disability Index the Friedman test revealed that from the 1st treatment to the 7th, the cervical adjustment group proved to have a statistical significance with regards to disability and pain \((p=0.01)\). The Wilcoxon Signed Rank test revealed statistical significance from the 1st treatment to the 4th \((p=0.01)\) and when comparing the 4th treatment to the 7th \((p=0.01)\). The subjective outcome measurements were favourable when using cervical adjustment as it had a positive effect
over time, with a decrease of disability and pain of 68%, when comparing the beginning of the study to the end. This is evident in table 4.8.

These effects are due to the fact that adjustment increases the level of opioids (neurochemical pain inhibitors) within the brain this leads to inhibition of nociceptive input to the spinal cord. The stimulation and regulation of the mechanoreceptive, proprioceptive and nociceptive input associated with spinal adjustments is believed to be the theory behind the effectiveness of spinal manipulation, therefore reducing the mechanical source of pain and disability (Bergmann and Peterson, 2002).

According to McMorland and Suter (2000), patients treated with chiropractic adjustment for mechanical neck pain or lower back pain, had statistically significant reductions in their pain-related disability after the treatment. Patients with neck pain had an average of 53.80% reduction in their pain and disability (McMorland and Suter, 2006). This was also found to be the case in this study.

When a chiropractic adjustment is delivered to a zygapophyseal joint it stretches the involved joint capsule which results in the activation of mechanoreceptors. This leads to presynaptic inhibition of nociceptive afferent input therefore reducing the perception of pain (Chapman-Smith, 2000). Chiropractic manipulation has also been found to increase the plasma beta endorphin levels which assist in pain reduction (Vernon, Dhami, Howley and Anett, 1986).

b) Intergroup Analysis

Intergroup analysis for NPRS compared measurements on the 1st, 4th and 7th sessions, between group A, B and group C. It resulted in p-values of 0.65, 0.55 and 0.90 consecutively. This proves that there was no statistical significance between the treatment groups with regards to pain perception. This might be due to the small test size of the population (Aberson, 2010). However there was a clinical improvement during the intra group analysis (79% versus 78% and 77%), which indicated that the dry needling group may be better. This is evident in table 4.5.
Similarly with the Vernon-Mior Pain and Disability Index the intergroup analysis compared measurements on the 1\textsuperscript{st}, 4\textsuperscript{th} and 7\textsuperscript{th} sessions, between group A, B and group C and it resulted in p-values of 0.63, 0.61 and 0.51 consecutively. This proves that there was no statistical significance between the treatment groups with regards to disability and pain. This might be due to the small test size of the population (Aberson, 2010). However there was again a clinical improvement during the intragroup analysis (79\% versus 78\% and 77\%), which indicated that the dry needling group may be better. This is evident in table 4.9.

5.4 Analysis of Objective Data

5.4.1 Pressure Algometer

To discuss the findings of the algometer, the study was divided into two separate analyses. They were an intragroup analysis and an intergroup analysis. A direct comparison of three different treatment protocols could then be made.

a) Intragroup analysis

Group A

The Friedman test revealed that from the 1\textsuperscript{st} treatment to the 7\textsuperscript{th}, cervical adjustment and dry needling proved to have a statistical significance with regards to pain threshold \( p=0.01 \). The Wilcoxon Signed Rank test revealed a statistical significance when comparing the 1\textsuperscript{st} treatment to the 4\textsuperscript{th} \( p=0.02 \) and when comparing the 4\textsuperscript{th} treatment to the 7\textsuperscript{th} \( p=0.01 \). The subjective
outcome measurements were favourable when combining cervical adjustment and dry needling had a positive effect over time, with an increase in pain threshold of 11%, when comparing the beginning of the study to the end. This is evident in table 4.10

**Group B**

The Friedman test revealed that from the 1st treatment to the 7th, dry needling proved to have a statistical significance with regards to pain threshold ($p=0.01$). The Wilcoxon Signed Rank test revealed a statistical significance when comparing the 1st treatment to the 4th ($p=0.01$) and when comparing the 4th treatment to the 7th ($p=0.01$). The subjective outcome measurements were favourable in this group as it demonstrated that dry needling had a positive effect over time, with an increase in pain threshold of 21%, when comparing the beginning of the study to the end. This is evident in table 4.11.

**Group C**

The Friedman test revealed from the 1st treatment to the 7th, cervical adjustment proved to have a statistical significance with regards to pain threshold ($p=0.01$). The Wilcoxon Signed Rank test revealed a statistical significance when comparing the 1st treatment to the 4th ($p=0.01$) and the 4th treatment to the 7th ($p=0.01$). The subjective outcome measurements were favourable when performing cervical adjustment as it had a positive effect over time, with an increase in pain threshold of 27%, when comparing the beginning of the study to the end. This is evident in table 4.12.

**Discussion of intragroup Algometer readings**

Since the NPRS and the pressure algometer readings both involve pain threshold and pain perception, the results of the pressure algometer prove similar to that of the NPRS results. This is in accordance to the popular belief that cervical adjustment and dry needling can be used to increase pain
tolerance and therefore decrease pain and MFTP sensitivity (Travell and Simons, 1999).

b) Intergroup Analysis

Intergroup analysis resulted in p-values of 0.69, 0.85 and 0.95 on the 1st, 4th and 7th visits consecutively. This proves that there was no statistical significance between the three different treatment groups at the 1st, 4th and 7th sessions with regards to pain threshold. This is evident in table 4.13.

5.4.2 Cervical Range of Motion Measuring Instrument (CROM)

To discuss the findings of the CROM, the study was divided into two separate analyses. They were an intragroup analysis and an intergroup analysis. A direct comparison of cervical adjustment therapy with dry needling, dry needling alone and cervical adjustment alone could then be made.

Cervical Forward Flexion Range of Motion

a) Intragroup analysis

- Group A

The Friedman test revealed that from the 1st treatment to the 7th, cervical adjustment and dry needling proved to have a statistical insignificance with regards to cervical forward flexion range of motion (p=0.09). Wilcoxon Signed Rank test revealed a statistical significance from the 1st treatment to the 4th (p=0.01) as well as from the 4th treatment to the 7th (p=0.01). The objective outcome measurements were favourable with regards to the combination group as it had a positive effect over time, with an increase in cervical forward flexion range of motion of 8%, when comparing the beginning of the study to the end. This is evident in table 4.15
- **Group B**

The Friedman test revealed that from the 1\textsuperscript{st} treatment to the 7\textsuperscript{th}, dry needling proved to have a statistical significance with regards to cervical forward flexion \((p=0.02)\). The Wilcoxon Signed Rank test revealed a statistical significance from the 4\textsuperscript{th} treatment to the 7\textsuperscript{th} \((p=0.01)\) and from the 1\textsuperscript{st} treatment to the 4\textsuperscript{th} \((p=0.01)\). The objective outcome measurements were favourable when performing dry needling as it had a positive effect over time, with an increase in cervical forward flexion range of motion of 11\%, when comparing the beginning of the study to the end. This is evident in table 4.16.

- **Group C**

The Friedman test revealed that from the 1\textsuperscript{st} treatment to the 7\textsuperscript{th}, cervical adjustment proved to have a statistical significance with regards to cervical forward flexion \((p=0.02)\). The Wilcoxon Signed Rank test revealed a statistical significance when comparing the 4\textsuperscript{th} treatment to the 7\textsuperscript{th} \((p=0.01)\) and when comparing the 1\textsuperscript{st} treatment to the 4\textsuperscript{th} \((p=0.01)\). The objective outcome measurements were favourable when performing cervical adjustment, as it had a positive effect over time, with an increase in cervical forward flexion range of motion of 9\%, when comparing the beginning of the study to the end. This is evident in table 4.17.

**b) Intergroup analysis**

Intergroup analysis resulted in \(p\)-values of 0.32, 0.60 and 0.54 on the 1\textsuperscript{st}, 4\textsuperscript{th} and 7\textsuperscript{th} visits consecutively. This proves that there was no statistical significance between dry needling, cervical adjustment and a combination of the two with regards to cervical flexion range of motion. This might be due to the small test size of the population (Aberson, 2010). However there was a clinical improvement during the intragroup analysis (8\% versus 11\% and 9\%), which indicated that the dry needling group may be better. This is evident in table 4.18.
Cervical Extension Range of Motion

a) Intragroup analysis

- Group A

The Friedman test revealed that from the 1\textsuperscript{st} treatment to the 7\textsuperscript{th}, cervical adjustment and dry needling proved to have a statistical significance with regards to cervical extension range of motion \( (p=0.01) \). The Wilcoxon Signed Rank test revealed a statistical significance when comparing the 1\textsuperscript{st} treatment to the 4\textsuperscript{th} \( (p=0.01) \) however this was not the case when comparing the 4\textsuperscript{th} treatment to the 7\textsuperscript{th} \( (p=0.46) \) as this is statistically insignificant. The objective outcome measurements were favourable when performing cervical adjustment and dry needling as they had a positive effect over time, with an increase of cervical extension range of motion of 9\%, when comparing the beginning of the study to the end. This is evident in table 4.19.

- Group B

The Friedman test revealed that from the 1\textsuperscript{st} treatment to the 7\textsuperscript{th}, dry needling proved to have a statistical significance with regards to cervical extension range of motion \( (p=0.01) \). The Wilcoxon Signed Rank test revealed a statistical significance when comparing the 1\textsuperscript{st} treatment to the 4\textsuperscript{th} \( (p=0.01) \) and when comparing the 4\textsuperscript{th} treatment to the 7\textsuperscript{th} \( (p=0.01) \). The objective outcome measurements were favourable when performing dry needling as it had a positive effect over time, with an increase of cervical extension range of motion of 10\%, when comparing the beginning of the study to the end. This is evident in table 4.20.

- Group C

The Friedman test revealed that from the 1\textsuperscript{st} treatment to the 7\textsuperscript{th}, cervical adjustment proved to have a statistical significance with regards to cervical extension range of motion \( (p=0.01) \). The Wilcoxon Signed Rank test revealed
a statistical significance when comparing the 1\textsuperscript{st} treatment to the 4\textsuperscript{th} \((p=0.01)\) and when comparing the 4\textsuperscript{th} treatment to the 7\textsuperscript{th} \((p=0.02)\). The objective outcome measurements were favourable when performing cervical adjustment as it had a positive effect over time, with an increase of cervical extension range of motion of 14\%, when comparing the beginning of the study to the end. This is evident in table 4.21.

b) Intergroup Analysis

Intergroup analysis resulted in p-values of 0.74, 0.42 and 0.38 on the 1\textsuperscript{st}, 4\textsuperscript{th} and 7\textsuperscript{th} visits consecutively. This proves that there was no statistical significance between dry needling, cervical adjustment and a combination of the two with regards to cervical flexion range of motion. This might be due to the small test size of the population (Aberson, 2010). However there was a clinical improvement during the intragroup analysis (9\% versus 10\% and 14\%), which indicated that the cervical adjustment group may be better. This is evident in table 4.22.

Cervical Left and Right Lateral Flexion Range of Motion

a) Intragroup analysis

- Group A

With regards to left lateral flexion the Friedman test revealed that from the 1\textsuperscript{st} treatment to the 7\textsuperscript{th}, cervical adjustment and dry needling proved to have a statistical significance with regards to cervical left lateral flexion range of motion \((p=0.01)\). The Wilcoxon Signed Rank test revealed a clinical significance when comparing the 1\textsuperscript{st} treatment to the 4\textsuperscript{th} \((p=0.01)\) and when comparing the 4\textsuperscript{th} treatment to the 7\textsuperscript{th} \((p=0.01)\). The objective outcome measurements were favourable when performing cervical adjustment and dry needling as they had a positive effect over time, with an increase of cervical left lateral flexion range of motion of 11\%, when comparing the beginning of the study to the end. This is evident in table 4.22.
With regards to right lateral flexion the Friedman test revealed that from the 1\textsuperscript{st} treatment to the 7\textsuperscript{th}, cervical adjustment and dry needling proved to have a statistical significance with regards to cervical right lateral flexion range of motion ($p=0.02$). The Wilcoxon Signed Rank test revealed a statistical significance when comparing the 1\textsuperscript{st} treatment to the 4\textsuperscript{th} ($p=0.01$) and the 4\textsuperscript{th} treatment to the 7\textsuperscript{th} ($p=0.01$). The objective outcome measurements were favourable with regards to the combination group as it had a positive effect over time, with an increase of cervical right lateral flexion range of motion of 13\%, when comparing the beginning of the study to the end. This is evident in table 4.26.

- **Group B**

With regards to left lateral flexion the Friedman test revealed that from the 1\textsuperscript{st} treatment to the 7\textsuperscript{th}, dry needling group proved to have a statistical significance with regards to cervical left lateral flexion range of motion ($p=0.01$). The Wilcoxon Signed Rank test revealed a statistical significance when comparing the 1\textsuperscript{st} treatment to the 4\textsuperscript{th} ($p=0.01$) however this was not the case when comparing the 4\textsuperscript{th} treatment to the 7\textsuperscript{th} ($p=0.06$) as this was statistically insignificant. The objective outcome measurements were favourable when performing dry needling as it had a positive effect over time, with an increase of cervical left lateral flexion range of motion of 18\%, when comparing the beginning of the study to the end. This is evident in table 4.23.

With regards to right lateral flexion the Friedman test revealed that from the 1\textsuperscript{st} treatment to the 7\textsuperscript{th}, dry needling proved to have a statistical significance with regards to cervical right lateral flexion range of motion ($p=0.01$). The Wilcoxon Signed Rank test revealed a statistical significance when comparing the 1\textsuperscript{st} treatment to the 4\textsuperscript{th} ($p=0.01$) and the 4\textsuperscript{th} treatment to the 7\textsuperscript{th} ($p=0.01$). The objective outcome measurements were favourable when performing dry needling as it similarly had a positive effect over time, with an increase of cervical right lateral flexion range of motion of 29\%, when comparing the beginning of the study to the end. This is evident in table 4.27.
With regards to left lateral flexion the Friedman test revealed that from the 1st treatment to the 7th, cervical adjustment proved to have a statistical significance with regards to cervical left lateral flexion range of motion \((p=0.01)\). The Wilcoxon Signed Rask test revealed a statistical significance when comparing the 1st treatment to the 4th \((p=0.01)\) and the 4th treatment to the 7th \((p=0.01)\). The objective outcome measurements were favourable when performing cervical adjustment as it had a positive effect over time, with an increase of cervical left lateral flexion range of motion of 20%, when comparing the beginning of the study to the end. This is evident in table 4.24.

With regards to right lateral flexion the Friedman test revealed that from the 1st treatment to the 7th, cervical adjustment proved to have a statistical significance with regards to cervical right lateral flexion range of motion \((p=0.01)\). The Wilcoxon Signed Rank test revealed a statistical significance when comparing the 1st treatment to the 4th \((p=0.01)\) and the 4th treatment to the 7th \((p=0.01)\). The objective outcome measurements were favourable when performing cervical adjustment as it similarly had a positive effect over time, with an increase of cervical right lateral flexion range of motion of 16%, when comparing the beginning of the study to the end. This is evident in table 4.28.

b) Intergroup Analysis

With regards to left lateral flexion the intergroup analysis resulted in p-values of 0.03, 0.54 and 0.20 on the 1st, 4th and 7th visits consecutively. This proves that there was no statistical significance between cervical adjustment, dry needling and a combination of the two with regards to cervical left lateral flexion range of motion. This might be due to the small test size of the population (Aberson, 2010). However there was a clinical improvement during the intragroup analysis, which indicated that the cervical adjustment group may be better. This is evident in table 4.25.
With regards to right lateral flexion the intergroup analysis resulted in p-values of 0.01, 0.03 and 0.03 on the 1st, 4th and 7th visits consecutively. This proves that there was no statistical significance between cervical adjustment, dry needling and a combination of the two with regards to cervical right lateral flexion range of motion. This might be due to the small test size of the population (Aberson, 2010). However there was a clinical improvement during the intragroup analysis, which indicated that the dry needling group may be better. This is evident in table 4.29.

Cervical Left and Right Rotation Range of Motion

a) Intragroup analysis

- Group A

With regards to left rotation the Friedman test revealed that from the 1st treatment to the 7th, cervical adjustment and dry needling proved to have a statistical significance with regards to cervical left rotation range of motion (p=0.01). The Wilcoxon Signed Rank test revealed a statistical significance when comparing the 1st treatment to the 4th (p=0.01) and when comparing the 4th treatment to the 7th (p=0.01). The objective outcome measurements were favourable when performing cervical adjustment and dry needling as they had a positive effect over time, with an increase of cervical left rotation range of motion of 8%, when comparing the beginning of the study to the end. This is evident in table 4.30.

With regards to right rotation the Friedman test revealed that from the 1st treatment to the 7th, cervical adjustment and dry needling proved to have a statistical significance with regards to cervical right rotation range of motion (p=0.01). The Wilcoxon Signed Rank test revealed a statistical significance when comparing the 1st treatment to the 4th (p=0.01) however this was not the case when comparing the 4th treatment to the 7th (p=0.29) as this was clinically insignificant. The objective outcome measurements were favourable with regards to the combination group as it had a positive effect over time,
with an increase of cervical rotation range of motion of 7%, when comparing the beginning of the study to the end. This is evident in table 4.34.

- Group B

With regards to left rotation the Friedman test revealed that from the 1st treatment to the 7th, dry needling proved to have a statistical significance with regards to cervical left rotation range of motion ($p=0.01$). The Wilcoxon Signed Rank Test revealed a statistical significance when comparing the 1st treatment to the 4th ($p=0.01$) and when comparing the 4th treatment to the 7th ($p=0.02$). The objective outcome measurements were favourable when performing dry needling as it had a positive effect over time, with an increase of cervical left rotation range of motion of 7%, when comparing the beginning of the study to the end. This is evident in table 4.31.

With regards to right rotation the Friedman test revealed that from the 1st treatment to the 7th, dry needling proved to have a statistical insignificance with regards to cervical right rotation range of motion ($p=0.01$). The Wilcoxon Signed Rank test revealed a statistical insignificance when comparing the 1st treatment to the 4th ($p=0.03$) and the 4th treatment to the 7th ($p=0.02$). The objective outcome measurements were favourable when performing dry needling as it similarly had a positive effect over time, with an increase of cervical right rotation range of motion of 9%, when comparing the beginning of the study to the end. This is evident in table 4.35.

- Group C

With regards to left rotation the Friedman test revealed that from the 1st treatment to the 7th, cervical adjustment proved to have a statistical significance with regards to cervical left rotation range of motion ($p=0.01$). The Wilcoxon Signed Rank test revealed a statistical significance when comparing the 1st treatment to the 4th ($p=0.01$) and when comparing the 4th treatment to the 7th ($p=0.01$). The objective outcome measurements were favourable when performing cervical adjustment as it had a positive effect
over time, with an increase of cervical left rotation range of motion of 8%, when comparing the beginning of the study to the end. This is evident in table 4.32.

With regards to right rotation the Friedman test revealed that from the 1st treatment to the 7th, cervical adjustment proved to have a statistical significance with regards to cervical right rotation range of motion (\( p=0.01 \)). The Wilcoxon Signed Rank test revealed a statistical significance when comparing the 1st treatment to the 4th (\( p=0.01 \)) and the 4th treatment to the 7th (\( p=0.01 \)). The objective outcome measurements were favourable when performing cervical adjustment as it similarly had a positive effect over time, with an increase of cervical right rotation range of motion of 12%, when comparing the beginning of the study to the end. This is evident in table 4.36.

b) Intergroup Analysis

With regards to left rotation the intergroup analysis resulted in p-values of 0.23, 0.25 and 0.06 on the 1st, 4th and 7th visits consecutively. This proves that there was no statistical significance between cervical adjustment, dry needling and a combination of the two on the 4th and 7th sessions with regard to cervical left rotation range of motion. This might be due to the small test size of the population (Aberson, 2010). However there was a clinical improvement during the intragroup analysis, which indicated that the dry needling group may be the least effective. This is evident in table 4.33.

With regards to right rotation the intergroup analysis resulted in p-values of 0.23, 0.33 and 0.06 on the 1st, 4th and 7th visits consecutively. This proves that there was no statistical significance between cervical adjustment, dry needling and a combination of the two on the 4th and 7th sessions with regard to cervical right rotation range of motion. This might be due to the small test size of the population (Aberson, 2010). However there was a clinical improvement during the intragroup analysis, which indicated that the cervical adjustment group may be better. This is evident in table 4.37.
Discussion of the Ranges of Motion

It was found over the duration of the study that when comparing the percentage changes in the cervical spine range of motion values all three treatment groups showed clinically significant increases in flexion, extension, right and left lateral flexion as well as right and left rotation. Group A showed the most clinically significant improvement in left rotation. Group B showed the most clinically significant improvement in Flexion and Right lateral flexion, while Group C demonstrated the greatest increase in extension, left lateral flexion and right rotation. These results suggest that chiropractic adjustment therapy showed a superior clinical significance with regards to cervical range of motion.

A possible explanation for the improvement in cervical spine range of motion following cervical spine adjustment in this study is also consistent with a study by Bergmann and Peterson (2002). The study stated that adjustment involves a high-velocity low-amplitude force and when applied to a joint will produce a reflex inhibition of hypertonic muscles by stimulating the mechanoreceptors. Therefore this will cause not only a reduction in pain but also an increase in cervical range of motion.

While all groups improved in terms of cervical spine range of motion, group C (cervical adjustment only) improved the most overall. This may be due to the fact that chiropractic adjustment may be effective in addressing the causes of joint dysfunction and thereby restoring normal joint range of motion (Bergmann and Peterson, 2002).

Dry needling therapy (Group B) has similar effects with regards to pain reduction and increased movement. This is due to the fact that dry needling uses hyper-stimulation analgesia to prevent reoccurrence of abnormal nociceptive activity. This will cause relaxation of previously hypertonic muscle fibres which will ultimately increase the muscle length therefore resulting in an increased range of motion (Gatterman, 1990).

Group A (the combination group) also increased but with less impressive results. This may be an attribution to over treatment or stimulation or perhaps
due to a small sample size. Had the sample size been increased there may have been a more impressive statistical significance with regards to this study (Albright, Winston and Zappe, 2009). It is also important to take into account post needling soreness which may have masked the results of the adjustments ability to increase range of motion as previously discussed. Local trauma may occur during dry needling to the muscle fibres when inserted near a motor end plate (Dommerholt, del Moral and Grobli.,2006). This could lead to increased bleeding and post needling soreness within the affected muscle causing an increased stiffness which would ultimately lead to a decreased range of motion in group A and B (Dommerholt et al., 2006).

5.5 Conclusion

Dry needling was the most effective in reducing pain and disability (subjective data). However the adjustment group was effective in increasing pain threshold and cervical spine range of motion. One would expect a synergistic effect from the combination group due to all the physiological and neurological effects they have on targeting not only the joints and their surrounding structures, but also the muscles themselves. Although the combined therapy was not as effective as the other modalities it still had a positive effect in reducing pain and increasing function.

From the discussion above it can be concluded that chiropractic adjustment, dry needling and combination therapy produce an improvement in pain, disability and cervical spine range of motion, in patients with chronic mechanical neck pain.
CHAPTER 6 - CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The aim of this study is to determine the effectiveness of cervical adjustment therapy, dry needling of the posterior cervical muscles and a combination of the two treatments in treating chronic mechanical neck pain with regards to changes in pressure pain threshold, pain perception and cervical spine ranges of motion. These effects were based on CROM measurements and the results obtained from the Vernon-Mior Pain and Disability Index questionnaire as well as the Numerical Pain Rating Scale questionnaire.

At the end of this study it was concluded that all three treatment protocols showed a significant clinical improvement in both their subjective and objective
findings in the posterior cervical musculature. All treatment protocols were effective in decreasing the pain experienced due to chronic mechanical neck pain. However chiropractic adjustment was the superior treatment protocol when compared to the others with regards to pain threshold and cervical spine range of motion. However with regards to the subjective findings dry needling proved superior. The lack of statistical significance in the combination of dry needling and cervical adjustment may be due to the small sample size used in this study.

Based on these results it can be concluded that cervical spine adjustment therapy and dry needling therapy of the posterior cervical musculature in the treatment of chronic mechanical neck pain do not have a synergistic effect. The lack of statistical outcome superiority of the three treatment protocols indicates that cervical spine adjustment therapy, in isolation, may be as effective in decreasing the signs and symptoms of chronic mechanical neck pain as dry needling therapy of the posterior cervical musculature and/or a combination of the two therapies.

6.2 Recommendations

• More extensive study may be done to include a larger sample group. Thereby representing the population more accurately.

• The inclusion criteria of the age variable could be narrowed down to avoid a large discrepancy in age present within the sample population.

• The duration of the study should be shorter. Although the benefits of dry needling twice per week for three weeks were noted, it may be that results of dry needling are more immediate and achieved after fewer treatments. Therefore it is suggested that fewer consultations are carried out in further studies.

• Immediate and long term effects of treatment can be ascertain, and compared, by taking subjective and objective measurements before and after each consultation.
• Long-term benefits of treatment can be determined by including a follow up consultation one month after the final consultation.

REFERENCES


APPENDIX A: ADVERTISEMENT

DO YOU SUFFER FROM NECK PAIN?

CHIROPRACTIC TREATMENT AT NO COST

DO YOU HAVE NECK PAIN?
ARE BETWEEN THE AGES OF 18 AND 50?
IF YOU ARE INTERESTED IN TAKING PART IN THIS
RESEARCH STUDY CONTACT JACQUI COOPER

PHONE NUMBER: (011) 559-6493
ADDRESS: TREATMENT IS CONDUCTED IN THE SUPERVISED UJ CLINIC AT GATE 7, SHERWELL ROAD DOORNFONTEIN

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APPENDIX B: INFORMATION AND CONSENT FORM

DEPARTMENT OF CHIROPRACTIC

INFORMATION AND CONSENT FORM

I, Jacqui Cooper, hereby invite you to participate in my research study. I am currently a Chiropractic student, completing my Masters Degree at the University of Johannesburg.

The aim of this study is to determine the effectiveness of cervical adjustment therapy, dry needling of the posterior cervical muscles and a combination of the two treatments in treating chronic mechanical neck pain.

Group one will receive chiropractic adjustment therapy, group two will receive dry needling to the posterior cervical muscles and group three will receive a combination of the above mentioned treatments. A case history, physical exam and cervical spine regional exam will be done at the first visit. Data in the form of a Numerical Pain Rating Scale, Vernon-Mior Neck Disability Index, Cervical spine...
range of motion readings and Algometer readings will be collected on the first, fourth and seventh consultations. The Chiropractic adjustment involves the restoration of normal joint motion. Abnormal joint motion will be detected by the researcher via motion palpation. Dry needling therapy involves the insertion of acupuncture needles into muscle spasm in order to release the spasm. The Chiropractic adjustment and dry needling are safe, non-invasive treatment techniques.

The research study will take place at the University of Johannesburg Chiropractic Day Clinic. Your privacy will be protected by ensuring your anonymity and confidentiality when compiling the research dissertation.

All procedures will be explained to you and all participation is entirely on a voluntary basis; withdrawal at any stage will not cause you any harm. The participant may experience some post needling soreness and muscle stiffness, this is considered normal and will reside in one to two days. All treatments will be explained to you so you know what your participation entails. After this study is complete, I will provide you feedback regarding the outcomes if you so wish.

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

Date: _______________________ Researcher: ________________________

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

Date: _______________________ Participant: _________________________
Should you have any concerns or queries regarding the current study, the following persons may be contacted.

Researcher: Jacqui Cooper  Telephone number: (011) 559-6493
Supervisor: Dr. C. Yelverton  Telephone number (011) 559-6218

APPENDIX C: CASE HISTORY
UNIVERSITY OF JOHANNESBURG
CHIROPRACTIC DAY CLINIC

CASE HISTORY

Date: ________________

Patient: __________________ File No: ________

Age: _____ Sex: ________ Occupation: ______________

Student: __________________ Signature: ____________

Complies with Inclusion criteria of the research:

Clinician: __________________
Signature: __________________

Examination:

Previous: UJ Other
Current: UJ Other

X-ray Studies:

Previous: UJ Other
Current: UJ Other

Clinical Path. Lab:

Previous: UJ Other
Current: UJ Other

Case status:

PTT: Conditional: Signed off: Final sign out:

Recommendations:
**Students case history**

1. *Source of history:*

2. *Chief complaint: (patient’s own words)*

3. *Present illness:*
   
   Location
   
   Onset
   
   Duration
   
   Frequency
   
   Pain (character)
   
   Progression
   
   Aggravating factors
   
   Relieving factors
   
   Associated Sx’s and Sg’s
   
   Previous occurrences
   
   Past treatment and outcome
4. Other complaints:

5. Past history
   General health status
   Childhood illnesses
   Adult illnesses
   Psychiatric illnesses
   Accidents/injuries
   Surgery
   Hospitalisation

6. Current health status and lifestyle
   Allergies
   Immunizations
   Screening tests
   Environmental hazards
   Safety measures
   Exercise and leisure
   Sleep patterns
   Diet
   Current medication
   Tobacco
   Alcohol
   Social drugs
7. **Family history:**
   **Immediate family:**
   - Cause of death
   - DM
   - Heart disease
   - TB
   - HBP
   - Stroke
   - Kidney disease
   - CA
   - Arthritis
   - Anaemia
   - Headaches
   - Thyroid disease
   - Epilepsy
   - Mental illness
   - Alcoholism
   - Drug addiction
   - Other

8. **Psychosocial history:**
   - Home situation
   - Daily life
   - Important experiences
   - Religious beliefs

9. **Review of systems:**
   - General
   - Skin
   - Head
Eyes
Ears
Nose/sinuses
Mouth/throat
Neck
Breasts
Respiratory
Cardiac
Gastro-intestinal
Urinary
Genital
Vascular
Musculoskeletal
Neurologic
Haematologic
Endocrine
Psychiatric
APPENDIX D: PHYSICAL EXAM

UNIVERSITY OF JOHANNESBURG
CHIROPRACTIC DAY CLINIC

PHYSICAL EXAMINATION

(NOTE: only if Cervical Spine Regional is complete)

Underline abnormal findings in RED.  

Date: _____________________

Patient: ___________________  File No: __________

Clinician: ____________________  Signature: __________

Student: ___________________  Signature: __________

Height: __________  Weight: __________  Temp: __________

Rates: Heart: __________  Pulse: __________  Respiration: __________

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<th>Arms:</th>
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<td>Legs:</td>
<td>L</td>
<td>R</td>
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General Appearance:
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

1

119
STANDING EXAMINATION

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

L. Rot

Flex.

R. Rot

L. Lat Flex

R. Lat Flex

Ext.

/ = pain-free limitation

// = painful limitation

5. Romberg’s sign
6. Pronator drift
7. Trendelenburg’s sign
8. Gait: - rhythm
   - balance
   - pendulousness
   - on toes
   - on heels
   - tandem

9. Half squat
10. Scapular winging
11. Muscle tone
12. Spasticity/Rigidity
13. Shoulder: skin
    symmetry
    ROM
    - glenohumeral
    - scapulo-thoracic
    - acromioclavicular
    - elbow
    - wrist
14. Chest measurement:
   - inspiration
   - expiration

15. Visual acuity

16. Breast examination:
   Inspection:
   - skin
   - size
   - contour
   - nipples
   - arms overhead
   - hands against hips
   - leaning forward
   Palpation
   - axillary lymph nodes
   - breast incl. tail

SEATED EXAMINATION

1. Spinal posture
2. Head
   - hair
   - scalp
   - skull
   - face
   - skin

3. Eyes:
   Observation
   - conjunctiva
   - sclera
   - eyebrows
   - eyelids
   - lacrimal glands
   - nasolacrimal duct
   - position and alignment
   - corneas and lenses

- corneal reflex
- ocular movement

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- visual fields
- accommodation
- Ophthalmoscopic
- Examination
  - iris
  - pupils
  - red reflex
  - optic disc
  - vessels
  - general background
- macula
- vitreous
- lens

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

5. Nose:
   - External
   - Internal
     - septum
     - turbinates
     - olfaction

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

7. Mouth and pharynx:
   - lips
   - buccal mucosa
   - gums and teeth
   - roof
   - tongue
     - inspection
     - movement
     - taste
     - palpation
   - pharynx
     - CN X
     - inspection
   - carotid arteries (thrills, bruit)
   - Cranial Nerves
     - CN V
     - CN VII
     - CN VIII (nystagmus)
     - CN IX
     - CN XI
     - CN X11

8. Peripheral vasculature:
   - Inspection
     - skin
     - nail beds
     - pigmentation
     - hair loss
• Palpation
  - pulses:  - femoral  - dorsalis pedis
  - popliteal  - radial
  - post. Tibial  - brachial
  - lymph nodes  - epitrochlear
  - femoral (horizontal & vertical)
  - temperature (feet and legs)

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

10. Musculoskeletal:
(i) ROM
• hip

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</table>

• knee
• ankle

(ii) leg length

• Co-ordination  - point to point
  - dysdiachokinesia

9. TMJ
• Inspection  - ROM
  - deviation
• Palpation  - crepitus
  - tenderness
10. Thorax
   • Inspection
     - skin
     - shape
     - respiratory distress
     - rhythm (respiratory)
     - depth (respiratory)
     - effort (respiratory)
     - intercostals/supraclavicular retraction
   • Palpation
     - tenderness
     - masses
     - respiratory expansion
     - tactile fremitus
   • Percussion
     - lungs (posterior)
     - diaphragmatic excision
     - kidney punch
   • Auscultation
     (i) breath sounds
     - vesicular
     - bronchial
     (ii) adventitious sounds
     - crackles (rales)
     - wheezes (rhonchi)
     - rubs
     (iii) voice sounds
     - bronchophony
     - whispered pectoriloquy
     - egophony
   • Cardiovascular
     - auscultation (aortic murmurs)
     - Allen's test

SUPINE EXAMINATION

1. JVP
2. PMI
3. Auscultation heart
   (L. lat. Recumbent)
4. respiratory excursion
5. percussion chest
   (anterior)
6. breast palpation
7. Abdominal Examination
   • Inspection
     - skin
     - umbilicus
     - contour
     - peristalsis
     - pulsations
     - hernias (umbilical/incisional)
• Auscultation
  - bowel sound
  - bruit

• Percussion
  - general
  - liver
  - spleen

• Palpation
  - superficial reflexes
  - cough
  - light
  - rebound tenderness
  - deep
  - liver
  - spleen
  - kidneys
  - aorta
  - intra-/retro-abdominal wall mass
  - shifting dullness
  - fluid wave

• Acute abdomen
  - where pain began and now
  - cough
  - tenderness
  - guarding/rigidity
  - rebound tenderness
  - rosving’s sign
  - psoas sign
  - obturator sign
  - cutaneous hyperaesthesia
  - rectal exam
  - Murphy’s sign

MENTAL STATUS

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

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

(ii) Mood

(v) Memory and attention
  • orientation (time, place, person)
  • remote memory
(vi) Higher cognitive functions

- recent memory
- new learning ability
- information and vocabulary
- (general and specialised knowledge)
- abstract thinking

### Neurological Examination (Lumbar Spine)

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<tr>
<th>Dermatomes</th>
<th>Left</th>
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<td>Patellar (L3, 4)</td>
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<td>Knee Extension (L2, 3, 4)</td>
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<td>Medial Hamstring (L5)</td>
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<td>Hip Int. Rot (L4/L5)</td>
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<td>Hip Ext. Rot (L5/S1)</td>
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<td>Hip Adduction (L2, 3, 4)</td>
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<td>Hip Abduction (L4/5)</td>
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APPENDIX E: CERVICAL SPINE REGIONAL

UNIVERSITY OF JOHANNESBURG
CHIROPRACTIC DAY CLINIC

REGIONAL EXAMINATION
CERVICAL SPINE

Date: __________________________

Patient: __________________________ File No: __________________________

Clinician: __________________________ Signature: __________________________

Student: __________________________ Signature: __________________________

OBSERVATION

- Posture
- Size
- Swellings
- Scars
- Discolouration
- Hairline
- Bony and soft tissue contours
- Shoulder level
- Muscle spasm
- Facial expression

5. RANGE OF MOTION

Flexion = 45° - 90°
Extension = 55° - 70°
L/R Rotation = 70° - 90°
L/R Lat Flexion = 20° - 45°
PALPATION
- Lymph nodes
- Trachea
- Thyroid gland
- Pulses/thrills
- Tenderness
- Muscle Tone
- Active MF Trigger Points
  - SCM
  - Trapezius
  - Scaleni
  - Levator Scapulae
  - Posterior Cervical musculature

ORTHOPAEDIC EXAMINATION
1. Doorbell Sign
2. Max. Cervical Compression
3. Spurling’s manoeuvre
4. Lateral Compression (Jackson’s test)
5. Kemp’s Test
6. Cervical Distraction
7. Shoulder abduction Test
8. Shoulder depression Test

9. Dizziness rotation Test

10. Lhermitte’s Sign

11. O’ Donoghue Manoeuvre

12. Brachial Plexus Tension

13. Carpal tunnel syndrome:
   - Tinel’s sign
   - Phalen’s Test

14. TOS:
   - Halstead’s test
   - Adson’s test
   - Eden’s (traction) test
   - Hyperabduction (Wright’s) test – Pec minor
   - Costoclavicular test

**Remarks:**

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<td>WALLENBERG’S TEST</td>
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**COMMENTS:**
## MOTION PALPATION

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## NEUROLOGICAL EXAMINATION

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APPENDIX F: SOAP NOTE

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A: P:

Comments:
APPENDIX G: CONTRA-INDICATIONS TO ADJUSTMENT
(Gatterman, 1990)

1. Vascular complications
   - Vertebral artery syndrome
   - Aneurysms

2. Tumours
   - Primary to the bone
   - Secondary

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

4. Traumatic injuries
   - Fractures
   - Instabilities
   - Dislocation
   - Unstable spondylolisthesis

5. Arthritis
   - Ankylosing spondylitis
   - Rheumatoid arthritis
   - Psoriatic arthritis
- Reiter’s syndrome
- Osteoarthritis

6. Psychological considerations
- Malingering
- Hysteria
- Hypochondriasis
- Pain intolerance
- Dependent personality
- Disability syndromes

7. Neurological complications
- Cervical disc lesions and Myelopathy
- Nerve root damage
APPENDIX H: CONTRA-INDICATIONS TO DRY NEEDLING
(Simons et al, 1999)

- Acute trauma
- Open wound next to the area being needled.
- Anti-coagulation or bleeding disorders.
- During 2\textsuperscript{nd} trimester of pregnancy.
- If the patient is currently on anti-coagulation medication.
- Local or systemic infections.
- Severe arteriosclerosis.
- Needle phobia.
APPENDIX I: NUMERICAL PAIN RATING SCALE

Name of patient: _____________________
File number: ________________________
Date: ______________________________

NUMERICAL PAIN RATING SCALE

Try to assign a number from 0 (zero) to 10 (ten) to your pain level. If you have no pain, use a 0. As the numbers get higher, they stand for pain that is getting worse. The middle of the scale describes a “moderate” pain. A 10 means the pain is the worst pain you have ever experienced.

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This questionnaire has been designed to give the doctor 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 ONE x.

<table>
<thead>
<tr>
<th>Section 1 – Pain Intensity</th>
<th>Section 4 – Reading</th>
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<tr>
<td>I have no pain at the moment. (0)</td>
<td>□ I can read as much as I want with no pain in my neck. (0)</td>
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<tr>
<td>The pain is very mild at the moment. (1)</td>
<td>□ I can read as much as I want with slight pain in my neck. (1)</td>
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<tr>
<td>The pain is moderate at the moment. (2)</td>
<td>□ I can read as much as I want with moderate pain in my neck. (2)</td>
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<tr>
<td>The pain is fairly severe at the moment. (3)</td>
<td>□ I cannot read as much as I want due to moderate pain in my neck. (3)</td>
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<tr>
<td>The pain is very severe at the moment. (4)</td>
<td>□ I cannot read at all. (5)</td>
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<tr>
<td>The pain is the worst imaginable at the moment. (5)</td>
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<table>
<thead>
<tr>
<th>Section 2 – Personal care (Washing, Dressing, etc.)</th>
<th>Section 5 – Headaches</th>
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</thead>
<tbody>
<tr>
<td>I can look after myself normally without causing extra pain. (0)</td>
<td>□ I have no headaches at all. (0)</td>
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<tr>
<td>I can look after myself normally but it causes extra pain. (1)</td>
<td>□ I have slight headaches that come infrequently. (1)</td>
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<tr>
<td>It is painful to look after myself &amp; I am slow. (2)</td>
<td>□ I have moderate headaches which come infrequently. (2)</td>
</tr>
<tr>
<td>I need some help but manage most of my personal care. (3)</td>
<td>□ I have moderate headaches which come frequently. (3)</td>
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<tr>
<td>I need help everyday in most aspects of self care. (4)</td>
<td>□ I have severe headaches which come frequently. (4)</td>
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<tr>
<td>I do not get dressed. I wash with difficulty &amp; stay in bed. (5)</td>
<td>□ I have headaches which come almost all the time. (5)</td>
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<table>
<thead>
<tr>
<th>Section 3 – Lifting</th>
<th>Section 9 – Sleeping</th>
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<tbody>
<tr>
<td>I can lift heavy weights without extra pain. (0)</td>
<td>□ I have no trouble sleeping. (0)</td>
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<tr>
<td>I can lift heavy weights but it gives extra pain. (1)</td>
<td>□ My sleep is slightly disturbed (&lt; 1 hr sleepless). (1)</td>
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<tr>
<td>Pain prevents me from lifting heavy weights off the floor, but I can manage if they are conveniently positioned. (2)</td>
<td></td>
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<tr>
<td>Pain prevents me from lifting heavy weights off the floor but I can lift medium weights if they are conveniently positioned. (3)</td>
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</table>
**Section 6 – Concentration**
- I can concentrate fully without difficulty. (0)
- I can concentrate full with slight difficulty. (1)
- I have a fair degree of concentrating when I want to. (2)
- I have a lot of difficulty concentrating when I want to. (3)
- I have a great deal of difficulty concentrating when I want to. (4)
- I cannot concentrate at all. (5)

**Section 7 – Work**
- I can do as much work as I want to. (0)
- I can do my usual work but no more. (1)
- I can do most of my usual work but no more. (2)
- I cannot do my usual work. (3)
- I can hardly do any work at all. (4)
- I cannot do any work at all. (5)

**Section 8 – Driving**
- I can drive my car without any neck pain. (0)
- I can drive my car as long as I want with slight neck pain. (1)
- I can drive my car as long as I like with moderate neck pain. (2)
- I cannot drive my car as long as I want because of moderate neck pain. (3)
- I can hardly drive at all due to severe neck pain. (4)
- I cannot drive my car at all. (5)

**Section 10 – Recreation**
- I am able to engage in all my recreation activities with no neck pain at all. (0)
- I am able to engage in all my recreation activities with some neck pain. (1)
- I am able to engage in most but not all of my recreation activities due to neck pain. (2)
- I am able to engage in few recreation activities. (3)
- I can hardly do any recreation activities. (4)
- I cannot do any recreation activities at all. (5)
## APPENDIX K: CROM DEVICE READINGS

Name: __________________________________

File number: __________________________________

Date: ______________________________________

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APPENDIX L: ALGOMETER READINGS

Name: _____________________________________

Group: _____________________________________

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7th consultation

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APPENDIX M: DATA TABLE

GENDER:  
1= Female
2= Male
Group 1: Cervical spine Manipulation and dry needling (combination group)

Group 2: Dry needling only

Group 3: Cervical Spine Manipulation only

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