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THE EFFECT OF CERVICAL SPINE ADJUSTMENT APPLIED WITH ISCHAEMIC COMPRESSION OR LOW LEVEL LASER THERAPY ON AN UPPER TRAPEZIUS MYOFASCIAL TRIGGER POINT

A dissertation submitted to the Faculty of Health Sciences, University of Johannesburg, in partial fulfilment of the requirement for the degree of Master of Technology:

Chiropractic

By

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Dr C. Yelverton
DECLARATION

I, Louise van Wyngaardt, declare that this dissertation represents my own work, both in conception and execution. It is being submitted for the degree of Masters of Technology at the University of Johannesburg. It has not been submitted previously for any degree or examination to any University or Technikon.

Signature of candidate: ________________________________

On this __________ (day) of __________(month) 2015.
DEDICATION

I dedicate this work to the most important people in my life.

To my mother, thank you for your support, understanding and unconditional love. There are not enough words to describe my gratitude.

To my aunt and grandmother, thank you for your support and love.

To my dear friend, Melanie Craig, thank you for your support and motivation.

To the love of my life, Jean-Pierre van Wyngaardt, thank you for your love, support, motivation and understanding. You have been my rock during difficult times and for that I love you even more.
ACKNOWLEDGEMENTS

I would like to thank my supervisor, Dr Chris Yelverton, for his guidance, support and understanding, without which this would not be possible.

Thank you to each and every person that contributed to the completion of this study.
ABSTRACT

Purpose of the study: According to Fernández-de-las-Peñas (2009), there is a clinical relationship between joint impairment and myofascial trigger points. The trapezius muscle is one of the muscles in the human body that is most affected by myofascial trigger points and trigger point one (TrP1) in this muscle is one of the most common trigger points identified (Simons, Travell & Simons, 1999). The purpose of this study was to compare the effectiveness of cervical spine adjustments combined with ischaemic compression or low level laser therapy in the treatment of patients with cervical spine pain with a myofascial trigger point in the upper trapezius muscle. Comparisons were made with regards to pain, disability, pressure pain threshold and cervical spine range of motion.

Method: The study consisted of thirty participants aged between eighteen and forty years of age. The participants were screened using the inclusion and exclusion criteria, case history, physical examination and a cervical spine regional examination to determine their suitability to participate in the study. The suitable participants were divided into two groups of fifteen, with group one receiving cervical spine adjustment and ischaemic compression of the upper trapezius trigger point and group two receiving cervical spine adjustment and low level laser therapy of the upper trapezius trigger point.

Procedure: The participants were treated six times over a period of three weeks. Prior to treatment each participant completed a numerical pain rating scale and a Vernon-Mior neck pain and disability index questionnaire to provide subjective readings. Pressure algometer readings of the active myofascial trigger point in the trapezius muscle and cervical spine range of motion goniometer readings in flexion, extension, left and right rotation and left and right lateral flexion were also obtained prior to treatment to provide objective readings. Both groups then received treatment of cervical spine restrictions by cervical spine adjustments, which were followed by treatment of the myofascial trigger point. Group one received ischaemic compression of the active trapezius trigger point and group two received low level laser therapy applied to the active trapezius trigger point. Subjective and objective data was collected prior to treatment at the first and fourth consultations and at the seventh final consultation.

Results: Intragroup analysis with regards to the subjective data demonstrated that both groups showed a statistically significant improvement with regards to pain and disability as
measured by the numerical pain rating scale and the Vernon-Mior neck pain and disability index questionnaire. Group one showed a greater improvement with regards to pain (numerical pain rating scale) while group two demonstrated a greater improvement with regards to pain and its associated disability (Vernon-Mior neck pain and disability index). Intragroup analysis with regards to objective data revealed that both groups demonstrated a similar improvement in their pressure algometer readings between the first and the last consultation. Both groups demonstrated an increase in all cervical spine ranges of motion however the only statistically significant differences were noted in cervical spine extension and right lateral flexion. Intergroup analysis demonstrated no statistically significance between the two groups for all data obtained with the exception of cervical spine right lateral flexion at the seventh visit.

**Conclusion:** It can be concluded that both treatment protocols are effective with regards to subjective pain and disability in participants with cervical spine pain caused by an active myofascial trigger point in the upper trapezius muscle. Both treatment protocols were also effective in increasing the pain pressure threshold and cervical spine range of motion however, since both treatments were effective and the group sizes were small no statistically significant differences were noted between the two groups and therefore no superior treatment protocol between cervical adjusting applied with ischaemic compression and cervical adjusting applied with low level laser therapy can be concluded.
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CHAPTER ONE: INTRODUCTION

1.1 Problem statement

Cervical spine pain or neck pain is the second most common condition presenting to chiropractors for treatment (Wyatt, 2004). Childs, Cleland, Elliot, Teyhen, Wainner, Whitman, Sopky, Godges & Flynn (2008), estimated that 22% to 70% of the population will suffer from neck pain at some stage during their life. They also suggested that the incidence of neck pain is increasing, that neck pain has a high recurrence rate and a chance of becoming chronic. These authors state that neck pain is an economic burden due to increased treatment costs, lost wages and inability to work (Childs, Cleland, Elliot, Teyhen, Wainner, Whitman, Sopky, Godges & Flynn, 2008).

Myofascial pain syndrome is defined as pain arising from the presence of myofascial trigger points (Al-Shenqiti & Oldham, 2009). According to Simons, Travell & Simons (1999), myofascial trigger points are very common and will affect almost everyone during their lifetime. Myofascial trigger points may cause restricted movement and abnormal postures (latent trigger points) or severe pain (active trigger points). The trapezius muscle is one of the muscles in the human body that is most affected by myofascial trigger points and trigger point one (TrP1) in this muscle is one of the most common trigger points identified (Simons, Travell & Simons, 1999).

A relationship between joint hypomobility and myofascial trigger points has also been recognised. It is suggested that both myofascial trigger points and joint hypomobility should be treated in pain patients due to this relationship (Fernández-de-las-Peñas, 2009).

Kannan (2012) stated that there is a lack of literature regarding the effectiveness of laser when it is compared to other modalities such as ischaemic compression and therapeutic ultrasound in the treatment of upper trapezius trigger points. In a study conducted by Kannan (2012), in which the effects of ultrasound, laser and ischaemic compression were compared in the treatment of upper trapezius trigger points, all three modalities increased cervical spine range of motion and decreased pain perception and intensity (Kannan, 2012).

Therefore, evidence exists to show the effectiveness of chiropractic spinal adjustment, laser and ischaemic compression used individually in the treatment of myofascial trigger points. It
has been suggested that the joint and muscle component should be treated and this study will provide information to demonstrate if treatment modalities used together has a greater beneficial effect.

1.2 Aim of the study

The aim of this study was to determine the effectiveness of two treatment protocols – chiropractic spinal adjustment combined with ischaemic compression versus chiropractic spinal adjustment combined with low level laser therapy - on active myofascial trigger points in the upper trapezius muscle. The study was conducted to determine if either of these treatment protocols was more effective by using the subjective pain reports from participants and objective data via the cervical spine range of motion and trigger point sensitivity measurements.

1.3 Possible outcome of the study

As cervical spine pain is a common condition affecting a large part of the general population, it is important to determine the most effective treatment protocol to reduce the pain and disability in these patients.

This study may determine if using a combination of treatments on upper trapezius myofascial trigger point has a greater effect than using one treatment alone. The potential benefits of the study include demonstrating that one treatment protocol is more effective in treatment of patients with neck pain due to trapezius trigger points thereby potentially reducing the recurrence of neck pain and the number of treatments required by patients.
CHAPTER TWO: LITERATURE REVIEW

This chapter discusses the cervical spine anatomy, cervical spine pain and its causes, the anatomy and physiology of skeletal muscle, myofascial trigger points and the trapezius muscle. The vertebral subluxation complex and the relationship between joint hypomobility and myofascial trigger points are also discussed. The chapter also reviews the treatment methods used in this study namely the chiropractic adjustment, low level laser therapy and ischaemic compression.

2.1 Definition of mechanical neck pain

According to Fernández-de-las-Peñas, Alonso-Blanco, Alguacil-Diego & Miangolarra-Page (2006), chiropractors assume that mechanical neck pain involves a muscular, joint and nerve impairment. They also state that trigger points in the cervical muscles can play an important role in the causation of mechanical neck pain. Therefore, according to these authors, mechanical neck pain can be defined as generalised neck and/or shoulder pain with the following mechanical characteristics: symptoms provoked by sustained neck postures, neck movement or palpation of the cervical spine muscles. (Fernández-de-las-Peñas, Alonso-Blanco, Alguacil-Diego & Miangolarra-Page, 2006).

2.2 Causes of cervical spine pain

According to Wyatt (2004), the nociceptive structures in the cervical spine that may be responsible for pain include the intervertebral discs, anterior and posterior longitudinal ligaments, facet joints and facet joint capsules, muscles and nerve roots (Wyatt, 2004).

The causes of myofascial neck pain include structural insufficiencies, tight clothing, systemic and inflammatory diseases, alcohol toxicity and deficiency in growth hormone (Kannan, 2012). According to Gerwin (2001), neck pain can be a direct consequence of myofascial trigger points in the trapezius, sternocleidomastoid, scalenes, levator scapulae, suboccipital and posterior cervical muscles. A forward head posture and rounded shoulder posture are postural stresses that are very common causes of trigger point related neck pain (Gerwin, 2001).
2.3 Incidence and prevalence of neck pain

Cervical spine pain is a very common condition that affects close to 34% of the population. According to Wyatt (2004), neck pain is the second most common musculoskeletal complaint seen in chiropractic practice (Wyatt, 2004). According to Childs et al. (2008), 22% - 70% of the population will experience neck pain during their life. They also suggest that neck pain is becoming a more common occurrence. Since neck pain is a source of disability it has financial and occupational impacts on society (Childs et al. 2008).

2.4 Chronic cervical spine pain

The International Association for the Study of Pain classifies neck pain that lasts less than 7 days as acute neck pain, while neck pain with duration of longer than 7 days and less than 3 months is defined as subacute neck pain. Chronic neck pain is defined as neck pain that is present for more than 3 months (Misailidou, Malliou, Beneka, Karagiannidis & Godolias, 2010).

Childs et al. (2008) suggested that the rate of recurrence and chronicity of neck pain is very high with 30% of patients developing chronic symptoms. These authors also quote a survey that suggests that 37% of patients with neck pain have persistent problems for at least a year. They also state that approximately 44% of neck pain patients will develop chronic symptoms (Childs et al. 2008).

2.5 Anatomy of the cervical spine

2.5.1 General anatomy of the cervical spine

The cervical spine is situated between the head superiorly and the thoracic spine and ribs inferiorly. It is divided into a cervicoencephalic and cervicobrachial portions. The cervicoencephalic portion refers to the upper cervical spine (C0-C2) and the cervicobrachial portion refers to the lower cervical spine (C3-C7) (Magee, 2008). Stability has been sacrificed for mobility in the cervical region by the thickness of the intervertebral discs, the horizontal facet joints and the limited amount of surrounding soft tissue (Moore & Dalley, 2006).
2.5.2 Cervical vertebrae

The cervical spine consists of seven cervical vertebrae with five typical cervical vertebrae (C3-C7) and two atypical cervical vertebrae (C1 and C2). C1 is also known as the atlas and C2 is referred to as the axis (Moore & Dalley, 2006).

The characteristics of a typical cervical vertebra are tabulated in table 2.1 and shown in figure 2.1 and the characteristics of the atypical cervical vertebrae are tabulated in table 2.2 and shown in figure 2.2.

Table 2.1: Characteristics of a typical cervical vertebra (Moore & Dalley, 2006).

<table>
<thead>
<tr>
<th>Vertebral component</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertebral body</td>
<td>Small, wider from side to side than anteroposteriorly with a concave superior surface and a convex inferior surface.</td>
</tr>
<tr>
<td>Vertebral foramen</td>
<td>The foramen is large and triangular in shape.</td>
</tr>
<tr>
<td>Transverse processes</td>
<td>Contains transverse foramina transmitting vertebral arteries, veins and sympathetic plexuses. C7 has absent or small transverse foramina transmitting small accessory vertebral veins. The transverse processes have anterior and posterior tubercles.</td>
</tr>
<tr>
<td>Articular processes</td>
<td>Superior facets face superoposteriorly, inferior facets face inferoanteriorly. Facet joints are oblique and nearly horizontal.</td>
</tr>
<tr>
<td>Spinous processes</td>
<td>C3-C5 have short spinous processes, the spinous processes of C3-C6 are bifid. C6 has a long spinous process. C7 has the longest spinous process and is known as vertebra prominens.</td>
</tr>
</tbody>
</table>
Figure 2.1: Typical cervical vertebrae (C₄ and C₇) (Netter, 2006).

Table 2.2: Characteristic features of atypical cervical vertebrae (C₁ and C₂) (Moore & Dalley, 2006).

<table>
<thead>
<tr>
<th>Vertebral component</th>
<th>Atlas</th>
<th>Axis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertebral body and/arches</td>
<td>Ring shaped, no vertebral body, contains two lateral masses from which the transverse processes arise and anterior and posterior arches.</td>
<td>Contains a bony projection that extends superiorly from its body known as the dens or odontoid process.</td>
</tr>
<tr>
<td>Articular surfaces</td>
<td>Has two kidney shaped, concave superior articular surfaces that articulate with occipital condyles.</td>
<td>Two large flat superior articular facets that articulate with the atlas.</td>
</tr>
<tr>
<td>Spinous processes</td>
<td>Contains no spinous process</td>
<td>Bifid spinous process</td>
</tr>
</tbody>
</table>
2.5.3 The intervertebral disc

The intervertebral disc consists of three parts: the nucleus pulposus, annulus fibrosus and the vertebral endplate. The nucleus is the central gelatinous mass consisting of mostly of water, proteoglycans and collagen and other cells including elastin, proteins, proteolytic enzymes and chondrocytes (Levangie & Norkin, 2005). The nucleus withstands axial compression and distributes compressive forces applied to the spine (Magee, 2008). The annulus fibrosus is a fibrous ring that surrounds the nucleus. It has more collagen and less proteoglycans and water than the nucleus but overall also consists of water, collagen and proteoglycans. It also contains elastin, fibroblasts and chondrocytes. The difference in the structure is due to the fact that the annulus fibrosus withstands tension within the disc. The vertebral endplate consists of hyaline and fibrocartilage that covers the nucleus pulposus and part of the annulus fibrosus thereby separating them from the bone of the adjacent vertebral bodies. The amount of fibrocartilage increases as a person ages and the hyaline cartilage decreases. This allows the endplates to withstand compressive forces (Levangie & Norkin, 2005).

The intervertebral discs in the cervical spine contribute about 25% of the height of this part of the spine. There are no intervertebral discs between the occiput and the atlas and between the atlas and the axis (Magee, 2008).
2.5.4 Ligaments of the cervical spine

The ligaments of the vertebral column include the anterior (ALL) and posterior longitudinal ligaments (PLL), the ligamentum flavum, interspinous, intertransverse and supraspinous ligaments (ligamentum nuchae in the cervical spine) (Levangie & Norkin, 2005).

Ligaments specific to the cervical spine include the: transverse ligament, alar ligaments and apical ligament (Levangie & Norkin, 2005).

2.5.5 Nerves of the cervical spine

There are eight cervical nerve roots that exit between the vertebrae. The nerve that exits between the occiput and C1 is referred to as the C1 nerve root. The roots are named according to the vertebra below in the cervical spine. The C8 nerve root exits between the C7 and T1 vertebrae (Magee, 2008).

2.5.6 Joints of the cervical spine

The atlanto-occipital joints are synovial joints formed between the superior articular facets of the atlas and the occipital condyles. The atlanto-axial joint consists of three joints. These include a median pivot joint formed between the dens and the anterior arch of the atlas, and two lateral synovial joints formed between the superior articular facets of the axis and the inferior articular facets of the atlas (Levangie & Norkin, 2005).

The joints formed between the adjacent vertebrae of the lower cervical spine are referred to as the zygapophyseal or facet joints. These joints are formed between the inferior articular processes of the superior vertebrae and the superior articular processes of the inferior vertebrae. There are two facet joints at each level, one on the left and one on the right. They are classified as synovial joints. These joints determine the direction and the amount of movement that can occur. The superior facets are directed superiorly, posteriorly and medially and the inferior facets are directed inferiorly, anteriorly and laterally (Magee, 2008).

The structure of the cervical spine is illustrated in figure 2.3.
Each facet joint is surrounded by a joint capsule posterolaterally. The capsule consists of a dense fibroelastic connective tissue outer layer, a vascular layer consisting of areolar tissue and loose connective tissue and an inner layer consisting of a synovial membrane. The facet joints are covered by the ligamentum flavum anteriorly and medially (Gatterman, 2005).

The facet joint capsules receive sensory innervation from the medial branch of the posterior primary division (dorsal ramus) at the specific level. It also receives a branch from the posterior primary division from the level above. The joint capsule contains three types of sensory receptors:

- Type 1 – very sensitive static and dynamic mechanoreceptors. These receptors fire continually even when the joint is not moving.
- Type 2 – less sensitive mechanoreceptors that only fire during movement.
- Type 4 – slow nociceptive mechanoreceptors (Gatterman, 2005).

### 2.5.7 Range of motion of the cervical spine

According to Magee (2008), the active range of motion occurring in the cervical spine is as follows:
• Atlanto-occipital joint: Flexion - 5° 
   Extension - 10° 
   Rotation – negligible 
   Lateral flexion – 5° 

• Atlanto-axial joint: Flexion - 5° 
   Extension - 10° 
   Rotation – 40-45° 
   Lateral flexion – negligible 

• Intracervical region (C2-C7): Flexion – 35° 
   Extension – 70° 
   Rotation – 45° 
   Lateral flexion – 35° 

• Total cervical range of motion: Flexion – 45-50° 
   Extension – 85° 
   Rotation – 90° 
   Lateral flexion – 40° 

2.6 The anatomy and physiology of skeletal muscle

Skeletal muscle is responsible for movement, maintaining postures and position of the body, 
supporting soft tissue, surrounding entrances and exits, maintenance of body temperature 
and storing reserves of nutrients (Martini, 2006).

The typical skeletal muscle is organised as follows:

The entire muscle is surrounded by collagen referred to as the epimysium which separates 
the muscle from surrounding tissues and organs. The muscle is divided into compartments 
containing a bundle of muscle fibers (also referred to as fascicle) by the perimysium. The 
perimysium contains blood vessels and nerve fibers that supply the muscle. The individual 
muscle fibers (muscle cells) within the fascicle are surrounded by a connective tissue layer
called the endomysium. The endomysium also contains capillaries, embryonic stem cells and nerve fibers (Martini, 2006).

The organisation of skeletal muscle is illustrated in figure 2.4.

---

**Figure 2.4: The organisation of skeletal muscle** (Martini, 2006).

The typical skeletal muscle fiber has the following structure:

The entire muscle fiber contains sarcoplasm and is surrounded by a membrane called the sarcolemma. The sarcolemma has a transmembrane potential caused by unequal distribution of positive and negative charges across it and this assists in the contraction of the muscle fiber. The entire muscle fiber must contract simultaneously and therefore the signal to contract must be distributed rapidly through the cell. The conduction occurs through narrow tubes that extend from the sarcolemma into the sarcoplasm referred to as transverse tubules (T tubules). The impulses that signal the cell to contract is referred to as action potentials. Each of the skeletal muscle fibers contains hundreds to thousands of cylindrical protein filaments called myofibrils. The myofibrils are surrounded by the transverse tubules. Each myofibril has two types of myofilaments: the thin filament consisting mainly of actin and the thick filament consisting mostly of myosin. The myofibrils
also contain a protein referred to as titin. Mitochondria and glycogen are found between the myofibrils and they are responsible for ATP production in the cells (Martini, 2006).

At the point where the myofibril is surrounded by the transverse tubule, the tubule is attached to the sarcoplasmic reticulum (SR). The SR is a membrane that forms a network around each myofibril. On each side of the T tubule the SR enlarges and fuses to form chambers referred to as the terminal cisternae. A pair of terminal cisternae and a transverse tubule is known as a triad. Skeletal muscle cells actively transports or pumps calcium ions into the extracellular fluid but they also remove calcium ions from the sarcoplasm by actively transporting them into the terminal cisternae. The terminal cisternae contain a protein that binds calcium. This protein is known as calsequestrin. The contraction of the muscle begins when the stored calcium is released into the surrounding sarcoplasm and diffuses into the sarcomeres. The sarcomeres are the individual contractile units that consist of repeating functional units of thin and thick myofilaments (Martini, 2006).

The structure of a skeletal muscle fiber is illustrated in figure 2.5.

Figure 2.5: The structure of a skeletal muscle fiber (Martini, 2006)
A typical sarcomere consists of thin and thick filaments, proteins responsible for stabilising the thick and thin filaments and proteins regulating the interaction between the filaments. The sizes, density and distribution of the thin and thick filaments cause a banded appearance of the myofibril. The sarcomere has dark bands known as A bands and light bands known as I bands (Martini, 2006).

The A bands are found subdivided into the following regions: M line, H zone and the zone of overlap (Martini, 2006).

The I bands consist only of thin filaments and are situated on either side of the A band to connect the A bands of adjacent sarcomeres. Adjacent sarcomeres are marked by the Z line which consists of proteins named actinins. Elastic proteins called titin attach to the tips of the thick filaments and attachment sites at the Z line. They function to keep the filaments in alignment and resist overstretching (Martini, 2006).

The structure of the sarcomere is illustrated in figure 2.6:

![Figure 2.6: The structure of a sarcomere – longitudinal section (Martini, 2006)](image)

The structure of the thick and thin myofilaments are illustrated in figure 2.7 and discussed thereafter.
The thin myofilaments consist of the following four proteins:

- **F actin** – a twisted strand consisting of two rows of G actin molecules.
- **Nebulin** - holds the F actin together. Each G actin has an active site where myosin can bind.
- **Tropomyosin** – protein strands that cover the binding sites on G actin thereby preventing interaction between actin and myosin.
- **Troponin** – a protein with three globular units: one unit binds to tropomyosin forming a troponin-tropomyosin complex, a second unit that binds to a G actin to maintain the position of the complex and a third unit with a binding site for a calcium ion (Martini, 2006).

The thick filaments are made up mainly by myosin molecules. The myosin molecules consist of myosin subunits twisted around each other. Each thick filament also has a titin strand making up its core (Martini, 2006).

The myosin thick filaments consist of:

- **Tail** – binds to other myosin molecules. All tails point toward the M line.
Head – free (not bound) and directed at the nearest thin filament. It has two subunits. No heads are found in the H zone (Martini, 2006).

The interaction between the myosin head and thin filament during contraction is known as cross-bridges. The head and tail forms a hinge that allows the head to pivot which causes the head to swing away or toward the M line (Martini, 2006).

The sliding filament theory explains the events occurring during contraction of a skeletal muscle fiber. This theory is divided into the following events:

i. The H zones and I bands get smaller
ii. The zones of overlap gets larger
iii. The Z line approximates
iv. The A band stays the same (Martini, 2006).

The contraction cycle is controlled by the nervous system via the neuromuscular junction where every muscle fiber is controlled by a neuron. An axon branches within the perimysium with each of these branches ending in a synaptic terminal. The cytoplasm in the synaptic terminal contains mitochondria and acetylcholine (ACh) filled vesicles. The area between the synaptic terminal and the opposing sarcolemma is known as the synaptic cleft. The surface of the sarcolemma contains receptors for ACh and is known as the motor end plate. The motor end plate has folds known as junctional folds that increase its surface area thereby increasing the number of ACh receptors. The synaptic cleft and sarcolemma has acetylcholinesterase (AChE) molecules responsible for the breakdown of ACh (Martini, 2006). The events occurring during the neurological stimulation of the muscle fiber are discussed below and are illustrated in figure 2.8:

The arrival of an action potential at the synaptic terminal signals the release of ACh into the synaptic cleft. The ACh moves across the cleft and binds to ACh receptors on the motor end plate which causes the end plate to become more permeable to sodium ions. Sodium ions move to the sarcoplasm until ACh is removed. The influx of the sodium ions gives rise to an action potential that starts at the edge of the sarcolemma and then moves inwards along the T tubules. AChE breaks down the ACh before the action potential has spread over the entire sarcolemma. This restores the initial state of the membrane (Martini, 2006).
Excitation-contraction coupling is the link between the generation of an action potential at the sarcolemma and the initiation of the muscle contraction. This coupling occurs at the triad where the action potential triggers the release of calcium ions from the cisternae of the SR. The concentration of calcium ions around the sarcomere increases rapidly (Martini, 2006).

The events occurring at the sarcomere during the contraction cycle are initiated. They are discussed below and illustrated in figure 2.9.

Calcium ions enter the sarcoplasm and bind to troponin. This interaction makes the bond between the troponin-tropomyosin complex and the actin molecule weak. Troponin changes its position and it moves the tropomyosin away from the active site of the actin molecule which facilitates interaction between the myosin heads. Following the exposure of the active sites, cross-bridges are formed when the energised myosin heads bind to the active sites on
the actin molecules. When the sarcomere is relaxed, the myosin head is directed away from
the M line. This is referred to as the “cocked” position. The cocking requires energy which
is obtained via the breakdown of ATP into ADP and phosphate (which remains attached to
the myosin head). After the cross-bridge is formed the energy is released (ADP and
phosphate) and the myosin head pivots towards the M line. This is referred to as the power
stroke. ATP binds to the myosin head again causing the actin and myosin molecules to
detach to expose the active site thereby allowing another cross-bridge formation. The ATP
cracle is broken down into ADP and phosphate again to release energy that allows the
myosin head to “recock” (Martini, 2006).

Figure 2.10 illustrates a summary of all the steps involve in the contraction of a skeletal
muscle.

![Figure 2.9: The skeletal muscle contraction cycle](http://www.sivabio.50webs.com/mus.htm)
2.7 The vertebral subluxation complex

A spinal motion segment is defined as two adjacent vertebrae and the tissues connecting them together. A subluxation is defined as a motion segment in which the alignment, movement integrity and/or physiological function are altered although the contact between the joint surfaces remains partially intact (Gatterman, 2005).

The original subluxation complex described consisted of the following five components:

- Neuropathophysiology
- Kinesiopathology
- Myopathology
- Histopathology
- Biochemical changes (Gatterman, 2005).

Pain is considered to be a symptom of the subluxation however it does not need to be present (Gatterman, 2005).
According to Gatterman (2005), nociceptors have a very high threshold for activation and require a noxious or injurious stimulus. Therefore, injury to the tissues or tissue abnormalities, initiate the firing of these nociceptors leading to the perception of pain. This is the neuropathophysiology component of the vertebral subluxation complex (VSC).

The kinesiopathology component of the VSC refers to changes in joint mobility such as hypomobility or hypermobility of the spinal joints. These changes may occur due to the degenerative changes in the joints of the spine (Gatterman, 2005).

The myopathology component refers to degeneration of the spinal muscles. The characteristics of muscle degeneration refer to a decrease in muscle size and infiltration of fat. Studies were done on the trunk muscles in patients with chronic lower back pain in which it was concluded that 45% of patients in the control group had paraspinal muscle degeneration with increased percentages in patients with moderate to severe pain (Gatterman, 2005).

The histopathology component of the VSC is described as the microscopic changes occurring in the spinal muscles, joints and intervertebral discs during the degeneration process. Tissue degeneration is associated with histopathological changes. Hypomobility also promotes histopathological changes (Gatterman, 2005).

The biochemical changes of the VSC refers to the chemical inflammatory mediators such as prostaglandin E-2, leukotriene-B4, thromboxane A-2, interleukin-1 and tumour necrosis factor that are released by strained or biomechanically stressed tissues. These mediators are known to be released by the cells of injured intervertebral discs or joint tissues. These biochemical changes stimulate the nociceptors leading to pain (Gatterman, 2005).

According to this model the spinal adjustment has a direct effect on the kinesiopathology component and indirect effects on the other components of the vertebral subluxation complex (Gatterman, 2005).

According to Bergmann & Peterson (2011), the mechanical component of the VSC refers to deranged or disordered somatic structures in the body which in turn leads to changes in the joint structure and function. Structure and function is interdependent therefore a change in either would cause a change in the other. When joints are subjected to acute or chronic
repetitive trauma it causes asymmetrical muscle action which maintains the misalignment. The misaligned joints cause restricted movement, inflammatory changes and pain due to nociceptor irritation (Bergmann & Peterson, 2011).

Another explanation of joint pain suggests that joint hypomobility causes pain and abnormal mechanics of the spine due to altered sensory input from the spinal and paraspinal tissues. When addressing joint hypomobility or fixation, there are several factors to consider. These include:

- **Soft tissue injury and repair**: injury to soft tissues causes fibrosis, decreased elasticity and strength which produce joint fixation. The soft tissue injury is caused by acute or repetitive trauma. This triggers an inflammatory reaction that causes exudates and blood to accumulate extracellularly. This process causes adhesion formation and therefore hypomobility (Bergmann & Peterson, 2011).

- **Myofascial cycle**: pain may trigger persistent hypotonicity of muscles. This is another source of joint hypomobility. Contraction of muscles is a source of pain and muscle hypotonicity. Splinting in the intrinsic muscles of the joint further decrease joint movement and also produces blocking of the mechanoreceptor stimulation induced pain inhibition. When the muscles maintain their contraction over time it would lead to muscle contractures. The myofascial cycle is illustrated in figure 2.11 (Bergmann & Peterson, 2011).
Figure 2.11: The myofascial cycle – myofascial conditions are triggered by many causes and can become self-perpetuating sources of pain, muscle spasm and joint dysfunction (Bergmann & Peterson, 2011).

- **Interarticular derangements**: the internal joint derangements capable of causing pain and joint locking include: interarticular block, intradiscal block and compressive buckling injuries. Interarticular block refers to posterior joint dysfunction due to entrapment of synovial folds of meniscoid. Intradiscal block occur due to pathophysiological changes within the disc occurring with aging, degeneration and trauma. A compressive buckling injury refers to intersegmental buckling occurring due to failure in neuromuscular control. This results in inadequate pre-stability of the segment or failure to respond with appropriate muscle activation. Joints are inherently stable due to the surrounding ligaments and joint capsules and
neuromuscular action. Errors in the motor control lead to inappropriate muscle force and stiffness thereby decreasing the stability of the segment. Therefore, when a joint is overloaded, intersegmental buckling may occur that results in a brief increase in movement that increases the load on the surrounding tissues. These interarticular derangements mechanically block movement and causes unleveling of the motion segment. This induces tension in the joint capsule and the annulus fibrosis of the intervertebral disc, which are pain-sensitive structures. Muscle splinting results and this further increases the mechanical block and joint hypomobility (Bergmann & Peterson, 2011).

2.8 Myofascial trigger points

2.8.1 Definition of a myofascial trigger point

According to Simons, Travell & Simons (1999), a myofascial trigger point (MTrP) can be defined as a hyperirritable zone in a skeletal muscle that consists of a hypersensitive palpable nodule in a tight band. It is painful during compression and may cause a characteristic pain referral, referred tenderness, motor dysfunction and autonomic symptoms (Simons, Travell & Simons, 1999).

2.8.2 Types of myofascial trigger points

Myofascial trigger points can either be active or latent. An active MTrP is defined as a trigger point that causes spontaneous clinical pain. A latent MTrP may have all the characteristics of an active MTrP except that it does not cause spontaneous pain. It is only painful during compression (Simons et al. 1999).

2.8.3 Features of a myofascial trigger point

Features of myofascial trigger points are listed in table 2.3.
Table 2.3: Features of myofascial trigger points: (Gerwin, 2010)

<table>
<thead>
<tr>
<th><strong>Motor</strong></th>
<th><strong>Sensory</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Taut band</td>
<td>Localised pain</td>
</tr>
<tr>
<td>Twitch response</td>
<td>Referred pain</td>
</tr>
<tr>
<td>Muscle weakness without atrophy</td>
<td>Central sensitisation</td>
</tr>
<tr>
<td>Loss of reciprocal inhibition</td>
<td>Peripheral sensitisation</td>
</tr>
<tr>
<td>Electromyographic endplate noise</td>
<td>Subject to sympathetic modulation</td>
</tr>
<tr>
<td>Subject to sympathetic modulation</td>
<td></td>
</tr>
</tbody>
</table>

The taut band refers to a linear band of hardened muscle not involving the entire muscle. It consists of contracted muscle fibers which consist of contracted sarcomeres located at or near the motor endplate zone. A local twitch response is the localised contraction of the tight band of muscle caused by palpation or dry needling. It is only found in trigger points and therefore not in normal muscle. Myofascial trigger points cause reversible weakness of the involved muscle without atrophy of the muscle. Reciprocal inhibition refers to inhibited contraction of a muscle occurring when its antagonist muscle contracts. This inhibition is decreased or absent when trigger points are present within the muscle. Endplate noise refers to the spontaneous electrical activity of the trigger point. It describes the persistent, low-amplitude, high frequency discharges occurring at a trigger point region. Higher amplitude waves are seen in active myofascial trigger points which cause endplate spikes. The endplate noise is related to the activity of the trigger point with greater activity noted in active trigger points (Gerwin, 2010).

The sensory manifestations include local and referred pain in the form of hyperalgesia or allodynia. The local pain is caused by the release of neuropeptides, cytokines and inflammatory substances including substance P, calcitonin gene-related peptide (CGRP), IL-1α and bradykinin. There is a release of protons which increase the acidity in the area (Gerwin, 2010).

2.8.4 Pathophysiology of myofascial trigger points

The integrated trigger point hypothesis is the most commonly used hypothesis to explain the pathophysiology of myofascial trigger points (Simons et al. 1999).
According to this hypothesis there are dysfunctional motor nerve terminals that release excessive amounts of acetylcholine (ACh) into the synaptic cleft resulting in activation of the ACh receptors in the postjunctional membrane, generating endplate potentials that combine to produce a sustained depolarisation of the postjunctional membrane. The depolarisation causes a continuous release and uptake of calcium ions from the sarcoplasmic reticulum (SR). The calcium produces a sustained contraction of the sarcomeres. The four steps that then result in an increased local energy demand are as follows:

- The production and release of acetylcholine
- The sustained depolarisation of the postjunctional membrane
- The continuous release and uptake of calcium from the sarcoplasmic reticulum
- The sustained contraction of the sarcomeres (Simons et al. 1999).

The sustained contraction of the muscle fibers compress the local blood vessels (reducing the energy supply) resulting in a decrease in the nutrient and oxygen supply thereby decreasing the available resources that would normally meet the energy demands causing an energy crisis. The energy crisis leads to the release of sensitising substances that interact with the autonomic and sensory (including nociceptive) nerves of the region. The released neuroactive substances also cause too much ACh to be released from the nerve terminal setting up a self-sustaining cycle (Simons et al. 1999).

The hypothesis is illustrated in figure 2.12.
Figure 2.12: A schematic drawing illustrating the integrated hypothesis (Simons, 2015).

2.9 Trapezius muscle

2.9.1 Anatomy of the trapezius muscle

The trapezius muscle consists of upper, middle and lower parts. The muscle as a whole attaches proximally to the medial third of the superior nuchal line, external occipital protuberance, nuchal ligament and the spinous processes of C7-T12 vertebrae. Distally it attaches to the lateral third of the clavicle, the acromion and the spine of the scapula (Moore & Dalley, 2006). The upper trapezius fibers attach to the medial third of the superior nuchal line and nuchal ligament proximally and to the posterior lateral third of the clavicle distally (Simons et al. 1999). The motor innervation to the trapezius muscle is supplied by the spinal portion of the spinal accessory nerve (cranial nerve eleven). In addition, motor and sensory innervation of the muscle is supplied by spinal nerves C2, C3 and C4 (Simons et al. 1999).

2.9.2 The function of the trapezius muscle

The trapezius muscle as a whole and acting bilaterally causes extension of the cervical and thoracic spine. The upper trapezius fibers acting unilaterally cause extension and lateral flexion of the head towards the same side. It also assists in extreme rotation. Acting
bilaterally, the upper fibers cause extension of the head and neck against resistance (Simons et al. 1999).

2.9.3 Symptoms experienced by patients with upper trapezius myofascial trigger points

Patients with trigger points at the trigger point one (TrP1) site in the muscle has constant posterolateral neck pain which may be associated with temporal headaches and pain at the angle of the jaw. Patients with trigger points at the trigger point two (TrP2) site in the muscle has similar neck pain but the patient usually does not have an associated headache. Patients will also experience pain when rotating the head and neck fully towards the opposite side (Simons et al. 1999).

2.9.4 Activation and perpetuation of trapezius myofascial trigger points

Trigger points may be activated by sudden trauma such as falling or a whiplash type injury. The trapezius muscle is involved in stabilisation of the neck and keeping the head and neck vertical and the eyes level. Therefore, trigger points may be activated by lower limb leg length discrepancies or a small hemipelvis. Trigger points in the trapezius muscle is also commonly caused by prolonged elevation of the shoulders, typically observed in anxious or stressed patients. Prolonged shortening of the muscle fibers or prolonged rotation of the head towards one side can also activate trigger points in the trapezius muscle. Upper trapezius trigger points may be activated by cervical radiculopathy (Simons et al. 1999).

Trigger points are commonly perpetuated by:

- Mechanical stresses such as structural inadequacy, postural stress or constriction of muscles.
- Nutritional inadequacies including vitamin $B_1$, vitamin $B_6$, vitamin $B_{12}$, folic acid and vitamin C deficiencies or deficiencies of calcium, magnesium and potassium.
- Metabolic and endocrine inadequacies for example hypometabolism (hypothyroidism), hypoglycemia and gout.
- Psychological factors such as depression, hopelessness, anxiety and tension.
- Chronic infections and infestations including viral, bacterial and parasitic infections.
• Other factors including allergic rhinitis, impaired sleep and radiculopathy (Simons et al. 1999).

2.9.5 Location and referral patterns of upper trapezius myofascial trigger points

The trapezius muscle is the most common muscle affected by myofascial trigger points and a trigger point at the trigger point one site of the trapezius muscle is the most frequent trigger point identified in the body (Simons et al. 1999).

The trapezius muscle as a whole has seven trigger point locations each with their own characteristic referral patterns. The upper trapezius muscle has two common trigger point locations. These trigger points are referred to as trigger point one (TrP1) and trigger point two (TrP2) (Simons et al. 1999).

TrP1 is a central trigger point located in the middle of the anterior border of the vertical upper trapezius fibers. This trigger point refers pain upward along the posterolateral aspect of the neck towards the mastoid process. The pain also extends toward the side of the head and concentrates in the temple and retro-orbital area. The trigger point may also refer pain to the angle of the jaw (Simons et al. 1999).

TrP2 is situated caudal and lateral to TrP1 in the middle of the horizontal fibers of the upper trapezius muscle. This trigger point refers pain to the suboccipital region (Simons et al. 1999).

Figure 2.13: Location and referral of trigger point one (TrP1) (Simons et al. 1999).
2.9.6 Examination of upper trapezius myofascial trigger points

Pincer palpation or flat palpation can be used to identify trigger points in the upper trapezius muscle, however pincer palpation is most effective. The patient is supine or seated. The muscle is relaxed by taking the ear towards the shoulder on the side to be examined. The trapezius muscle is lifted and rolled between the forefinger and the thumb to palpate the trigger point (illustrated in figure 2.15) (Simons et al. 1999).

Figure 2.15: Pincer palpation of a myofascial trigger point (Simons et al. 1999).
2.10 Relationship between cervical joint hypomobility and muscle trigger points

According to Fernández-de-las-Peñas (2009), there is a clinical relationship between joint impairment and myofascial trigger points. It has been suggested that manipulation of a joint segment has an effect on the trigger points in the muscle innervated by the segment (Fernández-de-las-Peñas, 2009).

According to Hong (2006), chiropractic adjustment of the cervical facet joint can relieve pain caused by a myofascial trigger point in the rhomboid muscle. It has been suggested that there is a connection of the sensory pathways of the myofascial trigger point nociceptors and the facet joint nociceptors in the spinal cord or that they use the same nociceptive pathway to the higher centers of the brain. Therefore a facet joint dysfunction may be a contributing factor to the activation of myofascial trigger points (Hong, 2006).

Studies regarding neck pain, have shown a significant relationship between myofascial trigger points in the upper trapezius muscle and joint hypomobility in the cervical spine especially involving the C3-C4 facet joints. There are several theories regarding this relationship (Fernández-de-las-Peñas, 2009). They include the following:

- Increased muscle tension can maintain displacement of the joints that it crosses therefore the trigger point causes the joint dysfunction (Fernández-de-las-Peñas, 2009).
- Abnormal sensory input into the muscle (due to the joint hypomobility) causes myofascial trigger points (Fernández-de-las-Peñas, 2009).

According to Fernández-de-las-Peñas, Fernández Carnero & Miangolarra Page (2005), Korr describes the theory of a facilitated segment – the tissues adjacent to a joint dysfunction have a lower pressure pain threshold, increased sympathetic activity and facilitation of motor pathways. The joint dysfunction causes an increase in the activity of the paraspinal muscles thereby suggesting that joint dysfunction can induce myofascial trigger point activity and that the activity of the trigger point can also worsen a joint dysfunction (Fernández-de-las-Peñas, Fernández Carnero & Miangolarra Page, 2005; Gatterman, 2005).

In a study by Fernández-de-las-Peñas et al. (2005), 150 patients with mechanical neck pain were examined for cervical joint dysfunction and myofascial trigger points. The results
indicate that 56% of these patients had latent trigger points in the upper trapezius muscle while 28% of these patients had active trigger points in the upper trapezius muscle. Tender points were found in the remainder of the patients. A cervical spine joint dysfunction was found on the same side as the trigger point/tender point in 97% of the patients. Their study also confirmed a significant relationship between an upper trapezius trigger point and an isolated joint dysfunction at the C₃ vertebra. A combination of dysfunctions at C₃ and C₄ vertebral levels were also found in association with the trigger points/tender points. Isolated dysfunctions at C₄, C₅ and C₇ levels were not significant (Fernández-de-las-Peñas et al. 2005).

Therefore it was proposed that treatment of both myofascial trigger points and joint hypomobility should be included in a treatment protocol (Fernández-de-las-Peñas, 2009).

2.11 Treatment of cervical spine joint hypomobility and trigger points

Joint hypomobility or dysfunction in the spine is commonly treated via chiropractic spinal adjustment or manipulation (Fernández-de-las-Peñas, 2009). Many different treatment techniques have been described in the treatment of myofascial trigger points. These treatments include trigger point compression, spray and stretch techniques, ultrasound, muscle stretching, electrical stimulation, laser, dry needling and trigger point injection (Gerwin, 2010).

2.12 Chiropractic adjustment

2.12.1 Definition

Chiropractic adjustment can be defined as any chiropractic therapeutic procedure that utilises a controlled force, leverage, direction, amplitude and velocity, directed at a specific joint or anatomical region. These procedures are done to produce an effect on the joint and neurophysiological function (Esposito & Philipson, 2005).
2.12.2 Aim of the chiropractic adjustment

The aim of the chiropractic adjustment is to have an effect on the joints and surrounding soft tissues. The chiropractic adjustment has this effect by restoring the normal function of joints, causing an increase in range of motion, changing chemical modulators thereby decreasing inflammation in the area and stimulating healing of tissues. The chiropractic adjustment also produces this effect by causing a change in the tone and strength of muscle and by changing the viscoelastic properties of collagen in the joint capsules and ligamentous connective tissue (Bergmann & Peterson, 2011).

2.12.3 Joint range of motion and the process of cavitation

According to Esposito & Philipson (2005), the range of motion of a joint can be divided into three zones and two barriers. The three zones consist of the following:

- Active range of motion
- Passive range of motion
- Paraphysiological space

The two barriers include the elastic barrier of resistance and the limit of anatomical integrity (Esposito & Philipson, 2005).

The barriers and zones making up joint range of motion are illustrated in the figure 2.16.

![Figure 2.16: Joint range of motion](Gatterman, 2005).
The chiropractic adjustment involves passing the elastic barrier of resistance and entering the paraphysiological space. Sandoz has described three events that occur when passing through this barrier:

- Sudden separation of the joint surfaces
- An audible cracking sound
- Formation of a radiolucent space in the joint (Esposito & Philipson, 2005).

The process involved in the production of these events is referred to as cavitation (Esposito & Philipson, 2005).

2.12.4 Effects of the chiropractic adjustment

According to Yeomans (2009), evidence of the following effects of the chiropractic adjustment can be summarised according to studies: sensory, motor and sympathetic effects.

Sensory and motor effects include (Yeomans, 2009):

- Increased range of motion of joints and reduction in pain
- Increased skin pain tolerance level
- Increased paraspinal muscle pressure pain tolerance
- Reduced muscle electrical activity and tension.

Sympathetic nervous system effects include (Yeomans, 2009):

- Increased blood flow and distal skin temperature
- Reduction in blood pressure

According to Yeomans (2009), there are changes in the blood chemistry following a chiropractic adjustment. These changes include increased secretion of melatonin, increased plasma beta endorphin levels, elevated substance P levels and enhanced neutrophil respiratory burst (Yeomans, 2009).

There are many theories with regard to the effects of spinal adjustment. These theories have in common that changes in the normal anatomical, physiological or biomechanical
dynamics of adjacent vertebrae has an effect on the function of the nervous system, and that spinal adjustment corrects these changes (Pickar, 2002).

According to Potter, McCarthy & Oldham (2005), the biomechanical effects include joint gapping and increased range of motion.

A study done by Sandoz (1976) indicates that distraction and cavitation of the metacarpophalangeal joint causes an increase in the radiolucent joint space. Méal & Scott (1986) and Conway, Herzog, Zhang, Hasler, & Ladly (1993) compared the cavitation sound of the metacarpophalangeal joint to the sound produced during facet joint cavitations and found similar sound waves suggesting that the same effect occurs in spinal joints. Cramer, Tuck, Knudsen, Fonda, Schliesser, Fournier & Patel (2000) compared joint space using MRI before and after spinal adjustment and concluded an increase joint space following spinal adjustment to hypomobile joints (Potter, McCarthy & Oldham, 2005).

The above evidence is also used to support the increased range of motion following spinal adjustments. Lehman & McGill (1999) showed small changes in the range of motion following spinal adjustment and also concluded that there is an increased improvement in patients with more pain (Potter et al. 2005).

The mechanical force created by the spinal adjustment changes the biomechanics of the segment by causing release of entrapped meniscoids and/or adhesions and reducing distortion of the annulus fibrosus of the intervertebral disc. Individual motion segments may also buckle to produce large vertebral motions and thereby lead to a new position of stable equilibrium. The mechanical changes produced by the adjustment may provide energy that may be used to restore the buckled segment to a lower energy level thereby placing less stress on paraspinal tissues. An important biomechanical effect of the spinal adjustment is the restoration of facet joint mobility and joint play. These biomechanical changes have physiological effects: changing the sensory input into the central nervous system and reducing the nociceptive input from the paraspinal tissues (Pickar, 2002).

The theoretical relationship between spinal adjustment, segmental biomechanics, nervous system and end-organ physiology is shown in figure 2.17:
Figure 2.17: A theoretical model showing components that describe the relationships between spinal adjustment, segmental biomechanics, the nervous system and physiology. The neurophysiological effects of spinal manipulation could be mediated at any of the numbered boxes (Pickar, 2002).

As indicated in figure 2.17 when a biomechanical change occurs between vertebral segments it results in a biomechanical overload which in turn changes the signalling properties of the neurons in the paraspinal tissues which are sensitive to mechanical and chemical changes. The changes in the sensory input have an effect on the central neural integration and/or directly on the reflex activity. The spinal adjustment causes a change in the sensory input from the paraspinal tissues (Pickar, 2002).

a) The effects of spinal adjustment on the sensory receptors in the paraspinal tissues

**Group I and II afferents:** these are primary sensory neurons that transmit impulses from the muscle spindles, golgi tendon organs and other low threshold mechanoreceptors to the
central nervous system. These afferents rapidly transmit information due to their large diameter and myelination (Cramer, Budgell, Henderson, Khalsa & Pickar, 2006).

It has been proposed that spinal adjustment increases the mobility of joints by causing a barrage of impulses in the muscle spindle afferents and smaller diameter afferents thereby silencing facilitated γ-motoneurons. The hypothesis is that spinal manipulation increases the γ-motoneuron discharge in the muscles of the adjusted segments. The gain of the γ loop decreases joint mobility by causing a sensitisation in the stretch reflex. The spinal adjustment stimulates the Group Ia and group II afferents causing a reduced gain of the γ loop. The above gamma loop is illustrated in figure 2.18 (Pickar, 2002).

Figure 2.18: A schematic showing the sensory pathways that could modulate γ-motoneuron discharge. High frequency discharge from muscle spindles input may affect descending input to the γ-motoneurons. Input from the smaller diameter group III and IV neurons may also affect the γ-motoneurons (Pickar, 2002).

Group III and IV afferents: these are primary sensory neurons and they have mechanically, chemically and thermally sensitive endings. These afferents transmit impulses slowly due to their smaller diameter and little or no myelination (Cramer et al. 2006). No studies have been done to determine the effects of spinal adjustment on these smaller thinly myelinated or unmyelinated neurons however it has been speculated that all sensory neurons are theoretically affected by spinal adjustment (Pickar, 2002).
b) The effects of spinal adjustment on neural tissue within the intervertebral foramen (IVF)

Spinal nerve roots have less protection and support by connective tissue when compared to peripheral nerves. When the nerve enters the IVF the epineurium separates from the nerve trunk and becomes continuous with the dura mater. The perineurium is lost when the trunk divides into the dorsal and ventral roots. The endoneurium persists however it becomes less dense and less protective. There is also a high concentration of sodium (Na+) channels in the dorsal root ganglia cells making them more excitable. Due to these properties the nerves in the IVF is very vulnerable to changes in the surrounding tissues (Pickar, 2002).

c) The effects of spinal adjustment on central facilitation

Studies have suggested that spinal adjustment changes the central processing of noxious stimuli leading to increased pain tolerance or pain threshold levels (Cramer et al. 2006).

Central facilitation can also be referred to as central sensitisation, and it refers to the increase in the excitability of the dorsal horn neurons to an afferent input. Central facilitation can occur when there is an increase in the spontaneous central neural activity, when there is an increased discharge of the central axons to an afferent input or when there are changes in the receptive field properties of central neurons. It has been shown that changes in the normal sensory input from the functional spinal unit causes an increased excitability of the neuronal cell and circuits in the spinal cord. Central facilitation allows mechanical stimuli to access the central pain pathways therefore subthreshold mechanical stimuli have the ability to cause pain. The spinal adjustment removes these subthreshold stimuli by increasing joint movement (Pickar, 2002).

Normal non painful mechanical inputs may also have a beneficial effect. According to the gate control theory proposed by Melzack and Wall (1965) non-noxious mechanics inputs travelling via the large myelinated A fibers have the ability to decrease the response of the dorsal horn of the spinal cord to stimuli travelling to the spinal cord via the nociceptive C fibers (Pickar, 2002; Melzack & Wall, 1965).
d) The effects of spinal adjustment on somatosomatic (muscle) reflexes

There is evidence that spinal adjustment causes paraspinal muscle reflexes and alters the motoneuron excitability. It has been shown that there is an increase in the paraspinal EMG activity in a pattern that is related to the adjusted segment. The effects of the adjustment on the EMG activity may be due to increased muscle strength following the adjustment (Pickar, 2002).

The reflexogenic effect produced by the spinal adjustment causes pain reduction, reduced muscle hypertonicity and improved function. A study done by Herzog, Scheele & Conway (1999) shows a reflex response in local and distant muscles in response to spinal manipulation (Potter, McCarthy & Oldham 2005).


e) The effects of spinal adjustment on somatovisceral reflexes

Sensory input from paraspinal tissues can effect visceral reflexes that affect the sympathetic nervous system to cause a change in end-organ function. Non-painful paraspinal stimuli inhibit sympathetic nerve activity while painful stimuli increase the sympathetic responses however very little research studies have been done to determine the effects of spinal adjustment on the sympathetic nervous system in terms of regional or segmental specificity. Spinal adjustment may also change the response of immune cells and the production of immune modulating and neuro modulating cytokines. Spinal adjustment increases the respiratory burst of polymorphonuclear leukocytes and monocytes (Pickar, 2002).

2.12.5 Effectiveness of the chiropractic adjustment

According to Cramer et al. (2006), a case study was performed by Vernon in which pressure pain thresholds were measured in six tender spots in the neck region before and after spinal adjustment. In this study it was found that spinal adjustment increased the pressure-pain threshold and decreased pain sensitivity (Cramer et al. 2006).

According to Kuan, Wu, Chen, Chen & Hong (1997) spinal adjustment delivered to the C3-C4 and C4-C5 levels has an immediate relieving effect on pain in patients with trapezius trigger points (Kuan, Wu, Chen, Chen & Hong, 1997).
Evidence suggests that spinal adjustment produces changes in muscle sensitivity. Kuan et al. (1997) found that spinal adjustment at C3-C4 and C4-C5 reduces pain and tightness in the trapezius muscle. Ruiz-Sáez, Fernández-de-las-Peñas, Rodriguez-Blanco, Martinez-Segura & Garcia-León (2007) showed that adjustment delivered to the C3-C4 vertebral segment causes changes in the pain sensitivity of latent upper trapezius trigger points. Therefore patients with upper trapezius trigger points may have beneficial results when the joint hypomobility is addressed via spinal adjustment (Fernández-de-las-Peñas, 2009).

2.13 Low level laser therapy

2.13.1 Definition and description of low level laser therapy

Low level laser therapy (LLLT) is also referred to as biostimulation laser, soft laser or healing laser. Laser is an acronym used to describe “light amplification by stimulated emission of radiation”. It is a form of light therapy that uses a specific wavelength that produces physiological changes in the cells that support the normal healing process. The stimulation of physiological processes at cellular level by the laser is known as photo-biostimulation. Cells communicate with each other using the same impulses to pass on information. This process is known as photo-biomodulation. Laser results in increased strength of these impulses and thereby revitalises and reactivates the body’s own healing processes (Füchtenbusch & Bringmann, 2004).

The radiation produced by the laser can be absorbed, scattered or transmitted when interacting with tissues (Pryor, 2011).

According to the Arndt-Schultz Law, there is stimulation of biological systems by weak stimuli, support of the biological systems by moderate stimuli, arrest of biological systems by strong stimuli and retardation of biological systems by very strong stimuli (Fitz-Ritson, 2001).

2.13.2 Aim of low level laser therapy

The aim of low level laser therapy in the treatment of myofascial trigger points is to decrease pain and muscle spasm (Fouda, Refai & Mohammed, 2013).
### 2.13.3 Effects of low level laser therapy

The function and physiological effects produced by low level laser therapy are described in table 2.4.

**Table 2.4: Physiological effects of low level laser therapy** (Füchtenbusch & Bringmann, 2004):

<table>
<thead>
<tr>
<th>Function</th>
<th>Physiological effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduces inflammation</td>
<td>Laser therapy:</td>
</tr>
<tr>
<td></td>
<td>- Improves phagocytosis</td>
</tr>
<tr>
<td></td>
<td>- Inhibits mast cell degranulation</td>
</tr>
<tr>
<td></td>
<td>- Activates immune cells by increasing leukocyte mobilisation</td>
</tr>
<tr>
<td></td>
<td>- Promotes microcirculation by increasing vasodilation</td>
</tr>
<tr>
<td></td>
<td>- Reduces inflammatory oedema and promotes lymphatic flow</td>
</tr>
<tr>
<td></td>
<td>- Inhibits synthesis of inflammatory prostaglandins</td>
</tr>
<tr>
<td>Relieves pain</td>
<td>Laser therapy:</td>
</tr>
<tr>
<td></td>
<td>- Promotes release of β-endorphins</td>
</tr>
<tr>
<td></td>
<td>- Increases production of ATP and thus energy resources of the cell</td>
</tr>
<tr>
<td></td>
<td>- Stabilises membrane potential of nerve cells</td>
</tr>
<tr>
<td></td>
<td>- Relaxes muscles and increases the threshold of pain perception</td>
</tr>
<tr>
<td></td>
<td>- Decreases the amount of circulating pain mediators such as substance P</td>
</tr>
<tr>
<td></td>
<td>- Reduces the activity of trigger and tender points</td>
</tr>
<tr>
<td></td>
<td>- Activates acupuncture points</td>
</tr>
</tbody>
</table>
**Regenerates tissue**

<table>
<thead>
<tr>
<th>Laser therapy:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Increases the rate of mitosis and collagen synthesis</td>
</tr>
<tr>
<td>• Activates fibroblasts, chondrocytes, osteocytes and other tissue specific cell types</td>
</tr>
<tr>
<td>• Increases production of ATP</td>
</tr>
<tr>
<td>• Increases granulation and epithelialisation in wound healing</td>
</tr>
<tr>
<td>• Promotes regeneration of peripheral nerves post-injury</td>
</tr>
<tr>
<td>• Reduces degenerative CNS processes</td>
</tr>
<tr>
<td>• Helps cerebral tissue to survive after transient ischemia</td>
</tr>
<tr>
<td>• Reduces or eliminates scars</td>
</tr>
</tbody>
</table>

**Promotes circulation**

<table>
<thead>
<tr>
<th>Laser therapy:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Has effects similar to lymph drainage</td>
</tr>
<tr>
<td>• Increases microcirculation</td>
</tr>
<tr>
<td>• Accelerates resorption of haematomas</td>
</tr>
<tr>
<td>• Reduces release of vasoactive amines</td>
</tr>
<tr>
<td>• Increases hyaluronidase activity.</td>
</tr>
</tbody>
</table>

According to Chow, Johnson, Lopes-Martins & Bjordal (2009), the mechanisms by which LLLT produce pain relief are not clear. According to Pryor (2011), the most supported mechanism of action of LLLT is that the Cytochrome C found in mitochondria act as a photoreceptor. Once the Cytochrome C has absorbed the light it is excited and binds with oxygen to form Cytochrome C Oxidase. Cytochrome C oxidase is a very important component for energy production within cells and therefore it leads to biological responses and secondary mechanisms including pain reduction, decreased inflammation and tissue healing (Pryor, 2011).

The reduction in pain can be produced via various mechanisms. According to Pryor (2011), LLLT increases serotonin levels. Serotonin has an effect on mood and also acts as a neurotransmitter. LLLT also increases beta-endorphin levels and this causes a decrease in
pain sensation. Nitric oxide (NO) levels are also increased during laser stimulation. NO has an effect on the production of an action potential and also causes vasodilation. Bradykinin is responsible for stimulating nociceptors in injured tissue, thereby inducing a pain sensation. LLLT has been shown to decrease bradykinin levels (Pryor, 2011). Laser therapy can also induce neural blockage by selectively inhibiting the Aδ and C nociceptive fibers (Chow, Johnson, Lopes-Martins & Bjordal, 2009). Therapeutic lasers have other positive effects on tissues that lead to a decrease in pain. These include: normalisation of ion channels, increased ACh release, nerve regeneration and increasing the resting action potential of nerve cells (Pryor, 2011).

The main anti-inflammatory effect produced by low level laser therapy is believed to be due to a decrease in prostaglandin (Gross, Dziengo, Boers, Goldsmith, Graham, Lilge, Burnie & White, 2013). The doses responsible for the anti-inflammatory effects of laser also decrease the oxidative stress and muscle fatigue on muscle tissue. According to these authors muscle fatigue normally precedes muscle pain and chronic trapezius muscle pain is associated with an increase in electromyograph (EMG) activity and impaired circulation. The reduction in oxidative stress and muscle fatigue would help patients with acute or chronic neck pain. Another mechanism suggested for the pain relief caused by LLLT includes inhibited transmission at the neuromuscular junction (Chow, Johnson, Lopes-Martins & Bjordal, 2009).

It has been suggested that increased amounts of endogenous opioids are produced in response to laser, that laser reduces oedema and stimulates healing (Gross, Dziengo, Boers, Goldsmith, Graham, Lilge, Burnie & White, 2013).

According to Simunovic (1996), LLLT increases the local microcirculation and thereby assists in the removal of waste products and supplies oxygen to the hypoxic cells in the area (Simunovic, 1996).

2.13.4 Effectiveness of low level laser therapy in the treatment of neck pain and myofascial trigger points

In a study done by Kannan (2012), the effectiveness of laser compared to ischaemic compression and therapeutic ultrasound on the upper trapezius muscle was determined. In this study it was shown that all three modalities decreased pain perception and pain intensity
and increased cervical spine range of motion, specifically lateral flexion. The author concluded that laser can be used as an effective treatment modality in the management of myofascial trigger points (Kannan, 2012).

Hakgüder, Birtane, Gürcan, Kokino & Turan (2003), performed a two group study in which one group was treated with LLLT and a muscle specific exercise program, while the second group was only given the muscle specific exercise program. These authors concluded that the stretching alone relieved pain significantly but the patients receiving LLLT in addition to the stretching program had a superior response in terms of pain relief of the active myofascial trigger points (Hakgüder, Birtane, Gürcan, Kokino & Turan, 2003).

Simunovic (1996) performed a clinical study in which low level laser therapy was applied to trigger points of more than 200 patients and it was reported that the LLLT increases mobility, decreases rigidity and spontaneous pain. According to the results of this study, LLLT resulted in a decrease in chronic pain by more than 60%. The author also suggested that LLLT can be used as a monotherapy or can be combined with other treatment modalities for the treatment of pain (Simunovic, 1996).

A study by Saayman, Hay & Abrahamse (2011) provided evidence that cervical spinal adjustment combined with low level laser therapy is more beneficial in the treatment of cervical facet dysfunction than either modality used in isolation (Saayman, Hay & Abrahamse, 2011).

According to Pryor (2011), studies have concluded that laser therapy immediately decreases pain in acute and chronic neck pain patients.

According to Pöntinen (1998), there is an immediate increase in the pressure pain threshold of trigger points following the application of helium-neon and infrared lasers. Pöntinen (1998) also interestingly noted that the contralateral, non-treated trigger point also improved.
2.14 Ischaemic compression

2.14.1 Definition

Trigger point compression involves therapeutic application of pressure to a myofascial trigger point to decrease muscle tension and inactivate trigger points that cause tight bands in the muscle (Kostopoulos, Nelson, Ingber & Larkin, 2008). According to Perle, Schneider & Seaman (1999), it is not clear that ischaemia actually occurs during the application of pressure to the trigger point and therefore the term trigger point pressure release is suggested as an alternative term (Perle et al. 1999).

2.14.2 Aim of ischaemic compression

The aim of ischaemic compression is to decrease muscle tension, decrease nodularity in the muscle fibers and immediately changing the symptom pattern of the patient (Perle et al. 1999).

2.14.3 Effects of ischaemic compression

According to Kostopoulos et al. (2008), the application of pressure to the trigger points causes further ischaemia. When the pressure is released there is a reactive hyperaemia that provides additional blood to the area. The increased blood flow provides oxygen and nutrients to meet the energy demand of the tissue. Ischaemic compression of the trigger point also acts as a counter-irritant thereby causing pain relief. The pressure could also activate the spinal reflex mechanism to cause a decrease in the muscle spasm (Kostopoulos et al. 2008). According to Gatterman & McDowell (2011), studies have demonstrated that the sustained pressure on the trigger point causes a decrease in pain perception and an increase in the pain tolerance due to changes in the tissue sensitivity (Gatterman & McDowell, 2011).

2.14.4 Effectiveness of ischaemic compression in the treatment of myofascial trigger points

A case report by Montañez-Aguilera, Valtueña-Gimeno, Pecos-Martin, Arnau-Masanet, Barrios-Pitarque & Bosch-Morell (2010), concludes that ischaemic compression increases range of motion and is effective in the treatment of active myofascial trigger points in patients

Gemmel, Miller and Nordstrom (2007) references a study done by Hou, Tsai, Cheng, Chung & Hong in 2002 in which it was concluded that ischaemic compression of active upper trapezius trigger points provided immediate pain relief and reduced sensitivity of the trigger point (Gemmel, Miller & Nordstrom, 2007).

In a study done by Dearing & Hamilton (2008) asymptomatic patients with upper trapezius trigger points were treated by ischaemic compression or a muscle energy technique. They concluded that both techniques decreased trigger point sensitivity but ischaemic compression seemed to be more effective (Dearing & Hamilton, 2008).

Considering the literature presented regarding the effect of cervical spine adjustment, ischaemic compression and low level laser therapy in previous work, it was decided to perform a research study to determine if a treatment protocol consisting of two treatment modalities is better than one treatment alone and to determine if one treatment protocol is more effective than the other in decreasing cervical spine pain due to a myofascial trigger point in the upper trapezius muscle. The treatment protocols selected for this study consisted of cervical spine adjustment combined with ischaemic compression of the trapezius trigger point and cervical spine adjustment combined with low level laser therapy of the trapezius trigger point. The methodology of the study is discussed in the next chapter.
CHAPTER THREE: METHODOLOGY

3.1 Introduction

This chapter serves as an explanation of the study design, participant recruitment, sample selection and size, group allocation and treatment protocols.

3.2 Study design

The study was designed as a comparative intervention study.

3.2.1 Participant recruitment

Participants were recruited by posting advertisements on the notice boards in the Chiropractic day clinic and on all campuses of the University of Johannesburg. Participants were also recruited via word of mouth.

3.2.2 Sample selection and size

Potential participants were screened by a full history taking (Appendix C), physical examination (Appendix D) and a cervical spine regional examination (Appendix E), taking the inclusion and exclusion criteria into account, to determine if they were suitable to partake in the study. Prior to any treatment, participants were required to read and sign information and consent forms (Appendix A and B). Thirty participants between the ages of 18 and 40 were selected to take part in the study. The participants were divided into two groups of fifteen. Group one received cervical spinal adjustment and ischaemic compression of the upper trapezius myofascial trigger point one. Group two received cervical spinal adjustment and low level laser therapy to the upper trapezius myofascial trigger point one.

3.2.3 Inclusion criteria

Participants were required to be between the ages of 18 and 40 and either male or female to participate in the study. All participants were also required to present with the following:

An active myofascial trigger point at the trigger point one location (TrP1) in the upper trapezius muscle. An active MTrP is defined as a MTrP that causes spontaneous clinical pain (Simons et al. 1999).
The diagnostic criteria for such a trigger point which included posterolateral neck pain or tension neckache, a palpable nodule in a tight band, pain referral to the temple or retro-orbital area, referred tenderness, restricted cervical spine range of motion and a local twitch response of the myofascial trigger point (Simons et al. 1999).

3.2.4 Exclusion criteria

Participants presenting with the following were excluded from the study:

- Participants with any contra-indications to chiropractic spinal adjustment.

According to Gatterman (1991) the following are contra-indications for the application of spinal manipulative therapy:

- Vascular complications including vertebral-basilar insufficiency, atherosclerosis of major blood vessels and aneurysms.
- Tumors (lung, thyroid, breast, bone, prostate).
- Bone infections (tuberculosis and osteomyelitis).
- Traumatic injuries including fractures, joint instability or hypermobility, severe sprains or strains and unstable spondylolisthesis.
- Arthritis including Rheumatoid arthritis, Ankylosing spondylitis, Psoriatic arthritis, Osteoarthritis (unstable phase), Osteoarthritis (late phases) and Uncoarthrosis.
- Psychological considerations including malingering, hysteria, hypochondriasis and pain intolerance.
- Metabolic disorders including clotting disorders, osteopenia including osteoporosis and osteomalacia.
- Neurological complications including a medial or massive disc protrusion with sacral nerve root involvement, disc lesions with progressive neurological deficits and space-occupying lesions.

- Participants with any contra-indications to ischaemic compression of myofascial trigger points (Perle, Schneider & Seaman, 1999)
  - Application over areas of recent trauma, haematoma or bruising.
  - Deep vein thrombosis or phlebitis.
  - Application over neurovascular bundles.
- Patient taking anti-coagulant medication or long term steroids.
- Patients taking medications or patients with nutritional deficiencies that may cause soft tissue bleeding or bruising.

- Participants with any contra-indications to low level laser therapy treatment (MKW Therapiesysteme, 2009)
  - Absolute contra-indications include irradiation of the eyes, photosensitivity, tumours, open fontanelles or epiphyseal cartilage and hyperthyroidism.
  - Relative contra-indications include pacemakers, epilepsy, pregnancy and endocrine organs (thorax, testicles and ovaries).
  - Therapy hindrances include deep x-ray, chronic medication and chemotherapy.

- Participants taking anti-inflammatory medication or those participating in other treatments that would alter the outcome of the study.

3.2.5 Random group allocation

All the selected participants were required to draw a number from a hat. Participants that drew a number one were placed in group one and participants that drew a number two were placed in group two.

3.3 Treatment approach

3.3.1 First and follow-up visits

During the first visit the participants were required to read and sign information and consent forms (Appendix A and appendix B) pertaining to the study. After this was completed the following approach was taken:

- The researcher completed a full case history (Appendix C), physical examination (Appendix D) and cervical spine regional examination (Appendix E).
- Participants completed a numerical pain rating scale (Appendix F) and Vernon-Mior neck pain and disability index (Appendix G) to provide subjective data.
• The researcher measured the cervical spine range of motion (using a CROM) (Appendix H) and the trigger point sensitivity (using the pressure algometer) (Appendix I) and recorded the values as objective data.
• Participants were treated according to their allocated groups.

During the follow up visits the following approach was taken:

• At the fourth and seventh visit the participants completed the numerical pain rating scale and the Vernon-Mior neck pain and disability index to provide subjective data (prior to treatment).
• At the fourth and seventh visit, the researcher measured the cervical spine range of motion and trigger point sensitivity to provide objective data (prior to treatment).
• All participants were treated according to their allocated groups on visit one to six.
  The seventh consultation only consisted of data collection.

Therefore, all participants received six treatments and a data collection consultation over a three week period.

3.4 Treatment

All thirty participants received a cervical spinal adjustment according to the cervical spine restrictions found during the assessment. The fifteen participants in group one received ischaemic compression to the upper trapezius trigger point. The fifteen participants in group two received low level laser therapy of the upper trapezius trigger point.

3.4.1 Treatment protocols

Group one

Participants in group one received cervical spine adjustments at the relevant levels as determined by motion palpation followed by ischaemic compression of the myofascial trigger point in the trapezius muscle.
Group two

Participants in group two received cervical spine adjustments at the relevant levels as determined by motion palpation followed by the application of low level laser therapy to the trigger point in the trapezius muscle.

3.4.2 Chiropractic adjustment

Restrictions in the cervical spine were identified using static and motion palpation and tenderness of the spine. These restrictions were confirmed by static and motion palpation of the cervical spine. After the restrictions were identified, a chiropractic adjustment was performed using a high velocity, low amplitude thrust to correct the restriction (Bergmann & Peterson, 2011).

3.4.3 Low level laser therapy

Participants were placed in a seated position after which the exact location of the trigger point one in the upper trapezius muscle was determined using pincer palpation. The skin over the treatment area was cleaned with an alcohol swab. The Medilaser de Luxe laser emitting a wavelength of 670 nanometer was applied to the trigger point using point application. The Medilaser de Luxe is a class 3B laser with a maximum power output of 20mW and a 9V DC power source. It is manufactured by Chris Engineering Industries CC, Randburg, Johannesburg. The laser probe was held perpendicular to and in direct contact with the skin. The laser parameters were set according to the accompanying manual. The laser was used on a high setting for chronic conditions with the following treatment parameters:

Table 3.1: Treatment parameters used for low level laser therapy treatment.

<table>
<thead>
<tr>
<th>Treatment area</th>
<th>Dosage in time (seconds)</th>
<th>Dosage in Joules</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myofascial trigger point</td>
<td>60</td>
<td>1,2</td>
<td>per point</td>
</tr>
</tbody>
</table>

3.4.4 Ischaemic compression

Participants were placed in a supine position after which the exact location of the trigger point one in the upper trapezius muscle was determined using manual palpation via pincer
Palpation. Pressure is applied to the trigger point. The ischaemic compression was applied to the trigger point for 30 seconds or until release of the tension is felt (Gatterman, 2005; Perle et al. 1999). The sustained pressure on the trigger point is released slowly when the trigger point tenderness disappears or after one minute depending on which occurs first (Gemmell, Miller & Nordstrom, 2008). Care should be taken during the application to not apply excessive pressure, to avoid too many repetitions and to hold the pressure for too long (Perle et al. 1999).

In a study by Hou, Tsai, Cheng, Chung & Hong (2002), pain threshold is defined as the minimum force applied to the muscle that induces pain and discomfort while pain tolerance is defined as the maximum force a patient can tolerate. According to these authors, the pressure that is applied during the ischaemic compression of a trigger point determines the effects. Insufficient pressure may be ineffective and excessive pressure may increase pain and muscle tension. These authors also state that the average pressure of pain threshold and tolerance requires only a 30 second treatment for pain relief to occur (Hou, Tsai, Cheng, Chung & Hong, 2002).

3.5 Subjective data

3.5.1 Vernon-Mior neck pain and disability index

The Vernon-Mior neck pain and disability index (NDI) was used as a questionnaire designed to determine the intensity of pain and the effects of this pain on various parts of the individuals life (personal care, lifting, reading, headaches, concentration, work, driving, sleeping and recreation). The NDI provides subjective data.

The questionnaire consists of 10 questions. Each question has 5 possible answers and each answer is assigned a score between 1 and 5. The total score of the questionnaire is 50. Participants are requested to complete the questionnaire by marking one answer per question. The total score is determined in percentage as follows:

Percentage disability = patient score / 50 x 100.

If a question is not applicable to a participant or not answered the disability should be calculated as follows:
Percentage disability = patient score / 45 x 100.

When three or more questions cannot be answered the questionnaire is regarded to be unacceptable.

The disability score is interpreted as follows:

- 0 - 4 = no disability
- 5 – 14 = mild disability
- 15 – 24 = moderate disability
- 25 – 34 = severe disability
- 35 or above = complete disability.

According to Vernon & Mior (1991) the NDI is highly reliable in “test-retest” reliability and also valid.

3.5.2 Numerical pain rating scale

The numerical scale was used to determine the intensity of the pain experienced by the patient at the first, fourth and seventh consultations. Participants were asked to circle a number that best represents the intensity of their pain at that moment. The numerical pain rating scale used is an 11 point scale. The end points represent the extremes of pain with zero being no pain and 10 being the worst pain imaginable (Williamson & Hoggart, 2005).

<table>
<thead>
<tr>
<th>No pain</th>
<th>Moderate pain</th>
<th>Worst pain</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>9</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

Williamson & Hoggart (2005) performed a study to review the three most commonly used pain rating scales (the visual analog scale, the verbal rating scale and the numerical rating scale). They concluded that all three scales are reliable and valid and that the numerical rating scale is more useful in research (Williamson & Hoggart, 2005).
3.6 Objective data

3.6.1 Cervical spine range of motion

The cervical spine range of motion was measured using the cervical range of motion (CROM) device. It is a goniometer designed specifically for measuring cervical range of motion. It consists of three inclinometers that measures range of motion in each plane of movement. The CROM measures cervical spine flexion, extension, lateral flexion and rotation. The values are recorded in degrees. Three readings were taken for each plane of movement and the average of these readings were used for statistical analysis.

The CROM was applied to the participants’ head and fastened with the Velcro straps. For cervical spine flexion the participant was instructed to place their chin on their chest and after the reading was recorded the participant was instructed to return to normal position. For cervical spine extension the participants were requested to look up at the ceiling. For left and right lateral flexion the participants were instructed to place the respective ear on the shoulder. An additional measurement inclinometer and magnet strap around the neck was added prior to measuring cervical spine rotation. Cervical spine rotation was measured by asking the participant to their head to each side as far as possible. Each of these movements was repeated three times.

The CROM is easy to apply, cost effective, and has a good validity and reliability (Reddy, Maiya & Rao, 2012).

3.6.2 Pressure algometer

The pressure algometer was used to measure the tenderness of a trigger point by applying pressure to a trigger point. A pressure algometer is a pressure gauge with a plunger that indicates pressure values in kg/cm² (Pöntinen, 1998). Two measurements can be taken with the algometer. The minimum amount of pressure that produces pain is referred to as the pressure pain threshold (PPT). The maximum pain that the patient can tolerate is referred to as the pressure tolerance (Kostopoulos et al. 2008). For this study the PPT was recorded. Participants were asked to sit in an upright position. The trigger point was located with manual palpation and pressure was applied with the pressure algometer directly over the
trigger point. Participants were asked to report the stage at which pain starts during the pressure application.

The pressure algometer is considered to be reliable and valid according to Hong (1998) and Kostopoulos et al. (2008).

![Pressure Algometer](www.wagnerforce.com/paintest/fpk_dial_pain_tester_algometer.php)

Figure 3.1: A pressure algometer

(www.wagnerforce.com/paintest/fpk_dial_pain_tester_algometer.php)

3.7 Data analysis

All objective and subjective data obtained from the trial was sent to and analysed by STATKON. Both intragroup and intergroup analyses were done for this study. The aim of the study was to compare two treatment protocols for the treatment of trapezius myofascial trigger points and to determine if one protocol is superior to the other.

The following tests were used to analyse the data:

- Shapiro-Wilks test
- Levene’s test for Equality of Variances
- Box’s test of Equality of Covariance Matrices
- Intragroup analysis was done using the Mixed between within subject ANOVA test, Friedman test and Wilcoxon Signed Ranks test.
- Intergroup analysis was done using the Independent t-test and the Mann-Whithey U test.
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 insured (prevention of harm). The information and consent form also explained that the participant’s privacy will be protected as only the doctor, patient and clinician will be in the treatment room and that anonymity would be insured as the patients 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. Should the participant have had any further questions, these were explained by the researcher and the researcher’s 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. It was explained that the results of the study would be made available on request.

With regards to this particular study the following risks and discomforts were possible:

- Post adjustment soreness
- Headache
- Damage to the eyes due to the laser beam
- Bruising due to ischaemic compression
- Exacerbation of symptoms
- Vertebral artery complications.

With regards to this particular study the following benefits were possible:

- Reduction of neck pain
- Increased cervical spine range of motion.

Participants would have been referred if necessary.
This document was submitted to the plagiarism scanner, Turnitin to review for plagiarism. The report is attached as Appendix J.
CHAPTER FOUR: RESULTS

4.1 Introduction

This chapter presents the results of the clinical trial. The sample group consisted of thirty participants divided into two groups of fifteen participants. The fifteen participants in group one received cervical spine adjustments and ischaemic compression of the trapezius trigger point. The fifteen participants in group two received cervical spine adjustments and low level laser therapy of the trapezius trigger point. The results are based on a small sample size and therefore may not be applied to the general population.

The p-value for all tests was set at 0.05 except for the Wilcoxon Signed Ranks test where the Bonferroni adjustment was applied and the p-value was set at 0.0167 (≈0.017). The Bonferroni adjustment involves dividing the p-value of 0.05 by three since the data is compared between three visits - visits one and four, visits four and seven and visits one and seven. These values denote the statistical significance of the results obtained.

Analysis of the following data is included:

- Demographic data analysis describing the number of participants, the gender and age of the participants.
- Subjective measurements consisting of the numerical pain rating scale and the Vernon-Mior neck pain and disability index.
- Objective measurements consisting of pressure algometer readings and the CROM goniometer readings.

Data analysis requires an assumption of normality of the distribution of the results. To determine normality the Shapiro-Wilk test and Levene’s test for Equality of Variances was performed. A p-value of more than 0.05 in the Shapiro-Wilk test indicates normality in the data distribution. A p-value of more than 0.05 in the Levene’s test for Equality of Variances indicates that equal variances may be assumed. If the p-value is smaller than 0.05, equal variances cannot be assumed however an alternative t-value is provided in these instances. Another test result to check before reporting the parametric data include the Box’s test of Equality of Covariance Matrices. The p-value is required to be greater than 0.001.
The effect size for the Independent t-test is determined by using the following formula: \( \text{Eta}^2 = \frac{t^2}{t^2 + (N1 + N2 - 2)} \). The effect size indicates the magnitude of difference between the two groups and provides information regarding the clinical significance of the results. According to Pallant (2007), the effect size is interpreted using the following values: 0.01 = small effect, 0.06 = moderate effect, 0.14 = large effect (Pallant, 2007).

The effect size for the Mann-Whitney U test is calculated with the following formula: \( r = \frac{z}{\sqrt{N}} \) where \( N \) is the number of cases. According to Pallant (2007), the criteria for the interpretation of the effect size is as follows: 0.1 = small effect, 0.3 = medium effect, 0.5 = large effect (Pallant, 2007).

### 4.2 Demographic data analysis

The demographic data regarding the gender and age of participants in the study is indicated in table 4.1 and table 4.2.

**Table 4.1: Table indicating the number and gender of participants**

<table>
<thead>
<tr>
<th>Gender</th>
<th>Number of participants</th>
<th>Percentage of total participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>4</td>
<td>13.30%</td>
</tr>
<tr>
<td>Female</td>
<td>26</td>
<td>86.70%</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>100%</td>
</tr>
</tbody>
</table>

**Table 4.2: Table indicating the mean, maximum and minimum age of groups.**

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean age (years)</th>
<th>Maximum age (years)</th>
<th>Minimum age (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>25.07</td>
<td>39</td>
<td>20</td>
</tr>
<tr>
<td>Group 2</td>
<td>23.33</td>
<td>25</td>
<td>22</td>
</tr>
</tbody>
</table>
Interpretation of demographic data

According to table 4.1, group one and two together consisted of thirty participants. Four (13.3%) of these were males and 26 (86.7%) were females. Table 4.2 demonstrates the ages of the participants. Group one had a mean age of 25.07 years (standard deviation ± 4.43) with a minimum age of 20 years and a maximum age of 39 years. Group two had a mean age of 23.33 years (standard deviation ± 1.18) with a minimum age of 22 years and a maximum age of 25 years.

4.3 Subjective data analysis

4.3.1 Numerical pain rating scale

![Figure 4.1: Bar graph indicating the mean values obtained from the numerical pain rating scale for both groups at visit 1, 4 and 7.]

Clinical interpretation of subjective data - Numerical pain rating scale

The numerical pain rating scale was completed by all participants at visit one, four and seven and the results are illustrated on figure 4.1. At visit one, group one had a mean score on the numerical pain rating scale of 5.80 (standard deviation ± 1.21) and group two had a mean score of 4.27 (standard deviation ± 2.25). At visit four, group one had a mean score of 3.17 (standard deviation ± 1.30) and group two had a mean score of 3.80 (standard deviation ± 2.00).
deviation ± 2.08). At visit seven, group one had a mean score of 1.20 (standard deviation ± 1.21) and group two had a mean score of 1.73 (standard deviation ± 1.58).

Based on figure 4.1, it can be concluded that the participants in both groups showed an improvement between visit one and visit seven. The mean values can be used to determine the overall percentage of improvement. Group one had an overall improvement of 79.31% and group two had an overall improvement of 59.48%

**Statistical analysis**

With regards to the normality results for the numerical pain rating scale:

- The Shapiro-Wilk test yielded a p-value of more than 0.05 for both groups at visit one (group one = 0.20, group two = 0.69), for group one at visit four (group one = 0.14, group two = 0.01) and for group two at visit seven (group one = 0.03, group two = 0.10).
- The Levene’s test for Equality of Variances: Equal variances cannot be assumed at visit one (p-value = 0.01) but equal variances can be assumed at visit four and visit seven (visit four p-value = 0.12, visit seven p-value = 0.18).
- The Box's test of Equality of Covariance Matrices had a p-value of 0.08.

Group one and group two is compared at visit one to determine if the two groups are comparable. At visit one the Independent t-test provided a p-value of 0.03 which indicate that there is a significant difference between the two groups (p-value ≤ 0.05). This suggests that the groups are not comparable with regards to the numerical pain rating scale scores. The Mann-Whitney U test provided a p-value of 0.05 (p-value ≥ 0.05) which suggests that the two groups are comparable at visit one with regards to the numerical pain rating scale.

**Intragroup analysis**

Non-parametric data analysis was done using the Friedman and Wilcoxon Signed Ranks test. Non-parametric data analysis using the Friedman test was used to make comparisons within each group over time. Group one had a p-value of 0.00 and group two had a p-value of 0.00 which indicates that there is a statistically significant difference in the numerical pain rating score over time within each group (p ≤ 0.05).
Further non-parametric testing was done using the Wilcoxon Signed Ranks test in order to determine where exactly the changes occurred within each group. The Bonferroni adjustment was applied to the p-value by dividing 0.05 by three to obtain a new p-value of 0.017. Group one had a p-value of 0.00 between visit one and four, between visit four and seven and between visit one and seven. Group two had a p-value of 0.03 between visit one and four and a p-value of 0.00 between visit four and seven and between visit one and seven. The values for group one, indicate that there is a significant difference within the group between visit one and four, visit four and seven and visit one and seven (p-value ≤ 0.017). The values for group two indicate that there is no significant difference within the group between visit one and four (p-value ≥ 0.017). However, there is a significant difference within the group between visit four and seven and visit one and seven (p-value ≤ 0.017).

**Intergroup analysis**

Parametric data analysis was done using the Independent-samples t-test and non-parametric data analysis was done using the Mann-Whitney U test. The results obtained are shown in table 4.3.

**Table 4.3: Table representing the results of the Independent t-test and Mann-Whitney U test for the numerical pain rating scale**

<table>
<thead>
<tr>
<th>Numerical pain rating scale</th>
<th>Independent t-test</th>
<th>Mann-Whitney U test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t score</td>
<td>p-value</td>
</tr>
<tr>
<td>Visit 1</td>
<td>2.33</td>
<td>0.03</td>
</tr>
<tr>
<td>Visit 4</td>
<td>-1.00</td>
<td>0.33</td>
</tr>
<tr>
<td>Visit 7</td>
<td>-1.04</td>
<td>0.31</td>
</tr>
</tbody>
</table>

Regarding the Independent t-test results: At visit one, the p-value was 0.03, which indicates that there is a significant difference between the two groups (p-value ≤ 0.05). At visit four and visit seven, the scores were 0.33 and 0.31 respectively which indicate no significant difference between the two groups at visit four and seven (p-value ≥ 0.05).

Regarding the Mann-Whitney U test: The numerical pain rating scale at visit one had a p-value of 0.05. At visit four the p-value was 0.64 and at visit seven the p-value was 0.38.
These results indicate that there are no significant differences between the two groups at visit one, four and seven with regards to the numerical pain rating scale (p-value ≥ 0.05).

4.3.2 Vernon-Mior neck pain and disability index

![Bar graph representing the mean values obtained from the Vernon-Mior neck pain and disability index (%) for both groups at visit 1, 4 and 7.](image)

**Clinical interpretation of subjective data – Vernon-Mior neck pain and disability index**

The Vernon-Mior neck pain and disability index was completed by all participants at visit one, four and seven. According to figure 4.2, at visit one, group one had a mean Vernon-Mior neck pain and disability index score of 23.47% (standard deviation ± 10.07) and group two had a mean Vernon-Mior neck pain and disability index score of 17.20% (standard deviation ± 6.63). At visit four, group one had a mean Vernon-Mior neck pain and disability index score of 13.20% (standard deviation ± 9.25) and group two had a mean Vernon-Mior neck pain and disability index score of 12.27% (standard deviation ± 9.59). At visit 7, group one had a mean Vernon-Mior neck pain and disability index score of 7.07% (standard deviation ± 6.32) and group two had a mean Vernon-Mior neck pain and disability index score of 4.67% (standard deviation ± 3.09).

Based on figure 4.3, it can be concluded that the participants in both groups showed an improvement between visit one and visit seven. The mean values can be used to determine
the overall percentage of improvement. Group one had an overall improvement of 69.88% and group two had an overall improvement of 72.85%.

**Statistical analysis**

With regards to the normality results for the Vernon-Mior neck pain and disability index:

- The Shapiro-Wilk test yielded a p-value of more than 0.05 for both groups at visit one (group one = 0.33, group two = 0.44), for group one at visit four (group one = 0.14, group two = 0.00) and for group two at visit seven (group one = 0.01, group two = 0.45).
- The Levene’s test for Equality of Variances: equal variances can be assumed at visit one and four but not at visit seven (visit one p-value = 0.32, visit four p-value = 0.37, visit seven p-value = 0.00).
- The Box’s test of Equality of Covariance Matrices had a p-value 0.02.

Group one and group two is compared at visit one to determine if the two groups are comparable. At visit one the Independent t-test and the Mann-Whitney U tests provided p-values of 0.05 and 0.06 respectively which indicate that there is no significant difference between the two groups (p-value ≥ 0.05) and therefore the groups are comparable with regards to the Vernon-Mior neck pain and disability index at visit one.

**Intragroup analysis**

Non-parametric data analysis was done using the Friedman and Wilcoxon Signed Ranks test. Non-parametric data analysis using the Friedman test was used to make comparisons within each group over time. Group one had a p-value of 0.00 and group two had a p-value of 0.00 which indicates that there is a significant difference (p ≤ 0.05) in the Vernon-Mior neck pain and disability index, over time within each group.

Further non-parametric testing was done using the Wilcoxon Signed Ranks test in order to determine where exactly the changes occurred within each group. The Bonferroni adjustment was applied to the p-value by dividing 0.05 by three to obtain a new p-value of 0.017. Group one had a p-value of 0.00 at visit one, 0.00 at visit four and 0.00 at visit seven. Group two had a p-value of 0.01 at visit one and a p-value of 0.00 at visit four and visit
seven. These values indicate that there is a significant difference ($p \leq 0.017$) within each group between visit one and four, visit four and seven and visit one and seven.

**Intergroup analysis**

For the intergroup analysis, parametric data analysis was done using the Independent-samples t-test and non-parametric data analysis was done using the Mann-Whitney U test. The results obtained are shown in table 4.4.

**Table 4.4: Table representing the results of the Independent t-test and Mann-Whitney U test for the Vernon-Mior neck pain and disability index**

<table>
<thead>
<tr>
<th>Vernon-Mior neck pain and disability index</th>
<th>Independent t-test</th>
<th>Mann-Whitney U test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t score</td>
<td>p-value</td>
</tr>
<tr>
<td>Visit 1</td>
<td>2.01</td>
<td>0.05</td>
</tr>
<tr>
<td>Visit 4</td>
<td>0.27</td>
<td>0.79</td>
</tr>
<tr>
<td>Visit 7</td>
<td>1.32</td>
<td>0.20</td>
</tr>
</tbody>
</table>

Regarding the Independent t-test: at visit one, the p-value was 0.05 ($p \geq 0.05$) and therefore it can be assumed that there is no significant difference between the two groups at visit one. At visit four and visit seven, the p-values were 0.79 and 0.20 respectively. These scores are higher than 0.05 and therefore it can be assumed that there is no significant difference between the two groups at visit four and seven.

Regarding the Mann-Whitney U test: the Vernon-Mior neck pain and disability index at visit one had a p-value of 0.06. At visit four the p-value was 0.82 and at visit seven the p-value was 0.58. These results indicate that there are no significant differences between the two groups at visit one, four and seven with regards to the Vernon-Mior Neck pain and disability index ($p\text{-value} \geq 0.05$).
4.4 Objective data analysis

4.4.1 Pressure algometer

Figure 4.3: Bar graph illustrating the mean values of the pressure algometer readings for both groups at visit 1, 4 and 7.

Clinical interpretation of objective data – Pressure algometer

Pressure algometer readings were obtained from all participants at visit one, four and seven. The data is summarised in figure 4.3 above. At visit one, group one had a mean algometer reading of 2.62 kg/cm$^2$ (standard deviation ± 0.76) and group two had a mean reading of 2.38 kg/cm$^2$ (standard deviation ± 0.49). At visit four, group one had a mean algometer reading of 3.07 kg/cm$^2$ (standard deviation ± 0.67) and group two had a mean reading of 2.61 kg/cm$^2$ (standard deviation ± 0.57). At visit seven, group one had a mean pressure algometer reading of 3.61 kg/cm$^2$ (standard deviation ± 0.87) and group two had a mean algometer reading of 3.28 kg/cm$^2$ (standard deviation ± 0.44).

Based on figure 4.5, it can be concluded that the participants in both groups showed an improvement between visit one and visit seven. The mean values can be used to determine the overall percentage of improvement. Group one had an overall improvement of 37.79% and group two had an overall improvement of 37.82%.
Statistical analysis

With regards to the normality results for the pressure algometer readings:

- The Shapiro-Wilk test yielded a p-value of more than 0.05 for both groups at all visits (group one: visit one = 0.99, visit four = 1.00, visit seven = 0.32; group two: visit one = 0.75, visit four = 0.09, visit seven = 0.72).
- The Levene’s test for Equality of Variances: equal variances can be assumed at visits one and four but not at visit seven (visit one p-value = 0.25, visit four p-value = 0.46, visit seven p-value = 0.04).
- The Box’s test of Equality of Covariance Matrices had a p-value 0.18.

Group one and group two is compared at visit one to determine if the two groups are comparable. At visit one the Independent t-test provided a p-value of 0.32 which indicate that there is no significant difference between the two groups (p-value ≥ 0.05). This suggests that the groups are comparable with regards to the pressure algometer readings. The Mann-Whitney U test provided a p-value of 0.32 which suggests that the two groups are comparable at visit one with regards to the pressure algometer readings (p-value ≥ 0.05).

Intragroup analysis

Non-parametric data analysis was done using the Friedman and Wilcoxon Signed Ranks test.

Non-parametric data analysis using the Friedman test was used to make comparisons within each group over time. Group one had a p-value of 0.00 and group two had a p-value of 0.00 which indicates that there is a significant difference in the pressure algometer readings over time within each group (p-value ≤ 0.05).

Further non-parametric testing was done using the Wilcoxon signed ranks test in order to determine where exactly the changes occurred within each group. The Bonferroni adjustment was applied to the p-value by dividing 0.05 by three to obtain a new p-value of 0.017. Group one had a p-value of 0.01 between visit one and four, a p-value of 0.01 between visit four and seven and a p-value of 0.00 between visit one and seven. Group two had a p-value of 0.05 between visit one and four, a p-value of 0.00 between visit four and seven a p-value of 0.00 between visit one and seven. The values for group one, indicate
that there is a significant difference within the group between visit one and four, visit four and seven and visit one and seven (p-value ≤ 0.017). The values for group two, indicate that there is no significant difference within the group between visit one and four (p-value ≥ 0.017). However, there is a significant difference within the group between visit four and seven and visit one and seven (p-value ≤ 0.017).

**Intergroup analysis**

Parametric data analysis was done using the Independent-samples t-test and non-parametric data analysis was done using the Mann-Whitney U test. The results obtained are shown in table 4.5.

**Table 4.5: Table representing the results of the Independent t-test and Mann-Whitney U test for the pressure algometer readings**

<table>
<thead>
<tr>
<th>Pressure algometer reading</th>
<th>Independent t-test</th>
<th>Mann-Whitney U test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t score</td>
<td>p-value</td>
</tr>
<tr>
<td>Visit 1</td>
<td>1.00</td>
<td>0.32</td>
</tr>
<tr>
<td>Visit 4</td>
<td>2.02</td>
<td>0.05</td>
</tr>
<tr>
<td>Visit 7</td>
<td>1.31</td>
<td>0.21</td>
</tr>
</tbody>
</table>

Regarding the Independent t-test results: At visit one, the p-value was 0.32 which indicate no significant difference between the two groups at visit one (p-value ≥ 0.05). At visit four and visit seven, the scores were 0.05 and 0.21 respectively which indicate no significant difference between the two groups at visit four and seven (p-value ≥ 0.05).

Regarding the Mann-Whitney U test: The pressure algometer readings at visit one had a p-value of 0.33. This indicates no significant difference regarding the pressure algometer readings between the two groups at visit one (p ≥ 0.05). At visit four the p-value was 0.04 which indicate a significant difference between the two groups at visit four regarding the pressure algometer readings (p ≤ 0.05). At visit seven the p-value was 0.08. This result indicates that there is no significant difference between the two groups at visit seven (p ≥ 0.05).
4.4.2 Cervical range of motion (CROM) goniometer

Cervical spine flexion

Figure 4.4: Bar graph illustrating the mean values of flexion for both groups at visit 1, 4 and 7.

Interpretation of objective data – Cervical range of motion goniometer

Cervical spine flexion

The cervical spine range of motion in flexion was measured on all participants at visit one, four and seven. The data obtained is summarised in figure 4.4. At visit one, group one had a mean cervical flexion reading of 62.71 degrees (standard deviation ± 10.41) and group two had a mean cervical flexion reading of 66.27 degrees (standard deviation ± 10.08). At visit four, group one had a mean cervical flexion reading of 66.13 degrees (standard deviation ± 10.73) and group two had a mean cervical spine flexion reading of 67.82 degrees (standard deviation ± 8.07). At visit seven, group one had a mean cervical spine flexion of 65.33 degrees (standard deviation ± 11.24) and group two had a mean cervical spine flexion of 69.38 degrees (standard deviation ± 10.37).

Based on figure 4.7, the mean values can be used to determine the overall percentage of improvement or lack of improvement. Group one had an overall improvement of 4.18% and group two had an overall improvement of 4.69%.
Statistical analysis

With regards to the normality results for the cervical spine range of motion goniometer readings in flexion:

- The Shapiro-Wilk test yielded a p-value of more than 0.05 for both groups at all visits (group one: visit one = 0.90, visit four = 0.76, visit seven = 0.19; group two: visit one = 0.41, visit four = 0.30, visit seven = 0.14).
- The Levene’s test for Equality of Variances: equal variances can be assumed at all visits (visit one p-value = 0.80, visit four p-value = 0.35, visit seven p-value = 0.64).
- The Box’s test of Equality of Covariance Matrices had a p-value 0.33.

Group one and group two is compared at visit one to determine if the two groups are comparable. At visit one the Independent t-test and the Mann-Whitney U test provided p-values of 0.35 and 0.51 respectively which suggests that the two groups are comparable at visit one with regards to the cervical spine range of motion in flexion (p-value ≥ 0.05).

Intragroup analysis

Non-parametric data analysis was done using the Friedman and Wilcoxon Signed Ranks test.

Non-parametric data analysis using the Friedman test was used to make comparisons within each group over time. Group one had a p-value of 0.21 and group two had a p-value of 0.19 which indicates that there is no significant difference in the cervical range of motion in flexion over time within each group (p-value ≥ 0.05).

Intergroup analysis

Parametric data analysis was done using the Independent-samples t-test and non-parametric data analysis was done using the Mann-Whitney U test. The results obtained are shown in table 4.6.
Table 4.6: Table representing the results of the Independent t-test and Mann-Whitney U test for the CROM goniometer readings in flexion

<table>
<thead>
<tr>
<th>Cervical range of motion goniometer - flexion</th>
<th>Independent t-test</th>
<th>Mann-Whitney U test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t score</td>
<td>p-value</td>
</tr>
<tr>
<td>Visit 1</td>
<td>-0.95</td>
<td>0.35</td>
</tr>
<tr>
<td>Visit 4</td>
<td>-0.49</td>
<td>0.63</td>
</tr>
<tr>
<td>Visit 7</td>
<td>-1.02</td>
<td>0.31</td>
</tr>
</tbody>
</table>

Regarding the Independent t-test results: At visit one, the p-value was 0.35 and at visit four and visit seven, the scores were 0.63 and 0.31 respectively. These p-values indicate no significant difference between the two groups at visit one, four and seven (p-value ≥ 0.05).

Regarding the Mann-Whitney U test: The cervical range of motion in flexion at visit one had a p-value of 0.51. At visit four the p-value was 0.53 and at visit seven the p-value was 0.29. These results indicate that there are no significant differences between the two groups at visit one, four and seven with regards to the cervical range of motion in flexion (p-value ≥ 0.05).

Cervical spine extension

![Figure 4.5: Bar graph illustrating the mean values of extension for both groups at visit 1, 4 and 7.](image)
Interpretation of objective data – Cervical range of motion goniometer

Cervical spine extension

The cervical spine range of motion in extension was measured on all participants at visit one, four and seven. The data obtained is summarised in figure 4.5. At visit one, group one had a mean cervical extension reading of 58.22 degrees (standard deviation ± 7.28) and group two had a mean cervical extension reading of 58.49 degrees (standard deviation ± 11.55). At visit four, group one had a mean cervical extension reading of 62.67 degrees (standard deviation ± 9.29) and group two had a mean cervical spine extension reading of 63.42 degrees (standard deviation ± 10.22). At visit seven, group one had a mean cervical spine extension of 66.93 degrees (standard deviation ± 9.74) and group two had a mean cervical spine extension of 62.89 degrees (standard deviation ± 9.84).

Based on figure 4.9, it can be concluded that the participants in both groups showed an improvement between visit one and visit 7. The mean values can be used to determine the overall percentage of improvement. Group one had an overall improvement of 15.77% and group two had an overall improvement of 7.52%.

Statistical analysis

With regards to the normality results for the cervical spine range of motion goniometer readings in extension:

- The Shapiro-Wilk test yielded a p-value of more than 0.05 for both groups at all visits (group one: visit one = 0.39, visit four = 0.76, visit seven = 0.13; group two: visit one = 0.68, visit four = 0.25, visit seven = 0.36).
- The Levene’s test for Equality of Variances: equal variances can be assumed at all visits (visit one p-value = 0.16, visit four p-value = 0.67, visit seven p-value = 0.98).
- The Box’s test of Equality of Covariance Matrices had a p-value 0.65.

Group one and group two is compared at visit one to determine if the two groups are comparable. At visit one the Independent t-test and Mann-Whitney U tests provided p-values of 0.94 and 0.98 respectively which suggests that the two groups are comparable at visit one with regards to the cervical spine range of motion in extension (p-value ≥ 0.05).
Intragroup analysis

Non-parametric data analysis was done using the Friedman and Wilcoxon Signed Ranks test. Non-parametric data analysis using the Friedman test was used to make comparisons within each group over time. Group one had a p-value of 0.00 and group two had a p-value of 0.01 which indicates that there is a significant difference in the cervical range of motion in extension over time within each group.

Further non-parametric testing was done using the Wilcoxon Signed Ranks test in order to determine where exactly the changes occurred within each group. The Bonferroni adjustment was applied to the p-value by dividing 0.05 by three to obtain a new p-value of 0.017. Group one had a p-value of 0.08 between visit one and four, a p-value of 0.00 between visit four and seven and a p-value of 0.00 between visit one and seven. Group two had a p-value of 0.03 between visit one and four, a p-value of 0.65 between visit four and seven and a p-value of 0.03 between visit one and seven. The values for group one, indicate that there is a no significant difference within the group between visit one and four (p-value ≥ 0.017). However, a significant difference is seen between visit four and seven and visit one and seven (p-value ≤ 0.017). The values for group two indicate that there is no significant difference within the group between visit one and four, visit four and seven and visit one and seven (p-value ≥ 0.017).

Intergroup analysis

Parametric data analysis was done using the Independent-samples t-test and non-parametric data analysis was done using the Mann-Whitney U test. The results obtained are shown in table 4.7.

Table 4.7: Table representing the results of the Independent t-test and Mann-Whitney U test for the CROM goniometer readings in extension

<table>
<thead>
<tr>
<th>Cervical range of motion goniometer – Extension</th>
<th>Independent t-test</th>
<th>Mann-Whitney U test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t score</td>
<td>p-value</td>
</tr>
<tr>
<td>Visit 1</td>
<td>-0.08</td>
<td>0.94</td>
</tr>
<tr>
<td>Visit 4</td>
<td>-0.21</td>
<td>0.83</td>
</tr>
<tr>
<td>Visit 7</td>
<td>1.13</td>
<td>0.27</td>
</tr>
</tbody>
</table>
Regarding the Independent t-test results: At visit one, the p-value was 0.94 which indicate that there is no significant difference between the two groups at visit one (p-value ≥ 0.05). At visit four and visit seven, the scores were 0.83 and 0.27 respectively which indicate no significant difference between the two groups at visit four and seven (p-value ≥ 0.05).

Regarding the Mann-Whitney U test: The cervical spine range of motion goniometer readings in extension at visit one had a p-value of 0.98. At visit four the p-value was 0.90 and at visit seven the p-value was 0.20. These results indicate that there are no significant differences between the two groups at visit one, four and seven with regards to the cervical spine range of motion in extension (p-value ≥ 0.05).

**Cervical spine left lateral flexion**

![Bar graph illustrating the mean values of left lateral flexion for both groups at visit 1, 4 and 7.](image)

**Figure 4.6:** Bar graph illustrating the mean values of left lateral flexion for both groups at visit 1, 4 and 7.

**Interpretation of objective data – Cervical range of motion goniometer**

**Cervical spine left lateral flexion**

The cervical spine range of motion in left lateral flexion was measured at visit one, four and seven. The data is summarised in figure 4.6. At visit one, group one had a mean cervical left lateral flexion reading of 38.31 degrees (standard deviation ± 7.05) and group two had a mean cervical left lateral flexion reading of 38.89 degrees (standard deviation ± 8.60). At
visit four, group one had a mean cervical left lateral flexion reading of 41.87 degrees (standard deviation ± 8.69) and group two had a mean cervical left lateral flexion reading of 38.93 degrees (standard deviation ± 8.05). At visit seven, group one had a mean cervical left lateral flexion reading of 44.58 degrees (standard deviation ± 9.60) and group two had a mean cervical left lateral flexion reading of 40.71 degrees (standard deviation ± 7.32).

Based on figure 4.6, it can be concluded that the participants in both groups showed an improvement between visit one and visit seven. The mean values can be used to determine the overall percentage of improvement. Group one had an overall improvement of 16.37% and group two had an overall improvement of 4.68%.

**Statistical analysis**

With regards to the normality results for the cervical spine range of motion goniometer readings in left lateral flexion:

- The Shapiro-Wilk test yielded a p-value of more than 0.05 for both groups at all visits (group one: visit one = 0.43, visit four = 0.29, visit seven = 0.38; group two: visit one = 0.64, visit four = 0.30, visit seven = 0.55).
- The Levene’s test for Equality of Variances: equal variances can be assumed at all visits (visit one p-value = 0.64, visit four p-value = 0.34, visit seven p-value = 0.18).
- The Box’s test of Equality of Covariance Matrices had a p-value 0.60.

Group one and group two is compared at visit one to determine if the two groups are comparable. At visit one the Independent t-test and Mann-Whitney U tests provided p-values of 0.84 and 0.95 which indicates that the two groups are comparable at visit one with regards to the cervical spine range of motion in left lateral flexion (p-value ≥ 0.05).

**Intragroup analysis**

Non-parametric data analysis was done using the Friedman and Wilcoxon Signed Ranks test. Non-parametric data analysis using the Friedman test was used to make comparisons within each group over time. Group one had a p-value of 0.06 and group two had a p-value of 0.12 which indicates that there is no significant difference in the cervical spine range of motion in lateral flexion over time.
Further non-parametric testing was done using the Wilcoxon Signed Ranks test in order to
determine where exactly the changes occurred within each group. The Bonferroni
adjustment was applied to the p-value by dividing 0.05 by three to obtain a new p-value of
0.017. Group one had a p-value of 0.03 between visit one and four, a p-value of 0.06
between visit four and seven and 0.01 between visit one and seven. Group two had a p-
value of 0.57 between visit one and four and a p-value of 0.10 between visit four and seven
and 0.21 between visit one and seven. The values for group one, indicate that there is no
significant difference within the group between visit one and four and visit four and seven (p-
value ≥ 0.017) while a significant difference is noted within the group between visit one and
seven (p-value ≤ 0.017). The values for group two indicate that there is no significant
difference within the group between visit one and four, visit four and seven and visit one and
seven (p-value ≥ 0.017).

Intergroup analysis

For the Intergroup analysis, parametric data analysis was done using the Independent-
samples t-test and non-parametric data analysis was done using the Mann-Whitney U test.
The results obtained are shown in table 4.8.

Table 4.8: Table representing the results of the Independent t-test and Mann-Whitney
U test for the CROM goniometer readings in left lateral flexion

<table>
<thead>
<tr>
<th>Cervical range of motion goniometer – left lateral flexion</th>
<th>Independent t-test</th>
<th>Mann-Whitney U test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t score</td>
<td>p-value</td>
</tr>
<tr>
<td>Visit 1</td>
<td>-0.20</td>
<td>0.84</td>
</tr>
<tr>
<td>Visit 4</td>
<td>0.96</td>
<td>0.35</td>
</tr>
<tr>
<td>Visit 7</td>
<td>1.24</td>
<td>0.23</td>
</tr>
</tbody>
</table>

Regarding the Independent t-test results: At visit one, the p-value was 0.84. At visit four and
visit seven, the scores were 0.35 and 0.23 respectively which indicate no significant
difference between the two groups at visit four and seven (p-value ≥ 0.05).

Regarding the Mann-Whitney U test: The cervical spine range of motion goniometer
readings in left lateral flexion at visit one had a p-value of 0.95. At visit four the p-value was
0.35 and at visit seven the p-value was 0.31. These results indicate that there are no significant differences between the two groups at visit one, four and seven with regards to the cervical range of motion in left lateral flexion (p-value ≥ 0.05).

Cervical spine right lateral flexion

![Bar graph](Image)

Figure 4.7: Bar graph illustrating the mean values of right lateral flexion for both groups at visit 1, 4 and 7.

Interpretation of objective data – Cervical range of motion goniometer

Cervical spine right lateral flexion

The cervical spine range of motion in right lateral flexion was measured at visit one, four and seven. The data is summarised in figure 4.7. At visit one, group one had a mean cervical right lateral flexion reading of 42.44 degrees (standard deviation ± 7.16) and group two had a mean cervical right lateral flexion reading of 37.96 degrees (standard deviation ± 7.57). At visit four, group one had a mean cervical right lateral flexion reading of 45.07 degrees (standard deviation ± 7.95) and group two had a mean cervical right lateral flexion reading of 39.82 degrees (standard deviation ± 6.72). At visit seven, group one had a mean cervical right lateral flexion reading of 49.29 degrees (standard deviation ± 8.39) and group two had a mean cervical right lateral flexion reading of 40.24 degrees (standard deviation ± 5.09).
Based on figure 4.13, it can be concluded that the participants in both groups showed an improvement between visit one and visit seven. The mean values can be used to determine the overall percentage of improvement. Group one had an overall improvement of 16.14% and group two had an overall improvement of 6.00%.

**Statistical analysis**

With regards to the normality results for the cervical spine range of motion goniometer readings in right lateral flexion:

- The Shapiro-Wilk test yielded a p-value of equal or more than 0.05 for both groups at all visits except for group two at visit four (group one: visit one = 0.22, visit four = 0.05, visit seven = 0.76; group two: visit one = 0.46, visit four = 0.05, visit seven = 0.98).
- The Levene’s test for Equality of Variances: equal variances can be assumed at all visits (visit one p-value = 1.00, visit four p-value = 0.54, visit seven p-value = 0.13).
- The Box's test of Equality of Covariance Matrices had a p-value 0.25.

Group one and group two is compared at visit one to determine if the two groups are comparable. At visit one the Independent t-test and Mann-Whitney U test provided p-values of 0.11 and 0.11 respectively which indicate that the two groups are comparable at visit one with regards to the cervical spine range of motion in right lateral flexion (p-value ≥ 0.05).

**Intragroup analysis**

Non-parametric data analysis was done using the Friedman and Wilcoxon Signed Ranks test. Non-parametric data analysis using the Friedman test was used to make comparisons within each group over time. Group one had a p-value of 0.00 and group two had a p-value of 0.03 which indicates that there is a significant difference in the cervical spine range of motion in right lateral flexion over time (p-value ≤ 0.05).

Further non-parametric testing was done using the Wilcoxon Signed Ranks test in order to determine where exactly the changes occurred within each group. The Bonferroni adjustment was applied to the p-value by dividing 0.05 by three to obtain a new p-value of 0.017. Group one had a p-value of 0.03 between visit one and four, a p-value of 0.01 between visit four and seven and a p-value of 0.00 between visit one and seven. Group two
had a p-value of 0.09 between visit one and four, a p-value of 0.83 between visit four and seven and a p-value of 0.08 between visit one and seven. The values for group one, indicate that there is a no significant difference within the group between visit one and four (p-value ≥ 0.017) but there is a significant difference within the group between visit four and seven and visit one and seven (p-value ≤ 0.017). The values for group two indicate that there is no significant difference within the group between visit one and four, visit four and seven and visit one and seven (p-value ≥ 0.017).

**Intergroup analysis**

For the Intergroup analysis, parametric data analysis was done using the Independent-samples t-test and non-parametric data analysis was done using the Mann-Whitney U test. The results obtained are shown in table 4.9.

**Table 4.9: Table representing the results of the Independent t-test and Mann-Whitney U test for the CROM goniometer readings in right lateral flexion**

<table>
<thead>
<tr>
<th>Cervical range of motion goniometer – Right lateral flexion</th>
<th>Independent t-test</th>
<th>Mann-Whitney U test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t score</td>
<td>p-value</td>
</tr>
<tr>
<td>Visit 1</td>
<td>1.67</td>
<td>0.11</td>
</tr>
<tr>
<td>Visit 4</td>
<td>1.95</td>
<td>0.06</td>
</tr>
<tr>
<td>Visit 7</td>
<td>3.57</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Regarding the Independent t-test results: At visit one and visit four the p-values were 0.11 and 0.06 which indicate that there is no significant difference between the two groups at visit one and visit four (p-value ≥ 0.05). At visit 7, the p-value is 0.00. This indicates a significant difference between the two groups at visit seven (p-value ≤ 0.05).

Regarding the Mann-Whitney U test: The cervical spine range of motion goniometer in right lateral flexion at visit one had a p-value of 0.11. At visit four the p-value was 0.02 and at visit seven the p-value was 0.00. These results indicate that there is no significant differences between the two groups at visit one (p-value ≥ 0.05), but a significant difference is noted between the two groups at visit four and seven with regards to the cervical range of motion in right lateral flexion (p-value ≤ 0.05).
Cervical spine left rotation

Figure 4.8: Bar graph illustrating the mean values of left rotation for both groups at visit 1, 4 and 7.

Interpretation of objective data – Cervical range of motion goniometer

Cervical spine left rotation

The cervical spine range of motion in left rotation was measured on all participants at visit one, four and seven. The readings are summarised in figure 4.8. At visit one, group one had a mean cervical spine left rotation of 65.64 degrees (standard deviation ± 11.01) and group two had a mean cervical spine left rotation of 65.02 degrees (standard deviation ± 9.04). At visit four, group one had a mean cervical spine left rotation of 70.75 degrees (standard deviation ± 7.97) and group two had a mean cervical spine left rotation of 68.13 degrees (standard deviation ± 6.02). At visit seven, group one had a mean cervical spine left rotation of 69.64 degrees (standard deviation ± 9.27) and group two had a mean cervical spine left rotation of 71.60 degrees (standard deviation ± 3.78).

Based on figure 4.15, it can be concluded that the participants in both groups showed an improvement between visit one and visit seven. The mean values can be used to determine the overall percentage of improvement. Group one had an overall improvement of 6.09% and group two had an overall improvement of 10.12%.
Statistical analysis

With regards to the normality results for the cervical spine range of motion goniometer readings in left rotation:

- The Shapiro-Wilk test yielded a p-value of more than 0.05 for both groups at all visits (group one: visit one = 0.77, visit four = 0.26, visit seven = 0.64; group two: visit one = 0.40, visit four = 0.48, visit seven = 0.53).
- The Levene’s test for Equality of Variances: equal variances can be assumed at visits one and four but not at visit seven (visit one p-value = 0.31, visit four p-value = 0.15, visit seven p-value = 0.04).
- The Box’s test of Equality of Covariance Matrices had a p-value 0.03.

Group one and group two is compared at visit one to determine if the two groups are comparable. At visit one the Independent t-test and Mann-Whitney U tests provided p-values of 0.87 and 1.00 respectively which indicate that the two groups are comparable at visit one with regards to the cervical spine range of motion in left rotation.

Intragroup analysis

Non-parametric data analysis was done using the Friedman and Wilcoxon Signed Ranks tests. Non-parametric data analysis using the Friedman test was used to make comparisons within each group over time. Group one had a p-value of 0.38 and group two had a p-value of 0.07 which indicates that there is no significant difference in the left rotation over time within each group (p-value ≥ 0.05).

Further non-parametric testing was done using the Wilcoxon Signed Ranks test in order to determine where exactly the changes occurred within each group. The Bonferroni adjustment was applied to the p-value by dividing 0.05 by three to obtain a new p-value of 0.017. Group one had a p-value of 0.02 between visit one and four, a p-value of 0.50 between visit four and seven and a p-value of 0.20 between visit one and seven. Group two had a p-value of 0.31 between visit one and four, a p-value of 0.06 between visit four and seven and a p-value of 0.04 between visit one and seven. The values for group one, indicate that there is no significant difference within the group between visit one and four, visit four and seven and visit one and seven (p-value ≥ 0.017). The values for group two
indicating that there is no significant difference within the group between visit one and four, visit four and seven and visit one and seven (p-value ≥ 0.017).

**Intergroup analysis**

For the Intergroup analysis, parametric data analysis was done using the Independent-samples t-test and non-parametric data analysis was done using the Mann-Whitney U test. The results obtained are shown in Table 4.10.

**Table 4.10: Table representing the results of the Independent t-test and Mann-Whitney U test for the CROM goniometer readings in left rotation**

<table>
<thead>
<tr>
<th>Cervical range of motion goniometer- Left rotation</th>
<th>Independent t-test</th>
<th>Mann-Whitney U test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t score</td>
<td>p-value</td>
</tr>
<tr>
<td>Visit 1</td>
<td>0.17</td>
<td>0.87</td>
</tr>
<tr>
<td>Visit 4</td>
<td>1.02</td>
<td>0.32</td>
</tr>
<tr>
<td>Visit 7</td>
<td>-0.76</td>
<td>0.46</td>
</tr>
</tbody>
</table>

Regarding the Independent t-test results: At visit one, the p-value was 0.87 which indicates that there is no significant difference between the two groups at visit one (p-value ≥ 0.05). At visit four and visit seven, the scores were 0.32 and 0.46 respectively which indicate no significant difference between the two groups at visit four and seven (p-value ≥ 0.05).

Regarding the Mann-Whitney U test: The cervical range of motion goniometer in left rotation at visit one had a p-value of 1.00. At visit four the p-value was 0.35 and at visit seven the p-value was 0.68. These results indicate that there are no significant differences between the two groups at visit one, four and seven with regards to left rotation (p-value ≥ 0.05).
Cervical spine right rotation

The cervical spine range of motion in right rotation was measured on all participants at visit one, four and seven. The readings are summarised in figure 4.9. At visit one, group one had a mean cervical spine right rotation of 67.20 degrees (standard deviation ± 6.10) and group two has a mean cervical spine right rotation of 66.22 degrees (standard deviation ± 11.49). At visit four, group one had a mean cervical spine right rotation of 68.22 degrees (standard deviation ± 9.23) and group two had a mean cervical spine right rotation of 67.11 degrees (standard deviation ± 8.65). At visit seven, group one had a mean cervical spine right rotation of 72.00 degrees (standard deviation ± 7.47) and group two had a mean cervical spine right rotation of 70.09 degrees (standard deviation ± 8.68).

Based on figure 4.17, it can be concluded that the participants in both groups showed an improvement between visit one and visit seven. The mean values can be used to determine the overall percentage of improvement. Group one had an overall improvement of 7.14% and group two had an overall improvement of 5.84%.

Figure 4.9: Bar graph illustrating the mean values of right rotation for both groups at visit 1, 4 and 7.

Interpretation of objective data – Cervical range of motion goniometer

Cervical spine right rotation
Statistical analysis

With regards to the normality results for the cervical spine range of motion goniometer readings in right rotation:

- The Shapiro-Wilk test yielded a p-value of more than 0.05 for both groups at all visits (group one: visit one = 0.74, visit four = 0.14, visit seven = 0.83; group two: visit one = 0.30, visit four = 1.00, visit seven = 0.89).
- The Levene’s test for Equality of Variances: equal variances can be assumed at all visits (visit one p-value = 0.08, visit four p-value = 0.41, visit seven p-value = 0.48).
- The Box’s test of Equality of Covariance Matrices had a p-value 0.11.

Group one and group two is compared at visit one to determine if the two groups are comparable. At visit one the Independent t-test and Mann-Whitney U test provided p-values of 0.77 and 0.72 respectively which indicate that the two groups are comparable at visit one with regards to the cervical spine range of motion in right rotation.

Intragroup analysis

Non-parametric data analysis was done using the Friedman and Wilcoxon Signed Ranks tests. Non-parametric data analysis using the Friedman test was used to make comparisons within each group over time. Group one had a p-value of 0.01 and group two had a p-value of 0.70. The p-value for group one indicates that there is a significant difference in the cervical range of motion in right rotation over time within the group (p-value ≤ 0.05). The p-value for group two suggests that there is no significant difference in the cervical range of motion in right rotation over time (p-value ≥ 0.05).

Further non-parametric testing was done using the Wilcoxon Signed Ranks test in order to determine where exactly the changes occurred within each group. The Bonferroni adjustment was applied to the p-value by dividing 0.05 by three to obtain a new p-value of 0.017. Group one had a p-value of 0.33 between visit one and four, a p-value of 0.04 between visit four and seven and a p-value of 0.02 between visit one and seven. Group two had a p-value of 0.64 between visit one and four, a p-value of 0.08 between visit four and seven and a p-value of 0.35 between visit one and seven. The values for group one indicate that there is no significant difference within the group between visit one and four,
visit four and seven and visit one and seven (p-value ≥ 0.017). The values for group two indicate that there is no significant difference within the group between visit one and four, visit four and seven and visit one and seven (p-value ≥ 0.017).

**Intergroup analysis**

For the Intergroup analysis, parametric data analysis was done using the Independent-samples t-test and non-parametric data analysis was done using the Mann-Whitney U test. The results obtained are shown in table 4.11.

**Table 4.11: Table representing the results of the Independent t-test and Mann-Whitney U test for the CROM goniometer readings in right rotation**

<table>
<thead>
<tr>
<th>Cervical range of motion goniometer – Right rotation</th>
<th>Independent t-test</th>
<th>Mann-Whitney U test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t score</td>
<td>p-value</td>
</tr>
<tr>
<td>Visit 1</td>
<td>0.29</td>
<td>0.77</td>
</tr>
<tr>
<td>Visit 4</td>
<td>0.34</td>
<td>0.74</td>
</tr>
<tr>
<td>Visit 7</td>
<td>0.65</td>
<td>0.52</td>
</tr>
</tbody>
</table>

Regarding the Independent t-test results: At visit one, the p-value was 0.77 which indicate that there is no significant difference between the two groups at visit one (p-value ≥ 0.05). At visit four and visit seven, the scores were 0.74 and 0.52 respectively which indicate no significant difference between the two groups at visit four and seven (p-value ≥ 0.05).

Regarding the Mann-Whitney U test: the cervical range of motion goniometer in right rotation at visit one had a p-value of 0.72. At visit four the p-value was 0.90 and at visit seven the p-value was 0.49. These results indicate that there are no significant differences between the two groups at visit one, four and seven with regards cervical range of motion in right rotation (p-value ≥ 0.05).
CHAPTER FIVE: DISCUSSION

5.1 Introduction

This chapter discusses the objective and subjective results outlined in chapter four. The results discussed include the statistical analysis of the numerical pain rating scale, Vernon-Mior neck pain and disability index, pressure algometer readings and cervical range of motion goniometer readings. In this chapter, the results in chapter four will also be discussed by referencing other relevant literature.

Participants completed the numerical pain rating scale and the Vernon-Mior neck pain and disability index questionnaire at visit one, four and seven. Pressure algometer readings and cervical range of motion goniometer readings were also obtained at visit one, four and seven. These results were compared to determine if one treatment protocol is more effective than the other.

5.2 Demographic data

The analysis of the demographic data included the number of participants in the study, the age and gender of the participants.

Thirty participants were recruited for this study. Group one (ischaemic compression) consisted of fifteen participants and group two (low level laser therapy) consisted of fifteen participants. Four of the total number of participants (13.3%) were males and 26 (86.7%) were females. Group one had a mean age of 25.07 (standard deviation ± 4.431) with a minimum age of 20 and a maximum age of 39. Group two had a mean age of 23.33 (standard deviation ± 1.175) with a minimum age of 22 and a maximum age of 25.

According to Fernández-de-las-Peñas, Alonso-Blanco, Alguacil-Diego & Miangolarra-Page (2006), mechanical neck pain will affect between 45% and 54% of the general population. They also stated that this neck pain may result in severe disability (Fernández-de-las-Peñas, Alonso-Blanco, Alguacil-Diego and Miangolarra-Page, 2006). According to Childs et al. (2008), between 22% and 70% of the population will have neck pain at some stage during their life. According to these authors, 10% - 20% of the population reports neck pain at any given time, 54% of individuals will have experienced neck pain in the last 6 months and 44% of patients with neck pain will develop chronic symptoms. They also stated that the
incidence of neck pain increases with age and is more common in women (Childs et al. 2008). Gemmel, Miller & Nordstrom (2007) stated that mechanical neck pain is more common in women. This may account for the higher percentage of female participants in this study.

Kannan (2012) reported that myofascial trigger points are a common cause of pain affecting 30% - 50% of individuals in their lifetime. According to Fernández de las Peñas, Fernández Carnero & Miangolarra Page (2005), mechanical neck pain is caused mainly by musculoskeletal causes therefore; cervical joint dysfunctions and myofascial trigger points. It is also thought that trigger points in the trapezius muscle is the principal cause of temporal headaches, cervicogenic headaches and neck pain (Fernández de las Peñas, Fernández Carnero & Miangolarra Page, 2005)

5.3 Subjective data

5.3.1 Numerical pain rating scale

Intragroup analysis of the numerical pain rating scale data using the Friedman test yielded a p-value of 0.00 for group one and a p-value of 0.00 for group two. Therefore since the p-value is less than 0.05 it indicated that both groups had a statistically significant difference over time. Therefore, both groups had a decrease in their subjective pain score over time between the firsts and the last visit. However, the ischaemic compression group had a much greater improvement with a 79.31% improvement compared to the low level laser therapy (LLLT) group who had a 59.48% improvement. This may be attributed to the fact that according to the Wilcoxon Signed Ranks test, group one had a statistically significant (p-value ≤ 0.05) difference between visit one and visit four and visit four and seven while group two only had a statistically significant difference between visit four and seven and not between visit one and four.

These scores indicated that both interventions were effective in decreasing the pain experienced from the trapezius myofascial trigger point.

Intergroup analysis using the Independent t-test revealed a statistically significant difference between the two groups at the first visit. This may be attributed to the difference in individuals within each group and their perception of subjective pain on the numerical pain
rating scale. The ischaemic compression group consisted of individuals experiencing more pain at the initial visit than the participants in the LLLT group. The Independent t-test indicated that there was no statistically significant difference between the two groups at visit four and visit seven. Intergroup analysis using the Mann-Whitney U test indicated that there were no statistically significant differences between the groups at visit one, visit four and visit seven. The contradiction between the two tests may be due to the increased sensitivity of the parametric Independent t-test as opposed to the non-parametric Mann-Whitney U test (Pallant, 2007).

5.3.2 Vernon-Mior neck pain and disability index

Intragroup analysis of the Vernon-Mior neck pain and disability index score using the Friedman test yielded a p-value of 0.00 for group one and a p-value of 0.00 for group two. This information was used to conclude that both groups had a statistically significant difference over time. Both groups showed a decrease in their neck pain and disability on the Vernon-Mior neck pain and disability index between the first and the last visit. The LLLT group had a greater decrease than the ischaemic compression group. The scores for the ischaemic compression group showed an improvement of 69.88% while the LLLT group had a 72.85% improvement. According to the Wilcoxon Signed Ranks test both groups had a statistically significant difference between visit one and four, visit four and seven.

These results indicated that both treatment protocols were effective in decreasing the pain and disability due to the upper trapezius myofascial trigger point.

Intergroup analysis using the Independent t-test revealed no statistically significant difference between the two groups at visit one, four and seven. Intergroup analysis using the Mann-Whitney U test confirmed these findings.

5.3.3 Discussion of subjective data results – numerical pain rating scale and Vernon-Mior neck pain and disability index

According to Misailidou et al. (2010), the use of a pain scale to record a patients initial and subsequent pain scores are essential to make conclusions about any changes. The drawback of these scales was that pain is subjective and the clinician relies on what the
patient reports, therefore accuracy cannot be determined. However, these scales are widely used to report pain experienced by patients (Misailidou et al. 2010).

According to Misailidou et al. (2010), self-assessment questionnaires are a common tool used in clinical practice and in research studies. They provide information regarding the impact of pain on the patient, the functional abilities or limitations experienced by the patient, the change in the treated condition over the treatment period and the effectiveness of the treatment.

Pain receptors are present within human tissues. These receptors or free nerve endings generate and then transmit pain impulses via the A-delta and C fibers in the peripheral nerves and the lateral spinothalamic tract in the spinal cord to the pain centre within the brain known as the thalamus (Melzack & Wall, 1965).

According to the gate control theory of pain proposed by these authors, when the skin is stimulated, nerve impulses travel to three different systems within the spinal cord. These include the substantia gelatinosa in the dorsal horn of the spinal cord, the dorsal-column fibers and the first central transmission cells (known as T cells) in the dorsal horn of the spinal cord. The substantia gelatinosa acts as the gate control system that controls the afferent input before it affects the T cells. The afferent impulses in the dorsal column activates selective processes within the brain which impact on the gate control system. The T cells activate neural actions that control the response to and perception of the pain. The interaction between these three systems controls pain via the gate control mechanism (Melzack & Wall, 1965). The A-delta and C fibers are known as small, unmyelinated or thinly myelinated pain fibers. Pressure receptors are larger and more thickly myelinated and therefore relay impulses faster than A-delta and C fibers. This causes the pain gate to be closed to painful stimuli. According to Melzack and Wall (1965), the balance between the small and large fibers activity control the opening and closing of the pain gate. When more nerve impulses, travelling in the small unmyelinated or thinly myelinated nerve fibers, reach the spinal cord it keeps the pain gate open. When the skin is stimulated gently, the large diameter fiber activity increases. This partially closes the pain gate. Increasing the intensity of the stimulus also increases the amount of large diameter fibers that are activated. Therefore it increases the closing of the pain gate (Melzack & Wall, 1965).
According to Bergmann & Peterson (2011), it is recognised that spinal adjustment provides analgesia since pain tolerance and pain threshold levels increase following an adjustment. There are various theories as to how the adjustment produces this effect. The theories include that the adjustment removes the mechanical cause of pain and that the adjustment causes a stimulus induced reduction in pain acting through the pain gate. The proprioceptive and nociceptive impulses induced by the adjustment also cause the release of enkephalins and an increase in systemic endorphin levels. These substances inhibit pain and may explain the decrease in pain following a spinal adjustment. Spinal adjustment also reduces muscle spasm which has the ability to cause joint dysfunction and pain (Bergmann & Peterson, 2011).

Many theories have been proposed regarding the mechanism by which ischaemic compression produces an effect. One theory is that the deep pressure applied over the trigger point induces ischaemia and therefore starves the sensory nerves of oxygen, producing a nerve block. Another theory proposes that following the release of the compression, there is a hyperaemia and vasodilation that increases the blood flow to the area. The increased blood flow can remove irritants and provide metabolites. It is also believed that the sustained pressure on the trigger point causes a stretch of the sarcomeres that are contracted within the trigger point (Bergmann & Peterson, 2011). Ischaemic compression may also provide pain relief by counter-irritant effects and a spinal reflex mechanism that produces relief from muscle spasm (Hou, Tsai, Cheng, Chung & Hong, 2002). Ischaemic compression may also cause a decrease in pain by acting through the pain gate (Melzack & Wall, 1965).

Low level laser therapy can be utilised to decrease pain in soft tissues such as in myofascial trigger points. Similarly to ischaemic compression, there are many theories as to how LLLT produces its effects. According to Al-Shenqiti & Oldham (2009), laser produces its effect by changing the local metabolism within the tissues, by directly stimulating the neural tissues and by stimulating the nociceptors. According to Hâkgüder, Birtane, Gürcan, Kokino & Turan (2003), LLLT increases the local microcirculation by relieving the spasm in the muscle arterioles thereby providing oxygen and ATP for normal function. Laser increases the release of endorphins that decrease the pain sensation. LLLT may also act on the pain gate (Hâkgüder, Birtane, Gürcan, Kokino & Turan, 2003). LLLT is also proposed to have an anti-
inflammatory action by reducing the inflammatory markers such as Prostaglandin E₂, Interleukin 1β and tumour necrosis factor α. A decrease in inflammation will result in a decrease in pain (Chow, Johnson, Lopes-Martins & Bjordal, 2009). Chow et al. (2009) also proposed that LLLT reduces oxidative stress and muscle fatigue both of which are precursors to muscle pain.

Considering the results in chapter four, the ischaemic compression group had a greater improvement over time in terms of subjective pain and disability as noted by the greater decrease in scores the for group on the numerical pain rating scale and the Vernon-Mior neck pain and disability index (intragroup analysis).

According to Al-Shenqiti & Oldham (2009), the contact technique in laser treatment is frequently used as it may increase the penetration of the laser light. It may be used either as light or firm skin contact but according to these authors firm contact seems to show better results for laser treatment (Al-Shenqiti & Oldham, 2009). Firm skin contact was used for this study.

The greater decrease in pain and disability of the participants in group one may be explained by referencing the pain gate control mechanism. Ischaemic compression involves the application of deep pressure to the trigger point (Gemmel, Miller & Nordstrom, 2007). The firm skin contact during the laser treatment has a smaller degree of pressure applied to the trigger point. In light of the above explanation regarding the activation of more large diameter fibers, it may be deduced that the greater the pressure applied to the trigger point the greater the effect is on the pain gate. Therefore, the greater degree of pressure applied during the treatment with ischaemic compression may explain the greater decrease in pain and disability experienced by the participants in group one (intragroup analysis). However, both groups showed a statistically significant change with regards to their subjective data. This may be explained by the increase in circulation effected by both the ischaemic compression and the low level laser therapy that subsequently increases the supply of oxygen and the removal of chemical irritants (Hakgüder et al. 2003; Bergmann & Peterson, 2011).
Regarding the intergroup analysis of the numerical pain rating scale and the Vernon-Mior neck pain and disability index, there is no statistically significant difference between the two groups at the conclusion of the clinical trial. This may be explained by the similarity in the proposed analgesic mechanisms of ischaemic compression and low level laser therapy.

From the subjective data, it was concluded that both treatment protocols are effective however no conclusive statement can be made in terms of which treatment protocol is superior.

In a study by Saavedra-Hernández, Arroyo-Morales, Cantarero-Villanueva, Fernández-Lao, Castro-Sánchez, Puentedura & Fernández-de-las-Peñas (2012), eighty two patients with chronic neck pain was selected to partake in a study determining the effects of spinal manipulation on the pain, disability and range of motion in the cervical spine. Their participants were divided into two groups with one group only receiving cervical spinal manipulation and the other group receiving mid-cervical, cervicothoracic and thoracic manipulations. Subjective results were obtained via the numerical pain rating scale and the neck disability index one week following the treatment. Both groups showed a decrease in self-reported disability and pain however the group receiving cervical and thoracic adjustments showed a greater decrease in disability (Saavedra-Hernández, Arroyo-Morales, Cantarero-Villanueva, Fernández-Lao, Castro-Sánchez, Puentedura & Fernández-de-las-Peñas, 2012). The results of the above study supports that cervical spine adjustments can decrease pain and disability experienced by participants as denoted by the decrease in the numerical pain rating scale and the Vernon-Mior neck pain and disability index in the current study.

Cagnie, Dewitte, Coppieters, van Oosterwijk, Cools & Danneels (2013), conducted a study in which the effect of ischaemic compression on the neck and shoulder muscles were studied in office workers. Their study had 19 participants who received ischaemic compression for one minute on their four most painful trigger points. The participants were treated twice a week for four weeks. Subjective data was collected via the numerical pain rating scale and the neck disability index. Their results indicate a significant difference in the numerical pain rating scale for neck and shoulder pain and an improvement in the neck disability index scores but no significant difference with regards to disability. They explained the lack of significant improvement in the disability index to be a result of low mean scores at the outset.
of the study (Cagnie, Dewitte, Coppieters, van Oosterwijk, Cools & Danneels, 2013). These results serve to confirm the effectiveness of ischaemic compression in the treatment of pain associated with myofascial trigger points as demonstrated by the decrease in the numerical pain rating scores over time within each group as shown in chapter four. In this study, there was a significant difference in the disability scores over time for group one as demonstrated in chapter four. This may be explained by the decreased disability associated with a decrease in pain.

Saayman, Hay & Abrahamse (2010) studied the effects of chiropractic manipulation and low level laser therapy in the treatment of cervical facet dysfunction. The study consisted of 60 participants that were divided into three groups. One group received chiropractic manipulation of the cervical spine, another group received low level laser therapy applied to the most painful facet joints and the last group received a combination of cervical manipulation with low level laser therapy. Their results indicate a significant improvement in the numerical pain scale and the neck disability in all groups following the six treatment sessions however the group that received the combination of cervical manipulation and low level laser therapy had a faster improvement (Saayman, Hay & Abrahamse, 2010). The above study confirm the results obtained from this study in that cervical spine adjusting combined with low level laser therapy is effective in decreasing neck pain and its associated disability as seen by decreases in the numerical pain rating scale and Vernon-Mior neck pain and disability index scores for the LLLT group.

5.4 Objective data

5.4.1 Pressure algometer

Intragroup analysis using the Friedman test produced p-values of 0.00 for group one and 0.00 for group two. This indicated a significant difference in the pressure algometer readings over time for both groups. There was a small difference between the two groups regarding the improvement. The ischaemic compression group had a percentage improvement of 37.79% while the LLLT group had a percentage improvement of 37.82%. Therefore, both interventions increased the pain pressure threshold of the upper trapezius myofascial trigger point.
Intergroup analysis using the Independent t-test indicated that there was significant differences between the two groups at visit one. No significant differences were noted between the two groups at visit four and visit seven. Intergroup analysis using the Mann-Whitney U test produced a result of no significant difference between the two groups at visit one and visit seven, but a significant difference between the two groups at visit four. The contradiction between the two tests may be due to the increased sensitivity of the parametric Independent t-test as opposed to the non-parametric Mann-Whitney U test (Pallant, 2007).

5.4.2 Cervical range of motion goniometer

**Flexion**

Intragroup analysis using the Friedman test produced p-values of 0.21 for group one and 0.19 for group two. This indicated that there was no statistically significant difference within each group over time regarding cervical spine flexion. There was an improvement in cervical spine flexion in the ischaemic compression group of 4.18%. There was an improvement of 4.69% in cervical spine flexion in the LLLT group.

Intergroup analysis using the Independent t-test and the Mann-Whitney U test indicated that there are no significant differences between the two groups at visit one, four and seven.

**Extension**

Intragroup analysis using the Friedman test yielded p-values of 0.00 and 0.01 for group one and two respectively. These results indicated a significant difference in cervical range of motion over time within each group. The ischaemic compression group had an overall improvement of 15.77% and the LLLT group showed an overall improvement of 7.52%. These results indicated that both treatment protocols increased the cervical spine range of motion in extension.

Intergroup analysis using the Independent t-test and the Mann-Whitney U test indicated that there was no significant difference between the two groups regarding cervical spine range of motion in extension at visit one, four and seven.
Left lateral flexion

Intragroup analysis using the Friedman test produced a p-value of 0.06 for group one and 0.12 for group two and therefore no statistically significant difference in the cervical spine range of motion in left lateral flexion for both groups over time. There was an overall improvement of 16.37% in the ischaemic compression group and an overall improvement of 4.68% in the LLLT group. Therefore, both treatment protocols increased the left lateral flexion range of motion in the cervical spine.

Intergroup analysis using the Independent t-test and the Mann-Whitney U test indicated no significant difference between the two groups at visit one, four and seven with regards to cervical spine range of motion in left lateral flexion.

Right lateral flexion

Intragroup analysis using the Friedman test produced p-values of 0.00 for group one and 0.03 for group two. Therefore there was a significant difference over time in terms of right lateral flexion for both groups. The ischaemic compression group had an improvement of 16.14% in right lateral flexion while the right lateral flexion for the LLLT group improved by 6.00%. Therefore, both treatment protocols increased the cervical spine range of motion in right lateral flexion.

Intergroup analysis using the Independent t-test showed no significant difference between group one and two at visit one and visit four. A significant difference was noted between the two groups at visit seven. The Mann-Whitney U test showed no significant difference between the two groups at visit one but a significant difference was noted at visit four and seven.

Left rotation

Intragroup analysis using the Friedman test noted p-values of 0.38 for group one and 0.07 for group two. Therefore, there was no significant difference for either group, between the first and the last visit (over time) regarding left rotation. There was a 6.09% improvement in the ischaemic compression group and a 10.12% improvement in the LLLT group. Both treatment protocols increased the left rotation range of motion of the cervical spine.
Intergroup analysis using the Independent t-test and the Mann-Whitney U test indicated no significant difference between the two groups at visit one, four and seven with regards to left rotation.

**Right rotation**

Intragroup analysis using the Friedman test noted a significant difference over time within group one with regards to right rotation (p-value ≤ 0.05). There was no significant difference within group two over time regarding right rotation (p-value ≥ 0.05). There was an improvement of 7.14% in the ischaemic compression group and an improvement of 5.84% in the LLLT group. Therefore, both treatment protocols increased the cervical range of motion in right rotation.

Intergroup analysis using the Independent t-test and the Mann-Whitney U test showed no significant difference between the two groups in terms if right rotation at visit one, four and seven.

**5.4.3 Discussion of objective data results**

**Pressure algometer**

Algometers are force gauges used to determine the amount of pressure needed to elicit pain. For this study pressure was applied until the patient first reported pain. This is known as the pressure pain threshold (PPT) (Bergmann & Peterson, 2011).

A clinical improvement in terms of the pressure algometer readings over time were noted for both groups. The changes over time within each group were also statistically significant. These changes can be explained in terms of the pain gate mechanism. Pressure applied to the trigger point has the ability to affect the pain gate mechanism. Pressure was applied to the trigger point in both groups and even though the degree or intensity of the pressure differed, large diameter pressure receptors were still stimulated which facilitated the closure of the pain gate to the smaller diameter and slower conducting nociceptive fibers.

Spinal adjustment has the ability to change the muscle sensitivity. Vernon, Aker, Burns, Viljakaanen & Short (1990), reported that cervical adjustment is effective is increasing the paraspinal muscle pain threshold with an average of 45% increase in the pressure pain
threshold. Kuan, Wu, Chen, Chen & Hong (1997), reported that there is a reduction in pain and tightness in the trapezius muscle following cervical adjustment of the C3-C4 and C4-C5 levels. Vernon & Gitelman (1990) presented a case report regarding the treatment of chronic headaches with spinal manipulation. The patient was a 39 year old female that had a history of headaches, chronic neck and upper thoracic pain. A pressure algometer was used pre and post adjustment on the medial occipital insertion of rectus capitis posterior minor before and after the adjustment of the C1-C2 facet joint. An increase in the pressure pain threshold of 53% was noted (Vernon & Gitelman, 1990). The increase in pressure pain threshold following spinal adjustment observed by Vernon, Aker, Burns, Viljakaanen & Short (1990) and the decrease in pain and tightness in the trapezius muscle following spinal adjustment observed by Kuan, Wu, Chen, Chen & Hong (1997) supports the increased pressure pain thresholds seen in the participants in both groups of this study.

The hypothesis is that the hypomobility at the joint causes an aberrant sensory input and thereby activates trigger points. Cervical manipulation increases the afferent input from the joint and muscle receptors which facilitate inhibition of the pain mechanisms (Fernández-de-las-Peñas, 2009). Since the participants in both groups received cervical spinal adjustments, this may serve as an explanation for the clinical improvement observed in both groups with regards to the pressure pain threshold of the trapezius myofascial trigger point.

In a study conducted by Kostopoulos, Nelson, Ingber & Larkin (2008), the effect of ischaemic compression and passive stretching, alone and in combination, on the spontaneous electrical activity and pressure pain threshold of an upper trapezius trigger point was investigated. Their results indicate that ischaemic compression caused a 45.3% increase in the pressure pain threshold (Kostopoulos, Nelson, Ingber & Larkin, 2008). It is postulated that the decrease in pain was due to the increased blood flow following the ischaemia that relieves hypoxia and provides metabolites for energy, counter-irritant effects and spinal reflex mechanisms causing muscle relaxation (Kostopoulos, Nelson, Ingber & Larkin, 2008). This may also serve as an explanation for the improved pressure pain threshold of the participants in group one of 37.79%. The smaller improvement in this study compared to the 45.3% in the quoted study may be due to the differences in the sample sizes.
According to Simunovic (1996), low level laser therapy interrupts the pain cycle by normalising the micro-circulation that causes removal of waste products and supplies oxygen. According to Hakgüder et al. (2003) there is a statistically significant increase in the pressure pain threshold following ten daily low level laser therapy sessions applied to a myofascial trigger point. These results support the increase in pressure pain threshold observed via the improved pressure algometer readings in group two.

Regarding the intergroup analysis of the pressure algometer readings, there was no statistically significant difference between the two groups at the conclusion of the clinical trial. This may be explained by the similarity in the proposed analgesic mechanisms of ischaemic compression and low level laser therapy. Both ischaemic compression and low level laser therapy has the ability to decrease the trigger point sensitivity as measured by the pressure pain threshold explaining the lack of statistically significant differences between the two groups.

**Cervical range of motion goniometer**

A joint restriction in the cervical spine can be the cause of pain and changes in the biomechanics of the spine. This is due to the changes in the sensory input from the spine and paraspinal tissues (Bergmann & Peterson, 2011). A myofascial trigger point consists of a hypersensitive nodule that can be palpated within a tight band of muscle. Myofascial trigger points can cause a limitation in range of motion. The restriction in the range of motion due to a myofascial trigger point is most commonly due to pain. Muscles with an active myofascial trigger point are painful when stretched and during muscle contraction (Simons et al. 1999). There are two theories regarding the interaction between joint restrictions and myofascial trigger points. The one theory states that the increased tension in tight muscles has caused a displacement stress of the joint that the muscle crosses thereby causing joint dysfunction. The second theory states that joint dysfunction causes an abnormal sensory input that causes the formation of a trigger point (Fernández-de-las-Peñas, 2009). Taking all this into consideration, both the cervical spine restrictions and the trapezius myofascial trigger point have the ability to restrict cervical spine range of motion so therefore, treatment of the restriction and the trigger point should increase cervical spine range of motion.
An important biomechanical effect of the spinal adjustment is the restoration of facet joint mobility and joint play. These biomechanical changes have physiological effects: changing the sensory input into the central nervous system and reducing the nociceptive input from the paraspinal tissues (Pickar, 2002).

The function of the trapezius muscle acting bilaterally (specific to the cervical spine) is to extend the head and neck against resistance. When the muscle acts unilaterally, it causes lateral flexion towards the same side extreme rotation towards the opposite side (Simons et al. 1999).

Pikula (1999) did a study to determine the effect of cervical spine adjustments on pain and range of motion in patients with acute neck pain. The study consisted of three groups. In two groups the patients were treated with cervical spine adjustments (one group treated on the side of pain and the other group treated on the opposite side) and the last group was treated with sham ultrasound and served as the placebo group. Measurements were taken via a visual analog scale and range of motion of the cervical spine was measured before and after the treatment was delivered. Both adjustment groups showed an increase in cervical spine range of motion post-adjustment with greater improvement noted in the group that was treated on the side of pain (Pikula, 1999).

In this study, both groups showed an increase in all cervical ranges of motion however not all these changes were statistically significant.

During cervical spine flexion, the trapezius muscle will be stretched. An active trigger point in this muscle will cause a restriction in cervical spine flexion due to the pain induced by stretching (Simons et al. 1999). It can therefore be concluded that treatments aimed at resolving the myofascial trigger point and decreasing pain will cause an increase in cervical spine flexion. Both groups showed a clinical improvement in cervical spine flexion over time however the changes were not statistically significant. There are also no significant differences between the two groups with regards to cervical spine flexion. It has already been noted previously that both ischaemic compression and low level laser therapy has the ability to decrease pain. Ischaemic compression is aimed at restoring the length of the shortened muscle fibers within the trigger point and releasing the contraction within the sarcomeres (Kostopoulos et al. 2008). According to Al-Shenqiti & Oldham (2009), low level
laser therapy decreases muscle tension. These serve as valuable explanations to describe the increased cervical spine flexion within each group at the conclusion of the trial.

During cervical spine extension, there is a contraction of the trapezius muscle. Similarly, the contraction and therefore the cervical spine extension may be restricted by an active myofascial trigger point in the trapezius muscle that causes pain (Simons et al. 1999). Both groups showed a clinical improvement in cervical spine extension between the first and the last visit. These changes were statistically significant within each group over time. There were no statistically significant differences between the two groups with regards to extension at the end of the study.

Acting unilaterally the trapezius muscle laterally flexes the neck toward the same side through contraction of the muscle. The opposite trapezius muscle is stretched during this movement (Simons et al. 1999). As noted earlier, a muscle with an active myofascial trigger point will be painful during stretching and contraction. Therefore, treatment protocols that reduce pain and decrease muscle tension such as ischaemic compression and low level laser therapy should increase the range of motion. Clinically both groups showed an increase in left and right lateral flexion between the first and last visit. There was no significant difference with regards to left lateral flexion within each group over time. There was no statistically significant difference between the two groups regarding left lateral flexion at the conclusion of the study. According to the collected data, there was a statistically significant difference within each group over time with regards to right lateral flexion. A statistically significant difference was also noted between the two groups at the final visit with regards to right lateral flexion.

With regards to cervical spine rotation, a clinical improvement was noted in left and right rotation but the differences for both groups were not significant over time. No significant differences were noted between the two groups in terms of left and right rotation at the final visit. The same explanations valid for flexion, extension and lateral flexion for the clinical improvement in the range of motion can be applied to left and right rotation.

No statistically significant differences were noted between the ischaemic compression group and the LLLT group in terms of flexion, extension, left lateral flexion, left rotation and right rotation even though clinical improvements in these ranges were noted.
According to a study by Saayman, Hay & Abrahamse (2011), both cervical spine adjustments and low level laser therapy applied to the cervical facet joints has the ability to increase all the ranges of motion in the cervical spine. Taking into consideration the above explanations regarding the effect on the trapezius muscle during the different ranges of motion in the cervical spine, and the effects produced by ischaemic compression and low level laser therapy, it could be postulated that treatment of the cervical spine restrictions with cervical spine adjusting and treatment of the trapezius myofascial trigger point with ischaemic compression or low level laser therapy should have an effect on all ranges of motion. The lack of statistically significant changes in the range of motion in all ranges except right lateral flexion may be attributed to the small sample sizes used in this study.

As a result no conclusive statement can be made regarding the more superior treatment protocol with regards to increasing the range of motion in the cervical spine.

5.5 Conclusion

Both groups showed clinical and statistically significant changes in some of the subjective and objective results.

The ischaemic compression group showed statistically significant improvement over time for the numerical pain rating scale, Vernon-Mior neck pain and disability index, pressure algometer readings, CROM goniometer readings in extension and CROM goniometer readings in right lateral flexion.

The low level laser therapy group showed statistically significant improvements over time for the numerical pain rating scale, Vernon-Mior neck pain and disability index, pressure algometer readings, CROM goniometer readings in extension and CROM goniometer readings in right lateral flexion.

The only statistically significant difference between the two groups was noted with the CROM goniometer readings in right lateral flexion at the last visit.

Therefore, it can be concluded that both treatment protocols are effective in the treatment of cervical spine pain caused by an active myofascial trigger point in the upper trapezius muscle. Since both treatments were effective and the group sizes were small no statistically significant differences were noted between the two groups and therefore no superior
treatment protocol between cervical adjusting applied with ischaemic compression and cervical adjusting applied with low level laser therapy can be concluded.
CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The aim of this study was to compare the effectiveness of cervical adjustment applied with ischaemic compression versus cervical adjustment applied with low level laser therapy, in the treatment of participants with cervical spine pain originating from an active myofascial trigger point one in the upper trapezius muscle.

Based on the results obtained from the subjective data there is a clinical and statistically significant improvement in both groups over the three week period of the trial pertaining to the numerical pain rating scale and the Vernon-Mior neck pain and disability index. With regards to the subjective data, no significant differences were noted between the two groups.

The objective data collected via the pressure algometer shows a significant difference over the three week period of the trial within both groups. The data showed a significant difference at between the two groups at visit one (before treatment started), however no significant difference was noted between the two groups at visit four and seven.

With regards to the cervical range of motion goniometer readings, both groups showed a clinical improvement in all ranges of motion but not all these results were statistically significant. The only statistically significant changes within each group were noted in extension and right lateral flexion. The only statistically significant difference between the two groups was noted with the CROM goniometer readings in right lateral flexion at the last visit.

In conclusion, both treatment protocols are effective in decreasing pain and disability experienced due to an upper trapezius myofascial trigger point based on the improved numerical pain rating scores and Vernon-Mior pain and disability index scores. Both treatment protocols are also effective in reducing the sensitivity of the upper trapezius myofascial trigger point by increasing the pressure pain threshold readings obtained with the pressure algometer. Based on the lack of significant differences between the two groups (integroup analysis) with regards to the numerical pain rating scale and the Vernon-Mior neck pain and disability index, no conclusions can be made regarding the most effective
treatment protocol for the treatment of pain and disability associated with an active upper trapezius myofascial trigger point. The lack of statistically significant differences with regards to pressure pain thresholds and range of motion readings between the two groups (intergroup analysis) (except right lateral flexion at visit seven) makes it impossible to decide upon a superior treatment protocol to increase pressure pain threshold in the trapezius muscle and range of motion of the cervical spine.

Therefore, no definitive conclusion can be made regarding the most effective treatment protocol in the treatment of cervical spine pain due to an upper trapezius myofascial trigger point.

The results of the study could be beneficial to the chiropractic profession since is shows that cervical spine adjustments combined with either ischaemic compression or low level laser therapy is effective in the treatment of cervical spine pain due to a upper trapezius myofascial trigger point. The effectiveness of the treatments in reducing pain and disability are indicated via the decrease in the numerical pain rating scores and the Vernon-Mior neck pain and disability index scores thereby providing practitioners with a subjective reason for treating patients with these treatment protocols. Decreased muscle tenderness and increased range of motion provided by these treatment protocols provide practitioners with objective reasons for using these treatment protocols. Since patients respond differently to treatment modalities, the outcome of the study showing that both treatment protocols are effective in the treatment of cervical spine pain due to an upper trapezius myofascial trigger points, provides practitioners and patients with a choice between these two options.

6.2 Recommendations

- Larger samples sizes could be used to obtain more applicable results.
- A study that includes measurements of the non-treated upper trapezius trigger points to determine if treatment of the symptomatic trigger points has an effect on the non-symptomatic trigger points.
- The study could include treatment of both upper trapezius trigger points on the same side to determine if this has a greater effect on the symptoms and data obtained from participants.
• A follow-up consultation could be included after one month to determine the long term effects of the treatment protocols

• A control group consisting of participants that only receive cervical spine adjusting could be included in the study to determine the contribution of the spinal adjustment to the change in subjective and objective measurements.

• A trapezius stretching program could be added to the treatment protocols to determine if the added intervention increases the benefits obtained from the treatments.
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APPENDIX A

DEPARTMENT OF CHIROPRACTIC

INFORMATION FORM

My name is Louise van Wyngaardt and I am currently a Chiropractic student, completing my Masters Degree at the University of Johannesburg. I would like to thank you for volunteering to participate in this study entitled “The effect of cervical spinal adjustment applied with ischaemic compression or low level laser therapy on an upper trapezius myofascial trigger point.”

The aim of this study is to determine whether chiropractic spinal adjustment combined with low level laser therapy or ischaemic compression is most effective in the treatment of myofascial trigger points in the upper trapezius muscle.

Participants will be recruited by word of mouth and advertisement. Pamphlets and posters will be used to advertise the study. The participants will be screened to determine if they are suitable for the study via a full history taking, physical examination and a cervical spine regional examination. Participants should also meet the inclusion criteria to partake in the study. Subjective measurements will be collected via the numerical pain scale and the Vernon-Mior pain and disability index. Objective measurements will be collected via the cervical spine range of motion and the trigger point sensitivity.

The study will consist of two groups of fifteen participants each. Both groups will receive spinal adjustment to the relevant spinal segments as determined by motion palpation. Group one will receive low level laser therapy to the upper trapezius trigger point. Group two
will receive ischaemic compression to the upper trapezius trigger point. Both groups will receive six (6) treatments during seven consultations over a three week period. Participants will receive three treatments per week. The last consultation will be a follow-up consultation during which no treatment will be given and measurements will be taken.

The Chiropractic adjustment involves the restoration of normal joint motion. Abnormal joint motion will be detected by the researcher via motion palpation. The Chiropractic adjustment is a safe, non-invasive treatment technique. Low level laser therapy and ischaemic compression are safe and non-invasive treatment techniques.

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

All procedures will be explained to you and all participation is entirely on a voluntary basis; withdrawal at any stage will not cause you any harm. Potential risks and discomforts include: Post adjustment soreness, headache, damage to the eyes due to the laser beam, bruising due to ischaemic compression, exacerbation of symptoms and vertebral artery complications however all measures will be taken to avoid these from occurring. Potential benefits specific to this study include reduction of neck pain due to trapezius trigger points and increased cervical spine range of motion. Results of this study will be made available to you on request.

University of Johannesburg’s ethics clearance number: AEC14-01-2013

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

Researcher: Louise van Wyngaardt Tel: 084 831 6990
Supervisor: Dr. C. Yelverton Tel: (011) 559 – 6218
APPENDIX B

DEPARTMENT OF CHIROPRACTIC

CONSENT FORM

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: ______________________________
APPENDIX C

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  Current: UJ
Other  Other

X-ray Studies:

Previous: UJ  Current: UJ
Other  Other

Clinical Path. Lab:

Previous: UJ  Current: UJ
Other  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

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>Blood pressure:</th>
<th>Arms:</th>
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<td>Legs:</td>
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General Appearance:

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

118
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°

\[\text{L. Rot} \quad \text{Flex.} \quad \text{R. Rot} \]
\[\text{L. Lat Flex} \quad \text{Ext.} \quad \text{R. Lat Flex}\]

/ = 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

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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
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 (Trendelenburg) test
• Arterial insufficiency test

10. Musculoskeletal:
   (i) ROM
   • hip

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   • 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/supraventricular retraction
   • Palpation
     - tenderness
     - masses
     - respiratory expansion
     - tactile fremitus
   • Percussion
     - lungs (posterior)
     - diaphragmatic excursion
     - 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
  - roving’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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<td>Medial Hamstring (L5)</td>
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<td>Lateral Hamstring (S1)</td>
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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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COMMENTS:
### MOTION PALPATION

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APPENDIX F

Numerical pain rating scale

Name of patient: ______________________________

File number: ______________________________

Date: ______________________________

Please assign a number from zero to ten to describe the pain experienced. Zero indicates no pain and ten indicates the worst pain ever experienced. Five represents moderate pain.

Visit 1

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Visit 4

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Visit 7

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APPENDIX G

Vernon-Mior neck pain and disability index

Patient name: ___________________

File number: ___________________

Date: ___________________

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 box which applies to you.

Section 1 – Pain Intensity

□ I have no pain at the moment. (0)

□ The pain is very mild at the moment. (1)

□ The pain is moderate at the moment. (2)

□ The pain is fairly severe at the moment. (3)

□ The pain is very severe at the moment. (4)

□ The pain is the worst imaginable at the moment. (5)

Section 2 – Personal care (Washing, Dressing, etc.)

□ I can look after myself normally without causing extra pain. (0)

□ I can look after myself normally but it causes extra pain. (1)

□ It is painful to look after myself & I am slow. (2)

□ I need some help but manage most of my personal care. (3)

□ I need help every day in most aspects of self-care. (4)

□ I do not get dressed. I wash with difficulty & stay in bed. (5)
Section 3 – Lifting

☐ I can lift heavy weights without extra pain. (0)

☐ I can lift heavy weights but it gives extra pain. (1)

☐ Pain prevents me from lifting heavy weights off the floor, but I can manage if they are conveniently positioned. (2)

☐ Pain prevents me from lifting heavy weights off the floor but I can lift medium weights if they are conveniently positioned. (3)

☐ I can lift very little weights. (4)

☐ I cannot lift or carry anything at all. (5)

Section 4 – Reading

☐ I can read as much as I want with no pain in my neck. (0)

☐ I can read as much as I want with slight pain in my neck. (1)

☐ I can read as much as I want with moderate pain in my neck. (2)

☐ I cannot read as much as I want due to moderate pain in my neck. (3)

☐ I can hardly read at all due to severe pain in my neck. (4)

☐ I cannot read at all. (5)

Section 5 – Headaches

☐ I have no headaches at all. (0)

☐ I have slight headaches that come infrequently. (1)

☐ I have moderate headaches which come infrequently. (2)

☐ I have moderate headaches which come frequently. (3)

☐ I have severe headaches which come frequently. (4)

☐ I have headaches which come almost all the time. (5)
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 with slight neck pain. (1)

☐ I can drive my car with moderate neck pain. (2)

☐ I cannot drive my car 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 9 – Sleeping

☐ I have no trouble sleeping. (0)

☐ My sleep is slightly disturbed (< 1 hr sleepless). (1)

☐ My sleep is mildly disturbed (1-2hrs sleepless). (2)

☐ My sleep is moderately disturbed (2-3hrs sleepless). (3)

☐ My sleep is greatly disturbed (3-5hrs sleepless). (4)

☐ My sleep is completely disturbed (5-7hrs sleepless). (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 H

Cervical range of motion goniometer readings

Name of patient: _______________________________

File number: _______________________________

Date: _______________________________

Flexion

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APPENDIX I

Pressure algometer readings

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File number: ____________________________

Date: ____________________________

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