THE EFFECTIVENESS OF AN ELECTROMECANICAL ADJUSTING INSTRUMENT COMPARED TO CERVICAL SPINE MANIPULATION IN THE TREATMENT OF CERVICOGENIC HEADACHES

By

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Dissertation submitted in partial compliance with the requirements for the Master’s Degree in Technology: Chiropractic

Durban University of Technology

I, Russell Whittaker, do hereby declare that this dissertation is representative of my own work in both conception and execution (except where acknowledgements indicate to the contrary)

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Date: ............................................
Dr. Desiree Varatharajullu
M.Tech: Chiropractic
DEDICATION

To my Mother and Father

Without you, quite simply “this would have never happened”.
Your belief in me is my inspiration.

I hope to one day be able to give my child even a fraction of the unlimited support, powerful love and honest guidance you two have shown me on my way to achieving my dream of becoming a chiropractor.

I thank you both from the bottom of my heart.
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LIST OF DEFINITIONS

Drop-out
A research participant who was unable to attend all six consultations at the Chiropractic Day Clinic within the allocated three-week time period.

Effectiveness
A measureable outcome of a desired effect (Dorland, 2011).

Extension
This refers to increasing the angle between parts of the body. For this study, it was defined as the movement of the neck in a backward direction out of the foetal position (Bergmann, Peterson and Lawrence, 1993).

Flexion
This refers to decreasing the angle between parts of the body. For this study, it was defined as the movement of the head and neck towards the chest into the foetal position (Bergmann, Peterson and Lawrence, 1993).

Incidence
The rate that new cases of a specific disease occur over a specific time period. It also describes the risk of contracting a disease within a population (Dorland, 2011).

Joint restriction
This refers to a temporary restriction of an articulation within its normal physiological range of motion (ROM). It is associated with shortened ligaments, muscular spasms or intra-articular origins (Haldeman, 2005).

Manipulation
This describes a treatment protocol in which a brief, high velocity/low amplitude (HVLA) impulse is directed at a dysfunctional synovial joint in order to move it past its normal physiological ROM but within its anatomical ROM (Bergman and Peterson, 2011).
Motion palpation
A chiropractic procedure involving various hand-palpation techniques used to assess the integrity, mobility and general functionality of a person's joint or anatomical structure in terms of tenderness, shape, size, consistency, position and ROM (Gatterman and Hansen, 1994).

Prevalence
The percentage of a population with a specific disease at a specific time (Dorland, 2011).
ABSTRACT

Background: Cervicogenic headaches are usually chronic, debilitating and tend to be unresponsive to common headache medications. Manual therapy has been shown to be an effective form of management for cervicogenic headache. The Electromechanical Adjusting Instrument is a hand-held device offered as an alternative to manual therapy for musculoskeletal treatment.

Aim: The aim of this study was to determine the effectiveness of the Electromechanical Adjusting Instrument compared to cervical spine manipulation in terms of subjective and objective measures in the treatment of cervicogenic headache.

Methodology: This study was a randomised single-blinded clinical trial. There were 41 participants between the ages of 18 and 59 years who were randomly divided into two groups of 21 and 20 respectively by means of a randomisation table drawn up by the statistician. Participants in Group A received cervical spine manipulation while those in Group B received the Electromechanical Adjusting Instrument. Subjective headache intensity was determined using a Numerical Pain Rating Scale. The effect of neck pain on the participants’ activities of daily living before and after treatment was assessed using the Neck Disability Index. The effect of the headache on the participants’ activities of daily living before and after treatment was assessed using the Headache Disability Index. Objective cervical range of motion in all six planes of motion was assessed using a CROM goniometer. Participants in both groups received six interventions over a three-week period with a minimum interval of 48 hours between each intervention. The subjective and objectives assessments were taken at baseline, post-third and post-sixth interventions. The data was analysed using the IBM SPSS version 24.0. Repeated measures ANOVA was used to examine the effect on each outcome measure separately of time and treatment group interaction. Profile plots were generated to show the rates of changes in outcomes over time by the intervention group. A p value <0.05 was considered statistically significant.

Results: For most of the outcomes, there was no clinical or statistical interaction present, i.e. the intervention effect was similar in both groups irrespective of the intervention.

Conclusion: The trends in each of the outcomes suggest that the Electromechanical Adjusting Instrument is as effective as cervical spine manipulation for the treatment of cervicogenic headache.
# LIST OF SYMBOLS AND ABBREVIATIONS

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
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<tbody>
<tr>
<td>%</td>
<td>Percent</td>
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<tr>
<td>°</td>
<td>Degrees</td>
</tr>
<tr>
<td>CDC</td>
<td>Chiropractic Day Clinic</td>
</tr>
<tr>
<td>CSM</td>
<td>Cervical spine manipulation</td>
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<tr>
<td>CROM</td>
<td>Cervical range of motion</td>
</tr>
<tr>
<td>DUT</td>
<td>Durban University of Technology</td>
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<tr>
<td>EAI</td>
<td>Electromechanical Adjusting Instrument</td>
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<tr>
<td>Ho</td>
<td>Null hypothesis</td>
</tr>
<tr>
<td>Ha</td>
<td>Alternative hypothesis</td>
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<tr>
<td>HVLA</td>
<td>High velocity low amplitude</td>
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<td>HDI</td>
<td>Headache Disability Index</td>
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<tr>
<td>NSAID</td>
<td>Non-steroidal Anti-inflammatory</td>
</tr>
<tr>
<td>IREC</td>
<td>Institutional Research and Ethics Committee</td>
</tr>
<tr>
<td>NDI</td>
<td>Neck Disability Index</td>
</tr>
<tr>
<td>NRS</td>
<td>Numerical Pain Rating Scale</td>
</tr>
<tr>
<td>RA</td>
<td>Research assistant</td>
</tr>
<tr>
<td>ROM</td>
<td>Range of motion</td>
</tr>
<tr>
<td>TENS</td>
<td>Transcutaneous electrical nerve stimulation</td>
</tr>
<tr>
<td>VAS</td>
<td>Visual Analogue Scale</td>
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<td>Viz.</td>
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CHAPTER 1: INTRODUCTION

1.1 INTRODUCTION

Cervicogenic headache (CGH) refers to a headache of cervical origin (Jull et al., 2007). It is a syndrome characterised by chronic hemi-cranial pain that is referred to the head from either bony or soft tissue structures of the neck (Biondi, 2005). The mean age of onset for CGH is 42.9 years and there is a 4:1 female disposition. Patients typically present with a restricted cervical range of motion (CROM) and an altered neck posture. Cervicogenic headache affects 13 to 17% of the population with chronic headaches. Globally an estimated 2.2% of the population is affected and is considered to be a debilitating pain problem (Liebert et al., 2013). Although the prevalence of CGH is lower than that of tension-type and migraine headaches, individuals tend to have a considerably lower quality of life in comparison to tension-type and migraine headache sufferers (Suijlekom et al., 2003).

The first three cervical spinal nerves and their rami are the primary peripheral nerve structures that can refer pain to the head (Biondi, 2005). Almost any pathology affecting the cervical spine has been implicated as a cause of CGH due to convergence of sensory input from the cervical structures within the spinal nucleus of the trigeminal nerve (Haldeman and Dagenais, 2001). Examples of such pathologies include: chronic tension, acute whiplash injury, intervertebral disc disease or progressive facet joint arthritis. The key differential diagnoses for CGH are tension type and migraine headaches as there is considerable overlap in symptoms and clinical features between these conditions (Haldeman and Dagenais, 2001).

Spinal manipulative therapy has been shown to be an effective form of treatment for CGH. Although manual therapy is advocated for treating a variety of headaches (Hall et al., 2008). Biomechanical changes effected by spinal manipulation are thought to have physiological consequences by influencing the inflow of sensory information to the central nervous system (Pickar, 2002). Neurophysiological effects of manipulation lead to decreased pain and affect muscle tone and motor control (Evans, 2002). The neurophysiological effects of manipulation are attributed to the stimulation of descending pain inhibitory systems of the central nervous system (Bialosky et al., 2009). Spinal manipulation has also been shown to increase both pain tolerance and threshold (Vicenzino et al., 1996).
The electromechanical adjusting instrument (EAI) is a medical device offered as an alternative to manual therapy for musculoskeletal treatment. Although preliminary research has demonstrated biomechanical and neurophysiological responses associated with its application (Colloca et al., 2005). The device was specifically made to deliver gentle and precise chiropractic adjustments to the joints of the spine and extremities to relieve pain and restore function (www.neuromechanical.com/Impulse/new).

There is limited clinical knowledge which exists on this device. Currently, there is a paucity of literature comparing the EAI to cervical spine manipulation (CSM) in the treatment of CGH. Therefore, this study investigated the effectiveness of the EAI compared to CSM in the treatment of CGH.

1.2 AIMS AND OBJECTIVES

1.2.1 Aim of the Study

The aim of this study was to determine the effectiveness of the EAI compared to CSM in terms of subjective and objective findings in the treatment of CGH.

1.2.2 Objectives of the Study

Objective One:

To determine the effectiveness of CSM in the treatment of CGH in terms of subjective and objective findings. The subjective outcome measures were the Numerical Pain Rating Scale (NRS), the Neck Disability Index (NDI) as well as the Headache Disability Index (HDI). The objective outcome measure was the CROM goniometer.

Objective Two:

To determine the effectiveness of the EAI in the treatment of CGH in terms of subjective and objective findings.
Objective Three:

To correlate the subjective and objective findings in terms of the overall effectiveness of CSM and the EAI in the treatment of CGH.

1.3 HYPOTHESIS

1.3.1 Null Hypothesis

The null hypothesis (Ho) stated that there will be no difference between the two groups in terms of subjective and objective findings.

1.3.2 Alternative Hypothesis

The alternative hypothesis (Ha) stated that the subjective and objective findings of the EAI group would be statistically significantly different ($p > 0.05$) to that of the manual CSM group.

1.4 RATIONALE

Manual therapists have for some time treated the cervical spine in an effort to relieve headache (Hall et al., 2008). While manual cervical spine manipulative therapy is a common treatment for CGH, the EAI is reported to be a good alternative as it is more precise, faster and gentler than CSM. The EAI provides an alternate option for those individuals that do not tolerate manual techniques or if their condition contraindicates the use of manual techniques. However, no studies have compared these two methods in their relative effectiveness in the treatment of CGH.
CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

This chapter will present the current literature on CGH, including incidence, prevalence, pathophysiology, aetiology, risk factors, associated signs and symptoms, diagnosis and treatment.

A headache is defined as “pain in various parts of the head, not confined to the area of distribution of any nerve” (Stedman's Medical Dictionary, 2006). Headaches are significant indicators that anatomic and physiologic changes have taken place. Headaches can result from cervical spine joint dysfunction, metabolic dysfunction, vascular disease, brain tumours and trauma (Alix and Bates, 1999).

Headaches are broadly classified into two groups viz. primary and secondary headaches. Primary headaches are benign, recurrent and do not have an underlying disease or structural basis (De Luca and Bartleson, 2010). Primary headaches are more dominant than secondary headaches (Scher et al., 1998). Secondary headaches are generally pathological in origin (Clinch, 2001) and occur in close temporal relationship to another disorder to which they are attributed (Olesen and Steiner, 2004). Cervicogenic headaches are classified by the International Headache Society (IHS) as secondary headaches, more specifically a headache attributed to a disorder of the neck (http://ihs-classification.org/en/02_klassifikation/).

2.2 ANATOMY OF THE CERVICAL SPINE

2.2.1 Overview

The superior boundary of the neck is the inferior margin of the mandible and the bony structures of the skull on its posterior aspect (Moore, Dalley and Agur, 2014). The inferior boundary of the neck can be defined as an imaginary line through the transverse process of the first thoracic vertebra posteriorly (Bogduk, 2003). The cervical region is highly specialised and has the greatest ROM and variety of movement of all the vertebral regions (Moore, Dalley and Agur, 2014).
2.2.2 Cervical Vertebrae

The cervical vertebrae make up the skeleton of the neck (Moore, Dalley and Agur, 2014). They are the smallest of the 24 movable vertebrae. There are seven cervical vertebrae that make up the cervical region of the vertebral column. The centrally placed vertebral bodies support the head and the intervertebral articulations (Moore, Dalley and Agur, 2014). The vertebral bodies increase in size as the vertebral bodies descend as a result of increased weight-bearing imposed demand. Moreover, the intervertebral canal, which is triangular in shape, also increases in diameter to accommodate the thickening of the spinal cord as it descends. The articular zygapophyseal joints are oblique, relatively horizontal and directed primarily superiorly and inferiorly. The transverse processes end laterally in two projections viz. the anterior tubercle and the posterior tubercle.

Although the cervical intervertebral discs are considerably thinner than those of the inferior regions of the vertebral column, they are relatively thick compared to the vertebral bodies they connect. This feature along with the horizontally-orientated zygapophyseal joints and the small amount of surrounding body mass allows for the wide range and variety of movement (Moore, Dalley and Agur, 2014).

The most distinctive feature of each cervical vertebra is the foramina transversarium or transverse foramen. This is a vertically-orientated canal located on the transverse process in which the vertebral arteries and their accompanying veins pass (with the exception of the C7 which only transmits small accessory veins). This accounts for the small size of the C7 foramen and its occasional absence (Middleditch and Oliver, 2005).

The first (C1), second (C2) and seventh (C7) cervical vertebrae are atypical vertebrae while third (C3), fourth (C4), fifth (C5) and sixth (C6) cervical vertebrae are typical vertebrae (Moore, Dalley and Agur, 2014; Tortora and Derrickson, 2013).
2.2.2.1 Typical cervical vertebrae

The third to sixth cervical vertebrae (C3-C6) are classified as typical and have five important characteristics. The vertebral bodies are larger horizontally than vertically with the superior and inferior surfaces being concave and convex respectively. They have a large, triangular intervertebral foramen and short spinous processes (Moore, Dalley and Agur, 2013). They also have a foramina transversarium which the vertebral vessels travel but this feature is not unique to the typical cervical vertebrae. The superior zygaphophyseal joints are supero-posteriorly orientated with the inferior zygaphophyseal joints being infero-posteriorly directed to allow horizontal translation.

2.2.2.2 Atypical cervical vertebrae

There are three atypical cervical vertebrae (C1, C2 and C7). The atlas (C1) lacks a spinous process as well as a vertebral body. It is a ring-like, kidney-shaped bone consisting of two lateral masses connected by anterior and posterior arches. It has concave superior articular zygaphophyseal joints which receive the occipital condyles. The axis (C2) has a unique adaptation known as the odontoid process which projects superiorly from its body and is approximately 1.5cm long (Moore, Dalley and Agur, 2014). This odontoid process provides a pivot around which the atlas and the head rotate. The odontoid process has a pointed tip which provides the attachment for the apical ligament (Middleditch and Oliver, 2005). The vertebra prominens (C7) has a large non-bifid spinous process as well as large transverse processes with small, (occasionally absent) foramina transversaria.
2.2.3 Joints of the Cervical Spine

2.2.3.1 Craniovertebral joints

There are two sets of craniovertebral joints viz. the atlanto-occipital joint which is formed between the atlas and the occipital bone and atlanto-axial joint which is formed between the atlas and the axis. The atlanto-occipital joints permit flexion and extension of the head and slight lateral flexion and rotation (Moore, Dalley and Agur, 2014).
The atlanto-axial joints are comprised of three synovial joints. One centrally-located atlanto-odontoid joint and two lateral atlanto-axial joints (Middleditch and Oliver, 2005). The atlanto-odontoid joint is a pivot joint comprised of the articulation between the zygapophyseal joint on the anterior surface of the odontoid process with the reciprocally-shaped zygapophyseal joint on the posterior arch of the atlas and the synovial cavity between the posterior arch of the odontoid and the cartilage-lined anterior surface of the transverse ligament of the axis. The two lateral atlanto-axial joints are between the inferior zygapophyseal joints of the lateral masses of C1 and the superior zygapophyseal joints of C2. These are gliding-type synovial joints and are flat in the coronal plane.

### 2.2.3.2 Joints between typical cervical vertebrae

There are three different types of joints which link adjacent cervical vertebrae viz. intervertebral joints, zygapophyseal joints and uncovertebral joints. Intervertebral joints or intervertebral discs are the joints between the vertebral bodies (Middleditch and Oliver, 2005). They provide strong attachments between the vertebral bodies forming a semi-rigid column as well as forming the inferior half of the anterior border of the intervertebral foramen. Although they permit excessive movement between adjacent vertebrae, vertebral stability is not compromised. The intervertebral discs are reinforcement anteriorly and posteriorly by the anterior longitudinal and posterior longitudinal ligaments respectively (Middleditch and Oliver, 2005).

They serve as shock absorbers due to their resilient deformability. Each intervertebral disc consists of a peripheral annulus fibrosis and a central nucleus pulposus. The annulus fibrosis is a bulging fibrous ring composed of concentrically-orientated layers (lamellae) of fibrocartilage forming the circumference of the intervertebral disc. Each lamella runs obliquely at 30° or more from one vertebra to another; these lamellae cross each other in opposite directions at angles of 60° or more forming a strong mesh of fibrocartilage. This orientation limits rotation between adjacent vertebrae while providing a strong bond between them (Moore, Dalley and Agur, 2014).

The nucleus pulposus is the core of the intervertebral disc. They are gelatinous in nature and, therefore, responsible for flexibility and resilience offered by the intervertebral disc. The nucleus becomes broader when compressed by load and thinner when tensed. Compression and tension occur simultaneously in the same intervertebral disc during flexion, lateral flexion, extension and rotation of the vertebral column. This is achieved by the turgid nucleus
becoming a semifluid fulcrum. The intervertebral discs are termed saddle articulations as they are concave in the frontal plane and convex in the sagittal plane.

The zygapophyseal joints are plane joints lined with articular cartilage. They are formed by the articulation of the inferior zygapophyseal joints and the subjacent superior zygapophyseal joints. The orientation of the zygapophyseal joints determines direction and range of movement. The inferior zygapophyseal joints of the typical cervical vertebrae face forward and downward, while the superior zygapophyseal joints are directed upwards and backwards. These joints allow flexion, extension, lateral flexion and rotation to occur. The zygapophyseal planes of the upper typical vertebrae are more horizontally-placed and are approximately 55° to the vertical, while the lower zygapophyseal joints planes are less horizontal and approximately 25° to the vertical (Middleditch and Oliver, 2005). Furthermore, the zygapophyseal joint capsules are highly innervated and may be a primary source of pain.

The uncovertebral joints, also known as the joints of Von Lushka, become apparent in the first or second decade of life. They are considered synovial joints by some while others consider them to be degenerative spaces or clefts in the intervertebral disc occupied by extra-cellular fluid (Moore, Dalley and Agur, 2014). They are lined by fibrocartilage and are formed by the uncinate process growing upward from the superiorolateral borders of the vertebral bodies of C3 to C6 projecting into the loose vascular fibrous tissue at the outer margins of the annulus and correspond with the reciprocally-shaped cavities of the vertebra above. They have important clinical significance as they have a tendency to develop marked degenerative changes and form bony exostoses which may impinge on the vertebral artery, the anterior part of the spinal cord or cervical nerve roots (Middleditch and Oliver, 2005). During flexion and extension, a gliding movement occurs at these joints and concentrates the plane of shear to the horizontal band within the annulus between the uncovertebral joints.

2.2.4 Ligaments of the Cervical Spine

The fibres of some fibrous capsules are arranged as parallel bundles of dense regular connective tissue called ligaments (Tortora and Derrickson, 2013). The principle function of the ligaments is to hold bones together in a synovial joint (Tortora and Derrickson, 2013). In the cervical spine the joints between vertebrae are reinforced and supported by ligaments (Gray and Standring, 2008).
2.2.4.1 Craniovertebral ligaments

The stability of the craniovertebral region depends on the integrity of the ligaments of the upper cervical spine. These ligaments include:

The transverse ligament of the atlas, which is arguably the most important ligament in the body as it is the primary stabiliser of the craniocervical junction (Middleditch and Oliver 2005). It forms a thick band which holds the odontoid in place. It passes behind the odontoid process attaching to a tubercle arising from the medial aspect of each lateral mass of the atlas (Middleditch and Oliver 2005). It also has upward and downward extensions attaching to the anterior edge of the foramen magnum and body of the axis respectively, forming the cruciate ligament; these extensions give the transverse ligament of the atlas a cross-like appearance (Pansky and Gest, 2013).

The alar ligaments are bilateral ligaments arising from the posterior aspect of the tip of the odontoid process (Middleditch and Oliver 2005). They extend from the sides of the odontoid
process to the lateral margins of the foramen magnum. These short, rounded cords attach the cranium to the atlas and act as check ligaments to prevent excessive rotation at the joints (Moore, Dalley and Agur, 2014). These ligaments are composed of collagen fibres and have limited extensibility (Middleditch and Oliver, 2005).

**The apical ligament** is shorter and thinner than the alar ligaments and attaches from the tip of the odontoid process to the anterior margin of the foramen magnum (Middleditch and Oliver, 2005).

**The tectorial membrane** is a strong superior continuation of the posterior longitudinal ligament that broadens and passes posteriorly over the atlanto-axial joint and its ligaments. It runs superiorly from the body of the axis through the foramen magnum to attach to the central part of the floor of the cranial cavity which is formed by the internal surface of the occipital bone.

**The anterior atlanto-occipital membrane** connects the foramen magnum to the arch of the atlas below. It is a continuation of the anterior longitudinal ligament and overlies the capsules of the atlanto-occipital joints laterally.

**The posterior atlanto-occipital membrane** connects the foramen magnum with the posterior arch of the atlas below and is continuous with the joint capsules laterally. It represents the ligamentum flava at this region of the spine. It also forms a channel for the vertebral artery and first cervical nerve to penetrate the atlanto-occipital membrane before transferring into the foramen magnum.

**The accessory atlanto-axial ligaments** pass upwards and laterally from the base of the odontoid process to the inferomedial aspect of the lateral masses of the atlas.

### 2.2.4.2 Lower cervical ligaments

There are several ligaments that bring stability to the lower cervical spine viz.:

1. **The anterior longitudinal ligament** which lies anterior to the vertebral body, it attaches to the anterior aspect of the vertebral bodies. It, therefore, limits extension by becoming relaxed during flexion and taut during extension.
2. **The posterior longitudinal ligament** is posterior to the vertebral bodies inside the vertebral canal. It is relaxed during extension and taut during flexion.

3. **The ligamentum flavum** connect the laminae of the adjacent vertebrae. These ligaments allow flexion to occur, but prevent hyperflexion by braking the movement so that the end ROM is not reached abruptly.

4. **The ligamentum nuchae** is posteriorly-located and is homogenous with the interspinous ligaments in the thoracic and lumbar spines; it is strongest in the cervical spine where it forms a septum for the attachment of the trapezius and splenius muscles. It has a crucial function in preventing flexion acceleration injuries because if the ligament is torn, there is likely to be significant damage to the intrinsic structures.

**2.2.5 Muscles**

**2.2.5.1 Muscle function**

The functions of the muscles of the vertebral column include:

1) Production of or accelerating movement by contacting concentrically.
2) Decelerating movement or providing stability by contracting isometrically or eccentrically.
3) Directing forces through tissues that are designed to absorb and transfer those forces to the intervertebral discs and articular cartilage.
4) Acting as a shock absorber themselves.
5) Providing afferent proprioceptive feedback to the central nerves system for coordination and regulation of muscle function (Middleditch and Oliver, 2005).

**2.2.5.2 Muscle structure**

Skeletal muscle consists of muscle cells, muscle-specific extracellular matrix, nerves and vessels. It is highly complex and specialised. A collagenous tissue known as an endomysium sheath encapsulates the muscle cells. A stronger collagenous sheath known as perimysial connective tissue covers the muscle fibres which are cylindrical and range from 10μm to approximately 100μm in diameter (Lieber, 1992). These muscle fibres are arranged in fascicles surrounded by epimysial connective tissue making up a muscle (Middleditch and Oliver, 2005). The layers of connective tissue fuse together at each end and form specialised connective tissue tendons. Each muscle fibre contains a bundle of myofibrils which are the
largest functional unit of contractile filaments. These myofibrils are made up of sarcomeres. Sarcomeres are made up of myofilaments which contain the proteins actin and myosin. These proteins interdigitate to form a hexagonal lattice. Myosin (thicker filaments) and actin (thinner filaments) are linked via cross-bridges where the actin filament is able to slide over the myosin filament because of the active inter-digitation between the two proteins. The muscle cell is secured by the attachment of the Z line to the sarcolemma. A sarcomere length is defined as the distance between the Z lines. The sliding of actin and myosin transmits a force to the Z line and then to the connective tissue matrix of the muscle into the tendon and then to the bone. Myofilaments can vary their state of stiffness due to the ability of the sarcomeres to change their length. Tension is generated during muscle contraction via the myosin-containing filament while tension is regulated by the actin-containing filament.

2.2.6 Muscles of the Cervical Spine

The cervical region is the most mobile segment of the spine. The muscles of the cervical spine have several functions viz. controlling movement and posture and balancing the head and neck.

Figure 0.3: The muscles of the cervical vertebral column
Source:
https://static1.squarespace.com/static/52994853e4b0a6ba0e3606bc/57969f02e6f2e187da351929/1469489189095/Screen+Shot+2016-07-25+at+6.21.17+PM.png?format=500w
<table>
<thead>
<tr>
<th>Muscle</th>
<th>Attachment</th>
<th>Innervation</th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Levator scapulae</td>
<td>Posterior tubercles of transverse processes of C2-C6 attaching inferiorly to the superior part of the medial border of the scapula.</td>
<td>Ventral rami of C3 and C4, from C5 through the dorsal scapular nerve</td>
<td>Extend the neck; laterally flex the neck</td>
</tr>
<tr>
<td>Longus capitis</td>
<td>Basilar part of occipital bone to anterior tubercles of C3-C6 transverse processes.</td>
<td>Ventral rami of C1-C3</td>
<td>Flex the head and the neck</td>
</tr>
<tr>
<td>Longus coli</td>
<td>Anterior tubercle of atlas, bodies of C1-C3 and transverse processes of C3-C6 descending to bodies of C5-T3 and transverse processes of C3-C5.</td>
<td>Ventral rami of C3,C4,C5 and C6</td>
<td>Flex the neck</td>
</tr>
<tr>
<td>Obliquus capitis</td>
<td>Proximally to the transverse processes of the atlas onto the spinous process of axis and adjacent lamina.</td>
<td>Dorsal ramus of C1</td>
<td>Rotate the head on the neck</td>
</tr>
<tr>
<td>inferior</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muscle</td>
<td>Description</td>
<td>Nerve</td>
<td>Effect</td>
</tr>
<tr>
<td>------------------------</td>
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</tr>
<tr>
<td>Obliquus capitis superior</td>
<td>Proximally between the superior and inferior nuchal lines of occipital bone onto the transverse processes of the atlas.</td>
<td>Dorsal ramus of C1</td>
<td>Extend the head on the neck</td>
</tr>
<tr>
<td>Rectus capitis anterior</td>
<td>Base of cranium, just anterior to occipital condyle, to anterior surface of lateral mass of atlas.</td>
<td>Ventral rami of C1 and C2</td>
<td>Flex the head on the neck</td>
</tr>
<tr>
<td>Rectus capitis lateralis</td>
<td>Jugular process of occipital bone descending onto the transverse process of atlas.</td>
<td>Ventral rami of C1 and C2</td>
<td>Laterally flex the head on the neck</td>
</tr>
<tr>
<td>Rectus capitis posterior major</td>
<td>Spinous process of axis ascending to lateral part of inferior nuchal line.</td>
<td>Dorsal ramus of C1</td>
<td>Extend the head on the neck</td>
</tr>
<tr>
<td>Rectus capitis posterior minor</td>
<td>Tubercles on the posterior arch of atlas ascending to medial part of inferior nuchal line.</td>
<td>Dorsal ramus of C1</td>
<td>Extend the head on the neck</td>
</tr>
<tr>
<td>Scalenius anterior</td>
<td>Transverse processes of C3-C6 descending onto the first rib.</td>
<td>Ventral rami of C4-C6</td>
<td>Rotate or flex or laterally flex the neck</td>
</tr>
<tr>
<td>Scalenius medius</td>
<td>Posterior tubercles of the C5-C7 transverse processes to superior surface of</td>
<td>Ventral rami of C3-C8</td>
<td>Laterally flex the neck</td>
</tr>
</tbody>
</table>
the first rib, posterior to the groove for the subclavian artery.

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scalenius posterior</strong></td>
<td>Posterior tubercles of the C5-C7 transverse processes to the external border of the second rib.</td>
</tr>
<tr>
<td></td>
<td>Ventral rami of C6-C8</td>
</tr>
<tr>
<td></td>
<td>Laterally flex the neck</td>
</tr>
<tr>
<td><strong>Semispinalis cervicis</strong></td>
<td>Transverse processes of T1-T5 and attaching to spinous processes of C2-C5.</td>
</tr>
<tr>
<td></td>
<td>Dorsal rami of adjacent cervical spinal nerves</td>
</tr>
<tr>
<td></td>
<td>Rotate the neck</td>
</tr>
<tr>
<td><strong>Splenius capitis</strong></td>
<td>Lateral aspect of mastoid process and lateral third of superior nuchal line to the inferior half of nuchal ligament and spinous processes of T1-T6.</td>
</tr>
<tr>
<td></td>
<td>Dorsal rami of C3-C5</td>
</tr>
<tr>
<td></td>
<td>Extend or rotate or laterally flex head and neck</td>
</tr>
<tr>
<td><strong>Splenius cervicis</strong></td>
<td>Spinous processes of T3-T6 passing upwards to attach to the posterior tubercles of the transverse process of C1-C3.</td>
</tr>
<tr>
<td></td>
<td>Dorsal rami of C5-C7</td>
</tr>
<tr>
<td></td>
<td>Extend or rotate or laterally flex head and neck</td>
</tr>
<tr>
<td><strong>Sternocleido-mastoid</strong></td>
<td>Lateral surface of mastoid process of temporal bone and lateral half of the superior nuchal line. Sternal head attaches to anterior surface of manubrium of sternum and clavicular head on superior surface of medial third of clavicle.</td>
</tr>
<tr>
<td><strong>Trapezius</strong></td>
<td>Medial third of superior nuchal line, external occipital protuberance, nuchal ligament, spinous processes of C7-T12 and lumbar and sacral spinous processes attaching to lateral third of clavicle, acromion and the spine of the scapula.</td>
</tr>
</tbody>
</table>
2.3 CERVICOGENIC HEADACHE

Cervicogenic headache is a syndrome characterised by chronic hemi-cranial pain that is often referred to the head by either bony structures or soft tissue structures of the neck (Biondi, 2005) and is associated with tenderness of the cervical paraspinal tissues (Haldeman and Dagenais, 2001).

2.3.1 Incidence and Prevalence

The estimated incidence among chronic CGH suffers is 13-17% (Liebert et al., 2013). Haldeman and Dagenais (2001) estimated the prevalence to be between 0.4% and 2.5% of the global population. Sjaastad and Bakketeig (2008), on the other hand, estimated the global prevalence of CGH to be between 2.5-4.1%.

Although the prevalence of CGH is lower than that of tension-type and migraine headaches, individuals tend to have a considerably lower quality of life in comparison to those types headache sufferers (Suijlekom et al., 2003; Hall, 2010). The mean age for CGH is 42.9 years and there is a 4:1 female preponderance (Haldeman and Dagenais, 2001).

2.3.2 Risk factors

Risk factors for CGH include fatigue, poor posture, sleeping difficulties, current or prior neck injuries, stress and intervertebral disc pathologies. The widespread use of computers and other visual display units in the workplace has resulted in an increase in neck discomfort due to the sustained static contraction of the neck muscles (Middleditch and Oliver 2005). In an occupational risk study by Shah and Nafee (1999) in India, with a sample that consisted of 55.7% employed as handicraft workers, 28.3% as labourers, 10.0% as clerks, 4.9% as business executives, and 1.6% as doctors, it was speculated that the poor ergonomics associated with the handicraft occupations may be a contributing factor for the higher prevalence in that group. Furthermore, Sjaastad et al. (2006) stated that certain occupations viz. hair-dressing, carpentry and truck/tractor drivers are at risk of developing bilateral CGH headaches. Cervicogenic headaches are reportedly one of the most common types of headache in weight lifting athletes (Rifat and Moeller, 2003).
2.3.3 Mechanism

Vernon (1998) proposed the vertebrogenic model of headache with the mechanisms described into four categories:

1. Extra-segmental: referring to the regional myofascial structures, the ligamentum nuchae and the interface between the associated muscles and the regional cervicothoracic structures.
2. Inter-segmental: referring to the three joint complexes of C2-C4 and the articulations of CO-C2, with their associated ligaments and deep intersegmental muscles.
3. Infra-segmental: referring to the nerve structures within and surrounding the intervertebral foramina.
4. Intra-segmental: referring to the spinal cord and medullary dorsal horn with the trigemino-cervical nucleus.

2.3.4 Pathophysiology

In the case of CGH, the neurophysiological and anatomical basis can be explained using the mechanisms described by Vernon (1998). The neurophysiologic basis for the condition encompasses the infra-segmental and the intra-segmental mechanisms while the anatomical basis encompasses the extra-segmental and inter-segmental mechanisms.

1. Neurophysiological

The neurophysiological basis can be explained, firstly, by convergence between the trigeminal afferents and efferent nerve roots from the upper three cervical spinal nerves and, secondly, by the sensitisation of trigemino-cervical neurons. Convergence occurs when the second-order nociceptive neurons in the trigemino-cervical nucleus that receive both cervical and trigeminal afferents cannot differentiate their activation from the cervical or trigeminal afferents (Alix and Bates, 1999). This lack of differentiation allows the neurons that are accustomed to trigeminal input to receive noxious stimuli from any source within the receptive fields of the first three cervical nerves (Biondi, 2005).

The convergence of trigeminal and cervical C1- C3 afferents allows the possibility of CGH to result from any pathologic condition affecting structures innervated by the above-mentioned
spinal nerves. Therefore, any joint complex dysfunction affecting the C1 to C3 spinal nerves has the potential to result in a CGH (Bogduk, 1992).

Central sensitisation occurs after tissue injury when nociceptors demonstrate spontaneous activity, lowered pain thresholds, and increased responsiveness to noxious stimuli, leading to hyper-excitability and an alteration of neuronal processing in the central nervous system (Vernon et al., 2009). This mechanism explains how a dysfunction in the cervical spine joint complex may be interpreted by the brain as a noxious input anywhere within the trigemino-cervical peripheral receptive fields leading to cranial pain.

2. Anatomical

The first three cervical spinal nerves and their rami are the primary peripheral nerve structures that can refer pain to the head (Biondi, 2005). The dorsal ramus of C1 (suboccipital nerve) innervates the atlanto-occipital joint (C0-C1). Therefore, any pathological condition or injury affecting this joint may refer pain to the occipital region. Furthermore, the spinal nerve of C2 and its dorsal root ganglion are in close proximity to the lateral capsule of the atlanto-axial zygapophyseal joints and innervate the atlanto-axial C1-C2 and C2-3 zygapophyseal joints. Therefore, any trauma or pathological change around these joints can be a source of referred head pain (Fernandez-de-las-penas et al., 2010). The dorsal ramus of C3 innervates the C2-C3 zygapophyseal joints and has a very close anatomical proximity to the C2-3 zygapophyseal joints. Pain from the C2-C3 zygapophyseal joints is referred to the occipital region but it may also refer to the fronto-temporal and peri-orbital regions (Fernandez-de-las-penas et al., 2010). Therefore, CGH may be caused by any structures innervated by the C1-C3 spinal nerves and include the upper cervical synovial joints and muscles (Bogduk, 2001).

Muscles are sensitive structures that react to all parts of the motor system (Middleditch and Oliver, 2005). Muscles themselves may be a source of local pain. The presence of pain or dysfunction in any element of the motion segment with the same segmental nerve supply may cause a response such as spasm and/or referred pain/ tenderness in the muscle controlling the segment (Middleditch and Oliver, 2005).

According to Watson and Trott (1993), Beeton and Jull (1994) and Jull et al. (1999) there is evidence that recruitment deficiency and endurance fatigue of the upper and deep cervical flexors is an important factor in patients with neck pain and CGH. In CGH, there is also an over-activation of the superficial sternocleidomastoid (SCM) muscles during neck flexion (Murphy, 2000; Jull, 2000). The deep neck flexors are primarily made up of the longus
coli and longus capitus muscles. They play a pivotal role in cervical spine conditions and are often overlooked as a source of locomotive system dysfunction. The orientation of the fibres would suggest these muscles have specific actions, including lateral flexion and flexion of the cervical spine (Murphy, 2000). However, these muscles appear to play a more important role as local stabilisers of the neck, allowing for correct movement to occur rather than creating it. This allows the larger global and more superficial muscles of the cervical spine, scapulae and thoracic spine that have cervical or cranial attachments to move the cervical spine without zygapophyseal joint compromise (Jull, 2000).

Janda (1994) noted specific patterns of muscle imbalances in patients with CGH. This pattern became known as upper cross syndrome and is described in several published studies on CGH (Moore, 2004). The upper crossed syndrome is characterised by tight upper trapezius, suboccipitals, pectoralis major, and levator scapulae and weak rhomboids, serratus anterior, middle and lower trapezius and the deep neck flexors, especially the scalene muscles (Moore, 2004). These patterns lead to locomotive system dysfunction.

2.3.5 Etiology

One of the most controversial areas within the CGH literature is the discussion of its underlying cause. The actual source of pain doesn’t originate in the head but in the cervical spine joint complex and the structures innervated by cervical nerves C1-C3. The possible sources of pain include the C2-C3 intervertebral disc annular fibres, muscles, joints, ligaments, and related dura mater of the upper cervical spine (Alix and Bates, 1999; Burger, 2007).

Almost every structure within the cervical spine and numerous pathologies affecting the cervical spine has been implicated as a cause of these headaches (Haldeman and Dagenais, 2001).

2.3.6 Signs and Symptoms

The signs and symptoms of CGH as described by Biondi (2005) include:

- Precipitation of headache, similar to the usual pain experienced by neck movement and/or sustained awkward head posture and by external pressure applied to the upper cervical or occipital region on the symptomatic side.
• Restricted CROM.
• Ipsilateral neck, shoulder or arm pain of a vague non-radicular nature. However, occasionally radicular arm pain may be present.
• Headache characteristics are moderate to severe in intensity, non-throbbing and usually begins in the neck.
• Headache episodes of varying duration or fluctuating, continuous pain.

Other signs and symptoms that are only occasionally present and of less importance as they may be attack-related phenomena include: nausea, phonophobia, photophobia, dizziness, ipsilateral blurred vision, dysphagia and ipsilateral periocular oedema (Biondi, 2005). Additionally, signs such as a decrease in CROM as well as shoulder and arm pain of the involved side are commonly present (Eldridge and Russell, 2005).

2.3.7 Diagnosis

The diagnosis of CGH has been driven by two schools of practice. Firstly, the clinical diagnosis approach which arose in Europe and is based on the belief that CGH has distinctive clinical features by which it can be diagnosed. Secondly, the interventional diagnosis approach by pain medicine which was developed in North America and Australia and is based on establishing a cervical source of pain in patients with headache by the use of controlled diagnostic blocks (Bogduk and Govind, 2009).

1. Clinical approach:

Antonaci and Sjaastad (2011) report that the diagnostic criteria for CGH include headache associated with neck pain and stiffness, starting unilaterally and posteriorly moving in a frontal direction and sometimes associated with ipsilateral arm discomfort. Sjaastad (2001) also identified another type of CGH which has bilateral head and neck pain aggravated by neck positions. Vincent (2010) described several factors one could use to differentiate CGH from other headaches. These include unilateral pain with zygapophyseal ‘locking’ radiating from the back of the head; evidence of cervical dysfunction presenting during manual examination; the pain may occur with trigger point palpation in the head and neck and aggravated by sustained neck positions.
2. Interventional Approach:

Practitioners use fluoroscopically-guided, controlled diagnostic blocks to test whether particular structures are the source of pain in patients with suspected CGH (Bogduk and Govind, 2009).

Studies have focused on three structures:

a) The lateral atlanto-axial joint can be anaesthetised by the use of intra-articular blocks.
b) The C2-C3 zygapophyseal joint can be blocked by anaesthetising the third occipital nerve where it crosses the joint.
c) The C3-C4 zygapophyseal joint can be anaesthetised by blocking the medial branches of the C3 and C4 dorsal rami.

A complete relief of the headache after such blocks, under controlled conditions, provides objective evidence of a cervical source of pain and is a diagnostic indicator of a CGH (Bogduk and Govind, 2009).

2.3.8 Differential Diagnosis

The main differential diagnoses for CGH are migraine and tension-type headache (Haldeman and Dagenais, 2001). The overlap in clinical features between CGH and the more common migraine and tension-type headache is the main reason for the controversy surrounding CGH (Jull et al., 2007). However, clinical studies have suggested that it is possible to discriminate between these three headache types (Jull et al., 2007).

Additionally, since the C2 spinal nerve is located posterior to the lateral atlanto-axial joint, two other conditions may also be confused with CGH. Firstly, neck-tongue syndrome, which is a condition resulting from a rapid movement of the neck that leads to a partial subluxation of the atlanto-axial joint. This disorder can be distinguished from CGH by the numbness of the tongue following pressure applied to the C2 spinal nerve. Secondly, C2 neuralgia caused by various inflammatory disorders; this condition can be distinguished from CGH by intermittent and lancinating pain in the occipital region (Bogduk and Govind, 2009).
2.3.8 Treatment

Cervicogenic headache treatment usually requires a multifaceted approach using pharmacological, non-pharmacological and occasionally surgical intervention in severe cases (Martelletti and van Suijlekom, 2004). Treatment usually begins with pharmacological intervention but many CGH patients do not respond to medication (Bogduk and Govind, 2009). Due to the risks associated with surgical interventions, more conservative interventions are typically prescribed unless the cases are severe (Page, 2011).

2.3.8.1 Pharmacological treatment

Pharmacological intervention for CGH includes medications which are used for the preventative or palliative management of migraine and neuropathic pain syndromes. Medications when used as the only mode of treatment do not generally provide substantial pain relief and as a result many patients with CGH overuse or become dependent on their medication. Examples of pharmacological drugs include, but are not limited to, tricyclic antidepressants, antiepileptic drugs, muscle relaxants and analgesics (Biondi, 2005).

Biondi (2005) explains the rationale for the use of each of these drugs. Tricyclic antidepressants have been used for various neuropathic, musculoskeletal, head and facial pain syndromes. Analgesic dosages are usually lower than those required for the treatment of depression. Antiepileptic drugs are believed to be modulators or stabilisers of peripheral and central pain transmission and are also commonly used for the above syndromes and CGH. Simple analgesics such as acetaminophen or non-steroidal anti-inflammatory drugs (NSAIDs) are commonly used for the management of chronic pain or as needed for the management of acute pain. Many muscle relaxants may have analgesic efficacy, especially those with central activity such as baclofen (Biondi, 2005).

The use of a nerve block or zygapophyseal joint blockage and corticosteroids can be used to assist with the diagnosis of CGH as previously described. However, they also play a role in the treatment of these headaches resulting in the alleviation of many of the symptoms (Da Silva and Bordini, 2006).
2.3.8.2 Non-pharmacological treatment

Physical and manual therapy are important for the treatment and rehabilitation of CGH (Nilsson et al., 1997). Jull and Stanton (2005) evaluated the effectiveness of therapeutic exercise and manipulative therapy for cases of CGH and found that the efficacy was not substantially affected by age, gender or the chronicity of headache in patients with moderate to serve pain intensity. This suggests that all patients with CGH could benefit from manual modes of therapy and physical conditioning (Biondi, 2005).

2.3.8.2.1 Modalities

Modalities are used to help reduce pain and facilitate healing. Examples of such modalities include TENS, cryotherapy and low level laser therapy. There are a few studies that support TENS and cryotherapy in combination with other therapies in the treatment of CGH. Low level laser therapy is becoming increasingly popular for the treatment of musculoskeletal conditions. However, there are no known studies on the effect of this treatment modality in CGH patients (Page, 2011). These modalities are mainly used by physical therapists and chiropractors.

2.3.8.2.2 Therapeutic exercise

There are a few studies that have focused on the effectiveness of therapeutic exercise in patients with CGH (Ylinen et al., 2010). A randomised, controlled trial of 200 patients with CGH by Jull et al. (1976) found that six weeks of cranio-cervical flexion exercise was as effective as spinal manipulation at reducing headache intensity and frequency. Therapeutic exercises are prescribed by biokinetists, physical therapists and chiropractors.

2.3.8.2.3 Dry needling

Sedighi et al. (2017) compared the acute effects of superficial and deep dry needling of the trigger points of the suboccipital and upper trapezius muscles in patients with CGH found that dry needling was effective in the treatment of CGH. The study consisted of 30 participants (eight men and 22 women) aged between 19 to 60 years with a clinical diagnosis of CGH who were randomly divided into a superficial and a deep needling group. A headache index, trigger point tenderness, CROM and a functional rating index were used to take measurements at baseline, immediately and one week after the treatment. The results of the two approaches of
dry needling showed reduction in headache index and trigger point tenderness. The deep dry needling group showed a significant improvement of CROM ($p < 0.001$) and functional rating index ($p < 0.01$) when compared to the superficial group. The authors concluded that the application of dry needling into trigger points of the suboccipital and upper trapezius muscles induced significant improvement in the headache index, trigger points tenderness, functional rating index and ROM in patients with CGH. However, deep dry needling had a greater effect on CROM and function (Sedighi et al., 2017).

2.3.8.2.4 Manipulative treatment

Due to CGH being related to cervical joint dysfunction, several studies on CGH treatment have focused on joint mobilisation or manipulation (Page, 2011). Various theories exist surrounding the mechanism of manipulative therapy with regards to mechanical and neurophysiological responses (Bergmann and Peterson, 2011), but the central theory implies the presence of a lesion (Gatterman, 1995) that affects the biomechanical function of a joint resulting in proximal and distal dysfunction and symptoms (Triano, 2000). According to Gibbons and Tehan (2001), the indications for manipulation are:

- Joint fixations
- Motion restriction
- Restoration of bony alignment
- Somatic dysfunction with loss of motion
- Acute joint locking
- Hypomobility
- Relaxation of muscles by reflex mechanisms
- Entrapment of meniscoids
- Pain modulation
- Adhesions
The effectiveness of manipulation is described by several theories as described by Gatterman (2005). These include:

1. **Mechanical**

This effect involves the correction of joint movement dysfunction and joint alignment. It is also thought that in the instance of an entrapped synovial membrane leading to restricted joint motion, the manipulative procedure will relieve pain by the separation of the joint surfaces.

2. **Soft tissue**

This involves the changes in the dynamics of the connective tissue and in the strength and tone of the supporting muscles.

3. **Neurological**

This includes a reduction in pain by restoring normal joint segmental motion, thereby, inhibiting the joint pain receptors. A common cause of joint dysfunction is incorrect neuromotor patterns caused by muscle imbalances. Therefore, correction of the joint dysfunction allows normal muscle and nerve control.

**2.3.8.2.4.1 Cervical spine manipulation**

According to Gibbons and Tehan (2001) CSM is commonly used as an intervention to resolve subluxations (fixation) in the neck and muscle guarding caused by the subluxation. A subluxation is a lesion within the zygapophyseal joints that is less than a dislocation, but one that alters physiological function, alignment and movement of the motion segment. Manipulation involves a brief, high velocity, low amplitude impulse directed at a dysfunctional synovial joint in order to move it past its normal physiological ROM but within its anatomical ROM (Bergman and Peterson, 2011). This enables the joint to move in its normal ROM, thereby restoring function to the joint (Di Fabio, 1992). There professions that can perform manipulation include chiropractors, physiotherapists and osteopaths.
Manipulation improves movement, malignment and overall function when directed to a joint subluxation (Gatterman, 2005). It also has a positive effect on the arthrogenic inhibitory reflex and breaks the pain cycle by stretching the surrounding muscle tissue and causing reflex relaxation (Van Tulder, Furnan and Gagnier, 2005). Cervical spine manipulation has also been found to increase active cervical ROM and decrease pain (Pikula, 1999; Whittingham and Nilsson, 2001) and a decreased ROM is a common finding in patients presenting with CHG. There are numerous studies of varying designs that have shown manipulation to be effective for CGH (Haas et al., 2004; Haas et al., 2010; Nilsson, 1995; Schoensee et al., 1995). A summary of the randomised clinical trials is shown in Table 2.2.

Table 2.2 Summary of randomised clinical trials of SMT in the treatment of CGH adapted from Chiabi and Russell (2012)

<table>
<thead>
<tr>
<th>Reference</th>
<th>Sample</th>
<th>Interventions</th>
<th>Outcome measures</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nilsson (1995)</td>
<td>39 participants (17 M, 22 F)</td>
<td>Half of the group received high-velocity, low-amplitude cervical manipulation twice a week for three weeks. The other half received low-level laser in the upper cervical region and deep friction massage (including trigger points) in the lower cervical/upper thoracic region, at the same intervention frequency as Group One.</td>
<td>The change from week two to week six in analgesics use per day. Headache intensity per episode. Number of headache hours per day.</td>
<td>A significant reduction in the manipulation group on all three outcome measures, however differences between the two treatment groups failed to reach statistical significance.</td>
</tr>
<tr>
<td>Nilsson et al. 1997</td>
<td>54 participants (23 M, 31 F)</td>
<td>28 of the participants received high-velocity, low-amplitude cervical manipulation twice a week for three weeks.</td>
<td>The change from week one to week five in analgesics use per day.</td>
<td>The use of analgesics decreased by 36% in the manipulation group, but was</td>
</tr>
</tbody>
</table>
Jull et al. (2002) 200 participants (60 M, 140 F) Age 18-60 years; mean age: 36.7 years

Participants were randomized into four groups: manipulative therapy group, exercise therapy group, combined therapy group, and a control group.

The primary outcome was a change in headache frequency.

Other outcomes included changes in headache intensity and duration, the Northwick Park Neck Pain Index, medication intake, and patient satisfaction.

Physical outcomes included pain on neck movement, upper cervical joint tenderness, analgesic use per day.

Headache intensity per episode.

Number of headache hours per day.

unchanged in the soft-tissue group; this difference was statistically significant ($p = .04$)

Headache intensity per episode decreased by 36% in the manipulation group, compared with 17% in the soft-tissue group; this was significant at $p = .04$.

The number of headache hours per day decreased by 69% in the manipulation group, compared with 37% in the soft-tissue group; this was significant at $p = 0.03$ (Mann-Whitney-U-test).

At the 12-month follow-up assessment, both manipulative therapy and specific exercise groups had significantly reduced headache frequency, intensity and the neck pain. The effects were maintained ($p < 0.05$ for all).

The combined therapies were not significantly superior to either therapy alone, but 10% more patients
<table>
<thead>
<tr>
<th>Study</th>
<th>Participants</th>
<th>Mean Age</th>
<th>Design/Procedure</th>
<th>Key Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haas et al. (2004)</td>
<td>24 participants (40.3 years)</td>
<td></td>
<td>Patients were randomly allocated to one, three, or four visits per week for 3 weeks. All patients received high-velocity low-amplitude spinal manipulation. Practitioner could apply up to 2 physical modalities at each visit from among heat and soft tissue therapy.</td>
<td>Outcomes included a 100-point Modified Von Korff pain and disability scale. There was substantial pain relief for 9 and 12 treatments compared with 3 visits. At 4 weeks, the advantage was ($p = 0.135$) for 3 visits per week and ($p = .041$) for 4 visits per week. At the 12-week follow-up, the advantage was ($p = 0.035$) for 3 visits per week and ($p = 0.048$) for 4 visits per week.</td>
</tr>
<tr>
<td>Borusiak et al. (2010)</td>
<td>52 participants (21 M, 31 F; mean age: 11.6 years)</td>
<td></td>
<td>After prospective baseline documentation for 2 months, patients were either assigned to a placebo or manipulation group with another 2-month follow-up.</td>
<td>The percentage of days with headache. Total duration of headache. Number of days absent from school due to headache. Consumption of analgesics. Intensity of headache. There was no significant difference comparing the groups with placebo and manipulation with respect to the defined main outcome measures.</td>
</tr>
<tr>
<td>Haas et al. (2010)</td>
<td>80 participants (36 years)</td>
<td></td>
<td>Participants were randomized to either 8 or 16 treatment sessions with either SMT or a minimal light massage as a control.</td>
<td>A modified Von Korff pain and disability scales for CGH and neck pain (minimum clinically important difference = 10) For the CGH pain scale, comparisons of 8 and 16 treatment sessions yielded small dose effects. There was an advantage for SMT</td>
</tr>
</tbody>
</table>
Participants were treated once or twice a week for 8 weeks. on 100-point scale)
Number of headaches in the last 4 weeks
Analgesic medication use.
Data was collected every 4 weeks for 24 weeks.
The primary outcome was the CGH pain scale.

Patients receiving SMT were also more likely to achieve a 50% improvement in pain scale.
For the SMT patients, the mean number of CGH were reduced by half.

All the studies in Table 2.2 used similar age parameters to that of this study. Those studies showed CSM to be an effective form of treatment for CGH, with only the study by Borusiak et al. (2010), in which participants were between the ages of 7-15 years showed no difference between the placebo and treatment group.

2.3.8.2.4.2 Electromechanical adjusting instrument

The EAI is a manual therapy device used for a variety of musculoskeletal conditions. The EAI is used for the delivery of manipulation and mobilization to the musculoskeletal system (Colloca et al., 2005). The EAI delivers multiple thrusts and provides a wide range of forces that have been shown to improve spinal motion responses when compared to the Activator Instrument (Colloca et al., 2005). The EAI is hypothesized to treat different areas of the body including joints, muscles and nerves in order to relieve pain and restore function (www.impulseseminars.com/impulse). The EAI has three different force settings (low [100 N], medium [200 N] and high [400 N]) for different parts of the body and to treat patients of all ages. The controlled low force thrust of the EAI makes treatment more comfortable and reduces the occurrence of post-treatment discomfort (www.impulseseminars.com/impulseiq).

The EAI exploits a microprocessor-controlled electromagnetic coil to generate a haversine-like impulse, approximately two milliseconds in duration. Haversine impulse profiles result in a uniform mechanical energy being delivered to the test structure over a broad frequency
range, ranging from zero to 200 Hertz (Hz) (Colloca et al., 2005). Embedded within the EAI is a motion sensor and a micro-computer which monitors alterations in movement and the frequency of the movement is ascertained in real-time by the acceleration responses acquired from the spine. As the tissue ricochets during the application, information is fed into the micro-computer and the Auto-sense® technology sets the frequency of succeeding thrusts. In this manner, the acceleration response is continuously monitored during treatment and adjusting terminates automatically when motion is maximised in an effort to control treatment dosage (http://impulseseminars.com/impulseiq).

The EAI has been shown to be more effective on spinal fixations when compared to various other adjusting instruments such as the Chiropractic Adjusting Tool (CAT) and the Activator Adjusting Instrument IV (Keller et al., 2006). The EAI has not been used to treat CGH previously and no such studies have been done on headaches using the EAI.

2.4 CONCLUSION

There are numerous clinical studies that have been conducted on the effectiveness of CSM in the treatment of CGH. The EAI is an alternate to CSM and, therefore, indicated for the treatment of CGH. However, no studies have been conducted demonstrating its effectiveness in the treatment of CGH. The EAI may be a more comfortable form of therapy for certain patients when compared to CSM. Research has shown the therapeutic effects of CSM on CGH; however, due to post-treatment soreness and some people having the fear of their necks being handled or manually manipulated, an alternative method for treatment which may be just as effective could be beneficial. In order to address the paucity in the literature, the aim of this study was to determine the effectiveness of the EAI compared to CSM in the treatment of CGH's.
CHAPTER 3: METHODOLOGY

3.1 STUDY DESIGN

The study paradigm was quantitative in nature and the design was a single-blinded, randomised clinical trial.

3.2 SAMPLING

3.2.1 Population

The study population consisted of participants with CGH residing within the eThekwini Municipality of KwaZulu Natal province.

3.2.2 Recruitment

Advertisements (Appendix A) were placed on the notice boards at the Durban University of Technology (DUT) (campuses and residences); the Chiropractic Day Clinic (CDC) and Spar supermarkets (on the free advertisement boards) after permission had been granted by the relevant authorities. Prospective participants were requested to contact the researcher telephonically for more information.

All prospective participants who contacted the researcher were informed that this was a preliminary selection and further inclusion and exclusion criteria were to be applied during the telephonic interview (Appendix B) as well as during the first consultation. The questions asked during the telephonic interview are shown in Table 3.1.
Table 3.1: Telephonic questions to determine preliminary eligibility for the study

<table>
<thead>
<tr>
<th>Question</th>
<th>Correct answers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Would you be willing to answer a few questions regarding your headache?</td>
<td>Yes</td>
</tr>
<tr>
<td>2. How old are you?</td>
<td>Between 18 and 60 years of age</td>
</tr>
<tr>
<td>3. Describe the character of your headache.</td>
<td>On one side without side changes</td>
</tr>
<tr>
<td>4. Is the headache brought on by neck movements?</td>
<td>Yes</td>
</tr>
<tr>
<td>5. Do you have any stiffness and/or decreased movement in your neck?</td>
<td>Yes</td>
</tr>
</tbody>
</table>

3.2.3 Sample Size

The sample size for the study was 47, the participants were randomly allocated into one of two groups i.e. CSM group and EAI group by means of a randomisation table drawn up by the statistician. However, for reason discussed in Chapter 5, three participants from each group dropped out, resulting in 21 participants in Group A and 20 in Group B respectively. Group sample sizes achieve a 97.339% power to reject the null hypothesis of equal means when the population mean difference is 1.4 with a standard deviation for both groups of 1.1 and with a significance level (alpha) of 0.050 using a two-sided two-sample equal-variance t-test (Esterhuizen, 2015).

3.2.4 Sample Allocation

Once the prospective participants’ eligibility was determined through the telephonic interview (Appendix B) an appointment was made at the DUT CDC. Each participant, thereafter underwent an appointment consisting of a case history (Appendix C), a physical examination (Appendix D) and cervical spine regional examination (Appendix E). In order to confirm eligibility. Thereafter, prospective participants were allocated into one of two intervention groups, utilising a randomisation table generated by a statistician. This randomisation table was kept by the clinic student administrator at the CDC, who allocated the participants into the
groups. Therefore, the researcher was not privy to the group allocations prior to determining eligibility of a participant.

3.3 RESEARCH PROCEDURE

After the participant met the criteria as per the telephonic interview, an appointment was made at the DUT CDC in which permission was obtained by the CDC clinic director (Appendix F), DUT Director of Research (Appendix G) and approval granted by the Institutional Research and Ethics committee (IREC) (REC90/16) (Appendix H). A verbal explanation of the research procedure was given to each participant at the initial consultation. A letter of information was given to each participant to read. Thereafter, written informed consent was obtained from each participant (Appendix I). The participant was then given the opportunity to ask any questions regarding the research procedure. Each participant, thereafter underwent an appointment consisting of a case history (Appendix C), a physical examination (Appendix D) and cervical spine regional examination (Appendix E). A SOAPE note (Appendix J) was completed and signed off by the clinician on duty.

Once the suitability of the participant was determined, the participant was then randomly allocated into one of the two intervention groups. A research assistant (RA) then took the CROM readings. The RA was unaware of the intervention the participant was receiving. The principle researcher was blinded to the objective findings in order to avoid researcher bias. The RA underwent training by the supervisor and researcher prior to the commencement of the research and was declared competent by the supervisor (Appendix K).

Participants in Group A then received CSM to one of the upper three cervical segments in the most restricted direction plane ascertained during the cervical spine regional examination. Participants in Group B received a single adjustment with the EAI to the most restricted upper cervical segment found during the cervical spine regional examination.
3.4 INCLUSION AND EXCLUSION CRITERIA

3.4.1 Inclusion Criteria

- All participants were between 18 and 60 years of age. A study by Nilsson et al. (1997) used participants between the ages of 20 to 60 years. The mean age of individuals who suffer from CGH is 42.9 years of age (Biondi, 2005).
- The diagnostic criteria for CGH has been established, with agreement that these headaches start in the neck or occipital region and are associated with tenderness of the cervical paraspinal tissues (Haldeman and Dagenais, 2001). At least one of the major diagnostic criteria described by Sjaastad (2000) had to be satisfied for a participant to be included in the study. The major diagnostic criteria for cervicogenic headaches are as follows:
  - Unilateral headache without side shift
  - Precipitation of the headache by neck movement, sustained awkward head positioning or by external pressure on the upper cervical or occipital area on the symptomatic side
  - Restricted range of motion of the upper cervical spine
  - Ipsilateral non-radicular neck, shoulder and arm pain
- A NRS scale score of five or greater at the initial consultation in terms of cervicogenic pain to ensure standardisation.
- Participants had to be able to comprehend English to be included in the study.

3.4.2 Exclusion Criteria

- Participants were excluded from the study if they were diagnosed with any of the following contraindications to manipulation (Gatterman, 1991):
  - Metabolic disorders such as osteoporosis, osteomalacia and clotting disorders
  - Vertebral-basilar artery insufficiency
  - Atherosclerosis of major vessels
  - Aneurysms
  - Tumours (lung, thyroid, breast and bone)
  - Bone infections (tuberculosis, osteomyelitis)
  - Traumatic injuries (instability, fractures and severe sprains)
  - Rheumatoid and psoriatic arthritis
- Neurological complications

All these contraindications were screened for in the case history, physical and cervical spine regional examinations.

- All participants taking anti-inflammatory or muscle relaxant medication had to have had a three day “wash out” period before participating in the study (Seth, 1999).
- Participants that were at the time receiving any treatment for their headache.

### 3.5 RESEARCH ASSISTANT

A research assistant was recruited to measure the objective variable (CROM readings), they were blinded as to the intervention the patient was receiving. The RA was trained by the supervisor and principle researcher and was declared competent by the supervisor (Appendix K). The RA received training suggested by Norkin and White (2009) on the use of the CROM device. The RA was trained on how to position the participant in the testing position so that the gravity inclinometer read zero degrees and how to place the CROM device on the participant’s head so that the nosepiece was on the bridge of the nose and the bands fitted snugly across the back of the participant’s head (Norkin and White, 2009). The RA was then trained on how to guide the participant’s neck into flexion, extension, rotation right, rotation left, lateral flexion right and lateral flexion left.

### 3.6 INTERVENTIONS

#### 3.6.1 Cervical Spine Manipulation

Cervical spine manipulation was administered to participants in Group A according to the techniques described by Bergmann and Peterson (2002). The entire cervical spine was motion palpated prior to the manipulation. At least one manipulative technique to the upper three cervical segments was performed with the participant seated in whichever motion plane was noted to be most restricted during the cervical spine regional examination.
3.6.2 Electromechanical Adjusting Instrument

Participants in Group B had their entire cervical spine motion palpated as previously described and the EAI was administered to at least one of the upper three cervical spine segments.

Before the intervention, the researcher explained to the participants that they would hear a rattling sound when the thrusts were delivered by the device and a beeping sound would be heard upon completion. The EAI has three different force settings viz. low, medium and high. The controlled low force thrust of the EAI makes treatment more comfortable and reduces the occurrence of post-treatment discomfort and is typically used for smaller segments such as the cervical spine. For the purpose of this study, the low force setting was used for every participant. The patient lay prone on a treatment table with their arms in a relaxed position. The manipulation was delivered with the participant’s neck in a neutral position. The involved segment may have been restricted on either side and in these instances the single stylus was placed on the involvement side and the thrust applied. The double cervical stylus was used in the presence of extension or flexion restrictions.

Figure 3.1: The Impulse Adjusting Instrument
Source: http://www.concordnhchiropractor.com/images/impulse-instrument.jpg
3.6.3 Intervention Frequency

Participants in both groups received six treatments over a three-week period with a minimum of 48 hours between each intervention. The RA took CROM readings at consultation one prior to the manipulation, at the third consultation post-manipulation and at the sixth consultation post-manipulation.

**Consultation One:** After the case history, physical and cervical regional examinations, all participants underwent baseline subjective and objective assessments prior to their respective interventions.

**Consultation Two:** Participants only received the relevant intervention at this consultation.

**Consultation Three:** The intervention was administered prior to the objective assessments to ensure the objective assessments were taken at the same intervention intervals as the subjective assessments (post third intervention).

**Consultation Four:** The intervention was administered following the subjective assessments to ensure the subjective assessments were taken at the same intervention intervals as the objective assessments (post third intervention).

**Consultation Five:** Only the intervention was administered at this consultation.

**Consultation Six:** The intervention was administered prior to subjective and objective assessments.
3.7 MEASUREMENT TOOLS

3.7.1 Subjective Assessments

3.7.1.1 Numerical Pain Rating Scale

The NRS (Appendix L) was used to rate the participants’ pain intensity on a numerical scale of zero to 10. The NRS is a valid and reliable tool used to subjectively monitor the degree of effectiveness of a treatment protocol (Bolton and Wilkinson, 1998). In a study of 79 participants Pool et al. (2007), compared the NRS to the Verbal Rating Scale (VRS) and the Visual Analogue Scale (VAS). The NRS was found to be the most responsive with an effect size of 0.86 and pain rating sensitivity and specificity of 0.8. Jenson et al. (1986) in a study using 75 patients who rated their pain using six different scales showed the NRS to be valid and reliable. Each of the scales met the five criteria to judge intensity scales. The scales all correctly had similar results in terms of predictability, however, the NRS was said to be the most predictable which yields it valid and reliable (Jenson et al., 1986). This scale was said to be a practical and easy to use scale (Jensen et al., 1986).

The participants of the current study completed the NRS at pre-initial intervention, post-third intervention and post-sixth intervention. The participants were asked to rate their current perceived pain on a scale that ranged from zero to ten with zero equal to no pain and ten equal to worst pain possible (Q1). Participants were also asked to rate their usual level of pain during the week (Q2). In this study, it was required that the NRS (Q1) be five or greater at the baseline reading to ensure sample homogeneity.

3.7.1.2 Headache Disability Index

The HDI (Appendix M) was used to determine the effects of the headache on the participant’s quality of life (Yeomans, 2000). Each participant completed the HDI at the first consultation prior to the intervention, at the fourth consultation prior to the intervention and at the final consultation post-intervention. The HDI is a 25-question tool that includes 12 emotional and 13 functional questions. Questions related to emotional and functional factors of daily life were answered with a “Yes”, “Sometimes” or “No”. Scores for each answer “Yes”= 4 points, “Sometimes”= 2 points and “No”= 0 points gives a total scale of 100% and two sub-scales for
emotional and functional status. This allowed for each participant’s disability to be monitored in response to the interventions they had received. Two questions related to the headache frequency and severity are also included in the HDI. Blizzard, Grimmer and Dwyer (2000) reported that headache questionnaires can be used successfully in determining the disability of headaches. Consent for the use of HDI in this study was granted (Appendix N).

3.7.1.3 Neck Disability Index

The NDI (Appendix O) was completed at the first consultation prior to the intervention, at the fourth consultation prior to the intervention and at the final consultation post-intervention. The NDI was used to determine how the participants’ neck pain affected their ability to manage in everyday life. Ten questions covering domains of pain intensity, personal care (e.g. washing and dressing), lifting, reading, headaches, concentration, work, driving, sleeping and recreation were individually evaluated and a total score was derived. Each domain had six possible answers from no significance to major significance in the participant’s life. Scores for each question were obtained in a zero to five approach for their severity and the total score divided by 50 provided the overall NDI score. Cleland (2006) reported that the test-retest reliability of the NDI was moderate (intra-class correlation coefficient [ICC] = 0.68; 95% confidence interval [CI], 0.30–0.90). Consent for the use of the NDI in this study was granted (Appendix P).

3.7.2 Objective Measurements

3.7.2.1 Cervical range of motion goniometer

The CROM goniometer has a magnetic yoke and gravity goniometers which measure the CROM in the frontal, transverse and sagittal planes. The CROM goniometer was placed on the participant’s nasal bridge, over the ears and fastened with velcro straps to back of the head. It was used to assess the active cervical flexion, extension, right and left rotation, and right and left lateral flexion with each movement occurring until the participant could not move further or if the pain resulted in restriction of the movement. The RA conducted the CROM assessments as described previously.

According to Youdas (1991), when compared to two other goniometers, the CROM showed a higher level of reliability and he also reported good inter- and intra-examiner reliability with the
procedure not affecting the participant’s condition. Tousignant, Duclos and Lafleche (2002) in their study reported CROM to have good validity with respect to the measuring flexion (ICC= 0.73-0.89), extension, right (ICC= 0.81-0.94) and left (ICC= 0.90-0.97) rotation and right (ICC= 0.66-0.93) and left (ICC=0.62-0.92) lateral flexion.

Rheault et al. (1992) described how the CROM measurements should be taken:

- **Step 1**: The CROM instrument should be placed on the bridge of the nose and on the ears of the participant and fastened at the back of the head with velcro straps.
- **Step 2**: The participant’s chair should then be positioned in such a way that the magnetic field is zeroed on the dial meter for the rotational measurement.
- **Step 3**: The participant has to sit erect with the low back against the backrest, and the mid-back away from the chair. The arms should hang freely at the sides and feet should be together on the floor.
- **Step 4**: The calibrated dials should be set to zero before assessing active cervical flexion, extension, right and left rotation, and right and left lateral flexion.
- **Step 5**: Each motion should be assessed twice with the final recorded value being an average of the two.

CROM assessments were taken by the RA prior to the first intervention, post the third intervention and post the sixth intervention.

### 3.8 STATISTICAL ANALYSIS

IBM SPSS version 24.0 was used to analyse the data. A p value <0.05 was considered as statistically significant. In order to assess completeness of randomization and if drop out bias had affected the study groups, baseline demographics and outcome measures were compared between the two groups using independent samples t tests for the continuous outcomes and Pearson’s chi square tests for the categorical outcomes Intra-group comparison of the outcomes over time was assessed using repeated measures ANOVA for within-subjects factor of time (3 time points). Intra-group comparisons of outcomes over time between the two groups was also assessed using repeated measures ANOVA including within and between subjects’ effects. Profile plots were used to assess the direction and trend of the effect (Esterhuizen, 2017).
CHAPTER 4: RESULTS

4.1 INTRODUCTION

In this chapter, data obtained from each subject was analyzed in the form of subjective and objective measures, as described in Chapter Three.

The analysis included:
1. Demographic data analysis comprising age and gender.
2. Subjective assessments obtained from the NRS (Q1 and Q2), HDI and NDI questionnaires.
3. Active cervical flexion, extension, right and left rotation, and right and left lateral flexion obtained using the CROM goniometer.

4.2 DEMOGRAPHICS

The sample size was 41 participants with 21 in Group A (CSM) and 20 in Group B (EAI). The participants were between 19 and 59 years of age with a mean age of 34.3 years. The participants in Group A had a mean age of 32.7 years, whereas those in Group B had a mean age of 35.7 years (Table 4.1). There was no significant difference between age groups \( (p = 0.443) \). Females made up 73.2% of the participants.

Table 4.1: Descriptive statistics of the age and gender of the participants

<table>
<thead>
<tr>
<th>Data</th>
<th>Group A</th>
<th>Group B</th>
<th>Combined Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age distribution (years)</td>
<td>19-54</td>
<td>19-59</td>
<td>19-59</td>
</tr>
<tr>
<td>Mean age (years)</td>
<td>32.7</td>
<td>35.7</td>
<td>34.3</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>11.6</td>
<td>13.0</td>
<td>12.5</td>
</tr>
<tr>
<td>Gender distribution</td>
<td>17 females</td>
<td>13 females</td>
<td>30 females</td>
</tr>
<tr>
<td></td>
<td>4 males</td>
<td>7 males</td>
<td>11 males</td>
</tr>
</tbody>
</table>
4.3 BASELINE MEASUREMENTS

There were no statistically significant differences for the CROM values, NRS1 Q1, NRS1 Q2, HDI, and NDI scores between the two groups at baseline (Table 4.2).

Table 4.2: Comparison of the baseline measurements between the groups

<table>
<thead>
<tr>
<th>Group Statistics</th>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>Std. deviation</th>
<th>Std. error mean</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>NRS1 Q1</td>
<td>A - CSM</td>
<td>21</td>
<td>5.71</td>
<td>1.189</td>
<td>0.260</td>
<td>-0.764</td>
<td>0.450</td>
</tr>
<tr>
<td></td>
<td>B - EAI</td>
<td>20</td>
<td>6.05</td>
<td>1.605</td>
<td>0.359</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NRS1 Q2</td>
<td>A - CSM</td>
<td>21</td>
<td>6.81</td>
<td>1.250</td>
<td>0.273</td>
<td>0.795</td>
<td>0.431</td>
</tr>
<tr>
<td></td>
<td>B - EAI</td>
<td>20</td>
<td>6.40</td>
<td>1.984</td>
<td>0.444</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NDI1</td>
<td>A - CSM</td>
<td>21</td>
<td>15.19</td>
<td>5.627</td>
<td>1.228</td>
<td>-1.074</td>
<td>0.290</td>
</tr>
<tr>
<td></td>
<td>B - EAI</td>
<td>20</td>
<td>17.35</td>
<td>7.191</td>
<td>1.608</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HDI1</td>
<td>A - CSM</td>
<td>21</td>
<td>49.33</td>
<td>20.281</td>
<td>4.426</td>
<td>-0.518</td>
<td>0.607</td>
</tr>
<tr>
<td></td>
<td>B - EAI</td>
<td>20</td>
<td>53.20</td>
<td>27.140</td>
<td>6.069</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexion</td>
<td>A - CSM</td>
<td>21</td>
<td>46.14</td>
<td>8.522</td>
<td>1.860</td>
<td>0.335</td>
<td>0.739</td>
</tr>
<tr>
<td></td>
<td>B - EAI</td>
<td>20</td>
<td>45.15</td>
<td>10.378</td>
<td>2.321</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extension</td>
<td>A - CSM</td>
<td>21</td>
<td>60.24</td>
<td>11.031</td>
<td>2.407</td>
<td>1.072</td>
<td>0.290</td>
</tr>
<tr>
<td></td>
<td>B - EAI</td>
<td>20</td>
<td>55.65</td>
<td>16.040</td>
<td>3.587</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lateral (R)</td>
<td>A - CSM</td>
<td>21</td>
<td>40.71</td>
<td>8.861</td>
<td>1.934</td>
<td>1.051</td>
<td></td>
</tr>
</tbody>
</table>
### 4.4 INTRA-GROUP ANALYSIS

#### 4.4.1 Numerical Pain Rating Scale Q1

The information from the table below indicates a highly significant decrease in pain over time ($p < 0.001$; repeated measures ANOVA) in both groups. (*Table 4.3*).

<table>
<thead>
<tr>
<th>Group</th>
<th>Effect</th>
<th>Value</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>time</td>
<td>Pillai's Trace</td>
<td>0.754</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wilks' Lambda</td>
<td>0.246</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hotelling's Trace</td>
<td>3.073</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Roy's Largest Root</td>
<td>3.073</td>
</tr>
<tr>
<td>B</td>
<td>time</td>
<td>Pillai's Trace</td>
<td>0.630</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wilks' Lambda</td>
<td>0.370</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hotelling's Trace</td>
<td>1.704</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Roy's Largest Root</td>
<td>1.704</td>
</tr>
</tbody>
</table>
### Table 4.4 Mean and standard deviation of NRS Q1 over time

<table>
<thead>
<tr>
<th></th>
<th>Group</th>
<th>Mean</th>
<th>Std. deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NRS (pre-initial) Q1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A - CSM</td>
<td>5.71</td>
<td>1.189</td>
<td></td>
<td>21</td>
</tr>
<tr>
<td>B - EAI</td>
<td>6.05</td>
<td>1.605</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>5.88</td>
<td>1.400</td>
<td></td>
<td>41</td>
</tr>
<tr>
<td><strong>NRS (post-third) Q1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A - CSM</td>
<td>2.86</td>
<td>2.575</td>
<td></td>
<td>21</td>
</tr>
<tr>
<td>B - EAI</td>
<td>3.60</td>
<td>1.957</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>3.22</td>
<td>2.297</td>
<td></td>
<td>41</td>
</tr>
<tr>
<td><strong>NRS (post-sixth) Q1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A - CSM</td>
<td>2.29</td>
<td>2.171</td>
<td></td>
<td>21</td>
</tr>
<tr>
<td>B - EAI</td>
<td>2.40</td>
<td>2.257</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>2.34</td>
<td>2.186</td>
<td></td>
<td>41</td>
</tr>
</tbody>
</table>

**Figure 4.1**: Mean NRS Q1 over time in Group A
4.4.2 Numerical Pain Rating Scale Q2

The table below indicates there was a highly significant decrease in pain over time ($p < 0.001$; $p = 0.001$ repeated measures ANOVA) in both groups.

**Table 4.5: NRS Q2**

<table>
<thead>
<tr>
<th>Group</th>
<th>Effect</th>
<th>Value</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>time</td>
<td>Pillai's Trace</td>
<td>.703</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wilks' Lambda</td>
<td>.297</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hotelling's Trace</td>
<td>2.372</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Roy's Largest Root</td>
<td>2.372</td>
</tr>
<tr>
<td>B</td>
<td>time</td>
<td>Pillai's Trace</td>
<td>.562</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wilks' Lambda</td>
<td>.438</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hotelling's Trace</td>
<td>1.283</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Roy's Largest Root</td>
<td>1.283</td>
</tr>
</tbody>
</table>
Table 4.6: Mean and Standard deviation of NRS Q2 over time

<table>
<thead>
<tr>
<th></th>
<th>Group</th>
<th>Mean</th>
<th>Std. deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>NRS (pre-initial) Q2</td>
<td>A - CSM</td>
<td>6.81</td>
<td>1.250</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>B - EAI</td>
<td>6.40</td>
<td>1.984</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>6.61</strong></td>
<td><strong>1.641</strong></td>
<td><strong>41</strong></td>
</tr>
<tr>
<td>NRS (post-third) Q2</td>
<td>A - CSM</td>
<td>3.81</td>
<td>1.914</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>B - EAI</td>
<td>4.15</td>
<td>2.254</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>3.98</strong></td>
<td><strong>2.067</strong></td>
<td><strong>41</strong></td>
</tr>
<tr>
<td>NRS (post-sixth) Q2</td>
<td>A - CSM</td>
<td>3.05</td>
<td>2.291</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>B - EAI</td>
<td>2.70</td>
<td>2.342</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>2.88</strong></td>
<td><strong>2.293</strong></td>
<td><strong>41</strong></td>
</tr>
</tbody>
</table>

Figure 4.3: Mean NRS Q2 over time in Group A
4.4.3 Neck Disability Index

The table below indicates there was a highly significant decrease in pain over time (p < 0.001; repeated measures ANOVA) in both groups.

**Table 4.7: NDI**

<table>
<thead>
<tr>
<th>Group</th>
<th>Effect</th>
<th>Value</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>time</td>
<td>Pillai’s Trace</td>
<td>.692</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wilks’ Lambda</td>
<td>.308</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hotelling’s Trace</td>
<td>2.247</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Roy's Largest Root</td>
<td>2.247</td>
</tr>
<tr>
<td>B</td>
<td>time</td>
<td>Pillai’s Trace</td>
<td>.696</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wilks’ Lambda</td>
<td>.304</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hotelling’s Trace</td>
<td>2.288</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Roy's Largest Root</td>
<td>2.288</td>
</tr>
</tbody>
</table>
Table 4.8: Mean and Standard deviation of NDI over time

<table>
<thead>
<tr>
<th></th>
<th>Group</th>
<th>Mean</th>
<th>Std. deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>NDI (pre-initial)</td>
<td>A - CSM</td>
<td>15.19</td>
<td>5.627</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>B - EAI</td>
<td>17.35</td>
<td>7.191</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>16.24</td>
<td>6.449</td>
<td>41</td>
</tr>
<tr>
<td>NDI (post-third)</td>
<td>A - CSM</td>
<td>8.57</td>
<td>6.439</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>B - EAI</td>
<td>8.55</td>
<td>7.884</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>8.56</td>
<td>7.089</td>
<td>41</td>
</tr>
<tr>
<td>NDI (post-sixth)</td>
<td>A - CSM</td>
<td>6.14</td>
<td>6.077</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>B - EAI</td>
<td>6.05</td>
<td>7.067</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>6.10</td>
<td>6.495</td>
<td>41</td>
</tr>
</tbody>
</table>

Figure 4.5: Mean NDI over time in Group A
Figure 4.6: Mean NDI over time in Group B
4.4.4 Headache Disability Index

The table below indicates there was a highly significant decrease in pain over time ($p < 0.001$; repeated measures ANOVA) in both groups.

**Table 4.9: HDI**

<table>
<thead>
<tr>
<th>Group</th>
<th>Effect</th>
<th>Value</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>time</td>
<td>Pillai's Trace</td>
<td>.659</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wilks' Lambda</td>
<td>.341</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hotelling's Trace</td>
<td>1.933</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Roy's Largest Root</td>
<td>1.933</td>
</tr>
<tr>
<td>B</td>
<td>time</td>
<td>Pillai's Trace</td>
<td>.611</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wilks' Lambda</td>
<td>.389</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hotelling's Trace</td>
<td>1.570</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Roy's Largest Root</td>
<td>1.570</td>
</tr>
</tbody>
</table>

**Table 4.10: Mean and Standard deviation of HDI over time**

**Descriptive statistics**

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean</th>
<th>Std. deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>HDI (pre-initial)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A - CSM</td>
<td>49.33</td>
<td>20.281</td>
<td>21</td>
</tr>
<tr>
<td>B - EAI</td>
<td>53.20</td>
<td>27.140</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td>51.22</td>
<td>23.651</td>
<td>41</td>
</tr>
<tr>
<td>HDI (post-third)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A - CSM</td>
<td>31.43</td>
<td>18.806</td>
<td>21</td>
</tr>
<tr>
<td>B - EAI</td>
<td>33.40</td>
<td>25.099</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td>32.39</td>
<td>21.841</td>
<td>41</td>
</tr>
<tr>
<td>HDI (post-sixth)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A - CSM</td>
<td>22.00</td>
<td>18.558</td>
<td>21</td>
</tr>
<tr>
<td>B - EAI</td>
<td>22.30</td>
<td>23.290</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td>22.15</td>
<td>20.734</td>
<td>41</td>
</tr>
</tbody>
</table>
Figure 4.7: Mean HDI over time in Group A

Figure 4.8: Mean HDI over time in Group B
4.4.5 Cervical Flexion

The table below indicates there was a significant increase cervical flexion over time ($p = 0.017$; 0.016 repeated measures ANOVA) in both groups.

**Table 4.11: Cervical flexion**

<table>
<thead>
<tr>
<th>Group</th>
<th>Effect</th>
<th>Value</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>time</td>
<td>Pillai's Trace</td>
<td>.350</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wilks' Lambda</td>
<td>.650</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hotelling's Trace</td>
<td>.538</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Roy's Largest Root</td>
<td>.538</td>
</tr>
<tr>
<td>B</td>
<td>time</td>
<td>Pillai's Trace</td>
<td>.370</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wilks' Lambda</td>
<td>.630</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hotelling's Trace</td>
<td>.586</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Roy's Largest Root</td>
<td>.586</td>
</tr>
</tbody>
</table>

**Table 4.12: Mean and Standard deviation of cervical flexion over time**

<table>
<thead>
<tr>
<th>Descriptive statistics</th>
<th>Group</th>
<th>Mean</th>
<th>Std. deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion (pre-initial)</td>
<td>A - CSM</td>
<td>46.14</td>
<td>8.522</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>B - EAI</td>
<td>45.15</td>
<td>10.378</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>45.66</td>
<td>9.366</td>
<td>41</td>
</tr>
<tr>
<td>Flexion (post-third)</td>
<td>A - CSM</td>
<td>49.14</td>
<td>11.333</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>B - EAI</td>
<td>47.80</td>
<td>9.945</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>48.49</td>
<td>10.567</td>
<td>41</td>
</tr>
<tr>
<td>Flexion (post-sixth)</td>
<td>A - CSM</td>
<td>51.19</td>
<td>10.342</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>B - EAI</td>
<td>51.55</td>
<td>7.156</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>51.37</td>
<td>8.823</td>
<td>41</td>
</tr>
</tbody>
</table>
Figure 4.9: Cervical flexion measurements over time in Group A

Figure 4.10: Cervical flexion measurements over time in Group B
4.4.6 Cervical Extension

The table below indicates that there was a significant increase in cervical extension over time in both groups ($p = 0.001$; $p = 0.005$ repeated measures ANOVA).

**Table 4.13: Cervical extension**

<table>
<thead>
<tr>
<th>Group</th>
<th>Effect</th>
<th>Value</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>time</td>
<td>Pillai's Trace</td>
<td>.521</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wilks' Lambda</td>
<td>.479</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hotelling's Trace</td>
<td>1.090</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Roy's Largest Root</td>
<td>1.090</td>
</tr>
<tr>
<td>B</td>
<td>time</td>
<td>Pillai's Trace</td>
<td>.446</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wilks' Lambda</td>
<td>.554</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hotelling's Trace</td>
<td>.806</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Roy's Largest Root</td>
<td>.806</td>
</tr>
</tbody>
</table>

**Table 4.14: Mean and Standard deviation of cervical extension over time**

**Descriptive statistics**

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean</th>
<th>Std. deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extension (pre-initial)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A - CSM</td>
<td>60.24</td>
<td>11.031</td>
<td>21</td>
</tr>
<tr>
<td>B - EAI</td>
<td>55.65</td>
<td>16.040</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td>58.00</td>
<td>13.728</td>
<td>41</td>
</tr>
<tr>
<td>Extension (post-third)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A - CSM</td>
<td>62.10</td>
<td>9.959</td>
<td>21</td>
</tr>
<tr>
<td>B - EAI</td>
<td>60.55</td>
<td>14.598</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td>61.34</td>
<td>12.306</td>
<td>41</td>
</tr>
<tr>
<td>Extension (post-sixth)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A - CSM</td>
<td>70.29</td>
<td>12.673</td>
<td>21</td>
</tr>
<tr>
<td>B - EAI</td>
<td>67.35</td>
<td>12.313</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td>68.85</td>
<td>12.431</td>
<td>41</td>
</tr>
</tbody>
</table>
Figure 4.11: Cervical extension measurements over time in Group A

Figure 4.12: Cervical extension measurements over time in Group B
4.4.7 Cervical right lateral flexion

The table below shows a highly significant increase in lateral right over time (p=0.001) in group A and only a marginal increase in lateral right over time in group B (p=0.046).

Table 4.15: Cervical right lateral flexion

<table>
<thead>
<tr>
<th>Group</th>
<th>Effect</th>
<th>Value</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>time</td>
<td>Pillai's Trace</td>
<td>.507</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wilks' Lambda</td>
<td>.493</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hotelling's Trace</td>
<td>1.028</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Roy's Largest Root</td>
<td>1.028</td>
</tr>
<tr>
<td>B</td>
<td>time</td>
<td>Pillai's Trace</td>
<td>.290</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wilks' Lambda</td>
<td>.710</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hotelling's Trace</td>
<td>.409</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Roy's Largest Root</td>
<td>.409</td>
</tr>
</tbody>
</table>

Table 4.16: Mean and Standard deviation of Cervical lateral right over time.

Descriptive statistics

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean</th>
<th>Std. deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lateral (R) (pre-initial)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A - CSM</td>
<td>40.71</td>
<td>8.861</td>
<td>21</td>
</tr>
<tr>
<td>B - EAI</td>
<td>37.60</td>
<td>10.091</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td>39.20</td>
<td>9.493</td>
<td>41</td>
</tr>
<tr>
<td>Lateral (R) (post-third)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A - CSM</td>
<td>43.05</td>
<td>5.334</td>
<td>21</td>
</tr>
<tr>
<td>B - EAI</td>
<td>39.10</td>
<td>8.156</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td>41.12</td>
<td>7.058</td>
<td>41</td>
</tr>
<tr>
<td>Lateral (R) (post sixth)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A - CSM</td>
<td>48.00</td>
<td>7.403</td>
<td>21</td>
</tr>
<tr>
<td>B - EAI</td>
<td>43.20</td>
<td>10.087</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td>45.66</td>
<td>9.035</td>
<td>41</td>
</tr>
</tbody>
</table>
Figure 4.13: Cervical right lateral flexion measurements over time in Group A

Figure 4.14: Cervical right lateral measurements over time in Group B
4.4.8 Cervical left lateral flexion

The table below shows a highly significant increase in lateral left in group A (p<0.001) and a non-significant change in group B (p=0.068).

Table 4.17: Cervical left lateral flexion

<table>
<thead>
<tr>
<th>Group</th>
<th>Effect</th>
<th>Value</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>time</td>
<td>Pillai’s Trace</td>
<td>.614</td>
</tr>
<tr>
<td>A</td>
<td>time</td>
<td>Wilks’ Lambda</td>
<td>.386</td>
</tr>
<tr>
<td></td>
<td>time</td>
<td>Hotelling’s Trace</td>
<td>1.589</td>
</tr>
<tr>
<td></td>
<td>time</td>
<td>Roy’s Largest Root</td>
<td>1.589</td>
</tr>
<tr>
<td>B</td>
<td>time</td>
<td>Pillai’s Trace</td>
<td>.258</td>
</tr>
<tr>
<td></td>
<td>time</td>
<td>Wilks’ Lambda</td>
<td>.742</td>
</tr>
<tr>
<td></td>
<td>time</td>
<td>Hotelling’s Trace</td>
<td>.348</td>
</tr>
<tr>
<td></td>
<td>time</td>
<td>Roy’s Largest Root</td>
<td>.348</td>
</tr>
</tbody>
</table>

Table 4.18: Mean and Standard deviation of cervical left lateral flexion

Descriptive statistics

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean</th>
<th>Std. deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lateral (L) (pre-initial)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A - CSM</td>
<td>42.86</td>
<td>7.519</td>
<td>21</td>
</tr>
<tr>
<td>B - EAI</td>
<td>40.80</td>
<td>13.241</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td>41.85</td>
<td>10.613</td>
<td>41</td>
</tr>
<tr>
<td>Lateral (L) (post-third)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A - CSM</td>
<td>45.38</td>
<td>7.460</td>
<td>21</td>
</tr>
<tr>
<td>B - EAI</td>
<td>41.30</td>
<td>8.060</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td>43.39</td>
<td>7.934</td>
<td>41</td>
</tr>
<tr>
<td>Lateral (L) (post-sixth)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A - CSM</td>
<td>50.81</td>
<td>8.681</td>
<td>21</td>
</tr>
<tr>
<td>B - EAI</td>
<td>44.55</td>
<td>9.093</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td>47.76</td>
<td>9.327</td>
<td>41</td>
</tr>
</tbody>
</table>
Figure 4.15: Cervical left lateral flexion measurements over time in Group A

Figure 4.16: Cervical left lateral measurements over time in Group B
4.4.9 Cervical right rotation

The table below indicates a significant increase in right rotation in group A (p=0.002) And in group B (p=0.028)

Table 4.19: Cervical right rotation

<table>
<thead>
<tr>
<th>Group</th>
<th>Effect</th>
<th>Value</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>time</td>
<td>Pillai’s Trace</td>
<td>.470</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wilks’ Lambda</td>
<td>.530</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hotelling's Trace</td>
<td>.888</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Roy’s Largest Root</td>
<td>.888</td>
</tr>
<tr>
<td>B</td>
<td>time</td>
<td>Pillai’s Trace</td>
<td>.328</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wilks’ Lambda</td>
<td>.672</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hotelling's Trace</td>
<td>.487</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Roy’s Largest Root</td>
<td>.487</td>
</tr>
</tbody>
</table>

Table 4.20: Mean and Standard deviation of cervical right rotation over time

<table>
<thead>
<tr>
<th>Descriptive statistics</th>
<th>Group</th>
<th>Mean</th>
<th>Std. deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotation (R) (pre-initial)</td>
<td>A - CSM</td>
<td>57.10</td>
<td>7.968</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>B - EAI</td>
<td>54.70</td>
<td>11.640</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>55.93</td>
<td>9.878</td>
<td>41</td>
</tr>
<tr>
<td>Rotation (R) (post-third)</td>
<td>A - CSM</td>
<td>61.71</td>
<td>6.604</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>B - EAI</td>
<td>57.65</td>
<td>10.535</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>59.73</td>
<td>8.874</td>
<td>41</td>
</tr>
<tr>
<td>Rotation (R) (post-sixth)</td>
<td>A - CSM</td>
<td>66.10</td>
<td>5.300</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>B - EAI</td>
<td>61.00</td>
<td>9.341</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>63.61</td>
<td>7.883</td>
<td>41</td>
</tr>
</tbody>
</table>
Figure 4.17: Cervical right rotation measurements over time in Group A

Figure 4.18: Cervical right rotation measurements over time in Group B
4.4.10 Cervical left rotation

The table below indicates a highly significant increase in left rotation in group A \( (p=0.001) \) and a non-significant change in group B \( (p=0.110) \).

**Table 4.21: Cervical left rotation**

<table>
<thead>
<tr>
<th>Group</th>
<th>Effect</th>
<th>Value</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>time</td>
<td>Pillai's Trace</td>
<td>.505</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wilks' Lambda</td>
<td>.495</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hotelling's Trace</td>
<td>1.018</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Roy's Largest Root</td>
<td>1.018</td>
</tr>
<tr>
<td>B</td>
<td>time</td>
<td>Pillai's Trace</td>
<td>.217</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wilks' Lambda</td>
<td>.783</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hotelling's Trace</td>
<td>.278</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Roy's Largest Root</td>
<td>.278</td>
</tr>
</tbody>
</table>

**Table 4.22: Mean and Standard deviation of cervical rotation left**

**Descriptive statistics**

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean</th>
<th>Std. deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotation (L) (pre-initial)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A - CSM</td>
<td>54.52</td>
<td>8.721</td>
<td>21</td>
</tr>
<tr>
<td>B - EAI</td>
<td>56.25</td>
<td>10.642</td>
<td>20</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>55.37</strong></td>
<td><strong>9.622</strong></td>
<td><strong>41</strong></td>
</tr>
<tr>
<td>Rotation (L) (post-third)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A - CSM</td>
<td>59.71</td>
<td>8.527</td>
<td>21</td>
</tr>
<tr>
<td>B - EAI</td>
<td>60.90</td>
<td>9.591</td>
<td>20</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>60.29</strong></td>
<td><strong>8.967</strong></td>
<td><strong>41</strong></td>
</tr>
<tr>
<td>Rotation (L) (post-sixth)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A - CSM</td>
<td>64.33</td>
<td>8.357</td>
<td>21</td>
</tr>
<tr>
<td>B - EAI</td>
<td>60.85</td>
<td>11.500</td>
<td>20</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>62.63</strong></td>
<td><strong>10.042</strong></td>
<td><strong>41</strong></td>
</tr>
</tbody>
</table>
Figure 4.19: Cervical left rotation measurements over time in Group A
4.5 INTER-GROUP ANALYSIS

4.5.1 Numerical Pain Rating Scale Q1

The effect of time was statistically significant ($p < 0.001$); however, there was no interaction effect of time and group ($p = 0.721$) (Table 4.23). Therefore, the change in NRS Q1 over time was not significantly different between the two groups.

Almost parallel slopes of the profiles of the two groups over time was demonstrated (Figure 4.21). Both groups had significant decrease in pain intensity, therefore, both groups had an effect on NRS Q1. Group B had a higher initial and final pain score compared to Group A. All participants' pain intensity decreased at the same time.

Figure 4.20: CROM rotation left measurements over time in Group B
Table 4.23: Effects for NRS Q1 in both groups’ within-subjects

<table>
<thead>
<tr>
<th>Effect</th>
<th>Statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>Wilk’s lambda = 0.114</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Time x group</td>
<td>Wilk’s lambda = 0.948</td>
<td>0.721</td>
</tr>
<tr>
<td>Group</td>
<td>F = 0.331</td>
<td>0.721</td>
</tr>
</tbody>
</table>

Figure 4.21: NRS Q1 measurements comparisons over time between Groups A and B

4.5.2 Numerical Pain Rating Scale Q2

The effect of time was statistically significant (p < 0.001); however, there was no interaction effect of time and group (p = 0.457) (Table 4.24). Therefore, the change in NRS Q2 over time was not significantly different between the two groups. (Figure 4.22) shows almost parallel slopes of the profiles of the two groups over time.

Table 4.24 Effects for NRS Q2 in both groups’ within-subjects

<table>
<thead>
<tr>
<th>Effect</th>
<th>Statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>Wilk’s lambda = 0.398</td>
<td>0.001</td>
</tr>
<tr>
<td>Time x group</td>
<td>Wilk’s lambda = 0.960</td>
<td>0.457</td>
</tr>
<tr>
<td>Group</td>
<td>F = 0.799</td>
<td>0.457</td>
</tr>
</tbody>
</table>
Figure 4.22: NRS Q2 measurements comparisons over time between Groups A and B

4.5.3 Neck Disability Index

The effect of time was statistically significant ($p < 0.001$); however, there was no interaction effect of time and group ($p = 0.601$) (Table 4.25). Therefore, no significant differences in the treatment effects were observed.

Almost parallel slopes of the profiles of the two groups over time was seen (Figure 4.23). Group B initially had a non-significant higher mean NDI score but there was a steady decrease for both groups; however, the trend in the graph suggests that the rate of decrease is higher for Group B when compared to Group A between time = 1 and time = 2. This was, however, not significant. The decrease slightly decreases in both groups between time = 2 and time = 3.

Table 4.25: Effects for NDI in both groups' within-subjects

<table>
<thead>
<tr>
<th>Effect</th>
<th>Statistic</th>
<th>$p$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>Wilk's lambda = 0.310</td>
<td>0.001</td>
</tr>
<tr>
<td>Time x group</td>
<td>Wilk's lambda = 0.974</td>
<td>0.601</td>
</tr>
<tr>
<td>Group</td>
<td>$F = 0.517$</td>
<td>0.601</td>
</tr>
</tbody>
</table>
4.5.4 Headache Disability Index

There was no significant difference on the effect of time between the two groups ($p < 0.001$) and there was also no significant difference in treatment effects between the two groups ($p = 0.875$; repeated measures ANOVA) (Table 4.26).

Almost parallel slopes of the profiles of the two groups were seen over time (Figure 4.24). There was steady decrease between time = 1 and time = 2 followed by a slight decrease between time = 2 and time = 3 in both groups. The trend in the graph suggests that the rate of decrease is equal in both groups. Therefore, there was no significant difference in treatment effects between the two groups.

Table 4.26: Effects for HDI in both groups’ within-subjects

<table>
<thead>
<tr>
<th>Effect</th>
<th>Statistic</th>
<th>$p$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>Wilk’s lambda = 0.372</td>
<td>0.001</td>
</tr>
<tr>
<td>Time x group</td>
<td>Wilk’s lambda = 0.993</td>
<td>0.875</td>
</tr>
<tr>
<td>Group</td>
<td>$F = 0.134$</td>
<td>0.875</td>
</tr>
</tbody>
</table>
There was no interaction effect of time and group ($p = 0.849$). This indicates that the outcome was not influenced by which treatment group the participant was in. There was no evidence of a differential treatment effect in the two groups for CROM flexion ($p = 0.849$) (Table 4.27).

Almost parallel slopes of the profiles of the two groups were seen over time (Figure 4.25). There was an identically steady increase between time = 1 and time = 2 in both groups followed by a further increase between time = 2 and time = 3 in both groups more so for group B. The trend in the graph suggests that the rate of increase of cervical flexion is equal in both groups. Therefore, there was no significant difference in treatment effects between the two groups.

### Table 4.27: Effects on cervical flexion in both groups’ within-subjects

<table>
<thead>
<tr>
<th>Effect</th>
<th>Statistic</th>
<th>$p$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>Wilk’s lambda = 0.640</td>
<td>0.001</td>
</tr>
<tr>
<td>Time x group</td>
<td>Wilk’s lambda = 0.991</td>
<td>0.849</td>
</tr>
<tr>
<td>Group</td>
<td>$F = 0.165$</td>
<td>0.849</td>
</tr>
</tbody>
</table>
4.5.6 Cervical Extension

No interaction effect of time and group ($p = 0.738$). This showed that cervical extension was not influenced by which treatment group the participant was in (Table 4.28).

Almost parallel slopes of the profiles of the two groups was seen over time (Figure 4.26). Group B shows a steeper trend between time = 1 and time = 2 than Group A; however; Group A steepens between time = 2 and time = 3. The overall trend in the graph suggests that the rate of increase is equal in both groups therefore there was no significant difference in treatment effects between the two groups.
Table 4.28: Effects on cervical extension in both groups' within-subjects

<table>
<thead>
<tr>
<th>Effect</th>
<th>Statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>Wilk's lambda = 0.522</td>
<td>0.001</td>
</tr>
<tr>
<td>Time x group</td>
<td>Wilk's lambda = 0.984</td>
<td>0.738</td>
</tr>
<tr>
<td>Group</td>
<td>F = 0.306</td>
<td>0.738</td>
</tr>
</tbody>
</table>

![Graph showing cervical extension measurements comparisons over time between Groups A and B]

Figure 4.26: Cervical extension measurements comparisons over time between Groups A and B

4.5.7 Cervical Right Lateral Flexion

No interaction effect of time and group ($p = 0.850$), therefore, the change in lateral right over time was not different between the treatment groups.

Almost parallel slopes of the profiles of the two groups over time was demonstrated (Figure 4.27). The overall trend in the graph suggests that the rate of increase is equal in both groups therefore there was no significant difference in treatment effects between the two groups.
Table 4.29: Effects on cervical right lateral flexion in both groups’ within-subjects

<table>
<thead>
<tr>
<th>Effect</th>
<th>Statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>Wilk’s lambda = 0.620</td>
<td>0.001</td>
</tr>
<tr>
<td>Time x group</td>
<td>Wilk’s lambda = 0.991</td>
<td>0.850</td>
</tr>
<tr>
<td>Group</td>
<td>F = 0.163</td>
<td>0.850</td>
</tr>
</tbody>
</table>

Figure 4.27: Cervical right lateral flexion measurements comparisons over time between Groups A and B

4.5.8 Cervical Left Lateral Flexion

There was no significant difference in the means of left lateral flexion between the two groups at time = 1 and time = 2 and time = 2 and time = 3 and time = 1 and time = 3. Almost parallel slopes of the profiles of the two groups were seen over time (Figure 4.28). The slope for group A was marginally steeper especially between time = 2 and time = 3. The overall trend in the graph suggests that the rate of increase is equal in both groups and, therefore, there was no significant difference in treatment effects on left lateral flexion between the two groups.
Table 4.30: Effects on cervical left lateral flexion in both groups’ within-subjects

<table>
<thead>
<tr>
<th>Effect</th>
<th>Statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>Wilk’s lambda = 0.634</td>
<td>0.001</td>
</tr>
<tr>
<td>Time x group</td>
<td>Wilk’s lambda = 0.950</td>
<td>0.379</td>
</tr>
<tr>
<td>Group</td>
<td>F = 0.996</td>
<td>0.379</td>
</tr>
</tbody>
</table>

Figure 4.28: Cervical left lateral measurements comparisons over time between Groups A and B

4.5.9 Cervical Right Rotation

No interaction effect of time and group ($p = 0.671$). Indicating that the outcome was not influenced by which treatment group the participant was in. Almost parallel slopes of the profiles of the two groups over time was demonstrated (Figure 4.29). The overall trend in the graph suggests that the rate of increase is similar in both groups; therefore, there was no significant difference in treatment effects on right rotation between the two groups.
Table 4.31: Effects on cervical right rotation in both groups’ within-subjects

<table>
<thead>
<tr>
<th>Effect</th>
<th>Statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>Wilk’s lambda = 0.597</td>
<td>0.001</td>
</tr>
<tr>
<td>Time x group</td>
<td>Wilk’s lambda = 0.979</td>
<td>0.671</td>
</tr>
<tr>
<td>Group</td>
<td>F = 0.404</td>
<td>0.671</td>
</tr>
</tbody>
</table>

Figure 4.29: Cervical right rotation measurements comparisons over time between Groups A and B

4.5.10 Cervical Left Rotation

No interaction effect of time and group \( (p = 0.283) \) indicating that the outcome was not influenced by which treatment group the participant was in.

Almost parallel slopes of the profiles of the two groups was seen over time (Figure 4.30). Although Group A’s slope was steeper between time = 2 and time = 3 as group B plateaued between that period. The overall trend in the graph suggests that the rate of increase is equal in both groups. Therefore, there was no significant difference in treatment effects on left rotation between the two groups.
### Table 4.32: Effects on cervical left rotation in both groups' within-subjects

<table>
<thead>
<tr>
<th>Effect</th>
<th>Statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>Wilk’s lambda = 0.664</td>
<td>0.001</td>
</tr>
<tr>
<td>Time x group</td>
<td>Wilk’s lambda = 0.936</td>
<td>0.283</td>
</tr>
<tr>
<td>Group</td>
<td>F = 1.305</td>
<td>0.283</td>
</tr>
</tbody>
</table>

**Figure 4.30**: Cervical left rotation measurements comparisons over time between Groups A and B

### 4.6 CONCLUSION

For most of the outcomes, there was no clinical or statistical interaction present i.e. the treatment effect was identical in both groups and, thus, it made no difference to the participant if they were treated with either modality. However, for left lateral and left rotation, there was a non-significant trend which suggested group A was superior to group B; however, this would have to be verified in a larger sample as this study was not powered sufficiently to show a difference of a small magnitude such as this.
CHAPTER 5 DISCUSSION

5.1 INTRODUCTION

This chapter will discuss the results and attempt to explain the subjective and objective data findings observed in this study. References will be made to relevant sections in Chapter Four in addition to the studies discussed in Chapter Two.

The statistical and clinical significance of the data obtained with respect to subjective and objective measurements at the three time periods will be discussed in relation to the relevant theories.

5.2 SAMPLE SIZE, AGE AND GENDER OF THE PARTICIPANTS

5.2.1 Sample Size

This study had a total sample size of 47 participants. However, six dropped out of the study (three from each group). The reasons for the drop outs were the inability to return for follow-ups because of work commitments, transport difficulties or student protest action on campus. This resulted in 41 participants with 21 in Group A and 20 in Group B. This was a similar number to that of the studies by Whittingham and Ellis (1994) and Nilsson (1995) who had sample sizes of 36 and 38 respectively.

5.2.2 Age

All participants had to be between 18 and 60 years of age in keeping with the inclusion criteria of this study. Studies done by Nilsson et al. (1997) and Jull et al. (2002) included participants between the ages of 20 to 60 years and 18 to 60 years respectively. The participants of the present study were between 19 and 59 years. Participants in Group A had a mean age of 32.71 years, whereas the participants in Group B had a mean age of 35.70 years. Groups A and B were, therefore, comparable in terms of age due to their similar mean values ($p = 0.443$).

The mean age of all participants was 34.3 years of age (Table 4.1). This is marginally lower than the 36.7 and 37 year mean age reported by Jull et al. (2002) and Nilsson et al. (1997)
respectively. This may be due to most of the participants being either students or staff members at the university where the study was conducted. Most students are between the ages of 18 to 25 years (Blauth et al., 2011). Since both students and staff have to attend daily classes, they have better access to the research premises in terms of exposure and convenience. Therefore, they would be more likely to respond to the advertisements and attend the follow-up consultations.

5.2.3 Gender

A systematic review on seven different clinical trials that used manual therapy for the treatment of CGH by Chaibi and Russell (2012) reported that all the trials reviewed had a female participant bias. There were more female participants (30 - 73.2%) than males (11 – 26.8%) despite the random allocation to the groups. This finding is similar to the 79.1% female and a 20.9% male preponderance found by Haldeman and Dagenais (2001). Furthermore, a female predominance has been shown in other studies. According to a study done by Cunningham, Boult and Popenoe (1997), it is more common for females to experience health related problems and injuries when compared with males and as a result, females are more likely to recognise signs of illness, seek treatment and utilise health services. This is further supported by a study which considered the demographics of patients utilising chiropractic services in Australia (French et al. 2013). The results showed that more females (67%) visited chiropractic clinics compared with males (33%).

5.3 SUBJECTIVE DATA ANALYSIS

5.3.1 Numerical Pain Rating Scale (Q1) and (Q2)

The NRS was used at three time variables (pre-initial treatment, post-third treatment and post-sixth treatment) to subjectively assess the participant’s headache status. The mean and standard deviation for each group are shown in Table 4.4 and Table 4.6 respectively.

With regards to (Q1) both Groups A and B had a statistically significant decrease in pain intensity over the three time points. The average improvement between visit one and the final visit for Group A was 1.71. This improvement was statistically significant ($p = 0.001$).
The average improvement between visit one and the final visit for Group B was 1.83. This improvement was also statistically significant ($p = 0.001$).

When comparing the mean NRS (Q1) value between Group A and Group B, Group B had a marginally superior mean decrease in pain intensity on average between consults (Table 4.23); however, this was not statistically or clinically significant as the larger mean decrease may be due to the superior decrease from the initial measurement to the second reading in this group. From a clinical perspective, it may be hypothesized that this slightly larger decrease in the mean pain intensity may be attributed to the controlled low force thrust of the EAI which resulted in reducing the post-treatment discomfort when compared to CSM. Furthermore, post-treatment discomfort may be subjectively perceived as pain intensity and this may explain the non-significant difference between mean changes between readings.

With regards to (Q2) both Groups A and B had a statistically significant decrease in pain intensity over the three time points ($p = 0.001$) (Table 4.24). Group A had an average improvement between visit one and the final visit of 1.88. This improvement was statistically significant ($p = 0.001$).

For Group B, the NRS (Q2) average improvement between visit one and the final visit was 1.85. This improvement was statistically significant ($p = 0.001$).

Intergroup analysis of the NRS (Q2) values between Groups A and B showed a similar mean decrease between the time periods (1.88(A), 1.85 (B)). Therefore, there was no significant difference between the treatment groups in terms of usual level of pain during the week.

These results concur with those of Whittingham and Ellis (1994). They treated 36 CGH sufferers with spinal manipulation and reported a statistically significant decrease in pain intensity. Nilsson et al. (1997) also reported similar decrease in pain intensity; however, in that study, the outcome measurement was VAS and not NRS. It must be noted that the NRS was shown to be superior to the VAS.

The Null Hypothesis (Ho) was accepted with regards to pain intensity as both groups showed a statistically significant decrease in pain intensity.
5.3.3 Neck Disability Index

The NDI was used at three time points (pre-initial treatment, post-third treatment and post-sixth treatment) to subjectively assess how the participants’ neck pain had affected their ability to manage everyday life. The mean and standard deviation are shown in Table 4.25.

Both Groups A and B had significantly decreased in NDI scores over the three time points ($p = 0.001$) (Figure 4.23). Both groups had similar mean NDI values at baseline measurements indicating that there was no statistically significant difference between the two groups ($p = 0.290$). Group A had a mean value of 15.19 and Group B had a mean value of 17.35. The groups were, therefore, comparable for the NDI at the start of the study. Cleland, Childs and Whitman (2008) proposed that the minimal detectable change (MDC) for the NDI was 19 percentage points (mean value of 9.5). Dundar et al. (2007) reported that the NDI had a mean value of 13.2 with a standard deviation of ±6.5; this was similar to the NDI values obtained in this study.

Intragroup analysis for Group A showed a steady and significant decrease in NDI scores over the three time intervals, with an average mean decrease of 4.53 NDI scores between each time interval and a total mean decrease of 9.05. This indicates that CSM decreased the impact of neck pain on the activities of daily living for the participants in this group.

Intragroup analysis for Group B showed a steady and significant decrease in NDI scores over the three time intervals, with an average mean decrease of 5.65 NDI scores between each of the three time intervals and a total mean decrease of 11.3. This indicates that EAI decreased the impact of neck pain on the activities of daily living for the participants in this group.

Intergroup analysis of the NDI scores between Group A and B showed that Group B had a slightly larger mean decrease between each time periods viz. 4.53 (A) and 5.65 (B) as well as a slightly larger total mean decrease of 11.3 compared to mean decrease of 9.05 in Group A. However, these differences were not significant to reject the Null Hypothesis (Ho).

The Null Hypothesis (Ho) was accepted as there was no significant difference in the mean NDI scores between the two groups.
5.3.4 Headache Disability Index

The HDI was used at three time variables (pre-initial treatment, post-third treatment and post-sixth treatment) to subjectively assess the participants’ ability to manage everyday life. The descriptive statistics are as follows:

Both groups had similar mean HDI values at baseline with no statistically significant difference between the two groups ($p = 0.607$). Group A had a mean HDI value of 49.33 while Group B had a mean HDI value of 53.20 at baseline. The groups were, therefore, comparable for the HDI at the start of the study.

Intragroup analysis for Group A showed a significant decrease in HDI scores over the three time intervals, with an average mean decrease of 13.67 HDI points between each time interval and a total mean decrease of 27.33. This infers that CSM decreased the impact of CGH on the activities of daily living for the participants in this group.

Intragroup analysis for Group B showed a significant decrease in HDI scores over the three time intervals, with an average mean decrease of 15.45 HDI scores between each of the three time intervals and a total mean decrease of 30.9. This indicates that EAI decreased the impact of CGH on the activities of daily living for the participants in this group.

Intergroup analysis of the HDI scores between Groups A and B showed that Group B had a slightly larger mean decrease between each time periods viz. 13.67 (A) and 15.45 (B) as well as a slightly larger total mean decrease of 30.9 compared to a mean decrease of 27.33 in Group A. This leans towards accepting the alternate hypothesis, that the EAI is more effective; however, the results were not significant enough to reject the Null Hypothesis (Ho).

The Null Hypothesis (Ho) is accepted as there was no significant difference in the mean HDI scores in both groups.
5.4 OBJECTIVE MEASURES

5.4.1 Cervical range of motion

The CROM goniometer was used at three time variables (pre-initial treatment, post-third treatment and post-sixth treatment) to objectively assess if there was any change in CROM as decreased CROM is one of the key features of CGH.

Youdas et al. (1992) observed good intra-tester and inter-tester reliability when measuring the active cervical spine ROM with the CROM instrument. The intra-class correlation coefficients were generally greater than 0.80°. A cohort study by Swinkles and Swinkels-Meewisse (2014) assessed 400 asymptomatic participants; 100 for each decade of age from 20 to 60 years. There were 50 males and 50 females in each subgroup to generate normal values for active CROM in asymptomatic individuals. The average CROM values for individuals aged between 30-39 years are shown in Table 5.5.

Table 5.5 Average CROM values for individuals aged between 30-39 years (Swinkles and Swinkels-Meewisse, 2014)

<table>
<thead>
<tr>
<th>Active CROM Movement</th>
<th>Degrees of Movement</th>
<th>Std. deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion</td>
<td>58</td>
<td>8.706</td>
</tr>
<tr>
<td>Extension</td>
<td>69</td>
<td>10.347</td>
</tr>
<tr>
<td>Lateral (Right)</td>
<td>42</td>
<td>7.091</td>
</tr>
<tr>
<td>Lateral (Left)</td>
<td>43</td>
<td>6.400</td>
</tr>
<tr>
<td>Rotation (Right)</td>
<td>79</td>
<td>8.891</td>
</tr>
<tr>
<td>Rotation (Left)</td>
<td>79</td>
<td>8.600</td>
</tr>
</tbody>
</table>

5.4.1.1 Cervical flexion

The normal cervical flexion is 58° in healthy individuals aged between 30 to 39 years (Swinkels and Swinkels-Meewisse, 2014). Earlier, Hole et al. (1995) stated that the mean cervical flexion in healthy individuals aged between 30 and 39 years was 58.9°.
Both groups had almost similar mean cervical flexion values at baseline measurements with no statistically significant difference between the two groups ($p = 0.739$). Group A had a mean of 46.14° while Group B had a mean of 45.15° at baseline. Therefore, the groups were comparable at the start of the study. The mean and standard deviation of the cervical flexion is shown in Table 4.11.

Intragroup analysis for Group A showed a significant increase in CROM flexion measurements over the three time intervals. There was an average mean increase of 2.53° between each time interval and a total mean increase of 5.05°. This indicates that CSM increased the active cervical flexion in CGH sufferers.

Intragroup analysis for Group B showed a significant increase in CROM flexion over the three time intervals. There was an average mean increase of 3.2° between each of the three time intervals and a total mean increase of 6.4°. This infers that EAI increased the active cervical flexion in CGH sufferers.

Intergroup analysis of CROM flexion measurements between Groups A and B shows that Group B had a slightly larger mean increase between each time period, as well as a statistically insignificant larger total mean increase of 6.2° compared to the mean increase of 5.05° in Group A. This leans towards accepting the alternate hypothesis, that the EAI is more effective; however, the results were not significant enough to reject the Null Hypothesis (Ho).

The results showed that both CSM and EAI increased active cervical flexion, it was not substantial with a mean increase of 5.7 degrees between both groups. A possible explanation for this is that only the upper three cervical vertebrae were treated in this study. According to several authors, only a small amount of cervical flexion occurs at these segments. Dvorak et al. (1988) and Lind et al. (1989) stated that only ten degrees of flexion occurs at the C2-C3 level. Therefore, a mean increase of 5.7 degrees between the groups is clinically substantial.

The Null Hypothesis (Ho) is accepted as there was no significant difference in the mean cervical flexion values in both groups.
5.4.1.2 Cervical extension

The normal cervical extension is 69° in healthy individuals between the ages of 30 and 39 years (Swinkels and Swinkels-Meewisse, 2014). Although Group A had a larger baseline value the difference was not statistically significant \((p = 0.290)\). Group A had a mean value of 60.24° while Group B had a mean value of 55.65° at baseline. Therefore, the groups were comparable for cervical extension at the start of the study. The mean and standard deviation for the cervical extension is shown in Table 4.14.

Intragroup analysis for Group A showed a significant increase in cervical extension measurements over the three time intervals. There was an average mean increase of 5.3° between each time interval and a total mean increase of 10.05°. This indicates that CSM increased the active cervical extension in CGH sufferers.

Intragroup analysis for Group B showed a significant increase in cervical extension over the three time intervals. There was an average mean increase of 5.85° between each of the three time intervals and a total mean increase of 11.7°. This indicates that EAI increased the active cervical extension in CGH sufferers.

Intergroup analysis of cervical extension measurements between Groups A and B showed that Group B had a slightly larger mean increase between each time period, as well as a statistically insignificant larger total mean increase of 5.85° compared to the mean increase of 5.3° in Group A between the time intervals. Furthermore, the total mean change was 1.2° more in Group B. This leans towards accepting the alternate hypothesis, that the EAI is more effective, however, the results were not significant enough to reject the Null Hypothesis (Ho).

Although the baseline cervical extension means were lower than the proposed normal cervical extension values, the final readings showed a superior cervical extension measure in both groups. The results showed that both CSM and EAI increased active cervical extension. The Null Hypothesis (Ho) is, therefore, accepted.
5.4.1.3. Right lateral flexion

The normal cervical right lateral flexion is 42° in healthy individuals between the ages of 30 and 39 years (Swinkels and Swinkels-Meewisse, 2014). Earlier, Trott et al. (1996) stated that the average cervical right lateral flexion in individuals aged between 30 and 39 years was 44.8°.

Although Group A had a larger baseline value, the difference was not statistically significant \((p = 0.300)\) from Group B. Group A had a mean right lateral flexion value of 40.71° while Group B had a mean value of 37.60° at baseline. The groups were, therefore, comparable for right lateral flexion at the start of the study. The mean and standard deviation for cervical right lateral flexion are shown in Table 4.16.

Intragroup analysis for Group A showed a significant increase in the mean cervical right lateral flexion values over the three time intervals, with an average mean increase of 3.65° between each time interval and a total mean increase of 7.29°. This infers that CSM increased the active cervical right lateral flexion in CGH sufferers.

Intragroup analysis for Group B showed there was a marginal increase in the mean cervical right lateral flexion values over the three time intervals, with an average mean increase of 2.8° between each of the three time intervals and a total mean increase of 5.6°. This indicates that the EAI increased the active cervical right lateral flexion in CGH sufferers.

Intergroup analysis of cervical right lateral flexion measurements between Groups A and B showed that Group A had a slightly larger mean increase between each time period, as well as a larger total mean increase of 3.65° compared to the mean increase of 2.8° in Group B between the time intervals. Furthermore, the total mean change was a 1.69° more in Group A. This leans towards rejecting both the alternate hypothesis and the null hypothesis, however the results were not significant enough to reject the Null Hypothesis (Ho).

The marginal changes in right lateral flexion in Group B can be explained using a study by McNair, Lapidos and Wheeler (2006), who stated that the greatest amount of positive change in CROM after one treatment with joint mobilisation therapy was obtained in flexion and extension movements. Lateral flexion ROM was the least detectable degree of improvement. A similar study by Gemmel (2008), who assessed only lateral flexion, concluded that the differences in lateral flexion were generally marginal and were not as easily detected when compared to changes in flexion and extension movements.
The results showed that both CSM and EAI increased the amount of active cervical right lateral flexion. Therefore, the Null Hypothesis (Ho) is accepted.

5.4.1.4. Left lateral flexion

The normal amount of cervical left lateral flexion is 43° in healthy individuals between the ages of 30 and 39 years (Swinkels and Swinkels-Meewisse, 2014). Although Group A had a larger mean baseline value, the difference was not statistically significant ($p = 0.542$). Group A had a mean value of 42.86° while Group B had a mean value of 40.80° at baseline. Therefore, for left lateral flexion, the groups were comparable at the start of the study. The mean and standard deviation of left lateral flexion are shown in Table 4.18.

Intragroup analysis for Group A showed a significant increase in cervical left lateral flexion over the three time intervals, with an average mean increase of 3.98° between each time interval and a total mean increase of 7.95°. This indicates that CSM increased the active cervical left lateral flexion in CGH sufferers.

Intragroup analysis for Group B showed there was non-significant increase in cervical left lateral flexion over the three time intervals, with an average mean increase of 1.88° between each of the three time intervals and a total mean increase of 3.75°. This indicates that EAI only marginally increased the active cervical left lateral flexion in CGH sufferers.

Intergroup analysis of cervical left lateral flexion between Groups A and B shows that Group A increased on average a mean 2.1° more than Group B between each time period, as well as having a larger total mean increase of 7.95° compared to a mean increase of 3.75° in Group B. Group A improved a 4.2° more than Group B. Since there were no significant differences in the left lateral flexion mean values between the two groups, the Null Hypothesis (Ho) is, therefore, accepted.

The results showed that both CSM and EAI increased the amount of active cervical left lateral flexion. There was a non-significant trend which suggested Group A was superior to Group B; however, this would have to be verified in a larger sample as this study was not powered sufficiently to show a difference of a small magnitude such as this.
5.4.1.5. Right rotation

The normal amount of active cervical rotation right in asymptomatic individuals between the ages of 30 and 39 years is 79° (Swinkels and Swinkels-Meewisse, 2014). Group A had a larger baseline value, but the difference was not statistically significant ($p=0.445$) indicating that there was no statistically significant difference between the two groups at baseline. Group A had a mean value of 57.10° while Group B had a mean value of 54.70° at baseline. The groups were, therefore, comparable for right rotation at the start of the study. The mean and standard deviation for right rotation is shown in Table 4.20.

Intragroup analysis for Group A showed a significant increase in right rotation measurements over the three time intervals, with an average mean increase of 4.5° between each time interval and a total mean increase of 9.0°. This infers that CSM increased the active cervical right rotation in CGH sufferers.

Intragroup analysis for Group B, showed there was a significant increase in right rotation over the three time intervals, with an average mean increase of 3.15° between each of the three time intervals and a total mean increase of 6.3°. This indicates that EAI increased the active cervical right rotation in CGH sufferers.

Intergroup analysis of right rotation measurements between Groups A and B showed that Group A increased on average 1.35 mean degrees more than Group B between each time period, as well as having a larger total mean increase of 9.0° compared to the mean increase of 6.3° seen in Group B. Group A improved 2.7 mean degrees more than Group B in total.

The baseline mean values for right rotation for both groups were lower than the mean amount of right rotation in asymptomatic individuals (Swinkels and Swinkels-Meewisse, 2014). This further highlights the decreased ROM experienced by CGH suffers and furthermore the implication of this in their activities of daily living. Cobian et al. (2009) stated that the most frequently executed movement of the cervical spine is axial rotation. Rotation of the neck is especially important during walking and driving (Zhao et al., 2008).

The results showed that both CSM and EAI increased the amount of active cervical right rotation. However, there is evidence to say that CSM was slightly superior to the EAI in terms of increasing the amount of active rotation. A possible explanation for this is the amount of rotation required to "lock up" the joint manually versus the very limited amount of rotation.
required to administer the EAI in a posterior to anterior plane. This, however, would have to be verified in a larger sample as this study was not powered sufficiently to show a difference of small magnitude such as this.

Since there were no significant differences in right rotation between the two groups, the Null Hypothesis (Ho) is accepted.

5.4.1.6. Left rotation

The normal amount of active cervical left rotation right is in asymptomatic individuals between the ages of 30 and 39 years is 79° (Swinkels and Swinkels-Meewisse, 2014). Group B had a larger baseline value, but the difference was not statistically significant ($p = 0.572$). Group A had a mean value of 54.52° while Group B had a mean value of 56.25° at baseline. The groups were, therefore, comparable for left rotation at the start of the study. The mean and standard deviation for right rotation is shown in Table 4.22.

Intragroup analysis for Group A showed a significant increase in left rotation measurements over the three time intervals, with an average mean increase of 4.91° between each time interval and a total mean increase of 9.81°. This shows that CSM increased the active cervical left rotation left in CGH sufferers.

Intragroup analysis for Group B showed there was a non-significant change in left rotation left over the three time intervals, with an average mean increase of 2.3° between each of the three time intervals and a total mean increase of 4.6°. This shows that EAI only marginally increased the active cervical left rotation in CGH sufferers.

Intergroup analysis of left rotation measurements between Groups A and B showed that Group A increased on average 2.61 mean degrees more than Group B between each time period, as well as having a larger total mean increase of 9.81° compared to the mean increase of 4.6° in Group B. Group A improved 5.21 mean degrees more than Group B in total. Since there were no significant differences in left rotation between the two groups, the Null Hypothesis (Ho) is accepted.
The baseline mean values for both groups in this study were lower than the mean left rotation in asymptomatic individuals. This highlights the decreased ROM experienced by CGH suffers and its impact in their activities of daily living. The results showed that CSM and EAI both increased the amount of active cervical left rotation. However, the amount of change was non-significant in Group B which implies a non-significant trend which suggested that Group A was superior to Group B but this would have to be verified in a larger sample as this study was not powered sufficiently to show a difference of a small magnitude such as this.
CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

The aim of this study was to determine the effectiveness of the EAI compared to CSM in the treatment of CGH. This aim arose because CSM, although a known and efficacious method of treating CGH, may in certain instances be contraindicated. This may be due to an underlying condition, patient apprehension with regards to their neck being handled and manually manipulated or possibly even having an extremely low pain threshold. Therefore, an alternative such as the EAI which does not require the amount of head and neck movement to manipulate a vertebral segment and allows the practitioner to be more direct and accurate with a controlled and gentle thrust with the patient in a comfortable position during the entire procedure may be beneficial. The EAI was shown to be effective on spinal fixations, but a paucity exists in the literature demonstrating its effectiveness in the treatment of CGH.

All subjective outcome measures revealed statistically significant improvements in both Groups A and B but no statistically significant difference between the groups.

Objective CROM goniometer readings revealed both groups improved significantly in most planes of movement with the exception of left lateral flexion and left rotation in Group B, which still showed improvement, but it was statistically not significant.

Inter-group analysis showed that the improvements in Group A in these planes were not statistically significant enough to show a significance between the treatment groups. This implies that both treatments had a positive effect on active CROM.

This study showed the EAI to be as effective as CSM. However, due to the small sample size and the relatively short treatment period for this condition it was difficult to show statistical differences between the two groups. Therefore, in conclusion, the trends in each of the outcomes suggest that the EAI is as effective as CSM for the treatment of CGH.

With regards to the hypotheses:
The null hypothesis which stated there would be no difference between the two independent samples being compared in terms of subjective and objective measurements was accepted.
The alternate hypothesis which stated that the EAI in the treatment of CGH will have a positive statistically significant difference ($p>0.05$) in comparison to manual CSM in terms of subjective and objective clinical findings was rejected.

### 6.2 LIMITATIONS OF THE STUDY

A small sample size might have been a limitation. Subjective assessment scoring depended on the honesty of the participant. This is, however, a difficult limitation to overcome. Patient compliance was also a limitation in this particular study as participants had to complete all six treatments in order for their results to be eligible.

### 6.3 RECOMMENDATIONS

Recommendations for future studies include:

- A better distribution between age and possibly a focus on one gender not only to decrease variables but also to determine the effects of the EAI on the genders in the treatment of CGH
- The addition of a control group receiving a sham adjustment
- A larger sample size to show clinical and statistical significance as well as to better represent the population
- A way to decrease perpetuating factors outside of the clinical setting such as a daily home stretching plan or a posture brace
- Objective readings to be taken a digital or electrical device to remove operator dependencies which may alter true results
- Measuring chemical and neurophysiological changes
- A study that incorporates a Headache diary as a subjective outcome measurement
- A study to investigate ROM improvements with the EAI
- A study comparing the EAI and CSM to other electromodalities for the treatment of CGH
REFERENCES


Hall, T.M. 2010. The clinical utility and validity of the cervical flexion-rotation test in the diagnosis and management of cervicogenic headache.


Sedighi, A., Ansari, N. N. and Naghdi, S. 2017. Comparison of acute effects of superficial and deep dry needling into trigger points of suboccipital and upper trapezius muscles in patients with cervicogenic headache. *Journal of Bodywork and Movement Therapies*.


Do you suffer from Headaches?

Are you between 18-60 years of age?

Please call the number below to see if you qualify for free Chiropractic treatment.

Russell Whittaker: 0825564631

DUT Chiropractic day clinic: (031)3732205
The following questions will be asked:

<table>
<thead>
<tr>
<th>Question</th>
<th>Correct Answers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Would you be willing to answer a few questions regarding your headache?</td>
<td>Yes</td>
</tr>
<tr>
<td>2) How old are you?</td>
<td>18-60 years of age</td>
</tr>
<tr>
<td>3) Describe the character of your headache.</td>
<td>On one side without side changes</td>
</tr>
<tr>
<td>4) Is the headache bought on by neck movements?</td>
<td>Yes</td>
</tr>
<tr>
<td>5) Do you have any stiffness and/or decreased movement in your neck?</td>
<td>Yes</td>
</tr>
</tbody>
</table>
APPENDIX C: CASE HISTORY

**CHIROPRACTIC PROGRAMME**

**CHIROPRACTIC DAY CLINIC CASE HISTORY**

<table>
<thead>
<tr>
<th>Patient:</th>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td>File #:</td>
<td></td>
</tr>
<tr>
<td>Sex:</td>
<td>Age:</td>
</tr>
<tr>
<td>Student:</td>
<td>Occupation:</td>
</tr>
<tr>
<td>Signature:</td>
<td></td>
</tr>
</tbody>
</table>

**FOR CLINICIANS USE ONLY:**

<table>
<thead>
<tr>
<th>Initial visit</th>
<th>Signature:</th>
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</table>

<table>
<thead>
<tr>
<th>Case History:</th>
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<table>
<thead>
<tr>
<th>Examination:</th>
<th>Previous:</th>
<th>Current:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>X-Ray Studies:</th>
<th>Previous:</th>
<th>Current:</th>
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</table>

<table>
<thead>
<tr>
<th>Clinical Path. lab:</th>
<th>Previous:</th>
<th>Current:</th>
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**CASE STATUS:**

<table>
<thead>
<tr>
<th>PTT:</th>
<th>Signature:</th>
<th>Date:</th>
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</thead>
</table>

**CONDITIONAL:**

Reason for Conditional:

<table>
<thead>
<tr>
<th>Signature:</th>
<th>Date:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Conditions met in Visit No:</th>
<th>Signed into PTT:</th>
<th>Date:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Case Summary signed off:</th>
<th>Date:</th>
</tr>
</thead>
</table>
**Student’s Case History:**

1. **Source of History:**

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

3. **Present Illness:**

<table>
<thead>
<tr>
<th></th>
<th>Complaint 1 (principle complaint)</th>
<th>Complaint 2 (additional or secondary complaint)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td></td>
<td></td>
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<tr>
<td>Onset:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recent:</td>
<td></td>
<td></td>
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<tr>
<td>Cause:</td>
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<td></td>
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<tr>
<td>Duration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pain (Character)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Progression</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aggravating Factors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relieving Factors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Associated S &amp; S</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Previous Occurrences</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Past Treatment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outcome:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. **Other Complaints:**

5. **Past Medical History:**

   - General Health Status
   - Childhood Illnesses
   - Adult Illnesses
   - Psychiatric Illnesses
   - Accidents/Injuries
   - Surgery
   - Hospitalizations
6. **Current health status and life-style:**

Allergies

Immunizations

Screening Tests incl. x-rays

Environmental Hazards (Home, School, Work)

Exercise and Leisure

Sleep Patterns

Diet

Current Medication
   Analgesics/week:
   Other (please list):

Tobacco
Alcohol
Social Drugs

7. **Immediate Family Medical History:**

Age of all family members
Health of all family members
Cause of Death of any family members

<table>
<thead>
<tr>
<th>Noted</th>
<th>Family member</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Alcoholism</td>
<td>Headaches</td>
</tr>
<tr>
<td>Anaemia</td>
<td>Heart Disease</td>
</tr>
<tr>
<td>Arthritis</td>
<td>Kidney Disease</td>
</tr>
<tr>
<td>CA</td>
<td>Mental Illness</td>
</tr>
<tr>
<td>DM</td>
<td>Stroke</td>
</tr>
<tr>
<td>Drug Addiction</td>
<td>Thyroid Disease</td>
</tr>
<tr>
<td>Epilepsy</td>
<td>TB</td>
</tr>
<tr>
<td>Other (list)</td>
<td></td>
</tr>
</tbody>
</table>

8. **Psychosocial history:**

Home Situation and daily life
Important experiences
Religious Beliefs
9. Review of Systems (please highlight with an asterisk those areas that are a problem for the patient and require further investigation)

General
Skin
Head
Eyes
Ears
Nose/Sinuses
Mouth/Throat
Neck
Breasts
Respiratory
Cardiac
Gastro-intestinal
Urinary
Genital
Vascular
Musculoskeletal
Neurologic
Haematological
Endocrine
Psychiatric
### APPENDIX D: PHYSICAL EXAMINATION

![CHIROPRACTIC PROGRAMME]

**PHYSICAL EXAMINATION:**
**SENIOR**

<table>
<thead>
<tr>
<th>Patient Name:</th>
<th>File no:</th>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student:</td>
<td>Signature:</td>
<td></td>
</tr>
</tbody>
</table>

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

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

#### SYSTEM SPECIFIC EXAMINATION:
- **CARDIOVASCULAR EXAMINATION**
- **RESPIRATORY EXAMINATION**
- **ABDOMINAL EXAMINATION**
- **NEUROLOGICAL EXAMINATION**

#### COMMENTS

**Clinician:**  
**Signature:**
APPENDIX E: CERVICAL REGIONAL EXAMINATION

CHIROPRACTIC PROGRAMME

REGIONAL EXAMINATION – CERVICAL SPINE

Patient: ___________________________ File No: ___________________________

Date: ___________________________ Student: ___________________________

Clinician: ___________________________ Sign: ___________________________

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

Shoulder position
- Left:
- Right:

Shoulder dominance (hand):

Facial expression:

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

PALPATION:
- Lymph nodes
- Thyroid Gland
- Trachea

MYOFASCIAL ASSESSMENT

<table>
<thead>
<tr>
<th>Tenderness</th>
<th>Right</th>
<th>Left</th>
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<tbody>
<tr>
<td>Trigger Points:</td>
<td>SCM</td>
<td></td>
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<tr>
<td></td>
<td>Scaleni</td>
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<tr>
<td></td>
<td>Post Cervicals</td>
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<tr>
<td></td>
<td>Trapezius</td>
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<tr>
<td></td>
<td>Lev scapular</td>
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ORTHOPAEDIC EXAMINATION:

<table>
<thead>
<tr>
<th>Test</th>
<th>Right</th>
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<tbody>
<tr>
<td>Adson’s test</td>
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<tr>
<td>Brachial plexus test</td>
<td></td>
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<tr>
<td>Cervical compression</td>
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<tr>
<td>Cervical distraction</td>
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<tr>
<td>Costoclavicular test</td>
<td></td>
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<tr>
<td>Dizziness rotation test</td>
<td></td>
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<tr>
<td>Doorbell sign</td>
<td></td>
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<tr>
<td>Eden’s test</td>
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### NEUROLOGICAL EXAMINATION:

<table>
<thead>
<tr>
<th>Dermatones</th>
<th>Left</th>
<th>Right</th>
<th>Myotomes</th>
<th>Left</th>
<th>Right</th>
<th>Reflexes</th>
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<tbody>
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<td>C3</td>
<td>C2</td>
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<td>C5</td>
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<td>C3</td>
<td>C2</td>
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<td>C4</td>
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<td>T1</td>
<td>C8</td>
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<td></td>
<td>T1</td>
<td></td>
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<td></td>
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<tr>
<td>Cerebellar tests:</td>
<td>Left</td>
<td>Right</td>
<td></td>
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<tr>
<td>Dysdiadochokinesis</td>
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</table>

### VASCULAR:

<table>
<thead>
<tr>
<th></th>
<th>Left</th>
<th>Right</th>
<th></th>
<th>Left</th>
<th>Right</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood pressure</td>
<td></td>
<td></td>
<td>Subclavian arts.</td>
<td></td>
<td></td>
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<tr>
<td>Carotid arts.</td>
<td></td>
<td></td>
<td>Wallenberg’s test</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### MOTION PALPATION & JOINT PLAY:

Left: Motion Palpation:
Joint Play:
Right: Motion Palpation:
Joint Play:

### BASIC EXAM: SHOULDER:

Case History:

ROM: Active:
Passive:
RIM:
Orthopaedic:
Neuro:
Vascular:

### BASIC EXAM: THORACIC SPINE:

Case History:

![Diagram of thoracic spine movements](image)

Motion Palpation:
Orthopaedic:
Neuro:
Vascular:
Observ/Palpation:
Joint Play:
APPENDIX F: PERMISSION TO USE CLINIC

MEMORANDUM

To : Prof Puckree
    Chair : RHDC

    Prof Adam
    Chair : IREC

From : Dr Charmaine Korporaal
       Clinic Director : FoHS Clinic

Date : 17/08/2015

Re : Request for permission to use the Chiropractic Day Clinic for research purposes

Permission is hereby granted to :

Mr Russell Whittaker (Student Number: 21122054)

Research title : "The effectiveness of an Electromechanical Adjusting Instrument compared to Cervical Spine Manipulation in the treatment of Cervicogenic Headaches."

It is noted that Mr Whittaker is currently a M.Tech: Chiropractic student, therefore it is requested that Mr Whittaker submit a copy of his RHDC / IREC approved proposal to the Clinic Administrators before he starts with his research in order that any special procedures with regards to his research can be implemented prior to the commencement of him seeing patients.

Thank you for your time.

Kind regards

Dr Charmaine Korporaal
Clinic Director : FoHS Clinic

Cc: Ms Pat van den Berg : Chiropractic Day Clinic
    Dr L’O’Connor : Research co-ordinator
    Dr D Varatharajullu : Research supervisor
9th November 2016

Mr Russell Curtis Whittaker  
c/o Department of Chiropractic and Somatology  
Faculty of Health Sciences  
Durban University of Technology  

Dear Mr Whittaker  

PERMISSION TO CONDUCT RESEARCH AT THE DUT  

Your email correspondence in respect of the above refers. I am pleased to inform you that the Institutional Research Committee (IRC) has granted full permission for you to conduct your research “The effectiveness of an electromechanical adjusting instrument compared to cervical spine manipulation in the treatment of cervicogenic headaches” at the Durban University of Technology.

We would be grateful if a summary of your key research findings can be submitted to the IRC on completion of your studies.

Kindest regards.  
Yours sincerely  

[Signature]

PROF. S. MOYO  
DIRECTOR: RESEARCH AND POSTGRADUATE SUPPORT
21 November 2016

IREC Reference Number: REC 90/16

Mr R C Whittaker
12 Curlew Drive
Beacon Bay
East London

Dear Mr Whittaker

The effectiveness of an electromechanical adjusting instrument compared to cervical spine manipulation in the treatment of cervicogenic headaches

The Institutional Research Ethics Committee acknowledges receipt of your gatekeeper permission letter.

In addition, the IREC acknowledges receipt of your unique Department of Health Trial Number.

Please note that Full Approval is granted to your research proposal. You may proceed with data collection.

Yours Sincerely,

[Signature]

[Position] J. A. M. [Name]
Chairperson: IREC

[Logo]

2013 -11- 21

INSTITUTIONAL RESEARCH ETHICS COMMITTEE
P.O. BOX 1334, DURBAN 4000 SOUTH AFRICA
APPENDIX I: INFORMED CONSENT

LETTER OF INFORMATION

Dear participant,

Welcome to my study, thank you for agreeing to participate. I am a chiropractic student trying to obtain my M.Tech Chiropractic degree. Outlined below is a brief description of the study and what will be needed from you. Your participation is greatly appreciated and your involvement is contributing to a successful study.

Title of the Research Study: “The effectiveness of an electromechanical adjusting instrument compared to cervical spine manipulation in the treatment of cervicogenic Headaches”

Researcher: Mr. Russell Whittaker (B.Tech: Chiropractic)
Supervisor: Dr Desiree Varatharajullu (M.Tech: Chiropractic)

Brief Introduction and Purpose of the Study:
You have been selected to take part in a study investigating the effectiveness of an electromechanical adjusting instrument compared to cervical spine manipulation in the treatment of cervicogenic headaches. The Electromechanical Adjusting Instrument (EAI) is a new handheld device offered as an alternative to manual therapy for musculoskeletal treatment. Basic scientific research has demonstrated biomechanical and neurophysiological responses similar to a manual adjustment associated with its use, however, very little clinical research exists on its use. The instrument is regarded to be safe for clinical use and has received FDA approval. There is paucity in the literature with respect to comparing the EAI to cervical spine manipulation in the effectiveness of treating cervicogenic headaches. Therefore, the aim of this study is to determine the effectiveness of the EAI compared to cervical spine manipulation in the treatment of cervicogenic headaches.

Outline of the Procedures:
After you have met the criteria as per the telephonic screening, an appointment will be made at the CDC in which permission has been granted (Appendix I).

On arrival at the initial appointment you will be given a verbal explanation of the research procedure and will be given a letter of information and informed consent (Appendix C) to read and sign. You will then be given an opportunity to ask any questions regarding the research procedure.
You will thereafter undergo an appointment consisting of a case history (Appendix J), a physical examination (Appendix K) and cervical spine regional examination (Appendix L). Following which a SOAPE note (Appendix M) will be completed and signed off by the clinician on duty.

Once your suitability is determined, you will then be randomly allocated in one of the two intervention groups by means of a randomization table drawn up by the statistician. You therefore have an equal chance of being in either group. A research assistant will measure the objective variable (CROM readings), they will be blinded as to the intervention the patient is receiving to avoid bias. The principal examiner will be blinded as to the objective findings to avoid the principal examiner from introducing bias into the results. Prior to this involvement, the assistant examiner will undergo training by the supervisor and principle researcher and will be declared competent by the supervisor (Appendix N).

Group A will receive CSM to one of the upper three cervical segments in which ever plane was noted to be most restricted during cervical spine regional and group B will receive treatment with the EAI with a single adjustment to the most restricted upper cervical segment found into be restricted in cervical spine regional.

Consultation 1: Patient will have all subjective and objective measurements taken prior to the treatment intervention in order to get base levels, after which they will receive the intervention specific to their group.

Consultation 2: Patients will only receive the intervention at this consultation.

Consultation 3: The treatment intervention will be administered before to the objective measures are taken. (To ensure the readings are taken, before 1 intervention, after 3 and after 6 interventions)

Consultation 4: All subjective measures will be taken before the intervention to be administered. (To ensure the readings are taken before 1 intervention, after 3 and after 6 interventions.)

Consultation 5: Only the treatment intervention will be administered at this consultation.

Consultation 6: The treatment intervention will be administered before the subjective and objective measures are taken.

An independent researcher will contact you telephonically two weeks after consultation 6 to obtain NPRS, HDI and a global impression of change measurements.

Risks or Discomforts to the Participant:
EAI participants may report tenderness over the area being treated and SMT group may experience post treatment soreness after treatment.

Benefits:
It will be of benefit to you by reducing your headaches and allowing for a better quality of life. From this study the researcher will be completing a master’s thesis.

You will be receiving either a manual cervical spine manipulation or a cervical spine manipulation done by the Impulse Adjuster both have previously been used for cervicogenic headache and neck pain. From this study the researcher will be completing a master’s thesis.

**Reason/s why the Participant May Be Withdrawn from the Study:**
You may be withdrawn from the study, if you do not show up for the appointment, if you have an unexpected adverse reaction to the treatment, or if you are involved in an accident or contract /develop a condition that is a stated contra-indication to manipulation.
Additionally you may withdraw at any time from the study. Your withdrawal will not result in any negative consequences for you from the DUT Chiropractic Clinic or any of its agents.

**Remuneration:**
There will be no payment due to you based on your participation in the study.

**Costs of the Study:**
There will be no costs to be borne by you due to your participation in the study.

**Confidentiality:**
Only the researcher, supervisor and reception staff (as necessary to draw your file) will have access to the personal information of the participant. Confidentiality will be maintained at all times and no personal information will be used in the write up of the dissertation. After a period of five years the data collected will be destroyed through shredding.

**Research-related Injury:**
The injury will need to be reported to the IREC, as the parent body that oversees the wellbeing of research participants. The DUT chiropractic clinic will bear the costs, should there be an adverse reaction or an injury.

**Persons to Contact in the Event of Any Problems or Queries:**
Head of Department: Dr. A. Docrat, Contact number: 031 373 2589.
Please contact the researcher, Russell Whittaker on (082 556 4631), Supervisor: Dr Desiree Varatharajullu (0313732533) or the Institutional Research Ethics administrator on 031 373 2900. Complaints can be reported to the DVC: TIP, Prof S. Moyo on (031) 373 2382 or dvctip@dut.ac.za.
CONSSENT

Statement of Agreement to Participate in the Research Study:
I hereby confirm that I have been informed by the researcher, Mr Russell Whittaker, about the nature, conduct, benefits and risks of this study - Research Ethics Clearance Number: ____REC 90/16____.
I have also received, read and understood the above written information (Participant Letter of Information) regarding the study.
I am aware that the results of the study, including personal details regarding my sex, age, date of birth, initials and diagnosis will be anonymously processed into a study report.
In view of the requirements of research, I agree that the data collected during this study can be processed in a computerised system by the researcher.
I may, at any stage, without prejudice, withdraw my consent and participation in the study.
I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.
I understand that significant new findings developed during the course of this research which may relate to my participation will be made available to me.

__________________________________________
Full Name of Participant Date Time Signature / Right Thumbprint

I, Mr Russell Whittaker herewith confirm that the above participant has been fully informed about the nature, conduct and risks of the above study.

_________________________ ________________
Full Name of Researcher Date Signature

_________________________ ________________
Full Name of Witness (If applicable) Date Signature

_________________________ ________________
Full Name of Legal Guardian (If applicable) Date Signature
# Appendix J: SOAPE

## CHIROPRACTIC PROGRAMME

<table>
<thead>
<tr>
<th>Date:</th>
<th>Visit:</th>
<th>Student:</th>
<th>File number:</th>
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<tr>
<td>Attending Clinician:</td>
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</table>

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

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Special attention to:  
Next appointment:

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<th>Visit:</th>
<th>Student:</th>
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<tr>
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**S:** Numerical Pain Rating Scale (Patient)  
Least: 0 1 2 3 4 5 6 7 8 9 10 Worst

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<td>O:</td>
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</table>

Special attention to:  
Next appointment:
APPENDIX K: ASSISTANT EXAMINER TRAINING

Assistant Examiner Training and Agreement.

How to use the CROM.

Rheault et al. (1992) described how the CROM measurements should be taken.

**Step 1**: The CROM instrument should be placed on the nasal bridge and ears of the patient and fastened at the back of the patient's head with Velcro straps.

**Step 2**: The patient's chair should then be positioned in such a way that the magnetic field is zeroed on the dial meter for the rotational measurement.

**Step 3**: The correct patient posture is to sit erect with lower back against backrest, mid-back away from the chair, arms hanging freely at the side and feet together on the floor.

**Step 4**: The Calibrated dials should be zero before measuring active cervical flexion, extension, right and left rotation, and right and left lateral flexion.

**Step 5**: Each motion should be measured twice and an average reading recorded.

I _____________________________, am in agreement with the set procedure outlined, with regards to examination and recording of the above mentioned test. I will be blinded as to which intervention each participant receives and will carry out the examinations to the best of my abilities and make myself available for scheduled patients.

**Competency declaration**

I _____________________________ (Supervisor) declare ___________________________ competent in their ability to take CROM measurements.
APPENDIX L: NUMERICAL PAIN RATING SCALE

Pain Numeric Rating Scale

1. On a scale of 0 to 10, with 0 being no pain at all and 10 being the worst pain imaginable, how would you rate your pain RIGHT NOW.

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

2. On the same scale, how would you rate your USUAL level of pain during the last week.

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No Pain</td>
<td>Worst Pain Imaginable</td>
<td></td>
<td></td>
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</tbody>
</table>
# APPENDIX M: HEADACHE DISABILITY INDEX

## Headache Disability Index

**Appendix E**

Patient Name: ________________________________

**Date: ________________________________**

**INSTRUCTIONS:** Please CIRCLE the correct response:

1. I have headache:  
   (1) 1 per month  
   (2) more than 1 but less than 4 per month  
   (3) more than one per week

2. My headache is:  
   (1) mild  
   (2) moderate  
   (3) severe

**Please read carefully:** The purpose of the scale is to identify difficulties that you may be experiencing because of your headache. Please check off “YES”, “SOMETIMES”, or “NO” to each item. Answer each question as it pertains to your headache only.

<table>
<thead>
<tr>
<th>YES</th>
<th>SOMETIMES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>___</td>
<td>___</td>
<td>___</td>
</tr>
<tr>
<td>Because of my headaches I feel disabled.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Because of my headaches I feel restricted in performing my routine daily activities.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No one understands the effect my headaches have on my life.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I restrict my recreational activities (eg, sports, hobbies) because of my headaches.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>My headaches make me angry.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sometimes I feel that I am going to lose control because of my headaches.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Because of my headaches I am less likely to socialize.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>My spouse (significant other), or family and friends have no idea what I am going through because of my headaches.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>My headaches are so bad that I feel that I am going to go insane.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>My outlook on the world is affected by my headaches.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am afraid to go outside when I feel that a headache is starting.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I feel desperate because of my headaches.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am concerned that I am paying penalties at work or at home because of my headaches.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>My headaches place stress on my relationships with family or friends.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I avoid being around people when I have a headache.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I believe my headaches are making it difficult for me to achieve my goals in life.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am unable to think clearly because of my headaches.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I get tense (eg, muscle tension) because of my headaches.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I do not enjoy social gatherings because of my headaches.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I feel irritable because of my headaches.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I avoid traveling because of my headaches.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>My headaches make me feel confused.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>My headaches make me feel frustrated.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I find it difficult to read because of my headaches.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I find it difficult to focus my attention away from my headaches and on other things.</td>
<td></td>
<td></td>
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</tbody>
</table>

**Instructions:** 1. Using this system, if "YES" is checked on any given line, that answer is given 4 points... a "SOMETIMES" answer is given 2 points and a "NO" answer is given zero.  
2. Using this system, a score of 10-28% is considered to constitute mild disability; 30-48% is moderate; 50-68% is severe; 72% or more is complete.

**Patient’s Signature:** ________________________________

**Date: ________________________________**
APPENDIX N: PERMISSION TO USE HDI

From: Steven Yeomans
Sent: 26 February 2015 08:53 PM
To: Charmaine Maria Korporaal
Subject: Re: Dear Prof Yeomans

Permission is not required if you're simply using the questionnaire in a clinical patient care setting. It is available in the open domain. You certainly can use my name as a reference if you need permission to be granted.

On Feb 26, 2015 11:19 AM, "Charmaine Maria Korporaal" <charmak@dut.ac.za> wrote:
I am wondering whether you could assist me …

One of my students is wishing to utilise the Headache disability index / inventory, which you have referred to in your book, published in 2000.

My questions would be, do week seek permission from yourself or from Jacobson, Ramadan and others in order to utilised this measurement tool ?

If the latter, would you have contact details for Jacobson, Ramadan and others ?

Your assistance would be greatly appreciated

Thank you kindly

Charmaine

Dr Charmaine Korporaal
M.Tech: Chiropractic, CCFC, CCSP, ICSSD
Registered Chiropractor
Senior lecturer and Clinic Director : Chiropractic Programme
Durban University of Technology, P.O.Box 1334, Durban, 4000
Tel: +27 31 3732611
Fax: + 27 866486360
E-mail: charmak@dut.ac.za

President : Chiropractic Association of South Africa
National Co-ordinator : Chiropractic Internship
Member : ICRC
APPENDIX O: NECK DISABILITY INDEX

Appendix G

Neck Disability Index

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

Section 1: Pain Intensity
- I have no pain at the moment
- The pain is very mild at the moment
- The pain is moderate at the moment
- The pain is fairly severe at the moment
- The pain is very severe at the moment
- The pain is the worst imaginable at the moment

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

Section 3: Lifting
- I can lift heavy weights without extra pain
- I can lift heavy weights but it gives extra pain
- Pain prevents me lifting heavy weights off the floor, but I can manage if they are conveniently placed, for example on a table
- Pain prevents me from lifting heavy weights but I can manage light to medium weights if they are conveniently positioned
- I can only lift very light weights

Section 4: Reading
- I can read as much as I want to with no pain in my neck
- I can read as much as I want to with slight pain in my neck
- I can read as much as I want with moderate pain in my neck
- I can't read as much as I want because of moderate pain in my neck
- I can hardly read at all because of severe pain in my neck
- I cannot read at all

Section 5: Headaches
- I have no headaches at all
- I have slight headaches, which come infrequently
- I have moderate headaches, which come infrequently
- I have moderate headaches, which come frequently
- I have severe headaches, which come frequently
- I have headaches almost all the time

Section 6: Concentration
- I can concentrate fully when I want to with no difficulty
- I can concentrate fully when I want to with slight difficulty
- I have a fair degree of difficulty in concentrating when I want to
- I have a lot of difficulty in concentrating when I want to
- I have a great deal of difficulty in concentrating when I want to
- I cannot concentrate at all
Section 7: Work
- I can do as much work as I want to
- I can only do my usual work, but no more
- I can do most of my usual work, but no more
- I cannot do my usual work
- I can hardly do any work at all
- I cannot do any work at all

Section 8: Driving
- I can drive my car without any neck pain
- I can drive my car as long as I want with slight pain in my neck
- I can drive my car as long as I want with moderate pain in my neck
- I cannot drive my car as long as I want because of moderate pain in my neck
- I can hardly drive at all because of severe pain in my neck
- I cannot drive my car at all

Section 9: Sleeping
- I have no trouble sleeping
- My sleep is slightly disturbed (less than 1 hr sleepless)
- My sleep is mildly disturbed (1-2 hrs sleepless)
- My sleep is moderately disturbed (2-3 hrs sleepless)
- My sleep is greatly disturbed (3-5 hrs sleepless)
- My sleep is completely disturbed (3-7 hrs sleepless)

Section 10: Recreation
- I am able to engage in all my recreation activities with no neck pain at all
- I am able to engage in all my recreation activities with some pain in my neck
- I am able to engage in most, but not all of my usual recreation activities because of pain in my neck
- I am able to engage in a few of my usual recreation activities because of pain in my neck
- I can hardly do any recreation activities because of pain in my neck
- I cannot do any recreation activities at all

Score: ___/50
Transform to percentage score x 100 = __%
points

Scoring: For each section the total possible score is 5; if the first statement is marked the section score = 0, if the last statement is marked it = 5. If all ten sections are completed the score is calculated as follows:

Example: 15 (total scored)

50 (total possible score) x 100 = 30%

If one section is missed or not applicable the score is calculated:

15 (total scored)

45 (total possible score) x 100 = 33.3%

Minimum Detectable Change (90% confidence); 3 points at 10 %points


APPENDIX P: PERMISSION TO USE NDI
LETTER OF PERMISSION
To Whom It May Concern:

My name is Russell Whittaker and I am currently doing my Master’s Degree in Chiropractic at the Durban University of Technology, South Africa.

The title of my research project is: The effectiveness of an Electromechanical Adjusting Instrument compared to Cervical Spine Manipulation in the treatment of Cervicogenic Headaches.

Name of supervisor: Dr. D. Varatharajullu +27 (31) 204 2533
M.Tech: Chiropractic
Name of Research Student: Russell Whittaker 082 556 4631
B.Tech: Chiropractic
Name of Institution: Durban University of Technology, South Africa

The purpose of the study:
The aim of this study is to determine the effectiveness of the Electromechanical Adjusting Instrument compared to cervical spine manipulation in the treatment of cervicogenic headaches.

Procedures:
The participants will be screened for fixations via motion palpation, after which they will either receive manual cervical spine manipulation or they will receive treatment with the Impulse Adjuster depending on which sample group they fall under.

Benefits:
This study will help to determine if the Impulse Adjusting Instrument is effective in treating Cervicogenic Headaches.

Based on the nature of this study, I am required to seek your permission to utilize the CMCC Neck Disability Index as a means of obtaining data from a participant in terms of neck pain improvement following the treatment intervention.

Yours sincerely,
Russell Whittaker                               Dr D. Varatharajullu
(Chiropractic Intern)                                  (Supervisor)

I __Dr. Howard Vernon___________________ (name) hereby give Russell Whittaker
consent to conduct the above-mentioned research using the CMCC Neck Disability Index.

Signature: ____________________________ Date: __February 17, 2015________
APPENDIX Q: MEMORANDUM OF UNDERSTANDING (MOU)

Appendix P

Durban University of Technology

Memorandum of understanding between:

The "RESEARCH INSTITUTION" - Durban University of Technology (this includes the respective research student and research supervisor, Departments of Chiropractic: The Faculty of Health Sciences Research Committee, The Institutional Research Committee and any other related DUT employees);

AND

The "MANUFACTURER" - Neuromechanical Innovations (including all members, employees, associates).

This Memorandum of Understanding pertains to the following research project and must be read in conjunction with:

APPENDIX B: Durban University of Technology Research Committee Research Ethics Policy and Guidelines

Title of the study:
The effectiveness of an Electromechanical Adjusting Instrument compared to Cervical Spine Manipulation in the treatment of Cervicogenic Headaches.

Research Supervisor: Dr D. Varanatharajah (Dept. Chiropractic and Osteopathy-Durban University of Technology)

The study is a Masters Mini Dissertation conducted in partial compliance with the Masters Degree in Technology in the Department of Chiropractic - Faculty of Health Sciences - Durban University of Technology. The study will obtain ethical approval from the Faculty of Health Sciences Research & Ethics Committee (FRC) of Durban University of Technology.

Please be aware the transient name will not be divulged to the participants and not included in any of the letters of information as well as the dissertation.

Section 1: Funding of the study and financial commitment

1.1 A research allowance of R5000.00 will be awarded by the Dept. Post-graduate Development & Support: The details of the funds approved will be described in Section A or the Research Proposal (R02a) attached - i.e. the budget as is outlined in the R02a.

1.2 The MANUFACTURER acknowledges that THE RESEARCH INSTITUTION will have no financial obligations or commitments to the MANUFACTURER whatsoever as a result of conducting this study.

1.3 The MANUFACTURER may not award or incentivise the study or its related parties in any manner whatsoever nor compensate, award or offer any financial or other donation or gift to any of those involved with the study.

1.4 It is noted, however, that the MANUFACTURER will be sponsoring an Electromechanical Adjusting Instrument to THE RESEARCH INSTITUTION for the purposes of completing the research project referred to in this document and to be utilised in further research studies which require the use of the Electromechanical Adjusting Instrument.

Section 2: Academic processes and outcomes

124
5.1 Ethical clearance of the proposed study will be granted by the DUT IREC (such ethical clearance will become invalid should there be any deviation from the approved research methodology described in the research proposal attached).

5.2 The 'MANUFACTURER' undertakes to abide by the DUT Research Ethics Policy and Guidelines (APPENDIX B).

5.3 In addition to 5.2 the 'MANUFACTURER' should note and refer to Section 1, 2 & 3 of this document.

Christopher J. Coolea
(name of representative of the 'MANUFACTURER')

herewith in my official capacity as representative of Neuromechanical Innovations hereby agree to abide by the regulations stated in this memorandum of understanding.

PH. Jan 2017

Chairperson, Neuromechanical Innovations

John M. Ransome
(name of representative of the 'THE RESEARCH INSTITUTION')

herewith in my official capacity as representative of Durban University of Technology hereby agree to abide by the regulations stated in this memorandum of understanding.

Signature of official representative of Durban University of Technology

03 August 2016

Date

Mr. Russell Whittaker

in my capacity as the research student hereby agree to abide by the regulations in this memorandum of understanding between the Neuromechanical Innovations (the "MANUFACTURER") and Durban University of Technology (the "RESEARCH INSTITUTION")

Signature of research student

12 Jan 2017

Date

Attachment: Information regarding Neuromechanical Innovations (the "MANUFACTURER").
Information regarding the "MANUFACTURER" - Neuromechanical Innovations - gleaned from their website: [http://www.neuromechanical.com/](http://www.neuromechanical.com/)

Founder and Chief Executive Officer at Neuromechanical Innovations is Dr. Christopher Cailoca, DC

Neuromechanical innovations is the world leader in instrument-assisted spinal manipulation and chiropractic adjusting products and clinical training. With over thirty domestic and international patents and trademarks, NMI is the manufacturer of the Impulse® and Impulse iQ. Adjusting instruments that are in use today in over 7,000 chiropractic offices in every state in the USA, all Canadian provinces, all Australian states, and in 46 countries around the world.

After the successful debut of Impulse in 2003, thousands of chiropractors made the switch to impulse to adopt the latest technology and save their hands from having to pull spring loaded activation devices. When Impulse iQ debuted in 2008, chiropractors were amazed to see the difference that computerized adjusting could make in their practice. The addition of a motion sensor and internal computer microprocessor functionality inside the impulse iQ provides feedback to both the doctor and patient while adjusting at the body's resonant frequency. Adjustments are crisper, results are faster, and the feedback gives confidence to the doctor and patient alike. In 2012, we've done it again with our release of Impulse DSA.

Devices are FDA registered, patented or patent-pending and our trademarks and copyrights are registered domestically in the US and have been filed in many countries throughout the world. Our adjusting instruments are in thousands of chiropractic offices in every state in the US and in over 30 countries around the world.

No other instrument adjusting company has FDA clearance, a CE mark, and Health Canada Class 2 medical device licensure backed by an ISO 13485 Medical Device Certification and UL listing (Underwriters Laboratories, Inc.)

ADDRESS:
101 S. Roosevelt Avenue
Chandler, AZ 85226

EMAIL:
INFO@NEUROMECHANICAL.COM

PHONE:
888 * 294 * 4750
APPENDIX U: FDA APPROVAL

510(k) Summary: K080261
Device Name: Impulse IQ Adjusting Instrument
Manufacturer: Neuromechanical Innovations, LLC
11011 S. 48th St., Suite 205
Phoenix, AZ 85044
Contact: Christopher J. Coloca, D.C.
Phone: 480-785-8442
Fax: 480-785-3918
Email: DrC100@aol.com
Trade Name(s): Impulse IQ Adjusting Instrument or Impulse iQ
Common or Usual Name: Chiropractic Adjusting Instrument
Product Code: LXIM
Classification Name: Manipulator, Plunger-like Joint
Classification: Unclassified
Predicate Devices for Substantial Equivalence: K023462 Impulse Adjusting Instrument
K930431 Arthrostim Manipulator
K973914 FRAS, Sense Technology, Inc.
K003185 Full Spectrum Activator III
K010851 Harrison Hand Held Adjusting Instrument
Panel: Physical Medicine
Performance Standards: None known established
Performance Data: The Impulse IQ Adjusting Instrument has been mechanically tested and found to produce approximately 100 N, 200 N, and 400 N on its low, medium, and high force settings respectively. Total peak force output is also dependent upon operator preload. The pulse rate varies between 4-12 Hz.
Device Description & Specifications: The Impulse IQ Adjusting Instrument is a hand-held electromechanical chiropractic adjusting instrument. The device has three force settings (low, medium, high), a preload-control indicator light that turns from red to green upon achieving the proper preload, and an internal accelerometer to provide closed-loop feedback controlling thrust pulse rate. The device is only intended for use from a health care professional licensed by the law of the state that he or she practices.
Intended Use: The Impulse IQ Adjusting Instrument is intended for chiropractic adjustment, mobilization, or manipulation of the musculoskeletal joints of the spine and/or extremities, or for soft-tissue musculoskeletal mobilization by a licensed health care professional only. For external use only.
Neuronechnical Innovations, LLC
Christopher J. Colloca, D.C.
11011 S. 48th Street, Suite 205
Phoenix, Arizona 85044

Re: K080261
Trade/Device Name: Impulse iQ Adjusting Instrument
Regulatory Class: Unclassified
Product Code: LXM
Dated: March 20, 2008
Received: March 25, 2008

Dear Dr. Colloca:

We have reviewed your Section 510(k) premarket notification of intent to market the device referenced above and have determined the device is substantially equivalent (for the indications for use stated in the enclosure) to legally marketed predicate devices marketed in interstate commerce prior to May 28, 1976, the enactment date of the Medical Device Amendments, or to devices that have been reclassified in accordance with the provisions of the Federal Food, Drug, and Cosmetic Act (Act) that do not require approval of a premarket approval application (PMA).

You may, therefore, market the device, subject to the general controls provisions of the Act. The general controls provisions of the Act include requirements for annual registration, listing of devices, good manufacturing practice, labeling, and prohibitions against misbranding and adulteration.

If your device is classified (see above) into either class II (Special Controls) or class III (PMA), it may be subject to such additional controls. Existing major regulations affecting your device can be found in the Code of Federal Regulations, Title 21, Parts 800 to 898. In addition, FDA may publish further announcements concerning your device in the Federal Register.

Please be advised that FDA’s issuance of a substantial equivalence determination does not mean that FDA has made a determination that your device complies with other requirements of the Act or any Federal statutes and regulations administered by other Federal agencies. You must comply with all the Act’s requirements, including, but not limited to: registration and listing (21 CFR Part 807); labeling (21 CFR Part 801); good manufacturing practice requirements as set forth in the quality systems (QS) regulation (21 CFR Part 820); and if applicable, the electronic product radiation control provisions (Sections 531-542 of the Act); 21 CFR 1000-1050.

This letter will allow you to begin marketing your device as described in your Section 510(k) premarket notification. The FDA finding of substantial equivalence of your device to a legally
marketed predicate device results in a classification for your device and thus, permits your device to proceed to the market.

If you desire specific advice for your device on our labeling regulation (21 CFR Part 801), please contact the Center for Devices and Radiological Health's (CDRH's) Office of Compliance at (240) 276-0120. Also, please note the regulation entitled, "Misbranding by reference to premarket notification" (21 CFR Part 807.97). For questions regarding postmarket surveillance, please contact CDRH's Office of Surveillance and Biometric's (OSB's) Division of Postmarket Surveillance at (240)-276-3474. For questions regarding the reporting of device adverse events (Medical Device Reporting (MDR)), please contact the Division of Surveillance Systems at (240)-276-3464. You may obtain other general information on your responsibilities under the Act from the Division of Small Manufacturers, International and Consumer Assistance at toll-free number (800) 638-2041 or (240) 276-3150 or Internet address http://www.fda.gov/cdrh/industry/support/index.html.

Sincerely yours,

Mark N. Melkerson
Director
Division of General, Restorative
and Neurological Devices
Office of Device Evaluation
Center for Devices and
Radiological Health

Enclosure
Hi

Please see email below for Russell's DOH number:

Regards
Laura

-----Original Message-----
From: confirmation@sanrr.co.za [mailto:confirmation@sanrr.co.za]
Sent: 15 November 2016 12:00 PM
To: Laura Wilson <lauraw@dut.ac.za>
Subject: National Ethics Application #: 4526

Dear Laura O'Connor

Your Application, "The effectiveness of an electromechanical adjusting instrument compared to cervical spine manipulation in the treatment of cervicogenic headaches", Protocol # "IREC 106/16" has been assigned the following unique DOH Trial Number: "DOH-27-1116-5526".

Kind regards,
Department of Health