The effects of an upper cervico-thoracic segment manipulation on posture and muscle activity in participants with forward head and round-shouldered posture

By

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I, Matthew Petzer, do declare that this dissertation is representative of my own work in both conception and execution (except where acknowledgments indicate to the contrary)

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DEDICATION

I dedicate this dissertation to my wonderful parents, Shane and Sandra Petzer. The time, love and support you have shown me over these six years has been immense. I pray that in the future I will be able to bless you in the same way you have blessed me growing up. I am forever grateful for you moulding me into the man I am today. I am so proud to be able to call you my parents! I love you to the moon and back.

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These acknowledgments are a huge appreciation and thank you to these people for never giving up on me and encouraging me to reach greater heights.

Lord, I start by give you all the praise for guiding me through all my trials and tribulations throughout my years. “Be strong and courageous. Do not be frightened, and do not be dismayed, for the Lord your God is with you wherever you go” - Joshua 1:9.

To my parents, Shane and Sandra, thank you for the unbelievable support and love. I appreciate you more than you will ever know.

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ABSTRACT

Background: Postural dysfunction in the cervico-thoracic spine often leads to segmental restrictions and hypomobility, and this is often caused by biomechanical alterations due to postural changes and over activity of skeletal muscles in that region. These muscles include the pectoralis and trapezius muscles. Postural dysfunction and joint restrictions are often treated by manual therapies, such as spinal manipulation. Previous studies have established that joint manipulation reduces postural dysfunction and improves joint mobility, which could be explained by a combination of neurophysiological, and biomechanical effects. In literature, the immediate benefits of a cervico-thoracic manipulation on muscle activity and posture are not well understood and, therefore, an investigation into the immediate effects of manipulation on muscle activity and posture was implemented in this study.

Aim: This study aimed to observe the immediate effect of an upper cervico-thoracic segment manipulation on posture and muscle activity in participants with forward head and round-shouldered posture**.**

Methods: This study was a quantitative, observational study with a pre-test post-test design. Surface electromyography was used to measure the muscle activity of the pectoralis major, upper and middle trapezius muscles prior to and after the cervico-thoracic intervention. A sample size of 40 asymptomatic participants were recruited to participate. The participants were randomly divided into two groups: group A, which was the control group, and group B, which was the intervention group. The intervention group received a cervico-thoracic manipulation, but the control group received no intervention and remained prone for 3 minutes between the pre-test and post-test readings. The within-group comparisons of pre- and post-muscle activity were achieved using paired T-tests. Within group and between group comparisons of the change between pre- and post-intervention were achieved using repeated ANOVA testing. A *p*-value below 0.05 was statistically significant. IBM Statistical Package for Social Sciences (SPSS) version 26 software was used to process the data.

Results: There was no statistically significant treatment effect of cervico-thoracic spinal manipulation in the effects on muscle activity. Although there was not a statistically significant change in muscle activity, there was a positive change in pectoralis major compared to the upper or middle trapezius. The upper and middle trapezius muscles decrease activity followed an evident trend between the participants who received the intervention compared to the control group. Postural results were not statistically significant but positive correlations to treatment were found. The craniovertebral angle was seen to decrease at a higher rate compared to the control group. Additionally, the study provided evidence of a treatment effect on the acromiovertebral angle, decreasing overall in severity.

Conclusion: The results of this study do not provide conclusive evidence that the intervention has any immediate statistical effect on the three muscle activity measurements outcomes observed. In terms of the Posture Pro Analysis System measurements, changes (decrease in angles) between the pre- and post-intervention were mostly significant in both groups, but statistically there was no difference between the control and intervention groups. Posture Pro ratings did not provide evidence of changes in categories within the groups. Therefore, the null hypothesis was retained.

Key words: Muscle activity, neurophysiology, biomechanics, spinal manipulation, forward head posture, round-shouldered posture, trapezius muscle, pectoralis muscle, cervico-thoracic spine.

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ABBREVIATIONS

DUT	=	Durban University of Technology
FHP	=	Forward head posture
RSP	=	Round-shouldered posture
MT	=	manipulative therapy
CM	=	Centimetres
CT	=	Cervico-thoracic
SMT	=	Spinal manipulative therapy
FHRSP	=	Forward head and round-shouldered posture
CVA	=	craniovertebral angle
AVA	=	Acromiovertebral angle
sEMG	=	surface electromyography
IREC	=	Institutional Research Ethics Committee
n	=	sample size
ROM	=	Range of motion
CNS	=	Central nervous system
IVD	=	Intervertebral disc
p	=	probability
HVLA	=	High velocity low amplitude manipulation
%	=	percent
m	=	meters
PA	=	posterior to anterior
CDC	=	Chiropractic day clinic
Std	=	standard
EMG	=	electromyography
mV	=	millivolts
<	=	Less than
>	=	Greater than
=	=	Equals
PPS8	=	PosturePro Software Version 8

DEFINITIONS

Surface Electromyography

Surface electromyography refers to the use of surface electrodes for recording electrical action potentials from the underlying musculature. It is used in the analysis of muscle activity and posture and inspecting for any evidence of postural dysfunction and abnormal muscle recruitment patterns (Criswell 2011).

Cavitation

An audible pop, through the local reduction of pressure, typically as a result of joint mobilisation and manipulation (Bergmann and Peterson 2011).

Joint Dysfunction / Fixation

These terms are used throughout this study. It is described as the restriction formation of a joint in a position of movement when the joint is at rest or when the joint is in movement, irrespective of the presence of pain (Bergmann and Peterson 2011).

Muscle Activity

The random, firing of action potentials of groups of muscle fibres (Criswell 2011).

CHAPTER 1: INTRODUCTION

This chapter provides a background to the study by introducing the research aims and objectives and linking how this study will contribute to scientific literature. The research problem, the structure of the dissertation and a brief literature review are given.

1.1 BACKGROUND

Musculoskeletal health is directly affected by posture, as it is an external manifestation of the musculoskeletal system's integrity and optimal state (Wilczyński *et al.* 2022). Posture can be defined as a group of connections between the musculoskeletal system with motor and sensory pathways from the central nervous system and whose primary function is to maintain an optimal state of muscle-skeletal balance (Carini *et al.* 2017). The Harvard Health Publishing (2014) explained posture as "keeping the cervical, thoracic, and lumbar curves in balance and aligned, with weight distributed evenly over the feet". Posture can additionally be defined as the subsequent of neurophysiological, biomechanical and conservational factors (Caballero *et al.* 2020).

Postural control is described as an isometric and motor action indicating a firm initial point for motion; it is a primary contributor to musculoskeletal function and for optimal easy in everyday activities (Carini *et al.* 2017). Musculoskeletal function begins with movement, which includes postural control. It is the initial point for movement and determines the range of motion of an individual.

Ideal and steady posture is vital for the execution of most range of motion bodily movements (Wilczyński *et al.* 2022). Good posture is a measure of optimal musculoskeletal functionality. Posture is a multifaceted communication of the skeletal system, muscular system, and nervous system. Optimal posture is the state in which parts of the body receive a small quantity of tension against gravity and the bodily position is correctly supported in space. Poor posture can lead to altered movements of the joints by directly affecting the stress and range of motion of the musculoskeletal system (Antonella *et al.* 2020).

The cervico-thoracic (CT) junction is the segment linking the cervical lordotic spine and the thoracic kyphotic spine and, hence, a probable segment for restrictions and decreased range of motion (Joshi *et al.* 2020). Improving the range of motion of the CT junction would decrease the need for compensatory movement in the middle and lower cervical segments, thus reducing the tension on the cervical spine. Common postural alterations initiated by postural dysfunction include round-shouldered posture and forward head posture (Da-In *et al.* 2016). Postural dysfunction may lead to a biomechanical strain of tendons and joints, and asymmetrical muscle activity generating potential muscular and skeletal strain (Antonella *et al.* 2020).

Round-shouldered posture increases the upper thoracic kyphosis and also increases the curvature of the lower cervical vertebrae, whilst triggering the scapula to anteriorly tilt, to rotate downwards then protract (Yun *et al.* 2020). This change in posture causes the pectoral muscles to shorten. Round-shouldered posture (RSP) has been observed to occur because of the strain placed on the musculoskeletal system due to repetitive movements and prolonged poor posture (Yun *et al.* 2020). These postural changes lead to abnormal force distribution about a joint which causes joint restrictions, stiffness, decreased joint range of motion, changes in muscle activity or impairment of muscle performance. Observing and measuring these potential changes are vital in understanding the effects of postural dysfunction on related skeletal structures and muscles in the head and neck region (Mankad and Jagad 2016).

Forward head posture (FHP) is an abnormal cervical posture that represents one of the more frequent postural alterations observed. FHP is greatly linked with multiple musculoskeletal conditions like head and neck dysfunction, myofascial trigger points in surrounding muscles, poor cervical mobility and functional disability of the cervical and thoracic spines (Kiatkulanusorn *et al.* 2021b). A forward head posture combined with round-shoulders caused by inadequate postural control is indicated as a anterior head position with concomitant anterior shoulder positions; such a posture is associated with altered scapular positions, kinematics, and muscle activities (Mylonas *et al.* 2021). These structural and biomechanical relationships of the cervico-thoracic spines are connected to range of motion and movement as well as becoming important factors in postural and structural changes (Cho *et al.* 2019).

Spinal manipulative therapy (SMT) has been observed to cause an immediate decrease in sensitivity by reducing temporal summation, increasing pressure tolerances, as well as lowering activation of the supraspinal areas involved in central motor management. A study by Joshi *et al*. (2020) showed the immediate changes obtained after a single spinal manipulation treatment to reduce postural dysfunction and improve range of motion, which can be clarified by a mixture of possible biomechanical, neurophysiological, and psychological effects (Joshi *et al.* 2020). The current literature and evidence is growing that shows spinal manipulation raises muscle strength in asymptomatic individuals and individuals with underlying postural and musculoskeletal dysfunctions (Niazi *et al.* 2020). However, the primary mechanism causing changes in muscle activity with spinal manipulation is less clear (Niazi *et al.* 2020). The present study aimed to observe the immediate effects of a single spinal manipulation on muscle activity in individuals with postural and biomechanical dysfunctions.

Most current literature mention the affects and outcomes of forward head posture and round-shouldered posture. Yet, there is an absence in the literature focusing on the immediate effect that forward head and round-shouldered posture has on the cervico-thoracic region (Singla and Veqar 2017). Understanding the immediate biomechanical, neurophysiological, and psychological effects of these abnormal postures on the musculoskeletal system will contribute to how therapists consider treatment of postural alterations in the region.

There have been limited studies observing a potential difference between the CVA angle with FHP with, and without, dysfunction (Dae-Hyun et al. 2018). Forward head and round-shouldered posture (FHRSP) is a frequently seen postural abnormality. This abnormality results in flexion of the spine, which increases the amount of stress on the nervous and musculoskeletal systems, which concomitantly affects muscle activity and function of the upper limbs. The present study was conducted to observe the immediate effect of spinal manipulation on individuals with FHRSP and its effect on surrounding musculature in asymptomatic participants and to observe the association between the craniovertebral angle (CVA) and acromiovertebral angle (Mosaad *et al.* 2020). Therefore, the differences in the craniovertebral and acromiovertebral angles were examined in FHRSP participants to clarify the changes in the angles to observe any treatment effect to postural and musculoskeletal dysfunction.

The present study aimed to observe the immediate effect of a cervico-thoracic manipulation on posture and muscle activity in participants with forward head and round-shouldered posture. This was done by observing the benefits of a single manipulation on muscle activity and posture, to provide additional information on treatment outcomes for practitioners.

1.2 RATIONALE

Musculoskeletal abnormalities and postural dysfunction are rising due to continued poor sitting and standing posture (Kim *et al.* 2018). Distinctive postural abnormalities initiated by dysfunction commonly include round-shouldered posture and forward head posture (Da-In *et al.* 2016). Previous studies report that musculoskeletal balance is achieved through proper head and shoulder position which limits stress and strain on the cervico-thoracic segment (Jung Won *et al.* 2015). Correcting poor posture to an erect neutral posture provides two functions. Firstly, it would limit additional stress on the cervico-thoracic joints caused by abnormal cervical and thoracic postures. Secondly, it may train the superficial and deep postural stabilizing muscles in the region to function optimally. Therefore, developing a good head position is a common method to treat head and neck dysfunction.

Forward head posture (FHP) and round-shouldered posture (RSP) are reported as the most common postural deviations of the cervico-thoracic region (Mylonas *et al.* 2021). FHP can be defined as an anterior head position, with hyper-flexion of the lower cervical vertebrae and upper thoracic vertebrae and relative hyper-extension of the upper cervical vertebrae. FHP causes tension and stress on the pectoralis major, upper trapezius, and middle trapezius muscles, resulting in cervico-thoracic restriction formation. (Cho *et al.* 2017). Recent literature shows that studies observing and utilizing manipulative therapy are becoming common; these studies indicate that manipulative therapy is more effective when administered to the cervical and thoracic spinal segment compared to only the cervical spine (Cho *et al.* 2019). Therefore, this study examined the immediate effect that the cervico-thoracic segment has on postural dysfunction and muscle activity.

The round-shouldered posture (RSP) is commonly observed as a structural abnormality affecting the cervico-thoracic segment and includes the acromion's forward displacement in relation to the 7th cervical vertebrae and is quantified using the acromiovertebral angle. RSP is associated with a protracted, forward tilted, internally rotated scapula. Musculoskeletal abnormalities and dysfunction are more frequent due to repetitive movements and poor postural control (Kim *et al*. 2018). This postural dysfunction leads to shortening of the pectoralis major and minor and lengthens trapezius muscles (Singla and Veqar 2017). Forward head and round-shoulder postures (FHRSP) may lead to cervico-thoracic restrictions and dysfunction in the region because of altered scapular kinematics and muscle activity which increases stress on the segment (Fathollahnejad *et al.* 2019).

There is a scarcity in the literature on the combined effect of FHP and RSP on the cervico-thoracic segment. This is important to observe to help practitioners understanding of the region and appropriate treatment strategies to limit restrictions and postural dysfunction.

Cervical hypo-lordosis has the possibility to increase strain onto the cervico-thoracic vertebrae, intervertebral discs and increase muscle activity as the head and neck muscles need to work more to maintain postural stability. On the other hand cervical hyper-lordosis will hypothetically increase the strain and stress on the facet joints and subsequent musculature (Bergmann and Peterson 2011). This resultant increase in load leads to restrictions and adhesion formation in the affected cervico-thoracic transitional segment.

Nejati *et al*. (2014) noted that FHP and RSP are associated with neck dysfunction and pain, although they did not find any statistical correlation between RSP, FHP and neck pain and dysfunction in their study (Nejati *et al.* 2014). These conflicting results provide the need to view asymptomatic participants and the effect they have on posture and muscle activity. This would provide a better baseline comparison between the asymptomatic and symptomatic neck dysfunction groups. This baseline will assist practitioners understanding on head and shoulder postural alterations in symptomatic and asymptomatic cases.

It was reported that when neck flexion increases, muscle activity in the cervico-thoracic region increases (De Bruyne *et al.* 2021). Electromyography is frequently utiized in postural studies to observe any potential changes in muscle activity that occur because of structural alterations and segment restrictions. (Singla and Veqar 2017). Surface electromyography (sEMG) is useful in detecting immediate muscle activity changes. Previous studies have noted that a decrease in the median frequency of electromyography signals may be used to notice muscle activity changes (Guo *et al.* 2021).

sEMG signals are important to clinical studies because it represents the pathway of motor neurons connection to the muscle because of the reflex activation. sEMG with attached electrodes onto specific musculature has been noted to have outstanding test-retest reliability (Bergmann and Peterson 2011). sEMG is utilized commonly in many facets of health care and has proven that the application of sEMG is easy and convenient to the researcher. Data can be captured from sEMG electrodes which includes specifics of muscles activity readings at rest (Nishi *et al.* 2021). sEMG therefore, is best fitted to the present study as it is a consistent and accurate tool used to measure the immediate effects of muscle activity of a regional group of muscles.

Photogrammetry is a effective and quantitative technique for observing postural segments and has demonstrated excellent legitimacy in the analysis of FHP (Salahzadeh *et al.* 2014). Lateral photographs measuring the acromiovertebral angle and cranio-vertebral angle can clinical indicate RSP and FHP respectively. It provides a gross measure of forward positioning of the head on the trunk. Individuals with a smaller cranio-vertebral angle are more likely to suffer from cervico-thoracic restrictions. (Alghadir and Iqbal 2021). This lateral angle is a good indicator for FHP, and its dependability and credibility has been noted and confirmed in previous literature (Salahzadeh *et al.* 2014).

Spinal manipulation uses a segment specific force that motions the vertebrae, manipulates the facet joints, and causes structural, neurological, and organic changes to the musculoskeletal structures. The main goal of adjustments is to realign the restricted vertebrae to restore optimal functionality within and around the affected region. Spinal manipulative therapy is the most frequently utilized method to treat present musculoskeletal and postural dysfunction (LaPelusa 2022b). Yet, current literature highlighting the effects of manipulative therapy, noted that there is a lack in research in the use of manipulative therapy for the improvement of postural abnormalities (Fagundes Loss *et al.* 2020).

Previous studies on asymptomatic subjects found an increase in the neurological and musculoskeletal structures directly after segment specific manipulation, as did Millan *et al*. who validated an immediate effect of spinal manipulation on musculoskeletal structures (Millan *et al.* 2012). Though, in recent literature, Aspinall *et al*. described significant changes in the musculoskeletal system over time in lower back dysfunction populations (Aspinall *et al.* 2019). These findings recommend that additional studies are necessary to gain a better understanding into the immediate effects of manipulation on spinal structures.

There is a scarcity of literature that assesses both the biomechanical and neurophysiological effects of manipulation on abnormal posture and muscle activity in asymptomatic participants. Such research is required to observe the association and alterations of a cervico-thoracic manipulation on FHP and RSP and concomitant changes in muscle activity. However limited, there is increasing literature that supports thoracic and cervical manipulation for treatment of head and neck postural dysfunction (Brown *et al.* 2014). FHP and RSP are common presentations in clinical practice that are frequently overlooked. Although multiple interventional studies are proceeding to better FHP and RSP, research on the link between these postures and cervico-thoracic segment is lacking in the literature (Kim *et al.* 2016). Therefore, this study aims to bridge the gap in the literature and observe the immediate effects of posture and muscle activity alterations on the cervico-thoracic segment.

1.3 AIM OF THE STUDY

The aim of this study is to determine the effect of a cervico-thoracic manipulation on muscle activity and posture in participants with forward head and round-shouldered posture.

1.3.1 Study Objectives

1.3.1.1 To determine the immediate effects of a cervico-thoracic manipulation on muscle activity of the pectoralis and trapezius muscles in forward head and round-shouldered participants.

1.3.1.2 To determine the immediate effects of cervico-thoracic manipulation on postural symmetry in terms of digital photographic measurements in forward head and round-shouldered participants.

1.3.1.3 To compare and correlate collective changes in forward head and round-shouldered participants muscle activity and postural symmetry pre- and post-cervico-thoracic manipulation.

1.3.2 Hypotheses

Null Hypothesis:

The null hypothesis states that there will be a significant difference (p<0.05) between the group receiving cervico-thoracic manipulation and the control group, in terms of postural deviation and mean muscle activity of the upper, middle trapezius and pectoralis muscles.

Alternate Hypothesis:

The alternate hypothesis states that there will not be a significant difference ($p>0.05$) between the group receiving cervico--thoracic manipulation and the control group, in terms of postural deviation and mean muscle activity of the upper, middle trapezius and pectoralis muscles.

1.4 FLOW OF DISSERTATION

Chapter One has introduced forward head posture and round-shouldered posture and the problem it creates in the cervico-thoracic segment leading to postural and muscular effects, as well as going over the aims, objectives and rationale of the study.

Chapter Two specifies an evaluation of the current literature relevant to the current study and will cover the relevant anatomy of the cervico-thoracic region and associated targeted musculature, the biomechanics of forward head and round-shouldered posture and the adaptations that occur because of these biomechanics in relation to posture and muscle activity, and the effect of a cervico-thoracic manipulation and potential improvements to muscle activity changes and postural correction.

Chapter Three gives in-depth description of the methodology of the study. The study design, procedure and the instruments used will be discussed in detail.

Chapter Four presents the results of the study.

Chapter Five provides a discussion of the results in terms of the current literature.

Chapter Six provides a conclusion to the study as well as mentioning any limitations to this study and any recommendations for future studies.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

This chapter describes an overview of posture and how it impacts the musculoskeletal system. Chapter two discusses the relevant anatomy of the cervical and thoracic spine and an outline of the physiology of the nervous system, musculoskeletal system, and joint structures. A detailed outline of forward head and round-shouldered posture is given. In addition to this, the association between forward head and round-shouldered postures effect on muscle activity and posture is discussed as it relates to the theories around the clinical effects of a cervico-thoracic manipulation.

2.2 OVERVIEW OF POSTURE

Every human being has a characteristic feature known as posture. It is an external reflection of the musculoskeletal systems biomechanical and functional state (Wilczyński *et al.* 2022). The purpose of posture is to maintain musculoskeletal balance during dynamic or static movements and to protect the body from external harm. Posture is maintained by the CNS by means of coordinated contraction of skeletal muscles to aid in support of related structures (Wilczyński *et al.* 2022). Therefore, posture can be explained as any position that can maintain musculoskeletal control with optimal stability, minimal range of motion and minimal strain on relevant surrounding structures (Carini *et al.* 2017). When postural changes occur in specific segments it may lead to formation of spinal fixations caused by altered biomechanics and neurophysiological changes.

Three postural curves coordinate balance in the spine: the lordotic vertebrae I the cervical and lumbar regions, which round forward, and the thoracic kyphosis, which concave forward. These postural curves are developed and steadied around six years of age (Carini *et al.* 2017). The three curves maintain postural balance, help support and persist against foreign strain or pressures. Lumbar lordosis is the most vital curve which is formed by five vertebrae starting from the sacrum. The thoracic kyphosis is formed by 12 vertebrae and the cervical lordosis is formed by seven vertebrae (Krause *et al.* 2014). The entire development of postural function takes place at around 11 years old, and then postural stability remains until about 65 years old (Carini *et al.* 2017).

Adequate development is a precursor of good posture, as well as static and dynamic ability of the musculoskeletal system (Caballero *et al.* 2020). Multiple aspects contribute to posture, including neurophysiological, biomechanical, and structural factors. Posture is an involuntary position and it characterizes the body's response to gravity. Posture is maintained through the stimulation and contraction of the musculoskeletal system, coordinated by motor and sensory fibres from the CNS (Antonella *et al.* 2020). Structural and musculoskeletal alterations in the cervico-thoracic orientation of the spine, may lead to inadequate postures, the most common being round-shouldered and forward head posture (Dae-Hyun *et al.* 2018).

2.3 OVERVIEW OF THE CERVICO-THORACIC ANATOMY

2.3 1 Cervical Anatomy

The cervical region consists of seven vertebrae, these vertebrae encompass the spinal cord and meninges within the spinal column. The centrally orientated vertebral bodies protect the head and neck region, and the intervertebral discs provide the flexibility and mobility required for the head and neck region.

The four typical cervical vertebrae (C3–C6) have the following characteristics:

- Broad vertebral bodies which are concave superiorly and convex inferiorly. The superior borders are raised posteriorly to form the uncinate processes (Moore 2017).
- Large, triangular vertebral foramina. The boundary of each vertebral foramen is formed by two pedicles and two laminae (Moore 2017). The pedicles are stump-like processes which are posteriorly orientated. They join with the laminae, which are wider and flatter, to make up the vertebral arch (Moore 2017).
- Superior articular facets that face superior-posteriorly and inferior articular facets that face inferior-anteriorly (Cramer and Darby 2014).
- Short, bifid spinous processes in C3–C5. The spinous process of C6 and C7 is long (Cramer and Darby 2014).
- Transverse foramina which admit the passage of neurovascular structures (Moore 2017).

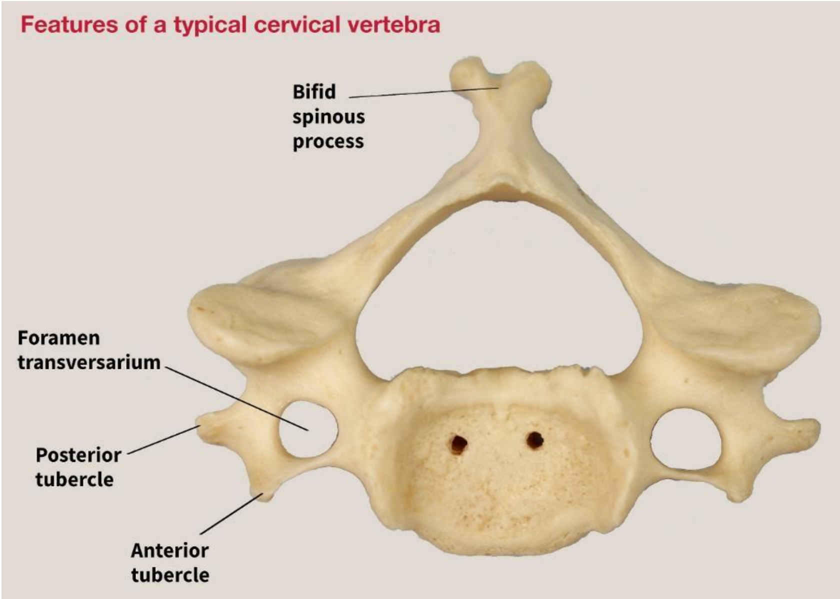

Figure 2.1 Feature of a typical cervical vertebrae (Bazira 2021)

Atypical cervical vertebrae include (C1, C2, and C7):

- The atlas (C1): a circular, kidney-shaped bone without a spinous process, consists of two lateral masses linked by anterior and posterior arches. (Moore 2017).
- The axis (C2): a peg-like dens odontoid process projects superiorly from its body (Moore 2017).
- The cervical prominence (C7): observed due to its long spinous process causing a prominence, which is not bifid. Its transverse processes are larger than other cervical vertebrae, but its foramina are small (Moore 2017).

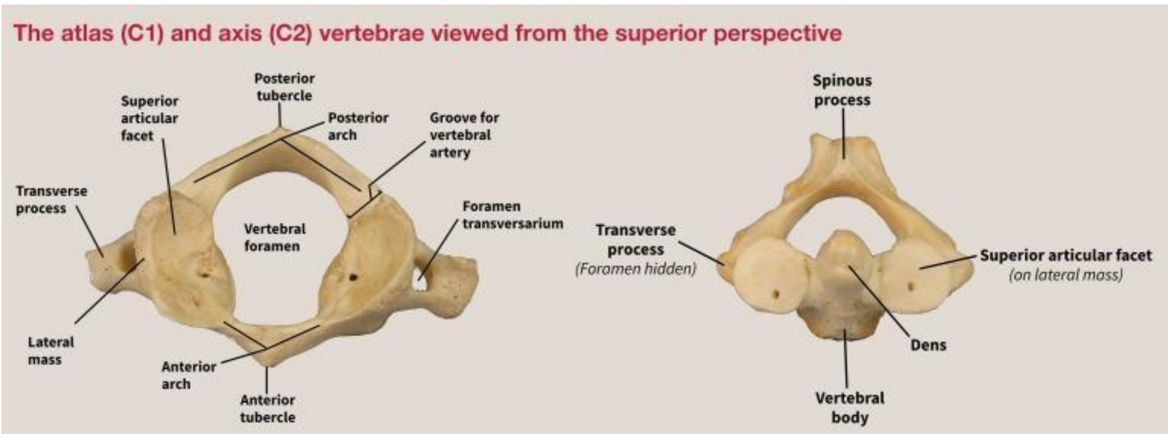

Figure 2.2 Superior view of the atlas and axis vertebrae (Bazira 2021)

The cervical vertebrae are located between the head and neck region. They are the smallest vertebrae in the spine and bear less weight than the other bigger vertebral bodies. The cervical vertebral bodies IVDs are thinner than the thoracic and lumbar regions, but are quiet thick in relation to their size (Moore 2017). The cervical IV discs thickness, the orientation of the articular facets, and the small amount of adjacent body size allows the cervical region a greater range of motion compared to other vertebral segments (Moore 2017).

The oval shaped foramen in the transverse process is the best observational feature of the cervical spine and vertebrae. (Cramer and Darby 2014). This foramen in the transverse process allows the veins to pass through to the bodily segments, C7 is the exception to this in the cervical spine, which only accompany small accessory veins. Consequently, because of the smaller veins passing through the formania is usually smaller compared to the other cervical vertebrae (Cramer and Darby 2014).

2.3 2 Thoracic Anatomy

The thoracic vertebrae are situated in the neck and upper back region. These vertebrae provide the articulations for the ribs and chest cavity. The costal facets articulate with the ribs to form the chest cavity and protect vital organs from foreign harm. This articulation is the most distinct characteristic seen in the thoracic spine. There are 12 thoracic vertebrae in total, and they split into atypical and typical vertebrae. The vertebrae from T5-T8 show distinct features of typical vertebrae (Moore 2017).

The IVDs form an arc centre due to the orientation of the vertically extended articular processes which have paired coronally positioned articular facets to from this arc. This arc formed in the vertebral body allows different range of motions in the thoracic region mainly rotation and some lateral flexion of the thoracic segment (Moore 2017). The costal attachments and rib cage cause the thoracic spine to have less mobility in range of motion, this fixation of the ribs cage doesn't effect rotation bilaterally but limits flexion and extension, as well as lateral flexion in the region.

The upper thoracic vertebrae (T1—T4) have similar features to the lower cervical vertebrae (C6—C7). The C7—T1 cervico-thoracic segment have a distinctive vertebral prominence that is visible. The T1 has a longer spinous process than additional thoracic making it atypical in the region due to the regional prominence (Moore 2017). T1 in addition to the spinal prominence has a complete costal facet for the attachment of the 1st rib and a demi facet lower and more inferior on te vertebral body to allow for the attachment of the 2nd rib (Moore *et al.* 2014).

The lower thoracic vertebrae (T9—T12) have similarities in terms of characteristic features compared to lumbar spine vertebrae. Yet, most of the change in features of vertebrae from the thoracic spine to the thoracolumbar region takes place over a single vertebral segment (T12) (Moore *et al.* 2014). Normally, T12s vertebral bodies upper half is thoracic in characteristic features, having costal facets for rib articulations and articular processes that allow range of motion in the segment, the lower half of the vertebral body is more lumbar in terms of features, having no costal facets and having articular processes that allows range of motion in the thoracolumbar segment for only flexion and extension (Moore 2017).

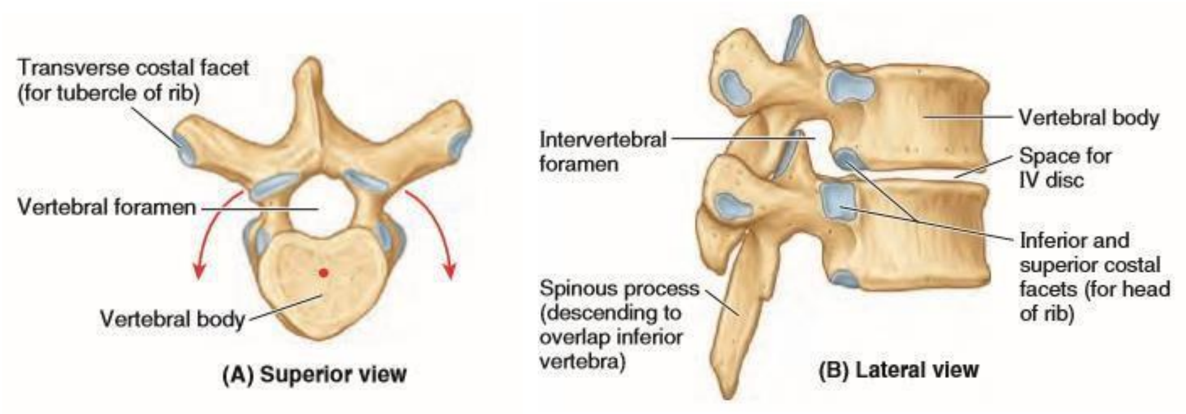

Figure 2.3 Superior and lateral views of typical thoracic vertebrae (Moore 2017)

2.3 3 Cervico-Thoracic Joints

2.3.3.1 Facet Joints

Facet joints are plane synovial joints where the upper articular processes articulate with the lower articular processes of the vertebra body superior to it (Moore, 2017). Each facet joint is surrounded by a thin joint capsule which helps protect the joint from harm. Due to the mobility of the cervical spine the joint capsules are typically thinner and looser, to allow an increased range of motion. There is an abundant supply of sensory innervation which is why dysfunction in these joints are more likely. In addition to this, there are also mechanoreceptors situated within the cervical and thoracic facet joints which assist in keeping the cervico-thoracic vertebrae aligned (Cramer and Darby 2014).

The facet joints allow the articular processes to move in a gliding motion. The range of motion in theses joints is permitted by the size of the IVDS. The facet joints receive nerve supply from articular branches that originate from the medial roots of the posterior rami (Moore 2017). Each joint is supplied by two spinal nerve roots from the posterior rami.

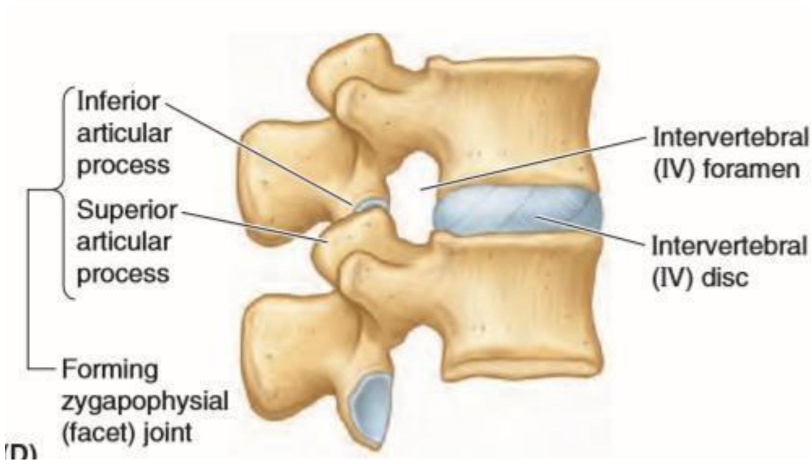

Figure 2.4 Facet joints (Moore 2017)

2.3.3.2 Costotransverse Joints

The costotransverse joint allows the ribs to connect with the vertebral column in the thoracic spine. This occurs when the articular tubercle of the rib and the costal facet of the transverse process articulate with one another. Articulations between the upper costal facet with the adjacent vertebrae and the lower costal facet with the rib is known as the costovertebral joint. The intervertebral disc creates the base of these facets (Moore 2017). The costotransverse joint is a synovial joint, and this allows the articulation between the thoracic spine and the ribs. The costotransverse joints act with the rib cage to provide postural stability. The rib cage limits range of motion primarily lateral flexion and rotation and, therefore, limited movements are achievable in the costotransverse joints. Due to the rib cage decreasing, motion on medial and lateral glides have been noted in the joints (Cramer and Darby 2014).

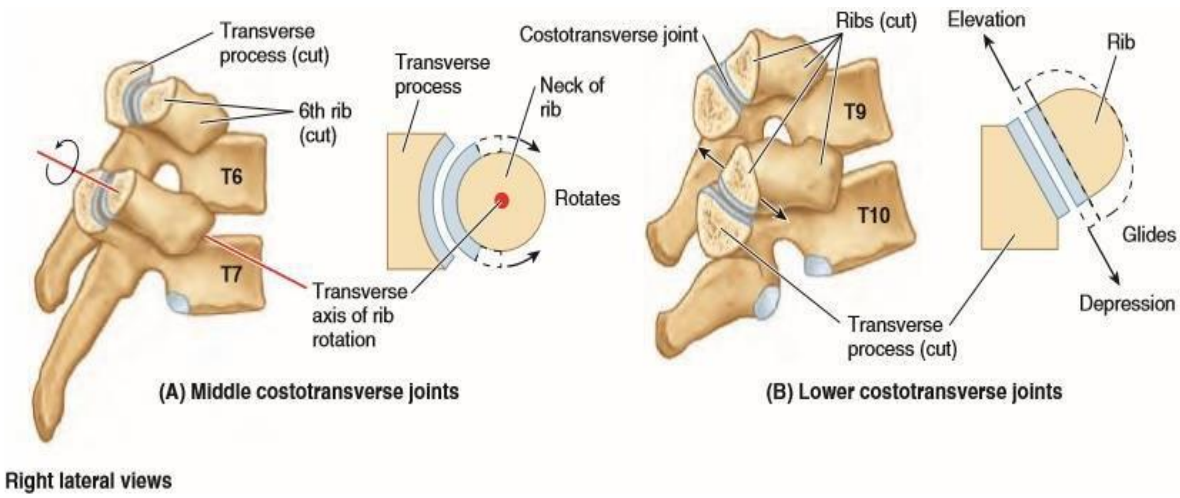

Figure 2.5 Articulations of the costotransverse joints (Moore 2017)

The endplate surfaces of the upper five or six costotransverse joints are curved, with the transverse costal facet being concave and the rib head being convex. The remaining joints are more two-dimensional in configuration. A thin, fibrous capsule lined by a synovial membrane is attached to the two adjacent articular surfaces (Moore 2017).

2.3.4 Muscles of the Cervico-Thoracic Region

2.3.4.1 Trapezius

The trapezius muscle is located on the posterior aspect of the body and is the most superficial back muscle. This muscle can be split into three portions the upper, middle and lower segments. It has a triangular fan-like shape and covers the lower aspect of the posterior neck and the upper portion of the back, this muscle receives nervous innervated by the spinal accessory nerve. Although innervated by the spinal accessory nerve, the trapezius muscle additionally receives some proprioceptive fibres from the third and fourth cervical ventral rami (Cramer and Darby 2014). The trapezius provides a direct attachment of the pectoral girdle to the trunk. The trapezius originates from the superior nuchal line in the midline, attaches to the external occipital protuberance, then to the ligamentum nuchae of the posterior neck, it then runs along and down from the spinous processes of C7 to T12, and along the supraspinous ligament between C7 and T12 (Cramer and Darby 2014). It attaches distally onto the spine of the scapula, acromion, and distal third of the clavicle.

Due to the size of the muscle, it has various different functions depending on the region where it is contracted (upper, middle, or lower). The middle trapezius functions to retract the scapula, while the lower trapezius lowers the scapula and, concomitantly, rotates the scapula in a specific way to superiorly move its lateral angle (Cramer and Darby 2014). The function and movement of the upper trapezius fibres heavily depends on the stability in the head and neck region. On head and neck range of motion, the upper trapezius muscles function and activity directly depends on whether the muscle is contracting on one side or both (Cramer and Darby 2014)

The trapezius muscle additionally supports the shoulders by pulling the scapulae posteriorly and superiorly, fixing them in a neutral position on the thoracic wall held in place by surrounding musculature; consequently, atrophy of the trapezius muscles would lead to round-shoulders due to laxity (Moore 2017). This muscle weakness may lead to postural and biomechanical changes in the head and neck region.

2.3.4.2 Pectoralis Major

The pectoralis major muscle is located on the anterior superior portion of the body and is biggest muscle of the anterior chest cavity. Its muscle fibres are broad, fan-shaped orientation which lies underneath the breast tissue and forms part of the anterior wall of the axilla (Ian and Muralitharan 2017). The pectoralis major muscle fibres are the most surface level muscle in the anterior chest wall. The muscle bulk has two attachments, the clavicular attachment and the sternocostal attachment. The sternocostal attachment of the pectoralis major much is bigger than the clavicular attachment, and its lateral border makes up most of the anterior wall of the axilla. Additionally, Its inferior border forms the visible fold by the axilla (Ian and Muralitharan 2017).

The clavicular attachment of the pectoralis muscle is innervated by the lateral pectoral nerve. The lateral cord of the brachial plexus is where the lateral pectoral nerve originates from. The larger sternocostal attachment is innervated by the medial pectoral nerve. The medial cord of the brachial plexus is where the medial pectoral nerve originates from (Ian and Muralitharan 2017).

The pectoral major muscle functions as a powerful adductor and medial rotator of the upper limb whilst working simultaneously. The two muscle attachments of the pectoralis major can function separately: the clavicular attachment can flex the humerus, and the sternocostal attachment can extend it back from the flexed position (Moore 2017). The sternocostal attachment being the most relevant attachment in postural dysfunctions in the cervico-thoracic region due to origin, size and insertion.

2.4 AN OVERVIEW OF ANATOMY RELATED TO POSTURE (FHP AND RSP)

Posture and the musculoskeletal system coordinate most of the bodies dynamic and static movements (Wilczyński *et al.* 2022). When there is a postural or musculoskeletal change this will influence both systems resulting in segmental dysfunction, changes in postural structures and altered muscle activity (Dae-Hyun *et al.* 2018). A good posture refers to the bodily control of optimal musculoskeletal motion and state. This control, refers to arrangement of the skeletal segments relative to one another so that minimum energy is needed to sustain this optimal postural state and to facilitate muscle activity (Augustsson *et al.* 2022). A poor posture can alter structural alignment of the spine, leading to round-shouldered or forward head posture. These postures effect the cervico-thoracic segment, leading to myofascial trigger points forming in surrounding muscles and changes in range of motion due to increased strain or loading of relative joints and muscles (Dae-Hyun *et al.* 2018).

Biomechanically, forward head posture increases cervical lordosis and changes the cervical posture relative to its centre of gravity, which leads to an increased strain on cervical spine flexors in comparison to good posture (Sirirat *et al.* 2020). These alterations lead to compensatory stimulation of agonistic cervical muscles to counteract the larger amount of stress of this altered posture. The primary issue of muscular dysfunction in FHP is shortening of the upper trapezius muscles, thereby increasing their electrical activities (Moon *et al.* 2018). Head and neck dysfunction in these individuals observed an association with raised muscle activity and of the upper trapezius muscle (Sirirat *et al.* 2020).

The postural dysfunction known as FHP is noted to cause dysfunction in the cervico-thoracic region (Dae-Hyun *et al.* 2018). These biomechanical alterations lead to muscular imbalances, changes to musculoskeletal strength, decreased range of motion and function in the cervico-thoracic spine, and changes in muscle activity around the head and neck region (Kiatkulanusorn *et al.* 2021a). It is possible that these structural and biomechanical changes have increased the strain on the musculoskeletal system in the head and neck region whilst preforming active movements in the cervico-thoracic segment.

The introduction of the musculoskeletal system to this increased strain on the craniovertebral extensors causes an alteration to the biomechanical movement of the cervico-thoracic region and changes to the muscle activity in the region (Augustsson *et al.* 2022). These biomechanical alterations are caused by abnormal rotation and glidingmovements inside the articular capsule during range of motion.

In a study on the link between the craniovertebral (CVA) degree and FHP, it was observed that the postural degree of FHP, according to the CVA measurement, can be utilized in determining the severity and presence of postural abnormalities in the head and neck region (Dae-Hyun *et al.* 2018, Kim *et al.* 2016). The cranio-vertebral angle is normally 48–50 degrees. A CVA lower than the normal range is considered to have a higher severity of forwarded head posture (Augustsson *et al.* 2022). Whilst, a increased CVA is associated with increased neck dysfunction. (Dae-Hyun *et al.* 2018).

FHP and RSP affect the biomechanics of the cervico-thoracic spine. Hypomobility in the thoracic spine leads to suboptimal biomechanics in the cervico-thoracic junction, which causes neck dysfunction (Deepa *et al.* 2014). Alterations in posture and changes in structural biomechanics leads to a decrease in muscular protection from foreign pressures in the head and neck complex. These structural and biomechanical relations of the cervico-thoracic spine are linked to range of motion and contribute to factors causing neck dysfunction and postural disturbances such as FHP and RSP (Cho *et al.* 2017).

As previously stated, there are common links between decrease range of motion in the head and neck region in individuals with FHP and RSP (Dae-Hyun *et al.* 2018). Therefore, there is a gap in the literature of an effective way to physical treat FHP and RSP collectively and examine the major postural and muscular effects that these postures have on the cervico-thoracic segment (Dae-Hyun *et al.* 2018).

2.4.1 Forward Head Posture

Forward head posture (FHP) is an inadequate cervical postural dysfunction that is frequently seen. FHP is frequently linked with multiple biomechanical conditions, for example neck dysfunction, myofascial trigger points in surrounding muscles, poor cervical mobility and functional disability of the cervical and thoracic spines (Kiatkulanusorn *et al.* 2021b).

This postural deviation involves an increase in cervical lordosis by extending the upper cervical vertebrae and flexing the inferior cervical vertebrae, which may lead to over compensation in the region causing increased thoracic kyphosis and round-shoulders (Kiatkulanusorn *et al.* 2021a). These postural changes to the head and neck region lead to changes in muscle tension, varied muscle strength, decrease range of motion in the cervical spine and thoracic spine and changes in muscle activity around the cervico-thoracic region (Kiatkulanusorn *et al.* 2021b)

Forward head posture is common in all age groups, with the mean age group in males being 22–44 years and 23–66 years of age in females (Worlikar *et al*. 2019). The prevalence of forward head posture is 61.3%, with it being more prevalent in office workers who work with computers, with the prevalence of rounded shoulders being 78.3%, mostly seen in university employees (Nejati *et al*. 2014). It is well known that rounded shoulders is highly correlated with forward head posture (FHP), and this condition seems also to correlate with age (Koseki *et al.* 2019). This demonstrates that both young adults and working adults are mainly affected by round-shouldered and forward head postures.

FHP is more prevalent in males, whereas round-shouldered posture is more prevalent in females (Vakili, L *et al*. 2016). A study of current literature observed that even after weight loss and ergonomic advice were changed, women were still at a greater risk for back and neck dysfunction. (Ali *et al.* 2021)

FHP alters the postural and musculoskeletal balance in the head and neck region. The altered posture causes biomechanical compensation towards the anterior position which shifts the centre of gravity leading to alterations in the length-tension relationship of various muscles.(Koseki *et al.* 2019) These muscles attach to the cervical area which leads to neck dysfunction, formation of trigger points and further restriction of the cervico-thoracic area (Koseki *et al.* 2019).

2.4.2 Round-Shouldered Posture

RSP increases the upper thoracic kyphosis and also increases the curve of the lower cervical vertebrae, whilst leading to anteriorly tilt the scapula, additionally rotating it downwards and causing the scapulae to protract (Yun *et al.* 2020). This change in posture causes the pectoral muscles to shorten. RSP has been noted in current literature to arise due to increased strain placed on surrounding musculature caused by decreased range of motion and prolonged postural dysfunction (Yun *et al.* 2020). This change in the scapula position results in a decrease in the vertebral height (Ali *et al.* 2021), which causes a decrease in the length tension relationship of the pectoralis muscle. Additionally, the scapula angle between the lower cervical vertebrae and the upper spine of the scapulae increases (Mosaad *et al.* 2020). In round-shouldered posture (RSP) there is anterior displacement of the acromion in relation to the 7th cervical spinous process, the degree of severity of this change can be measured by utilizing the acromio-vertebral angle. An increase in this angle is directly related to head and neck dysfunction (Fathollahnejad *et al.* 2019).

Current literature has observed that the frequency of forward head posture (FHP) and round-shouldered posture (RSP) in a group of 20–50 year old participants indicated, in the group 66% had a FHP, 73% had a right RSP, and 66% had a left RSP (Mosaad *et al.* 2020). The frequency of postural dysfunction among adolescents noted rounded shouldered posture being the most common abnormality seen, followed by forward head posture (Mosaad *et al.* 2020).

Underlying aetiologies of RSP can be related to continuous overhead exercises, mouth breathing, inadequate posture, computer and laptop use, prolonged study hours and poor ergonomics (Singla and Veqar 2017). RSP additionally results in raised muscle strain in the upper and middle trapezius muscles, contraction and laxity in the pectoralis minor and pectoralis major, and alterations of the shoulder stability and posture due to an imbalance form laxity in the middle and lower trapezius muscle (Yun *et al.* 2020). Prolonged strain on the cervical vertebrae results in alterations of the cervico-thoracic complex, leading to degeneration of related joints, round-shouldered posture and forward head posture (Cho, J. *et al*. 2017).

Although neck dysfunction is frequently seen in current literature, there is a gap in the literature identifying an effective intervention to treat and mange this biomechanical alteration (Fathollahnejad *et al.* 2019) In addition, RSP is structurally associated with FHP (Han *et al.* 2015). FHP and RSP present with acute and chronic complications. Whilst multiple reviews and studies are observing ways to better FHP, literature on the potential link between round-shoulder and cervico-thoracic dysfunction hasn't been addressed (Kim *et al*. 2016).

2.5 MUSCLE ACTIVITY IN FHP AND RSP

When ligaments and tendons are subjected to increased strain, this increases the stress-strain relationship increasing muscle activity due to loading (Evans 2002). FHP and RSP alter biomechanics in the shoulder and neck region, which increases the stress-strain relationship in the muscles surrounding the cervico-thoracic segment (Singla and Veqar 2017).

The body's biomechanical response is to compensate for the altered posture, leading to further dysfunction and altered muscle activity caused by the stress-strain muscle relationship (Singla and Veqar 2017). A change in the postural alignment of the cervico-thoracic region is associated with shortening or lengthening of cervical musculature. Stretched or shortened muscles cause laxity in and around the surrounding structures in the area due to the sarcomeres not being aligned in the most efficient orientation (Khayatzadeh *et al.* 2017). This laxity leads to structural restrictions forming and altered muscle activity.

Forward head posture is a result of hyper-extension of the superior cervical vertebrae and hyper-flexion of the inferior cervical vertebrae and hyper-flexion of the superior thoracic vertebrae. If the cervico-thoracic segment is locked in this abnormal state for a long time, it may result in biomechanical alterations in head and neck region and cause major muscle strain in the surrounding joint structures (Khayatzadeh *et al.* 2017). FHP directly impacts neck extensor muscle activity, and the structural and postural misalignment of the spine has a negative effect on the adjacent musculoskeletal system and decreases range of motion in the region (Lu *et al.* 2020). Additional studies have observed postural dysfunction has a negative correlation to the musculoskeletal system, it results in muscle laxity, and may affect active and passive range of motion and function (Lu *et al.* 2020)

Current literature has noted a decreased proprioception in individuals with head and neck dysfunction (Kuo *et al.* 2019). This alteration in proprioception can lead to decrease head-on-trunk orientation and altered control to maintain a good posture (Kuo *et al.* 2019). Round-shouldered posture alters the head and neck region causing dysfunction. This will lead to changes in proprioception and muscle activity during movement of the cervico-thoracic trunk (Kuo *et al.* 2019). Round-shouldered posture may additionally result in raised muscle stress on the surrounding upper trapezius muscle, on the other hand the pectoralis major muscle may result in stiffness and laxity, there is additional laxity in the middle and lower trapezius caused by the altered posture, which results in alterations of the shoulder joint due to stretching of the muscles. (Yun *et al.* 2020)

Round-shouldered and forward head posture cause a great variety of neurological and biomechanical changes in the cervico-thoracic region, alterations in muscle length, muscle activity, proprioception and soft tissue flexibility (Mankad and Jagad 2016). These alterations can cause abnormal range of motion in the region which leads to spinal joint fixations, decreased range of motion, changes in muscle activity or impairment of muscle performance. Observing and measuring these potential changes are vital in understanding the effects of postural dysfunction on related skeletal structures and muscles in the head and neck region (Mankad and Jagad 2016).

2.6 OVERVIEW OF SPINAL MANIPULATION

The main goal of spinal manipulation is to realign the restricted vertebrae to restore optimal functionality within and around the affected segment (Elder 2022). High velocity and low amplitude thrusts (HVLA) are the most utilized spinal manipulation.

This occurs when a thrust is targeted at a specific vertebral segment by a small lever arm following skin slack removal over the joint adjacent to the transverse processes or spinous processes to motion the vertebral body into the para-physiological space (LaPelusa 2022a). This is done to remove the restriction in the facet joints and produce mechanical, physiological and biological effects (LaPelusa 2022a).

Physiologically, a HVLA thrust moves through the elastic barrier to stretch a contracted muscle, this stimulation produces several afferent impulses from the muscle spindles to the central nervous system to relax the contracted muscle (Hammell 2021). Spinal adjustments function to regain normal joint functions and range of motion. A segment specific adjustment is used that motion the vertebral body, by separating the facet joints, and by doing this causing biomechanical and neurophysiological changes to the musculoskeletal structures. (Elder 2022).

Chiropractic treatment was frequently observed as a treatment for musculoskeletal dysfunctions that aims to improve spinal biomechanics. Current literature have noted spinal manipulations usefulness for disorders such as neck dysfunction and postural changes (Niazi *et al*. 2020). A increase in literature proposes the favourable effects of chiropractic spinal manipulations have a biomechanical and neurophysiological foundation and the potential benefits on spinal manipulation go well past the treatment of just musculoskeletal dysfunction (Niazi *et al*. 2020).

The proposed benefit of spinal manipulation is to increase tissue flexibility, better passive and active range of motion, adjust and remove present soft tissue and joint restrictions, reduce discomfort or pain and decrease any regional soft tissue swelling (LaPelusa 2022a). A comprehensive knowledge of the neurological and biomechanical effects of spinal manipulation is not well documented or understood in current literature. Yet, recent literature has theorized various mechanisms to supporting its usefulness.

2.6.1 Biomechanical Theory

Biomechanics are involved in multiple elements throughout the musculoskeletal system. One of the most important being spinal stability which is a complex mechanism involving neuromuscular control utilizing spinal muscles and passive spinal tissues. These mechanisms are highly coordinated and optimized to provide stability to the spine (Abboud *et al.* 2016). Current literature has observed changes in muscle activity due to altered biomechanics, this has a direct correlation with structural abnormalities resulting from muscle atrophy or increase range of motion (Abboud *et al.* 2016). The literature review by Abboud *et al*. (2016) provides the basis for further research into the effects of biomechanical changes in muscle activity caused by decreased postural stability in spinal segments.

FHP and RSP are postural abnormalities that lead to decreased spinal stability. Therefore, individuals with asymptomatic FHP and RSP will be more prone to musculoskeletal dysfunctions. Moreover, various recent studies reported that subjects with FHP exhibit deficits in proprioception and muscle activity in the cervico-thoracic segment (Battal 2021).

A study examining Iranian office workers noted that the subjects with lower cranio-vertebral angles (forward head posture) and higher acromiovertebral angle (round-shouldered posture) experienced more neck dysfunction and alterations in muscle activity (Nejati *et al.* 2014).

These studies show the need for further research into observing an effective treatment for postural dysfunctions in the head and neck region. Photography-based technique is one of the more frequently utilized tools to assess postural dysfunction in the head and neck region. The dependability of the photography assessment has been reported as acceptable when viewing the lateral aspect (Nejati *et al.* 2014). This was used in the present study to measure and observe postural changes before and after interventions.

Manipulative therapy to the cervical and thoracic spine was described in symptomatic individuals to have an observed lack of evidence in effectiveness and provided a bases for further investigations (Masaracchio *et al.* 2019). Various hypothesise have been noted to have multiple biomechanical alterations due to vertebral motion during a HVLA manipulation. The segment specific force to the spinal vertebrae can cause immediate changes to biomechanics in the specific region. This is achieved by freeing restricted muscular adhesions or by limiting postural dysfunction (Pickar 2002). Hence, there is evidence that HVLA manipulation has been proven to improve structural and biomechanical functionality, by directly stimulating or inhibiting the nervous system (Castello Branco and Moodley 2016; Pickar 2002).

This supports the studies hypothesis in cervico-thoracic manipulations potential effectiveness and biomechanical effect to reduce postural dysfunction. Additionally, the specific HVLA manipulation could potentially either excite or inhibit nociceptive, mechanosensitive nerves in muscle fibres, synovial joints and intervertebral discs (Pickar 2002). This provides further evidence of a segment specific spinal manipulations potential effect on muscle activity by stimulating or inhibiting nerve fibres.

According to Gatterman (2005), the biomechanical effects of spinal manipulation are mainly correction in joint alignment, abnormal joint movement and changes in spinal curvatures (Castello Branco and Moodley 2016; Gatterman 2005). Therefore, spinal manipulation can be utilized as an effective tool in treating forward head and round-shouldered postural dysfunctions.

Postural dysfunction is corrected by HVLA manipulation by stretching the surrounding musculature of the specific vertebral segment being treated. The "stretch" of the surrounding muscles stimulates the muscle fibres and Golgi tendon reflexes. Therefore, resulting in decreased hypertonicity in the muscles and alterations in muscle activity (Castello Branco and Moodley 2016). This resultant change in muscle activity can lead to biomechanical alterations in spinal alignment and correction in postural dysfunction due to decreased hypertonicity in the surrounding musculature.

HVLA manipulation to the thoracic spine for postural dysfunction may also be useful; though, the current literature for segment specific manipulation to both the cervical and thoracic spine is inconsistent (Masaracchio *et al.* 2013). Masaracchio *et al.* (2013) observed individuals who received an intervention of cervical mobilisations and thoracic manipulations noted more favourable results compared to individuals who had non-thrust mobilization to the neck only. These observed results were similar to Saavedra-Hernandez *et al.* (2013) who discovered that patients with head and neck dysfunction that received cervico-thoracic manipulation had a decrease in postural dysfunction than those who were only manipulated in the cervical spine.

Current literature discussed above support the present hypothesis of this study in utilizing a cervico-thoracic adjustment in treatment of postural dysfunction and its potential benefits to muscle activity in the head and neck region.

2.6 2 Neurophysiological Theory

Spinal joint manipulations were historically believed to be characterized as structural and biomechanical, but recent literature has found that these alterations be due to a neurophysiological effect (Saavedra-Hernández *et al.* 2013). Additionally, it has been observed that cervical spine or cervico-thoracic segment adjustments have decreases postural dysfunction and has raised pain thresholds to a larger degree than observed in control groups with no intervention (Miller *et al.* 2010). These alterations and potential neurophysiological effects can lead to a reduction of head and neck dysfunction. A decrease in perceived dysfunction is more when individuals receive HVLA manipulation to either their cervical, cervico-thoracic junction or thoracic vertebral levels (Saavedra-Hernández *et al.* 2013).

The systematic review by Masaracchio *et al*. (2019) concluded thoracic spinal manipulation to be more beneficial in improving neck dysfunction and disability compared to mobilization to both the cervical and thoracic vertebral segments, yet no real difference when compared to cervical HVLA manipulation or placebo. This provides the basis for the present study observing the immediate effect of a cervico-thoracic manipulations on neck dysfunction collectively to improve neurophysiological alterations caused by postural abnormalities.

Bialosky *et al*. (2009) created a model that observed mechanical stimulus caused by a spinal manipulation to gain insight into a potential neurophysiologic effect such as pain reduction, changes in muscle activity and even a reduction in postural dysfunction (Young *et al.* 2014, Bialosky *et al.* 2009).

Musculoskeletal alterations like lessening resting muscle activity and reducing muscle inhibition have previously been link with HVLA manipulations and have shown to cause a neurophysiological response due to excitement of mechanoreceptors or proprioceptors leading to a neurological change (Bialosky *et al.* 2009, Masaracchio *et al.* 2019).

Two other studies compared thoracic spine manipulation with mobilization the results concluded positive outcomes with individuals who received thoracic spinal manipulation (Cleland *et al.* 2007, Salom-Moreno *et al.* 2014). The current literature and above mentioned studies provide favourable evidence for the utilization of HVLA manipulations in the treatment of postural dysfunction and alterations in muscle activity.

Cleland *et al.* (2007) examined the relationship between the audible pop of manipulation and changes in cervical range of motion and cervical dysfunction. It was observed that the amount and region of audible clicks had a limited impact on bettering cervical ROM and head and neck dysfunction. This study supports the use of a single manipulative adjustment utilized in the present study.

Literature reviewed by Fernandez-de-la-Peñas *et al*. (2007) observed the immediate effects of thoracic HVLA manipulation on head and neck dysfunction and discovered a positive correlation in increasing range of motion and reduced dysfunction post-manipulation (Krauss *et al.* 2008, Fernández-de-las-Peñas *et al.* 2007). This gives a basis to observe the immediate effect of spinal manipulation on postural dysfunction in the cervico-thoracic segment, because it has been observed to have a positive effect post-manipulation.

Lau *et al* (2011) observed individuals that received eight sessions of thoracic HVLA manipulation had a more favourable decrease in postural dysfunction and increased range of motion. Additionally, current literature noted a lack of evidence favouring a single treatment of thoracic HVLA manipulation when compared to placebo for reduction in neck dysfunction (Lau *et al.* 2011). Though limited there is evidence and positive outcomes with a single treatment of cervico-thoracic segment adjustments and its possible short-term effects for postural dysfunction reduction.

The rationale to include HVLA manipulation to the thoracic vertebrae in the reduction of individuals with head and neck dysfunction is theorized that any disturbances in joint range of motion in the superior thoracic spine can be a causal contributor to musculoskeletal and postural disorders in the cervical spine (Dunning *et al.* 2012). This confirms the need to examine the cervico-thoracic segment when treating cervical and thoracic postural dysfunctions. Dunning *et al* (2012), investigated the impact of spinal manipulation specifically administered to the cervical and thoracic spines in individuals with head and neck dysfunction, he observed that individuals who received HVLA manipulations had more favourable outcomes compared to non-thrust manipulations or placebos (Dunning *et al.* 2012).

It has previously noted that both non-thrust and thrust manipulations lead to similar neurophysiological effects that help decrease painful stimulus, changes in muscle activity and alter postural dysfunction. These neurophysiological alterations are observed in the region of the segmentally specific manipulative thrust which has a direct effect on the surrounding musculature. A momentary biomechanical alteration can additionally arise. These beneficial changes may be immediate or last for minutes to hours post intervention (Griswold *et al.* 2018).

A manipulation to a specific segment stimulates a response from multiple nerve endings in the autonomic nervous system which are directly related to the treatment outcomes of the individual (Elder 2022). Current evidence has shown a potential treatment outcome when utilizing a placebo form of treatment. It was theorized that favourable outlooks have a huge impact on the treatment and outcomes for individuals with head and neck dysfunction and present restrictions. Manipulation can promote and enhance these positive expectations (Elder 2022). This study aids in the rational of utilizing spinal manipulation in observing muscular and postural alterations in head and neck dysfunctions.

2.7 OVERVIEW OF THE RELATIONSHIP BETWEEN POSTURE AND MUSCLE ACTIVITY

In the world today, musculoskeletal conditions and dysfunction are rising due to poor ergonomics and inadequate posture (Kim *et al.* 2018). RSP has been shown to be one of the more frequently seen postural dysfunctions of the cervico-thoracic segment and is linked with a hyper-flexion of cervical vertebra and the hper-extension of the superior thoracic vertebra, this alteration leads to protrusion of the shoulder, turn inferiorly, and tilt forward (Kiatkulanusorn *et al.* 2021b). Alterations to muscular length and activity, cause potential dysfunction in the head and neck region. Due to the change in the cervico-thoracic region caused by this postural dysfunction, the pectoralis major, and upper trapezius muscles may be altered in terms of length. (Kim *et al.* 2018)

RSP leads to hyper-kyphosis of superior thoracic vertebrae and alterations to the cervical curvature, with this alteration the scapula tilts forward, its inferiorly rotated, and the scapula is protracted (Yun *et al.* 2020). RSP can cause raised muscle strain of the upper trapezius muscle, associated weakness and rigidity in the pectoralis minor and pectoralis major, and dysfunction of the shoulder joint due to an disproportion caused by muscle laxity due to stretching of the middle and lower trapezius (Yun *et al.* 2020). Forward head and round-shoulder postures (FHRSP) may lead to cervico-thoracic restrictions and biomechanical changes in the region because of changes in scapular range of motion and muscle activity which increases stress on the segment (Fathollahnejad *et al.* 2019)

Forward head posture can lead to alterations in muscle proprioception, decreasing functionality of mechanoreceptor, and changes to muscle fibres receptibility in the cervico-thoracic region, additional decrease in normal range of motion in the head and neck region (Kiatkulanusorn *et al.* 2021b). The upper limb posture of forward head individuals is relatively similar to the characteristics seen in round-shoulders (Ali *et al.* 2021). The head and neck regions are anatomically connected to the same musculoskeletal structures which means the cervico-thoracic segment can easily get affected by postural dysfunctions (Kiatkulanusorn *et al.* 2021b).

Forward head posture increases head and neck extensor muscle activity because of superior cervical extension stimulators (desk jobs, poor ergonomics). To reduce the need for muscular hyperactivity and increased strain on cervical tissues and structures the adoption of optimal head and neck posture is important. The FHP positioning increases the strain on head and neck muscles by 3.6 times when compared to good posture (Cho *et al.* 2017). Whereas, RSP may cause an increased muscle strain in the upper trapezius and surrounding musculature, rigidity and fatigue in the pectoralis minor and pectoralis major has been observed, and alterations in the shoulder joint caused by stretching of the middle and lower trapezius due to an imbalance caused by laxity in the region (Yun *et al.* 2020).

RSP leads to the pectoralis minor and to a lesser degree the major to decrease in length because of the need to compensate for the postural dysfunction and decrease scapular range of motion, showing potential weakness due to the shortening of the muscle fibres (Kim *et al.* 2018). The different muscle activity seen with postural dysfunction in the cervical and thoracic segments provide a probable reasoning as to how optimal musculoskeletal activity in the cervico-thoracic region can be altered due to both FHP and RSP (Edmondston *et al.* 2011). Due to the biomechanical and neurophysiological dysfunctions of FHP and RSP, an investigation into treatment effects is warranted.

2.8 SUMMARY OF THE REVIEW OF LITERATURE

This chapter has provided an overview of posture and its relation to the musculoskeletal system. It provided an overview of cervical and thoracic anatomy, blood supply and innervation, as well as facet joints and costotransverse joints in the spine. It correlated the link between forward head and round-shouldered posture to the cervico-thoracic region.

This chapter has provided a summary of FHP and RSP effect on muscle activity. An overview of spinal manipulation was provided highlighting the neurophysiological effect and biomechanical effects on posture. Additionally, the effect of manipulation on posture and muscle activity was summarized. This review of the literature provided an insight into why the study was conducted and the gap it would fill.

CHAPTER 3: METHODOLOGY

3.1 INTRODUCTION

This chapter will provide an in-depth description of the research process performed in this study. In doing so, we will discuss the study design and the approval granted to the present study, participant recruitment, sampling method, study setting, measurement tools, the research procedure, and the analysis of the data collected, as well as going over the ethical considerations relevant to this study.

3.2 STUDY DESIGN

This study utilized a quantitative observational pre-test post-test design. Quantitative research is utilized to test and observe objective theories by examining and comparing any relations amongst variables. A factor that can be controlled or changed in an experiment is known as a variable (Ingham-Broomfield 2014). This design was chosen as it is the most suitable way to evaluate and compare the variables which are the intervention with a control group. The design also allows an efficient way to observe and calculate any alterations caused by the investigational intervention.

3.3 STUDY LOCATION

The present study utilized the Durban University of Technology Chiropractic Day Clinic. The individuals were allocated to clinic room 12 for observation.

3.4 STUDY POPULATION

The study recruited adult male and female participants between the age of 18 and 45, of any gender or race, who were asymptomatic in terms of head and neck pain and resided within the eThekwini Municipality. Gatekeeper permission was obtained from the DUT Research Director (Appendix A) to utilise the DUT campus to conduct the research. In addition to this, gatekeeper permission was obtained from the DUT Clinic Director (Appendix B) to utilise the clinic for research purposes.

Furthermore, the study did not commence until the DUT Institutional Research Ethics Committee (IREC) granted full ethical approval to perform the study (Appendix G).

3.5 PARTICIPANT RECRUITMENT

The participants were recruited via means of advertisements (Appendix C). These were placed at the various campuses of DUT. These campuses include Steve Biko, Brickfield, ML Sultan and City campuses. The research was additionally advertised via DUT pinboard and social media platforms. Permission obtained to place these advertisements (Appendix F) was obtained first. Permission was additionally obtained from the research director (Appendix A) and the clinic director (Appendix B). This was done to ensure the use of the clinic for participant recruitment and ethical considerations.

When potential participants were interested, they contacted the researcher. A telephonic consultation was conducted (Appendix K) to confirm that the individual met the inclusion criteria.

Table 3.1 Pre-screening telephonic consultation

Questions for potential participants	**Expected Answers**
Please may I ask you some questions?	Yes
How old are you?	Between 18–45
Have you experienced neck or shoulder pain in the last six weeks?	No
Have you been received any spinal manipulation in the last two weeks?	No
Have you been diagnosed with scoliosis, osteoporosis, osteoarthritis or ankylosing spondylitis?	No
Are you in good health?	Yes

3.6 SAMPLING

3.6.1 Sample Size

The total sample size for the study was 40. The sample size was calculated using standard deviations of 14,8 for group 1 and 8,0 for group 2, and with a significance level (alpha) of 0,050 using a two-sided two-sample unequal-variance t-test, a confidence interval of equal means and power analysis of 0.80% (Esterhuizen 2020). A sample size of 40 participants were utilized in this study: 20 in the control group (Group A) and 20 in the intervention group (Group B).

3.6.2 Sampling Strategy

The participants were randomly allocated to either Group A or Group B. To ensure randomization and concealment, 40 pieces of folded paper were put into a sealed envelope, 20 pieces with the letter A and 20 with the letter B (Esterhuizen 2020). When the individuals arrived for their consultation, they were randomly allocated into Group A or Group B by asking the receptionist on duty to assign them a letter by choosing a slip of paper from the envelope. Gender stratification was observed to ensure equal numbers of males and females to account for natural flexibility differences.

3.7 POPULATION OF STUDY

For the prospective participants to be included into the study, they had to meet the following criteria:

3.7.1 Inclusion Criteria

- The participants were asked to sign and read the letter of information (Appendix E) and provide their informed consent (Appendix F).
- The participants were observed with normal range of motion but were restricted in the region of the C6–T1 (Vernon and Mrozek 2005) lead to an increased neurological effect.
- The participants presented with cervico-thoracic spine (C6–T2) fixations; these were determined by means of motion palpation as this is the most reliable method of determining whether fixations are present (Nyberg and Russell Smith 2013).
- One or both postural abnormalities of forward head and round-shouldered posture were present. There are frequently observed relations between movement of FHP and RSP as they are connected to the same anatomical trunk.
- The participants were between the ages of 18–45 years of age. The age of 18 excluded the need for a legal guardian being present. Individuals who are 45 years old and above have an increased likelihood of presenting with pathologies, such as degeneration and this will alter the outcomes of the study (Britton *et al.* 2018).

3.7.2 Exclusion Criteria

- The participants who received chiropractic treatment on the cervical spine and thoracic spine within four weeks of recruitment were excluded. This allows an adjustment time to see the relative effect for the study period, which avoids the effects of previous interventions from altering results recorded during the study.
- The participants with a history of surgery were excluded because of the risk of spinal curvature flattening after spinal cord decompression surgery and spinal fusions effecting a change in posture.
- The participants who had been diagnosed with arthritides or osteoporosis were excluded (Misra *et al.* 2011).
- The participants with contraindications to sEMG at the region of electrode placement were excluded as well. These contraindications include psoriasis, skin rashes, open wounds or any skin irritations (Gallina *et al.* 2017).
- Individuals with a body mass index that is 30 or higher were excluded. The presence of adipose tissue alters the ability to take accurate muscle activity readings (Gallina *et al.* 2017).

3.8 MEASUREMENT TOOLS

3.8.1 PosturePro 8 Software

PosturePro is a commercially available postural analysis software used for the photographic analysis of posture. According to Senthil *et al.* (2018), the PosturePro 8 Software (PPS8) is an effective and reliable method of analysing posture (Senthil *et al.* 2018). For the present study, the PPS8 was utilized to observe the degree of severity of forward head posture, by measuring the craniovertebral angle, and rounded-shoulder posture, by measuring the acromiovertebral angle. The software was loaded onto a laptop and was used in conjunction with a digital camera.

3.8.1.1 Quantification of Posture Measurements (all in degrees)

Head angle (craniovetebral angle):

- Ideal head angle: ≤ 36
- Mild forward head angle: 37–41

- Moderate forward head angle: 42–46
- Severe forward head angle: >46
- Shoulder angle (acromiovertebral angle)
- Ideal shoulder angle: ≤ 22
- Mild forward shoulder angle: 23–37
- Moderate forward shoulder angle: 38–52
- Severe forward shoulder angle: >52

3.8.8.2 Digital Camera

A digital camera was used to take the photographs required for the posture assessment. The camera was placed 1m high and 3.5m away from the wall a tripod was used to ensure correct placement. The participants were required to stand 40cm away from the wall, which was marked on the floor with tape. This was in line with the procedure set out by Thigpen *et al*. (2010) and was performed to ensure that the measurements taken from each photo were accurate and reproducible (Thigpen *et al.* 2010).

a=camera placement X= participant placement

Figure 3.1 Camera placement for postural images

3.8.8.3 Surface EMG

The most effective setup of sEMG sensors and data collection is to orientate two electrodes bilaterally placed over the relevant region, each electrode would analyse the intended musculature. The two electrode signals are amplified and subtracted, resulting in a one differential signal, which is more receptive to the specific muscular region its placed on compared to muscles originating further away. As the distance between the inter-electrode increases, the resultant crosstalk signal and target signal increase in magnitude. The target signal remains stable until the borders of the muscle inhibit activity, and the length of the inter-electrode spacing equals that of the action potentials. Thus, the inter-electrode placement and spacing must be considered and acceptable to minimize the crosstalk signal and maximize the target signal. Surface electrodes (Biometrics Ltd, UK) were set at fixed positions with participant at rest measured for 30 seconds on shaved and cleansed skin. They were mounted in bipolar pattern and were allied along the major axis of the muscle with a 20mm inter-electrode distance.

Electrode Placement is according to the SENIAM Project Recommendations (seniam.org) and Cram's “Introduction to Surface Electromyography, 2nd edition” (Criswell 2011):

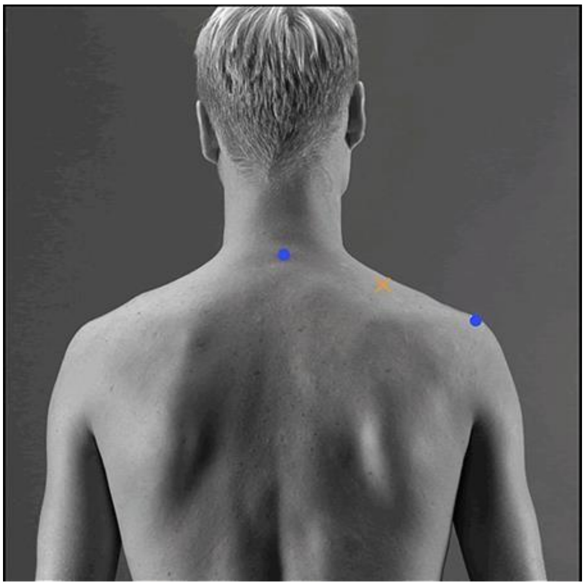

Figure 3.2 Upper trapezius: location = The electrodes orientation must be placed at 1/2 on the line from the acromion to the prominence on the C7 vertebrae. Orientation = placement on the line between the acromion and the C7 vertebral prominence (seniam.org)

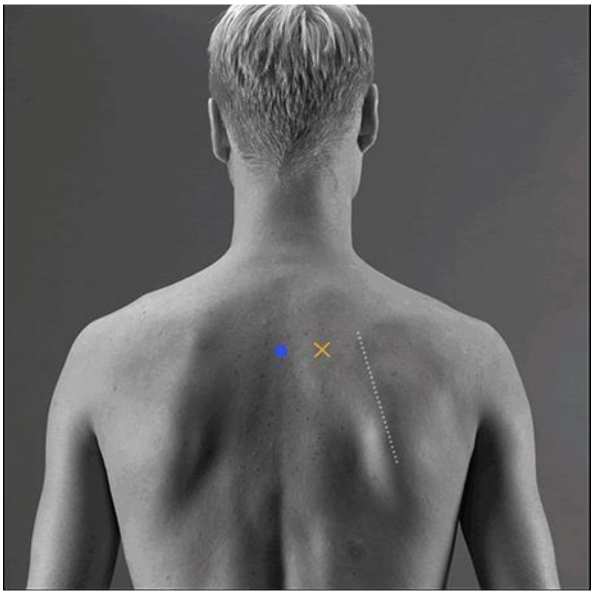

Figure 3.3 Middle trapezius: Location = The electrodes orientation must be placed at the level of T3, ½ way between the medial border of the scapula and the spine. Orientation = placed by the line between T5 and the acromion (seniam.org)

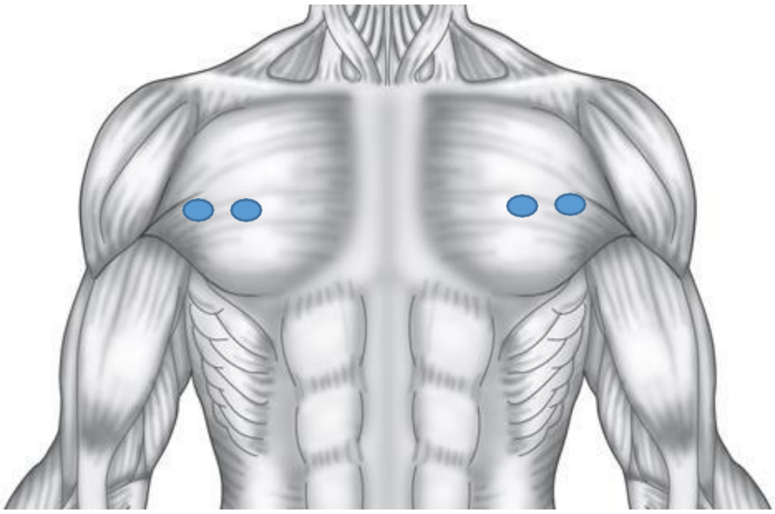

Figure 3.4 Pectoralis major: For clavicular placement, locate the clavicle. Two sEMG electrodes (2 cm apart) are orientated at an oblique angle toward the clavicle on the chest wall, just medial to the axillary fold, approximately 2cm below the clavicle (Criswell 2011)

3.8.8.4 Validity and Reliability

To maintain rigour and ensure that the quality of the study was as high as possible, the researcher ensured that all of the measurement tools used in the study were valid and reliable (Senthil *et al.* 2018). All the measurement tools utilized in the current study were calibrated before the testing procedure. To provide reproducibility of the results, each participant was given the same set of instructions prior to the beginning of the testing procedure and the procedure was carried out in the same order for each participant.

3.8.9 Intervention

Group A (control group) received a control procedure. The participant lay prone for three minutes and in this way there was a relaxing and lowering of possible stress influence on the sympathetic nervous system.

In Group B, the participants received an upper cervico-thoracic spinal manipulation on the side of the restriction. This is a HVLA manipulation moving the participant through the end range of motion and engaging the elastic barrier. The adjustment was performed in the following way.

The participant lay prone with the head firmly into the head piece. Palpation of the upper cervico-thoracic segment observed the side of the restriction. Once this was obtained, the participants head was rotated to the contralateral side of the restriction. The practitioner's hand contacted the forehead and the other hand's thumb contacted the spinous process of the restricted side. A low amplitude, high velocity thrust towards the axilla was applied, using the PA rotation-thumb spinous technique.

- Doctor position: Fence stance position.
- Participant position: Prone.
- Contact point on participant: Spinous processes of the superior cervico-thoracic vertebrae (the side of the restriction).
- Contact point on doctor: Thumb.
- Vector of the movement: towards the axilla.

3.9 RESEARCH PROCEDURE

When the participant met the criteria via telephonic screening, an appointment was made at the DUT Chiropractic Day Clinic (CDC). The participant was asked to wear a tight-fitting vest/strapless shirt/shirt with thin straps and tight-fitting gym shorts/pants or leggings/tights. The participants wore only black, white or navy clothes, to ensure the white ball markers would be easily recognised by the Posture Pro Analysis System (Posture Pro). This was done to ensure it did not incorrectly analyse similar colours on the clothing worn by the participants.

Once the participant was included into the study, the researcher verbally explained the procedure and the participant was given a letter of information (Appendix E) and signed the informed consent form (Appendix F). Time was then given to the participant to ask any questions on aspects they required clarification.

The consultation entailed a physical examination, regional examination, and case history of the thoracic spine and cervical spine. The upper cervico-thoracic region was targeted specifically for any dysfunction or restrictions present.

Once all physical findings were recorded, the participant went for the lateral imaging for postural analysis. After the imaging, the participant moved to the research lab, where electrodes were placed on the upper, middle trapezius muscles and pectoralis major muscles. The electrodes obtained results of baseline muscle activity.

The participant then received the spinal manipulation or the control intervention which was timed at three minutes rest. After this the muscle activity was remeasured for immediate effects.

The participant was moved into the postural room for additional lateral imaging.

3.10 COVID-19 SAFETY PROTOCOLS

All COVID-19 protocols were adhered to throughout the study. The Chiropractic Day Clinic has strict protocols. Once participants expressed interest in the study, they were screened telephonically by the researcher. Upon arrival at the clinic, participants were screened and sanitised at the gate by security, and then at the front entrance, before being allowed into the clinic, the participant was screened for any COVID-19 symptoms and their temperature was captured and recorded.

Once the screening process was completed, the researcher met the participant. Both the researcher and participant were always wearing masks. The clinic has clearly demarcated areas to maintain social distancing and adequate sanitizing stations. The participant were required to fill in the COVID-19 clinic paper work of informed consent (Appendix O).

After group allocation, the participant sanitized before moving to the treatment room. The room and all equipment were fully sanitized (bed, chairs, hands and equipment). Once all protocols were met, the researcher obtained the desired readings and performed the necessary intervention. On completion of the observation, the participant sanitized before leaving the clinic and researcher re-sanitized all equipment before the next participant. All EMG electrodes utilised were discarded after every treatment.

3.11 DATA REDUCTION AND ANALYSIS

IBM SPSS version 28 was used to analyse the data. The outcome measurements were found to be normally distributed using the Shapiro Wilks test ($p>0.05$) and were thus analysed using parametric statistical tests. Independent samples t-tests were used to compare baseline measurements between the two treatment groups. Repeated measures ANOVA tests were used to compare the change from pre- to post-intervention between the two treatment groups in terms of the muscle activity and Posture Pro quantitative measurements. The time*group interaction indicated intervention effectiveness.

Profile plots were used to visually assess trends over time between the two groups. The Posture Pro measurement were also converted in categorical ratings (ordinal variable) and compared between pre and post within each of the treatment groups using paired McNemar tests. Pearson's corelation analysis and paired t-tests on the change between pre- and post-intervention were used on the sample to assess whether one or more muscle activity measurement experienced a higher change than another. A p-value <0.05 was considered as statistically significant (Esterhuizen 2020).

3.12 ETHICAL CONSIDERATIONS

3.12.1 Autonomy

Informed consent (Appendix F) was obtained from each participant, which confirmed the principle of autonomy. The participants were free to leave the study should they wish to do so, without prejudice.

3.12.2 Non-Maleficence

The rights and the welfare of the participants were protected by blacking out their eyes in the photographs which were stored safely on a flash drive to which only the researcher has access. No intentional harm was done to the participant throughout the study.

3.12.3 Justice

The participants were not coerced into participating in the study. Every participant who met the inclusion criteria was invited to participate in the study and there was no discrimination in terms of race, gender, or age, which ensured that the research principle of justice was maintained.

3.12.4 Beneficence

Participation was voluntary and did not involve financial benefits. However, this study was beneficial to the participants in obtaining knowledge of posture abnormalities and correction.

3.12.5 Confidentiality

The postural assessment, Posture Pro Analysis, is non-invasive and had no risk to participants. The participants were referred to under codes and their names were not used on the data sheets. For a period of five years the research data are kept in a safe place at the CDC, after which the research data will be shredded. The rights and the welfare of the participants are protected.

3.12.6 Consent

Permission to use the Chiropractic Day Clinic for research purposes, distribute advertisements on DUT campuses and permission to access staff and students of DUT were obtained from the gatekeeper's committee research director (Appendix B).

3.12.7 Professionalism

The participants were treated professionally, and the confidentiality of participant details and results were secure. Half the participants received upper cervico-thoracic spinal manipulation (intervention) and the other half (control) did not move at all or have any stimulation other than the placement of the electrode pads, because of the small neurological difference that is measured in one adjustment.

The research was under supervision and indemnity cover of the clinic. The participants' safety and care was very important to keep a level of professionalism and ethical considerations. Participant confidentiality was maintained by keeping the participants' file with all the details and documents.

3.13 CONCLUSION

In conclusion, this chapter has given a detailed summary into the methodology approach to this study, showing in detail why this design was chosen, how the data were collected, what inclusion and exclusion criteria was utilized and all additional steps and procedures to keep in accordance with national regulations for the COVID-19 pandemic.

CHAPTER 4 RESULTS

4.1 INTRODUCTION

The current chapter gives an overview of the results of the current study in the form of graphs and tables. The data were collected from participants and analysed as mentioned in methodology in Chapter Three.

The analysis included:

- Normal measurements outcome measurements were found using the Shapiro Wilks test ($p>0.05$) and were thus analysed using parametric statistical tests.
- The independent samples t-tests were used to compare baseline measurements between the two treatment groups.
- Repeated measures ANOVA tests were used to compare the change from pre- to post-intervention between the two treatment groups in terms of the muscle activity and Posture Pro quantitative measurements.
- Profile plots were used to visually assess trends over time between the two groups.
- The Posture Pro measurement were also converted in categorical ratings (ordinal variable) and compared between pre- and post-intervention within each of the treatment groups using paired McNemar tests.
- Pearson's corelation analysis and paired t-tests on the change between pre- and post-intervention were used on the sample to assess whether one or more muscle activity measurement experienced a higher change than another.

This research study was based on the following hypotheses:

Null hypothesis: There will be a significant difference ($p<0.05$) between the group receiving cervico-thoracic manipulation and the control group, in terms of postural deviation and mean muscle activity of the upper, middle trapezius and pectoralis muscles.

Alternative hypothesis: There will not be a significant difference ($p>0.05$) between the group receiving cervico-thoracic manipulation and the control group, in terms of postural deviation and mean muscle activity of the upper, middle trapezius and pectoralis muscles.

4.2 CONSORT FLOW DIAGRAM

The flow diagram of Figure 4.1 demonstrates the distribution of the participants throughout the research. After all inclusion and exclusion criteria were met, 20 participants were randomly allocated to the Intervention Group (B) and 20 participants were randomly allocated to the Control Group (A). Group allocation was done through 40 folded pieces of paper, 20 with the letter A and 20 with the letter B. These were randomly drawn by the reception staff to avoid bias.

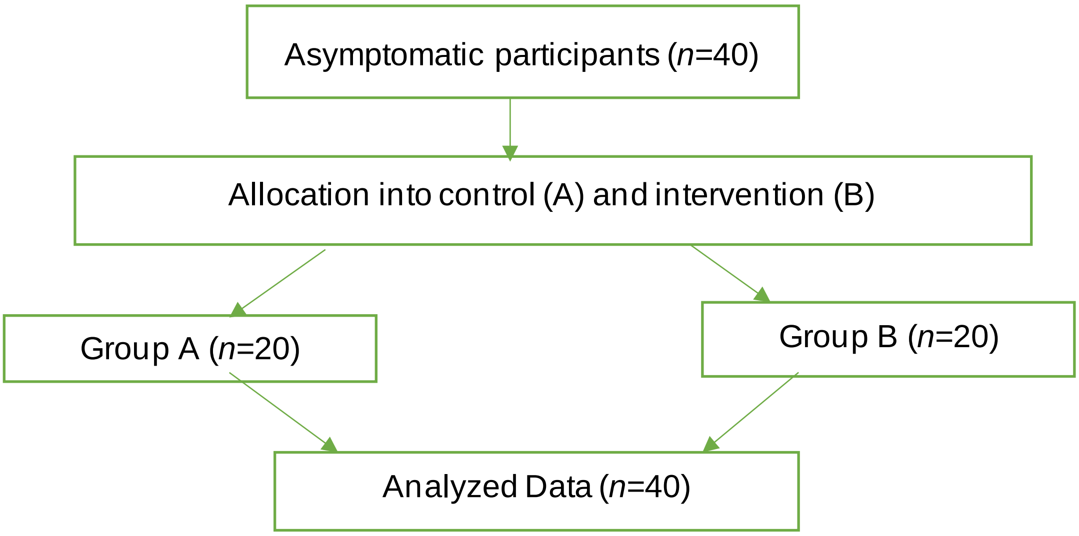

Figure 4.1 Consort flow diagram

4.3 MUSCLE ACTIVITY MEASUREMENTS (SEMG)

The EMG baseline readings were captured using the mean muscle activity values for each muscle. Table 4.1 summarises the EMG baseline readings for group statistics pre-intervention and control for the left pectoralis major, upper trapezius and middle trapezius muscles.

Table 4.1 Baseline electromyography measurements compared between the two treatment groups

Group Statistics						
	Group	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**	***p*-value**
Pectoralis major	Control	20	.8718805	.03188352	.00712937	0.907
	Intervention	20	.8731620	.03717999	.00831370	
Upper trapezius	Control	20	.7858625	.03048978	.00681772	0.495
	Intervention	20	.7920160	.02578259	.00576516	
Middle trapezius	Control	20	.8176615	.02807153	.00627698	0.128
	Intervention	20	.8376140	.05009243	.01120101	

There was no difference prior to treatment between the two groups in terms of any of the outcome measurements. Table 4.1 shows that no significant differences were found in terms of baseline muscle activity measurements between the intervention and control groups.

4.3.1 Mean Muscle Activity

Repeated measures ANOVA tests were done to assess whether the change over time from pre- to post-treatment differed between the two groups. This was assessed using the time*group interaction effect. The time effect indicated overall if there was a change from pre to post, and the group effect indicated over both time points whether the two groups were different.

4.3.1.1 Pectoralis Major

Table 4.2 Repeated measures ANOVA results for pectoralis major

Effect	**Wilk's Lambda**	***p*-value**
Time	0.939	0.125
Time*group	0.999	0.841
Group	0.083	0.775

Table 4.2 shows there was no evidence of an intervention effect on this outcome (p=0.841).

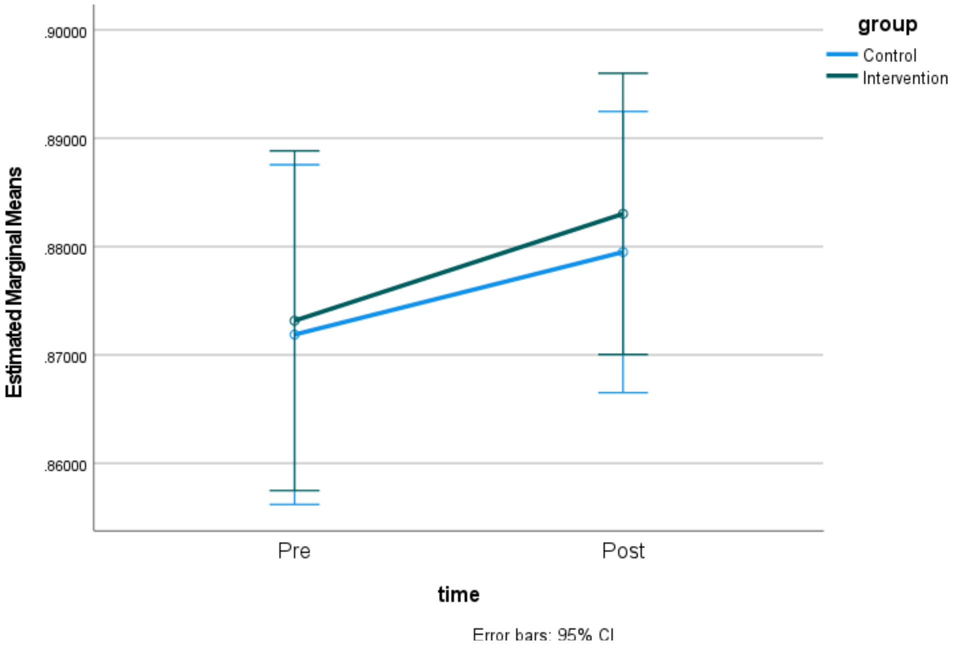

Figure 4.2 Profile plot of time by group for pectoralis major

Figure 4.2 shows that the profiles of the two groups were roughly parallel and the rate of change was slightly increase over both groups.

Table 4.3 Marginal means for pectoralis major

Group	Time	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Control	1	.872	.008	.856	.888
	2	.879	.006	.867	.892
Intervention	1	.873	.008	.857	.889
	2	.883	.006	.870	.896

The mean and standard error values for pectoralis major at each time point for each group are shown above.

4.3.1.2 Upper Trapezius

Table 4.4 Repeated measures ANOVA results for upper trapezius

Effect	**Wilk's Lambda**	***p*-value**
Time	1.000	0.968
Time*group	0.997	0.754
Group	0.407	0.527

Table 4.4 shows there was no evidence of an intervention effect on this outcome (*p*=0.754).

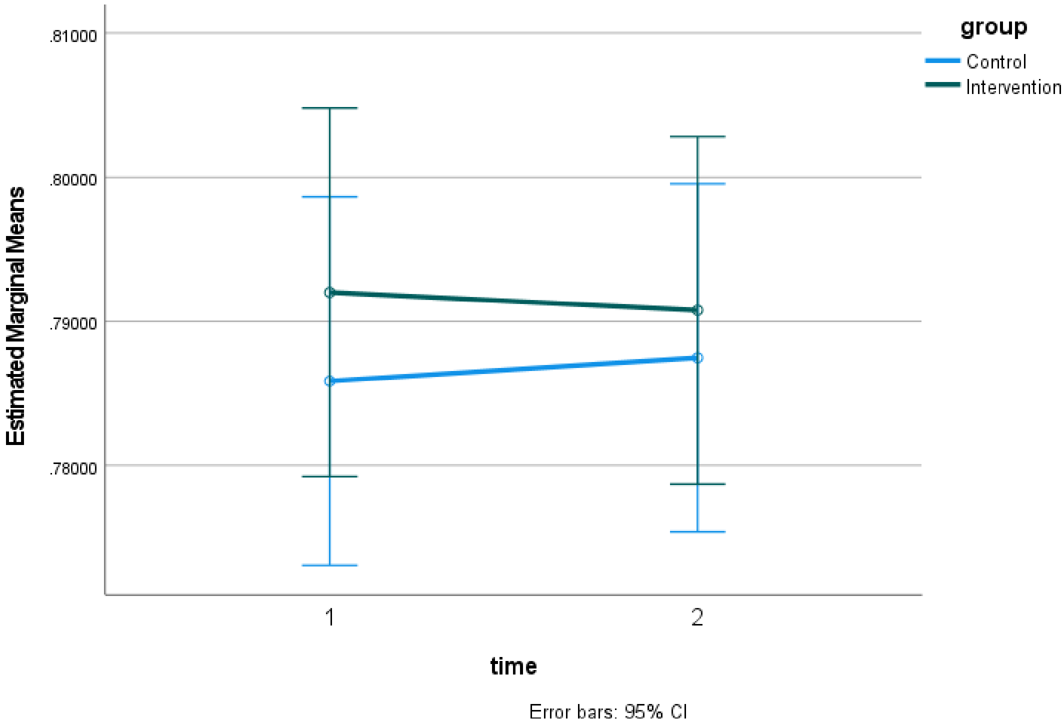

Figure 4.3 Profile plot of time by group for upper trapezius

Figure 4.3 shows that the profiles of the two groups over time were similar and the lines were roughly parallel.

Table 4.5 Marginal means for upper trapezius

Group	Time	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Control	1	.786	.006	.773	.799
	2	.787	.006	.775	.800
Intervention	1	.792	.006	.779	.805
	2	.791	.006	.779	.803

Table 4.5 shows that the mean and standard error values for upper trapezius at each time point for each group are shown.

4.3.1.3 Middle Trapezius

Table 4.6 Repeated ANOVA measurements for middle trapezius

Effect	Wilk's Lambda	*p*-value
Time	0.991	0.556
Time*group	0.995	0.671
Group	2.307	0.137

There was no evidence of an intervention effect on this outcome (p=0.671).

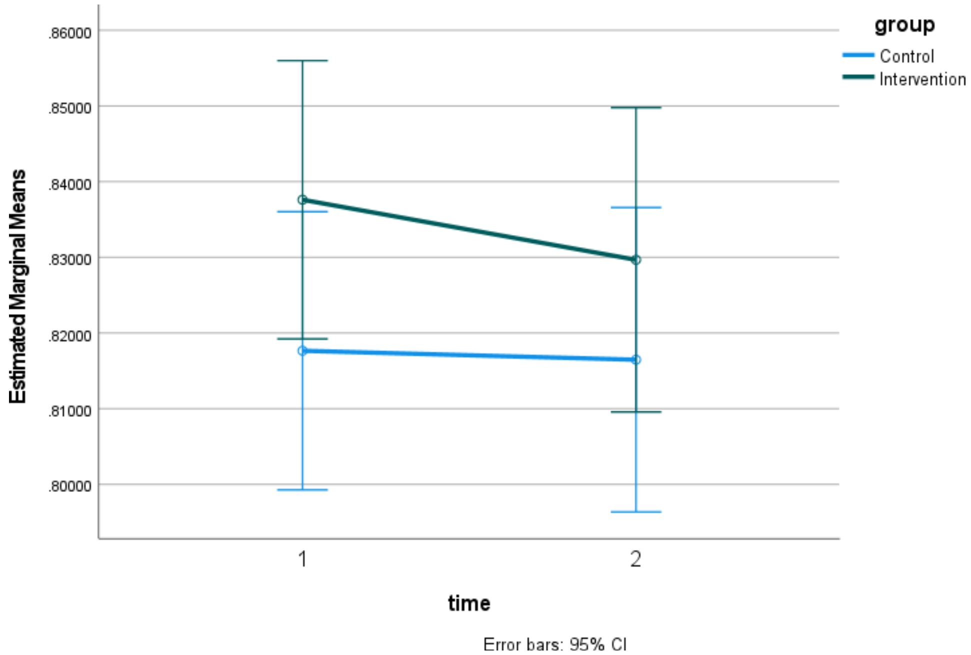

Figure 4.4 Profile plot of time by group for middle trapezius

Figure 4.4 shows that the profiles of the two groups over time were similar and the lines were roughly parallel with a slight decrease seen in the intervention group.

Table 4.7 Marginal means for middle trapezius

Group	Time	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Control	1	.818	.009	.799	.836
	2	.816	.010	.796	.837
Intervention	1	.838	.009	.819	.856
	2	.830	.010	.810	.850

The mean and standard error values for middle trapezius at each time point for each group are shown.

4.3.2 Changes in Outcomes Between Pre- and Post-Treatment Per Group

The change between pre and post was calculated as post minus pre value.

4.3.2.1 Correlations Between Changes in Variables by Treatment Group

There was a positive moderate correlation in the control group between change in upper and middle trapezius (r=0.575, *p*=0.008), meaning that as upper trapezius increased, so did middle trapezius. No other correlations between pairs of variables were detected.

Table 4.8 Correlations between variables by treatment group

Paired Samples Correlations					
Group			N	Correlation	Sig.
Control	Pair 1	Change in Pectoralis Major & Change in Upper Trapezius	20	-.018	.941
	Pair 2	Change in Pectoralis Major & Change in Middle Trapezius	20	.031	.898
	Pair 3	Change in Upper Trapezius & Change in Middle Trapezius	20	.575	.008
Intervention	Pair 1	Change in Pectoralis Major & Change in Upper Trapezius	20	.167	.482
	Pair 2	Change in Pectoralis Major & Change in Middle Trapezius	20	-.070	.770
	Pair 3	Change in Upper Trapezius & Change in Middle Trapezius	20	.122	.607

4.3.2.2 Comparison between changes in variables by treatment group

There was no statistically significant difference between the changes in the outcomes within the treatment groups, meaning each outcome changed to the same extent within a treatment group, although there was a slightly more positive change in pectoralis major than upper or middle trapezius in both the control and intervention groups. In the intervention group, the mean change was negative for middle and upper trapezius, meaning a decrease had taken place on average. The absolute values of these changes were very small, as was Cohen's D effect size for all comparisons (0,2 = small, 0.5 = medium, 0.8 = large effect size).

Table 4.9 Comparison between changes in variables by treatment group

Group			Mean	Cohen's D	Std. Deviation	*p*-value
Control	Pair 1	Change in Pectoralis Major	.0076	0.109	.04304	0.631
		Change in Upper Trapezius	.0016		.03356	
	Pair 2	Change in Pectoralis Major	.0076	0.167	.04304	0.464
		Change in Middle Trapezius	-.0012		.03172	
	Pair 3	Change in Upper Trapezius	.0016	0.093	.03356	0.683
		Change in Middle Trapezius	-.0012		.03172	
Intervention	Pair 1	Change in Pectoralis Major	.0099	0.360	.02513	0.124
		Change in Upper Trapezius	-.0012		.02253	
	Pair 2	Change in Pectoralis Major	.0099	0.257	.02513	0.265
		Change in Middle Trapezius	-.0079		.06288	
	Pair 3	Change in Upper Trapezius	-.0012	0.104	.02253	0.646
		Change in Middle Trapezius	-.0079		.06288	

Figure 4.5 compares the change in variables by group. The confidence intervals were wide and overlapped between the groups and the variables. The change in middle trapezius was the most negative in the intervention group, and the change in pectoralis major was the post positive in the intervention group.

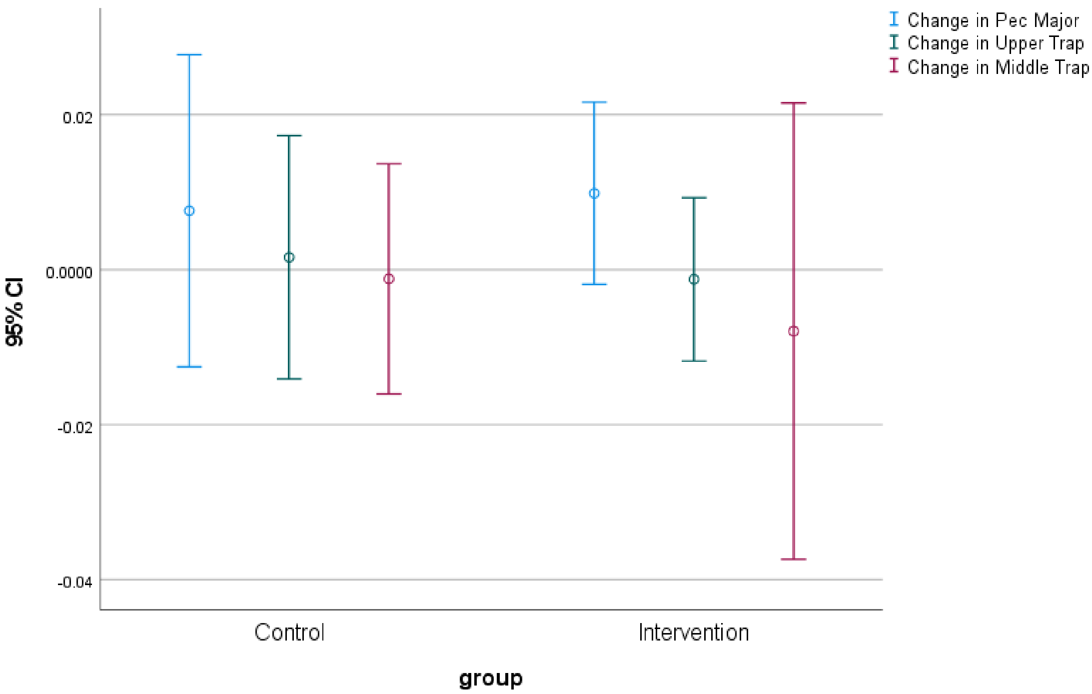

Figure 4.5 Change in outcome measure by group

4.4 POSTURE PRO MEASUREMENTS

The data collected in the study were analysed based on the following objective to compare the posture measurements pre- and post-intervention. The objective was also to compare the dominant and non-dominant angles and to compare and contrast the change in acromiovertebral and craniovertebral angles between an intervention and control group.

4.4.1 Postural Analysis of Acromiovertebral and Craniovertebral Angles Pre-Test

The acromiovertebral measurements from the dominant and non-dominant side were significantly higher in the control group than intervention group at baseline. These differences were considered in the between group analyses.

Table 4.10: Postural analysis of acromiovertebral and craniovertebral angles pre-test

	group	N	Mean	Std. Deviation	Std. Error Mean	*p*-value
Acromiovertebral angle dominant measurement PRE	control	20	43.00	3.494	.781	0.046
	intervention	20	40.30	4.703	1.052	
Acromiovertebral angle non-dominant measurement PRE	control	20	44.20	4.607	1.030	0.016
	intervention	20	39.80	6.330	1.415	
Craniovertebral angle dominant measurement PRE	control	20	35.90	5.830	1.304	0.819
	intervention	20	36.25	3.508	.784	
Craniovertebral angle non-dominant measurement PRE	control	20	35.30	4.508	1.008	0.178
	intervention	20	37.15	4.004	.895	

4.4.1.1 Acromiovertebral Angle Dominant Measurement

There was a large, statistically significant change over time for this measurement, regardless of which treatment the participants received (time effect *p*<0.001). However, the treatment effect was not significant (*p*=0.570), which is shown visually by the profiles of both groups decreasing to the same extent over time in parallel.

Table4.11 Acromiovertebral angle dominant measurement

Effect	Wilk's Lambda	*p*-value
Time	0.702	<0.001
Time*group	0.991	0.570
Group	0.329	0.570

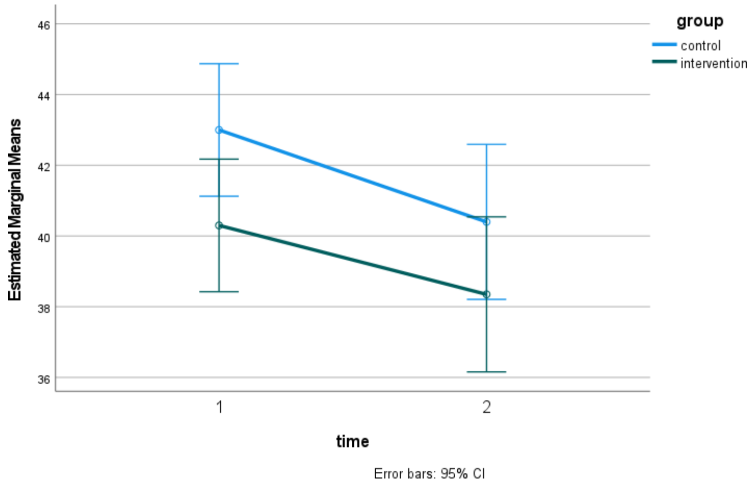

Figure 4.6 Acromiovertebral angle dominant measurement

4.4.1.2 Acromiovertebral Angle Non-Dominant Measurement

There was a significant treatment effect for this measure (p=0.022). The profile plot shows that the control group decreased to a larger extent than the intervention group. The table of marginal means per group per time period confirms that the control group decreased from a mean of 44,2 to 41.05, while the intervention mean decreased only from 39.8 to 39.2. Therefore, the effect in the control group was higher than in the intervention group.

Table 4.12 Acromiovertebral angle non-dominant measurement

Effect	**Wilk's Lambda**	***p*-value**
Time	0.743	0.001
Time*group	0.870	0.022
Group	3.694	0.062

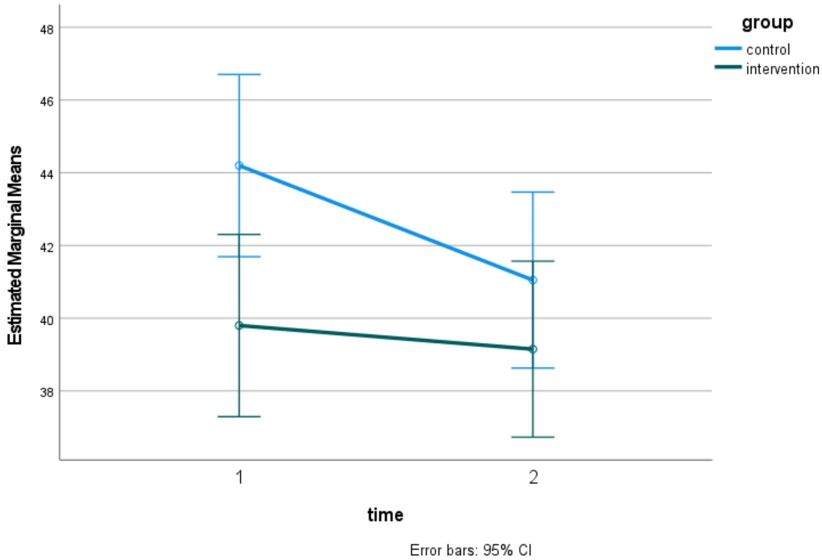

Figure 4.7 Acromiovertebral angle non-dominant measurement

Table 4.13 Comparison between dominant and non-dominant arms

Group	**Time**	**Mean**	**Std. Error**	**95% Confidence Interval**	
				Lower Bound	Upper Bound
Control	1	44.200	1.238	41.694	46.706
	2	41.050	1.195	38.631	43.469
Intervention	1	39.800	1.238	37.294	42.306
	2	39.150	1.195	36.731	41.569

4.4.1.3 Craniovertebral Angle Dominant Measurement

There was a significant time effect (p=0.014), which means that both treatments decreased over time, but there was no significant intervention effect (p=0.252), meaning that both groups decreased to the same extent over time. The profile plot suggests a trend that the intervention group decreased at a higher rate, but it is possible that the study was underpowered to detect this statistically. The table of marginal means bears this trend out but shows that the changes were quite small.

Table 4.14 Craniovertebral angle dominant measurement

Effect	Wilk's Lambda	*p*-value
Time	0.851	0.014
Time*group	0.966	0.252
Group	0.022	0.883

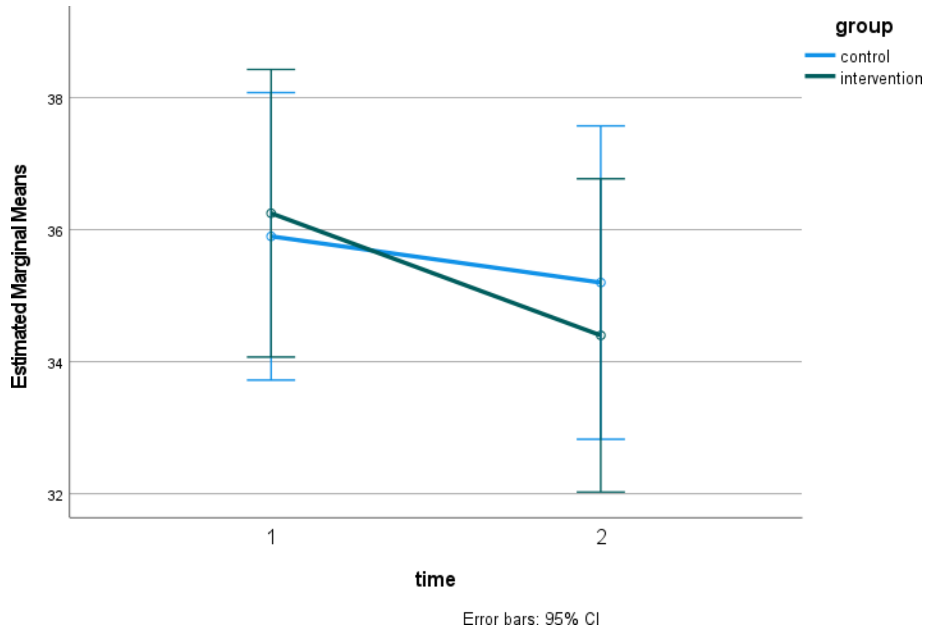

Figure 4.8 Craniovertebral angle dominant measurement

Table 4.15 Comparison between groups

Group	Time	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Control	1	35.900	1.076	33.722	38.078
	2	35.200	1.172	32.827	37.573
Intervention	1	36.250	1.076	34.072	38.428
	2	34.400	1.172	32.027	36.773

4.4.1.4 Craniovertebral Angle Non-Dominant Measurement

There was a significant time effect (p=0.004), which means that both treatments decreased over time, but there was no significant intervention effect (p=0.145), meaning that both groups decreased to the same extent over time. The profile plot suggests a trend that the intervention group decreased at a higher rate, but it is possible that the study was underpowered to detect this statistically. The table of marginal means bears this trend out but shows that the changes were quite small.

Table 4.16 Craniovertebral angle non-dominant measurement

Effect	**Wilk's Lambda**	**p-value**
Time	0.805	0.004
Time*group	0.945	0.145
Group	0.842	0.365

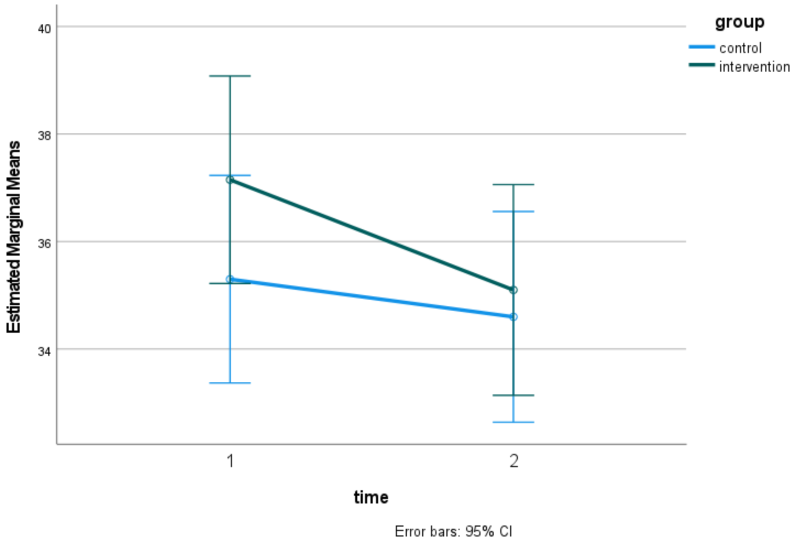

Figure 4.9 Craniovertebral angle non-dominant measurement

Table 4.17 Comparison between dominant and non-dominant arms

Group	**Time**	**Mean**	**Std. Error**	**95% Confidence Interval**	
				Lower Bound	Upper Bound
Control	1	35.300	.953	33.370	37.230
	2	34.600	.968	32.640	36.560
Intervention	1	37.150	.953	35.220	39.080
	2	35.100	.968	33.140	37.060

4.4.2 Posture Pro Ratings

The measurements were converted in categorical ratings (ordinal variable) and compared between pre and post within each of the treatment groups using paired McNemar Bowker tests.

4.4.2.1 Acromiovertebral Angle Dominant Ratings

The pre- and post-ratings were cross-tabulated by treatment group. There was no difference in the ratings from pre to post by group (the value could not be calculated for the control group since all were rated 3) but, overall (ignoring group), there was a significant difference (p=0.003). Table 4.18 shows that the change from a rating “3” to “2” was predominant, meaning there was a decrease in the angle.

Table 4.18 Acromiovertebral angle dominant ratings

Group			Acromiovertebral Angle Dominant Rating Post		Total
			2	3	
Control	Acromiovertebral Angle Dominant Rating PRE	3	8	12	20
	Total		8	12	20
Intervention	Acromiovertebral Angle Dominant Rating PRE	2	4	1	5
		3	4	11	15
	Total		8	12	20
Total	Acromiovertebral Angle Dominant Rating PRE	2	4	1	5
		3	12	23	35
	Total		16	24	40

Table 4.19 Group comparisons

Group		Value	Exact Sig. (2-sided)
Control	N of Valid Cases	20	
	McNemar-Bowker Test	.	
Intervention	McNemar Test		0.375[a]
	N of Valid Cases	20	
Total	McNemar Test		0.003[a]
	N of Valid Cases	40	

4.4.2.2 Acromiovertebral Angle Non-Dominant Ratings

There was no significant change in ratings in either of the groups or in total.

Table 4.20 Acromiovertebral angle non-dominant ratings

Group			Acromiovertebral angle non-dominant rating post		Total
			2	3	
Control	Acromiovertebral angle non-dominant rating PRE	2	3	0	3
		3	0	17	17
	Total		3	17	20
Intervention	Acromiovertebral angle non-dominant rating PRE	2	5	0	5
		3	2	13	15
	Total		7	13	20
Total	Acromiovertebral Angle angle non-dominant rating PRE	2	8	0	8
		3	2	30	32
	Total		10	30	40

Table 4.21 Group comparisons

Chi-Square Tests			
Group		**Value**	**Exact Sig. (2-sided)**
Control	McNemar Test		1.000[a]
	N of Valid Cases	20	
Intervention	McNemar Test		0.500[a]
	N of Valid Cases	20	
Total	McNemar Test		0.500[a]
	N of Valid Cases	40	
a. Binomial distribution used			

4.4.2.3 Craniovertebral Angle Dominant Rating

There was no significant change in ratings in either of the groups or in total.

Table 4.22 Craniovertebral angle dominant rating

Group			Craniovertebral angle dominant rating POST				Total
			1	2	3	4	
Control	Craniovertebral angle dominant rating PRE	1	11	0	0	0	11
		2	1	3	2	0	6
		3	0	1	1	0	2
		4	0	0	0	1	1
	Total		12	4	3	1	20
Intervention	Craniovertebral angle dominant rating PRE	1	9	2	0		11
		2	6	1	1		8
		3	1	0	0		1
	Total		16	3	1		20
Total	Craniovertebral angle dominant rating PRE	1	20	2	0	0	22
		2	7	4	3	0	14
		3	1	1	1	0	3
		4	0	0	0	1	1
	Total		28	7	4	1	40

Table 4.23 Group comparison

Chi-Square Tests				
Group		**Value**	**Df**	**Asymptotic Significance (2-sided)**
Control	McNemar-Bowker Test	1.333	2	.513
	N of Valid Cases	20		
Intervention	McNemar-Bowker Test	4.000	3	.261
	N of Valid Cases	20		
Total	McNemar-Bowker Test	4.778	3	.189
	N of Valid Cases	40		

4.4.2.4 Craniovertebral Angle Non-Dominant Rating

There was no significant change in ratings in either of the groups or in total.

Table 4.24 Craniovertebral angle non-dominant rating

Group			Craniovertebral angle non-dominant rating POST			Total
			1	2	3	
Control	Craniovertebral angle non-dominant rating Rating PRE	1	11	2	0	13
		2	2	2	0	4
		3	0	0	3	3
	Total		13	4	3	20
Intervention	Craniovertebral angle non-dominant rating PRE	1	7	1	0	8
		2	5	3	1	9
		3	1	2	0	3
	Total		13	6	1	20
Total	Craniovertebral angle non-dominant rating PRE	1	18	3	0	21
		2	7	5	1	13
		3	1	2	3	6
	Total		26	10	4	40

Table 4.25 Group comparison

Chi-Square Tests				
Group		Value	Df	Asymptotic Significance (2-sided)
Control	McNemar-Bowker Test	.000	1	1.000
	N of Valid Cases	20		
Intervention	McNemar-Bowker Test	4.000	3	0.261
	N of Valid Cases	20		
Total	McNemar-Bowker Test	2.933	3	0.402
	N of Valid Cases	40		

4.5 CONCLUSION

This chapter summarized that this study does not provide conclusive evidence that the intervention had any effect on the three muscle activity measurements outcomes measured. In terms of the Posture Pro measurements, changes (decrease in angles) between the pre- and post-intervention were mostly significant in both groups but, statistically, there was no difference between the two treatment groups. Posture Pro ratings did not provide evidence of changes in categories within the groups. Therefore, the null hypothesis was retained.

CHAPTER 5

5.1 INTRODUCTION

This chapter entails the discussion of the results observed in Chapter Four in context of current literature. The statistical and clinical significance of the sEMG data and Posture Pro data from the intra-group and inter-group analysis is discussed regarding possible theories. References are made to relevant sections in Chapter Four, as well as the studies reviewed in Chapter Two.

5.2 MUSCLE ACTIVITY

This study observed the immediate effect before and after a cervico-thoracic manipulation on muscle activity. The results showed no difference prior to treatment between the intervention and control groups in terms of any of the outcome measurements. Table 4.1 shows that no statistically significant differences were found in terms of baseline muscle activity measurements between the intervention and control groups. These findings can be due to the single manipulative session and warranting further research into the effect of multiple treatment sessions on muscle activity.

5.2.1 Intervention Group

Neurophysiological effects have been noted with cervical spine or cervico-thoracic segment manipulation which decreases postural dysfunction and raises pain thresholds to a greater degree compared to control groups (Miller *et al.* 2010). In previous studies, it has been observed that spinal manipulation of restricted spinal segments in the spine has the ability to significantly alter muscle activity levels, by decreasing the muscle activity, of the muscles that attach to the respective areas of the spine (Masaracchio *et al.* 2019, Haavik and Murphy 2012).

In this study, there was no statistically significant difference between the changes in the outcomes within the treatment groups, meaning each outcome changed to the same extent within a treatment group. Although there was a slightly more positive change in pectoralis major than upper or middle trapezius in both the intervention groups and the control, in the intervention group, the mean change was negative for middle and upper trapezius, meaning a decrease had taken place on average. The absolute values of these changes were very small, as was Cohen's D effect size for all comparisons (0,2 = small, 0.5 = medium, 0.8 = large effect size). Even though changes in muscle activity were small, they agreed with the hypothesis of changes in muscle recruitment patterns, due to over compensation resulting from muscle laxity or reduced neuromuscular control caused by postural instability and dysfunction (Abboud *et al.* 2016).

5.2.2 Control Group

There was a positive moderate correlation in the control group between change in upper and middle trapezius (r=0.575, p=0.008), meaning that as upper trapezius increased, so did the middle trapezius. No other correlations between pairs of variables were detected. Due to these participants being asymptomatic, an increase in muscle activity does not necessarily imply a clinical effect and could be attributed to muscle stimulation or postural dysfunction.

Abboud *et al* (2016) explains that joint dysfunction, whether there is pain or not, alters the normal biomechanics within the spine and, consequently, increases the stimulation of the muscles that are anatomically related to the dysfunctional joints. (Abboud *et al.* 2016). These participants presented with cervico-thoracic joint restrictions caused by altered biomechanics and postural dysfunction. This increase in muscle activity can be due to the lack of intervention in the joint restrictions present in the region causing increased strain on surrounding musculature.

5.2.3 Comparison Between Intervention and Control Groups

The participants were selected to study to observe the effects of HVLA manipulation on the cervico-thoracic segment immediately after the segment specific adjustment. Only asymptomatic participants were selected to remove any added neuropsychological and physiological consequences of pain. Assessing the immediate effects of HVLA manipulation on asymptomatic individuals may provide additional knowledge about the neurophysiological response of spinal manipulation without the effects of abnormal muscle activity related to injury and pain (Grindstaff *et al.* 2009). The use of an asymptomatic sample size was intended to further research and contribute to the body of knowledge by assessing the effects of spinal manipulation on posture and muscle activity without the abnormal neurophysiological changes associated with pain.

The current study, aimed to observe the immediate effect of a cervico-thoracic manipulation on posture and muscle activity in participants with FHP and RSP.

Although there was a lack of a statistically significant effect and outcome of the cervico-thoracic spinal manipulation, there was a positive change in pectoralis major compared to the upper or middle trapezius. In the intervention group, the mean change was negative for middle and upper trapezius, meaning a decrease had taken place on average. The upper and middle trapezius muscles decrease in activity followed an evident trend between the participants who received the intervention compared to the control group. This illustrates that spinal manipulation did, in fact, elicit a beneficial effect on the muscle activity of the trapezius muscle and agrees with the findings from studies by Han *et al* (2016) and Lee *et al* (2016).

There was a positive moderate correlation in the control group between change in upper and middle trapezius (r=0.575, *p*=0.008), meaning that as upper trapezius increased, so did middle trapezius. This increase in muscle activity can be attributed to the lack of intervention in the control group. For the greater part of the study, there were no statistically significant differences between the intervention and control groups in terms of establishing a treatment effect.

5.3 POSTURE PRO RATING

The study was conducted to observe the efficacy of spinal manipulative therapeutic approach for improving forward head posture and round-shouldered posture. In existing and current literature, the researcher was unable to find a relative study that was similar to all the results of the present study showing the immediate effect of spinal manipulation on muscle activity and postural dysfunction in FHP and RSP. A few studies have explored treatment of round-shouldered and forward head posture individually in improving ROM, pain and optimizing muscular activity.

The pre- and post-ratings were cross tabulated by treatment group. There was no difference in the ratings from pre to post by group but, overall, there was a significant difference (*p*=0.003). The degree of severity change from a rating “3” to “2” was predominant, meaning a decrease in the acromiovertebral angle. This provided evidence that the intervention helped decrease the severity of round-shouldered posture by decreasing the acromiovertebral angle.

5.3.1 Postural Readings

Fathollahnejad *et al* supported the present study's results considering postural function improvement and reduction through manipulative therapy (Fathollahnejad *et al.* 2019). Additional studies supported functional improvement through spinal manipulation, it was observed that both manipulative therapy and stretching were beneficial for acute treatments to reduce both strain-evoked and spontaneous dysfunction in individuals with prolonged head and neck dysfunction (Häkkinen *et al.* 2007).

Howe *et al*. (1983) observed the effect of manipulation and medication as an intervention for their individuals. The individuals that received the HVLA manipulation had relief from cervical dysfunction after treatment and an immediate improvement in ROM.

Ludewig and Reynolds (2009) found the degree of thoracic kyphosis correlate with the amount of cervical lordosis (Ludewig and Reynolds 2009). The 228 individuals were divided into two groups based on radiological findings. The first group of individuals were categorised by loss of cervical lordosis, and the second group of individuals had physiologic lordotic cervical curvature. The complete thoracic spine was measured (T1–12), upper (T1–6), and the lower (T6–12) thoracic kyphosis were observed with the Cobb method. The mean values for the first group were less than the mean values for second group (Ludewig and Reynolds 2009). An additional study observed a significant correlation between FHP and round-shouldered posture (Lewis *et al.* 2005). These studies provide evidence of a positive correlation between FHP and RSP. There is additional evidence that a thoracic kyphosis is caused by these abnormal postures creating a biomechanical alteration in the spine.

5.3.2 Round-Shouldered Posture (Acromiovertebral Angle)

Every human being has a characteristic feature known as body posture. Musculoskeletal health is directly affected by posture, as it's a outer reflection of the musculoskeletal systems functional and structural state (Wilczyński *et al.* 2022). Out of the multiple musculoskeletal conditions between ages 20–45-year, 73% constitutes round-shouldered posture (Kaur and Jayaraman 2019).

The acromiovertebral measurements from the dominant and non-dominant side were significantly higher in the control group than intervention group at baseline. These differences were considered in the between group analyses. This proves that the intervention group had a positive effect on round-shouldered posture as the intervention caused a decrease in the angle on the dominant and non-dominant sides.

5.3.2.1 Dominant Hand Vs Non-Dominant Hand

The dominant (right hand) side had a large, statistically significant change over time for this measurement, regardless of which treatment they received (time effect $p<0.001$). However, the treatment effect was not significant ($p=0.570$) even though the intervention group decreased slightly more than the control group.

The non-dominant side had a significant treatment effect for this measure ($p=0.022$). The data results show that the control group decreased to a larger extent than the intervention group. The table of marginal means per group per time period confirms that the control group decreased from a mean of 44,2 to 41.05, while the intervention mean decreased only from 39.8 to 39.2. Therefore, the effect in the intervention group was lower compared to the control group.

5.3.3 Forward Head Posture (Craniovertebral Angle)

5.3.3.1 Dominant Hand Vs Non-Dominant Hand

There was a significant time effect ($p=0.014$) which means that both treatments decreased over time, but there was no significant intervention effect ($p=0.252$), meaning that both groups decreased to the same extent over time. The study's results suggest a trend that the intervention group decreased at a higher rate. The table of marginal means bears this trend out but shows that the changes were quite small.

There was a significant time effect ($p=0.004$) which means that both treatments decreased over time, but there was no significant intervention effect ($p=0.145$) meaning that both groups decreased to the same extent over time. The profile plot suggests a trend that the intervention group decreased at a higher rate, but it is possible that the study's participant numbers were too small to detect this statistically. The table of marginal means bears this trend out but shows that the changes were quite small.

5.4 CONCLUSION

This study demonstrated that cervico-thoracic manipulation can affect the muscle activity within the pectoralis major, upper, and middle trapezius muscles bilaterally based on the trends observed in the intervention group. For the greater part of the study, there were no statistically significant differences between the intervention and control groups in terms of establishing a treatment effect. This lack of treatment effect can be warranted due to the single treatment session in this study and, therefore, provide the basis for future research and the effect of multiple treatment sessions. Additionally, if muscle activity readings were taken after a longer time than the immediate reading, the changes in muscle activity may have been of more statistical value.

The Posture Pro data provided evidence of the intervention group having an immediate postural effect over both the intervention and control groups. The craniovertebral angle was seen to decrease at a higher rate compared to the control group. Additionally, the study provided evidence of a treatment effect on the acromiovertebral angle decreasing overall in severity. The results were statistically insignificant, which warrants further research on manipulation therapy and the effect it has on muscle activity and posture over time and with multiple sessions.

CHAPTER 6 CONCLUSION, LIMITATIONS AND RECOMMENDATIONS

6.1 CONCLUSION

This current study aimed at determining the immediate effects of a cervico-thoracic HVLA manipulation on the muscle activity in the pectoralis major, upper and middle trapezius muscles in forward head and round-shouldered posture individuals. A sample size of 40 participants was observed in this study and were randomly assigned into a control or intervention group. The intervention group received the cervico-thoracic spinal manipulation.

The outcomes of the current study show that, overall, there was a lack of statistical significant intervention effect for the cervico-thoracic spinal manipulation on the pectoralis major, upper and middle trapezius muscles muscle activity, although, the upper and middle trapezius muscles decrease activity, following an evident trend between the participants who received the intervention compared to the control group.

The postural effect of the intervention proved to be significant in the round-shouldered posture showing a clinical trend to a decreased severity of acromiovertebral postural angle. The forward head posture (craniovertebral angle) revealed a trend that the intervention group decreased at a higher rate compared to the control group. However, these changes observed were not statistically significant. As a result, the null hypothesis was retained.

6.2 LIMITATIONS

The following limitations were identified throughout the study:

1. The sample size (n=40) was too small. Since clinical trends were identified, the study could potentially have shown a positive treatment effect if the sample size were larger.
2. The single treatment session, although it was effective in observing the immediate effect of the cervico-thoracic adjustment, could be observed over multiple sessions to gain a better understanding into any long-term effect.

Additional research could be beneficial and statistically more significant over multiple treatment sessions.

3. Concerning the sEMG electrode placement, although a lot of time and effort was considered to produce duplicability, the exact sEMG electrode placement between participants could not be identical or validated. It was difficult to isolate the pectoralis major muscle specifically and this should be considered in future sEMG studies when determining electrode placement.
4. Posture was only addressed whilst standing and the lateral aspects were observed for postural significance. For future studies on posture, the additional views of anterior and posterior aspects, with the added standing and seated postural observation, may have improved clinical trends overall.
5. The study only observed asymptomatic participants and, therefore, the results may not be directly applicable to symptomatic individuals with current pain and dysfunction.

6.3 RECOMMENDATIONS

A larger sample size should be considered to further assess the accuracy of results and positive trends present in this study.

A research assistant should be considered to assist in sEMG electrode placement and Posture Pro imaging with the aim to standardise and verify electrode placement and postural observation.

Additional postural views should be observed – for example anterior and posterior aspects, with the combined observation of the effect of standing and seated postures.

Symptomatic participants should also be included into future studies to gain a better understanding of the immediate effect of spinal manipulation and how this directly relates to posture and muscle activity changes in the cervico-thoracic segment.

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APPENDICES

Appendix A Permission to Conduct Research

Directorate for Research and Postgraduate Support
Durban University of Technology
Tromso Annexe, Steve Biko Campus
P.O. Box 1334, Durban 4000
Tel.: 031-3732576/7
Fax: 031-3732946

23rd April 2021
Mr Petzer Matthew
c/o Department of Chiropractic and Somatology
Faculty of Health Sciences
Durban University of Technology

Dear Mr Matthew

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 and Innovation Committee (IRIC) has granted **Gatekeeper Permission** for you to conduct your research "The effects of an upper cervico-thoracic segment manipulation on posture and muscle activity in participants wit forward head and round-shouldered posture" at the Durban University of Technology. **Kindly note that this letter must be issued to the IREC for approval before you commence data collection.**

The DUT may impose any other condition it deems appropriate in the circumstances having regard to nature and extent of access to and use of information requested.

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

Kindest regards.
Yours sincerely

DR LINDA ZIKHONA LINGANISO
DIRECTOR: RESEARCH AND POSTGRADUATE SUPPORT DIRECTORATE

Appendix B Permission to Conduct Research at DUT

MEMORANDUM

To : Prof Adam
Chair: IREC

From : Dr Desiree Varatharajullu
Head of Department: Chiropractic
Clinic Director: Chiropractic Day Clinic: Chiropractic

Date : 23.04.2021

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

Permission is hereby granted to:

Mr Matthew Petzer (Student Number: 21618560)

Research title: "The effects of an upper cervico-thoracic segment manipulation on posture and muscle activity in participants with forward head and round-shouldered posture".

Mr Petzer is requested to submit a copy of his FRC/IREC approved proposal along with proof of his M.Tech: Chiropractic registration to the Clinic Administrator/s 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 D Varatharajullu

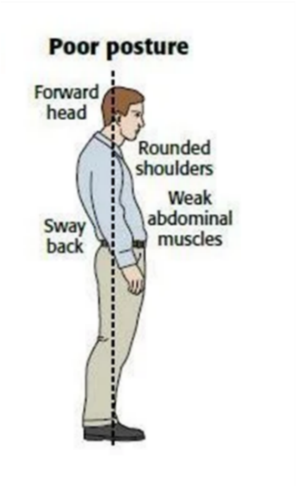
Head of Department: Chiropractic

Clinic Director: Chiropractic Day Clinic: Chiropractic

Cc: Mrs Linda Twiggs: Chiropractic Day Clinic
Dr A. Abdul-Rasheed: Supervisor

Appendix C Advertisement (English)

Are you between the ages of 18-45 years of age?



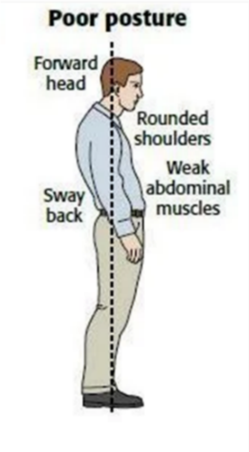
Do you have Rounded Shoulders or Forward Head Posture?

If this is You

Contact:
Matthew Petzer- 0744072777
or
DUT Chiropractic Clinic- 0313732511

Appendix D Advertisement (Zulu)

Ingabe uneminyaka engama-18 kuya kuma-45?



Ingabe ujwayele ukuma engathi amahlombe akho ama kwasandilinga noma engathi ikhanda lakho liya phambili njalo?

Uma ngabe nguwe lo ochazwe lapha ngenhla

Xhumana:

noMatthew Petzer - 074 407 2777

noma

Umtholampilo Wamathambo/ weKhayirophrakthikhi wase DUT - 031 373 2511

Appendix E Letter of Information (English)

LETTER OF INFORMATION

Title of the Research Study: the effects of an upper cervico-thoracic segment manipulation on posture and muscle activity in participants with forward head and round shoulder posture

Principal Investigator/s/researcher: Matthew Petzer [BTech: Chiropractic]

Co-Investigator/s/supervisor/s: Dr Ashura Abdul-Rasheed [MTech: Chiropractic]

Brief Introduction and Purpose of the Study: This research study aims to determine the immediate effects of upper cervico-thoracic manipulation on the muscle activity of the trapezius muscles and pectoralis major muscle in asymptomatic patients. 40 individuals will be required to complete the study. The purpose is to find if a single adjustment can have a positive effect on muscle activity and posture.

Greeting: Hello, I hope you are doing well today. Thank you for showing interest in my study.

Introduction and invitation to potential participant: My name is Matthew Petzer I am a 5th year student at DUT doing research for my Master's degree in chiropractic. I would like to invite you to participate in my research.

What is Research: Research is a systematic search or enquiry for generalized new knowledge. My study is investigating effects of a chiropractic manipulation on posture and muscle activity. Posture and muscle activity are common elements that affect our day to day activities.

Outline of the Procedures: If you agree to take part in this research, you will need to sign a consent form. Following this, the researcher will take a case history and perform a general physical examination and a cervical and thoracic spine regional examination. This is done to ensure that you are able to participate in the study. If you do, you will then be allocated to one of the two groups in the research – the one group will be the intervention group and the other group will be a control group to compare the intervention to. You will then be asked to remove any clothing covering the upper back area and appropriate clothing (clinic gown for females) will be provided. You may be required to remove any hair in the upper back region and upper chest region for placement of the electrodes in this area. Three baseline muscle activity readings will be taken while you are asked to perform specific muscle contractions for 10 seconds each time. Treatment will then be administered according to group allocation. If you are in the intervention group, you will receive adjustment in the region of C5-T2 and if you are in the control group, you will be asked to lie still on your stomach. Muscle activity readings will then be taken straight after the intervention where you will perform the same muscle contractions again.

Risks or Discomforts to the Participant: The treatment intervention or control given to you will be under the supervision of a qualified chiropractor at all times. A high amplitude low thrust manipulation will be performed which has little to no risk. The possible factor that may cause discomfort is post manipulation stiffness which will be explained by the researcher and is easily managed with ice and rest.

Explain to the participant the reasons he/she may be withdraw from the Study: If you experience any adverse effects and wish to withdraw from the study – you are allowed to do so. If you are not compliant with what is expected of you during the study, you will be withdrawn. If you don't meet the inclusion criteria.

Benefits: You will benefit by receiving insight into what chiropractors do and potentially gain insight into potential postural abnormalities. I the researcher, will benefit by completing my dissertation and publishing it.

Remuneration: There will be no form of remuneration offered to you for taking part in this study.

Costs of the Study: There is no additional cost to take part in the study.

Confidentiality: All your medical information will be kept confidential and will be stored at the Chiropractic Day Clinic for 5 years – after which it will be shredded. All electronic data will be password-secured and stored in the Chiropractic Day Clinic for 5 years – after which it will be deleted as well. Your name and personal details will not appear on any of the data sheets nor will it appear in the dissertation. After uploading photographs of participants onto a computer system, a photo editing software will be used to place a black circle over the faces of the participants, preventing identification of the participants, thus ensuring the protection of the rights and welfare of the participants.

Results: recordings will be examined and analyzed after data collection by a qualified statistician. This will form a data pool showing if there was any difference from the control and intervention group.

Research-related Injury: No injuries are anticipated during this study. If by some reason injury does occur participant will qualify for DUT insurance which will cover any additional costs. This can only occur once gatekeeper's permission is acquired.

Storage of all electronic and hard copies including tape recordings: All your medical information will be kept confidential and will be stored at the Chiropractic Day Clinic for 5 years – after which it will be shredded. All electronic data will be password-secured and stored in the Chiropractic Day Clinic for 5 years – after which it will be deleted as well. The information will be accessible to the researcher, supervisor, research head of department and the chiropractic head of department.

Persons to Contact in the Event of Any Problems or Queries:
Please contact the researcher, Matthew Petzer on 074 407 2777, my supervisor, Dr Ashura Abdul-Rasheed on ashuraa@dut.ac.za or the Institutional Research Ethics Administrator on 031 373 2375. Complaints can be reported to the Director: Research and Postgraduate Support Dr L Linganiso on 031 373 2577 or researchdirector@dut.ac.za.

Appendix F Consent (English)

CONSENT

Full Title of the Study: the effects of an upper cervico-thoracic segment manipulation on posture and muscle activity in participants with forward head and round shoulder posture

Names of Researcher/s: Matthew Petzer

Statement of Agreement to Participate in the Research Study:

- I hereby confirm that I have been informed by the researcher, ________________________ (name of researcher), about the nature, conduct, benefits and risks of this study - Research Ethics Clearance Number:____,
- 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,__________________(name of researcher) 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 G Letter of Information (Zulu)

INCWADI YOLWAZI

Mnumzane/ Medemu othandekayo

Ngiyabonga ngokukhetha ukuthi ube umbambiqhaza kulolu cwaningo lwami.

Isihloko socwaningo/ sophenyo: Umthelela/ umphumela wokwelulwa kwengxenye ephezulu yomgogodla/ yomqolo (lapho ihlangana khona nentamo/ nomqala) endleleni yokuma neyokusebenza kwemisipha okanye amamasela kulabo bahlanganyeli/ babambiqhaza abajwayele ukuma ngendlela ebeka ikhanda phambili, futhi baphinde babe namahlombe ame kwasandilinga.

Umcwaningi/ umphenyi: UMatthew Petzer [IBTech: yeKhayirophrakthikhi]

Umphathi/ umbhekeleli wocwaningo: UDkt. A Abdul-Rasheed [IMTech: yeKhayirophrakthikhi]

Isingeniso kafushane kanye nenhloso yocwaningo/ yophenyo: Lolu cwaningo luhlose ukuthola umphumela/ umthelela osheshayo wokwelulwa kwengxenye ephezulu yomgogodla/ yomqolo (lapho ihlangana khona nentamo/ nomqala) endleleni yokusebenza kwemisipha okanye amamasela, i-thrapheziyasi kanye nephekthoralisi meja kulabo babambiqhaza abangakhombisi izimpawu zokugula. Kuzodingeka amalunga angama-40 ukuze kuphothulwe lolu cwaningo/ phenyo.

Uhlaka lwenqubo yocwaningo/ yophenyo: Uma uvuma ukubamba iqhaza/ ukuhlanganyela kulolu cwaningo, kuzomele ukuthi usayine ifomu lesivumelwano esicatshangisisiwe. Emva kwalokhu, umcwaningi uzobe esethatha umlando wakho omayelana nesigulo, bese ke ekuxilonga wena siqu sakho jikelele aphinde akuhlole ngokugcwele, intamo/ umqala nengxenye engaphezulu yomgogodla wakho. Lokhu kuzobe kwenziwelwa ukuthi kuqinisekiswe ukuthi uyafaneleka ukuhlanganyela kulolu cwaningo. Uma ufaneleka, uzobe sewufakwa kwelilodwa iqembu kulawa amabili azobe esetshenziswa kulolu cwaningo- elilodwa iqembu kuzobe kuyiqembu lokwelapha/ lokungenelela kanti leli elinye kuzobe kuyiqembu lokulawula noma ukuqhathanisa nokungenelela naleli qembu lokwelapha. Uzobe sowucelwa ukuthi ususe okanye ukhumule konke lokho okwembethe/ okugqokile okumboze ingenhla lomzimba/ lomhlane, kanti izingubo ezifanelekile nezisetshenziswa emtholampilo (igawoni/ ingubo yasemtholampilo kwabesimame) zizohlinzekwa. Kungenzeka kudingakale ukuthi ugunde bonke uboya/ izinwele ezikhona kwisingenhla somzimba/ somhlane kanye nasesifubeni maphezulu ukuze kubekwe kahle ama-elekthrodi kulezo zindawo. Kuzothathwa imibhalo emithathu eyisisekelo yokusebenza kwemisipha/ kwamamasela, ngaleso sikhathi wena uzobe ucelwa ukuthi wenze uhlobo oluthize lokukhontraktha amamasela amasekhendi ayi-10 ngokuphindelela kuze kube kathathu. Ukwelashwa kuzobe sekwenziwa ngokuhlukana kwamaqembu. Uma ukwiqembu lokwelashwa/ lokungenelela uzobe usuyelulwa kwisigaba uC5-T2 kumgogodla noma kumqolo wakho bese kuthi uma ukwiqembu lokulawula, uzocelwa ukuthi ulale phansi ngesisu unganyakazi. Imibhalo yokusebenza kwemisipha/ kwamamasela izobe seyithathwa futhi emva kokwelashwa, lapho uzobe sowuphinda futhi wenza amakhontrakshini amamasela afanayo nasekuqaleni.

Ubungozi noma Ukuphazamiseka kukambambiqhaza: Kuzobe kukhona iKhayirophraktha/ udokotela wamathambo ozobe ekhona eqaphe ukwelashwa noma ukulawulwa kwakho zikhathi zonke. Ukwelulwa komgogodla okuzokwenziwa kunokuphakama okuphezulu, kepha akunaso isibhudukezi/ isihluku futhi kuphephile okanye akunabo ubungozi.

Inzuzo: Uzohlomula ngokuthola ukuqonda ngalokho okwenziwa amaKhayirophraktha, futhi uphinde uthole ukuqonda ngezindlela ezithize zokuma ezingaqondile ongase ube semathubeni okuba nazo. Mina mcwaningi, ngizozuza ngokuthi ngiphothule incwadi yami yezocwaningo/ idezetheshini yami bese ngiyayishicilela ukuthi ibonwe yizwe lonke.

Izizathu ezingenza ukuthi umbambiqhaza ahoxiswe ekubambeni iqhaza kulolu phenyo: Uma kwenzeka uzwa unokungazizwa kahlehle okwenza ufise ukuhoxa ekubambeni iqhaza kulolu cwaningo - uvumelekile ngenkululeko ukwenzenjalo. Uma ungathobeli umthetho okanye ungenzi lokho okulindelekile kuwe okumayelana nalolu cwaningo, uzokhishwa kulolu cwaningo. Uma ungenazo izinkomba zalabo abafanelekile ukuthi babambe iqhaza.

Umkomelo/ umholo: Angeke kube khona mholo okanye mali ozoyinikezwa ngokubamba iqhaza kulolu cwaningo.

Inani elikhokhwa umbambiqhaza wocwaningo/ wophenyo: Akunazindleko ezengeziwe ozozikhokha ukuze ubambe iqhaza kulolu cwaningo.

Ubumfihlo: Yonke imininingwane yakho ephathelene nokwelashwa kwakho izogcinwa iyimfihlo futhi ivalelwe emtholampilo weKhayirophrakthikhi iminyaka eyisihlanu – bese kuthi emuva kwalokho izobe seyahlaphazwa/ seyenziwa izimvithi. Yonke imininingwane engama-elekthronikhi datha nayo izogcinwa ivikelwe ngephasiwedi emtholampilo weKhayirophrakthikhi iminyaka eyisihlanu - bese emuva kwalokho nawo ayacishwa. Igama lakho kanye nemininingwane yakho angeke kushicilelwe kumadatha shithi okanye kwincwadi yami yezocwaningo/ idezetheshini.

Ukulimala okuphathelene nocwaningo/ nophenyo: Akukho ukulimala okubonakala kungase kwenzeke ngenxa/ okumayelana nalolu cwaningo. Asikho isinxephezelo ozosithola uma kwenzeka ulimala.

Abantu ongaxhumana nabo uma unezinkinga okanye unemibuzo:

Uyacelwa ukuthi uxhumane nomcwaningi, uMatthew Petzer ku 074 407 2777, umphathi wami, uDkt. Ashura Abdul-Rasheed ku ashuraa@dut.ac.za noma Umlawuli weZimiso Zokuhle kweZocwaningo weSikhungo ku 031 373 2375. Izikhalazo zingabikwa ku DVC: Wezocwaningo, Nokusungula kanye Nezokuxhumana Ezingeni eliphezulu uSolwazi S Moyo kule nombolo 031 373 2577 noma moyos@dut.ac.za.

Ozithobayo,

UMatthew Petzer

(Umcwaningi)

Appendix H Consent (Zulu)

IMVUME
Isitatimende Semvumelwano Yokubamba Iqhaza kuCwaningo/ kuPhenyo:

- Mina ngiyaqinisekisa ukuthi umcwaningi, uMatthew Petzer, ungazisile ngenkambo, uhlobo, inzuzo kanye nobungozi balolu cwaningo- Inombolo yeZimiso Zokuhle yoCwaningo: ______
- Ulwazi kanye nencazelo emayelana nalolu cwaningo ebhalwe lapha ngenhla (Incwadi Yolwazi kaMbambiqhaza) nayo ngiyitholile, ngayifunda futhi ngayiqondisisa.
- Ngiyaqonda ukuthi imiphumela yocwaningo, okubala imininingwane yami yobulili, iminyaka, usuku lokuzalwa, ama-inishiyali nokuthi ngiphethwe yini kuzosetshenziswa ngokungaziwa/ ngobumfihlo ukuze kwenziwe umbiko wocwaningo.
- Ngokubona izidingo zocwaningo, mina ngiyavuma ukuthi imininingwane yami etholakale kulolu cwaningo isetshenziswe ngu mcwaningi ohlelweni lwekhompiyutha.
- Ngingakwazi, kunoma yisiphi isigaba, ukuthi ngihoxise imvume nokubamba kwami iqhaza kulolu cwaningo ngale kwengcindezi.
- Ngibe nethuba elanele lokubuza imibuzo futhi (ngokuzikhethela/ ngokuzithandela kwami) ngiyafunga ukuthi ngikulungele ukubamba iqhaza kulolu cwaningo.
- Ngiyaqonda ukuthi lolo lwazi olusha, olubalulekile futhi oluthintana nokubamba kwami iqhaza ngenkathi kwenziwa lolu cwaningo ngizovumeleka ukulazi.

Igama eliphelele loMbambiqhaza	**Usuku**	**Isikhathi**	**Isiginisha /**	**Isithupha sakwisandla sokudla**

Mina, <u>Matthew Petzer</u>, ngiyaqinisekisa ukuthi lo mbambiqhaza ongenhla uchazeliwe kabanzi ngohlobo, inkambo kanye nobungozi balolu cwaningo olungenhla.

Matthew Petzer	**Usuku**	**Isiginisha**
Igama eliphelele likaFakazi (Uma kufanelekile)	**Usuku**	**Isiginisha**
Igama eliphelele loMnakekeli Osemthethweni (Uma kufanelekile)	**Usuku**	**Isiginisha**

Appendix I Case History

DUT DURBAN UNIVERSITY OF TECHNOLOGY — DEPARTMENT OF CHIROPRACTIC

CHIROPRACTIC DAY CLINIC
CASE HISTORY

Patient: ______________________________ Date: __________

File #: __________ Age: __________

Gender: __________ Occupation: ______________________

Student: ______________________ Signature ______________

FOR CLINICIANS USE ONLY:

Initial visit

Clinician: Signature:

Case History:

Examination:

Previous: Current:

X-Ray Studies:

Previous: Current:

Clinical Path. lab:

Previous: Current:

CASE STATUS:

PTT: Signature: Date:

CONDITIONAL:

Reason for Conditional:

Signature: Date:

Conditions met in Visit No: Signed into PTT: Date:

Case Summary signed off: Date:

Student's Case History:

Page 1 of 4

1. **Source of History:**

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

3. **Present Illness:**

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

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

	Noted	Family member		Noted	Family member
Alcoholism			Headaches		
Anaemia			Heart Disease		
Arthritis			Kidney Disease		
CA			Mental Illness		
DM			Stroke		
Drug Addiction			Thyroid Disease		
Epilepsy			TB		
Other (list)					

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 J Physical Examination

CHIROPRACTIC DAY CLINIC PHYSICAL EXAMINATION

DUT DURBAN UNIVERSITY OF TECHNOLOGY — DEPARTMENT OF CHIROPRACTIC

Patient:______________________________________ File#:__________ Date:________

Clinician:______________________________ Signature:______________________

Student:______________________________ Signature:______________________

1. VITALS

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

2. GENERAL EXAMINATION

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

Urinalysis:

3. CARDIOVASCULAR EXAMINATION

1) Is this patient in **Cardiac Failure**?
2) Does this patient have signs of **Infective Endocarditic**?
3) Does this patient have **Rheumatic Heart Disease?**

Inspection
- Scars
- Chest deformity:
- Precordial bulge:
- Neck -JVP:

Palpation:
- Apex Beat (character + location):
- Right or left ventricular heave:
- Epigastric Pulsations:
- Palpable P2: Palpable A2:

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Pulses:
- General Impression:
- Radio-femoral delay:
- Carotid:
- Radial:
- Dorsalis pedis:
- Posterior tibial:
- Popliteal:
- Femoral:

Percussion: - borders of heart

Auscultation: - heart valves (mitral, aortic, tricuspid, pulmonary)
- Murmurs (timing, systolic/diastolic, site, radiation, grade).

4. RESPIRATORY EXAMINATION

1) Is this patient in **Respiratory Distress**?

Inspection
- Barrel chest:
- Pectus carinatum/cavinatum:
- Left precordial bulge:
- Symmetry of movement:
- Scars:

Palpation
- Tracheal symmetry:
- Tracheal tug:
- Thyroid Gland:
- Symmetry of movement (ant + post)
- Tactile fremitus:

Percussion
- Percussion note:
- Cardiac dullness:
- Liver dullness:

Auscultation
- Normal breath sounds bilateral:
- Adventitious sounds (crackles, wheezes, crepitations)
- Pleural frictional rub:
- Vocal resonance
- Whispering pectoriloquy:
- Bronchophony:
- Egophony:

5. ABDOMINAL EXAMINATION

1) Is this patient in **Liver Failure**?

Inspection
- Shape:
- Scars:
- Hernias:

Palpation
- Superficial:
- Deep = Organomegally:
- Masses (intra- or extramural)
- Aorta:

Percussion
- Rebound tenderness:
- Ascites:
- Masses:

Auscultation
- Bowel sounds:
- Arteries (aortic, renal, iliac, femoral, hepatic)

Rectal Examination
- Perianal skin:
- Sphincter tone & S4 Dermatome:
- Obvious masses:
- Prostate:
- Appendix:

6. G.U.T EXAMINATION

External genitalia:
Hernias:
Masses:
Discharges:

7. NEUROLOGICAL EXAMINATION

Gait and Posture
- Abnormalities in gait:
- Walking on heels (L4-L5):
- Walking on toes (S1-S2):
- Romberg's test (Pronator Drift):

Higher Mental Function
- Information and Vocabulary:
- Calculating ability:
- Abstract Thinking:

G.C.S.:
- Eyes:
- Motor:
- Verbal:

EVIDENCE OF HEAD TRAUMA:

Evidence of Meningism:
- Neck mobility and Brudzinski's sign:
- Kernig's sign:

Cranial Nerves:

I Any loss of smell/taste:
Nose examination:

II External examination of eye:
- Visual Acuity:
- Visual fields by confrontation:
- Pupillary light reflexes = Direct:
  = Consensual:
- Fundoscopy findings:

III Ocular Muscles:
Eye opening strength:

IV Inferior and Medial movement of eye:

V
a. Sensory
- Ophthalmic:
- Maxillary:
- Mandibular:

b. Motor
- Masseter:
- Jaw lateral movement:

c. Reflexes
- Corneal reflex
- Jaw jerk

VI Lateral movement of eyes

VII
a. Motor
- Raise eyebrows:
- Frown:
- Close eyes against resistance:
- Show teeth:
- Blow out cheeks:

b. Taste
- Anterior two-thirds of tongue:

VIII	General Hearing:		
	Rinne's = L:	R:	
	Weber's lateralisation:		
	Vestibular function	- Nystagmus:	
		- Romberg's:	
		- Wallenberg's:	
	Otoscope examination:		

IX &	Gag reflex:
X	Uvula deviation:
	Speech quality:
XI	Shoulder lift:
	S.C.M. strength:
XII	Inspection of tongue (deviation):

Motor System:

a.	Power		
	- Shoulder	= Abduction & Adduction:	
		= Flexion & Extension:	
	- Elbow	= Flexion & Extension:	
	- Wrist	= Flexion & Extension:	
	- Forearm	= Supination & Pronation:	
	- Fingers	= Extension (Interphalangeals & M.C.P's):	
	- Thumb	= Opposition:	
	- Hip	= Flexion & Extension:	
		= Adduction & Abduction:	
	- Knee	= Flexion & Extension:	
	- Foot	= Dorsiflexion & Plantar flexion:	
		= Inversion & Eversion:	
		= Toe (Plantarflexion & Dorsiflexion):	
b.	Tone	- Shoulder:	
		- Elbow:	
		- Wrist:	
		- Lower limb - Int. & Ext. rotation:	
		- Knee clonus:	
		- ankle clonus:	
c.	Reflexes	- Biceps:	
		- Triceps:	
		- Supinator:	
		- Knee:	
		- Ankle:	
		- Abdominal:	
		- Plantar:	

Sensory System:

a. Dermatomes
- Light touch:
- Crude touch:
- Pain:
- Temperature:
- Two point discrimination:

b. Joint position sense
- Finger:
- Toe:

c. Vibration:
- Big toe:
- Tibial tuberosity:
- ASIS:
- Interphalangeal Joint:
- Sternum:

Cerebellar function:

Obvious signs of cerebellar dysfunction:
= Intention Tremor:
= Nystagmus:
= Truncal Ataxia:

Finger-nose test (Dysmetria):
Rapid alternating movements (Dysdiadochokinesia):
Heel-shin test:
Heel-toe gait:
Reflexes:
Signs of Parkinsons:

8. SPINAL EXAMINATION: (SEE REGIONAL EXAMINATION)

Obvious Abnormalities:
Spinous Percussion:
R.O.M:
Other:

9. BREAST EXAMINATION:

Summon female chaperon.

Inspection
- Hands rested in lap:
- Hands pressed on hips:
- Arms above head:
- Leaning forward:

Palpation
- masses:
- tenderness:
- axillary tail:
- nipple:
- regional lymph nodes:

Appendix K Cervical Exam

DUT DURBAN UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF CHIROPRACTIC AND SOMATOLOGY

CHIROPRACTIC PROGRAMME

REGIONAL EXAMINATION – CERVICAL SPINE

Patient: ______________________ File No: __________

Date: __________ Student: ______________________

Clinician: ______________________ Sign: ______________________

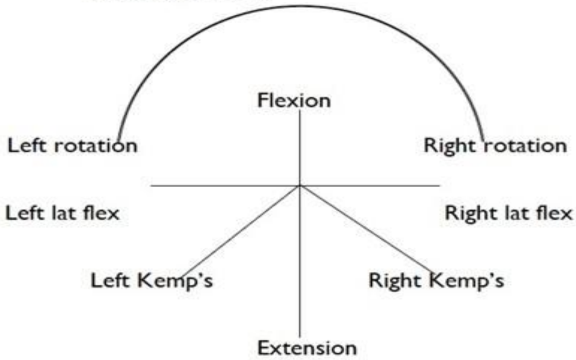
OBSERVATION:

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

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

RANGE OF MOTION:

Extension (70°):
L/R Rotation (70°):
L/R Lat flex (45°):
Flexion (45°):



PALPATION:

Lymph nodes
Thyroid Gland
Trachea

MYOFASCIAL ASSESSMENT

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

ORTHOPAEDIC EXAMINATION:

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

Page 1 of 2

NEUROLOGICAL EXAMINATION:

Dermatones	Left	Right	Myotomes	Left	Right	Reflexes	Left	Right
C2			C1			C5		
C3			C2			C6		
C4			C3			C7		
C5			C4					
C6			C5					
C7			C6					
C8			C7					
T1			C8					
			T1					
Cerebellar tests:		Left		Right				
Dysdiadochokinesis								

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

MOTION PALPATION & JOINT PLAY:

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

BASIC EXAM: SHOULDER:

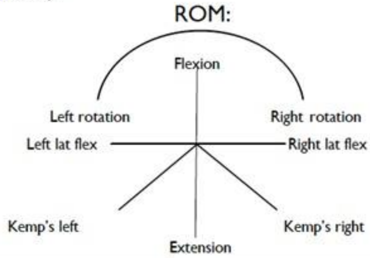
Case History:

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

BASIC EXAM: THORACIC SPINE:

Case History:

ROM:



Motion Palpation:	
Orthopaedic:	
Neuro:	
Vascular:	
Observ/Palpation:	
Joint Play:	

THORACIC SPINE
REGIONAL EXAMINATION

Patient:______________________________ File:__________ Date:____________________

Student:______________________________ Signature:______________________________

Clinician: ______________________________ Signature:______________________________

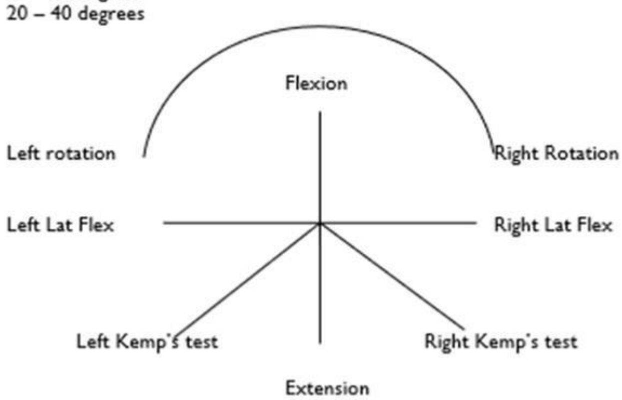
STANDING:

Posture (incl. L/S & C/S)
Muscle tone
Skyline view – Scoliosis
Spinous Percussion
Breathing (quality, rate, rhythm, effort)
Deep Inspiration

Scars
Chest deformity
(pigeon, funnel, barrel)

RANGE OF MOTION:

Forward Flexion	20 – 45 degrees (15cm from floor)
Extention	25 – 45 degrees
L/R Rotation	35 – 50 degrees
L/R Lat Flex	20 – 40 degrees



RESISTED ISOMETRIC MOVEMENTS: (in neutral)

Forward Flexion
L/R Rotation

Extension
L/R Lateral Flexion

SEATED:

Palpate Auxillary Lymph Nodes
Palpate Ant/Post Chest Wall
Costo vertebral Expansion (3 – 7cm diff. at 4th intercostal space)
Slump Test (Dural Stretch Test): LOCAL PAIN (T/S) DISTAL PAIN (L/S) DISTAL PAIN (LEG)

SUPINE:

Rib Motion (Costo Chondral joints)
Soto Hall Test (#, Sprains)

SLR
Palpate abdomen

PRONE:

Appendix L Thoracic Exam

Passive Scapular Approximation
Facet Joint Challenge
Vertebral Pressure (P-A central unilateral, transverse)
Active myofascial trigger points:

	Latent	Active	Radiation Pattern		Latent	Active	Radiation Pattern
Rhomboid Major				Rhomboid Minor			
Lower Trapezius				Spinalis Thoracic			
Serratus Posterior				Serratus Superior			
Pectoralis Major				Pectoralis Minor			
Quadratus Lumborum							

COMMENTS:____

NEUROLOGICAL EXAMINATION:

	DERMATOMES											
	T 1	T 2	T 3	T 4	T 5	T 6	T 7	T 8	T 9	T 10	T 11	T 12
Left												
Right												

Basic LOWER LIMB neuro:

Myotomes	T11	T12	L1	L2	L3	L4	L5	S1	S2	S3
Dermatomes	T11	T12	L1	L2	L3	L4	L5	S1	S2	S3
Reflexes	Patella – Left					Achilles – Left				
	Patella - Right					Achilles – Right				

MOTION PALPATION:

			Right	Left
Thoracic Spine				
Ribs	Calliper (Costo-transverse joints)			
	Bucket Handle	Opening		
		Closing		
Lumbar Spine				
Cervical Spine				

BASIC EXAM	History	ROM	Neuro/Ortho
LUMBAR			
CERVICAL			

Page 2 of 2

Appendix M Verbal Consultation

Questions for potential participants	Expected Answers
Please may I ask you some questions?	Yes.
How old are you?	Between 18-45.
Have you experienced neck or shoulder pain in the last six weeks?	No.
Have you been received any spinal manipulation in the last two weeks?	No.
Have you been diagnosed with scoliosis, osteoporosis, osteoarthritis or ankylosing spondylitis?	No.
Are you in good health?	Yes.

Appendix N Data Collection Sheet (sEMG)

Participant no	Pec major (pre)	Upper trap (pre)	Middle trap (pre)	Pec major (post)	Upper trap (post)	Middle trap (post)
A01						
A02						
A03						
A04						
A05						
A06						
A07						
A08						
A09						
A10						
A11						
A12						
A13						
A14						
A15						
A16						
A17						
A18						
A19						
A20						
B01						
B02						
B03						
B04						
B05						
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B09						
B10						
B11						
B12						
B13						
B14						
B15						
B16						
B17						
B18						
B19						
B20						

Appendix O Data Collection Sheet (Posture Pro)

studyID	date	dominance	head angle	shoulder angle	AADM PRE	AADR PRE	AANM PRE	AANR PRE	CADM PRE	CADR PRE	CANM PRE	CANR PRE	AADM POST	AADR POST	AANM POST	AANR POST	CADM POST	CADR POST	CANM POST	CANR POST
A01																				
A02																				
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Appendix P COVID-19 Consent

CONSENT FOR CHIROPRACTIC TREATMENT DURING THE COVID-19 PANDEMIC

I,____, knowingly and willingly consent for myself or for a minor____, under my care, to receive elective Chiropractic or emergency Chiropractic treatment from the Durban University of Technology Chiropractic Day clinic during the COVID-19 pandemic.

I understand the COVID-19 virus has a long incubation period during which carriers of the virus may not show symptoms but still be highly contagious. Chiropractic procedures/treatment take place with the patient in very close proximity to the practitioner. This potentially exposes the patient and the practitioner to the COVID-19 virus. I understand that due to the frequency of other Chiropractic patients, the characteristics of the virus, and the characteristics of Chiropractic practice, that I have an elevated risk of contracting the virus simply by being in the Chiropractic clinic.________________(Initial)

I confirm that I am not presenting with ANY of the following symptoms of COVID-19 listed below:

- Fever
- Shortness of Breath
- Dry Cough
- Runny Nose
- Sore throat

High risk patients relating to the severity of COVID-19 are persons of the age of 60 and persons who have pre-existing medical conditions such as: asthma; chronic lung conditions; hypertension; autoimmune diseases; organ transplants; cancer; immunocompromised; obesity (BMI over 40); more than 27 weeks pregnant; and liver or kidney conditions.

a.) I confirm that I do not fall into any of these high risk categories______________(Initial)

or

b.) I confirm that I do fall into these high health risk categories and I am aware of the increased risk of severe infection due to my age/pre-existing medical conditions should I contract Covid-19 ______________ (Initial)

I am aware of the risks involved with the spread of COVID-19 and the risks it may hold to my health and the health of others I come into contact with. I accept those risks and hereby indemnify and hold the Durban University of Technology Chiropractic Day Clinic and its students and staff blameless should I contract the disease at the clinic premises or from the clinic staff and/or students.

________________________________ ____________________

Patient's signature DATE

________________________________ ____________________________

Student Signature Clinician Signature

Appendix Q IREC Approval

Institutional Research Ethics Committee
Research and Postgraduate Support Directorate
2nd Floor, Berwyn Court
Gate 1, Steve Biko Campus
Durban University of Technology

P O Box 1334, Durban, South Africa, 4001

Tel: 031 373 2375
Email: lavishad@dut.ac.za
http://www.dut.ac.za/research/institutional_research_ethics

www.dut.ac.za

10 May 2021

Mr M Petzer
80 Currie Road
Musgrave
Durban

Dear Mr Petzer

The effects of an upper cervico-thoracic segment manipulation on posture and muscle activity in participants with forward head and round-shouldered posture.
Ethical Clearance number IREC 049/21

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

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

Any adverse events [serious or minor] which occur in connection with this study and/or which may alter its ethical consideration must be reported to the IREC according to the IREC Standard Operating Procedures (SOP's).

Please note that any deviations from the approved proposal require the approval of the IREC as outlined in the IREC SOP's.

Yours Sincerely

Dr K Padayachy
Deputy Chairperson: IREC

The immediate effect of an upper cervico-thoracic segment manipulation on posture and muscle activity in participants with forward head and round-shouldered posture

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