The effect of spinal manipulative therapy and ischaemic compression versus muscle energy technique in chronic nonspecific neck pain

By

Tyron Dicks

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

Durban University of Technology

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

… ……….. Date: …….22/10/2021…………………
Tyron Dicks

Approved for Final Submission

… ……………………. Date: ………22 October 2021…………..
Dr. D. Varatharajullu
M. Tech: Chiropractic

22 October 2021

……………………………………….. Date: ………………………………………
Dr. A. Abdul – Rasheed
M. Tech: Chiropracti

DEDICATION

I dedicate this dissertation to my family:

My parents, Alan and Antoinette and my brother Jason Dicks. Thank you for always believing in me. Your motivation and encouragement have meant the world and I would not have been able to get here without you. Mom and Dad, you have put it all on the line to give Jason and me all of the opportunities for which we could ever ask. Jason, thank you for your continued assistance and advice which has helped to get me to this stage. For my family, I will forever be grateful. I love and appreciate you all so very much.

ACKNOWLEDGEMENTS

I wish to acknowledge the following role players who have assisted in making this dissertation possible:

1. My parents, I am who I am today because of you. Without your endless support and sacrifice, none of this would have been possible. Thank you for showing me what it means to have perseverance and determination. I will forever be grateful for having you both in my life and I appreciate all you have done.
2. My brother, thank you for inspiring me to join the world of Chiropractic. Leading by example, you have shown me just what I accomplish with dedication and commitment.
3. My partner, I cannot express my gratitude for the continual help. Your love and support have made a world of a difference throughout this entire process.
4. Dr Desiree Varatharajullu, your guidance and words of wisdom have helped me tremendously during this study. The hours of help and assistance is hugely appreciated.
5. Dr Ashura Abdul–Rasheed, thank you for your help and guidance, your input has made a big difference in helping me get this study completed.
6. Dr Charmaine Korporaal, thank you for the direction, support and encouragement throughout the past several years, your role in this program is inspirational.
7. My research assistants, thank you for your help and dedication. Your outstanding work is appreciated.
8. Mrs Linda Twiggs, Mrs Amanda Makhonza and the rest of the clinic staff, your work and excellence has helped make this all possible. Your assistance in the chiropractic program is immense and the clinic would not be as great as it is without you.
9. All my research participants, this study would not have happened without you. Thank you for taking the time out your busy schedules to take part in my study.
10. The Durban University of Technology for the research funds provided for this study.

ABSTRACT

Aim: Neck pain has become a problem experienced worldwide and it poses a global healthcare challenge to practising medical professions. There are numerous manual and non-manual treatments available for this frequently encountered problem. Frequently utilised and effective therapies are spinal manipulative therapy (SMT) and ischaemic compression (IC); however, these have been associated with several contraindications. An alternative form of treatment with less contraindications that may be of benefit to the patient is muscle energy technique (MET). Therefore, the aim of this study was to determine the effect of spinal manipulative therapy and ischaemic compression compared to muscle energy technique in chronic nonspecific neck pain.

Methodology: This study was a quantitative randomised, single blinded clinical trial. Forty participants with nonspecific pain, aged 20-50 years, were randomly allocated into two groups using a random allocation chart provided by a statistician. Group one received SMT and IC, whereas group two received MET alone. The numerical pain rating scale (NRS) was used to determine the level of neck pain. The cervical range of motion (CROM) goniometer was used to calculate the degree of lateral flexion occurring at the neck. The pain pressure algometer was used to determine the pain pressure thresholds (PPT). The Canadian Memorial Chiropractic College (CMCC) Neck Disability Index (NDI) was used to assess the disability in activities of daily living as a consequence of neck pain. Each participant had four consultations over a two-week period, receiving treatment on the first three consultations with the fourth being purely subjective and objective measurements.

Results: Repeated measures ANOVA testing was utilised to examine the changes over time in each group. Profile plots were used to visually explore the trends of each group over time. Intra-group analysis of subjective and objective measurements revealed that both groups had a beneficial response to the treatment over time. Inter-group analysis showed that there were no statistically significant differences between the two groups in terms of subjective and objective measurements.

Conclusion: In conclusion, this study revealed that the use of MET is as equally effective as a combination of SMT and IC in the treatment of chronic nonspecific neck pain.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF SYMBOLS AND ABBREVIATIONS

%	Percent
º	Degree
Ach	Acetylcholine
AROM	Active range of motion
ART	Active release technique
CDC	Chiropractic Day Clinic
CMCC	Canadian Memorial Chiropractic College
CNS	Central nervous system
CROM	Cervical range of motion
CP	Creatine phosphate
DUT	Durban University of Technology
EMG	Electromyography
HE	Home exercises
HP	Hot pack
HVLA	High velocity low amplitude
IC	Ischaemic compression
IFC	Intraferential current
IREC	Institutional Research and Ethics Committee
LTR	Local twitch response
MET	Muscle energy technique
MFTPs	Myofascial trigger points
MPS	Myofascial pain syndrome
MR	Myofascial release
MS	Muscle spindle
MVC	Maximum voluntary contraction
NDI	Neck disability index
NRS	Numerical rating scale
NSAIDs	Non-steroidal anti-inflammatory drugs
PPT	Pressure pain threshold
PS	Passive stretching
RA	Research assistant

ROM	Range of motion
SMT	Spinal manipulative therapy
SS	Spray and stretch
TENS	Transcutaneous electrical nerve stimulation
TP	Trigger point
USA	Ultrasound analysis
VAS	Visual analogue scale
VRS	Verbal rating scale

CHAPTER 1: INTRODUCTION

1.1 INTRODUCTION

Neck pain is regarded as a significant individual and socioeconomic problem to health (Yesil et al. 2018: E1174-E1183). Trauma, inflammatory disorders, or degenerative changes of the spine can cause neck pain; however simple, or nonspecific neck pain, is more common and is often brought about by mechanical factors such as sprains and strains (Lauche et al. 2012: 429718-429710). There are studies that show patients presenting with nonspecific neck pain commonly have active myofascial trigger points (MFTPs) which are defined as hyperirritable pain spots found within skeletal muscle or fascia (Simons, Travell and Simons 1999: 11-89; Fernández-de-las-Peñas et al. 2006a: 3-9). Myofascial pain is thought to be a multifaceted neuromuscular dysfunction including both motor and sensory abnormalities involving the peripheral as well as the central nervous system (Park et al. 2018: e11432). The increase in chronic neck pain prevalence has been associated with an increase in both personal and health care system costs (Anstey et al. 2016: 894-901).

Numerous manual and non-manual interventions have shown to be effective in inactivating MFTPs associated with neck pain and disability. Non-manual interventions include acupuncture, dry needling, spray and stretch techniques and electrical modalities such as Interferential Current (IFC), Transcutaneous Electrical Nerve Stimulation (TENS) and ultrasound. Manual interventions include spinal manipulative therapy (SMT), mobilisation, therapeutic exercise, proprioceptive neuromuscular facilitation, muscle energy technique (MET) and ischaemic compression (IC) (Kumar, Sneha and Sivajyothi 2015: 22-26).

Two frequently utilised and effective therapies for the treatment of musculoskeletal conditions are SMT and IC (Bicalho et al. 2010: 469-475; Montañez-Aguilera et al. 2010: 101-104). Spinal manipulative therapy recovers movement and general function as well as a reduction in pain when directed to a joint restriction (Gatterman 2005; Saavedra-Hernández et al. 2013: 504-512). The technique of IC, which is one of the most commonly practiced MFTP treatments and makes use of slowly increasing pressure over the MFTP (Simons, Travell and Simons 1999: 11-89; Kumar, Sneha and Sivajyothi 2015: 22-26). This treatment technique has demonstrated its effectiveness at decreasing tension and tenderness associated with MFTPs (Ravichandran et al. 2016: 186-192).

Another form of treatment is MET which is purely voluntary and controlled solely by the patient (Chaitow and Crenshaw 2006). The voluntary contraction allows MET to be a safe procedure as the dosage is controlled by the patient, hence treatment can be halted if pain is experienced. Muscle energy technique (MET) is currently understudied and not frequently compared to other forms of manual therapies (Fernández-de-las-Peñas, Cleland and Huijbregts 2011). The use of MET is typically implemented in a treatment package, however, there is a need for an increased number of studies examining the effectiveness of MET as a stand-alone technique (Hamilton, Boswell and Fryer 2007: 42-49; Franke et al. 2015).

Since neck pain is regarded as a multi-faceted condition, it is often investigated with combination theories, this is done in order to achieve maximum patient care (Kohlbeck and Haldeman 2002: 288-302; Dagenais et al. 2008: 142-149; Gross et al. 2010: 315-333; Yeganeh Lari et al. 2015: 204-209). Various studies have shown therapies like IC to be more effective when combined with another treatment technique (Hanten et al. 2000: 997-1003; Iqbal, Khan and Miraj 2010: 10-15; Nasb et al. 2020: 44-50)

Muscle energy technique (MET) has both an effect on the muscle and the restriction, which needs to be considered when comparing to other manual therapies like SMT and IC. There are several contra-indications, as well as post-treatment soreness, and discomfort that can be associated with SMT and IC, which may make MET more desirable for some individuals (Gatterman 1990; Whittingham and Nilsson 2001: 552-555; Bergmann and Peterson 2011; Saavedra-Hernández et al. 2013: 504-512). Therefore, the aim of this study is to compare the effect of cervical spine manipulation and ischaemic compression of a selected trapezius MFTP to MET in the treatment of chronic nonspecific neck pain.

1.2 AIMS AND OBJECTIVES

1.2.1 Aim of the Study

The aim of this study was to determine the effect of spinal manipulative therapy and ischaemic compression compared to muscle energy technique in chronic nonspecific neck pain.

1.2.2 Objectives of the Study

Objective One:

1) To determine the effect of spinal manipulative therapy and ischaemic compression in the treatment of chronic nonspecific neck pain in terms of objective and subjective outcomes.

The subjective tools used were Numerical pain rating scale (NRS) and Canadian Memorial Chiropractic College (CMCC) neck disability index (NDI) questionnaire. The objective tools used were patient pain threshold over tender segments of trigger point via Algometer and Cervical range of motion (CROM) via CROM - II Goniometer.

Objective Two:

2) To determine the effect of muscle energy technique in the treatment of chronic nonspecific neck pain in terms of objective and subjective outcomes.

Objective Three:

3) To compare and correlate the effectiveness of SMT and IC, compared to MET, in the treatment of chronic nonspecific neck pain in terms of subjective and objective outcomes.

1.3 HYPOTHESIS

1.3.1 Null Hypothesis

The null hypothesis specified that there would be no difference between the two study groups being compared in terms of subjective and objective outcomes.

1.3.2 Alternative Hypothesis

The alternative hypothesis specified that muscle energy technique for the treatment of nonspecific neck pain will have a statistically significant difference compared to the combination of spinal manipulative therapy and ischaemic compression in terms of subjective outcomes (i.e. subjective pain perception) and objective outcomes (i.e. pain threshold and degrees of motion).

1.4 RATIONALE FOR THE STUDY

1.4.1 Rationale One

In sub-Saharan Southern Africa, the point prevalence of neck pain is 4.7% in males and 6.7% in females. These statistics are rather high and are only outranked by the United States, Western Europe and East Asia (Vos et al. 2012: 2163-2196; Hoy et al. 2014a: 968-974; Basson, Olivier and Rushton 2019: e1-e9). Zungu (2009) found that 76% of office workers were hospitalised in a private South African hospital due to musculoskeletal conditions, with neck pain being the second most common complaint following low back pain. Musculoskeletal disorders (MSDs) in industrialised areas receive a greater priority when compared to developing countries ~~much~~ like South Africa, as industrialised countries have a higher priority in terms of employee safety, health and wellness (Sieberhagen, Rothmann and Pienaar 2009: 1-9). This may be due to the fact that most of South Africans (84%) utilise public health care. These services are often struggling with insufficient staff with limited resources (Ranchod et al. 2017: 101-110; Basson, Olivier and Rushton 2019: e1-e9). Therefore, there is a need for an increase in research regarding neck pain and the most effective treatment option available for South Africans.

1.4.2 Rationale Two

There are many manual therapies that have been utilised in the treatment of MFTPs, such as stretching, IC, SMT and passive mobilization (Kumar, Sneha and Sivajyothi 2015: 22-26). Various therapists such as masseuses, chiropractors, physical therapists, and osteopaths provide these interventions (Harper et al. 2016: 684-691). These manual therapies have been proven to be effective when administered individually (Miller et al. 2010: 334-354). However, numerous studies have shown combination treatments to be effective, sometimes more so than individual therapies (Hanten et al. 2000: 997-1003; Iqbal, Khan and Miraj 2010: 10-15; Yeganeh Lari et al. 2015: 204-209; Nasb et al. 2020: 44-50). Neck pain is regarded as a multi-faceted condition and in order to obtain maximum patient care, a combination treatment may prove more beneficial; therefore, in this study SMT combined with IC is investigated and compared to MET alone.

1.4.3 Rationale Three

Spinal manipulative therapy is directed at joint restrictions and is effective at decreasing pain and increasing range of motion in the treatment of spinal and extremity musculoskeletal pain disorders (Miller et al. 2010: 334-354; Brantingham et al. 2013: 143-201). Ischaemic compression (IC) addresses MFTPs by alleviating tension and tenderness associated with these tender spots (Ravichandran, Karthika Ponni and Antony Leo Aseer 2016). In many circumstances IC and other electrical modalities (i.e. IFC, TENS and ultrasound) are used to accompany other manual therapies (Yap 2007: 43-48). Therefore, combining SMT with a technique like IC should prove to be more beneficial than when applied individually. For this reason, SMT and IC have been used in combination in this study in order to address the joint restriction and MFTP

1.4.4 Rationale Four

The MET is a direct technique meaning it is purely voluntary and controlled solely by the patient, as opposed to the healthcare practitioner (Chaitow and Crenshaw 2006; Patel et al. 2018: 41-51). Muscle energy technique (MET) is regarded as a safe procedure as it is voluntary, however, is currently understudied and is often not compared to other manual therapies (Fernández-de-las-Peñas, Cleland and Huijbregts 2011; Oliveira-Campelo et al. 2013: 300-309). This manual technique is considered a safer option to manipulation due to its fewer contraindications (includes tissue fragility, hypermobility, myositis, tumours) with minimal muscle soreness (Greenman 2003; Fernández-de-las-Peñas, Cleland and Huijbregts 2011). The body of literature will benefit from a study of this nature. If MET is effective, it may be utilised in patients presenting with contra-indications to SMT and IC, thus eliminating the consequences associated with contra-indications.

1.5 CONCLUSION

This study is a quantitative randomised, single blinded clinical trial. In this dissertation, the literature related to nonspecific neck pain, MFTPs and various treatment methods, will be reviewed. Spinal manipulative therapy (SMT), IC and MET will be discussed in detail in terms of why and how they are utilised as a treatment option. The design and methodology of the study will then be described followed by the study’s results and discussion. Finally, the conclusions and recommendations are addressed allowing the findings and any issues that occurred to be presented.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

This chapter presents the literature related to the topic, highlighting and discussing the main headings of epidemiology, anatomy and physiology, clinical features, diagnosis and differential diagnosis. The various treatment methods will be discussed with emphasis on SMT, IC and MET. The following databases and search engines were utilised in order to obtain literature for this this review: the Durban University of Technology Library, Summon, Google Scholar, PubMed, Science Direct and Cochrane Reviews.

2.2 EPIDEMIOLOGY

Neck pain is an extremely common debilitating musculoskeletal condition (Hoy et al. 2014b: 1309-1315). The Global Burden of Disease 2015 Report stated that neck pain and low back pain were the leading causes of disability (Vos et al. 2016: 1545-1602). Neck pain has become a problem experienced worldwide and poses a global healthcare challenge to medical professionals (Fernández-de-las-Peñas, Cleland and Huijbregts 2011). The prevalence of neck pain for the overall population over a 12-month period is 30% to 50% (Fernández-de-las-Peñas et al. 2006b: 475-482; Namvar et al. 2016: 500-506). Neck pain has a global point prevalence of 4.7% with a lifetime prevalence ranging from 14.2% to 70%, however this can change depending on the country where the measurement took place (Hoy et al. 2014b: 1309-1315). There are only three regions that outrank the sub-Saharan Southern Africa (4.7% in males, 7.6% in females) region with respect to the point prevalence of neck pain. These three regions are the United States (5.3% in males, 7.6% in females), Western Europe (5.2% in males, 7.4% in females) and East Asia (4.8% in males, 7.0% in females) (Vos et al. 2012: 2163-2196; Hoy et al. 2014b: 1309-1315).

Risk factors associated with neck pain include working in awkward positions, continual work in a certain position and psychosocial factors (i.e. high job demands, sedentary lifestyle, poor work environment) (Kim et al. 2018: 77-83). Other factors may include genetics, sleep disorders, smoking and obesity (Cohen 2015: 284-299). Obese individuals may be more predisposed to neck pain when compared to non-overweight individuals due to higher systemic inflammation, structural changes, greater mechanical stress, decreased muscle strength and more psychosocial problems (Vincent et al. 2013: 481-491).

Based on the results of a systematic review by Lluch et al. (2015), MFTPs can be seen as a predominant clinical entity in patients suffering from neck pain. Neck pain has the highest prevalence rates of MFTPs, among other spinal pain conditions. Active MFTPs are significantly more evident in patients with neck pain in comparison to asymptomatic subjects and the most prevalent locations for these active MFTPs in neck pain patients include the trapezius, levator scapulae and suboccipital muscles (Lluch et al. 2015: 587-600).

2.3 OVERVIEW OF RELATED ANATOMY TO THIS STUDY

2.3.1 Bones of the cervical spine

Moore, Agur and Dalley (2018) described the cervical spines osseous structure as being made up of seven small vertebral bodies, which are regarded as the smallest movable vertebra. There are two types of vertebrae in the cervical spine, which includes atypical (C1 also called the atlas and C2 also called the axis) and typical (C3 to C7) vertebrae (Bogduk 1999: 261-285; Windsor et al. 2011: 1). The axis (C2) has a large vertebral body and dens which articulates with the ring-shaped atlas (C1), which has no body. The rest of the cervical vertebrae, or typical vertebrae (C3-C7), all contain vertebral bodies, elevated uncinated processes and spinous processes (Gatterman 1990; Windsor et al. 2011: 1). With regards to spinous processes, the C3 to C6 are short and bifid, whereas, C7 has a longer spinous process (Moore, Agur and Dalley 2018).

2.3.2 Joints of the cervical spine

The cervical spine contains three different types of joint articulations and include zygapophyseal, uncovertebral and craniovertebral joints (Moore, Agur and Dalley 2018).

Another name for zygapophyseal joints is facet joints, which are paired joints between two successive vertebrae (Moore, Agur and Dalley 2018). These joints consist of hyaline cartilage, menisci, synovium and joint capsule (Kim et al. 2015: 2242-2251). Facet joints experience compressive, shear and axial loading and may be linked to intervertebral disc degeneration (Suri et al. 2011: 202; Kim et al. 2015: 2242-2251).

Uncovertebral joints are located on the posterolateral and lateral aspects of the intervertebral discs, occurring between the C3 to C6 vertebral body’s uncinated processes and the vertebral bodies above them (Moore, Agur and Dalley 2018). They are clinically significant as degenerative changes tend to form within these joints and bony exostoses develop which can possibly impinge the vertebral artery, spinal cord (anterior section) or cervical nerve roots (Middleditch and Oliver 2005).

The craniovertebral articulations include the atlanto-occipital and atlanto-axial joints (Windsor et al. 2011: 1). The super articular facets of C1 articulates with the occipital condyles of the occiput to form the atlanto-occipital joint (Moore, Agur and Dalley 2018). There is a medial and lateral joint making up the atlanto-axial joint. The medial occurs between the odontoid process of the C2 vertebra and the anterior arch of the C1 vertebra. The inferior facets of C1 articulates with the superior facets of C2 to form the lateral joint which is a gliding joint (Gatterman 2005; Windsor et al. 2011: 1; Moore, Agur and Dalley 2018).

2.3.3 Trapezius muscle

The trapezius muscle is described as a large quadrilateral, diamond-shaped and superficial muscle (Moore, Agur and Dalley 2018). This muscle can be divided into three sections which includes the upper, middle and lower sections; with the upper part being the most common site for MFTPs (Simons, Travell and Simons 1999: 11-89).

The trapezius muscle can be broken down into three sections - anatomical attachments, innervation and function. These are presented in **Table 2.1** (Simons, Travell and Simons (1999); Moore, Agur and Dalley (2018).

Table 2.1: Attachments, innervation and function of the trapezius muscle

Attachments		
<u>Upper section attachments:</u> The proximal attachments begin at the medial third of the superior nuchal line, ligamentum nuchae and the spinous processes of the superior five cervical vertebrae (**Figure 2.1**). The muscle fibres move distally and converge to attach to the lateral third of the clavicle.	<u>Middle section attachments:</u> These muscle fibres attach medially to the spinous processes and interspinous ligaments of the sixth cervical vertebra to the third thoracic vertebra. It the moves laterally in an almost horizontal manner to attach to superior edge of the spine of the scapula and the medial border of the acromion (**Figure 2.1**).	<u>Lower section attachments:</u> These muscle fibres attach medially to the spinous processes and interspinous ligaments of the fourth to twelfth thoracic vertebra. The fibres move laterally and converge to attach to the medial end of the spine of the scapula and more distal and lateral to the attachment of the levator scapulae muscle (**Figure 2.1**).

Innervation

While the motor fibres of the trapezius muscle are innervated by the spinal part of the eleventh cranial nerve, also known as the accessory nerve, the sensory fibres of the muscle are innervated by the second to fourth cranial nerves.

Function

- The upper section helps the shoulder by supporting it and aids in scapula elevation. Unilateral contraction of this section brings about neck lateral flexion or rotation on the same side. While the shoulders are stabilised, the bilateral contraction of the trapezius muscle can cause head and neck extension.
- The middle section is responsible for scapula retraction.
- The lower section causes depression and medial rotation of the scapula as well as the lowering of the shoulder.

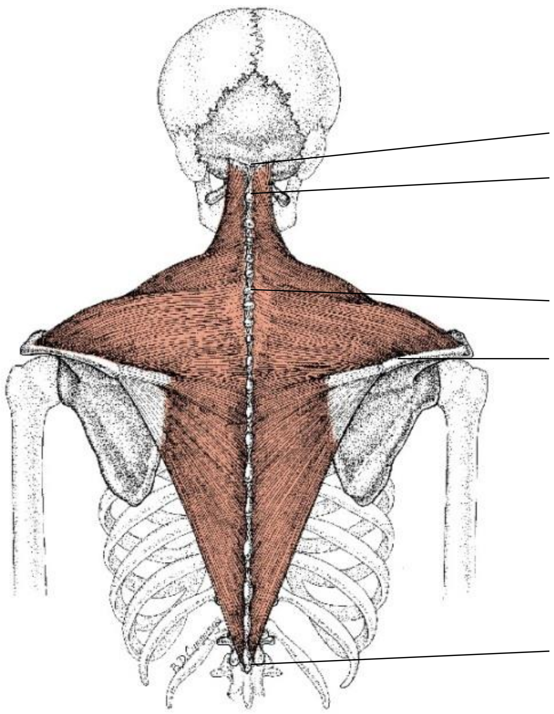


Figure 2.1: Anatomy of the Trapezius muscle (Simons, Travell and Simons (1999)

2.4 PHYSIOLOGY OF SKELETAL MUSCLE

The trapezius muscle is made up of skeletal muscle and is voluntarily controlled by the somatic nervous system. This skeletal muscle is formed by bundles of parallel fibres (Zatsiorsky and Prilutsky 2012). Muscle refers to numerous muscle fibres bundled together with connective tissue and are often attached to bones by a collection of collagen fibres called tendons (Widmaier, Raff and Strang 2015). Numerous thick and thin filaments are arranged in a regular manner which gives skeletal muscle its striated pattern. Small cylindrical bundles made up of these filaments form part of myofibrils and extend from one side of the fibre to the other, thereby linking to the tendons at the fibres ends (Widmaier, Raff and Strang 2015). Each myofibril has the thick and thin filaments organised in a repeating pattern along the myofibrils length and a single unit of this repeating pattern is called a sarcomere (Guo and Yin 2012: 1589-1595; Widmaier, Raff and Strang 2015). Craig and Padrón (2004) stated that the sarcomere is made up of contractile, regulatory and structural constituent proteins. Myosin and actin make up the contractile proteins. The myosin makes up almost the entire thick filament, whereas the actin makes up the majority of the thin filament (Widmaier, Raff and Strang 2015). These two proteins accumulate in order to form a polymeric filament which interrelate with one another and in turn cause force generation and shortening (Craig and Padrón 2004: 129-144). Troponin and tropomyosin are two other proteins which are associated with the thin filament and these assist in regulating the contraction (Widmaier, Raff and Strang 2015).

The thick and thin filaments overlap within the sarcomere and the space between these filaments is bridged by extensions known as cross-bridges. These cross-bridges extend in the direction of the thin filaments from the surface of the thick filaments and are myosin molecules. These cross-bridges make contact with the thin filaments during contraction of the muscle thus exerting a force on them (Widmaier, Raff and Strang 2015).

The sarcomere can be isolated by removing the overlying plasma membrane (Mcnally, Lapidos and Wheeler 2006: 674-681). The outer most connective tissue layer is known as the endomysium and surrounds each muscle fibre's cell membrane or sarcolemma. The next connective tissue layer surrounds a bundle of muscle fibres and is called the perimysium, this forms the muscle fascicle. Each individual muscle fibre is connected to and supplied by motor neurons and capillaries which traverse the endomysium and perimysium. The final connective tissue layer covers several fascicles and is called the epimysium. This final layer continues through from the muscle to the tendon which connects the muscle to the skeleton (Schleip et al. 2013; Liu 2016).

Skeletal muscle fibres are individually innervated by motor neurons. The axon of the motor neuron splits into many branches and forms single junctions with muscle fibres. A motor neuron, along with the muscle fibre it supplies, is known as a motor unit (Widmaier, Raff and Strang 2015). A single motor neuron supplies multiple muscle fibres, therefore allowing entire muscles to contract simultaneously. There is an increase in tension in these fibres or muscle and this in turn causes movement (Waterhouse 2008: 264-269; Guo and Yin 2012: 1589-1595). The axon ends close to the muscle fibre surface and forms short processes that are embedded in grooves on the surface of the muscle fibre. The portion of plasma membrane belonging to the muscle fibre, which is directly below the terminal end of the axon, is called the motor endplate. The junction of a muscle fibres motor end plate and terminal axon of the motor neuron is called a neuromuscular junction (Wilson and Deschenes 2005: 803-828; Widmaier, Raff and Strang 2015). At this junction there is a synaptic transmission of signals that allows muscle contraction, therefore enabling the muscle to function by means of maintaining muscle tone, creating contractions and preventing atrophy. Action potentials of the motor neuron arrive at the presynaptic cleft of the axon, resulting in the opening of voltage-dependent calcium channels to release calcium into the presynaptic neuron. The influx of calcium results in the neurotransmitter acetylcholine (Ach) being released by the motor neuron and depolarises the muscle fibre to create an action potential and subsequently a muscle contraction (Gonzalez-Freire et al. 2014: 208; Widmaier, Raff and Strang 2015; Liu 2016).

Movements of the cross-bridges propel the thick and thin overlapping filaments to move past each other within each sarcomere, therefore creating force and shortening of the skeletal muscle fibre. The length of the thick and thin filaments does not change during the sarcomere shortening. This is known as the sliding filament theory (Widmaier, Raff and Strang 2015) (**Figure 2.2**). Guyton and Hall (2006) stated the following with regards to the sliding filament theory: "*muscle contraction begins with an action potential travelling along the motor neuron to the neuromuscular junction with the muscle fibre*".

A small amount of Ach is released at the nerve ending and opens many ion channels by having an effect on a muscle fibre area. These now open gated channels permit sodium ions to move through the membrane and into the muscle fibre. Another action potential is started at the membrane as a result and moves along the muscle fibres membrane, therefore causing the membrane to depolarize. The action potential electricity (large amounts) flow through T-tubules which are centrally located within the muscle fibre. This electricity reaches the calcium storage structure, called the sarcoplasmic reticulum, causing a large amount of calcium ions to flow out into the sarcolemma. These calcium ions effect the actin and myosin filaments by causing attractive forces between them.

Tropomyosin is moved away from binding sites on the myosin by troponin, allowing the myosin to attach to the actin. The actin and myosin can now slide along each other and create a contraction, but only when this occurs over the entire muscle fibre.

Once the above has occurred, a calcium pump returns the calcium ions to the sarcoplasmic reticulum and is stored here until the arrival of a new action potential. The calcium ions removal from the sarcolemma allows slackening or relaxation of the muscle.

There are tropomyosin molecules that cover each actin molecule's myosin-binding site. These tropomyosin molecules prevent cross-bridges forming, which are myosin-extension heads that connect to the actin protein. Troponin holds each tropomyosin molecule in this blocking position in order to prevent stiffness.

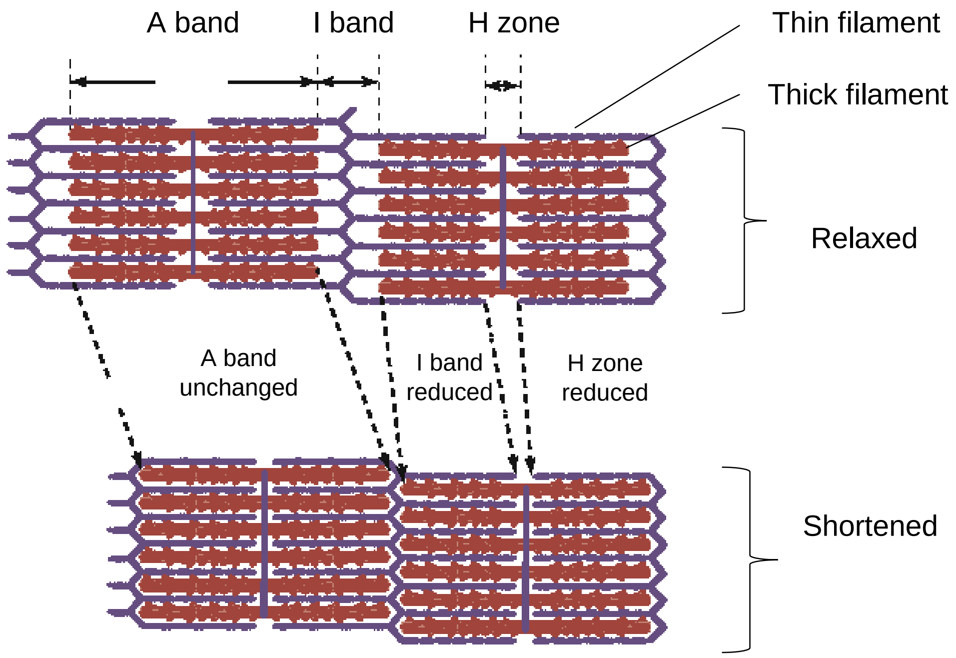


Figure 2.2: Sliding filament theory of the sarcomere (Widmaier, Raff and Strang (2015).

Stretch receptors contain afferent nerve fibre endings encompassing modified muscle fibres. Several stretch receptors are grouped within a connective tissue capsule and collectively are regarded as a muscle spindle (MS) (Widmaier, Raff and Strang 2015). The MS is formed by a collection of intrafusal fibres and can consist of between three and twelve muscle fibres. These intrafusal fibres are skeletal muscle fibres located within a muscle, whereas extrafusal fibres are skeletal muscle fibres and make up the bulk of the muscle and create its movement and force.

The central nervous system (CNS) receives information from these intrafusal fibres via its sensory receptors in order to assess muscle length and the rate of change in muscle length (proprioception) (Rumsey et al. 2010: 8218-8227; Guo et al. 2017: 179-187). There two kinds of stretch receptors that innervate MS. The primary (type Ia) sensory fibres convey the speed at which muscles lengthen or stretch to the CNS, whereas the secondary (type II) sensory fibres react to positioning after movement has occurred and not to speed

(Rumsey et al. 2010: 8218-8227; Widmaier, Raff and Strang 2015). Connective tissue attaches the MS parallel to the extrafusal fibres, therefore the intrafusal fibres are pulled when the muscle is stretched by external forces and result in receptor activation. A greater degree or speed of stretch of a muscle causes greater receptor firing (Widmaier, Raff and Strang 2015). Type III sensory afferents supply pressure sensitivity and a number of these fibres provide information on chemical or temperature changes occurring in the muscle fibre. Type IV sensory afferents are known as mechanoreceptors and are sensitive to pain stimulus (nociceptive) (Rotto et al. 1990: 861-867). Both Type III and IV receptors located in afferent fibres are sensitive to pain, cold, itch, cramping and muscular burning (Basbaum et al. 2009: 267-284).

The stretch reflex is a reflex arc created by the muscle spindle's afferent fibres entering the CNS and making an excitatory synapse with the motor neuron that returns to the muscle being stretched. The most familiar example of this reflex is the knee jerk, where a medical examiner taps on the patient's patella tendon. The tendon is pushed in during the tap therefore stretching the thigh muscles attached to the patella tendon, and in turn activates the muscle's stretch receptors. There is a burst of action potentials from the stretch receptors in the afferent nerve fibres. The motor neurons that are in charge of controlling these same muscles have excitatory synapses activated by these action potentials. The knee jerk is observed due to the patient's lower limb extending by the muscle contraction caused by the stimulation of motor units (Widmaier, Raff and Strang 2015).

The Golgi tendon reflex is different in that it causes an inhibition of the contracted muscle. When an extrafusal muscle contracts, it creates a tension within the tendon. This activates the Golgi tendon organs and releases action potentials to be transmitted to the CNS. Afferent neuron branches that emerge from the Golgi tendon organs cause general inhibition of the contracting muscles. The function of this reflex is opposite to that of the stretch reflex. The muscle spindle in the stretch reflex offers control of the muscle length, whereas, the Golgi tendon organs in the Golgi tendon reflex allows for control of the muscle tension (Jami 1992: 623-666; Widmaier, Raff and Strang 2015).

The intrafusal muscle fibres sensory information is regulated by gamma motor neurons. When signals are sent along these neurons away from the CNS (efferent innervation), it allows the intrafusal fibres to remain taut. In the afferent innervation, these gamma motor neurons, when activated, affect the intrafusal muscle fibres by changing their sensitivity to stretch (Rumsey et al. 2010: 8218-8227). The gamma motor neurons regulate the sensory information in order to adjust the intrafusal muscle fibres to the required length, whereas alpha motor neurons innervate the extrafusal muscle fibres (Rumsey et al. 2010: 8218-

8227; Widmaier, Raff and Strang 2015). Active and passive stretching affects muscle spindles by contracting homonymous extrafusal muscle fibres. This occurs as a result of excitatory impulses being sent to the homonymous alpha motor neuron within the anterior horn and in turn causing a localised twitch response (Mtui, Gruener and FitzGerald 2011).

2.5 AETIOLOGY

2.5.1 Aetiology of Neck Pain

Neck pain has become a global public health problem. Causes of neck pain include poor posture, mechanical and degenerative changes, trauma and neoplasm (Namvar et al. 2016: 500-506; Li et al. 2019: e14649). However, the most common cause of neck pain is due to mechanical issues, which occur as a result of damaged joints, discs, or soft tissue (Karnath 2012: 82). The symptoms associated with neck pain can be provoked by maintaining certain neck postures, neck movement or by palpating the cervical muscles (Phadke et al. 2016: 5-11). In a study by Eggers, Pillay and Govender (2018) on the musculoskeletal pain among South African teachers (n=97), it was found that certain actions associated with teaching such as the forward and backward bending of their heads for extended periods of time and the stretching of their arms above chest height contributed to neck and shoulder pain. The South African teachers assessed in this study do not represent the South African population as a whole, as there were greater numbers of females (n=63) than males (n=9) and most participants were between the ages of 45 and 54 years (n=38). However, the above actions are common movements that anyone may utilise in activities of daily living.

There is an emphasis on the importance of psychosocial factors as risk factors contributing to neck pain. These include high job demands, co-worker support and fear-avoidance beliefs (Kim et al. 2018: 77-83; Basson, Olivier and Rushton 2019: e1-e9). Other risk factors for neck pain include social factors (i.e. a work-family imbalance, or a hostile work environment), high job strain and sleep disturbances (Rasmussen-Barr et al. 2014). Females and older individuals are identified as non-modifiable risk factors (Walton et al. 2013: 494).

2.5.2 Aetiology of Myofascial Pain Syndrome

When compared to healthy individuals (controls) patients suffering with chronic non-traumatic neck pain had a higher prevalence of MFTPs (Ribeiro et al. 2018: 1-13). These MFTPs presenting in skeletal muscle and its related pain are the characteristics of myofascial pain syndrome (MPS) (Simons, Travell and Simons 1999). Myofascial pain syndrome is thought to be a multifaceted neuromuscular dysfunction including both motor and sensory abnormalities involving the peripheral as well as the central nervous system (Park et al. 2018: e11432). Hong (2006) stated that MPS is caused by MFTPs that are frequently triggered by a soft tissue lesion, instead of the muscle itself. Bron and Dommerholt (2012) added to this by concluding the MFTP development can occur due to overuse or direct trauma to any kind of muscle.

2.5.3 Aetiology of Myofascial Trigger Points

It is important to have knowledge about the potential causative factors of MFTPs in order to avoid their formation and recurrence; however, inactivating and eliminating MFTPs is also significant. There is a general understanding that MFTP development can occur due to overuse or direct trauma to any kind of muscle (Bron and Dommerholt 2012: 439-444). Muscle overload may be due to various muscle contractions such as sustained or repetitive minor muscle contractions, eccentric muscle contractions, as well as maximal or sub-maximal concentric muscle contractions (Gerwin 2010: 329-347). Other various causes of MFTP development include poor posture, nerve compression, increased cold, heat or dampness experienced, decreased oxygenation of tissue, compensation of synergistic and antagonistic muscles as well as the formation of satellite MFTPs within a referral zone (Baldry and Thompson 1993; Simons, Travell and Simons 1999: 11-89). Muscle damage is not essential for the formation of MFTPs, however, the cell membrane and sarcoplasmic reticulum may be disturbed, thereby increasing the calcium ions, as well as the cytoskeletal proteins (i.e. desmin, titin and dystrophin) (Larsson et al. 2000: 379-387; Bron and Dommerholt 2012: 439-444).

Sustained low level contractions and intramuscular pressure:

Muscle contraction has been shown to temporarily obstruct blood flow through the local capillaries, however, this stops when the blood flow is returned immediately through the body's natural physiological mechanism. Muscle metabolism occurring during sustained muscle contractions require oxygen and glucose, which are decreased, due to the obstruction of the blood flow. Intramuscular blood circulation may even be significantly impaired with low levels of maximum voluntary contraction (MVC) as these contractions can create increased intramuscular pressure (Palmerud et al. 2000; Bron and Dommerholt 2012). According to Dommerholt, Mayoral del Moral and Gröbli (2006), the increased pressure during minimal exertions may add to the formation of pain and ultimately to the development of MFTPs.

Oxygen and glucose are essential for ATP synthesis which is the source of energy for muscle contractions to occur. Therefore, a lack of oxygen during sustained muscle contraction may produce a local energy crisis. In these circumstances, the muscle switches to anaerobic glycolysis in order to supply an adequate amount of ATP. During anaerobic and aerobic circumstances, pyruvic acid is released along with ATP; however, during anaerobic glycolysis, the pyruvic acid is converted into lactic acid and in return increases the intramuscular acidity (pH) (Bron and Dommerholt 2012). The low intramuscular pH is able to activate muscle nociceptors (Shah et al. 2005; Gautam, Benson and Sluka 2010). Inflammation, high muscle work and ischaemia can lead to increases in hydrogen ions concentration, which can be enough to activate muscle group IV endings, therefore, adding to mechanical hyperalgesia (an increased response/sensitivity to mechanical stimulus) and central sensitisation (nociceptors within the CNS increase in response to normal or subthreshold afferent input). Additionally, a low pH decreases the regulation of acetylcholinesterase (AchE), increases the effect of Ach and sustains the sarcomere contraction (Dommerholt, Mayoral del Moral and Gröbli 2006).

Once the cross-bridges between the myosin and actin have detached or broken, relaxation can occur within the muscle cells. The myosin head is released from the actin after ATP attaches to the myosin, weakening the link between myosin and actin. Large amounts of calcium ions move back into the sarcoplasmic reticulum through the calcium pump during normal physiological circumstances, therefore, there is a demand for ATP during relaxation. The sarcomere may remain contracted in cases of extreme energy depletion until sufficient ATP is present to correct the intracellular calcium ion build-up (Bron and Dommerholt 2012). Thus, muscle disorders and MFTPs are thought to develop as a result of sustained motor unit activity and calcium ion accumulation (Gissel and Clausen 2001).

Maximal or submaximal concentric contraction

High levels of energy (ATP) are needed throughout maximal and sub-maximal concentric contractions. In the beginning, ATP is used from storage deposits found within the muscle fibres; however, after an average of 4 to 6 seconds, direct phosphorylation of ADP starts in the muscle by creatine phosphate (CP) in order to produce ATP. Maximum muscle power can be sustained for about 14 to 16 seconds with the energy provided by ATP and CP stores. After this, intracellular ATP and CP reserves need replenishing through a short rest period. When current ATP demands are kept within the ability of the aerobic pathway, muscular activity can be sustained for long durations of time (hours) in healthy, conditioned individuals. Should the exercise demands start to surpass the capability of the muscle cells to perform the essential reactions quickly enough, increased amounts of the total ATP will be generated through anaerobic glycolysis. In end, the muscles ATP will be depleted and sarcomere contractions may be sustained, thus causing the formation of MFTPs (Bron and Dommerholt 2012).

Eccentric contractions

Eccentric contraction occurs during lengthening of muscles in normal activity. These eccentric contractions are commonly utilised to regulate the rate of movement. There is minimal evidence supporting the development of MFTPs through eccentric loading. However, some studies have found relationships between eccentric contractions and MFTP development (Gerwin, Dommerholt and Shah 2004; Itoh, Okada and Kawakita 2004). Under a microscope, eccentrically exercised muscles show higher levels of abnormal fibres when compared to concentric exercise and passive stretching (Fridén and Lieber 1998; Bron and Dommerholt 2012). All enlarged fibres were found to be fast glycolytic type, which are highly fatigable. It is hypothesised that these fast glycolytic fibres fatigue during the early stages of exercise due to their inability to reproduce ATP and consequently fall into a state of rigor or high stiffness. Evidence is available showing increased levels of intracellular calcium in eccentrically exercised muscles, most likely due to sarcoplasmic reticulum disruption (Fridén and Lieber 1998). As mentioned previously, myosin and actin are kept together when experiencing increased levels of calcium ions. Additionally, high concentrations of calcium ions have the potential to further impair the cell membrane and cytoskeletal disruption through the activation of several mechanisms. This contributes to stiff muscles and MFTP development (Bron and Dommerholt 2012).

2.6 CLINICAL FEATURES OF NECK PAIN AND MYOFASCIAL TRIGGER POINTS

Neck pain has been described by Hoy et al. (2014) as pain experienced in the neck and may or may not have referral pain into one or both of an individual’s upper limbs. Features of neck pain can include tenderness over the posterior neck area, asymmetry seen musculature, increased tension and a decrease in neck movements (Nagrale et al. 2010: 37-43). Individuals suffering from neck pain may exhibit fear avoidance behaviour, which implies that these individuals limit movement and physical actions that are thought to provoke pain (Gatchel et al. 2016: 38-43; Neelapala, Raja and Bhandary 2019: 277-281). It has been proposed by a number of authors that MFTPs play a role in the development of neck pain (Simons, Travell and Simons 1999: 11-89; Navarro-Santana et al. 2020: 3300).

Myofascial trigger points (MFTPs) are defined as hyperirritable areas that are located within muscles or its fascia. Pain is experienced when the MFTP is palpated, stretched and when compressed manually can cause referred pain (Simons, Travell and Simons 1999: 11-89; Vernon and Schneider 2009: 14-24; Bron and Dommerholt 2012: 439-444). In order to diagnose a MFTP within skeletal muscles, there has to be the presence of a taut band, pain and a jump sign (Simons, Travell and Simons 1999: 11-89). A jump sign is the patient's reaction to TP palpation causing facial grimacing, verbal response or jumping or retracting from the examiner (Simons, Travell and Simons 1999: 11-89; Tough et al. 2007: 278-286).

There are various types of MFTPs which include: active, associated, central, key, latent, primary and satellite (Simons, Travell and Simons 1999: 11-89), which are described in more detail below:

- Active MFTPs can be described as a clinical pain complaints which are constantly painful, unable to reach the muscles' maximum elongation, muscle weakness, referring a pain pattern that is recognised by the patient when compressed and enabling a local twitch response (LTR) (Simons, Travell and Simons 1999: 11-89). An active MFTP can cause both referred motor phenomena and frequently autonomic phenomena when stimulated and compressed, while not exceeding the patient's pain tolerance. This generally occurs within the MFTP's pain reference zone and results in soreness (Simons, Travell and Simons 1999: 11-89).
- A TP that is found within a muscle and occurs alongside a MFTPs found within another muscle is known as an associated MFTP (Simons, Travell and Simons 1999: 11-89).
- The clinical definition of a central MFTP is a hyperirritable spot located within a skeletal muscle and within a taut band a palpable hypersensitive nodule is found (Simons, Travell and Simons 1999: 11-89).
- The key MFTPs are also known as the primary MFTPs being addressed (Simons, Travell and Simons 1999: 11-89).
- ~~A~~ Latent MFTPs were described by Simons, Travell and Simons (1999) as a clinically silent TP with regards to unprompted pain, therefore, pain is produced only with palpation. These latent MFTPs have a taut band causing muscle tension and a decreased range of motion (ROM) and may produce clinical features of active MFTPs.
- The existence of active MFTPs can cause the formation of secondary or satellite MFTPs within their referred zones (Simons, Travell and Simons 1999: 11-89).

Taut bands and active MFTPs are typically found within muscles of clinically symptomatic muscles (Chang 2017). These MFTPs are considered the pathognomonic feature of myofascial pain syndrome (MPS), which is a regional muscular disorder and includes changes to motor, autonomic and sensory (Simons, Travell and Simons 1999: 11-89; Cerezo-Téllez et al. 2016: 2369-2377). Myofascial pain syndrome is a regional pain issue and can be found in any muscle or its fascia causing a variety of symptoms, although it is often described as a deep or steady achy pain. This depends on a few different aspects such as location of the MFTP, degree of muscular spasm and pain threshold of the patient. Due to this occurring, the pain intensity can vary from mild, to slight discomfort, to an intense pain almost "lightning-like" in nature (Starlanyl and Copeland 2001). There may also be work-related or functional complaints experienced by the patient such as a decrease in work activity, fatigue or muscle weakness (Borg-Stein and Simons 2002: S40-S47; Cerezo-Téllez et al. 2016: 2369-2377).

2.7 DIAGNOSIS OF MYOFASCIAL PAIN SYNDROME AND MYOFASCIAL TRIGGER POINTS

Even with the prevalence of MFTPs being high, many of the cases are misdiagnosed or missed as a result of minimal soft tissue disorder (such as MFTPS) awareness. Myofascial trigger points require skilled training in palpation, which is uncommon in undergraduate and postgraduate medical course teachings (Gerwin 2001: 412-420; Sharan 2014: S22-S25). Various healthcare professionals found these disorders controversial, difficult to diagnose through objective testing or imaging and as a result, do not attempt to diagnose or treat these disorders (Sharan 2014: S22-S25).

It is essential to identify the following when diagnosing MFTPs (Simons, Travell and Simons 1999: 11-89; Sharan 2014: S22-S25):

- A tender spot located within a taut band of skeletal muscle.
- The patient acknowledges the existing pain complaint when applying pressure to the tender spot, hence an active MFTP is identified.
- Pain experienced when achieving range of motion limit through passive stretching.

2.8 MANAGEMENT OF NECK PAIN, MYOFASCIAL PAIN SYNDROME AND MYOFASCIAL TRIGGER POINTS

Musculoskeletal disorders, particularly neck pain, have been shown to have complex clinical management and may require a combination of multiple modalities (multimodal care) in order to address its related symptoms and consequences (Leaver et al. 2013: 254-257; Bussieres et al. 2016: 523-604). Bussieres et al. (2016) recommended a number of management protocols for neck pain that include the use of multimodal care, manipulation or mobilization, ROM home exercises, strengthening exercises, soft tissue therapy and supervised yoga. Cervical and thoracic spinal mobilisation has be supported to reduce pain and improve function in short and intermediate time periods (Gross et al. 2015).

A systematic review by Gross et al. (2016) identified cervical, shoulder, as well as scapula-thoracic strengthening exercises are beneficial at decreasing pain and improving function in chronic neck pain. It has been suggested that modalities like acupuncture, intermittent traction and laser therapy are more beneficial than placebo in the treatment of chronic neck pain (Graham et al. 2013: 440-460). Gemmell, Miller and Nordstrom (2008) stated that MFTPs are a common cause of the severe and disabling pain experienced by many neck pain cases.

Managing MPS during its early stages requires identifying the involved MFTPs, treating the MFTPs and applying corrective action to prevent reoccurrence (Gerwin 2001). Treatment is aimed at addressing the affected muscle by decreasing pain and restoring normal functionality, length and contractibility (Simons, Travell and Simons 1999). Psychosocial and physiological influences need to be addressed, as these may lead to activation of MFTPs (Auleciems 1995: 18, 21-12, 24-18; Hoy et al. 2014b: 1309-1315; Sharan 2014: S22-S25).

Numerous non-invasive techniques have been utilised in the treatment of MFTPs; however, no single treatment has shown to be comprehensively successful (Borg-Stein and Simons 2002). **Table 2.2** shows these various non-invasive MFTP treatment techniques. Physical therapy (e.g. ischaemic compression) and electrical modalities such as IFC, TENS and ultrasound are commonly used as accompanying modalities, as they both help control muscle stiffness and pain (Yap 2007).

Table 2.2: Various non-invasive myofascial trigger point treatment techniques.

Treatment Technique	Area Treated	Results
Ischaemic compression (Oliveira-Campelo et al. 2013: 300-309).	Upper trapezius MFTPs, n=24	Decrease in pain and increase in CROM.
Passive stretching (Oliveira-Campelo et al. 2013: 300-309).	Upper trapezius MFTPs, n=23	Decrease in pain and increase in CROM.
Laser therapy (Kannan 2012: 46).	Upper Trapezius MFTPs, n=15	Decrease in pain and increase in CROM.
Heat therapy (Wang et al. 2014).	Upper Trapezius MFTPs, n=29	Decrease in pain and pressure pain threshold, with increase in CROM.
Ultrasound (Unalan et al. 2011: 657-662).	Upper trapezius MFTPs, n=25	Decrease in pain and increase in CROM.
TENS (Suh, Kim and Han 2015).	Upper Trapezius MFTPs, n=24	Decrease in pain and pressure pain threshold, with increase in CROM.

With neck pain being a common and clinically costly complaint, a multi-disciplinary approach is required (Ferrari and Russell 2003; Fernández-de-las-Peñas et al. 2007; Gross et al. 2007). Many guidelines recommend a combination of treatments to be utilised in the management of neck pain instead of single technique approaches as these do not represent the optimal treatment outcomes for patients (Miller et al. 2010: 334-354; Bussieres et al. 2016: 523-604; Cohen and Hooten 2017; Bier et al. 2018: 162-171). Combination therapies have been found to be superior in decreasing pain in the treatment of neck pain (Hurwitz et al. 2008).

2.9 SPINAL MANIPULATIVE THERAPY

Spinal manipulative therapy (SMT) is regarded as the foundation of the chiropractic profession; however, it is also utilised by osteopaths, physiotherapists and other health care professionals (Haldeman 2005; Bergmann and Peterson 2011). Spinal manipulative therapy is a manual therapy and is frequently utilised for the treatment of musculoskeletal conditions (Bicalho et al. 2010: 469-475; Bergmann and Peterson 2011). This therapy is considered a group of techniques utilised in the assessment of joint motion and congruency, detecting hypermobile, hypomobile or fixed joints and then correcting the abnormal joint motion (Leach 2004). The manual examination technique of motion palpation is used to assess movements of active, passive and accessory joints and to detect any dysfunction (Leach 2004; Vernon 2010: 22-32; Bergmann and Peterson 2011). A joint fixation may occur due to intradiscal derangement, posterior joint derangement, formation of inter-capsular adhesions, spasmodic muscles and fibrosis of tissue, resulting in dysfunction of the motion segment (Leach 2004). The physiological changes occurring to connective tissue, muscles, ligaments and/or nerves result in abnormal joint movement, decreased joint play and end feel, along with changes to the soft tissue such as bogginess, swelling and muscle hypertonicity (Leach 2004; Morris 2006).

Altering the biomechanics of a single component of the vertebral motion segment affects the function of neighbouring spinal segments and structures (Bergmann and Peterson 2011; Cardinale et al. 2015: 121-126).

Spinal manipulative therapy involves the use of a high velocity-low amplitude (HVLA) thrust which is directed at a dysfunctional joint, moving past its physiological ROM but remaining within the normal anatomical limit (Bergmann and Peterson 2011). This manual therapy can result in an audible crack or pop due to biochemical changes occurring within the joint cavity, but this is not required for the manipulation to be regarded as successful (Pickar 2002: 357-371; Evans and Lucas 2009: 286-291; Bergmann and Peterson 2011; Cardinale et al. 2015: 121-126). The paraphysiologic space is the target when moving through the HVLA technique, which is located between the physiological zone (this occurs in both active and passive ROM limits) and the pathological zone (this occurs at the anatomical limit of the joint) (Vernon and Mrozek 2005: 68-72). The cavitation associated with HVLA spinal manipulation occurs due to separation of articular surfaces by moving the joint pass the elastic barrier of end play and into the paraphysiologic space (Vernon and Mrozek 2005: 68-72; Bergmann and Peterson 2011). This technique results in the effects of SMT and are related to analgesia (Maigne and Vautravers 2003: 336-341).

2.9.1 Spinal Manipulative Therapy Theories

There are various theories available based on manipulative therapy mechanisms when addressing mechanical and neurophysiological reactions (Bergmann and Peterson 2011); however, the central theory suggests there is a lesion present (Gatterman 1991: 232-236) and affects the joints' biomechanical function resulting in dysfunctions and symptoms proximal and distal to the joint (Triano 2001: 121-130).

Curl (1994) explained that the therapeutic effect of spinal manipulation works through two different mechanisms. The first shows us that the mechanical effect results in stimulated mechanoreceptors, stretched muscle spindles and broken-down joint adhesions resulting in greater active and passive joint motion. The second mechanism states that spinal manipulation results in autonomic nervous system stimulation causing pain and muscle hypertonicity inhibition.

Schafer and Faye (1990) had a similar hypothesis, stating that normal movement is restored to fixated joints through the HVLA thrust associated with spinal manipulation. The sudden stretching of the muscle spindles causes the paravertebral musculature to relax as well as ~~a~~ sending an impulse to the CNS which has a normalising effect on abnormal muscle tone by stimulating the CNS reflexes. Clinically this effect will allow ROM to increase and muscle spasm to decrease (Lewit 1999).

The effectiveness of SMT is thought to occur according to a number of different theories (Bergmann and Peterson 2011):

1. Mechanical

There is a rapid separation of articulating joint surfaces resulting in periarticular tissue stretching, thereby freeing up any intra-articular and extra-articular adhesions. The cavitation is thought to stimulate the joints nociceptors and mechanoreceptors, therefore, stimulating the Golgi tendon organs, causing somatic afferent receptor activity. The effectiveness of spinal manipulation in breaking the pain cycle is due to a combination of the above events rather than the cavitation alone. This results in a decrease in pain and muscle spasm and an increase in joint mobility and soft tissue flexibility (Bergmann and Peterson 2011). During SMT, tissue extensibility is maintained by stimulating repair of soft tissue and cartilage. It has also been found to prevent excessive fibrosis, atrophy and degeneration formation.

2. Analgesic

Spinal manipulation has been hypothesised to inhibit central pain transmission with the use of strong afferent impulses to the spinal cord by activating both deep and superficial mechanoreceptors, proprioceptors and nociceptors during manipulation. It was theorised by Korr (1986) that pain sensation is also decreased with spinal manipulation by releasing endogenous opioids (enkephalis and endorphins).

Another theory to consider is the placebo effect as a skilled and concerned practitioner may cause an analgesic effect during consultation. Bialosky, Bishop and Penza (2017) conceptualised the placebo effect as an important aspect of manual therapies. They stated that placebo is one of the pathways that pain is inhibited with manual therapies and should be considered as an important aspect of the treatment effect. Placebo was traditionally believed to be an inert innervation and produce no treatment effect. However, placebo treatments are linked with marked analgesia (Vase et al. 2009: 36-44; Bialosky, Bishop and

Penza 2017: 301-304). Additionally, the placebo response of the patient is a neurophysiological process linked with consistent reactions in the spinal cord as well as the supraspinal regions (Bialosky, Bishop and Penza 2017: 301-304). Bialosky, Bishop and Penza (2017) compared various manual therapies with respect to their effectiveness in alleviating pain and found that despite these therapies differing in theories and approaches, not one is more effective than the other.

3. Neurobiological

Spinal manipulation restores normal joint mechanics and in turn has the capacity to have an effect on both local and distant somatic and visceral tissues, therefore, resulting in the termination of altered neurogenic reflexes linked with dysfunctional joints (Bergmann and Peterson 2011).

4. Circulatory

The effects of spinal manipulation on circulation are categorised into two theories. Firstly, joint dysfunction can cause segmental vasoconstriction by altering the segments' sympathetic tone, thus removing the irritation and improving the circulation with manipulation. Secondly, the effectiveness of the circulatory system is dependent on the current integrity of the musculoskeletal system which is due to the venous and lymph systems being dependent on body motioning and muscular pumping actions. According to Leach (1994), the biggest clinical effect of spinal manipulation is attributed to both the mechanical and circulatory effects.

2.9.2 The Effect of Cervical Spinal Manipulative Therapy on Neck Pain

Manipulation has been found to improve movement, malignment and all-round function when treating a joint subluxation (fixation) (Gatterman 2005). A subluxation is known as a lesion present within the zygapophyseal joints and is not as severe as a dislocation; however, it is still capable of altering the physiological function, alignment and movement of the affected motion segment (Bergmann and Peterson 2011). Gibbons and Tehan (2001) found cervical spine manipulation to be commonly used in the treatment and resolution of subluxations in the neck and the muscle guarding often related to the subluxation. There are various studies available which used a variety of designs that have proven spinal manipulative therapy to be effective at treating neck pain (Cassidy et al. 1992: 495-500; Gross et al. 2002: 193-205; Bronfort et al. 2012: 1; Saavedra-Hernández et al. 2013: 504-512). **Table 2.3.** summarises studies investigating the effect of spinal manipulation on chronic neck pain.

Table 2.3: The effects of spinal manipulative therapy on neck pain

Reference	Sample	Interventions	Outcome measures	Results
Cassidy et al. (1992)	n= 50, neck pain, age= ≥ 17 years	Single cervical SMT	Pain intensity (NRS) and CROM	The intervention was effective at increasing CROM and decreasing pain intensity
van Schalkwyk and Parkin-Smith (2000)	n= 105, neck pain, age= ≥ 17 years	1. Rotatory cervical SMT 2. Lateral flexion cervical SMT	Pain intensity (NRS), neck disability (NDI) and CROM	Both groups showed to be equally effective in improving in all measurements
Bronfort et al. (2001)	n=187, neck pain, age= 20-65 years	1. SMT and rehabilitative exercises 2. Rehabilitative exercises 3. Manipulation	Pain intensity (NRS), neck disability (NDI), CROM and muscle strength and endurance	SMT combined with rehabilitative exercises showed the greatest improvement in pain, CROM and muscle strength and endurance
Giles and Muller (2003)	n=109, neck pain, age= ≥ 17 years	1. Medication (NSAIDs) 2. Acupuncture 3. SMT	Pain intensity (VAS) and neck disability (NDI)	Greater reduction in pain intensity found in SMT group
Maduro de Camargo et al. (2011)	n=37, neck pain, age= 18-45 years	1. SMT 2. Control	EMG (MyoSystem-Br1 device) and PPT (algometer)	Greater reduction in EMG readings and PPT in SMT group
Puentedura et al. (2011)	n= 24, neck pain, age= 18-60 years	1. Thoracic SMT and exercise 2. Cervical SMT and exercise	Pain intensity (NRS) and neck disability (NDI)	Greater reduction in pain intensity found in cervical SMT and exercise group
Bronfort et al. (2012)	n= 272, neck pain, age= 18-65 years	1. SMT 2. Medication (NSAIDs) 3. HE and advice	Pain intensity (NRS), self-reported disability, global improvement, general health status.	Greater reduction in pain intensity found in SMT and exercise group
Saavedra-Hernández et al. (2013)	n= 82, neck pan, age= ≥ 17 years	1. Cervical SMT 2. Cervical and thoracic SMT	Neck disability (NDI) and CROM	The cervical and thoracic SMT group showed a greater improvement in neck disability, and both groups improved in CROM

Maiers et al. (2014)	n=241, neck pain, age= ≥ 65 years	1. SMT with home exercise 2. Supervised rehabilitation with HE 3. HE alone	Pain intensity (NRS), neck disability (NDI), general health status (medical outcomes study short form-36)	The SMT with HE saw a greater reduction in pain after 12 weeks of treatment compared to other two groups
Gorrell, Beath and Engel (2016)	n= 65, neck pain, age= 18 - 35 years	1. Stretching (control) 2. Stretching plus manual applied manipulation (MAM) 3. Stretching plus instrument applied manipulation (IAM)	Pain intensity (VAS), PPT (algometer), CROM and hand-grip strength	Pain decrease greater in MAM group than control, increase in CROM in MAM and increase in hand-grip strength in IAM group

(SMT= spinal manipulative therapy, NRS= numerical rating scale, CROM= cervical range of motion, NDI= neck disability index, NSAIDs = non-steroidal anti-inflammatory drugs, VAS= visual analogue scale, PPT= pressure pain threshold, EMG= Electromyography, HE= home exercises)

Spinal manipulative therapy was found to be the most effective form of treatment in the above studies. The SMT combined with home exercise studies noted better results than SMT alone in decreasing pain intensity and increasing CROM (Bronfort et al. 2001: 788-797; Puentedura et al. 2011: 208-220; Bronfort et al. 2012: 1; Maiers et al. 2014: 1879-1889).

Manipulation comes with several contra-indications varying in severity, hence there is an increased importance for a thorough patient evaluation in order to determine whether the patient will benefit from this form of manual therapy (Gatterman 1990; Whittingham and Nilsson 2001: 552-555). Contra-indications to SMT include vertebral artery insufficiency syndrome, history of positional vertigo, transient ischaemic attack or severe arteriosclerosis, uncontrolled hyper or hypotension, severe cardiovascular disease or diabetes, patients on medications such as anticoagulants, rheumatoid arthritis or other arthritides, vertebral malignancy, spondylolisthesis or recent traumatic injuries (Gatterman 1990). Some individuals have a fear of post-treatment soreness due to previous experiences with SMT. Adverse effects commonly occur after manual therapies and are often transient. According to Paanalahti et al. (2014) post-treatment soreness was the most commonly experienced adverse effect. However, this may be expected since the treatment is directed at an injured part of the body which has the potential to cause patient discomfort post-treatment (Paanalahti et al. 2014: 77). Some patients may find an alternative effective treatment method to be more beneficial.

2.10 ISCHAEMIC COMPRESSION

Ischaemic compression (IC) is one of the techniques used most commonly for MFTP treatment (Montañez-Aguilera et al. 2010: 101-104). This therapy can be defined as the application of slowly increasing, non-painful pressure over a MFTP until a resistance of tissue barrier is felt while sustaining the contact until the tissue barrier releases and the compressive force is increased to reach another barrier. This serves to decrease the MFTPs tautness and sensitivity (Simons, Travell and Simons 1999: 11-89). There is evidence showing that IC is beneficial in a short-term period when treating MFTP related symptoms in patients suffering with neck pain (Vernon and Schneider 2009: 14-24; Cagnie et al. 2015: 573-583). When reviewing the literature, Vernon and Schneider (2009) found IC to be effective in the immediate relief of pain associated with MFTPs; however, there was limited evidence for pain relief over a long-term period.

2.10.1 Ischaemic Compression Theories

Ischaemic compression (IC) is thought to affect the fascia through its density, tonus, viscosity or arrangement by mechanical means (Threlkeld 1992: 893-902; Cantu and Grodin 2001; Schleip et al. 2013). In relation to this mechanical effect, Simmonds, Miller and Gemmell (2012) stated that the slow stretch occurring with IC causes sliding of the collagen fibres within these restricted areas, therefore, decreasing fibrous bundle crimping and increasing the extensibility of the tissue. Schneider (1996) hypothesised that IC brings about therapeutic advantage by causing a localised stretch. Schneider (1996) indicated that the division of actin and myosin cross fibre links is associated with manual pressure application over a taut band. This is due to IC being intense and precise is lengthening actin and myosin fibres when applied to these taut bands.

The neurophysiological response involved in IC is thought to be due to loading the connective tissue in the area through various types of mechanoreceptors (Hammer 2007). The nerve block theory suggests that deep pressure application has the ability to interrupt the reflex motor neuron activity for a short-term by inhibiting incoming sensory input. It is also proposed that the ischaemia created by prolonged pressure inhibits the presence of oxygen and the propagation of action potentials (Schneider 1996: 55-88). Simmonds, Miller and Gemmell (2012) concluded that mechanical and neurophysiological mechanisms both contribute to the beneficial effects of IC and other manual therapies.

Schneider (1996), also proposed that there is influx of fresh blood, along with oxygen and ATP to the involved area of the specific muscle following ischaemia and blanching due to a reflex vasodilation. This influx flushes and removes end product metabolites and substances known to sustain muscle contraction. It was also hypothesised that there is a discharge of endorphins (by the dorsal horn) when there is resultant severe pain from deep prolonged pressure associated with IC causing hyper-stimulation analgesia (Schneider 1996: 55-88).

2.10.2 The Effect of Ischaemic Compression on Neck Pain

Numerous studies have verified the efficacy of IC (Hains 2002: 257; Hou et al. 2002: 1406-1414; Fryer and Hodgson 2005: 248-255; Aguilera et al. 2009: 515-520). Further studies have revealed that IC can be used as a preventative or prophylactic measure in MFTP (Zadeh 2007). Ischaemic compression can be recommended in the treatment of upper trapezius MFTPs in neck pain patients (Cagnie et al. 2015: 573-583). According to Ravichandran et al. (2016), IC was found to be effective in improving PPT as well as functional outcome in individuals suffering with neck pain. There is some evidence supporting the effectiveness of IC to reduce MFTP related symptoms associated with neck pain patients, in the short-term period following treatment; however, there is inadequate evidence showing the long-term decrease in pain of MFTPs (Vernon and Schneider 2009: 14-24; Cagnie et al. 2015: 573-583). Various studies which have investigated the effect of IC on neck pain and are highlighted below in **Table 2.4.**

Table 2.4: The effects of IC on neck pain

Reference	Sample	Interventions	Outcome measures	Results
Hou et al. (2002)	n= 119, neck pain, age= 30-60 years	Stage1: IC alone, two different pressures and three different durations. Stage2: B1. HP and AROM B2. B1 plus IC B3. B2 plus TENS B4. B1 plus SS B5. B4 plus TENS B6. B1 plus IFC and MR	Pain intensity (VAS), PPT (algometer), and CROM (goniometer)	IC (low pressure and long duration or high pressure and long duration) showed immediate pain relief. Group B4, B5 and B6 were found to be superior in decreasing pain and increasing CROM
Fryer and Hodgson (2005)	n= 37, neck pain, age= ≥ 17 years	1. IC 2. Sham IC	Pain intensity (VAS) and PPT (algometer)	IC was found to be superior to sham IC in decreasing pain and increasing PPT.
Gemmell, Miller and Nordstrom (2008)	n= 45, neck pan, age= 18 - 55 years	1. trigger point pressure release 2. IC 3. sham ultrasound	Pain intensity (VAS), neck disability (NDI), PPT (algometer) and CROM (goniometer)	IC was found to be superior to sham ultrasound in decreasing pain

Kannan (2012)	n= 45, neck pain, age= 20 - 40 years	1. laser therapy 2. ultrasonic therapy 3. IC	Pain intensity (VAS), provocative pain test (tenderness grading scale) and CROM (goniometer)	All three groups showed to be effective in improving in all measurements, however, the laser group showed the greater improvement
Cagnie et al. (2013)	n= 19, neck pain, age= ≥ 17 years	1. IC short term 2. IC long term	Pain intensity (NRS), neck disability (NDI), and CROM (inclinometer)	There was an improvement in all outcomes in the short term, as well as long term, except in disability (NDI)
Oliveira-Campelo et al. (2013)	n= 117, neck pain, age= ≥ 17 years	1. IC 2. MET 3. PS 4. Control (PS-placebo) 5. Control (wait-and-see)	Pain intensity (VAS), PPT (algometer) and CROM (inclinometer)	IC, MET and PS groups were effective at improving all outcome measures; however, IC showed the most improvement after one week
Ravichandran et al. (2016)	n= 30, neck pain, age= 23 - 58 years	1. IC and stretching 2. control (ultrasonic therapy)	Pain intensity (VAS), PPT (algometer), neck disability (NDI) and CROM (goniometer)	Both groups showed to be equally effective in improving in all measurements; however, the IC group had a greater increase in CROM

(IC= ischaemic compression, HP= hot pack, AROM= active range of motion, TENS= transcutaneous electric nerve stimulation, SS= spray and stretch, IFC= interferential current, MR= myofascial release, VAS= visual analogue scale, PPT= pressure pain threshold, NDI= neck disability index, NRS= numerical rating scale, CROM= cervical range of motion, MET= muscle energy technique, PS= passive stretching)

It can be seen that IC is a superior treatment for neck pain when compared to a sham or control therapy. However, IC was found to be equally effective as various other therapies i.e. ultrasound therapy, laser therapy, MET and passive stretching (Kannan 2012: 46; Oliveira-Campelo et al. 2013: 300-309).

A systemic review of 18 studies found that 35.1% of chiropractors use soft tissue therapy (i.e. massage techniques, trigger-point release, IC and other manual therapies) as a form of treatment. This was second to spinal manipulation which used by 79.3% of chiropractors (Beliveau et al. 2017: 1-17). The above mentioned studies have proven IC to be an effective MFTP intervention, but it may be uncomfortable for some individuals (Hou et al. 2002: 1406-1414). Ischaemic compression is regarded as a safe technique, but contra-indications do exist such as peripheral vascular disease, the use of anticoagulants and steroids, muscle strain or haematoma of the trapezius muscle and compromised skin surface due to a compromised nutritional status (Perle, Schneider and Seaman 1999: 6-19). The common

IC technique of the pincer grip causes an increased load on the practitioner's distal interphalangeal joint predisposing the joint to arthrosis (Jensen, Bøggild and Johansen 1999: 383-388).

2.11 MUSCLE ENERGY TECHNIQUE

Muscle energy technique (MET) is a form of manual therapy (Fernández-de-las-Peñas, Cleland and Huijbregts 2011; Thomas et al. 2019: 35-18). It makes use of an isometric or isotonic muscle contraction of a patient's muscle, in a direction that is accurately controlled against the manual therapist's applied counter-force. This contraction is voluntary and controlled solely by the patient (Chaitow and Crenshaw 2006; Patel et al. 2018: 41-51). This action causes the muscle to pull on the bone on which it is attached, consequently moving one bone with regards to the bone it articulates with, thus restoring normal ROM of the joint and decreasing the joint restriction. Muscle energy technique can be used to treat weakened muscles, lymphatic drainage, fixated joints and shortened muscles (Fernández-de-las-Peñas, Cleland and Huijbregts 2011; Thomas et al. 2019: 35-18).

It is thought that MET is commonly utilised to release (inhibit) tonus in a muscle prior to stretching (Nagrale et al. 2010: 37-43; Thomas et al. 2019: 35-18). The presence of an isometric contraction influences the Golgi tendon organs within the muscle, thus producing a post-isometric relaxation (Robertshawe 2007: 114-115; Nagrale et al. 2010: 37-43; Thomas et al. 2019: 35-18). There may be an assortment of neurological and biomechanical mechanisms that bring about the therapeutic action of MET including hypoalgesia, change in proprioception, motor programming and tissue fluid control and change (Fernández-de-las-Peñas, Cleland and Huijbregts 2011).

Muscle energy technique can be used in the following circumstances (Greenman 2003):

- ❖ Short or spasmodic muscle lengthening, and/or
- ❖ Physiologically weakened collection of muscles or individual muscle strengthening, and/or
- ❖ Reduction of pain by decreasing localised oedema and therefore relieving passive congestion, and/or
- ❖ Restricted mobility of an articulation through mobilization.

2.11.1 Muscle Energy Technique Theories

Muscle energy technique (MET) effectiveness as a manual therapy can be defined by the following physiological mechanisms:

1) Pain relief:

Muscle energy technique (MET) may have an effect on pain mechanisms and encourage hypoalgesia (Sadria et al. 2016: 920-925). This may be due to central and peripheral modulatory mechanisms, which include muscle and joint mechanoreceptor activation involved in centrally mediated pathways (Sadria et al. 2016: 920-925). It is suggested that during the MET application, while joint motioning and isometric muscle contraction occur, the proprioceptors of the joint and muscle are stimulated (Fernández-de-las-Peñas, Cleland and Huijbregts 2011).

Muscle energy technique is thought to enhance fluid drainage and increase hypoalgesia (Fernández-de-las-Peñas, Cleland and Huijbregts 2011). Muscle blood flow and lymph flow are believed to increase with the relevant muscle contraction (Fernández-de-las-Peñas, Cleland and Huijbregts 2011). Mechanical forces act on the connective tissue by causing changes in the interstitial pressure via fibroblasts and lead to an increase in transcapillary blood flow (Fernández-de-las-Peñas, Cleland and Huijbregts 2011). Injury to the paraspinal muscles can result in a build-up of passive congestion that may be relieved with MET application, thus relieving the pain. Muscle energy technique is believed to decrease inflammatory cytokines and desensitise peripheral nociceptors (Fryer and Ruszkowski 2004: 79-84; Chaitow and Crenshaw 2006).

2) Proprioception:

Overactivity of superficial spinal muscles result in these muscles overacting to stimuli and this is believed to be due to motor programming, disturbed proprioception and motor control, as well as inhibiting paraspinal and deep muscles associated with spinal pain (Fernández-de-las-Peñas, Cleland and Huijbregts 2011). It is suggested that the joint motioning, while recruiting muscles during MET application, affects proprioception feedback, motor control and motor learning (Fryer and Ruszkowski 2004: 79-84; Fernández-de-las-Peñas, Cleland and Huijbregts 2011). This is thought to occur resultant from the theory that since MET utilises deep segmental muscles, MET helps the CNS in enabling coordination and movement in the relevant region (Fryer and Ruszkowski 2004: 79-84; Fernández-de-las-Peñas, Cleland and Huijbregts 2011).

3) Application to spinal dysfunction:

The characteristics of acute spinal dysfunction are local pain and decreased motion which are caused by sprain and inflammation of the zygapophyseal joints. Muscle energy technique stimulates the Golgi tendon organ and causes a direct inhibition of agonist muscles and a reflex inhibition of the antagonist muscles, therefore allowing further movement of the joint into the restricted ROM (Yang et al. 2007: 1307-1315; Jaiswal, Saketa and Rajsekhar 2019).

Chronic spinal dysfunctions have characteristics of decreased ROM, thicker tissue and localised pain and tenderness (Fernández-de-las-Peñas, Cleland and Huijbregts 2011). Sensitised nociceptive pathways may affect proprioception which subsequently interfere with segmental muscle control. Therefore, when MET is applied to chronic joint dysfunctions, it influences proprioception and muscle control (Fernández-de-las-Peñas, Cleland and Huijbregts 2011). Stimulating trans-synovial flow within the zygapophyseal joint capsule during MET is also thought to cause increased ROM and decreased pain. Movement of the joint via MET application may cause the joint capsule to have fluctuations in intra-synovial pressure, which leads to the outflow of trans-synovial fluid in the joint. This results in decreased pain and increased ROM by decreasing the joint effusion (Fryer and Ruszkowski 2004: 79-84; Chaitow and Crenshaw 2006; Fernández-de-las-Peñas, Cleland and Huijbregts 2011).

4) Increasing muscle length:

Various studies have demonstrated the effectiveness of MET in increasing muscle length (Kumar, Sneha and Sivajyothi 2015: 22-26; Sadria et al. 2016: 920-925). Reflex muscle relaxation is often regarded as the mechanism for length, ROM and tissue texture changes after applying MET (Fryer 2011: 439). There is, however, growing support for increased tolerance to stretching as the cause for increased muscle extensibility instead of reflex relaxation (Fryer and Ruszkowski 2004: 79-84; Fryer 2011: 439). Muscle energy technique applied in order to stretch and lengthen myofascial tissue seems to influence viscoelastic and plastic tissue properties, extracellular fluid dynamics and mechanotransduction of fibroblasts; however, there has been few lasting human muscle property changes found (Fryer 2011: 439; Sadria et al. 2016: 920-925). It has been suggested that muscle lengthening is the result of increased tolerance to a stretching force that has been increased (Ballantyne, Fryer and McLaughlin 2003: 59-63; Fryer 2011: 439).

2.11.2 The Effect of Muscle Energy Technique on Neck Pain

Fernández-de-las-Peñas, Cleland and Huijbregts (2011) stated that MET is still largely understudied even though it is found to be an effective type of manual therapy. Although further investigation into MET is still needed, there is available evidence that supports the use of MET in treating restricted mobility and spinal pain (Fernández-de-las-Peñas, Cleland and Huijbregts 2011). A study by Sadria et al. (2016) showed that there was a decrease in pain intensity in the treatment of upper trapezius MFTPs after MET application. Several studies have investigated the effect of MET on neck pain and are presented in **Table 2.5**.

Table 2.5: The effects of IC on neck pain

Reference	Sample	Interventions	Outcome measures	Results
Burns and Wells (2006)	n= 32, neck pain, age= ≥ 17 years	1. MET 2. Control (sham manipulation)	CROM (motion analysis system)	MET showed an increase in CROM.
Dearing and Hamilton (2008)	n= 50, neck pain, age= ≥ 17 years	1. IC 2. MET	PPT (algometer)	Both groups showed to be equally effective in improving in PPT.
Kumar, Sneha and Sivajyothi (2015)	n= 45, neck pain, age= ≥ 17 years	1. MET 2. IC 3. Strain counter strain technique	Pain intensity (VAS), neck disability (NDI) and CROM (goniometer)	All three were effective at improving all outcome measures, however, MET showed a superior improvement.
Phadke et al. (2016)	n= 60, neck pain, age= 18 - 50 years	1. MET 2. Control (static stretching)	Pain intensity (VAS) and neck disability (NDI)	MET was found to be superior to the control group in decreasing pain intensity and neck disability.
Sadria et al. (2016)	n= 64, neck pain, age= 18 - 50 years	1. MET 2. ART	Pain intensity (VAS), active range of cervical lateral flexion (measuring tape) and trapezius thickness (USA)	Both groups showed to be equally effective in improving in all measurements.

(MET= muscle energy technique, CROM= cervical range of motion, IC= ischaemic compression, PPT= pressure pain threshold, VAS= visual analogue scale, NDI= neck disability index, ART= active release technique, USA= ultrasound analysis)

It is revealed that MET is effective at decreasing pain and increasing mobility in patients suffering from neck pain. Muscle energy technique is superior to the control group in the study by Phadke et al. (2016); however, it is equally effective as IC, strain counter strain and active release techniques in treating neck pain.

The voluntary contraction allows MET to be a safe procedure as the dosage is controlled by the patient, hence treatment can be halted if pain is experienced. This manual technique is considered a safer option to manipulation due to it having fewer contra-indications with minimal muscle soreness (Greenman 2003; Küçükşen et al. 2013: 2068-2074). However, some contra-indications do occur such as tissue fragility, hypermobility, myositis and tumours (Chaitow and Crenshaw 2006; Fernández-de-las-Peñas, Cleland and Huijbregts 2011). The presence of an underlying pathology, for example arthritis or osteoporosis, does not exclude MET application as a possible treatment option. The practitioner will simply have to alter the MET dosage and application by means of repetitions and force (Chaitow and Crenshaw 2006).

2.12 CONCLUSION

Spinal manipulative therapy has been shown, by numerous clinical studies, to be an effective treatment of neck pain. Ischaemic compression and MET are effective manual therapies and may be used as an alternative to SMT or in conjunction with SMT in the treatment of neck pain. Muscle energy technique has fewer contra-indications than SMT, therefore, it is considered to be a safer manual therapy. Spinal manipulative therapy and IC are associated with post-treatment soreness and may be an uncomfortable experience for some individuals, even though they have shown to have therapeutic effects on neck pain. Therefore, an alternative therapy, which may be as effective, could be valuable. Although MET has shown to be an effective manual therapy, it is currently understudied and not frequently compared to other manual therapies. Ergo, the aim of this study was to compare the effect of cervical spine manipulation and ischaemic compression of a selected trapezius MFTP, to MET in the treatment of chronic nonspecific neck pain.

CHAPTER 3: METHODOLOGY

3.1 INTRODUCTION

This chapter describes the methodology used in this study. It includes details of the study's design, permission obtained to conduct the study, location of the study, sampling done, study procedure, and the study's inclusion and exclusion criteria. The intervention procedure and frequency, measurement tools and the statistical analysis are discussed in this chapter. Ethical considerations are also outlined in order to ensure the participants' well-being and safety.

3.2 STUDY DESIGN

This study is a quantitative randomised, single blinded clinical trial.

3.3 STUDY PERMISSION

This study received approval by the Institutional Research and Ethics Committee (IREC) (IREC clearance number 079/19) (Appendix A). It was also registered with the Pan African Clinical Trial Registry (identification number PACTR201906639063537) (Appendix B).

3.4 STUDY LOCATION

The Durban University of Technology (DUT) Chiropractic Day Clinic (CDC) was the location where the study took place. Permission was obtained from the clinic director of the DUT CDC (Appendix C) and the Research Director at DUT (Appendix D) in order for the study to take place at the DUT CDC.

3.5 SAMPLING

3.5.1 Population

The study population consisted of individuals residing within the eThekwini Municipality region who met the inclusion criteria.

3.5.2 Recruitment

Advertisements (Appendix E) were placed on the notice boards at the DUT, CDC, around the DUT Berea and City campuses, Spar shops (free advertisement boards) and local gymnasiums and sporting facilities, after permission was given by the appropriate authorities with the use of a letter of request (Appendix F). Potential participants contacted the researcher telephonically for more information.

All potential participants who contacted the researcher were informed that this was the introductory selection and additional inclusion/exclusions were to be applied at the first consultation. Potential participants were asked specific questions (Appendix G) to determine if they qualified to participate in the study (**Table 3.1**)

Table 3.1: Telephonic interview

Questions asked	Required answers for inclusion
"Would you mind answering a few questions to gauge your eligibility to participate in the study?"	Yes
"How old are you?"	20-50
"For how long have you had the pain?"	≥ 12 weeks
"Where is the pain?"	Lower neck region
"Do you have a history of trauma or surgical intervention?"	No
"Are you currently taking any anti-inflammatory medication?"	No
"Are you currently taking any blood thinning medication?"	No

Once the participant met the criteria implemented by the telephonic screening, the first consultation was scheduled at the DUT CDC. The participant received a verbal explanation of the procedure of the research study on arrival at the first consultation and was presented with a letter of information (Appendix H) and informed consent (Appendix I) to read and sign. The participant had an opportunity to ask any questions with regard to the research procedure.

3.5.3 Sample Size

A sample size of 40 participants were recruited and randomly allocated into one of two groups of 20 each i.e. SMT and IC group and MET group.

3.5.4 Sample Allocation

The clinic receptionist used a computer-generated list, provided by the statistician, to randomly allocate the participants to groups in a concealed manner. This list was kept at the reception so that the researcher was blinded to the treatment allocation of any participant. The clinic receptionist distributed interventions via opaque sealed envelopes marked according to the allocation schedule. Each participant, therefore, had an equal chance of being in either group.

3.6 RESEARCH PROCEDURE

Once allocated to a group, potential participants were screened for research compliance by completing a consultation consisting of a case history (Appendix J), a physical examination (Appendix K) and cervical spine regional examination (Appendix L). This was done in order to determine if the potential participants met the remaining inclusion criteria of the study.

3.7 INCLUSION AND EXCLUSION CRITERIA

3.7.1 Inclusion Criteria

- Participants were between the ages of 20 and 50 years. With respect to age, individuals in their mature years (31 to 50 years) are more likely to suffer from MPS (Simons, Travell and Simons 1999: 11-89). However, the condition does occur in younger individuals. These conclusions supported the current age group limits set for this study (Simons, Travell and Simons 1999: 11-89). This was applied during the telephonic screening.
- Signed consent (available in English and isiZulu) for involvement in the study was acquired for inclusion.
- Non-specific neck pain (≥12 weeks duration) of at least 4 and a maximum of 6 on an 11-point Numerical Pain Rating Scale 101 (NRS 101) (to maintain sample homogeneity) (Gemmell, Miller and Nordstrom 2008: 30-36) with associated myofascial pain syndrome of the upper trapezius.
- Participants diagnosed with active trigger points one and/or two in the trapezius muscle that shows the characteristics as outlined by Travell, Simons and Simons, (1999), including:

- Taut band of muscle fibres palpated by snapping or rolling the muscle under the finger.
  - Tender nodule palpated within this taut band of muscle fibres.
  - Local twitch response of the taut band fibres to snapping palpation.
  - Pain reference to the reference zone specific to the muscle involved.
  - In this study, the palpatory diagnosis was utilised as it is practical and is validated as a reliable and effective patient examination method with regards to MPS (Hsieh et al. 2000: 258-264).

The inclusion criteria were applied during the initial consultation.

3.7.2 Exclusion Criteria

- Any participant for whom spinal manipulation is contraindicated as described by Gatterman (1990) were excluded from the study. These included:
  - Vertebral artery insufficiency syndrome;
  - history of positional vertigo, transient ischaemic attack, or severe arteriosclerosis;
  - uncontrolled hyper or hypotension;
  - severe cardiovascular disease and diabetes;
  - patients on medications such as anticoagulants that could predispose to vascular insult;
  - rheumatoid arthritis or other arthritides;
  - vertebral malignancy, spondylolisthesis or recent traumatic injuries (whiplash).
- Presence of neurological symptoms such as chronic headaches, visual disturbances, drop attacks, transient weakness in the legs and family history of stroke.
- Participants were excluded from the study even after case history, physical and regional examinations had any contra-indications been found or noted.
- Participants who displayed any of the following contra-indications to myofascial manipulation therapy as recommended by Nook (1997):
  - Vascular compromise;
  - use of anticoagulants and haemophiliacs;
  - severe diabetes with associated peripheral neuropathy;
  - sensory deficit; and
  - infection which can either be local or systemic.

- Participants who display any contra-indications of MET (including but not limited to): tissue fragility, hypermobility, myositis and tumours (Chaitow and Crenshaw 2006; Fernández-de-las-Peñas, Cleland and Huijbregts 2011).

- Participants who were on any oral NSAIDs were required to participate in a three-day wash out period prior to entering the study (Poul et al. 1993: 1000-1003). This was applied during the telephonic screening.

- Participants who exhibit signs of fibromyalgia syndrome (Schneider 1996: 55-88). Individuals diagnosed with fibromyalgia often exhibit symptoms suggestive of alternative diagnoses which includes peripheral neuropathy, polymyalgia, spondylitis, early systemic lupus erythematosus, metabolic myopathy, early rheumatoid arthritis or chronic fatigue syndrome (Bennett 1989: 58-61). These patients have a history of broad pain for greater than three months' duration (pain presents bilaterally, above and below waist), located in no less than 11 of the 18 tender sites on digital palpation (Schneider 1996: 55-88).

- Participants who refused to sign the informed consent form (Appendix I).

- Participants who suffered from neck or shoulder pain caused by trigger points other those included in the study.

The exclusion criteria were applied during the initial consultation.

3.8 RESEARCH ASSISTANT

This study required the recruitment (Appendix M) of a research assistant (RA). Due to unforeseen circumstances, a further three RAs were recruited in order to complete the data collection process as certain RAs became unavailable to assist. The purpose of the study, together with the recommended training protocols suggested by Goulet, Clark and Flack (1993), were sent to the RAs. The researcher trained each of the RAs over a one-day period. In order to improve inter-rater reliability, the algometer training procedure consisted of the recommendations of Goulet, Clark and Flack (1993). This procedure was performed by applying the algometer device at a 90-degree angle to the flat surface along with even and constant pressure application. In order to evaluate the RAs competency in algometer usage, there was testing involved after completion of the training. The evaluation required the RAs to make five successive algometer applications at a rate of 5 Newtons/second (N/s), with a 15 second gap between each application (Chesterton et al. 2007: 760-766).

Application was performed on a volunteer participant’s first dorsal interosseous muscle for a 10 second duration per application (Chesterton et al. 2007: 760-766). Performing all five applications at a rate of 5N/s over a 10 second duration would regard the evaluation as successful, this due to the fact the dorsal interosseous muscle generally has a pressure pain threshold within this timeframe (Chesterton et al. 2007: 760-766).

It was also required for the RAs to undergo CROM device training recommended by Norkin and White (2016). Training was aimed at proper positioning of the participant during testing in order to get a zero-degree reading on the gravity inclinometer. Correct CROM device positioning on the participant’s head was emphasised to ensure that the nosepiece is on the bridge of the nose with the bands fitting securely around the back of the participant’s head (Norkin and White 2016).

Since the participants were tested in lateral flexion the RAs were trained in guiding the participant’s head into this direction. Once end ROM was achieved, the participant’s shoulder was stabilised by the RA’s one hand, while the other hand on the participant’s head maintained end ROM and the dial readings were recorded at end ROM by the RAs (Norkin and White 2016).

3.9 INTERVENTIONS

Henna stain was used to mark MFTPs one and two of the upper trapezius muscle in order for the RAs to determine the precise location to allow accurate algometer placing at all four consultations. Henna markings are found to be durable and do not easily fade with bathing (Mehendale et al. 2011: 311-315). Should the markings look as if they were fading, the stain was reapplied.

For SMT and IC group, fixations in the cervical spine were located through motion palpation (Peterson and Bergmann 2002) of the cervical spine and manipulated using the diversified technique, as described by Schafer and Faye (1990) and Peterson and Bergmann (2002). Fixations were manipulated in the direction of the restriction (decreased motion). To standardise treatment protocol, patients were treated in the supine position using an index contact. The participant was then be placed in the seated position, with the involved side exposed appropriately. The MFTP was located and determined by flat or pincer palpation as defined by Simons, Travell and Simons (1999). Henna was used to mark the MFTP undergoing treatment and measurements were used on the same spot during every consultation.

Treatment was administered by the researcher once the MFTP was located, as prescribed by Hains (2002). A steady even pressure using the thumb, for a period of seven to ten seconds, was applied to the MFTP. This was repeated two to three times at successfully deeper levels (Schneider 1996: 55-88). According to Hains (2002), disproportionate pressure or holding pressure for extended periods of time may cause the patient to become bruised.

For MET Group, the cervical spine was examined for fixations using motion palpation and the upper trapezius was screened for MFPTs, as described above for Group One. MET was then applied to the fixation and MFTP using the method outlined by Greenman (2003). The technique was applied to all lateral flexion fixations located during motion palpation. The isometric contraction was held for a duration of five seconds per fixation.

An example of MET applied to a typical vertebra (e.g. C4-C5) with a left lateral flexion fixation:

1. The participant is placed in the supine position and the researcher is seated at the head of the bed.
2. The researcher's left hand palpates both articular pillars of C5; this is the vertebra below the restricted C4 vertebra.
3. C5 is then stabilised with the researcher's left hand, so C4 can move on it.
4. The researcher's right hand is used to support the head and move it to the left, into left lateral flexion.
5. The researcher's left hand pushes C5 posteriorly toward the floor, causing a degree of flexion to the cervical spine. The researcher's right hand then places the participant's neck into left lateral flexion until a fixation barrier is reached.
6. The participant is instructed to push their neck into right lateral flexion against the researcher's fixed resistance. Once the participant is placed in this position, the participant maintains the position.
7. The participant is asked to hold the position for five seconds.
8. The technique is repeated three times, with the researcher reaching a new fixation barrier each time.

The technique was applied in the same manner on both left and right fixations. If the fixation was found on the right (as opposed to their left side), then the researcher used his or her left hand (as opposed to their right hand if it was the participant's right side that was problematic). This was done to move the participant's cervical spine into the desired direction whilst the right hand stabilised the vertebra inferior to the dysfunctional vertebra.

3.10 INTERVENTION FREQUENCY

Participants in both groups received three treatments and a follow-up consultation over a maximum period of two weeks allowing for a two-to-three-day break between consultations. Algometry and CROM measurements per participant were only taken by the RAs in order to add blinding.

The consultation process is described below:

Consultation One:

Participants took part in a full case history (Appendix J), a physical examination (Appendix K) and a cervical orthopaedic examination (Appendix L). The researcher completed the subjective measurements i.e. NRS (Appendix N) and Canadian Memorial Chiropractic College (CMCC) Neck Disability Index Questionnaire (NDI) (Appendix O), in order to describe the participant's pre-treatment state. The RAs took the objective measurements, which included the usage of an algometer over MFTP 2 of the trapezius muscle on the related side (pain threshold was measured by the tool over the most painful segment of the MFTP) and CROM-II goniometer (measuring cervical range of motion) readings in lateral flexion.

After this, the researcher gave treatment in accordance with the group allocation of the participant.

Consultation Two:

Within two to seven days of the initial consultation, participants took part in a second consultation depending on their availability. The researcher and RAs took the subjective readings and objective readings, respectively, and treatment (by the researcher) was applied according to group allocation.

Consultation Three:

This took place within a week and a half of the initial consultation. It included the same protocol as the above consultation two with objective and subjective measurements taken and treatment administered following measurements.

Consultation Four:

This took place in the second week and dependent on the participant's availability. The final consultation was for subjective and objective measurements only.

3.11 MEASUREMENT TOOLS

3.11.1 Subjective Measurements:

3.11.1.1 Numerical pain rating scale (NRS)

The NRS (Appendix N) was used in order to get the participant to rate their pain severity on a numerical scale of zero to 10. Jensen, Turner and Romano (1994) compared six different procedures of pain measurement on 75 patients experiencing chronic pain, based on the scale being easy to use and understand. The NRS was considered to be the most practical index to use. Pool et al. (2007) conducted a study involving 79 participants and found the NRS to be more responsive with an effect size of 0.86, when compared to the Verbal Rating Scale (VRS). The same study found NRS to have pain sensitivity and specificity of 0.8. The NRS 101 is a scale that asks the patient to grade their pain severity out of 10, where zero is the least severe pain perceived and the most severe pain perceived is 10. The scale can be easily administered and customised, therefore making it a practical index to use. The least and worst pain perceived was used to create an average score by adding them together, upon completion of the scale.

3.11.1.2 Canadian Memorial Chiropractic College (CMCC) Neck Disability Index Questionnaire (NDI)

The CMCC NDI (Appendix O) is a self-administered questionnaire that was given at the beginning of every consult. The participants' progress was noted over the time of this study and the questionnaire was scored out of 50. This questionnaire is designed to assess disability in activities of daily living as a consequence of neck pain (Vernon and Mior 1991: 409-415). According to Pool et al. (2007), the minimal detectable change for the NDI is 10.5 points when assessing the minimal clinical important change for pain in patients with neck pain. In a study conducted by Cleland et al. (2006), test-retest reliability of the NDI was moderate (intra-class correlation coefficient [ICC] = 0.68; 95% confidence interval [CI], 0.30–0.90) and high for the PSFS (ICC = 0.82; 95% CI, 0.54–0.93). Permission to use the index was obtained from Mapi Research Trust (Appendix P).

3.11.2 Objective Measurements

To introduce blinding, the algometry and CROM measurement readings per participant were taken by the RAs.

3.11.2.1 Algometer readings

The algometer device (Appendix Q) was utilised in order to obtain pressure pain thresholds (PPT) of each participant (Rodríguez-Huguet et al. 2018: 16-22). The PPT was the moment at which pressure brought about pain and was shown as kilograms per square centimetre. Algometer readings were taken at all four consultations. The algometer device is a valuable and reliable instrument often used in the assessment of MFTPs' sensitivity. All measurements were performed and recorded by the trained RAs. This form of measurement has been proven to be useful for the assessment of treatment results (Fischer 1986: 207-214) with a p-value of (p=0.0094) and a very high ICC= 0.91; 95 CI 0.82, 0.97 (Chesterton et al. 2007: 760-766). Pressure pain threshold (PPT) measurements showing a difference of more than 1.77 kg/cm2 are likely to surpass the degree of measurement error and therefore can be used to show true change (Chesterton et al., 2007). With the dial on the gauge reading zero, the RAs localized the MFTP, placed the disc perpendicular to the skin and pressure was then gradually intensified at 1 kg/cm^2 per second. The participant was instructed to say "yes" at the point where the pain first appeared (Fischer 1986: 207-214; Rodríguez-Huguet et al. 2018: 16-22).

3.11.2.2 CROM device readings

The cervical range of motion is measured in frontal and sagittal planes using a CROM device (Appendix Q) consisting of a magnetic yoke and gravity goniometers. Lateral cervical flexion measurements done by the CROM device have been found to have good to excellent inter-examiner reliability (ICC = 0.73—0.89) (Hole, Cook and Bolton 1995: 36-42). The measurements standard of error ranged from 2.5° to 4.1° and the minimal detectable change ranged from 5.4° (Fletcher and Bandy, 2007). Due to the structure of the tested upper trapezius muscle (a cervical spine lateral flexor), only active range of motion measurements were recorded before the start of each consultation. In the study by Tousignant et al. (2002), it was reported that the CROM-II goniometer has good validity with regards to flexion, extension, bilateral rotation and lateral flexion.

The CROM device was positioned on the nasal bridge and ears of the participant and fastened to the back of the participant's head with Velcro straps. With the participant seated in a chair, good posture was ensured and a set of three readings were noted at each consultation.

3.12 MEASUREMENT FREQUENCY

The subjective measurements were noted before each consultation with the NRS collected at each consultation as part of the SOAPE (Appendix R).

The objective measurements were also noted before each consultation.

3.13 ETHICAL CONSIDERATIONS

1. The participant's name was not to be used on the data sheets, instead a code was given to the participant. Only the clinic reception and researcher had access to the names and the codes. The research and all the participants' personal data will be kept in a safe place at the CDC for a period of 5 years, after which, it will be shredded and disposed of.

2. Autonomy for the participant was maintained during this study and each individual was informed of what the study entailed verbally and in writing (in the form of an information and consent letter). Participants were told that they were free to leave the study at any time, for any reason should they wish to do so, without prejudice. Participants were not coerced into participating in the study.

3. Non-maleficence was enforced, ensuring no harm was done to the participant. Only established interventions and measurement tools were applied to the participant, that have been authenticated and shown to be safe.

4. The ethical principle of justice was accounted for; therefore, no participants were discriminated from the study based on race, gender, nationality, religion or occupation. Everyone was treated equally and fairly.

5. Participant information was kept confidential by coding all data, therefore not allowing participant names or details to be published in this study.

6. The rights and the welfare of the participants were protected.

7. Participation was voluntary and did not involve financial benefits.

8. Permission to use the CMCC Neck Disability Scale (Appendix O) was obtained from the relevant owners (Appendix P). Permission to use the CDC for research purposes was obtained (Appendix C and D).

9. The study may affect how this condition is treated, therefore benefiting the profession and its patients. This follows the ethical principle of beneficence.

3.14 STATISTICAL ANALYSIS

Data analysis was made using IBM SPSS VERSION 27 (IBM Corp. Released 2010.IBM SPSS Statistics for Windows, Version 27.0. Armonk, NY: IBM Corp.). Statistical significance was expected at a $p < 0.05$ level. Intra-group and inter-group comparisons were measured by means of repeated measures ANOVA testing. Profile plots were used to evaluate the direction and trend of the intervention effect (Esterhuizen personal communication, 2019).

CHAPTER 4: RESULTS

4.1 INTRODUCTION

In this chapter, each participant's subjective and objective measurements were obtained and analysed. IBM SPSS version 27 was utilised to analyse this study's data. A *p* value <0.05 was considered as statistically significant. Baseline and demographic comparisons were done using independent sample t-tests for normally distributed continuous variables and chi square tests for categorical variables. Repeated measures ANOVA testing was used to examine the changes in each group over the four consultations. For intra-group testing, only a time effect was specified, and this was conducted per treatment group. For inter-group comparisons, the time and group effects were specified as well as an interaction between treatment and time, which was considered as the intervention effect. Profile plots with 95% confidence intervals were generated to visually explore each group's trends over time.

This study's data analysis included:

1. Demographic data analysis consisting of age and gender.
2. Subjective measurements consisting of the NRS and the CMCC NDI questionnaire.
3. Objective measurements consisting of algometer (PPT) and CROM device readings.
4. Comparison of the two groups by means of subjective and objective measurements.

4.2 DEMOGRAPHICS

The study consisted of 40 participants, 22 in the SMT and IC group and 18 in the MET group. The ages of the participants ranged from 20 to 50 years of age. The average ages of the two groups were very similar with the participants mean age in the SMT and IC group being 30.41 years and a mean age of 30.61 years in the MET group (**Table 4.1**). The study consisted of 45% females and 55% males (**Table 4.2**). There were no differences between the two treatment groups in terms of age (*p*=0.941) and gender (*p*=0.565).

Table 4.1: Demographic data analysis of age

Group Statistics						
	group	N	Mean	Std. Deviation	Std. Error Mean	P value
Age	SMT and IC	22	30.41	8.523	1.817	0.941
	MET	18	30.61	8.396	1.979	

Table 4.2: Demographic data analysis of gender

			group		Total
			SMT and IC	MET	
Gender	F	Count	9	9	18
		% within group	40.9%	50.0%	45.0%
	M	Count	13	9	22
		% within group	59.1%	50.0%	55.0%
Total		Count	22	18	40
		% within group	100.0%	100.0%	100.0%

4.3 BASELINE MEASUREMENTS

To ensure randomisation was achieved, the outcomes at baseline were compared between the two treatment groups. All outcomes were approximately normally distributed, thus independent sample t-tests were used for group comparisons of the means. There were no statistically significant differences at baseline NRS, NDI, algometer (PPT) and CROM device readings (**Table 4.3**).

Table 4.3: Comparison between each groups baseline measurements

Group Statistics						
	group	N	Mean	Std. Deviation	Std. Error Mean	P value
NRS 1	SMT and IC	22	5.36	1.049	.224	0.448
	MET	18	5.11	1.023	.241	
NDI 1	SMT and IC	22	11.18	3.065	.653	0.203
	MET	18	9.89	3.234	.762	
PPT 1	SMT and IC	22	2.136	.7719	.1646	0.793
	MET	18	2.200	.7372	.1738	
CROM L 1	SMT and IC	22	26.05	6.743	1.438	0.086
	MET	18	30.00	7.452	1.756	
CROM R 1	SMT and IC	22	27.41	5.861	1.250	0.362
	MET	18	29.39	7.717	1.819	

4.4 OBJECTIVE ONE

The first objective was to determine the effect of SMT and IC in the treatment of chronic nonspecific neck pain, in terms of objective and subjective outcomes. The objective measures utilised in this study were NRS and NDI, whereas the subjective measures were PPT as well as CROM.

4.4.1 NRS

There was a regular and highly significant decrease in pain over the four consultations in terms of NRS measurements ($p<0.001$; repeated measure ANOVA) within the SMT and IC group. The rate of decrease in pain was at its most accelerated between consultation one and two (**Figure 4.1**).

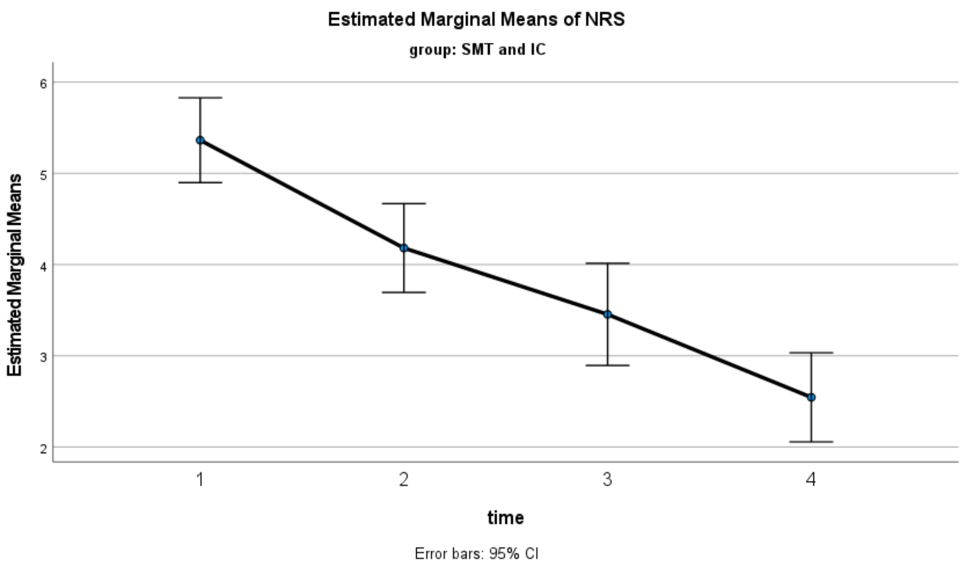


Figure 4.1: Mean NRS over time in SMT and IC Group

4.4.2 NDI

The SMT and IC group had a steady and highly significant decrease in NDI scores over the four consultations ($p<0.001$) (**Figure 4.2**). This shows that the neck disability experienced by the SMT and IC participants improved during this study.

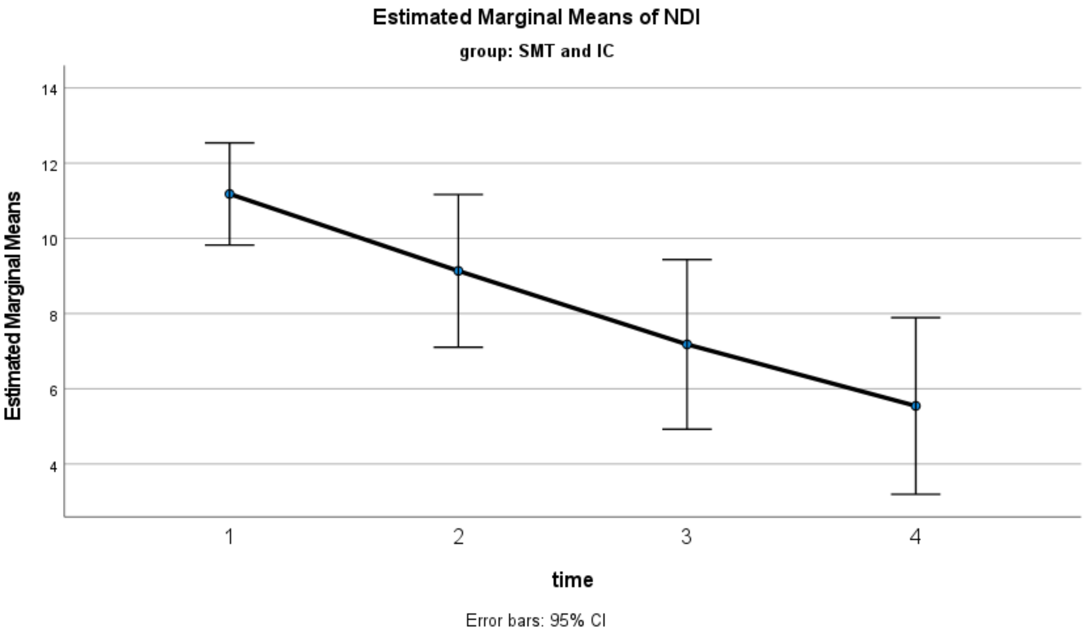


Figure 4.2: Change in NDI measurements over time in SMT and IC Group

4.4.3 Algometer (PPT)

There was a statistically significant increase over the four consultations for algometer (PPT) measurements in the SMT and IC group (p=0.010). There was a lower rate of increase in PPT between consultations three and four (**Figure 4.3**).

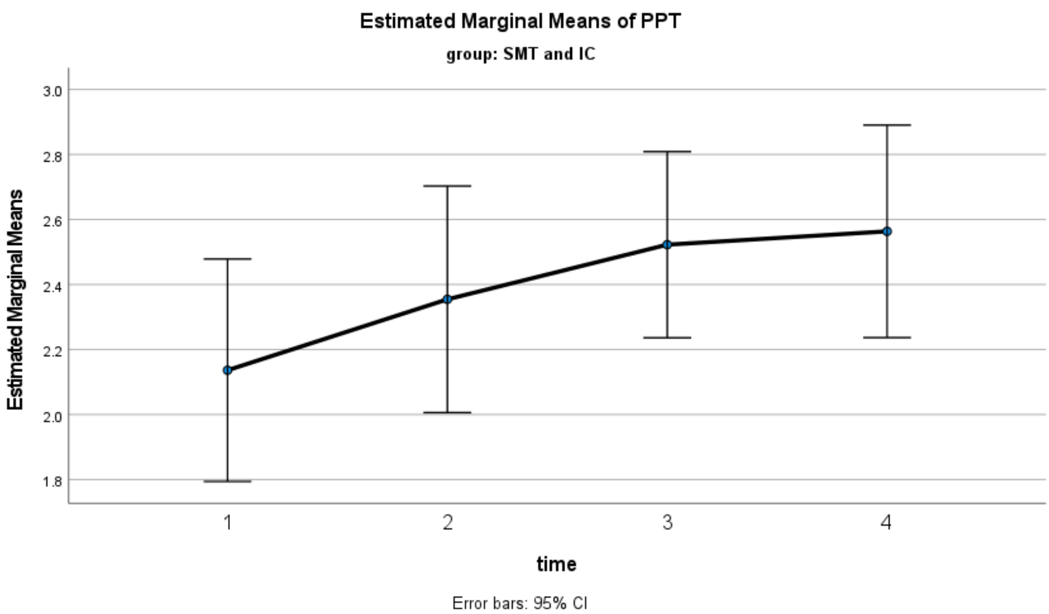


Figure 4.3: Algometer (PPT) readings over time in SMT and IC Group

4.4.4 CROM Left Lateral Flexion

There was a highly statistically significant increase in CROM left lateral flexion measurements over time for the SMT and IC group (*p*<0.001). The SMT and IC group saw a greater rate of increase in CROM left lateral flexion from the second consultation onwards (**Figure 4.4**).

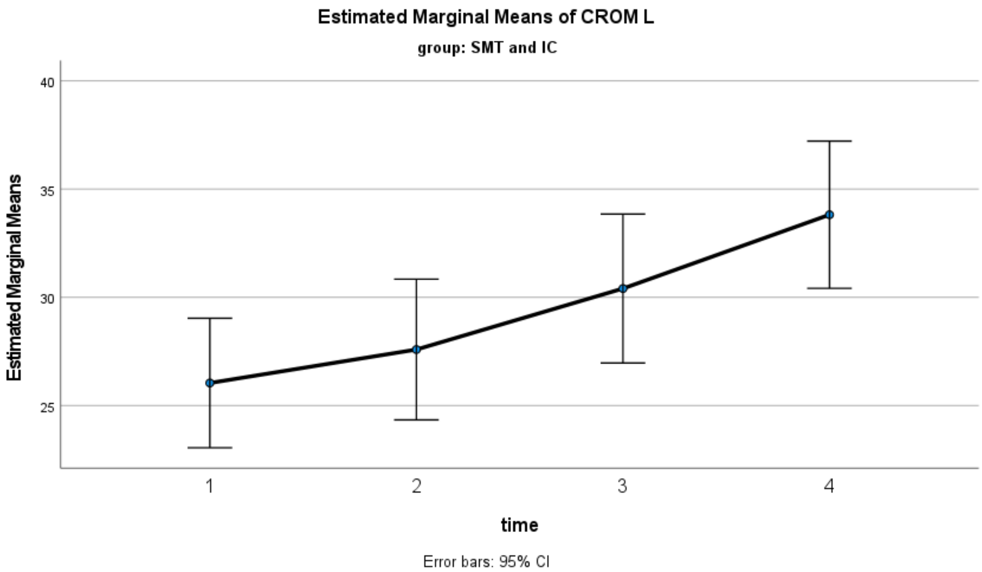


Figure 4.4: CROM left lateral flexion measurements overtime in SMT and IC Group

4.4.5 CROM Right Lateral Flexion

The SMT and IC group also experienced a highly statistically significant increase in CROM right lateral flexion measurements over the four consultations (*p*<0.001). There was a greater rate of increase in CROM right lateral flexion between consultations one and two (**Figure 4.5**).

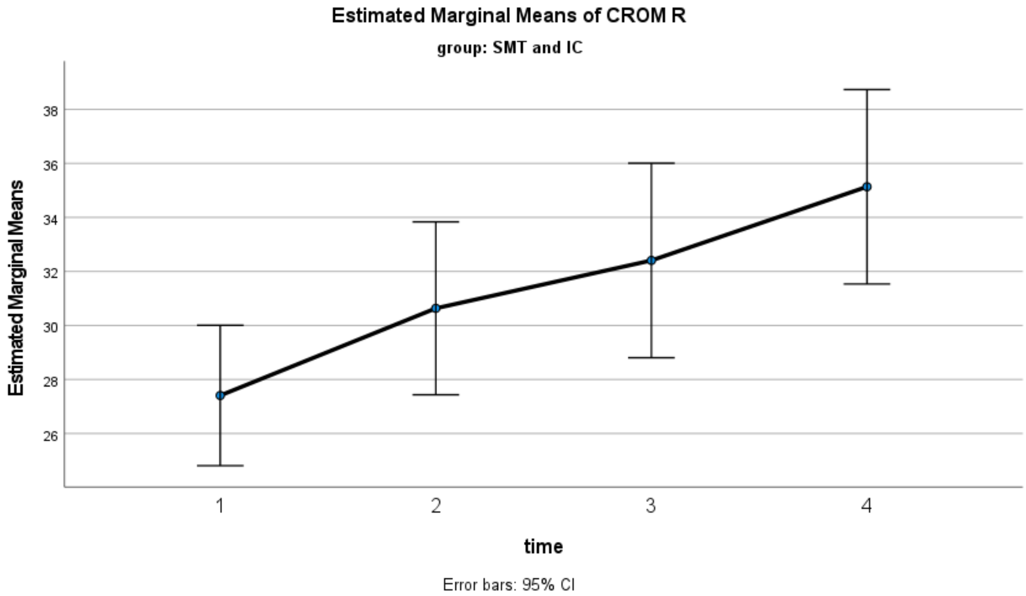


Figure 4.5: CROM right lateral flexion measurements overtime in SMT and IC Group

4.5 OBJECTIVE TWO

The second objective was to determine the effect of MET in the treatment of chronic nonspecific neck pain in terms of objective and subjective outcomes.

4.5.1 NRS

There was a steady and highly significant decrease in pain over the four consultations in terms of NRS measurements (p<0.001) within the MET group. **Figure 4.6** shows an almost straight line as a result of the regular rate of decrease in the participants' perceived pain during this study.

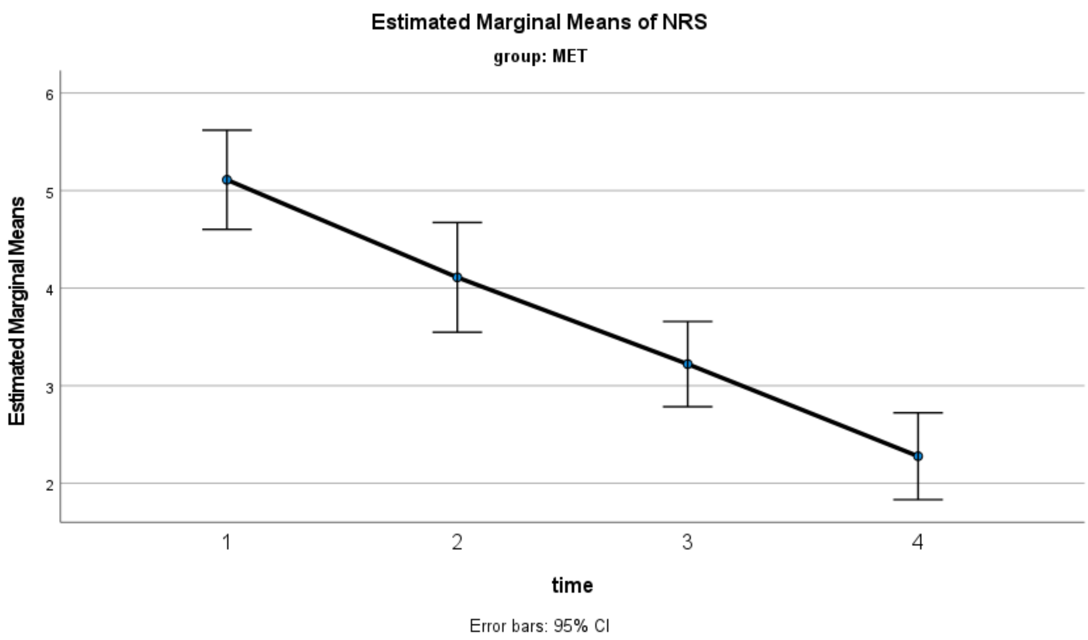


Figure 4.6: Mean NRS over time in MET Group

4.5.2 NDI

The MET group experienced a highly significant decrease in NDI scores over the four consultations (p<0.001). The line formed by the four points shows a gradual decrease in NDI measurements with each consultation (**Figure 4.7**).

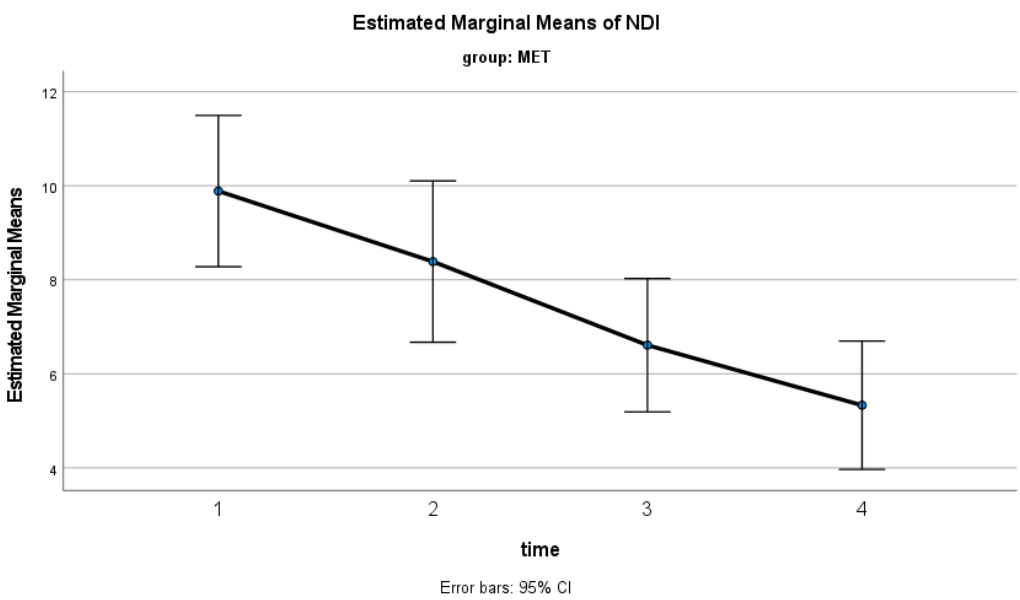


Figure 4.7: Change in NDI measurements over time in MET Group

4.5.3 Algometer (PPT)

There was a statistically significant increase over the four consultations for algometer (PPT) in the MET group (*p*=0.015). This can be seen as a steady increase in the participants' pain threshold between each consultation (**Figure 4.8**).

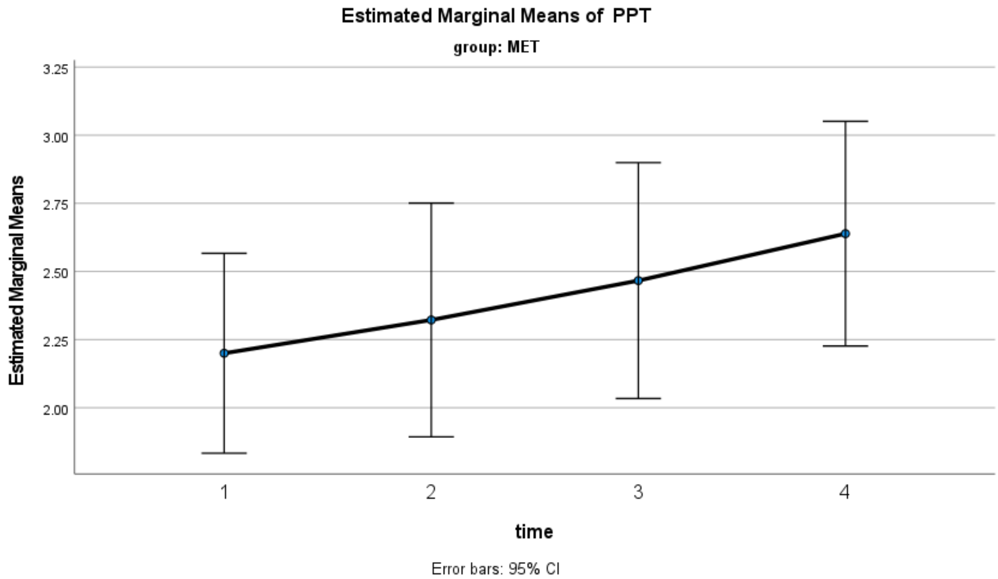


Figure 4.8: Algometer (PPT) readings over time in MET Group

4.5.4 CROM Left Lateral Flexion

There was a statistically significant increase in CROM left lateral flexion measurements over time for the MET group (*p*=0.012). The CROM measurements for the MET group experienced the greatest increase between consultations two and three (**Figure 4.9**).

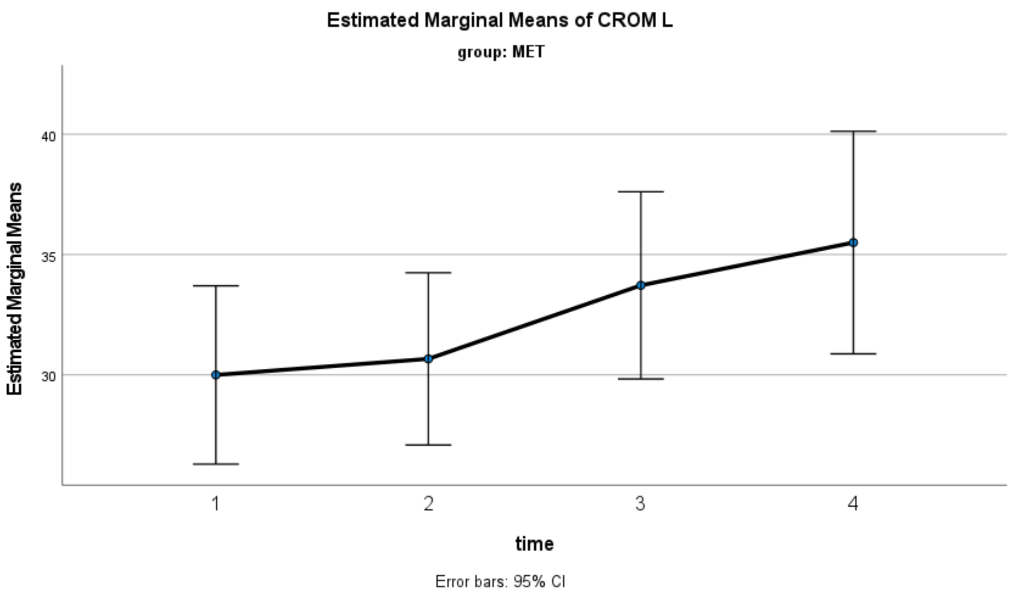


Figure 4.9: CROM left lateral flexion measurements overtime in MET Group

4.5.5 CROM Right Lateral Flexion

During the course of the fourth consultation, the MET group had a highly statistically significant increase in CROM right lateral flexion measurements (*p*=0.001). The rate of increase in CROM measurements was greater between consultations one and three, in comparison to the lower increase between consultations three and four (**Figure 4.10**).

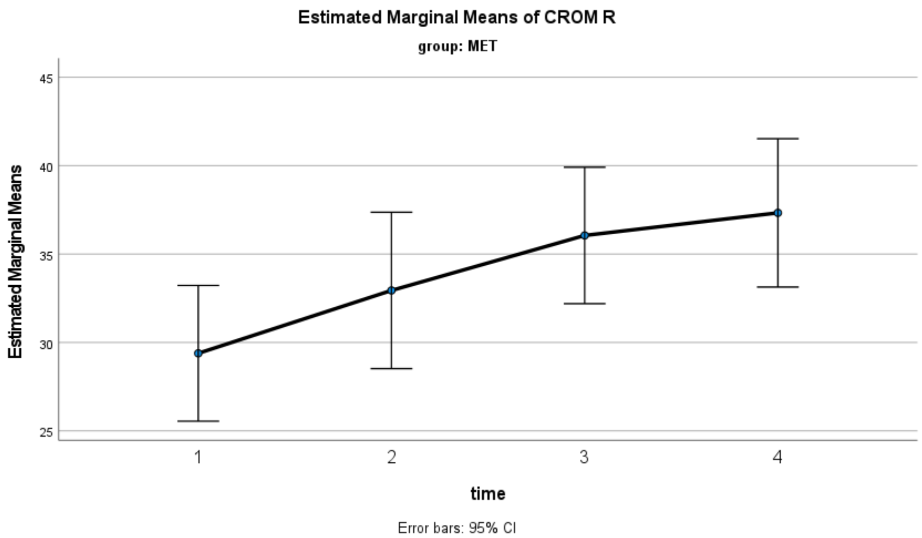


Figure 4.10: CROM right lateral flexion measurements overtime in MET Group

4.6 OBJECTIVE THREE

The third objective was to determine the effect of SMT and IC compared to MET in the treatment of chronic nonspecific neck pain, in terms of objective and subjective outcomes.

4.6.1 NRS

There was no difference in the rate of change over time between the two treatment groups in terms of NRS scores (p=0.960) (**Table 4.4**). Regardless of the group, there was an overall time effect (p<0.001). The profile plot shows that the two groups experienced the same rate of decrease in subjective pain over the four consultations (**Figure 4.11**).

Table 4.4: Effects for NRS on both groups within subjects

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
time	Wilks' Lambda	.154	65.831[b]	3.000	36.000	.000
time * group	Wilks' Lambda	.992	.098[b]	3.000	36.000	.960

a. Design: Intercept + group

Within Subjects Design: time

b. Exact statistic

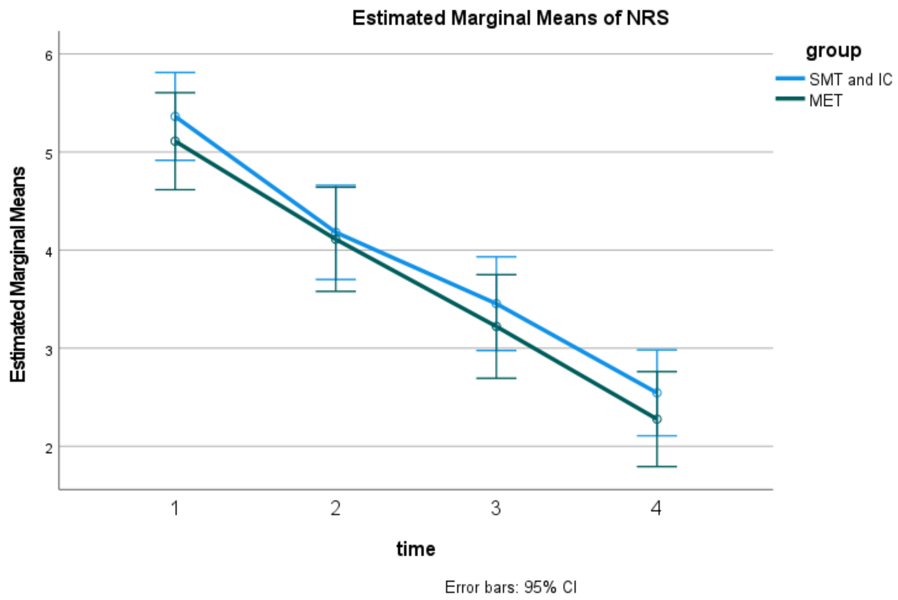


Figure 4.11: NRS comparisons overtime between SMT and IC group and MET Group

Figure 4.11 shows the two almost parallel lines of each treatment group. It can be seen that the SMT and IC group had a higher baseline measurement when compared to the MET group. However, both groups had nearly identical rate of decrease in pain experienced by the participants. Therefore, both the SMT and IC group as well as the MET group had an effect on NRS.

4.6.2 NDI

There was an overall time effect regardless of the treatment group (*p*<0.001). It can also be said that there was no difference in the rate of change over time between the two treatment groups in terms of NDI scores (*p*=0.870) (**Table 4.5**). The two groups experienced a very similar rate of decrease in NDI scores over the four consultations (**Figure 4.12**).

Table 4.5: Effects for NRS on both groups within subjects

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
time	Wilks' Lambda	.340	23.267[b]	3.000	36.000	.000
time * group	Wilks' Lambda	.981	.237[b]	3.000	36.000	.870

a. Design: Intercept + group
Within Subjects Design: time
b. Exact statistic

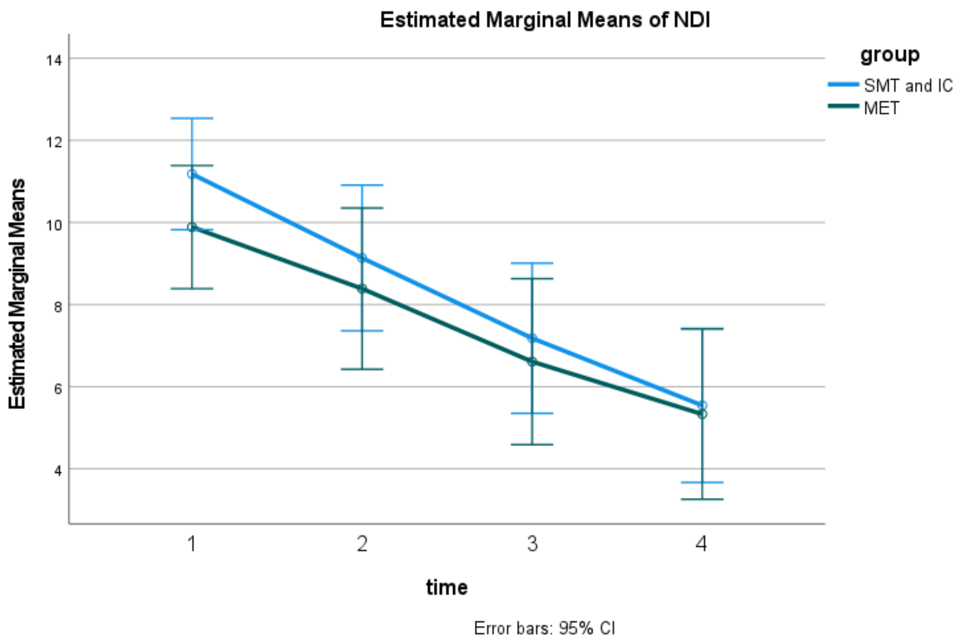


Figure 4.12: NDI comparisons overtime between SMT and IC group and MET Group

Figure 4.12 shows the SMT and IC group began with higher NDI baseline scores compared to the MET group; however, both groups showed a statistically significant parallel change and decreased at similar rates.

4.6.3 Algometer (PPT)

In terms of algometer PPT readings, the rate of change over the four consultations had no difference that was statistically significant (p=0.825). Regardless of the group, both had an overall time effect (p<0.001) (**Table 4.6**). The linear figure below shows that the two groups both had a similar pain threshold rate of increase over the four consultations (**Figure 4.13**).

Table 4.6: Effects for algometer (PPT) on both groups within subjects

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
time	Wilks' Lambda	.561	9.375[b]	3.000	36.000	.000
time * group	Wilks' Lambda	.976	.300[b]	3.000	36.000	.825

a. Design: Intercept + group

Within Subjects Design: time

b. Exact statistic

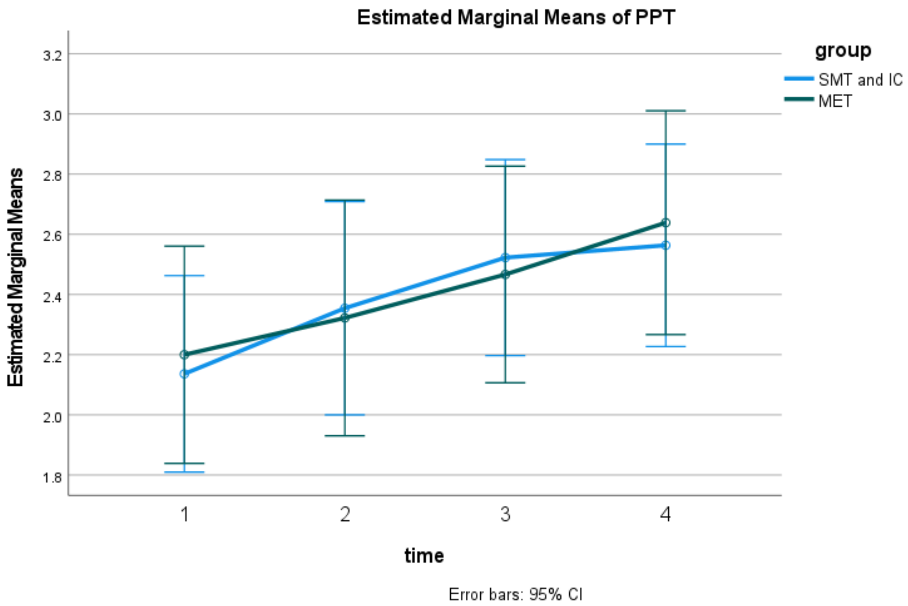


Figure 4.13: Algometer (PPT) readings comparisons overtime between SMT and IC group and MET Group

Figure 4.13 shows that both treatment groups experienced a steady increase in PPT over the four consultations. There was a higher rate of increase in the SMT and IC group between the first and third consultations, whereas the MET group saw a greater rate of increase towards the end of the study, between the third and fourth consultations.

4.6.4 CROM Left Lateral Flexion

There was no difference in the rate of change over time between the two treatment groups, in terms of CROM left lateral flexion (p=0.585), and both groups had an overall time effect (p<0.001) (**Table 4.7**). Over the four consultations, the two groups experienced a very similar rate of increase in CROM measurements (**Figure 4.14**).

Table 4.7: Effects for CROM left lateral flexion on both groups within subjects

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
time	Wilks' Lambda	.451	14.584[b]	3.000	36.000	.000
time * group	Wilks' Lambda	.948	.656[b]	3.000	36.000	.585

a. Design: Intercept + group
Within Subjects Design: time
b. Exact statistic

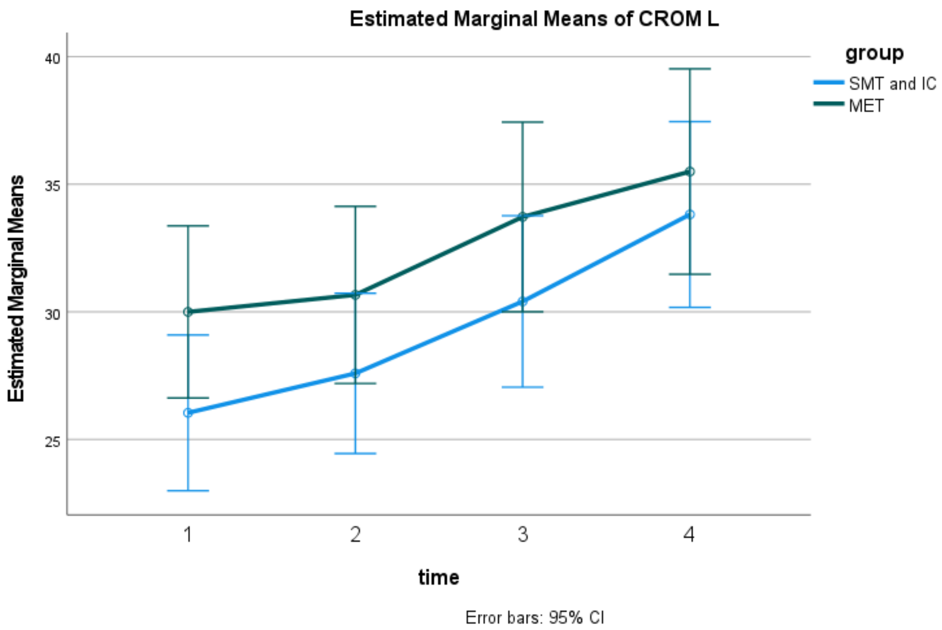


Figure 4.14: CROM left lateral flexion measurements comparisons overtime between SMT and IC group and MET Group

Figure 4.14 shows that even though the MET group started with a higher baseline measurement compared to the SMT and IC group, both groups showed a very similar rate of increase in CROM left lateral flexion.

4.4.5 CROM Right Lateral Flexion

The two groups had no difference in the rate of change over time in terms of CROM right lateral flexion (p=0.712), whilst there was an overall time effect in the SMT and IC group as well as the MET group (p<0.001) (**Table 4.8**). The profile plot shows that the two groups had an almost equal rate of increase in CROM measurements over the four consultations (**Figure 4.15**).

Table 4.8: Effects for CROM right lateral flexion on both groups within subjects

Multivariate Tests[a]						
Effect		Value	F	Hypothesis df	Error df	Sig.
time	Wilks' Lambda	.365	20.903[b]	3.000	36.000	.000
time * group	Wilks' Lambda	.963	.460[b]	3.000	36.000	.712
a. Design: Intercept + group						
Within Subjects Design: time						
b. Exact statistic						

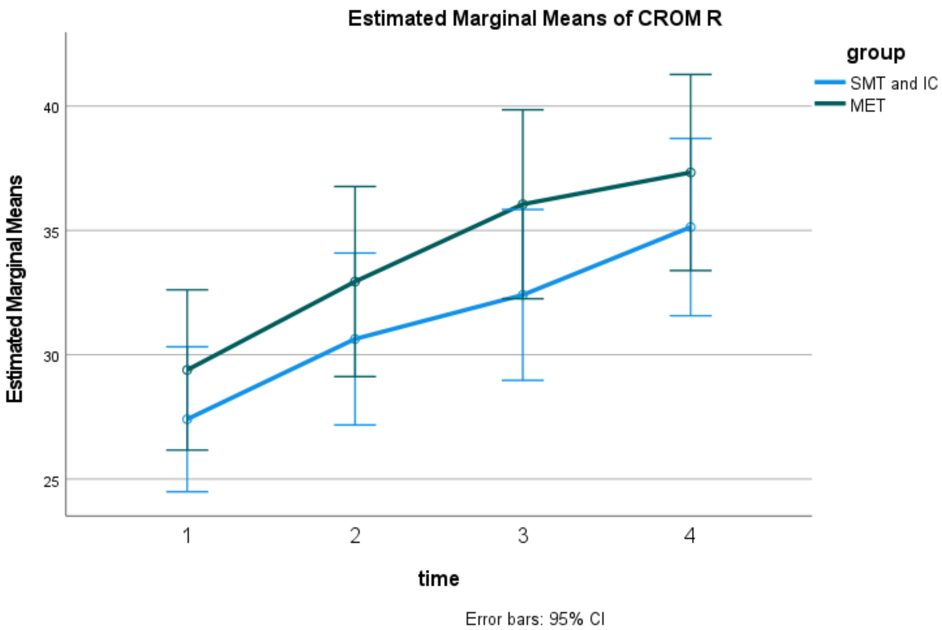


Figure 4.15: CROM right lateral flexion measurements comparisons overtime between SMT and IC group and MET Group

Figure 4.15 shows the two groups have parallel rates of increase. The MET group started with a higher baseline measurement than the SMT and IC group; however, both groups have a very similar effect on CROM right lateral flexion over the four consultations.

CHAPTER 5: DISCUSSION

5.1 INTRODUCTION

In this chapter, the results and data obtained while conducting this study will is discussed in detail. The subjective and objective measurements is analysed, along with mentions of previous areas of work in Chapter 4 and past studies discussed in Chapter 2 of this study. The statistical analysis of the following is discussed within the groups and between the groups:

- Demographic data
- Subjective measurements – NRS and NDI results
- Objective measurements – Algometer and CROM readings

5.2 DEMOGRAPHIC DATA ANAYLSIS

The participants were required to be between the ages of 20 and 50 years in order to participate in this study. Individuals in their mature years (31 to 50) are more likely to experience MPS (Simons, Travell and Simons 1999: 11-89). Elderly and middle-aged individuals have been associated with a higher risk of developing osteoarthritis, and the incidence rate increases drastically after the age of 50 years and may triple in frequency above the age of 70 years (Zhang and Jordan 2008: 515-529; Castell et al. 2015: 359-359). The age range used in this study were similar to the study conducted by Sadria et al. (2016), which was between the ages of 18 and 50 years. Neck pain does occur in younger individuals; hence, the minimum age was set to 20 years.

The participants in this study ranged from 20 to 50 years of age. **Table 4.1** shows the average age of participants in the SMT and IC group was 30.41 years, similarly the participants in the MET group had an average age of 30.61 years (**Table 4.1**). The almost exact mean ages implies that the two groups are comparable based on their similar mean ages.

Advertisements were placed in locations that attracted younger individuals, such as the DUT campuses, which has many young students. The study done by Jull et al. (2002) had a higher mean age than this study with a reported mean age of 36.7 years. Ziaeifar et al. (2014) conducted a study with mean ages lower than this study, 26.5 years in the one group and 30.06 years in the second group. In the study done by Phadke et al. (2016), the average ages were found to be similar to this study, with the mean ages in the MET group being 31.78 years and 33.22 years in the stretching group.

The younger ages seen in this study and more recent studies may also be due to younger individuals informing people of similar social groups of this study. Neck pain has been shown to be one of the most common causes of musculoskeletal pain syndromes among young people (Hoftun et al. 2011: 2259-2266). It is also worth noting that neck pain can affect up to 24.4% of younger individuals aged between 14 to 17 years (Scarabottolo et al. 2017: 2274-2280). In the past few decades, starting from 1991, the prevalence of neck pain among adolescents (16 to 18 years) was 22.9% and this has since increased to 29.5% in 2011 (Ståhl, El-Metwally and Rimpelä 2014: 296). Therefore, this study age group is in alignment with the literature and the results can be applicable to younger and middle aged patients.

The study consisted of 40 participants, of which 18 (45%) were female and 22 (55%) were male (**Table 4.2**). The SMT and IC group contained 22 individuals, 13 males and nine females. Whereas the MET group contained 18 individuals, nine males and nine females. The statistics of this study are very similar to that of Fernández-de-las-Peñas, Arendt-Nielsen and Simons (2006c), who also had more male participants (57.5%) than female participants (42.5%). Other studies have found that the prevalence of neck pain is greater among females than males (Haldeman and Dagenais 2001: 31-46; Hoy et al. 2010: 783-792). The study conducted by French et al. (2013) found more females (67%) compared to males (33%) made use of chiropractic services in Australia.

5.3 SUBJECTIVE DATA ANALYSIS

5.3.1 Numerical Pain Rating Scale (NRS)

The NRS was utilised in this study in order to determine the patient subjective perception of pain and to give pain a numerical value. The scale ranges from zero to ten, with zero being no pain experienced and ten being the most extreme possible pain. Each participant was asked to give their pain a score along this scale at each consultation prior to treatment. In order to be included in this study, each possible participant had to have a NRS score of between four and six.

The intra-group analysis found that there was a highly significant decrease in pain in terms of subjective NRS measurements over the four consultations in the SMT and IC group (p<0.001; repeated measure ANOVA). **Figure 4.1** shows the SMT and IC group had a mean NRS score of 5.4 at the initial consultation, 4.2 at the second, 3.5 at the third and finally 2.6

at the fourth consultation. The SMT and IC group had an average decrease in perceived pain of 0.9 between each consultation.

These results agree with various studies that also found SMT and IC to be effective at decreasing perceived pain associated with neck pain (Giles and Muller 2003: 1490-1502; Bronfort et al. 2012: 1; Cagnie et al. 2013: 482-489; Oliveira-Campelo et al. 2013: 300-309; Maiers et al. 2014: 1879-1889). Some studies investigating SMT and IC made use of a visual analogue scale (VAS) in order to measure perceived pain (Kannan 2012: 46; Gorrell, Beath and Engel 2016: 319-329; Ravichandran et al. 2016: 186-192). The study conducted by Bronfort et al. (2012) made use of the NRS to investigate the effect of SMT on sub-acute (two-to-12-week duration) nonspecific neck pain. Combination treatments such as SMT and home exercise, SMT and stretching, as well as IC and stretching have been found to be effective treatments in decreasing perceived pain (Maiers et al. 2014: 1879-1889; Gorrell, Beath and Engel 2016: 319-329; Ravichandran et al. 2016: 186-192). This concurs with previous findings that combination therapies are superior in decreasing pain in patients suffering from neck pain (Hurwitz et al. 2008).

The intra-group analysis of the MET treatment group also showed a highly significant decrease in NRS scores and is therefore an effective pain reliever (p<0.001; repeated measure ANOVA). The mean NRS scores of the MET group was 5.1 at the initial consultation, 4.1 at the second, 3.2 at the third and 2.4 at the fourth and final consultation, as seen in **Figure 4.6**. The average decrease in perceived pain between each consultation was 0.9 for the MET group, being the same as the SMT and IC group.

The above results are similar to numerous studies investigating the effect of MET on perceived pain in the treatment of neck pain (Kumar, Sneha and Sivajyothi 2015: 22-26; Phadke et al. 2016: 5-11; Sadria et al. 2016: 920-925). However, the above mentioned studies made use of the VAS method of measuring perceived pain. Sadria et al. (2016) used the VAS to determine the effectiveness of MET at decreasing pain in latent trigger points located in the upper trapezius muscle, as opposed to active MFTPs.

Inter-group analysis of the mean NRS scores of the SMT and IC group, compared to the MET group, revealed no difference that was statistically significant. Both the groups were found to be effective at the rate of change over time (p=0.960; repeated measure ANOVA), and their time effect was also significant (p<0.001) (**Table 4.4**). Although NRS is a subjective tool, it has been utilised in many studies as a valid outcome measure. It can be deduced from this information that there is no difference in perceived pain reduction capabilities between the SMT and IC group when compared to the MET group in terms of subjective NRS measurements.

5.3.2 Neck Disability Index (NDI)

The Canadian Memorial Chiropractic College (CMCC) NDI is a self-administered questionnaire that was used in this study and, like the above instrument (NRS), is a subjective measurement tool. However, the NDI is used to assess how the patient's neck pain affects the patient's activities of daily living (Vernon and Mior 1991: 409-415). The questionnaire consists of 10 sections, with ratings from 0 to 6 per section, resulting in a total out of 50. It was given to the patients at the beginning of each consultation and their scores were noted once completed.

The intra-group analysis of the SMT and IC treatment group revealed there to be a highly significant decrease in terms of subjective NDI scores over the four consultations ($p<0.001$; repeated measure ANOVA). **Figure 4.2** illustrates that the SMT and IC treatment group had a mean NDI score of 11.2 at the initial consultation, 9.2 at the second, 7.2 at the third and 5.6 at the final consultation. There was an average decrease of 1.87 in NDI scores between each consultation. These results are in line with various studies that investigated the effect of SMT and IC on NDI scores in the treatment of neck pain (Puentedura et al. 2011: 208-220; Oliveira-Campelo et al. 2013: 300-309; Saavedra-Hernández et al. 2013: 504-512). The study by Cagnie et al. (2013) found an improvement in NDI measurements when assessing the effect of IC on neck pain over a short-term period (4 weeks); however, did not improve over a long-term period (6 months).

The MET group had a highly significant decrease in NDI during intra-group analysis ($p<0.001$; repeated measure ANOVA). **Figure 4.7** shows that the MET treatment group had a mean score at the initial consultation of 9.8, at the second 8.4, at the third 6.6 and finally at the fourth 5.4. The MET group experienced an average NDI score decrease of 1.47 between each visit. There are various studies investigating the effect of MET on NDI measurements in the treatment of neck pain that concur with these results (Kumar, Sneha and Sivajyothi 2015: 22-26; Phadke et al. 2016: 5-11). In a study by Kumar, Sneha and Sivajyothi (2015), when investigating the effectiveness of IC, MET and strain counter strain in the treatment of upper trapezius MFTPs, it was shown that MET had a greater improvement in NDI measurements than IC.

The inter-group analysis of the SMT and IC group's mean NDI scores, compared to the MET treatment group's scores, shows there to be no difference that was statistically significant. The rate of change over time was effective in both groups ($p=0.870$; repeated measure ANOVA), and both time effects were significant ($p<0.001$) (**Table 4.5**). Both groups are effective at improving activities of daily living that are negatively influenced by neck pain. It can be seen in **Figure 4.12** that the SMT and IC group had a slightly higher initial NDI score (11.2), compared to the MET group (9.8); however, both groups finish with a similar score of 5.4 and 5.6 respectively.

5.4 OBJECTIVE DATA ANALYSIS

5.4.1 Algometer readings

The algometer device was used in this study to measure the patient's pressure pain threshold (PPT) over the four consultations and differs from the above two tools as it is an objective measurement. Measurements that increase over a set period indicate that the pain threshold has also increased, therefore showing a desensitization of the MFTP.

Over the four consultations, it can be seen that the intra-group analysis of the SMT and IC group had a statistically significant increase in algometer PPT measurements (p=0.010; repeated measure ANOVA). **Figure 4.3** shows that there was a steady increase in PPT between the first and third consultation, which almost plateaus to the fourth consultation.

A study by Maduro de Camargo et al. (2011), which contained a similar sample size to this study (n=37), comparing SMT to a control group (no treatment given) in the treatment of neck pain, noted an increase in PPT within the SMT group. In addition to this, Gorrell, Beath and Engel (2016), also concluded that SMT, combined with stretching, was superior in increasing PPT than stretching alone in the treatment of neck pain. When investigating the effect of IC on PPT experienced by neck pain patients, IC proved to be beneficial and helped increased PPT measurements in numerous studies (Hou et al. 2002: 1406-1414; Fryer and Hodgson 2005: 248-255; Gemmell, Miller and Nordstrom 2008: 30-36; Oliveira-Campelo et al. 2013: 300-309; Ravichandran et al. 2016: 186-192). A literature search found it to be more common for PPT to be used as a measurement of MFTP sensitivity in studies investigating IC and its effect on neck pain compared to studies investigating SMT and its effect on neck pain.

The intra-group analysis of the MET treatment group also revealed that in terms of the PPT measurements, there was a statistically significant increase over the treatment period (p=0.015; repeated measure ANOVA). There is a uniform increase from the first to the fourth (being the last) consultation. Dearing and Hamilton (2008), investigated the effect of MET in the treatment of neck pain and also concluded it to be effective at increasing PPT. Another study by Oliveira-Campelo et al. (2013) found IC, MET and passive stretching to all be equally as effective in increasing PPT in the treatment of neck pain. Much like SMT, a review of the literature shows that PPT is not a common measurement compared to IC when investigating the effect of MET on neck pain patients.

The inter-group analysis of the two treatment groups showed there to be no difference that was statistically significant in the rate of change between the two treatments when addressing PPT (p=0.825; repeated measure ANOVA). **Table 4.6** shows there was an overall time effect regardless of group (p<0.001). These results show that both groups increased, and therefore improved, the threshold at which the participants experience pain. **Figure 4.13** shows the SMT and IC group had a more accelerated increase in PPT compared to the MET group; however, the SMT and IC group almost plateaus after the third consultation. The MET moves at a steady rate of increased PPT measurements throughout the study period. This implies that SMT and IC may have a greater increase in PPT over a shorter period than MET; however, MET may have a statistically greater increase than SMT and IC, should the period be lengthened further than two weeks (used in this study).

5.4.2 CROM device readings

The CROM-II goniometer device was utilised in this study in order to measure and obtain CROM in lateral flexion. Each patient had both his and/or her left and right lateral flexion measured at all four consultations. The upper trapezius muscle was being tested, which is a cervical spine lateral flexor, therefore only lateral flexion CROM was measured.

The intra-group analysis of the SMT and IC showed that both left and right lateral flexion had a highly statistically significant increase in CROM. It can be seen that the left CROM had a steady increase over the four consultations; however, there was a greater increase in CROM from the second consultation (p<0.001; repeated measure ANOVA) (**Figure 4.4**). The right CROM also showed a steady increase over the four consultations, but there was less of an increase between consultation two and three (p<0.001; repeated measure ANOVA) (**Figure 4.5**). These results can conclude that SMT, in combination with IC, is effective at increasing CROM lateral flexion in individuals with active upper trapezius MFTPs, which are associated with a decrease in muscle elongation (Simons, Travell and Simons 1999: 11-89).

The study done by Saavedra-Hernández et al. (2013), found cervical SMT alone, and in conjunction with thoracic SMT, to be beneficial at increasing CROM in individuals suffering from neck pain. Other studies have also noted the same increase in CROM when administering SMT to treat patients suffering from neck pain (van Schalkwyk and Parkin-Smith 2000: 324-331; Bronfort et al. 2001: 788-797; Gorrell, Beath and Engel 2016: 319-

329). Like this study, numerous past studies have also found IC to be beneficial at increasing CROM when administered alone in treating neck pain (Gemmell, Miller and Nordstrom 2008: 30-36; Cagnie et al. 2013: 482-489; Oliveira-Campelo et al. 2013: 300-309; Ravichandran et al. 2016: 186-192). Oliveira-Campelo et al. (2013) found IC to have a greater increase in CROM measurements in neck pain patients over the first week of their study when compared to MET, passive stretching (PS) and two control groups. When IC was compared to laser and ultrasonic therapy in the treatment of neck pain, Kannan (2012) found all three to be effective at increasing CROM. Both SMT and IC have been shown to be individually beneficial at improving CROM, and in this study a combination of the two have also resulted in similar findings.

In the MET group, the intra-group analysis shows that both left and right CROM experienced a statistically significant increase in the lateral flexion movement. However, when compared the right CROM, the statistically significant increase experienced was higher than the left CROM. In **Figure 4.9** it can be seen that the CROM left lateral flexion saw its greatest increase between consultations two and three (p=0.012; repeated measure ANOVA). **Figure 4.10** shows that the CROM lateral flexion on the right had a steady increase over the four consultations but had less of an increase from the third to the fourth consultation (p=0.001; repeated measure ANOVA). Both the CROM lateral flexion on the left and right had very similar mean baseline measurements (30º on the left and 29º on the right); however, the CROM lateral flexion on the right finished with a higher final mean goniometer measurement (37º), compared to the right (35º).

The study done by Burns and Wells (2006) also found MET to be beneficial at increasing CROM in neck pain patients, when compared to a sham manipulation. Another study provided by Kumar, Sneha and Sivajyothi (2015) shows that MET, IC and strain counter strain treatment techniques are all helpful at increasing CROM in neck pain patients; however, MET had resulted in superior improvements. Much like the above mentioned studies, this study suggests that MET is an effective treatment at increasing CROM.

The inter-group analysis of the two groups shows that there is no difference in rate of change over time for the CROM lateral flexion on the left (p=0.585; repeated measure ANOVA) (**Table 4.7**) as well as for the CROM lateral flexion on the right (p=0.712; repeated measure ANOVA) (**Table 4.8**). Both groups' left and right CROM lateral flexion results had an overall time effect (p<0.001) (**Table 4.7** and **Table 4.8**). These results show that both treatments are equally effective at improving CROM in patients suffering with nonspecific neck pain. It can be seen that the SMT and IC group's mean CROM lateral flexion results on the left and right were all lower than the MET group's results. Nonetheless, the course of the lines may imply that with a longer treatment period (over two weeks), the SMT and IC group results may surpass the MET group.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

The aim of this single blinded, randomised clinical trial was to determine the effect of SMT and IC compression, compared to muscle energy technique, in patients suffering from chronic nonspecific neck pain. The use of MET has been found to be an effective form of manual therapy; however, MET is understudied and is not compared to other manual therapies very often. MET may be preferred to SMT and IC which are associated with several contra-indications, post-treatment soreness and may cause the patient to have an uncomfortable experience. With MET, the patient is able to control the dosage, as the technique uses a voluntary contraction, and this may make the patient feel safer and more relaxed.

Permission to conduct this study was granted by the Institutional Research and Ethics Committee (IREC). The study consisted of 40 participants, who were randomly allocated into one of the two treatment groups, and each received three treatments and one follow up consultation. Each consultation involved recording the following subjective and objective measurements before treatment: NRS, CMCC NDI, PPT algometer and CROM in lateral flexion. While using the IBM SPSS Version 27 and repeated ANOVA testing, the recorded data was analysed in order to establish the effectiveness of each treatment over time and between each other.

The results revealed that both groups had a statistically significant improvement in subjective measurements. Both groups were effective at decreasing their NRS and NDI scores over the four consultations. There was no statistically significant difference between the two groups' improvements. This shows that the treatment therapy of MET is equally as effective as SMT and IC at decreasing perceived pain and improving activities of daily living associated with neck pain.

In this study, the objective measurements also enhanced in both groups and had a statistically significant improvement. The study population showed increases in their PPT and CROM readings regardless of which group the participants belonged to. The difference in improvements between the groups was not statistically significant. Muscle energy technique (MET) as well as SMT and IC are equally effective at increasing the participants' MFTP sensitivity and cervical range of motion in lateral flexion.

Upon assessing the results created by this study, it can be concluded that MET is as effective as the combination of SMT and IC in all subjective and objective measurements. Therefore, MET can be considered as a valid form of treatment therapy in patients suffering from nonspecific neck pain and are contra-indicated or do not wish to receive SMT and IC therapies.

The following was concluded with regards to the hypotheses stated in the beginning of this study:

The null hypothesis, which specified that there would be no difference between the two study groups in terms of subjective and objective measurements, was accepted.

The alternative hypothesis, which specified that MET, will have a statistically significant difference compared to the combination of SMT and IC, in terms of subjective and objective measurements when treating chronic nonspecific neck pain, was rejected.

6.2 LIMITATIONS

During this study, the following limitations were identified:

1. The sample size (n=40) experienced a positive effect in all measurements; however, this is a smaller sample size and therefore may be a limitation.
2. The subjective assessment of the participants was fully dependent on their honesty. This can be a limitation; however, this is difficult to avoid, as the researcher has no control over the participants' honesty.
3. In order for a participant to be used in this study, each participant needed to complete four consultations in a period of two weeks. Participant compliance with this criterion may be a limitation.

6.3 RECOMMENDATIONS

The following recommendations can be made in order to aid future studies:

1. A larger sample size may be used to obtain a greater clinical and statistically significant result. This will help make the result trends more apparent.
2. The addition of a control group. This can include a sham adjustment.

3. The addition of a home stretching program or posture brace in order to decrease continual factors that are outside the clinical setting.
4. Making use of a digital or electrical device that measures objective readings. This will eliminate operator dependencies, as these can alter results and data.
5. Utilising devices that measure chemical and/or neurophysiological changes.
6. The addition of an observation period. This would take place after treatment has been completed to determine if no treatment received over a longer time period will show continual improvement.
7. A larger sample size with greater variations in age, gender and occupation to get a better representation of the South African population. This may create a better clinical picture.
8. A gender specific study, as this removes variables that would influence the study. This is because different genders are affected differently by various treatment methods.

References

Aguilera, F., Martín, D., Masanet, R., Botella, A., Soler, L. and Morell, F. 2009. Immediate Effect of Ultrasound and Ischemic Compression Techniques for the Treatment of Trapezius Latent Myofascial Trigger Points in Healthy Subjects: A Randomized Controlled Study. *Journal of manipulative and physiological therapeutics*, 32 (7): 515-520.

Anstey, R., Kongsted, A., Kamper, S. and Hancock, M. J. 2016. Are People With Whiplash-Associated Neck Pain Different From People With Nonspecific Neck Pain? *The Journal of orthopaedic and sports physical therapy*, 46 (10): 894-901.

Auleciems, L. M. 1995. Myofascial pain syndrome: a multidisciplinary approach. *The Nurse Practitioner*, 20 (4): 18, 21-12, 24-18.

Baldry, P. and Thompson, J. W. 1993. *Acupuncture, trigger points and musculoskeletal pain: a scientific approach to acupuncture for use by doctors and physiotherapists in the diagnosis and management of myofascial trigger point pain*. Churchill Livingstone.

Ballantyne, F., Fryer, G. and McLaughlin, P. 2003. The effect of muscle energy technique on hamstring extensibility: the mechanism of altered flexibility. *Journal of osteopathic medicine*, 6 (2): 59-63.

Basbaum, A. I., Bautista, D. M., Scherrer, G. and Julius, D. 2009. Cellular and molecular mechanisms of pain. *Cell*, 139 (2): 267-284.

Basson, C. A., Olivier, B. and Rushton, A. 2019. Neck pain in South Africa: An overview of the prevalence, assessment and management for the contemporary clinician. *South African Journal of Physiotherapy*, 75 (1): e1-e9.

Beliveau, P. J., Wong, J. J., Sutton, D. A., Simon, N. B., Bussières, A. E., Mior, S. A. and French, S. D. 2017. The chiropractic profession: a scoping review of utilization rates, reasons for seeking care, patient profiles, and care provided. *Chiropractic & manual therapies*, 25 (1): 1-17.

Bennett, R. 1989. Confounding features of the fibromyalgia syndrome: a current perspective of differential diagnosis. *The Journal of rheumatology. Supplement*, 19: 58-61.

Bergmann, T. F. and Peterson, D. H. 2011. *Chiropractic technique: principles and procedures*. 3rd ed. St. Louis, Mo: Elsevier/Mosby.

Bialosky, J. E., Bishop, M. D. and Penza, C. W. 2017. Placebo Mechanisms of Manual Therapy: A Sheep in Wolf's Clothing? *The Journal of orthopaedic and sports physical therapy*, 47 (5): 301-304.

Bicalho, E., Setti, J. A. P., Macagnan, J., Cano, J. L. R. and Manffra, E. F. 2010. Immediate effects of a high-velocity spine manipulation in paraspinal muscles activity of nonspecific chronic low-back pain subjects. *Manual therapy*, 15 (5): 469-475.

Bier, J. D., Scholten-Peeters, W. G. M., Staal, J. B., Pool, J., Tulder, M. W. v., Beekman, E., Meerhoff, G. and Verhagen, A. P. 2018. Clinical Practice Guideline for Physical Therapy Assessment and Treatment in Patients With Nonspecific Neck Pain. *Physical Therapy*, 98 (3): 162-171.

Bogduk, N. 1999. The neck. *Best practice & research Clinical rheumatology*, 13 (2): 261-285.

Borg-Stein, J. and Simons, D. G. 2002. Myofascial pain. *Archives of physical medicine and rehabilitation*, 83: S40-S47.

Brantingham, J. W., Cassa, T. K., Bonnefin, D., Pribicevic, M., Robb, A., Pollard, H., Tong, V. and Korporaal, C. 2013. Manipulative and multimodal therapy for upper extremity and temporomandibular disorders: a systematic review. *Journal of manipulative and physiological therapeutics*, 36 (3): 143-201.

Bron, C. and Dommerholt, J. D. 2012. Etiology of myofascial trigger points. *Current Pain and Headache Reports*, 16 (5): 439-444.

Bronfort, G., Evans, R., Anderson, A. V., Svendsen, K. H., Bracha, Y. and Grimm, R. H. 2012. Spinal manipulation, medication, or home exercise with advice for acute and subacute neck pain: a randomized trial. *Annals of internal medicine*, 156 (1 Pt 1): 1.

Bronfort, G., Evans, R., Nelson, B., Aker, P. D., Goldsmith, C. H. and Vernon, H. 2001. A randomized clinical trial of exercise and spinal manipulation for patients with chronic neck pain. *Spine*, 26 (7): 788-797.

Burns, D. K. and Wells, M. R. 2006. Gross range of motion in the cervical spine: the effects of osteopathic muscle energy technique in asymptomatic subjects. *The Journal of the American Osteopathic Association*, 106 (3): 137-142.

Bussieres, A., Stewart, G., Al Zoubi, F., Decina, P., Descarreaux, M. and Hayden, J. 2016. The treatment of whiplash and neck pain associated disorders: Canadian Chiropractic Guideline Initiative clinical practice guidelines. *J Manip Physiol Ther*, 39 (8): 523-604.

Cagnie, B., Castelein, B., Pollie, F., Steelant, L., Verhoeyen, H. and Cools, A. 2015. Evidence for the Use of Ischemic Compression and Dry Needling in the Management of Trigger Points of the Upper Trapezius in Patients with Neck Pain: A Systematic Review. *American Journal of Physical Medicine & Rehabilitation*, 94 (7): 573-583.

Cagnie, B. P. T. P., Dewitte, V. P. T., Coppieters, I. P. T., Van Oosterwijck, J. P., Cools, A. P. and Danneels, L. P. 2013. Effect of Ischemic Compression on Trigger Points in the Neck and Shoulder

Muscles in Office Workers: A Cohort Study. *Journal of manipulative and physiological therapeutics*, 36 (8): 482-489.

Cantu, R. I. and Grodin, A. J. 2001. *Myofascial manipulation: theory and clinical application*. Aspen Pub.

Cardinale, M., Boccia, G., Greenway, T., Evans, O. and Rainoldi, A. 2015. The acute effects of spinal manipulation on neuromuscular function in asymptomatic individuals: A preliminary study. *Physical Therapy in Sport*, 16 (2): 121-126.

Cassidy, J., Quon, J., LaFrance, L. and Yong-Hing, K. 1992. The effect of manipulation on pain and range of motion in the cervical spine: a pilot study. *Journal of manipulative and physiological therapeutics*, 15 (8): 495-500.

Castell, M. V., van der Pas, S., Otero, A., Siviero, P., Dennison, E., Denkinger, M., Pedersen, N., Sanchez-Martinez, M., Queipo, R., van Schoor, N. M., Zambon, S., Edwards, M., Peter, R., Schaap, L. A. and Deeg, D. J. H. 2015. Osteoarthritis and frailty in elderly individuals across six European countries: results from the European Project on OSteoArthritis (EPOSA). *BMC musculoskeletal disorders*, 16 (357): 359-359.

Cerezo-Téllez, E., Torres-Lacomba, M., Mayoral-del Moral, O., Sánchez-Sánchez, B., Dommerholt, J. and Gutiérrez-Ortega, C. 2016. Prevalence of Myofascial Pain Syndrome in Chronic Non-Specific Neck Pain: A Population-Based Cross-Sectional Descriptive Study. *Pain Medicine*, 17 (12): 2369-2377.

Chaitow, L. and Crenshaw, K. 2006. *Muscle energy techniques*. Elsevier Health Sciences.

Chang, S. 2017. Complex Regional Pain Syndrome is a Manifestation of the Worsened Myofascial Pain Syndrome: Case Review. *Journal of Pain & Relief*, 6

Chesterton, L. S., Sim, J., Wright, C. C. and Foster, N. E. 2007. Interrater reliability of algometry in measuring pressure pain thresholds in healthy humans, using multiple raters. *The Clinical Journal of Pain*, 23 (9): 760-766.

Cleland, J. A., Fritz, J. M., Whitman, J. M. and Palmer, J. A. 2006. The reliability and construct validity of the Neck Disability Index and patient specific functional scale in patients with cervical radiculopathy. *Spine*, 31 (5): 598-602.

Cohen, S. P. and Hooten, W. M. 2017. Advances in the diagnosis and management of neck pain. *Bmj*, 358

Cohen, S. P. M. D. 2015. Epidemiology, Diagnosis, and Treatment of Neck Pain. *Mayo Clinic proceedings*, 90 (2): 284-299.

Craig, R. and Padrón, R. 2004. Molecular structure of the sarcomere. *Myology*, 3: 129-144.

Curl, D. D. 1994. *Chiropractic approach to head pain*. Baltimore, Md: Williams & Wilkins.

Dagenais, S., Mayer, J., Wooley, J. R. and Haldeman, S. 2008. Evidence-informed management of chronic low back pain with medicine-assisted manipulation. *The Spine Journal*, 8 (1): 142-149.

Dearing, J. and Hamilton, F. 2008. An examination of pressure-pain thresholds (PPT's) at myofascial trigger points (MTrP's), following muscle energy technique or ischaemic compression treatment. *Manual therapy*, 13: 87-88.

Dommerholt, J., Mayoral del Moral, O. and Gröbli, C. 2006. Trigger Point Dry Needling. *Journal of Manual & Manipulative Therapy*, 14 (4): 70E-87E.fletche

Eggers, L., Pillay, J. and Govender, N. 2018. Musculoskeletal pain among school teachers: are we underestimating its impact?: original research-peer reviewed. *Occupational Health Southern Africa*, 24 (2): 46-50.

Evans, D. W. and Lucas, N. 2009. What is 'manipulation'? A reappraisal. *Manual therapy*, 15 (3): 286-291.

Fernández-de-las-Peñas, C., Alonso-Blanco, C., Fernández-Carnero, J. and Carlos Miangolarra-Page, J. 2006a. The immediate effect of ischemic compression technique and transverse friction massage on tenderness of active and latent myofascial trigger points: a pilot study. *Journal of Bodywork & Movement Therapies*, 10 (1): 3-9.

Fernández-de-las-Peñas, C., Arendt-Nielsen, L. and Simons, D. G. 2006c. Contributions of myofascial trigger points to chronic tension type headache. *Journal of Manual & Manipulative Therapy*, 14 (4): 222-231.

Fernández-de-las-Peñas, C., Ge, H.-Y., Arendt-Nielsen, L., Cuadrado, M. L. and Pareja, J. A. 2006b. Referred pain from trapezius muscle trigger points shares similar characteristics with chronic tension type headache. *European Journal of Pain*, 11 (4): 475-482.

Fernández-de-las-Peñas, C., Simons, D. G., Cuadrado, M. L. and Pareja, J. A. 2007. The role of myofascial trigger points in musculoskeletal pain syndromes of the head and neck. *Current Pain and Headache Reports*, 11 (5): 365-372.

Fernández-de-las-Peñas, C. s., Cleland, J. and Huijbregts, P. 2011. *Neck and arm pain syndromes: evidence-informed screening, diagnosis, and management*. Philadelphia, Pa.: Elsevier/Churchill Livingstone.

Ferrari, R. and Russell, A. S. 2003. Neck pain. *Best practice & research Clinical rheumatology*, 17 (1): 57-70.

Fischer, A. A. 1986. Pressure Threshold Measurement for Diagnosis of Myofascial Pain and Evaluation of Treatment Results. *The Clinical Journal of Pain*, 2 (4): 207-214.

Fletcher, J. P. and Bandy, W. D. 2007. Unique positioning for using elastic resistance band in providing strengthening exercise to the muscles surrounding the ankle. *North American journal of sports physical therapy: NAJSPT*, 2 (1): 51.

Frankjulle, H., Fryer, G., Ostelo, R. W. and Kamper, S. J. 2015. Muscle energy technique for non-specific low-back pain. *Cochrane Database of Systematic Reviews*, (2)

French, S. D., Densley, K., Charity, M. J. and Gunn, J. 2013. Who uses Australian chiropractic services? *Chiropractic & manual therapies*, 21 (1): 1-8.

Fridén, J. and Lieber, R. L. 1998. Segmental muscle fiber lesions after repetitive eccentric contractions. *Cell and tissue research*, 293 (1): 165-171.

Fryer, G. 2011. Muscle energy approaches. *SD-Neck and Arm Pain Syndromes E-Book: Evidence-informed Screening, Diagnosis and Management*: 439.

Fryer, G. and Hodgson, L. 2005. The effect of manual pressure release on myofascial trigger points in the upper trapezius muscle. *Journal of Bodywork & Movement Therapies*, 9 (4): 248-255.

Fryer, G. and Ruszkowski, W. 2004. The influence of contraction duration in muscle energy technique applied to the atlanto-axial joint. *Journal of osteopathic medicine*, 7 (2): 79-84.

Gatchel, R. J., Neblett, R., Kishino, N. and Ray, C. T. 2016. Fear-avoidance beliefs and chronic pain. *Journal of Orthopaedic & sports Physical therapy*, 46 (2): 38-43.

Gatterman, M. 1990. *Chiropractic management of spine related disorders. Baltimore: Williams and Wilkins. 437p*. ISBN 0-683-03438-3.

Gatterman, M. I. 1991. Standards of practice relative to complications of and contraindications to spinal manipulative therapy. *The Journal of the Canadian Chiropractic Association*, 35 (4): 232-236.

Gatterman, M. I. 2005. *Foundations of chiropractic: subluxation*. Elsevier Health Sciences.

Gautam, M., Benson, C. and Sluka, K. 2010. Increased response of muscle sensory neurons to decreases in pH after muscle inflammation. *Neuroscience*, 170 (3): 893-900.

Gemmell, H., Miller, P. and Nordstrom, H. 2008. Immediate effect of ischaemic compression and trigger point pressure release on neck pain and upper trapezius trigger points: a randomised controlled trial. *Clinical Chiropractic*, 11 (1): 30-36.

Gerwin, R. 2010. Myofascial pain syndrome: here we are, where must we go? *Journal of Musculoskeletal Pain*, 18 (4): 329-347.

Gerwin, R. D. 2001. Classification, epidemiology, and natural history of myofascial pain syndrome. *Current Pain and Headache Reports*, 5 (5): 412-420.

Gerwin, R. D., Dommerholt, J. and Shah, J. P. 2004. An expansion of Simons' integrated hypothesis of trigger point formation. *Current Pain and Headache Reports*, 8 (6): 468-475.

Gibbons, P. and Tehan, P. 2001. Spinal manipulation: indications, risks and benefits. *Journal of Bodywork and Movement therapies*, 5 (2): 110-119.

Giles, L. G. and Muller, R. 2003. Chronic spinal pain: a randomized clinical trial comparing medication, acupuncture, and spinal manipulation. *Spine*, 28 (14): 1490-1502.

Gissel, H. and Clausen, T. 2001. Excitation-induced Ca2+ influx and skeletal muscle cell damage. *Acta Physiologica Scandinavica*, 171 (3): 327-334.

Gonzalez-Freire, M., de Cabo, R., Studenski, S. A. and Ferrucci, L. 2014. The neuromuscular junction: aging at the crossroad between nerves and muscle. *Frontiers in aging neuroscience*, 6: 208.

Gorrell, L., Beath, K. and Engel, R. 2016. Manual and Instrument Applied Cervical Manipulation for Mechanical Neck Pain: A Randomized Controlled Trial. *Journal of manipulative and physiological therapeutics*, 39 (5): 319-329.

Goulet, J. P., Clark, G. T. and Flack, V. F. 1993. Reproducibility of examiner performance for muscle and joint palpation in the temporomandibular system following training and calibration. *Community dentistry and oral epidemiology*, 21 (2): 72-77.

Graham, N., Gross, A. R., Carlesso, L. C., Santaguida, P. L., Macdermid, J. C., Walton, D., Ho, E. and Icon. 2013. An ICON Overview on Physical Modalities for Neck Pain and Associated Disorders. *The open orthopaedics journal*, 7 (1): 440-460.

Greenman, P. E. 2003. *Principles of manual medicine*. Lippincott Williams & Wilkins.

Gross, A. R., Goldsmith, C., Hoving, J. L., Haines, T., Peloso, P., Aker, P., Santaguida, P. and Myers, C. 2007. Conservative management of mechanical neck disorders: a systematic review. *The Journal of rheumatology*, 34 (5): 1083-1102.

Gross, A., Kay, T., Kennedy, C., Gasner, D., Hurley, L., Yardley, K., Hendry, L. and McLaughlin, L. 2002. Clinical practice guideline on the use of manipulation or mobilization in the treatment of adults with mechanical neck disorders. *Manual therapy*, 7 (4): 193-205.

Gross, A., Langevin, P., Burnie, S. J., Bédard-Brochu, M. S., Empey, B., Dugas, E., Faber-Dobrescu, M., Andres, C., Graham, N. and Goldsmith, C. H. 2015. Manipulation and mobilisation for neck pain contrasted against an inactive control or another active treatment. *Cochrane Database of Systematic Reviews*, (9)

Gross, A., Miller, J., D'Sylva, J., Burnie, S. J., Goldsmith, C. H., Graham, N., Haines, T., Brønfort, G. and Hoving, J. L. 2010. Manipulation or mobilisation for neck pain: a Cochrane Review. *Manual therapy*, 15 (4): 315-333.

Gross, A. R., Paquin, J. P., Dupont, G., Blanchette, S., Lalonde, P., Cristie, T., Graham, N., Kay, T. M., Burnie, S. J., Gelley, G., Goldsmith, C. H., Forget, M., Santaguida, P. L., Yee, A. J., Radisic, G. G., Hoving, J. L., Bronfort, G., Group, C. O. and Cervical Overview, G. 2016. Exercises for mechanical neck disorders: A Cochrane Review Update. *Manual therapy*, 24: 25-45.

Guo, X., Colon, A., Akanda, N., Spradling, S., Stancescu, M., Martin, C. and Hickman, J. J. 2017. Tissue engineering the mechanosensory circuit of the stretch reflex arc with human stem cells: sensory neuron innervation of intrafusal muscle fibers. *Biomaterials*, 122: 179-187.

Guo, Z. and Yin, Y. 2012. A dynamic model of skeletal muscle based on collective behavior of myosin motors—Biomechanics of skeletal muscle based on working mechanism of myosin motors (I). *Science China Technological Sciences*, 55 (6): 1589-1595.

Guyton, A. C. and Hall, J. E. 2006. Textbook of medical physiology 11th ed. *Elsiever Saunders*: 788-817.

Hains, G. 2002. Locating and treating low back pain of myofascial origin by ischemic compression. *The Journal of the Canadian Chiropractic Association*, 46 (4): 257.

Haldeman, S. 2005. *Principles and practice of chiropractic*. 3rd ed. New York: McGraw-Hill Medical Publishing Division.

Haldeman, S. and Dagenais, S. 2001. Cervicogenic headaches: a critical review. *The Spine Journal*, 1 (1): 31-46.

Hamilton, L., Boswell, C. and Fryer, G. 2007. The effects of high-velocity, low-amplitude manipulation and muscle energy technique on suboccipital tenderness. *International journal of osteopathic medicine*, 10 (2): 42-49.

Hammer, W. I. 2007. *Functional soft-tissue examination and treatment by manual methods*. Jones & Bartlett Learning.

Han, S. C. and Harrison, P. 1997. Myofascial pain syndrome and trigger-point management. *Regional Anesthesia and Pain Medicine*, 22 (1): 89-101.

Hanten, W. P., Olson, S. L., Butts, N. L. and Nowicki, A. L. 2000. Effectiveness of a Home Program of Ischemic Pressure Followed by Sustained Stretch for Treatment of Myofascial Trigger Points. *Physical Therapy*, 80 (10): 997-1003.

Harper, B., Jagger, K., Aron, A., Steinbeck, L. and Stecco, A. 2016. A Commentary Review of the Cost effectiveness of Manual Therapies for Neck and Low Back Pain. *Journal of Bodywork & Movement Therapies*, 21 (3): 684-691.

Hoftun, G. B., Romundstad, P. R., Zwart, J.-A. and Rygg, M. 2011. Chronic idiopathic pain in adolescence–high prevalence and disability: the young HUNT Study 2008. *PAIN®*, 152 (10): 2259-2266.

Hole, D., Cook, J. and Bolton, J. 1995. Reliability and concurrent validity of two instruments for measuring cervical range of motion: effects of age and gender. *Manual therapy*, 1 (1): 36-42.

Hong, C.-Z. 2006. Treatment of myofascial pain syndrome. *Current Pain and Headache Reports*, 10 (5): 345-349.

Hou, C.-R., Tsai, L.-C., Cheng, K.-F., Chung, K.-C. and Hong, C.-Z. 2002. Immediate effects of various physical therapeutic modalities on cervical myofascial pain and trigger-point sensitivity. *Archives of physical medicine and rehabilitation*, 83 (10): 1406-1414.

Hoy, D., March, L., Brooks, P., Blyth, F., Woolf, A., Bain, C., Williams, G., Smith, E., Vos, T. and Barendregt, J. 2014a. The global burden of low back pain: estimates from the Global Burden of Disease 2010 study. *Annals of the rheumatic diseases*, 73 (6): 968-974.

Hoy, D., March, L., Woolf, A., Blyth, F., Brooks, P., Smith, E., Vos, T., Barendregt, J., Blore, J., Murray, C., Burstein, R. and Buchbinder, R. 2014b. The global burden of neck pain: estimates from the Global Burden of Disease 2010 study. *Annals of the rheumatic diseases*, 73 (7): 1309-1315.

Hoy, D., Protani, M., De, R. and Buchbinder, R. 2010. The epidemiology of neck pain. *Best practice & research Clinical rheumatology*, 24 (6): 783-792.

Hsieh, C.-Y. J., Hong, C.-Z., Adams, A. H., Platt, K. J., Danielson, C. D., Hoehler, F. K. and Tobis, J. S. 2000. Interexaminer reliability of the palpation of trigger points in the trunk and lower limb muscles. *Archives of physical medicine and rehabilitation*, 81 (3): 258-264.

Hurwitz, E. L., Carragee, E. J., van der Velde, G., Carroll, L. J., Nordin, M., Guzman, J., Peloso, P. M., Holm, L. W., Côté, P., Hogg-Johnson, S., Cassidy, J. D. and Haldeman, S. 2008. Treatment of neck pain: noninvasive interventions: results of the Bone and Joint Decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders. *Spine*, 33 (4 Suppl): S123-S175.

Iqbal, A., Khan, S. A. and Miraj, M. 2010. Efficacy of ischaemic compression technique in combination with strain counterstrain technique in managing upper trapezius myofascial trigger point pain. *Indian journal of physiotherapy and occupational therapy*, 4 (2): 10-15.

Itoh, K., Okada, K. and Kawakita, K. 2004. A proposed experimental model of myofascial trigger points in human muscle after slow eccentric exercise. *Acupuncture in medicine*, 22 (1): 2-13.

Jaiswal, N., Saketa, J. and Rajsekhar, H. 2019. Efficacy of muscle energy techniques as an adjunct with Mulligan's mobilization in adhesive capsulitis of the shoulder. *International Journal of Physiotherapy*, 6 (2)

Jami, L. 1992. Golgi tendon organs in mammalian skeletal muscle: functional properties and central actions. *Physiological Reviews*, 72 (3): 623-666.

Jensen, M. P., Turner, J. A. and Romano, J. M. 1994. What is the maximum number of levels needed in pain intensity measurement? *Pain*, 58 (3): 387-392.

Jensen, V., Bøggild, H. and Johansen, J. 1999. Occupational use of precision grip and forceful gripping, and arthrosis of finger joints: a literature review. *Occupational Medicine*, 49 (6): 383-388.

Jull, G., Trott, P., Potter, H., Zito, G., Niere, K., Shirley, D., Emberson, J., Marschner, I. and Richardson, C. 2002. A randomized controlled trial of exercise and manipulative therapy for cervicogenic headache. *Spine*, 27 (17): 1835-1843.

Kannan, P. 2012. Management of myofascial pain of upper trapezius: a three group comparison study. *Global journal of health science*, 4 (5): 46.

Karnath, B. M. 2012. Identifying the musculoskeletal causes of neck pain. *The Journal of musculoskeletal medicine*, 29 (3): 82.

Kim, J. S., Ali, M. H., Wydra, F., Li, X., Hamilton, J. L., An, H. S., Cs-Szabo, G., Andrews, S., Moric, M., Xiao, G., Wang, J. H. C., Chen, D., Cavanaugh, J. M. and Im, H. J. 2015. Characterization of degenerative human facet joints and facet joint capsular tissues. *Osteoarthritis and Cartilage*, 23 (12): 2242-2251.

Kim, R., Wiest, C., Clark, K., Cook, C. and Horn, M. 2018. Identifying risk factors for first-episode neck pain: a systematic review. *Musculoskeletal Science and Practice*, 33: 77-83.

Kohlbeck, F. J. and Haldeman, S. 2002. Medication-assisted spinal manipulation. *The Spine Journal*, 2 (4): 288-302.

Korr, I. M. 1986. Somatic dysfunction, osteopathic manipulative treatment, and the nervous system: a few facts, some theories, many questions. *The Journal of the American Osteopathic Association*, 86 (2): 109-114.

Küçükşen, S. M. D., Yilmaz, H. M. D., Sallı, A. M. D. and Uğurlu, H. M. D. 2013. Muscle Energy Technique Versus Corticosteroid Injection for Management of Chronic Lateral Epicondylitis: Randomized Controlled Trial With 1-Year Follow-up. *Archives of physical medicine and rehabilitation*, 94 (11): 2068-2074.

Kumar, G. Y., Sneha, P. and Sivajyothi, N. 2015. Effectiveness of Muscle energy technique, Ischaemic compression and Strain counterstrain on Upper Trapezius Trigger Points: A comparative study. *International Journal of Physical Education, Sports and Health*, 1 (3): 22-26.

Larsson, B., Björk, J., Henriksson, K.-G., Gerdle, B. and Lindman, R. 2000. The prevalences of cytochrome c oxidase negative and superpositive fibres and ragged-red fibres in the trapezius muscle of female cleaners with and without myalgia and of female healthy controls. *PAIN®*, 84 (2-3): 379-387.

Lauche, R., Cramer, H., Hohmann, C., Choi, K.-E., Rampp, T., Saha, F. J., Musial, F., Langhorst, J. and Dobos, G. 2012. The effect of traditional cupping on pain and mechanical thresholds in patients with chronic nonspecific neck pain: a randomised controlled pilot study. *Evidence-based complementary and alternative medicine : eCAM*, 2012: 429718-429710.

Leach, R. 1994. The Chiropractic Theories, Principles and Clinical Applications, Williams and Wilkins Publishing, 1984. Also see Rockwell J. *Clinical Perspectives on Myofascial Therapy, Applied Physiotherapeutics, Jascouvea and Schafer*: 530-532.

Leach, R. A. 2004. *The chiropractic theories: a textbook of scientific research*. 4th ed. Philadelphia, Pa: Lippincott Williams & Wilkins.

Leaver, A. M., Maher, C. G., McAuley, J. H., Jull, G. A. and Refshauge, K. M. 2013. Characteristics of a new episode of neck pain. *Manual therapy*, 18 (3): 254-257.

Lewit, K. 1999. *Manipulative therapy in rehabilitation of the locomotor system*. Butterworth-Heinemann Medical.

Li, Y., Li, S., Jiang, J. and Yuan, S. 2019. Effects of yoga on patients with chronic nonspecific neck pain: A PRISMA systematic review and meta-analysis. *Medicine (Baltimore)*, 98 (8): e14649.

Liu, H. 2016. Understanding the mechanisms of muscle atrophy. Dissertation/Thesis, ProQuest Dissertations Publishing.

Lluch, E., Nijs, J., De Kooning, M., Van Dyck, D., Vanderstraeten, R., Struyf, F. and Roussel, N. A. 2015. Prevalence, incidence, localization, and pathophysiology of myofascial trigger points in patients with spinal pain: a systematic literature review. *Journal of manipulative and physiological therapeutics*, 38 (8): 587-600.

Maduro de Camargo, V.., Alburquerque-Sendín, F., Bérzin, F. P., Cobos Stefanelli, V., Rodrigues de Souza, D. and Fernández-de-las-Peñas, C. 2011. Immediate Effects on Electromyographic Activity and Pressure Pain Thresholds After a Cervical Manipulation in Mechanical Neck Pain: A Randomized Controlled Trial. *Journal of manipulative and physiological therapeutics*, 34 (4): 211-220.

Maiers, M., Bronfort, G., Evans, R., Hartvigsen, J., Svendsen, K., Bracha, Y., Schulz, C., Schulz, K. and Grimm, R. 2014. Spinal manipulative therapy and exercise for seniors with chronic neck pain. *Spine Journal, The*, 14 (9): 1879-1889.

Maigne, J.-Y. and Vautravers, P. 2003. Mechanism of action of spinal manipulative therapy. *Joint Bone Spine*, 70 (5): 336-341.

Mcnally, E. M., Lapidos, K. A. and Wheeler, M. T. 2006. Skeletal muscle structure and function. In: *Principles of Molecular Medicine*. Springer, 674-681.

Mehendale, V. G., Chaudhari, N. C., Shenoy, S. N. and Mehendale, A. V. 2011. Henna as a durable preoperative skin marker. *World journal of surgery*, 35 (2): 311-315.

Middleditch, A. and Oliver, J. 2005. *Functional anatomy of the spine*. Elsevier Health Sciences.

Miller, J., Gross, A., D'Sylva, J., Burnie, S. J., Goldsmith, C. H., Graham, N., Haines, T., Brønfort, G. and Hoving, J. L. 2010. Manual therapy and exercise for neck pain: a systematic review. *Manual therapy*, 15 (4): 334-354.

Montañez-Aguilera, F. J., Valtueña-Gimeno, N., Pecos-Martín, D., Arnau-Masanet, R., Barrios-Pitarque, C. and Bosch-Morell, F. 2010. Changes in a patient with neck pain after application of ischemic compression as a trigger point therapy. *Journal of back and musculoskeletal rehabilitation*, 23 (2): 101-104.

Moore, K. L., Agur, A. M. R. and Dalley, A. F., II. 2018. *Clinically oriented anatomy*. Eighth, International ed. Philadelphia: Wolters Kluwer.

Morris, C. E. 2006. *Low back syndromes: integrated clinical management*. New York: McGraw-Hill, Medical Publishing Division.

Mtui, E., Gruener, G. and FitzGerald, M. T. 2011. *Clinical Neuroanatomy and Neuroscience E-Book*. Elsevier Health Sciences.

Nagrale, A. V., Glynn, P., Joshi, A. and Ramteke, G. 2010. The efficacy of an integrated neuromuscular inhibition technique on upper trapezius trigger points in subjects with non-specific neck pain: a randomized controlled trial. *Journal of Manual & Manipulative Therapy*, 18 (1): 37-43.

Namvar, H., olyaei, G., Moghadam, B. A. and Hosseinifar, M. 2016. Effect of myofascial release technique on pain, disability, maximum isometric contraction of the extensor muscles, and pressure pain threshold in patients with chronic nonspecific neck pain: Double blinded randomized clinical trial. *International Journal of Medical Research and Health Sciences*, 5 (7S): 500-506.

Nasb, M., Qun, X., Ruckmal Withanage, C., Lingfeng, X. and Hong, C. 2020. Dry cupping, ischemic compression, or their combination for the treatment of trigger points: a pilot randomized trial. *The Journal of Alternative and Complementary Medicine*, 26 (1): 44-50.

Navarro-Santana, M. J., Sanchez-Infante, J., Fernández-de-las-Peñas, C., Cleland, J. A., Martín-Casas, P. and Plaza-Manzano, G. 2020. Effectiveness of Dry Needling for Myofascial Trigger Points Associated with Neck Pain Symptoms: An Updated Systematic Review and Meta-Analysis. *Journal of clinical medicine*, 9 (10): 3300.

Neelapala, Y. R., Raja, R. and Bhandary, A. 2019. A preliminary biopsychosocial analysis of online information on causes of neck pain. *Musculoskeletal care*, 17 (2): 277-281.

Nook, B. and Nook, D. 1997. Demographics of athletes and support personnel who used chiropractic physicians at the 6th all African games. *Journal of Sports Chiropractic & Rehabilitation*, 11 (4): 136-139.

Norkin, C. C. and White, D. J. 2016. *Measurement of joint motion: a guide to goniometry*. FA Davis.

Oliveira-Campelo, N. M., de Melo, C. A., Alburquerque-Sendín, F. and Machado, J. P. 2013. Short- and medium-term effects of manual therapy on cervical active range of motion and pressure pain sensitivity in latent myofascial pain of the upper trapezius muscle: a randomized controlled trial. *Journal of Manipulative & Physiological Therapeutics*, 36 (5): 300-309.

Paanalahti, K., Holm, L. W., Nordin, M., Asker, M., Lyander, J. and Skillgate, E. 2014. Adverse events after manual therapy among patients seeking care for neck and/or back pain: a randomized controlled trial. *BMC musculoskeletal disorders*, 15 (1): 77.

Palmerud, G., Forsman, M., Sporrong, H., Herberts, P. and Kadefors, R. 2000. Intramuscular pressure of the infra-and supraspinatus muscles in relation to hand load and arm posture. *European Journal of Applied Physiology*, 83 (2-3): 223-230.

Park, K. D., Lee, W. Y., Park, M.-H., Ahn, J. K. and Park, Y. 2018. High- versus low-energy extracorporeal shock-wave therapy for myofascial pain syndrome of upper trapezius: A prospective randomized single blinded pilot study. *Medicine*, 97 (28): e11432.

Patel, V. D., Eapen, C., Ceepee, Z. and Kamath, R. 2018. Effect of muscle energy technique with and without strain–counterstrain technique in acute low back pain — A randomized clinical trial. *Hong Kong Physiotherapy Journal*, 38 (1): 41-51.

Perle, S., Schneider, M. and Seaman, D. 1999. Chiropractic management of peripheral neuropathy: pathophysiology, assessment, and treatment. *Topics In Clinical Chiropractic*, 6 (4): 6-19.

Peterson, D. H. and Bergmann, T. F. 2002. *Chiropractic technique: principles and procedures*. Mosby Incorporated.

Phadke, A., Bedekar, N., Shyam, A. and Sancheti, P. 2016. Effect of muscle energy technique and static stretching on pain and functional disability in patients with mechanical neck pain: A randomized controlled trial. *Hong Kong Physiotherapy Journal*, 35: 5-11.

Pickar, J. G. 2002. Neurophysiological effects of spinal manipulation. *The Spine Journal*, 2 (5): 357-371.

Pool, J. J., Ostelo, R. W., Hoving, J. L., Bouter, L. M. and de Vet, H. C. 2007. Minimal clinically important change of the Neck Disability Index and the Numerical Rating Scale for patients with neck pain. *Spine*, 32 (26): 3047-3051.

Poul, J., West, J., Buchanan, N. and Grahame, R. 1993. Local action transcutaneous flurbiprofen in the treatment of soft tissue rheumatism. *Rheumatology*, 32 (11): 1000-1003.

Puentedura, E. J., Landers, M. R., Cleland, J. A., Mintken, P., Huijbregts, P. and Fernandez-De-Las-Peñas, C. 2011. Thoracic spine thrust manipulation versus cervical spine thrust manipulation in patients with acute neck pain: a randomized clinical trial. *Journal of Orthopaedic & sports Physical therapy*, 41 (4): 208-220.

Ranchod, S., Adams, C., Burger, R., Carvounes, A., Dreyer, K., Smith, A., Stewart, J. and van Biljon, C. 2017. South Africa’s hospital sector: old divisions and new developments. *South African Health Review*, 2017 (1): 101-110.

Rasmussen-Barr, E., Grooten, W., Hallqvist, J., Holm, L. and Skillgate, E. 2014. Are job strain and sleep disturbances prognostic factors for neck/shoulder/arm pain? A cohort study of a general population of working age in Sweden. *BMJ open*, 4 (7)

Ravichandran, P., Karthika Ponni, H. and Antony Leo Aseer, P. 2016. Effectiveness of Ischemic Compression on Trapezius Myofascial Trigger Points in Neck Pain. *International Journal of Physiotherapy*, 3 (2)

Ravichandran, P., Ponni, H. K., Aseer, P. and Leo, A. 2016. Effectiveness of Ischaemic Compression on Trapezius Myofascial Trigger Points in Neck Pain. *International Journal of Physiotherapy*, 3 (2): 186-192.

Ribeiro, D. C., Belgrave, A., Naden, A., Fang, H., Matthews, P. and Parshottam, S. 2018. The prevalence of myofascial trigger points in neck and shoulder-related disorders: a systematic review of the literature. *BMC musculoskeletal disorders*, 19 (1): 1-13.

Robertshawe, P. 2007. Niel-Asher S. The Concise Book of Trigger Points. *Journal of the Australian Traditional-Medicine Society*, 13 (2): 114-115.

Rodríguez-Huguet, M., Gil-Salú, J. L., Rodríguez-Huguet, P., Cabrera-Afonso, J. R. and Lomas-Vega, R. 2018. Effects of Myofascial Release on Pressure Pain Thresholds in Patients With Neck Pain: A Single-Blind Randomized Controlled Trial. *American Journal of Physical Medicine & Rehabilitation*, 97 (1): 16-22.

Rotto, D. M., Schultz, H. D., Longhurst, J. C. and Kaufman, M. P. 1990. Sensitization of group III muscle afferents to static contraction by arachidonic acid. *Journal of applied physiology*, 68 (3): 861-867.

Rumsey, J. W., Das, M., Bhalkikar, A., Stancescu, M. and Hickman, J. J. 2010. Tissue engineering the mechanosensory circuit of the stretch reflex arc: sensory neuron innervation of intrafusal muscle fibers. *Biomaterials*, 31 (32): 8218-8227.

Saavedra-Hernández, M., Arroyo-Morales, M., Cantarero-Villanueva, I., Fernández-Lao, C., Castro-Sánchez, A. M., Puentedura, E. J. and Fernández-de-las-Peñas, C. 2013. Short-term effects of spinal thrust joint manipulation in patients with chronic neck pain: a randomized clinical trial. *Clinical Rehabilitation*, 27 (6): 504-512.

Sadria, G., Hosseini, M., Rezasoltani, A., Bagheban, A., Davari, A.. and Seifolahi, A. 2016. A Comparison of the Effect of the Active Release and Muscle Energy Techniques on the Latent Trigger Points of the upper Trapezius. *Journal of Bodywork & Movement Therapies*, 21 (4): 920-925.

Scarabottolo, C. C., Pinto, R., Oliveira, C., Zanuto, E., Cardoso, J. and Christofaro, D. 2017. Back and neck pain prevalence and their association with physical inactivity domains in adolescents. *European Spine Journal*, 26 (9): 2274-2280.

Schafer, R. and Faye, L. 1990. Motion palpation and chiropractic technique: principles of dynamic chiropractic. *Huntington Beach, CA: The Motion Palpation Institute*: 1990332-1990352.

Schleip, R., Findley, T. W., Chaitow, L. and Huijing, P. 2013. *Fascia: the tensional network of the human body-e-book: the science and clinical applications in manual and movement therapy*. Elsevier Health Sciences.

Schneider, M. 1996. Chiropractic management of myofascial and muscular disorders. *Adv Chiropr*, 3: 55-88.

Shah, J. P., Phillips, T. M., Danoff, J. V. and Gerber, L. H. 2005. An in vivo microanalytical technique for measuring the local biochemical milieu of human skeletal muscle. *Journal of applied physiology*, 99 (5): 1977-1984.

Sharan, D. 2014. Myofascial pain syndrome: Diagnosis and management. *Indian Journal of Rheumatology*, 9: S22-S25.

Sieberhagen, C., Rothmann, S. and Pienaar, J. 2009. Employee health and wellness in South Africa: The role of legislation and management standards. *SA Journal of Human Resource Management*, 7 (1): 1-9.

Simmonds, N., Miller, P. and Gemmell, H. 2012. A theoretical framework for the role of fascia in manual therapy. *Journal of Bodywork and Movement therapies*, 16 (1): 83-93.

Simons, D. G., Travell, J. G. and Simons, L. S. 1999. Myofascial pain and dysfunction: the trigger point manual, vol 1. Upper half of body. *Baltimore, MA: Williams & Wilkins*: 11-89.

Ståhl, M. K., El-Metwally, A. A. S. and Rimpelä, A. H. 2014. Time trends in single versus concomitant neck and back pain in finnish adolescents: results from national cross-sectional surveys from 1991 to 2011. *BMC musculoskeletal disorders*, 15 (1): 296.

Starlanyl, D. and Copeland, M. E. 2001. *Fibromyalgia & chronic myofascial pain: a survival manual*. New Harbinger Publications Incorporated.

Suh, H. R., Kim, T. H. and Han, G.-S. 2015. The effects of high-frequency transcutaneous electrical nerve stimulation for dental professionals with work-related musculoskeletal disorders: a single-blind randomized placebo-controlled trial. *Evidence-Based Complementary and Alternative Medicine*, 2015

Suri, P., Miyakoshi, A., Hunter, D. J., Jarvik, J. G., Rainville, J., Guermazi, A., Li, L. and Katz, J. N. 2011. Does lumbar spinal degeneration begin with the anterior structures? A study of the observed epidemiology in a community-based population. *BMC musculoskeletal disorders*, 12 (1): 202.

Thomas, E., Cavallaro, A. R., Mani, D., Bianco, A. and Palma, A. 2019. The efficacy of muscle energy techniques in symptomatic and asymptomatic subjects: a systematic review. *Chiropractic & manual therapies*, 27 (1): 35-18.

Threlkeld, A. J. 1992. The effects of manual therapy on connective tissue. *Physical Therapy*, 72 (12): 893-902.

Tough, E. A., White, A. R., Richards, S. and Campbell, J. 2007. Variability of criteria used to diagnose myofascial trigger point pain syndrome—evidence from a review of the literature. *The Clinical Journal of Pain*, 23 (3): 278-286.

Tousignant, M., Duclos, E., Lafleche, S., Mayer, A., Tousignant-Laflamme, Y., Brosseau, L. and O'sullivan, J. P. 2002. Validity study for the cervical range of motion device used for lateral flexion in patients with neck pain. *Spine*, 27 (8): 812-817.

Triano, J. J. 2001. Biomechanics of spinal manipulative therapy. *The Spine Journal*, 1 (2): 121-130.

Unalan, H. M. D., Majlesi, J. M. D., Aydin, F. Y. M. D. and Palamar, D. M. D. 2011. Comparison of High-Power Pain Threshold Ultrasound Therapy With Local Injection in the Treatment of Active Myofascial Trigger Points of the Upper Trapezius Muscle. *Archives of physical medicine and rehabilitation*, 92 (4): 657-662.

van Schalkwyk, R. and Parkin-Smith, G. F. 2000. A clinical trial investigating the possible effect of the supine cervical rotatory manipulation and the supine lateral break manipulation in the treatment of mechanical neck pain: a pilot study. *Journal of Manipulative & Physiological Therapeutics*, 23 (5): 324-331.

Vase, L., Petersen, G. L., Riley III, J. L. and Price, D. D. 2009. Factors contributing to large analgesic effects in placebo mechanism studies conducted between 2002 and 2007. *PAIN®*, 145 (1-2): 36-44.

Vernon, H. 2010. Historical overview and update on subluxation theories. *Journal of Chiropractic Humanities*, 17 (1): 22-32.

Vernon, H. and Mior, S. 1991. The Neck Disability Index: a study of reliability and validity. *Journal of manipulative and physiological therapeutics*, 14 (7): 409-415.

Vernon, H. and Mrozek, J. 2005. A Revised Definition of Manipulation. *Journal of manipulative and physiological therapeutics*, 28 (1): 68-72.

Vernon, H. and Schneider, M. 2009. Chiropractic management of myofascial trigger points and myofascial pain syndrome: a systematic review of the literature. *Journal of manipulative and physiological therapeutics*, 32 (1): 14-24.

Vincent, H. K., Adams, M. C., Vincent, K. R. and Hurley, R. W. 2013. Musculoskeletal pain, fear avoidance behaviors, and functional decline in obesity: potential interventions to manage pain and maintain function. *Regional Anesthesia & Pain Medicine*, 38 (6): 481-491.

Vos, T., Allen, C., Arora, M., Barber, R. M., Bhutta, Z. A., Brown, A., Carter, A., Casey, D. C., Charlson, F. J. and Chen, A. Z. 2016. Global, regional, and national incidence, prevalence, and years lived with disability for 310 diseases and injuries, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. *The Lancet*, 388 (10053): 1545-1602.

Vos, T., Flaxman, A. D., Naghavi, M., Lozano, R., Michaud, C., Ezzati, M., Shibuya, K., Salomon, J. A., Abdalla, S. and Aboyans, V. 2012. Years lived with disability (YLDs) for 1160 sequelae of 289 diseases and injuries 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. *The Lancet*, 380 (9859): 2163-2196.

Walton, D. M., Carroll, L. J., Kasch, H., Sterling, M., Verhagen, A. P., MacDermid, J. C., Gross, A., Santaguida, P. L. and Carlesso, L. 2013. Suppl 4: An Overview of Systematic Reviews on Prognostic Factors in Neck Pain: Results from the International Collaboration on Neck Pain (ICON) Project. *The open orthopaedics journal*, 7: 494.

Wang, G., Gao, Q., Hou, J. and Li, J. 2014. Effects of temperature on chronic trapezius myofascial pain syndrome during dry needling therapy. *Evidence-Based Complementary and Alternative Medicine*, 2014

Waterhouse, J. 2008. Muscle types. *Anaesthesia & Intensive Care Medicine*, 9 (6): 264-269.

Whittingham, W. and Nilsson, N. 2001. Active range of motion in the cervical spine increases after spinal manipulation (toggle recoil). *Journal of manipulative and physiological therapeutics*, 24 (9): 552-555.

Widmaier, E. P., Raff, H. and Strang, K. T. 2015. Vander's Human Physiology. *The Mechanisms of Body Function*,

Wilson, M. H. and Deschenes, M. R. 2005. The neuromuscular junction: anatomical features and adaptations to various forms of increased, or decreased neuromuscular activity. *International journal of neuroscience*, 115 (6): 803-828.

Windsor, R., Malanga, G., Benjamin, M. and Chawla, J. 2011. Cervical spine anatomy. *American Academy of Pain Medicine*, 9 (2): 1.

Yang, J.-l., Chang, C.-w., Chen, S.-y., Wang, S.-F. and Lin, J.-j. 2007. Mobilization techniques in subjects with frozen shoulder syndrome: randomized multiple-treatment trial. *Physical Therapy*, 87 (10): 1307-1315.

Yap, E. C. 2007. Myofascial pain - An overview. *ANNALS ACADEMY OF MEDICINE SINGAPORE*, 36 (1): 43-48.

Yeganeh Lari, A., Okhovatian, F., Naimi, S. s. and Baghban, A. A. 2015. The effect of the combination of dry needling and MET on latent trigger point upper trapezius in females. *Manual therapy*, 21: 204-209.

Yesil, H., Hepguler, S., Dundar, U., Taravati, S. and Isleten, B. 2018. Does the Use of Electrotherapies Increase the Effectiveness of Neck Stabilization Exercises for Improving Pain, Disability, Mood, and Quality of life in Chronic Neck Pain? A Randomized, Controlled, Single Blind Study. *Spine*, 43 (20): E1174-E1183.

Zadeh, D. K. 2007. *Apparatus, systems, and methods for continuous pressure technique therapy*: Google Patents.

Zatsiorsky, V. M. and Prilutsky, B. I. 2012. *Biomechanics of skeletal muscles*. Human Kinetics.

Zhang, Y. and Jordan, J. M. 2008. Epidemiology of osteoarthritis. *Rheumatic Disease Clinics of North America*, 34 (3): 515-529.

Ziaeifar, M., Arab, A. M., Karimi, N. and Nourbakhsh, M. R. 2014. The effect of dry needling on pain, pressure pain threshold and disability in patients with a myofascial trigger point in the upper trapezius muscle. *Journal of Bodywork and Movement therapies*, 18 (2): 298-305.

Zungu, L. 2009. Self-reported musculoskeletal disorders among office workers in a private hospital in South Africa: Prevalence and relation to physicla demands of the work.

APPENDICES

Appendix A

DUT DURBAN UNIVERSITY OF TECHNOLOGY

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

16 September 2019

Mr T D Dicks
P.O. Box 15725
Beacon Bay
5201

Dear Mr Dicks

The effect of spinal manipulative therapy and ischaemic compression versus muscle energy technique in chronic nonspecific neck pain
Ethical Clearance number: IREC 079/19

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

Professor J K Adam
Chairperson: IREC

DUT
2019 -09- 16
INSTITUTIONAL RESEARCH ETHICS COMMITTEE

Appendix B

19 June 2019

To Whom It May Concern:

RE: The effect of spinal manipulative therapy and ischaemic compression versus muscle energy technique in chronic nonspecific neck pain.

As project manager for the Pan African Clinical Trial Registry (www.pactr.org) database, it is my pleasure to inform you that your application to our registry has been accepted. Your unique identification number for the registry is **PACTR201906639063537**.

Please be advised that you are responsible for updating your trial, or for informing us of changes to your trial.

Additionally, please provide us with copies of your ethical clearance letters as we must have these on file (via email or post or by uploading online) at your earliest convenience if you have not already done so.

Please do not hesitate to contact us at +27 21 938 0835 or email epienaar@mrc.ac.za should you have any questions.

Yours faithfully,

Elizabeth D Pienaar
www.pactr.org Project Manager
+27 021 938 0835

PACTR
PAN AFRICAN CLINICAL TRIALS REGISTRY

The South African Medical Research Council
Cochrane South Africa | PO Box 19070, Tygerberg, 7505
Tel: +27 (0)21 938 0438 | Email: cochrane@mrc.co.za | Web: www.southafrica.cochrane.org

Appendix C

MEMORANDUM

To : Prof Adam
Chair: IREC

From : Dr Laura O'Connor
Head of Department: Chiropractic

Dr Desiree Varatharajullu
Clinic Director: Chiropractic Day Clinic: Chiropractic

Date : 15.07.2019

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

---

Permission is hereby granted to:

Mr Tyron Dale Dicks (Student Number: 21329221)

Research title: "The effect of spinal manipulative therapy and ischaemic compression versus muscle energy technique in chronic nonspecific neck pain".

Mr Dicks, is requested to submit a copy of his FRC / IREC approved proposal along with proof of his M.Tech:Chiropractic registration to the Clinic Administrators before he starts with his research in order that any special procedures with regards to his research can be implemented prior to the commencement of his seeing patients.

Thank you for your time.

Kind regards

Dr L O'Connor
Head of Department:
Chiropractic

Dr Desiree Varatharajullu Clinic
Director: Chiropractic Day Clinic:
Chiropractic

Cc: Mrs Linda Twiggs: Chiropractic Day Clinic
Dr D Varatharajullu: Supervisor
Dr A Abdul-Rasheed: Co-supervisor

Appendix D

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

09th September 2019

Mr Tyron Dale Dicks
c/o Department of Chiropractic
Faculty of Health Sciences
Durban University of Technology

Dear Mr Dicks

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 full permission for you to conduct your research "The effect of spinal manipulative therapy and ischaemic compression versus muscle energy technique in chronic nonspecific neck pain" at the Durban University of Technology.

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 can be submitted to the IRIC on completion of your studies.

Kindest regards.
Yours sincerely

PROF KEVIN DUFFY
ACTING DIRECTOR: RESEARCH AND POSTGRADUATE SUPPORT DIRECORATE

Appendix E

DO YOU SUFFER FROM NECK AND SHOULDER PAIN?

ARE YOU BETWEEN THE AGES OF 20 AND 50?

Research is currently being conducted at the Durban University of Technology Chiropractic Day Clinic

<u>TREATMENT MAY BE PROVIDED</u>

To those who qualify to take part in this study

Contact Tyron Dicks on 076 636 8684

Or the Chiropractic Day Clinic on 031 373 2205

To see if you qualify for this study.

Appendix F

Request for Permission to Place Advertisements

Dear Sir/Madam

My name is Tyron Dicks, a chiropractic student at the Durban University of Technology. The research I wish to conduct for my Masters dissertation involves the effect of spinal manipulative therapy and ischaemic compression versus muscle energy technique in chronic nonspecific neck pain. I am hereby seeking your consent to place an advertisement, which is attached, on your premises to recruit participants for my research.
I have provided you with a copy of my proposal which includes copies of the data collection tools and consent and/ or assent forms to be used in the research process, as well as a copy of the approval letter which I received from the Institutional Research Ethics Committee (IREC).

If you require any further information, please do not hesitate to contact me:
Cell – 0763638684
Email –dickstyron@gmail.com
Thank you for your time and consideration in this matter.

Yours sincerely,

Tyron Dicks
Durban University of Technology

Appendix G

Telephonic Screen

Title: The effect of spinal manipulative therapy and ischaemic compression versus muscle energy technique in chronic nonspecific neck pain.

Name of prospective participant ……………………………………………………..

Date ………………………………. **Time** …………………………………

Questions to be asked	Anticipated Answers	Participant's Answers
"Would you mind answering a few questions to gauge your eligibility to participate in the study?"	Yes	
"How old are you?"	20-50	
"For how long have you had the pain?"	≥ 12 weeks	
"Where is the pain?"	Lower neck region	
"Do you have a recent history of trauma?"	No	
"Are you currently taking any anti-inflammatory medication?"	No	
"Are you currently taking any blood thinning medication?"	No	

Researcher Signature ………………………………….

Witness Signature ……………………………………..

Appendix H

LETTER OF INFORMATION

Title of the Research Study: The effect of spinal manipulative therapy and ischaemic compression versus muscle energy technique in chronic nonspecific neck pain.

Principle Investigator: Tyron Dicks [B.Tech Chiropractic]

Supervisor: Dr. D. Varatharajullu [M.Tech Chiropractic]

Co-supervisor: Dr. A. Abdul – Rasheed [M.Tech Chiropractic]

Brief Introduction and Purpose of the Study:
This research study aims to investigate the effect of spinal manipulative therapy and ischaemic compression versus muscle energy technique in nonspecific neck pain. 40 participants will be required to complete the study.

Outline of the Procedures:
At the first consultation at the Chiropractic Day Clinic you will read this information sheet and ask the researcher any questions about the research. Once you have decided to take part in the study, you will have to sign an informed consent form. During the hour long appointment a case history, physical examination and cervical spine regional examination will be done by the researcher. You will then be allocated into one of the two manual therapy groups. No medication or other forms of treatment should be taken 24 hours before the first appointment and the duration of the study.

Both groups will have their algometer and CROM device readings gathered by the researcher prior to receiving their treatment intervention and solely done on the third consultation. One group will receive manipulation and ischaemic compression while the other group will receive muscle energy technique.

Group one and two participants will receive two treatments and a follow-up consultation over a maximum of two weeks. Algometry and CROM measurements will only be taken by the researcher. The first consultation will include baseline readings taken before the initial treatment. A second set of readings will be taken before the second treatment. At the third consultation, a final set of readings will be taken for subjective and objective clinical findings and no treatment will be administered. You will be treated twice in a one-week period with the third and final consultation taking place the following week.

Participants may experience brief discomfort and some post treatment soreness associated with spinal manipulation, ischaemic compression and muscle energy technique. You can ask to stop the treatment and withdraw from the research at any point.

Benefits:

This study will determine which form of treatment is more superior, manipulation and ischaemic compression versus muscle energy technique, in the treatment of chronic nonspecific neck pain.

Reasons why the Subject May withdraw from the study:

Should you wish to withdraw from the study you are able to do so at any point. Additionally you may be taken off the study if the instructions are not followed, become ill or experience adverse reactions to the treatment.

Remuneration:

You will not be receiving any form of remuneration for taking part in this study.

Costs of the Study:

You will not have to pay any money for the initial treatment of this study.

Confidentiality:

All your medical information will be kept confidential and stored in the Chiropractic Day Clinic for five years, after which will be shredded. The results of this study will be made available at the Durban University of Technology library, while keeping the patients' details anonyms.

Research-related Injury:

No compensation will be given should an injury occur.

Persons to Contact in the Event of Any Problems or Queries:

Supervisor: Dr. D. Varatharajullu **Contact number:** 031 373 2533

Co-supervisor: Dr. A. Abdul - Rasheed **Contact number:** 031 373 2102

Please contact the researcher (076 636 8684), my supervisor (031 373 2533/2102) or the Institutional Research Ethics Administrator on 031 373 2375. Complaints can be reported to the DVC: Research, Innovation and Engagement Prof S Moyo on 031 373 2577 or moyos@dut.ac.za

Appendix I

CONSENT

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 J

DUT DURBAN UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF CHIROPRACTIC AND SOMATOLOGY

CHIROPRACTIC PROGRAMME

CHIROPRACTIC DAY CLINIC
CASE HISTORY

Patient: ______________________________________ Date: __________

File #: __________ Age: __________

Sex: __________ 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:

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 K

DUT DURBAN UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF CHIROPRACTIC AND SOMATOLOGY

CHIROPRACTIC PROGRAMME

PHYSICAL EXAMINATION: SENIOR

Patient Name: ______________________ **File no:** __________ **Date:** __________

Student: **Signature:**

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

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

SYSTEM SPECIFIC EXAMINATION:

CARDIOVASCULAR EXAMINATION

RESPIRATORY EXAMINATION

ABDOMINAL EXAMINATION

NEUROLOGICAL EXAMINATION

COMMENTS

Clinician: **Signature:**

Appendix L

CHIROPRACTIC PROGRAMME

Appendix L

REGIONAL EXAMINATION – CERVICAL SPI

Patient: ______________________ File No: ____________

Date: ____________ Student: ______________________

Clinician: ______________________ Sign: ______________________

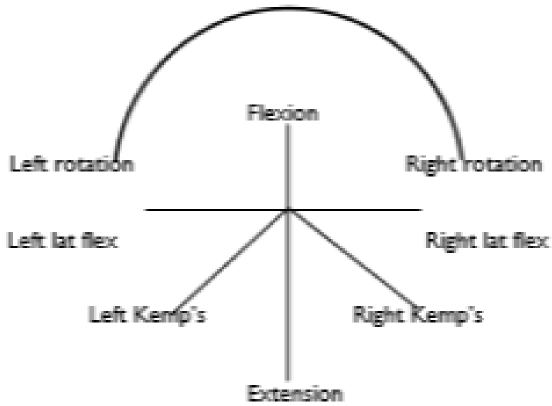
OBSERVATION:

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:

Dermatomes	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:

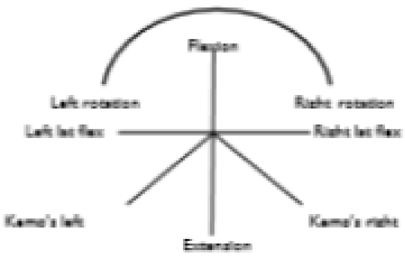
Case History:

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

BASIC EXAM: THORACIC SPINE:

Case History:

ROM:



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

Appendix M

Statement of Agreement to Participate in the Research Study as a Research Assistant:

I ………………........................., ID number………………………………………………… voluntarily agree to participate in this study: **"The effect of spinal manipulative therapy and ischaemic compression versus muscle energy technique in chronic nonspecific neck pain"** as a research assistant**.**

I will ensure that I maintain a level of confidentiality with regards to the research data that is collected.

Research assistant's name (print) ………………………………………………………………….

Research assistant's signature: ………………………………….

Date: ………………………………….

Researcher's name (print)…………………………………………….

Signature: ………………………………………

Date: ………………………………….

Witness name (print)……………………………………………………. Signature……………………………………

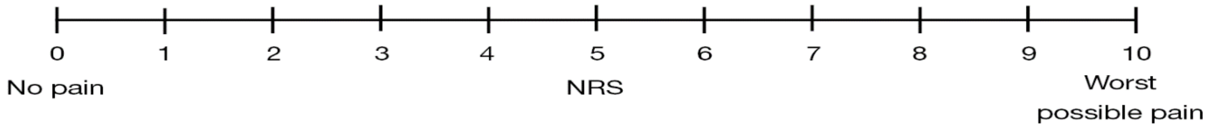
Date: ………………………………….

Appendix N

Numerical Rating Scale

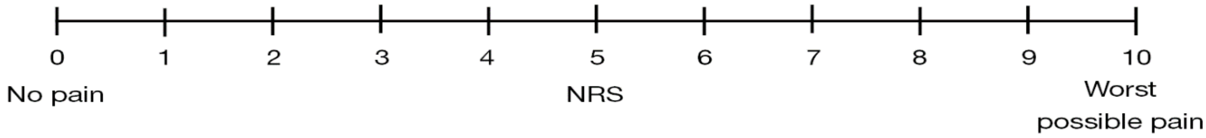
Date: File: Visit no:

Indicate on the line below a number between 0 and 10 that most appropriately describes the pain experience when it is at its worst. Zero (0) would mean “no pain at all” and ten (10) would mean “the worst possible pain”. Please circle only one number.



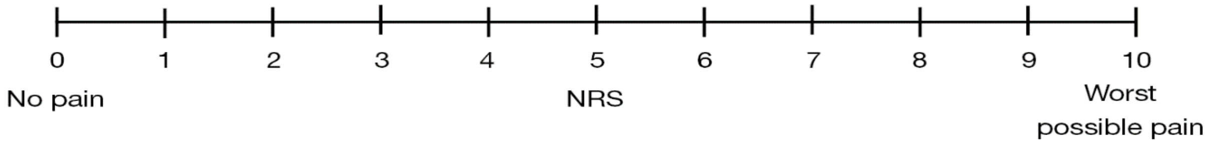
Date: File: Visit no:

Indicate on the line below a number between 0 and 10 that most appropriately describes the pain experience when it is at its worst. Zero (0) would mean “no pain at all” and ten (10) would mean “the worst possible pain”. Please circle only one number.



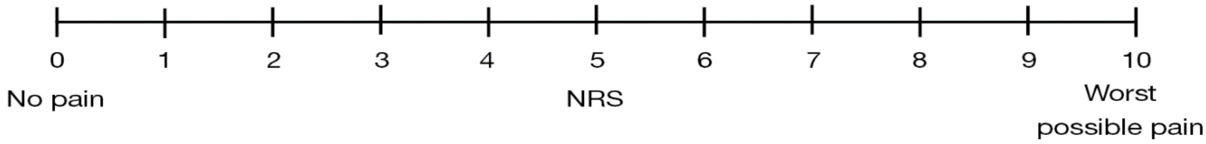
Date: File: Visit no:

Indicate on the line below a number between 0 and 10 that most appropriately describes the pain experience when it is at its worst. Zero (0) would mean “no pain at all” and ten (10) would mean “the worst possible pain”. Please circle only one number.



Date: File: Visit no:

Indicate on the line below a number between 0 and 10 that most appropriately describes the pain experience when it is at its worst. Zero (0) would mean “no pain at all” and ten (10) would mean “the worst possible pain”. Please circle only one number.



Appendix O

Neck Disability Index

THIS QUESTIONNAIRE IS DESIGNED TO HELP US BETTER UNDERSTAND HOW YOUR **NECK PAIN** AFFECTS YOUR ABILITY TO MANAGE EVERYDAY -LIFE ACTIVITIES. PLEASE MARK IN EACH SECTION THE **ONE BOX** THAT APPLIES TO YOU.

ALTHOUGH YOU MAY CONSIDER THAT TWO OF THE STATEMENTS IN ANY ONE SECTION RELATE TO YOU, PLEASE MARK THE BOX THAT **MOST CLOSELY** DESCRIBES YOUR PRESENT -DAY SITUATION.

SECTION 1 - PAIN INTENSITY

- ❑ I have no neck pain at the moment.
- ❑ The pain is very mild at the moment.
- ❑ The pain is moderate at the moment.
- ❑ The pain is fairly severe at the moment.
- ❑ The pain is very severe at the moment.
- ❑ The pain is the worst imaginable at the moment.

SECTION 2 - PERSONAL CARE

- ❑ I can look after myself normally without causing extra neck pain.
- ❑ I can look after myself normally, but it causes extra neck pain.
- ❑ It is painful to look after myself, and I am slow and careful.
- ❑ I need some help but manage most of my personal care.
- ❑ I need help every day in most aspects of self -care.
- ❑ I do not get dressed. I wash with difficulty and stay in bed.

SECTION 3 – LIFTING

- ❑ I can lift heavy weights without causing extra neck pain.
- ❑ I can lift heavy weights, but it gives me extra neck pain.
- ❑ Neck pain prevents me from lifting heavy weights off the floor but I can manage if items are conveniently positioned, ie. on a table.
- ❑ Neck pain prevents me from lifting heavy weights, but I can manage light weights if they are conveniently positioned.
- ❑ I can lift only very light weights.
- ❑ I cannot lift or carry anything at all.

SECTION 4 – READING

- ❑ I can read as much as I want with no neck pain.
- ❑ I can read as much as I want with slight neck pain.
- ❑ I can read as much as I want with moderate neck pain.
- ❑ I can't read as much as I want because of moderate neck pain.
- ❑ I can't read as much as I want because of severe neck pain.
- ❑ I can't read at all.

SECTION 5 – HEADACHES

- ❑ I have no headaches at all.
- ❑ I have slight headaches that come infrequently.
- ❑ I have moderate headaches that come infrequently.
- ❑ I have moderate headaches that come frequently.
- ❑ I have severe headaches that come frequently.
- ❑ I have headaches almost all the time.

SECTION 6 – CONCENTRATION

- ❑ I can concentrate fully without difficulty.
- ❑ I can concentrate fully with slight difficulty.
- ❑ I have a fair degree of difficulty concentrating.
- ❑ I have a lot of difficulty concentrating.
- ❑ I have a great deal of difficulty concentrating.
- ❑ I can't concentrate at all.

SECTION 7 – WORK

- ❑ I can do as much work as I want.
- ❑ I can only do my usual work, but no more.
- ❑ I can do most of my usual work, but no more.
- ❑ I can't do my usual work.
- ❑ I can hardly do any work at all.
- ❑ I can't do any work at all.

SECTION 8 – DRIVING

- ❑ I can drive my car without neck pain.
- ❑ I can drive my car with only slight neck pain.
- ❑ I can drive as long as I want with moderate neck pain.
- ❑ I can't drive as long as I want because of moderate neck pain.
- ❑ I can hardly drive at all because of severe neck pain.
- ❑ I can't drive my car at all because of neck pain.

SECTION 9 – SLEEPING

- ❑ I have no trouble sleeping.
- ❑ My sleep is slightly disturbed for less than 1 hour.
- ❑ My sleep is mildly disturbed for up to 1-2 hours.
- ❑ My sleep is moderately disturbed for up to 2-3 hours.
- ❑ My sleep is greatly disturbed for up to 3-5 hours.
- ❑ My sleep is completely disturbed for up to 5-7 hours.

SECTION 10 – RECREATION

- ❑ I am able to engage in all my recreational activities with no neck pain at all.
- ❑ I am able to engage in all my recreational activities with some neck pain.
- ❑ I am able to engage in most, but not all of my recreational activities because of pain in my neck.
- ❑ I am able to engage in only a few of my recreational activities because of neck pain.
- ❑ I can hardly do recreational activities due to neck pain.
- ❑ I can't do any recreational activities due to neck pain.

PATIENT NAME ____ DATE ______________

SCORE _________ [50]

Appendix P

SPECIAL TERMS

These User License Agreement Special Terms ("Special Terms") are issued between Mapi Research Trust ("MRT") and Tyron Dicks ("User").

These Special Terms are in addition to any and all previous Special Terms under the User License Agreement General Terms.

These Special Terms include the terms and conditions of the User License Agreement General Terms, which are hereby incorporated by this reference as though the same was set forth in its entirety and shall be effective as of the Special Terms Effective Date set forth herein.

All capitalized terms which are not defined herein shall have the same meanings as set forth in the User License Agreement General Terms.

These Special Terms, including all attachments and the User License Agreement General Terms contain the entire understanding of the Parties with respect to the subject matter herein and supersedes all previous agreements and undertakings with respect thereto. If the terms and conditions of these Special Terms or any attachment conflict with the terms and conditions of the User License Agreement General Terms, the terms and conditions of the User License Agreement General Terms will control, unless these Special Terms specifically acknowledge the conflict and expressly states that the conflicting term or provision found in these Special Terms control for these Special Terms only. These Special Terms may be modified only by written agreement signed by the Parties.

1. **User information**

User name	Tyron Dicks
Category of User	Student
User address	8 Madura Grove House Durban 4001 Berea South Africa
User VAT number	
User email	dickstyron@gmail.com
User phone	0766368684
Billing Address	8 Madura Grove House Durban 4001 Berea South Africa

2. **General information**

Effective Date	Date of acceptance of these Special Terms by the User
Expiration Date ("Term")	Upon completion of the Stated Purpose
Name of User's contact in charge of the request	Tyron Dicks

3. **Identification of the COA**

Name of the COA	NDI - Neck Disability Index
Author	Vernon H Mior S
Copyright Holder	
Copyright notice	NDI © Dr Howard Vernon, 1991. All Rights Reserved
Bibliographic reference	Vernon H, Mior S. The Neck Disability Index: a study of reliability and validity. J Manipulative Physiol Ther. 1991 Sep;14(7):409-15. Erratum in: J Manipulative Physiol Ther 1992 Jan;15(1) (PubMed abstract)
Modules/versions needed	NDI

4. **Context of use of the COA**

The User undertakes to use the COA solely in the context of the Stated Purpose as defined hereafter.

4.1 Stated Purpose

Clinical research

Title	The effect of spinal manipulative therapy and ischaemic compression versus muscle energy technique in chronic nonspecific neck pain.
Study/protocol reference	
Sponsor	
Disease or condition	Chronic nonspecific neck pain
Type of research	Other: Clinical trial
COA used as primary end point	Yes
Number of screened patients	40
Number of submissions of the COA for each patient	4
Planned Term*	Start: 08/2019; End: 03/2020
Mode of Administration*	Paper

If electronic administration, please indicate mode of data collection	
Use of IT Company (e-vendor)	No

4.2 Country and languages

MRT grants the License to use the COA on the following countries and in the languages indicated in the table below:

Version/Module	Language	For use in the following country
NDI	English	Canada

The User understands that the countries indicated above are provided for information purposes. The User may use the COA in other countries than the ones indicated above.

5. **Specific requirements for the COA**

- The Copyright Holder of the COA has granted ICON LS exclusive rights to translate the COA in the context of commercial studies or any project funded by for-profit entities. ICON LS is the only organization authorized to perform linguistic validation/translation work on the COA.

- In case the User wants to use an e-Version of the COA, the User shall send the Screenshots of the original version of the COA to MRT or ICON LS for approval

- In case the User wants to use an e-Version of the COA, the User shall send the Screenshots of the translations of the COA to ICON LS for approval.

Appendix Q

Algometer and CROM Devise Readings

Participant’s name:

Participant’s code:

File number:

Visit	Date	Trigger point(s) affected	Algometer Reading	Final CROM Device Reading	
				Left	Right
1st					
2nd					
3rd					
4th					

CROM Devise Measurements for Lateral Range of Motion

CROM Measurements in Degrees

Visit	Date	Left Lateral Flexion Readings			Right Lateral Flexion Readings		
		1st	2nd	3rd	1st	2nd	3rd
1st							
2nd							
3rd							
4th							

Appendix R

DUT DURBAN UNIVERSITY OF TECHNOLOGY | DEPARTMENT OF CHIROPRACTIC AND SOMATOLOGY

CHIROPRACTIC PROGRAMME

Patient Name: File number: Page:

Date: Visit: Student:

Attending Clinician: Signature:

S: Numerical Pain Rating Scale (Patient) Student Rating A:

Least 0 1 2 3 4 5 6 7 8 9 10 Worst

0: P:

E:

Special attention to: Next appointment:

Date: Visit: Student:

Attending Clinician: Signature:

S: Numerical Pain Rating Scale (Patient) Student Rating A:

Least 0 1 2 3 4 5 6 7 8 9 10 Worst

O: P:

E:

Special attention to: Next appointment:

Date: Visit: Student:

Attending Clinician: Signature

S: Numerical Pain Rating Scale (Patient) Student Rating A:

Least 0 1 2 3 4 5 6 7 8 9 10 Worst

O: P:

E:

Special attention to: Next appointment: