A randomized clinical trial comparing the effects of two different durations of Muscle Energy Technique on neck pain, trigger points, range of motion and neck disability index.

BY

KERISHA NAIDOO

Dissertation submitted in partial compliance with the requirements for the

Master's Degree in Technology: Chiropractic

Durban University of Technology

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

[redacted] 28/05/2014

Kerisha Naidoo Date

Approved for Final Submission

[redacted] 28/5/2014

Dr Charmaine Korporaal, Date
M.Tech: Chiropractic, CCFC, CCSP, ICSSD

DEDICATION

My humble obeisance to you Mother Saraswathi, the Goddess of knowledge and to you Lord Ganesha, the remover of obstacles. Thank you for your guidance. I offer my prostrations.

To my dear father, it has been seventeen years since your passing and although you may not have been around to witness this achievement, I want you to know that it was those life lessons you instilled in me as a little girl that led me to where I am right now. I know that you are smiling down on me from heaven. I miss you daddy. I love you with all my heart.

To my loving mum, thank you for your guidance, love and support through this journey. The sacrifices you have made for me, never go unnoticed. I am eternally grateful. Having a mum like you is an absolute blessing. I love you.

To my darling older sisters Ansuya, Retashia and Urisha, you girls have been an absolute inspiration to me. Following in the footsteps of my three older sisters has led me to become an independent young lady. Thank you for the sacrifices you all have endeavoured to make this achievement possible for me. My precious baby sister Darashana, I just want you to know how dear you are to me. You have played a major role in the completion of this study and I just want to thank you from the bottom of my heart. Thank you all for the love, support and many hours of giggles. Each and every one of you is so dear to me and I will love you forever.

To my precious angel Nushen, words cannot express how eternally grateful I am to you. You held my hand throughout this process and never lost faith in me. Thank you for your daily positivity and words of encouragement. I could have never done this without your love and support. I love you.

ACKNOWLEDGEMENTS

My brothers-in-law Amar, Kuvashen and Raegan, thank you all for being the older brothers I never had. You have all come to my rescue on numerous occasions. Amar you are my computer superhero! Thank you for the words of encouragement.

Dr Charmaine Korporaal, thank you so much for being my supervisor and thank you for your help and guidance through the research process. I really appreciate and value your hard work.

Mr and Mrs Naidoo, thank you for your kindness and words of encouragement.

Uncle sunny, thank you for being there for us at all times.

To Tonya Esterhuizen, thank you for your help with the statistical analysis.

Bronwyn Jones, thank you for proof reading my thesis and thank you for the words of encouragement.

Avenal Jane Finlayson, thank you for your help with tracking down articles.

Linda, Pat, Wendy and Kershnee, your hard work never go unnoticed. Thank you!

To my lecturers, thank you for your guidance and words of encouragement.

To my amazing friends and classmates, Wow! What an amazing Journey it’s been. Thank you for all the laughs and all the fun times. I wish each and every one of you a bright and successful future.

To all the participants, thank you from the bottom of my heart. This would have never been possible without each and every one of you. Thank you!

ABSTRACT

BACKGROUND

Mechanical neck pain (MNP) has been described as any condition which changes joint mechanics and muscle structure / function. A review of the current literature shows that Muscle Energy Technique (MET) is an effective manual therapy for patients with acute or chronic MNP. The most useful contraction of MET however remains unknown. Some authors advocate the use of a two to seven second MET (Brous, 2005; Greenman, 2003 Mitchell, Moran, and Pruzzo, 1979) whilst other authors have recommended contraction durations of 30 to 60 seconds (Chaitow, 2006; Feland *et al.*, 2001; Bandy and Irion, 1994). This study aimed to establish the most suitable contraction duration of MET in the treatment of chronic MNP by comparing a short duration MET to a long duration MET.

OBJECTIVES

Objectives included the comparison of a five-second (short duration) MET and a 45-second (long duration) MET in terms of subjective and objective findings in the treatment of chronic MNP.

METHOD

This randomized clinical trial, with 53 participants utilised a randomization table for group allocation. For the purpose of this study an average of the short contraction durations reported in the literature i.e. five seconds, was used for the short duration MET treatment and an average of the long contraction durations reported in the literature i.e. 45 seconds, was used for the long duration MET. Group A (n=26) received the five-second MET contraction and Group B (n=27) received the 45-second MET contraction treatment. Objective measures included the cervical range of motion (CROM Goniometer) and tenderness levels (algometer). The subjective measures were pain (Numerical Rating Scale-101) and MNP related disability (CMCC Neck Disability Index). Each participant received four treatments over a two week period, with all data collected prior to the first and third consultations and at the final follow up. Data were analysed using the SPSS version 20 (IBM), with a statistically significant p value set at <0.05. Repeated measures ANOVA testing determined the intergroup effects. To assess intergroup effects and effects of the intervention a time x treatment group interaction analysis was conducted. Profile plots assessed direction and trend of the effect of the treatment.

RESULTS

Intra-group analysis of both groups showed significant improvement in all of the range of motion measures (over time) except for Flexion, Right Lateral Flexion and Left Rotation in Group A and Flexion, Extension, Right Lateral Flexion and Left Lateral Flexion in Group B. The intra-group analysis also showed a significant improvement in the neck disability index scores and the tenderness measurements in both groups. The results of the inter-group analysis revealed that only Left Lateral Flexion showed a significant treatment effect (p=0.011) where increased scores were shown in Group

A and not in Group B. There was no treatment effect for the neck disability index scores or the tenderness measurements.

CONCLUSION

It may be concluded that both treatment protocols were equally effective for all outcomes except for Left Lateral Flexion where the five-second MET seemed to show greater degree of improvement than the 45-second MET. The neck disability index scores and the pain levels of participants in both groups showed an improvement. No treatment was better than the other in terms of these two variables. This therefore seems to support the use of the shorter duration MET in clinical practice.

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF TABLES

CHAPTER TWO

CHAPTER THREE

CHAPTER FOUR

CHAPTER FIVE

LIST OF FIGURES

CHAPTER TWO

CHAPTER FOUR

DEFINITIONS

Acute	Pain that lasts for a period of less than six weeks (Grieve, 1988)
Afferent fibers	Nerve fibers that convey a nerve impulse in the brain or spinal cord (Moore and Dalley, 2006).
Agonistic muscles	Muscles or portion of muscles so attached anatomically that when they contract they develop forces that reinforce each other (Moore and Dalley, 2006).
Ankylosis	Severe or complete loss of movement of a joint (Tortora and Derrickson, 2006).
Antagonistic muscles	Muscles or portion of muscles so attached anatomically that when they contract they develop forces that oppose each other (Moore and Dalley, 2006).
Chronic	Pain experienced for more than six weeks (Grieve, 1988).
Closed-packed position	The closed-pack position of the cervical spine is extension (Magee, 2006)
Contra-indication	Any condition or disease that renders one type of treatment improper or undesirable (Gatterman, 1990).
Creep	Deformation (A change in length or shape) of a viscoelastic material with time when it is subjected to a constant, suddenly applied load (Bergmann, Peterson and Lawrence, 1993).
Deformation	A change in length or shape (Bergmann, Peterson and Lawrence, 1993).
Elastic Barrier	The elastic resistance that is felt at the end of passive range of motion.
End feel	Discrete short range movements of a joint independent of the action of voluntary muscles that is determined by springing each vertebra at the limit of its passive range of motion (Bergmann, Peterson and Lawrence, 1993).
Extension	In context of this research it is movement of the neck in a backward direction out of

the foetal position (Bergmann, Peterson and Lawrence, 1993).

Flexion Decreasing the angle between parts of the body. In context of this research it refers to movement of the head and neck towards the chest into the foetal position (Bergmann, Peterson and Lawrence, 1993).

Hypoalgesia A decrease in sensitivity as a result of an increase in the pain threshold (Bergmann, Peterson and Lawrence, 1993).

Incidence Number of new cases within a study period (Longmore *et al.*, 2007).

Intersegmental stability. Stability between the segments or vertebrae (Bergmann, Peterson and Lawrence, 1993).

Isometric contraction When the muscle, or group of muscles, or a joint, or region of the body, is called upon to contract, or move in a specified direction, and in which that effort is matched by the practitioner/ therapists effort, so that there is no change in muscle length (Chaitow, 2006). There are two types of isometric contractions i.e. Post-isometric relaxation (PIR) technique and the reciprocal inhibition (RI) technique. The PIR MET technique applied to the cervical restrictions refers to the reduction in the tone of the agonist muscle that occurs after the isometric contraction (Chaitow, 2006).RI refers to the inhibition of the antagonist muscle when isometric contraction occurs in the agonist. When MET is applied to a specific joint in the cervical spine, the muscles are used to bring about the desired movement of the joint. Although the muscles are being used, this technique is applied for the correction of the cervical joint restriction (Chaitow, 2006).

Isotonic contraction There are two types of isotonic contractions used in MET application i.e. the concentric and eccentric isotonic contraction. The concentric isotonic contraction occurs when the counterforce applied by the manual therapist is weaker than the contractile force. This allows for movement to occur in the direction of the muscle force. This results in strengthening and shortening the muscle thus strengthening the physiologically weak muscle. The eccentric isotonic contraction is used to improve elasticity and circulation (Chaitow, 2006).

Joint dysfunction An area where joint mechanics shows an area of disturbance of function without there being any structural change. Subtle joint dysfunction may affect quality of range of motion. It can be diagnosed through motion palpation and specific signs and symptoms (Bergmann, Peterson and Lawrence, 1993).

Joint play Small or short ranges of a movement of a joint that occurs independent of the action of voluntary muscles and is determined by the springing of each vertebra in the neutral position (Bergmann, Peterson and Lawrence, 1993).

Lancinating Pain described as sharp piercing, cutting sensation (Simons, Travell and Simons, 1999).

Lateral flexion Movement of the body to the side in the coronal plane. In context of this research, it is movement of the head to the side so that the ear and shoulder approximate (Bergmann, Peterson and Lawrence, 1993).

Long duration MET For the purpose of this study, a long duration MET is defined as the application of MET using a 45-second contraction duration.

Muscle Energy Technique Incorporates the voluntary contraction of a muscle by a patient in a precisely controlled direction with different levels of intensities against an equal and opposite counter-force applied by the therapist (Greenman, 1996).

Malposition Abnormal or anomalous position (Bergmann, Peterson and Lawrence, 1993).

Manipulation A passive manoeuvre in which a manual force is applied to vertebral and extra-vertebral articulations of the body with the object of restoring mobility to restricted areas (Bergmann, Peterson and Lawrence, 1993).

Mechanical neck pain Any event or condition (e.g. incorrect posture, ageing and acute injury) which leads to altered joint mechanics, muscle structure or function (Bergman and Peterson, 2011).

Mechanoreceptors Sensory nerve endings that is sensitive to mechanical stimuli such as deformation, bending or stretching of cells (Tortora and Derrickson, 2006).

Motion palpation	Palpatory diagnosis of passive and active segmental joint range of motion (Gatterman, 1998).
Motor Control	A systematic transmission of nerve impulses from the motor cortex to motor units, resulting in coordinated contractions of muscles (Tortora and Derrickson, 2006).
Motor learning	Defined as the process for improving ones motor skills through practice (Tortora and Derrickson, 2006).
Nociceptors	A group of cells that act as receptors and respond to painful stimuli resulting from physical or chemical damage to tissue (Tortora and Derrickson, 2006).
Nociceptors desensitization	To remove the painful stimuli that nociceptors respond to (Tortora and Derrickson, 2006).
Non- specific neck pain-	Pain felt predominantly in the cervical region and is of a mechanical or postural basis (Binder, 2007).
Pathomechanics	Abnormal mechanical function (Bergmann, Peterson and Lawrence, 1993).
Plastic deformation	A non-recoverable deformation (Bergmann, Peterson and Lawrence, 1993).
Point prevalence	Prevalence at that point in time (Longmore *et al*., 2007).
Preloaded state	The intervertebral disc has the ability to imbibe (absorb) water causing it to "swell' within its inextensible casing. The pressure in the centre of the nucleus is never zero in a healthy disc. The preloaded state gives the disc greater resistance to compressive forces (Bergmann, Peterson and Lawrence, 1993).
Prevalence	The number of cases, at any time during the study period, divided by the population at risk (Longmore *et al.*, 2007).
Proprioception	Sensing the motion and position of the body (Moore and Dalley, 1999).
Proprioceptors	Sensory nerve terminals that give information concerning movements and position of the body. They occur chiefly in the muscles, tendons, joints and labyrinths (Tortora and Derrickson, 2006).

Reciprocal inhibition	Inhibition of the antagonistic muscles when the agonist is stimulated (Chaitow, 2006).
Reciprocal innervation	When the agonist contracts the central nervous system sends messages to the antagonist to relax and vice versa (Chaitow, 2006).
Referred pain	Pain felt in a part other than that in which the cause that produced It is situated (Simons, Travell and Simons, 1999).
Regional stability	Stability within a specific region in the body (Bergmann, Peterson and Lawrence, 1993).
Restrictive barrier	When used in relation to soft tissue structures, it refers to that point where the first signs of resistance are noted and is when the greatest range of motion of the neck is not obtainable (Chaitow, 2006).
Rotation of the neck	Motion of a body around an axis. In context of this research, it is movement of the head and neck in a direction signifying the answer "NO" (Tortora and Derrickson, 2006).
Short duration MET`	For the purpose of this study, a short duration MET is defined as the application of MET using a five second contraction duration.
Supine	The position in which a person lies with the ventral side/ face upward (Bergmann, Peterson and Lawrence, 1993).
Transcapillary blood flow	Blood flow across the capillary walls (Tortora and Derrickson, 2006).
Viscoelastic properties	The term viscoelastic is used to describe tissue that represents both viscous and elastic properties. The viscous properties permit permanent deformation and the elastic properties result in deformation that is recoverable (Bergmann, Peterson and Lawrence, 1993).

LIST OF ABBREVIATIONS

CMNP	Chronic Mechanical Neck Pain
CROM	Cervical range of motion
DJD	Degenerative Joint Disease
DUT	Durban University of Technology
E	Extension
F	Flexion
HVLA	High-velocity, low-amplitude
LLF	Left Lateral Flexion
LR	Left Rotation
MET	Muscle Energy Technique
MNP	Mechanical Neck Pain
MFTP	Myofascial Trigger Point
n	Number of subjects in the sample
NDI	Neck disability index
NRS	Numerical pain rating scale
p	Probability
PA	Posterior to Anterior
RLF	Right Lateral Flexion
ROM	Range of Motion
RR	Right Rotation
S	Seconds
SD	Standard Deviation

TENS	Transcutaneous Electrical Nerve Stimulation
TP	Trigger Point (Myofascial Trigger point)
YLD	Years Lived with Disability

CHAPTER ONE

INTRODUCTION

1.1 THE PROBLEM AND ITS SETTING

Neck pain presents as a global healthcare challenge to the medical profession and is a common problem encountered worldwide (Dennison and Leal, 2011). In the general population studies have shown there to be an overall prevalence in neck pain ranging between 0.4% and 86.8 % (Hoy, Protani and Buchbinder, 2010; Haldeman *et al*., 2008). Vernon, Humphreys and Hagino (2007) suggest that in the general population, the prevalence of neck pain is ranked second in the musculoskeletal practice. Binder (2007) further suggests that approximately two thirds of the population presents with non-specific neck pain. Non-specific neck pain is of a non-pathological origin and the symptoms are usually of a postural or mechanical basis (Binder, 2007).

The neck is designated as the area from the base of the skull to the base of the seventh cervical vertebra (Tortora and Derrickson, 2006). Neck pain is described as pain that occurs in the area bound laterally by the lateral borders of the neck, superiorly by the superior nuchal line and inferiorly by an imaginary line running through the tip of the spinous process of the first thoracic vertebra (Bogduk, 2003). In the context of this research, neck pain of mechanical origin has been described as any event or condition which leads to changes in the structure and functioning of a muscle as well as changes in the mechanics of the joint (Bergmann, Peterson and Lawrence, 1993). These events may result from incorrect posture, ageing and acute or repetitive-injury (Bergmann and Peterson, 2011). Neck pain may either be of an acute or chronic nature. According to Grieve (1988) chronic neck pain may be considered when the patient experiences neck pain for a period of six weeks or longer whereas acute neck pain may be defined as neck pain for a period of less than six weeks.

There are various conservative treatment options available in chiropractic practice for the treatment of chronic mechanical neck pain (CMNP). These treatment options may be categorized into physical or manual therapy. Physical therapies may include: use of interferential current, heat therapy, cold therapy, massage, acupuncture and low-level laser treatments (Haldeman *et al*., 2008; Hoving *et al*., 2002). Manual therapies include manipulation (high-velocity, low-amplitude thrust techniques) or mobilization (Haldeman *et al*., 2008; Hoving *et al*., 2002). In the manual therapy group of treatment options, one of the commonly used treatments is Muscle Energy Technique (MET).

Muscle Energy Technique is a type of manual therapy which involves the voluntary contraction of a patient's muscle against a counter-force applied by the manual therapist (Mitchell, Moran, and Pruzzo, 1979). When applied to the neck, MET causes the muscle to pull on its attachment to the bone, thus moving one vertebra in relation to its articulating counterpart. This technique is known to restore normal joint range of motion (Edwards, 1993). MET is utilized in the (Greenman, 1996):

- Lengthening of shortened or spastic muscles;
- Strengthening of a physiologically weakened muscle individually or even a group of muscles;
- Reduction of localized oedema thus relieving passive congestion and hence reducing pain and / or
- Mobilization of a joint with restricted mobility.

Although MET is shown to be an effective treatment in the management of CMNP, the most suitable contraction time of MET remains an area of debate. Greenman (2003) and Mitchell, Moran, and Pruzzo (1979) recommend two to seven seconds, just enough time for joint slack to be taken out (short duration). Similarly, Ballantyne, Fryer and McLaughlin (2003) and Lenehan, Fryer and McLaughlin (2003) have also utilized techniques using a contraction duration of five to seven seconds, until a new elastic barrier (resistance felt at the end of passive range of motion) was reached. In contrast Chaitow (2006) recommends stretch contraction to be held for at least 30 to 60 seconds (long duration) for the treatment of chronically shortened muscles which concurs with a 30-second (Bandy and Irion, 1994) and a 60-second (Feland *et al*., 2001) contraction duration which have shown to be more effective in increasing muscle extensibility.

For this reason, the treatment effectiveness of MET utilizing a short duration contraction versus the effect of a long duration contraction was compared, of which the results may provide a valuable contribution to the manual professions, such as osteopathy and chiropractic.

1.2 AIM:

The aim of the study was to compare the effects of Muscle Energy Technique using a short duration contraction versus a long duration contraction in the treatment of CMNP in terms of subjective and objective clinical outcomes.

1.3 OBJECTIVES:

The objectives of the study are outlined below:

Objective One

To determine the effectiveness of a short duration (five-second) MET in terms of subjective (Numerical Pain Rating Scale and Neck Disability Index) and objective (Range of motion and tenderness) measurements in the treatment of CMNP.

Objective Two

To determine the effectiveness of a long duration (45-second) MET in terms of subjective (Numerical Pain Rating Scale and Neck Disability Index) and objective (Range of motion and tenderness) measurements in the treatment of CMNP.

Objective Three

To compare a short duration (five-second) and long duration (45-second) MET in terms of subjective and objective (Range of motion and tenderness) measurements in the treatment of CMNP.

1.4 RATIONALE:

Spinal manipulation is a principle treatment modality; however there are instances where its application is contra-indicated. In such instances, MET can be utilized (Liebenson, 2006; Greenman, 1996). MET is different to manipulation in that it is a patient initiated contraction allowing the patient full control over the treatment which contributes to the corrective force, whereas manipulation is a high-velocity, low amplitude (HVLA) thrust technique that is administered by the manual therapist providing the treatment (Hamilton, Boswell and Fryer, 2007).

MET is a common manual technique, which has a high rate of success in the treatment of CMNP (Greenman, 2003; Boodhoo, 2002). However, the most effective contraction duration of MET in the treatment of CMNP is still unknown. Some authors have recommended contraction duration of two to three seconds (Mitchell, Moran, and Pruzzo, 1979) and three to five seconds (Brous, 2005 ; Greenman, 2003) whilst other authors have recommended contraction durations of 30 to 60 seconds (Chaitow, 2006; Feland *et al.*, 2001; Bandy and Irion, 1994). The current available research literature provides little guidance regarding the most effective contraction duration (Fernandez-de-las-Penas, Cleland and Huijbregts, 2011; Smith and Fryer, 2008). This study was designed to provide a better understanding of an optimal MET application duration so that effective treatment protocols can be established for patients to reduce their CMNP.

Following an extensive review of the available literature, there seems to be paucity of information with regard to the comparison of a short- duration MET to a long duration MET in the treatment of CMNP at all levels in the cervical spine.

It is suggested that if this study indicates that the application of a long duration MET contraction was more effective than the short duration MET contraction in the treatment of CMNP, then the new information could be utilized to educate the patient and their manual therapist (e.g. chiropractor), thus the results of the study will contribute to a more effective treatment protocol for patient's complaining of CMNP.

In contrast, if the application of the short duration MET was shown to be more effective than the long duration MET, then it is important for the manual therapist to be aware that some patients may react differently and therefore manual therapist would need to offer the different techniques to their patient to test which intervention works best for their patient.

1.5 NULL HYPOTHESIS AND ALTERNATIVE HYPOTHESIS

Null hypothesis

It was hypothesized that the short duration MET would not show any difference in the degree of improvement in range of motion and pain in comparison to the long duration MET in the treatment of CMNP.

Alternative hypothesis

It was hypothesized that the short duration MET would show a difference in the degree of improvement in range of motion and pain in comparison to the long duration MET in the treatment of CMNP.

1.6 ASSUMPTIONS/LIMITATIONS

It was assumed that the participants were entirely honest and open in completing the Numerical Pain Rating Scale-101 (**Appendix I**) and the CMCC Neck Disability Index (**Appendix J**) Questionnaire and that their answers reflected their reality at the time of completion.

It was required that the participants maintain the contraction duration at the same strength throughout the treatment. It was therefore expected that the participant maintained the contraction for the precise duration expected of them as per group allocation.

The outcomes of the study are limited in that the results and final decision in terms of the clinical effectiveness of the two protocols may only be made in relation to CMNP and not to other spinal conditions like low back pain. The study is only on individuals presenting with CMNP. Low back pain and other spinal conditions were not investigated in this study and it is therefore unknown whether the results of this study on CMNP can be applied to low back pain or any other spinal condition.

1.7 CONCLUSION

This chapter provided a preliminary literature review. The argument presented was in support of the aims and objectives of the study. Upon review of the available literature MET has been shown to be an effective treatment in the management of CMNP (Chaitow, 2006; Greenman, 2003; Boodhoo, 2002). However there seems to be paucity of information in terms of the most effective contraction duration in the treatment method. This research is therefore aimed at determining the most effective contraction duration of MET in the treatment of CMNP

Chapter Two provides a more detailed description of the literature with Chapter Three describing the methodology of the study. Chapter Four presents the results of the study. These results are then discussed in Chapter Five. Chapter Six concludes this study and also offers future recommendations to other researchers who may be interested in investigating the effects of CMNP.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter provides a review of the literature relating to mechanical neck pain and MET. An extensive review of the literature was done which entailed the use of books and journal articles. The journal articles provided important research on the epidemiology of neck pain, clinical trials and anatomy. The textbooks used provided information on the anatomy, physiology and pathophysiology of the neck and neck pain. Information on MET was also obtained from textbooks and journal articles.

2.2 EPIDEMIOLOGY OF NECK PAIN

2.2.1 THE INCIDENCE AND PREVALENCE OF NECK PAIN IN THE GENERAL POPULATION

The World Health Organization's (WHO) 2010 Global Burden of Disease (GBD) Report , shows that 332, 049 million people suffer from neck pain and that neck pain is one of the main contributors to disability with an estimate of 33.6 million years lost to disability (Vos *et al*., 2012). Neck pain is ranked as the fourth leading cause of years lived with disability (YLD) globally. According to the GBD report in 2010, the regional results show that neck pain is ranked as high as the third most common cause of YLD in countries such as Australasia, Eastern Europe and East Asia (Vos *et al*., 2012). **Table 2.1** provides the years lived with disability due to neck pain in each region.

A world population study concluded that the 12 month prevalence of neck pain ranges from 16.7% to 75.1% (Fejer, Kyvik and Hartvigsen, 2006). Similar results were obtained in a study by Haldeman *et al*. (2008) which suggest that the 12 month prevalence of neck pain in the general population ranges from 12.1 % to 75.1%. A more recent study concluded that the overall prevalence of neck pain in the general population ranged between 0.4% and 86.8% with a mean of 23.1% (Hoy, Protani and Buchbinder, 2010). Hoy, Protani and Buchbinder (2010) also concluded, based on four different studies that the one year incidence of neck pain in the general population ranged from 10.4% to 21.3%. One of the four studies was a Saskatchewan population-based study in Canada which revealed that 600 out of 100 000 adults experience a new episode of disabling neck pain a year (Cote *et al*., 2004).

Table 2.1: Ranking of countries (by region) based on years lived with disability (YLDs) due to neck pain in 2010

COUNTRY	RANKING	COUNTRY	RANKING
Australasia	3	Central Asia	5
Central Latin America	3	Western sub-Saharan Africa	5
East Asia	3	North Africa and Middle East	6
Eastern Europe	3	Eastern sub-Saharan Africa	6
High-income Asia Pacific	3	Southeast Asia	6
Southern Latin America	3	Southern sub-Saharan Africa	6
Tropical Latin America	3	Central sub-Saharan Africa	7
High-income North America	4	South Asia	7
Central Europe	4	Caribbean	8
Western Europe	4	Oceania	8
Andean Latin America	5		

(**Adapted from Vos *et al.*, 2012)**

2.2.2 THE INCIDENCE AND PREVALENCE OF NECK PAIN ACROSS DIFFERENT ETHNIC/RACIAL GROUPS

Pain is perceived differently by different ethnic and racial groups (Carey *et al.*, 2010). A study conducted in the United States (US) during the period of 2000-2005 revealed that the non–Hispanic Whites had a higher prevalence (16%) of neck pain than the non-Hispanic Blacks (11.5%) (Plesh, Adams, and Gansky, 2012). Carey *et al.* (2010) had found similar results in a South-eastern United States study conducted in North Carolina in which the prevalence of neck pain was found to be higher in Whites. This study is contradictory to the South African studies conducted in the greater Durban area, which show that the prevalence of neck pain in the black population is 50% (Ndlovu, 2006) and is higher than that of the White population which is 45% (Slabbert, 2010), and the Indian population of 36.8% (Muchna, 2011).

2.2.3 THE INCIDENCE AND PREVALENCE OF NECK PAIN ACROSS GENDER AND AGE

Research conducted by Skillgate *et al.* (2012) on the general population indicates that the 12 month prevalence of neck pain within the female population (25%) is higher than that of the male population (16%). This recent statistic is in keeping with previous epidemiologic studies conducted which also suggests that females have a higher prevalence of neck pain (Hoy, Protani and Buchbinder, 2010; Leboeuf –Yde *et al*., 2009; Fejer, Kyvik and Hartvigsen, 2006; Brandt *et al*., 2004; Cote *et al*., 2004). Females are also more likely than their male counterparts to report neck pain that is persistent and they are less likely to experience complete resolution of neck pain and disability (Cote *et al*., 2004). Evidence further suggests that the incidence of neck pain is also higher in females than males (Hoy, Protani and Buchbinder, 2010). Croft *et al.* (2001) suggest that the one year cumulative incidence of neck pain in females showed higher percentages than the male population.

The age-specific prevalence of neck pain shows an increase with age (Cote *et al*., 2009; Croft *et al*., 2001). Studies have shown that the highest prevalence of neck pain in the general population peaks around the middle-age (Skillgate *et al*., 2012; Hogg-Johnson *et al*., 2009; Leboeuf-Yde *et al*., 2009; Croft *et al*., 2001). According to Croft *et al*. (2001), the 12 month incidence of neck pain shows little fluctuation across age groups. However, several authors suggest that there is an increased risk of developing neck pain at the ages of 35-49 years, after which the risk decreases (Skillgate *et al.,* 2012; Hoy, Protani and Buchbinder, 2010; Cote *et al*., 2004).

2.2.4 THE INCIDENCE AND PREVALENCE OF NECK PAIN RELATED TO OCCUPATION

Occupational related neck pain is a common phenomenon and is found in all occupational categories (Hoy, Protani and Buchbinder, 2010; Haldeman *et al*., 2008). The annual prevalence and incidence of neck pain varies across different occupational groups (Hoy, Protani and Buchbinder, 2010; Cote *et al*., 2009). Research indicates that office and computer workers have the highest incidence of neck conditions (Cote *et al*., 2009). A US study indicates that the annual incidence of neck pain was 57% in previously asymptomatic office workers (Cote *et al.*, 2009). Haldeman *et al*. (2008) suggest that between 11% and 14% of workers report that their activities are limited as a result of neck pain on a yearly basis. Work activities that involve repeated lifting of heavy objects, head bent for prolonged periods of time and working with arms at or above the level of the shoulder have shown to have a higher prevalence of neck pain (Sim, Lacey and Lewis, 2006).

A study on the risk factors of neck pain in healthy undergraduate students, aged 18-25 years, was conducted by Kanchanomai *et al*. (2011). The results of the study revealed that 46% of the students developed neck pain from onset of the study to the follow-up consultation that was a year later, of whom 33% reported persistent neck pain. With an increase in the use of computers at both secondary and tertiary levels, students are at an increased risk for developing neck pain (Cote *et al*., 2009; Green, 2008; Sim, Lacey and Lewis, 2006; Schlossberg *et al*., 2004). A US study conducted on the engineering and computer science students at Harvard University revealed that 64% of the participants experienced neck or shoulder pain of which 60% relate the cause of pain to computer usage (Schlossberg *et al*., 2004). According to Kanchanomai *et al*. (2011) neck pain is often a result of the computer screen and mouse being in the incorrect position.

2.2.5 THE INCIDENCE AND PREVALENCE OF NECK PAIN IN RELATION TO HEIGHT, WEIGHT AND OVERALL BODY MASS INDEX (BMI).

According to Croft *et al*. (2001), weight and height are not important factors in the incidence of neck pain. The evidence from the Bone and Joint Decade 2000-2010 report revealed that the results linking weight and height in relation to neck pain varied in four different studies (Cote *et al.,* 2009). Two of these studies found that individuals with a BMI of $\geq 30 kg/m^2$, which is classified as obese, was linked to an increased risk of neck pain in English nurses (Smedley *et al*., 2003) and in nursing home employees in the Netherlands (Luime *et al*., 2004). However, this relationship was not supported by studies conducted on Danish technicians (Brandt *et al*., 2004) or American office workers (Gerr *et al*., 2002). A South African study on the Indian population revealed that participants with a BMI of 24.8 kg/m^2 were more likely to complain of neck pain (Muchna, 2011). Gerr *et al.* (2002) found similar results in their study of American office workers in which the highest percentage of participants who complained of neck pain had a BMI of 18.5-24.9 kg/m^2. This study also reported that females with a height of less than 1.58m and males with a height of less than 1.73m had a lower incidence of neck pain.

2.3 SUMMARY OF THE PERTINENT ANATOMY OF THE CERVICAL SPINE

2.3.1 DESCRIPTION OF THE NECK

The neck extends from the head above to the upper thorax and shoulders below (Standring, 2008). The superior boundary of the neck is the inferior margin of the mandible and the bony structures of the skull on its posterior aspect (Moore and Dalley, 2006). The neck is bound inferiorly by the top of the sternum in front, extending along the left and right clavicle onto the acromion of the scapula adjacent to the clavicle (Standring, 2008). The base of the neck can be defined as an imaginary line through the transverse process of the first thoracic vertebra posteriorly (Bogduk, 2003). The cervical region of the vertebral column is referred to as the cervical spine. The cervical spine is convex anteriorly and concave posteriorly thus producing a lordotic curve (Bergmann and Peterson, 2011).

2.3.2 CERVICAL VERTEBRAE

The cervical vertebrae make up the skeleton of the neck (Moore and Dalley, 2006). There are seven cervical vertebrae that make up the cervical region of the vertebral column. The cervical vertebrae are smaller bones that bear less weight than the vertebrae bellow them. The distinctive feature of these vertebrae is the oval foramen of the transverse process (Standring, 2008; Magee, 2006). The first (C1), second (C2) and seventh (C7) cervical vertebrae are atypical vertebrae and the third (C3), fourth (C4), fifth (C5) and sixth (C6) cervical vertebrae are typical vertebrae (Moore and Dalley, 2006; Tortora and Derrickson, 2006). An illustration of a typical vertebra is shown in **Figure 2.1a** and **2.1b.**

2.3.2.1 TYPICAL CERVICAL VERTEBRAE

The features of a typical cervical vertebra are summarised in the **Table 2.2** below and is illustrated in **Figures 2.1a and 2.1b.**

Table 2.2: Typical features of a cervical vertebra

BONEY PART	DESCRIPTION
SPINOUS PROCESS	Extends posteriorly from the junction of the lamina. Short and bifid to allow for better ligamentous and muscle attachment.
VERTEBRAL BODY	Short in height. Superior surface is concave and inferior surface is convex. The postero-lateral margins of the superior aspect form the uncinate process which stabilizes the region. The inferior surface has two articular facets that articulate with the uncinate processes of the vertebra below it.
TRANSVERSE PROCESS	Contains the transverse foramen. The vertebral artery, venous and sympathetic plexuses lie in here. Arise anteriorly from the vertebral body and posteriorly from the articular process. Bifid at the ends, with an anterior and posterior tubercle for the attachment of the scalene muscles.
VERTEBRAL FORAMEN	Triangular Large to accommodate the cervical enlargement of the spinal cord which provides innervation

(Adapted from Bergmann and Peterson, 2011; Middleditch and Oliver, 2005; Moore and Dalley, 2006)

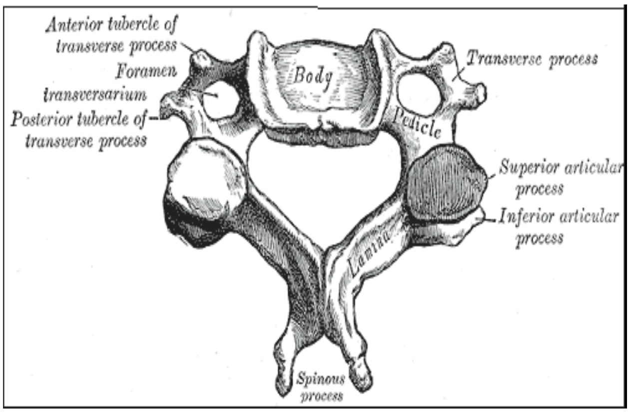


Figure 2.1a: A Typical cervical vertebra
No copyright (Grey, 1960)

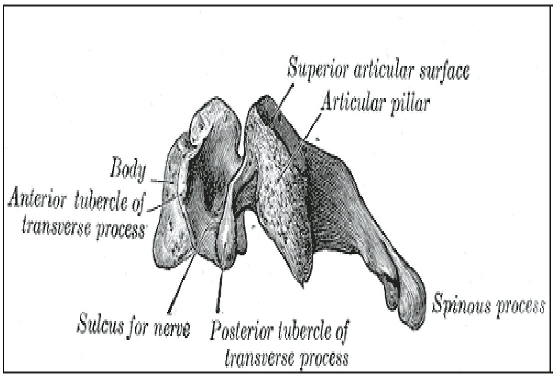


Figure 2.1b: Side view of a typical cervical vertebra
No copyright (Grey, 1960)

2.3.2.2 ATYPICAL VERTEBRAE

Three of the cervical vertebrae are atypical and are discussed below:

2.3.2.2a THE FIRST CERVICAL VERTEBRA (ATLAS)

The C1 vertebra is also known as the atlas and is illustrated in **Figure 2.2**. It is the widest cervical vertebrae and does not have a body or a spinous process. The bone is shaped in the form of a ring with an anterior and posterior arch (Tortora and Derrickson, 2006). There are two lateral masses that are connected via the posterior and anterior arches. These arches have a posterior and anterior tubercle respectively. The posterior arch of the atlas is the equivalent to the lamina (part of bone connecting the spinous process to the vertebral body) of a typical vertebra. The superior surface of the posterior arch contains a groove for the vertebral artery. This groove also contains the first cervical nerve (Standring, 2008; Moore and Dalley, 2006). The superior articular processes of the atlas are concave and kidney shaped, so as to articulate with the protuberances of the condyles of the occiput (Moore and Dalley, 2006), which forms the atlanto-occipital joints (Tortora and Derrickson, 2006; Bergmann, Peterson and Lawrence, 1993).

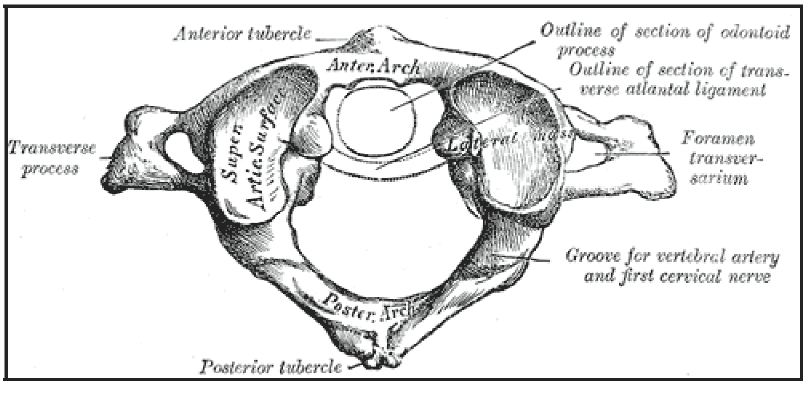


Figure 2.2 First cervical vertebra (Atlas)
No Copyright (Grey, 1960)

2.3.2.2b THE SECOND CERVICAL VERTEBRA (AXIS)

The second cervical vertebra is shown in **Figure 2.3a and 2.3b**. It is also referred to as the axis. It is one of the strongest cervical vertebra as it allows C1 to rotate on it (Moore and Dalley, 2006) as in the side-to-side movement to signify the answer "no" (Tortora and Derrickson, 2006). This movement is made possible by the articulation of the atlanto-dental joint (Moore and Dalley, 2006). The superior articulating facets of the axis are flat and large and allows for the articulation of the atlas. The main distinguishing feature of the axis is the peg-like process (Tortora and Derrickson, 2006) called the dens or odontoid process. This process projects superiorly, from the body of the axis (Moore and Dalley, 2006) and through the anterior portion of the vertebral foramen of the atlas (Tortora and Derrickson, 2006). The dens / odontoid process is held in place by the transverse ligament (Moore and Dalley, 2006). The articulation between the axis and the atlas is called the atlanto-axial joint (Tortora and Derrickson, 2006).

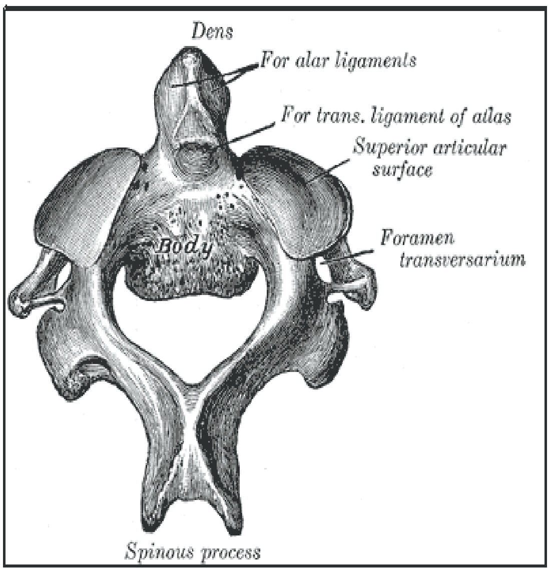


Figure 2.3a:Second cervical vertebra (Axis)
No copyright (Grey, 1960)

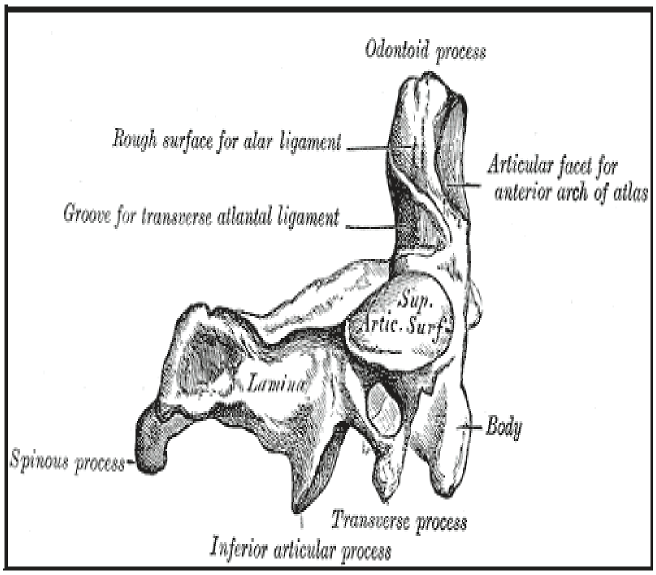


Figure 2.3b: Second cervical vertebra (Axis) Side view
No copyright (Grey, 1960)

2.3.2.2c. C7 CERVICAL VERTEBRA (VERTEBRA PROMINENS)

The seventh cervical vertebra is shown in **Figure 2.4**. It is also known as the vertebra prominens because it has a longer spinous process, when compared to the spinous processes of the other cervical vertebrae (Moore and Dalley, 2006). The vertebra prominens contains features of the cervical and thoracic vertebrae (Bergmann and Peterson, 2011). The spinous process is not bifid like the spinous processes of the other cervical vertebrae. The transverse process is large but the foramen in these transverse processes are much smaller and do not transmit the vertebral artery. The rest of the features of C7 are similar to the features of the typical vertebra (Moore and Dalley, 2006).

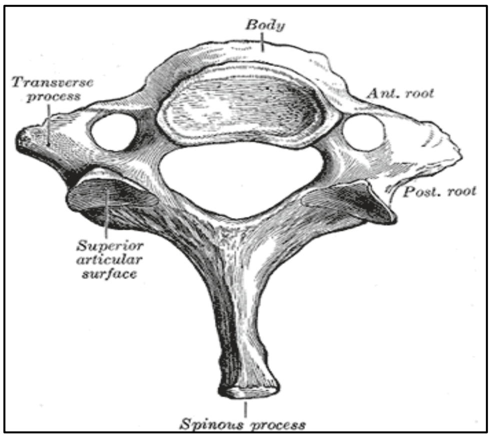


Figure 2.4: Seventh cervical vertebra (Vertebra prominens)
No Copyright (Grey, 1960)

2.3.3 JOINTS OF THE CERVICAL SPINE

2.3.3.1 ATLANTO-OCCIPITAL JOINT

The lateral masses of atlas have superior articular facets that are concave (Moore and Dalley, 2006). This is for articulation with the convex protuberances of the occipital condyles therefore forming the atlanto-occipital joint (Middleditch and Oliver, 2005). This joint allows for the movement of the head signifying the answer "yes" i.e. nodding (Tortora and Derrickson, 2006). The atlas therefore carries the skull and the weight of the skull is transmitted to the vertebral column via these condyles (Bergmann and Peterson, 2011; Moore and Dalley, 2006).

2.3.3.2 ATLANTO-AXIAL JOINT

The atlanto-axial joint consists of three synovial joints; these are the two lateral atlanto-axial joints and one median atlanto-axial joint (Bergmann and Peterson, 2011; Bergmann, Peterson and Lawrence, 1993).

- *The two lateral atlanto-axial joints*. These are gliding type of synovial joints (Middleditch and Oliver, 2005). The axis has two superior articulating facets which articulate with the inferior articulating facets of the atlas. The atlas rotates on these superior facets of the axis (Moore and Dalley, 2006).

- The *median atlanto-axial joint* is also known as the *atlanto-odontoid joint* (Moore and Dalley, 2006).The facet on the anterior surface of the dens of the axis articulates with the posterior facet of the anterior arch of the atlas (Middleditch and Oliver, 2005). This is a pivot joint and allows for rotation of the atlas (Tortora and Derrickson, 2006).

2.3.3.3 FACET JOINTS (ZYGAPOPHYSEAL JOINTS)

The facet joints are also referred to as the zygapophyseal joints and are joints formed between the inferior facets of one vertebra and the superior facets of the vertebra below it (Moore and Dalley, 2006). The joint is enveloped in a capsule which is richly innervated with nociceptors (pain receptors) and mechanoreceptors for proprioception which allow the supporting structures to react to combinations of tension and compression movements produced during changes in posture and physical activity (Moore and Dalley, 2006; Bergmann, Peterson and Lawrence, 1993). The function of theses joints are to protect the disc from shear forces, provide support for the spinal column and control patterns of motion (Bergmann and Peterson, 2011; Bergmann, Peterson and Lawrence, 1993). The movement that is allowed at these joints depends on the orientation of the articular facets. The inferior facets are positioned forward and downward and the superior facets are positioned backward and upward. These joints allow for the movements of flexion, rotation, extension and lateral flexion. These joints are also lined with articular cartilage and share the weight of the skull, the vertebral bodies and discs (Middleditch and Oliver, 2005; Moore and Dalley, 2006). The zygapophyseal joint forms a three-joint complex with the intervertebral disc (IVD). Degenerative changes in the IVD cause the zygapophyseal joint to carry more weight which most often leads to degenerative changes in these joints (Bergmann and Peterson, 2011).

2.3.3.4 THE UNCOVERTEBRAL JOINTS (JOINTS OF LUSHKA)

The C3 to C6 vertebrae have uncinate processes that grow upwards from the superior border of the vertebral body (Middleditch and Oliver, 2005). These processes are located on the postero-lateral aspect of the vertebra and correspond with the similar shaped cavities of the vertebra above it and this forms the uncovertebral joint or the joints of Luschka. The uncovertebral joint is classified as a synovial joint. The uncovertebral joints may be a frequent site of degenerative changes which may contributes to the development of neck pain (Middleditch and Oliver, 2005; Moore and Dalley, 2006).

2.3.3.5 INTERVERTEBRAL DISCS (IVDS)

The bodies of the cervical vertebrae below C2 are linked by an intervertebral disc (Standring, 2008). Each disc has an outer annulus fibrosus, which is a ring of fibrocartilage, and an inner soft, elastic substance called the nucleus pulposus. With age the nucleus pulposus hardens and becomes less elastic (Bergmann, Peterson and Lawrence, 1993). These IVDs form strong joints and allow for certain movements as well as serve as shock absorbers in the spine (Tortora and Derrickson, 2006). The varying shapes of the IVDs produce the secondary curvatures of the vertebral column (Moore and Dalley, 2006). The IVDs in the cervical spine are thicker anteriorly than posteriorly therefore contributing to the cervical lordosis (Nordin and Frankel, 2001). In the cervical region the IVDs allow a considerable amount of mobility (Middleditch and Oliver, 2005).

2.3.3.6 THE INTERVERTEBRAL FORAMEN (IVF)

The intervertebral foramen (IVF) form exits from the vertebral canal (Middleditch and Oliver, 2005). The upper and lower borders of the IVF are formed by the inferior vertebral notch of the pedicle above and the superior vertebral notch of the pedicle below it. The anterior border is formed by the posterior aspect of the IVD and the adjacent vertebral body. The posterior border is formed by the zygapophyseal joint on each side. The IVF allows for blood vessels and spinal nerves to pass in and out of the vertebral canal. A pathology affecting any of the structures forming the boundaries of the IVF may affect the structures within the IVF (Standring, 2008 ; Bergmann, Peterson and Lawrence, 1993).

2.3.4 LIGAMENTS OF THE CERVICAL SPINE

The fibers of some fibrous capsules are arranged as parallel bundles of dense regular connective tissue called ligaments (Tortora and Derrickson, 2006). The principle function of the ligaments is to hold bones together in a synovial joint (Tortora and Derrickson, 2006). In the cervical spine, joints between vertebrae are reinforced and supported by ligaments (Standring, 2008). Ligaments of the upper cervical spine can be damaged or weakened by systemic inflammatory diseases or trauma and can be completely congenitally absent or malformed. For this reason, it has been advocated to test for their integrity prior to the administration of any manipulative therapy (Bergmann, Peterson and Lawrence, 1993). **Table 2.3** provides the anatomical attachments of the ligaments in the cervical spine, their function and the effects of damage or tear to these ligaments.

Table 2.3: Ligaments of the cervical spine

LIGAMENT	ATTACHMENT	FUNCTION/ROLE	DAMAGE/TEAR
Transverse Ligament	Tubercles on the medial aspect of lateral mass of atlas	Prevents displacement of the dens by holding it in place.	Stability compromised. Dens may impinge upon spinal cord.
Alar Ligament	Origin: Either side of dens Insertion: Lateral margins of foramen magnum	Attach skull to atlas and check rotation of the head	Allows excess movement at atlanto-axial and occipital joints reducing blood flow in vertebral artery
ALL	Superiorly: Base of skull, extends inferiorly attaching to the anterior surface of the IVDs. and VB. Inferiorly: Anterior surface of sacrum	Provides stability to the C-Spine Prevents hyperextension	C-Spine instability Hyperextension of Vertebral column.
PLL	Runs down posterior aspect of VB attaching along its length to the VBs and IVDs	Prevents hyperflexion of vertebral column and herniation of IVDs	Possible herniation of IVD or hyperflexion.
Ligamentum Flavum	Anterior surface of the lamina of vertebra above, to the posterior surface of lamina of vertebra below.	Prevents hyperflexion	Hypertrophy can result in decrease in vertebral canal size
Ligamentum Nuchae	EOP of skull to each cervical SP and inserts on the tip of C7 SP.	Supports the skull and resists flexion Provides muscle attachment	Cervical spine instability

VB: Vertebral body, IVD: Intervertebral disc, SP: Spinous process, C-Spine: Cervical spine, EOP: External occipital protuberance, ALL: Anterior longitudinal ligament, PLL: Posterior longitudinal ligament.

(Adapted from: Standring, 2008; Moore and Dalley, 2006; Middleditch and Oliver, 2005)

2.3.5 MUSCLES OF THE CERVICAL SPINE

The cervical spine is the most mobile region in the spine (Vernon, 1988). The function of the neck muscles are to produce and guide movement, control posture and balance the head on the neck (Middleditch and Oliver, 2005). The posterior neck muscles function to control head and neck position (Bergmann and Peterson, 2011). Muscles are the medium through which the compensatory effects of the central nervous system are channelled (Liebenson, 1996). If a joint is dysfunctional, a muscle or muscle group will react with a spasm or pain (Middleditch and Oliver, 2005; Liebenson, 1996). The reverse is also true in that if a muscle or group of muscles are affected, a joint may react by becoming restricted (Liebenson, 1996). The musculature of the cervical spine can be classified as global muscles or local muscles (Middleditch and Oliver, 2005). Local muscles attach directly to the vertebra and are responsible for intersegmental stability and must function independent of the global muscles (O'Sullivan, 2005). The global muscles are responsible for regional stability of the spine (Middleditch and Oliver, 2005). The muscles of the neck may also be described as intrinsic (deep) muscles or extrinsic (superficial) muscles (Moore and Dalley, 2006). Muscles in the neck are innervated by a high proportion of afferent fibers which makes them more sensitive to pain and changes in position (Bergmann, Peterson and Lawrence, 1993). The sub-occipital area, which is the area below the occiput, is a common site for the attachment of neck muscles (Simons, Travell and Simons, 1999). This area is therefore a common site of pain due to pulling of the affected muscles on the tenoperiosteal junction (where the tendon of a muscle attaches to the bone) which is a result of the muscle going into spasm (Middleditch and Oliver, 2005). Some of the main muscles involved in the development of neck pain (mechanical neck pain in particular) are the trapezius, splenius, levator scapulae and posterior cervical muscles of the neck. **Table 2.4** gives a summary of these muscles.

Table 2.4: Muscles of the cervical spine

MUSCLE	ANATOMY	INNERVATION	ACTION
Splenius capitis	O: Ligamentum Nuchae, SP's of C7-T3 I: Mastoid process, lateral 3rd of superior nuchal line	Dorsal rami of spinal nerve	When acting alone : LF and rotation of head When acting together: LR and rotation of the head and neck.
Splenius cervicis	O: Ligamentum Nuchae, SP's of C7-T3 I : Tubercles of TVPs C1-C3/C4	Dorsal rami of spinal nerve	When acting alone : LF and rotation of head When acting together: LR and rotation of the head and neck.
Semispinalis capitis	O: Articular processes of C4 to C6 , TVPs T1-T6. I: Between superior and inferior nuchal line of occiput	Branches of posterior primary division of C1-C4/C5 spinal nerves	Extension of head from the flexed position
Semispinalis cervicis	O: TVPs of T1-T6. I: SP's C2-C5	Spinal nerves C3-C6	Neck extension and contralateral rotation
Longissimus Capitis	O: Art. process of C3-C7 and TVPs T1-T5 I: Posterior margin of mastoid process of temporal bone	Branches of posterior primary division of cervical spinal nerve	Neck extension, secondary action in LF and rotation to the same side
Trapezius (Upper fibers)	O: Middle 3rd superior nuchal line, EOP, lig Nuchae, SPs C7-T12, lumbar and sacral SPs I: lateral 3rd clavicle, acromion and spine of Scapula	Spinal root of accessory nerve and C3 and C4 nerve	Elevates, rotates and retracts the scapula LF of the neck to the same side Rotation of the neck to the opposite side.
Levator scapulae	O: TVPs of C1 and C2 and posterior tubercles of TVPs of C3 and C4 I: Medial border of scapula	Dorsal scapula nerve (C3,C4,C5)	Elevation of scapula, extension and lateral flexion of neck and rotation of the neck to the ipsilateral side

Art: Articular, I: Insertion, O: Origin, LF: Lateral Flexion, LR: Left rotation Lig: Ligament, nn: Nerve/s, SP: Spinous process, TVP: Transverse process.

(Adapted from Simons, Moore and Dalley, 2006; Middleditch and Oliver, 2005; Travell and Simons, 1999)

2.3.6 THE BLOOD SUPPLY OF THE VERTEBRAE OF THE CERVICAL SPINE

Vertebral arteries and ascending cervical arteries give rise to segmental arteries (Moore and Dalley, 2006; Bergmann, Peterson and Lawrence, 1993).

- A typical vertebra is supplied by segmental arteries.
- Segmental artery supplies little branches to the vertebral body.
- The dorsal branches supply the spinous processes.
- Spinal branches enter the vertebral canal via the IVF and supply the periosteum, bones and ligaments that form the inner walls of the vertebral canal.

2.3.7 THE VENOUS DRAINAGE OF THE VERTEBRAL COLUMN

The spinal veins form a venous plexus along the vertebral columns (Moore and Dalley, 2006; Bergmann, Peterson and Lawrence, 1993).

- The internal vertebral venous plexus forms internally and communicates with the occipital and basilar sinuses of the skull superiorly via the foramen magnum.
- The external venous plexus forms externally.
- The basivertebral veins within the vertebral body drain into both the internal and external vertebral venous plexus.

2.3.8 THE NERVE SUPPLY OF THE VERTEBRAL COLUMN

There are eight pairs of cervical spinal nerves (C1-C8) (Standring, 2008), that arise from the spinal cord and exit through the IVF. The first cervical nerve exits the vertebral canal between the occiput and the atlas. The other cervical nerves lie above the cervical vertebra with the corresponding number, except for the eighth cervical nerve which exits below the seventh cervical vertebra (Middleditch and Oliver, 2005). The spinal nerves originate from the spinal cord via nerve rootlets that converge to form the ventral (anterior) root and the dorsal (posterior) root (Moore and Dalley, 2006). These two roots then unite forming a mixed spinal nerve which divides into the dorsal primary rami and ventral primary rami (Standring, 2008; Moore and Dalley, 2006). The sinuvertebral nerves originate from one or two rami communicantes (Middleditch and Oliver, 2005) and it gives rise to the posterior vertebral plexus (Bogduk, 2003). The anterior vertebral plexus originates from the cervical sympathetic trunks and the vertebral nerve is formed by branches of the cervical gray rami communicantes (Bogduk, 2003). The structures supplied by the above mentioned nerves and rami are summarised in the **Table 2.5**.

Table 2.5: The nerve supply of structures within the cervical spine

Nerve/Rami	Structures innervated
Cervical dorsal rami	Synovial joints of the vertebral column and posterior neck muscles.
Cervical ventral rami	Prevertebral and lateral neck muscles.
C1	Atlanto-occipital joint.
C2	Lateral atlanto-axial joint.
Sinuvertebral nerve (C1,C2,C3)	Atlanto-dental joint, dura mata and cervical spinal cord.
Paravertebral plexus	Periosteum of VB, ALL and PLL. Anterior aspect of IVD is supplied by the anterior plexus. Posterior aspect of IVD is supplied by the posterior plexus.
Vertebral nerve	Lateral aspect of IVD.

VB: Vertebral body; ALL: Anterior longitudinal ligament; PLL: Posterior longitudinal ligament; IVD: Intervertebral disc

(Adapted from Standring, 2008; Moore and Dalley, 2006; Middleditch and Oliver, 2005; Bogduk, 2003)

2.4 BIOMECHANICS OF THE CERVICAL SPINE

2.4.1 CERVICAL CURVE

In utero, the entire vertebral column is in the flexed position (Middleditch and Oliver, 2005). The cervical curve is a secondary curve (Moore and Dalley, 2006) as it begins to develop at three months intrauterine (Middleditch and Oliver, 2005). However, it only becomes noticeable during infancy when the infant begins to hold up his head (Moore and Dalley, 2006) and sits upright at six to nine months (Middleditch and Oliver, 2005). The function of the cervical curve is to balance the centre of gravity of the skull over the spine and to add resilience to the spine in response to any axial compression forces that were exerted (Bergmann and Peterson, 2011). The cervical curve is concave posteriorly (Moore and Dalley, 2006) and forms a lordotic curve (Standring, 2008). There are conflicting studies to determine what the cervical curve measurement should be and exactly how it should be measured (Bergmann and Peterson, 2011) which accounts for the different measurement values of the angle of cervical lordosis as 23.4° (McAviney *et al.*, 2005) and 40° (Yochum and Rowe, 2005).

A decrease in the cervical curve is known as a hypolordosis, which causes more weight to shift onto the vertebral bodies and discs (Bergmann and Peterson, 2011). As a result, the posterior neck muscles also have to increase their protective function (Bergmann and Peterson, 2011). An increase in the cervical curve is called hyperlordosis, which causes an increase in the compressive load on facets and posterior elements of the cervical spine (Bergmann, Peterson and Lawrence, 1993). The degree of the lordosis can be determined by the facet angulation, IVD planes (Bergmann and Peterson, 2011), and ligament and muscle attachment (Bogduk, 2003). Studies have previously indicated that the cervical lordosis can be affected by factors such as the sagittal orientation of the cervico-thoracic junction (Tsang, Szeto and Lee, 2013), gender and race (Christensen and Hartvigsen, 2008) as well as diseases like degenerative joint disease (Wiegand *et al.,* 2003). The above mentioned factors may result in either an increase or decrease in the cervical lordosis (Bergmann and Peterson, 2011).

2.4.2 RANGE OF MOTION OF THE CERVICAL SPINE

The range of motion that exists in the cervical spine is both at an intersegmental spinal level (between vertebrae) and at a global or regional spinal level (Middleditch and Oliver, 2005; Bergmann and Peterson, 2011). The different ranges of motion that can occur in the cervical spine are: forward flexion, extension, lateral flexion (side-bending), and rotation (Moore and Dalley, 2006). The range of motion of the cervical spine has shown to differ slightly in various studies. The results of two such studies are shown in **Table 2.6**.

Table: 2.6 Range of motion within the cervical spine according to two studies

Movement	Feipel *et al.*, 1999	Bergmann and Peterson, 2011
Flexion	65°	60°
Extension	57°	75°
LR	72°	80°
RR	72°	80°
LLF	44°	45°
RLF	44°	45°

LR-Left rotation, RR-Right rotation, LLF-Left lateral rotation, RLF-Right lateral flexion

(Adapted from Bergmann and Peterson, 2011; Feipel et al., 1999)

Factors affecting the movement at a motion segment may include the thickness of the IVD, the compliance of its fibrocartilage and the shape and dimensions of the vertebral end plate (Middleditch and Oliver, 2005). Statistical analysis has revealed a difference in cervical range of motion in the different gender groups (Strimpakos, 2011; Smith and Fryer, 2008 and Stemper, Yoganandan and Pintar, 2003). Females are shown to have shorter vertebral end plates than males, which are one of the reasons they have a greater range of motion than males of a comparable age (Strimpakos, 2011; Smith and Fryer, 2008 and Stemper, Yoganandan and Pintar, 2003). A study conducted by Stemper, Yoganandan and Pintar (2003) revealed that an increase in any of the segmental motions can lead to increased stretch which results in pain being produced in the innervated structures of the affected level within the cervical spine (Smith and Fryer, 2008). The ligaments, muscles and shape and orientation of the articular facets of the cervical spine determine the direction of movement, guide the type of movement and determine the amount of movement that is possible at a motion segment (Middleditch and Oliver, 2005).

A comprehensive assessment of a patient with neck pain includes the measurement of the range of motion of the neck (Strimpakos, 2011). The cervical range of motion (CROM) Goniometer is used to measure the range of motion (ROM) in the cervical spine. An increase in ROM could be a result of an increase in ligament laxity as seen in rheumatoid arthritis (Yochum and Rowe, 2005). Reduced cervical range of motion, at a segmental or multiple segmental level, is a common finding in patients presenting with neck pain (Rudolfsson, Bjorklund and Djupsjobacka, 2012; Kanlayanaphotporn, Chiradejnant and Vachalathiti, 2009). Causes of reduced ROM may be as a result of degenerative joint disease (Yochum and Rowe, 2005; Wiegand *et al.,* 2003), myofascial trigger points (MFTPs) in the cervical muscles as well as conditions such as ankylosing spondylitis and other pathologies causing ankylosis of the cervical spine (Yochum and Rowe, 2005).

2.4.3 SPINAL COUPLED MOTION

Spinal coupled motion is described as the involuntary segmental coupling of one plane of motion with another and is attributed to the combination of ligamentous tension, IVD mechanics and the anatomical joint plane (Fryer, 2011; Gibbons and Tehan, 1998). There are two types of spinal coupled motions (Type 1 and Type 2). Type 1 coupled motion is described as the coupling of the contralateral rotation and side bending and is thought to occur when the spine is in the neutral position. Type 2 coupled motion is described as coupling of the ipsilateral rotation and side bending (Fryer, 2011). The cervical spine however, displays variability in the upper and lower regions (Fryer, 2011; Cook *et al*., 2006). Cook *et al*. (2006) conducted a systemic review on the coupling behaviour of the cervical spine. The results of the study indicated that in the lower cervical spine the spinal coupling is ipsilateral rotation and lateral flexion. Whilst this may be the case for the lower cervical spine, the study further indicated that the upper cervical spine displays variation in the spinal coupling motion and that contralateral rotation and lateral flexion may exist suggesting that an improvement in rotation to one side may also have an improvement in the contralateral lateral flexion.

2.5 DEFINITION OF NECK PAIN

Neck pain describes pain originating in the area bound laterally by the lateral borders of the neck, superiorly by the superior nuchal line and inferiorly by an imaginary line running through the tip of the spinous process of the first thoracic vertebra (Bogduk, 2003). According to Munchikanti *et al*., (2013) persistent chronic neck pain is found in 60% of patients for a year, or longer, after the initial episode. Grieve (1988) describes chronic pain as being pain experienced for a period of six weeks or longer and acute pain as pain experienced for less than six weeks. A new conceptual model, proposed by The Neck Pain and Task Force (2008) describes neck pain as an episodic occurrence experienced over a lifetime with the recovery being inconstant between the episodes (Haldeman *et al*., 2008).

2.6 ETIOLOGY OF NECK PAIN

Neck pain has many causes and is categorised between pathological causes and non-pathological causes (Dennison and Leal, 2011; Guzman *et al*., 2008, Doherty, Lanyon and Ralston, 2002; Moore and Dalley, 2006).

2.6.1 NON-PATHOLOGICAL CAUSES

- Mechanical factors: Degenerative joint disease
  Facet joint dysfunction
  Facet syndrome
- Muscle related : Muscle spasm
  Muscle strain
  Myofascial trigger points
  Torticollis

2.6.2 PATHOLOGICAL CAUSES

- Trauma : Dislocation (e.g. Facet dislocation)
  Fracture
  Whiplash
- Metabolic : Osteoporosis
  Paget's disease
- Inflammatory : Osteomyelitis
  Rheumatoid Arthritis

2.7 THE DEFINITION OF MECHANICAL NECK PAIN (MNP)

MNP is a non-pathological type of neck pain and is of a multidimensional nature (Jensen and Harms-Ringdahl, 2007). There appears to be wide variability in defining neck pain (Hoy, Protani and Buchbinder, 2010; Fejer, Kyvik and Hartvigsen, 2006). Dennison and Leal (2011) attribute the cause of variability to physical and psychosocial contributing factors. For this reason, any symptomatic disorder of the cervical spine that cannot be diagnosed is assigned the term non-specific neck pain (Dennison and Leal, 2011).

The term MNP has been used synonymously with non-specific neck pain by many authors and clinicians (Dennison and Leal, 2011; Binder, 2007). MNP is described as any event or condition that could lead to an alteration in joint mechanics or muscle function (Bergmann and Peterson, 2011). These events could be caused by incorrect posture, ageing and/or generated from acute injury to the cervical spine (Bergmann and Peterson, 2011). Munoz-Munoz *et al.* (2012), describe MNP as pain in the cervical spine and/or in the shoulder with symptoms aggravated by neck movements and postures as well as palpation of the cervical muscles which is in accordance with Vincent *et al*. (2012) and Kanlayanaphotporn, Chiradejnant and Vachalathiti, (2009) whose studies reveal similar findings. The pathology behind MNP is poorly understood but can be related to dysfunctions in the zygapophyseal joints, ligaments, IVDs, neural tissue and muscles in the cervical spine (Martinez-Segura *et al*., 2006; Simons, Travell and Simons, 1999). An inability to explore all the causes of MNP including the psychosocial factors could potentially contribute to the development of chronic mechanical neck (CMNP) (Fernandez-de-las-Penas, Cleland and Huijbregts, 2011). Grieves (1988) describes CMNP as MNP that lasts for a period of six weeks or longer and acute MNP as MNP experienced for a period of less than six weeks.

2.8 DIAGNOSIS OF MECHANICAL NECK PAIN

A diagnosis of mechanical neck pain can be made according to the following criteria (Bergmann and Peterson, 2011; Grieve, 1988):

- Localized cervical spine pain that is with or without arm pain,
- Apposition of hypo-/hyper-mobile segments of the cervical spine that are as a result of spondylitic changes,
- Asymmetrical neck pain that increases as the day progresses and is intensified by activities such as driving, repetitive lifting (especially of heavy or large objects), computer use and reading,
- Occipital pain and neck pain that is unilateral,

- Movements that are restricted and painful, especially rotation and lateral flexion of the neck towards the painful side and / or
- Myofascial trigger points or prominent neck muscles especially levator scapulae and the upper and middle fibers of the trapezius muscle.
- A diagnosis of CMNP can be made if the patient is experiencing neck pain for a period of six weeks or longer (Grieve, 1988).

2.9 THE CAUSES OF MECHANICAL NECK PAIN

2.9.1 BIOMECHANICAL AND ANATOMICAL FACTORS

According to Vernon (1988), abnormal mechanical function can be described as “pathomechanics”. Vernon (1988) further suggests that muscles and joints as well as muscle inhibition which may cause altered movement patterns can all lead to MNP as a result of altered biomechanics of the cervical spine. According to Bogduk (2003), any structure within the cervical spine that is innervated is a potential source of neck pain. This means that zygapophyseal joints, posterior neck muscles and intervertebral joints may all be potential causes of MNP (Bogduk, 2003). Changes in the cervical curve, such as hypolordosis, may also cause and increase strain on the posterior muscles, which could result in pain (Bergmann and Peterson, 2011).

2.9.2 POSTURE RELATED CAUSES

Poor posture is identified as a contributing factor to MNP. A positive correlation has been found between posterior cervical muscle dysfunction, forward head posture (FHP) and round upper back posture. Research also suggests that FHP is often associated with large breasts, increased thoracic kyphosis and rounded shoulders (Quek *et al*., 2013; Silva and Johnson, 2013; Ciesla and Polom, 2010; Szeto, Straker and Raine, 2002; Raine and Twomey, 1997). Sustained neck postures or movements also affect the cervical structure with resultant MNP (Strimpakos, 2011). Authors like Grieve (1988) and Vernon (1988) hypothesize that those compressive forces on the facet joints could be as a result of poor posture. Based on the three-way link between joints, muscles and the central nervous system, it can be concluded that muscle dysfunction can lead to poor posture which in turn causes more strain on the cervical zygapophyseal joints which may result in MNP (Bergmann and Peterson, 2011; Liebenson, 1996; Grieve, 1988; Vernon, 1988). The opposite may also be true, in that the zygapophyseal joints in the cervical spine are richly supplied with afferent stimuli. Degeneration of these joints and soft tissues can lead to alteration in the discharge of the afferent impulses which results in the disturbance in posture and balance (Middleditch and Oliver, 2005).

2.9.3 DEGENERATIVE JOINT DISEASE

Degenerative joint disease is a common physiologic manifestation (Wiegand *et al*., 2003). Synovial joints in the cervical spine are designed to withstand wear, however heavy use over a prolonged period of time can result in degenerative changes (Moore and Dalley, 2006). The articular cartilage loses its ability to carry out its function as a shock absorber which inevitably makes it more vulnerable to repeated frictions from movement of the neck. The result is most often pain (Moore and Dalley, 2006). Pathomechanical alterations of cervical geometry and loading are implicated in patients with degenerative joint disease that experience neck pain. A study conducted by Wiegand *et al*. (2003) identified five geometric variables (**Figure 2.5**) that positively correlate with the development of degenerative disease in the cervical spine. These five variables which were found to be 79% predictive are C2 angle, C3 disc angle, C5 posterior disc height, gravitational line and the flexion angle of the lower radius of curvature. A decrease in these five variables are thought to cause anterior head translation which results in increased loading, mechanical stress as well as unbalanced pressure gradients acting on the anterior cervical column. These results are also in accordance with the findings of Bergmann and Peterson (2011), who suggest that a decrease in the radius (as seen in **Figure 2.5**) will result in a decrease in the cervical curve thus resulting in a hypolordotic cervical spine curve. Hypolordosis has the ability to shift more weight anteriorly onto the vertebral body and disc therefore increasing the effort of the posterior neck muscles (Bergmann and Peterson, 2011).

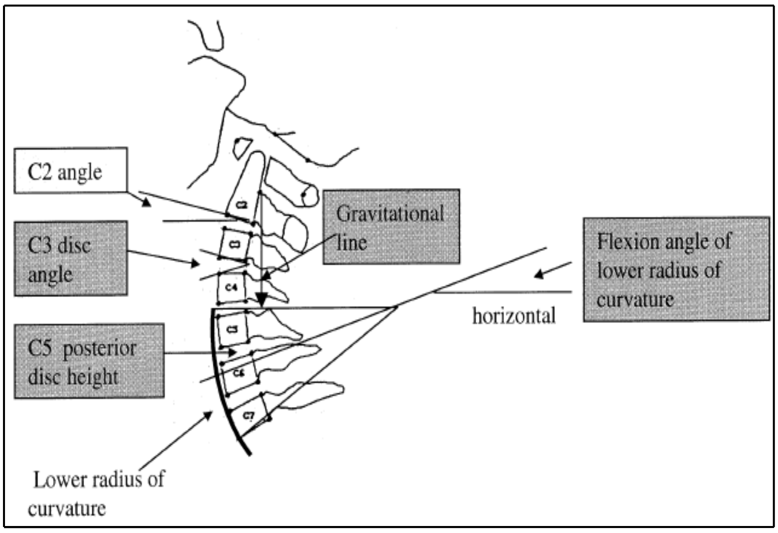


Figure 2.5: The 5 geometric variables correlating with the development of degenerative disease in the cervical spine (Adapted from Wiegand *et al*. (2003)with permission (Appendix N)).

2.9.4 INTERVERTEBRAL DISC DISEASE

According to Bogduk (2003), a structure needs to be innervated in order for it to be a source of pain. This belief may therefore imply that the IVD could potentially be a source of pain (Bogduk, 2003). Posterolateral cervical disc herniation's are rare but could occur as a result of degenerative changes to the posterior annulus which allows transverse annular bulges to protrude posteriorly (Middleditch and Oliver, 2005). These bulges may result in compression of the spinal cord thus producing symptoms of a cervical myelopathy (Middleditch and Oliver, 2005; Bogduk, 2003). Degeneration of the IVD is a common finding with an increase in age (Bergmann and Peterson, 2011; Middleditch and Oliver, 2005; Wiegand *et al*., 2003). Tsai *et al*. (2012) suggests that degenerative changes of the IVD and impingement in the IVF commonly occur at C5/C6 and C6/C7 spaces. The preloaded state provides the IVD with resistance to compressive forces (Bergmann, Peterson and Lawrence, 1993). With an increase in age, exposure to biomechanical stresses changes the composition of the IVD making it more fibrous. This causes less water to be absorbed and hence decreases the preloaded state (Bergmann and Peterson, 2011; Bergmann, Peterson and Lawrence, 1993). A diseased IVD causes forces to be distributed in different directions, which results in more forces being exerted on the facet joints that leads to dysfunction and degeneration and hence result in pain (Bergmann, Peterson and Lawrence, 1993). The Kirkaldy-Willis' model may be used to demonstrate that the reverse may also be true (Kirkaldy-Willis, 1992). The model shows that joint hypomobility is believed to initiate the degenerative cycle through the development of altered segmental biomechanics (Bergmann, Peterson and Lawrence, 1993; Kirkaldy-Willis, 1992).

2.9.5 CERVICAL FACET DYSFUNCTION OR SYNDROME

A change in the joint mechanics that results in reducing the optimum functioning of the joint is termed joint dysfunction (Bergmann and Peterson, 2011; Saayman, Hay and Abrahamse, 2011). A non-lethal injury to the facet joints in the cervical spine are potential sources of MNP (Schneider *et al*., 2012; Quinn and Winkelstein, 2007) and have been linked to the development of cervical facet syndrome which may lead to acute and chronic MNP (Uhrenholt *et al*., 2009). Evidence suggests that the prevalence of facet joint mediated pain ranges between 36% - 67% (Munchikanti *et al*., 2013; Lord *et al*., 1996). By way of the three-joint complex one vertebra is linked to the adjacent vertebra by the IVD and the two zygapophyseal joints (Bergmann and Peterson, 2011; Bergmann, Peterson and Lawrence, 1993). This suggests that degenerative changes in the IVD may result in more weight-bearing on the zygapophyseal joints and hence result in degenerative changes in the joint which results in changes in the functioning of the joint. This understanding is also in accordance with the findings of Kirpalani and Mitra (2008) who suggest that cervical facet joint dysfunction is a result of minor trauma and / or degenerative changes.

The capsule that surrounds the zygapophyseal joint is richly innervated with nociceptors for pain and mechanoreceptors for proprioception (Bergmann and Peterson, 2011). Activation of the nociceptors results in pain whilst activation of the mechanoreceptors results in the inhibition of nociceptors (Bergmann, Peterson and Lawrence, 1993). The joint has a nerve supply and this makes it a source of pain which can be activated by excessive or abnormal weight bearing or forces (Bogduk, 2003). Any irritation to the joint capsule can cause pain (Schneider *et al.*, 2012; Bergmann and Peterson, 2011; Bogduk, 2003). A gold standard for detecting joint dysfunction does not exist (Bergmann and Peterson, 2011; Kirpalani and Mitra, 2008). A diagnosis is therefore based on presenting symptoms and physical findings (Bergmann and Peterson, 2011). An orthopaedic Kemp's Test may be suggestive of cervical facet syndrome or dysfunction if there is local tenderness at the joint (Magee, 2006). Motion palpation findings may also be used to find a dysfunctional facet joint (Bergmann and Peterson, 2011; Magee, 2006). **Table 2.7** provides a list of the clinical features of cervical facet dysfunction.

Table 2.7: The clinical features of a joint dysfunction

CLINICAL FEATURES OF A JOINT DYSFUNCTION
Local palpatory tenderness
Decreased or altered joint movement
Altered or painful joint play
Local pain (which commonly changes with movement)
Altered or painful end-feel
Decreased cervical range of motion

(Adapted from Bergmann and Peterson, 2011; Kirpalani and Mitra, 2008; Fernandez-de-las-Penas, Alonso-Blanco and Miangolarra, 2007)

2.9.6 MYOFASCIAL TRIGGER POINTS IN THE DEVELOPMENT OF MNP

2.9.6.1 DEFINITION

Myofascial trigger points (MFTPs) have been proposed to be involved in the pain processes of MNP (Simons, Travell and Simons, 1999). MFTPs are described by Simons, Travell and Simons (1999), as a distinct focus in taut bands of any skeletal muscle which may be felt as a nodule. These are tender on palpation and may produce an autonomic phenomenon once compressed.

The autonomic phenomenon include: Abnormal lacrimation, persistent coryza, abnormal sweating, excessive salivation and proprioceptive disturbances e.g. loss of balance, dizziness, tinnitus and distorted perception of the weight of objects (Simons, Travell and Simons, 1999).

MFTPs may be either active or latent (Simons, Travell and Simons, 1999). Active MFTPs in the cervical muscles produce symptoms such as the autonomic phenomenon, pain and restricted movement. Latent MFTPs will only present with pain on compression as well as the referred pain pattern of that muscle (Simons, Travell and Simons, 1999). It is imperative to treat the latent MFTPs as it is highly probable that they may become active once the muscle is overloaded, even if slightly overloaded (Mehdikhani and Okhovatian, 2012). Other factors that may activate a MFTP are psychological stress, repetitive overuse of muscles; sustained overload of the muscle or even other MFTPs in the surrounding area (Dennison and Leal, 2011). Treaster *et al.* (2006) conducted a study in which the results identified computer usage as a contributory factor to the development of MFTPs, which resulted in mechanical neck pain. Static postural and visual stress has also been identified as causative factors in the development of MFTPs causing MNP (Treaster *et al*., 2006).

2.9.6.2 THE KEY CHARACTERISTIC FEATURES OF A MFTP

It is imperative to isolate MFTPs from normal tender points to ensure that proper treatment can be utilized for maximum treatment effect (Meseguer *et al*., 2006).

According to Mehdikhani and Okhovatian (2012), Meseguer *et al*., (2006) and Huguenin (2004), the key characteristic features of a MFTP include:

- The presence of referred pain (pain felt elsewhere in the body),
- The autonomic phenomenon,
- Local twitch response of the muscle,
- Muscle contracture and / or
- Jump sign (whole body moves in response to pressure applied to the MFTP).

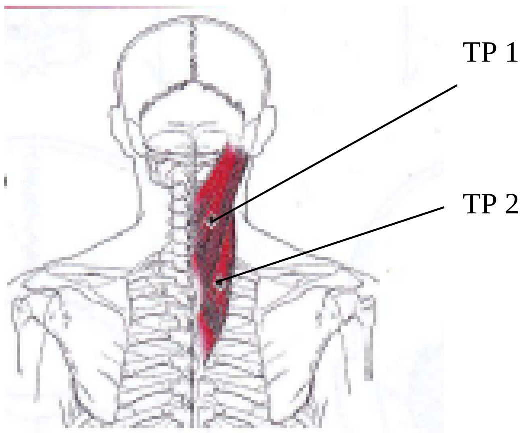
2.9.6.3 THE LINK BETWEEN MFTPS AND JOINT RESTRICTIONS FOUND IN MNP

The most common MFTPs contributing to MNP has been identified as the trapezius muscle, the posterior cervical muscles, levator scapulae muscle and suboccipital muscles (Bennett, 2007). According to Fernandez-de-las-Penas, Alonso-Blanco and Miangolarra, (2007) a plausible relationship between MFTPs of the upper fibers of the trapezius muscles and cervical impairment may exist. Cervical impairment refers to hypomobility, improper gliding of joints over each other and an increase in resistance at end-feel (Bergmann, Peterson and Lawrence, 1993). It is hypothesized that increased tension on taut bands as well as an increase in muscle activity can result in an increase in the stress placed on the joint and the development of a MFTP and this could provoke the joint dysfunction (Simons, Travell and Simons, 1999). One of the contributing factors to discomfort during computer use is due to active MFTPs (Hoyle *et al.,* 2011; Treaster *et al*., 2006). Alternatively, it has been hypothesized that a MFTP may be activated by abnormal sensory input from a dysfunctional joint (Fernandez-de-las-Penas, Alonso-Blanco and Miangolarra, 2007). Ruiz-Saez *et al.* (2007) hypothesised that treatment of an intervertebral joint could possibly produce a therapeutic effect on the MFTP. The results of their study showed a positive therapeutic outcome of the trapezius muscle MFTP after the dysfunctional joint was manipulated.

2.9.6.4 MYOFASCIAL TRIGGER POINT REFERRAL PATTERNS

Myofascial pain as a result of MFTPS is very common in MNP (Simons, Travell and Simons, 1999). The trapezius muscle, the posterior cervical muscles, levator scapulae muscle and suboccipital muscles will be discussed as these are some of the main muscles identified in the development of MNP (Bennett, 2007). **Table 2.4** provides the anatomical attachments of the muscles discussed in this section. The abbreviation 'TP' refers to the MFTP.

2.9.6.4a THE POSTERIOR CERVICAL MUSCLES



The posterior cervical muscles usually have latent MFTPs present (Bennett, 2007). The image shows the splenius capitis and cervicis muscles. The MFTPs, TP1 and TP2, may be found in the muscle belly (Vizniak, 2010) along the length of the posterior cervical muscles (Simons, Travell and Simons, 1999) (**Figure 2.6)**. Pain from the MFTP is referred over the posterior aspect of the neck, the top of the head and above the ear (Vizniak, 2010). Activation of these MFTPs results in restricted flexion and rotation of the cervical spine (Simons, Travell and Simons, 1999). MFTPs in these muscles are often as a result of decreased lordosis which causes the posterior cervical muscles to take strain (Bergmann and Peterson, 2011).

Figure 2.6 : Sketch of the Posterior Cervical Muscle Showing the trigger point location
(Adapted from Vizniak (2010) with permission (Appendix 0))

2.9.6.4bTHE LEVATOR SCAPULAE MUSCLE

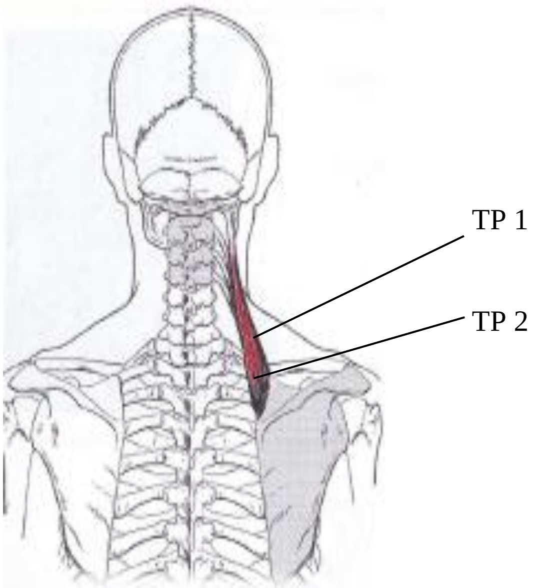


Figure 2.7 : Sketch of the Levator Scapulae muscle showing trigger point location

(Adapted from Vizniak (2010) with permission)

The levator scapulae muscle is referred to as the "stiff neck muscle". There are two MFTPs (TP1 and TP2) in this muscle. **Figure 2.7** shows the location of the MFTPs. TP1 is located at the angle of the neck, as the muscle emerges from under the trapezius muscle. TP2 is located at the attachment of the levator scapulae muscle to the scapula (Vizniak, 2010). The activation of the MFTPs in this muscle limits the rotation movement of the cervical spine and pain is often referred to the base of the neck (Simons, Travell and Simons, 1999). The referred pain also spills over to the medial border of the scapula and posterior shoulder (Vizniak, 2010; Simons, Travell and Simons, 1999). A study conducted by Fernandez-de-las-Penas, Alonso-Blanco and Miangolarra, (2007) indicated that MFTPs in this muscle was commonly found in patients with MNP. The pain is often described as lancinating or sharp (Bennett, 2007).

2.9.6.4c THE SUBOCCIPITALMUSCLE

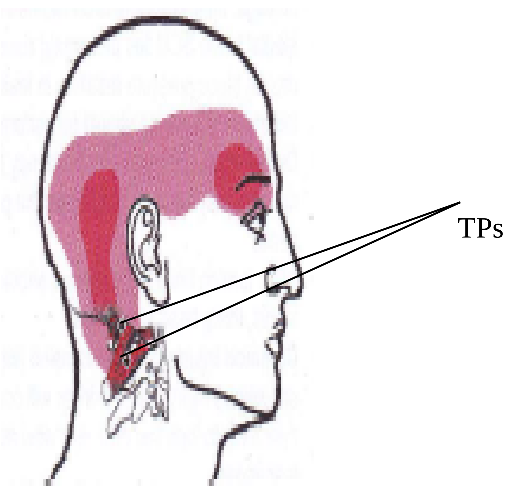


Figure 2.8 : Sketch of the Suboccipital Muscle Showing trigger point location

(Adapted from Vizniak (2010) with permission)

The MFTPs **(Figure 2.8)** are located in the mid belly of the muscle (Vizniak, 2010). MFTPs in this muscle affect head rotation (Simons, Travell and Simons, 1999). MFTPs in the suboccipital muscles are the most prevalent in chronic-tension type headaches (Fernandez-de-las-Penas *et al.*, 2010). A study on the presenting MFTPs in MNP patients revealed that the presence of suboccipital MFTPs were the most prevalent in patients presenting with headaches (Fernandez-de-las-Penas, Alonso-Blanco and Miangolarra, 2007).

2.9.6.4d. THE TRAPEZIUS MUSCLE

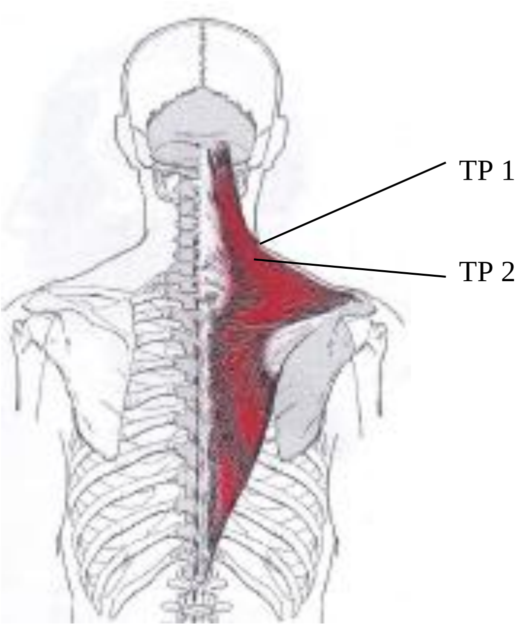


Figure 2.9: Sketch of The Trapezius Muscle Showing the trigger point location
(Adapted from Vizniak (2010) with permission)

The trapezius muscle is the muscle that mostly experiences MFTP activation (Yoon *et al.,* 2009; Treaster *et al.,* 2006). TP1 and TP2 (**Figure 2.9**) contribute to the cause of MNP as the upper part of the muscle plays a role in movement of the neck (Simons, Travell and Simons, 1999). These MFTPs may be commonly found in MNP (Munoz-Munoz *et al*., 2012). TP1 is located in the mid portion of the middle vertical fibers and more anteriorly located and the referred pain pattern is centred on the side of the neck, the temple and the angle of the jaw (Vizniak, 2010; Simon, Travell and Simon, 1999). TP2 is located on the horizontal fibers of the middle portion. Pain is referred to the higher cervical paraspinal muscles (Vizniak, 2010; Simons, Travell and Simons, 1999). A study conducted by Treaster *et al.* (2006) identified that MFTPs in the trapezius muscle can be easily activated by computer usage and could activate other muscles in the area (Bennett, 2007).

2.9.7 PSYCHOSOCIAL FACTORS CAUSING MNP

Psychosocial factors, for example stress and depression, have been identified in research as the link between MNP and the healing of the affected tissues in MNP (Keijsers *et al.,* 2010; Carroll *et al*., 2008; Karels *et al*., 2007). This ultimately suggests that failure to assess psychosocial factors is one of the reasons for acute MNP progressing into chronic MNP (Dennison and Leal, 2011). Patients with depression and anxiety are more likely to complain of pain (Schneider *et al*., 2012; Henderson and Bass, 2006; Velly, Gornitsky and Philippe, 2003). Depressed patients often present to the clinician with pain and often have a poor perception of their ability to cope with pain (Henderson and Bass, 2006). A significant concept with patients is the fear-avoidance behaviour (Dennison and Leal, 2011; Henderson and Bass, 2006). Patients tend to avoid the activities they would normally take on in the fear that it would cause them pain. Alternatively, the inability to carry out activities of daily living contributes to the development of depression in the patient (Henderson and Bass, 2006).

Christensen and Knardahl (2010) suggest that MNP is present in workers even in the absence of biomechanical loads and that psychosocial factors could be involved in the pathogenesis of MNP.

Poor job satisfaction (Henderson and Bass, 2006) and high quantitative job demands (Cote *et al.*, 2009) are identified as possible psychosocial factors for the development of MNP. Other factors include low social support, conflicts at work and lack of supervisory support (Christenson and Knardahl, 2010; Keijsers *et al.,* 2010). The hypothesised pathophysiology of psychosocial factors causing neck pain is that sustained muscle contraction with an increase in the metabolic demands (stress and anxiety) of the muscle fibers may be far greater than the energy supply. This results in an energy crisis which then produces pain (Schneider *et al.*, 2012; Christenson and Knardahl, 2010).

2.9.8 OCCUPATION AND STUDY RELATED CAUSES OF MNP

In the working population, neck disorders are associated with a high burden of pain and disability (Cote *et al.,* 2009). A study conducted by the Task Force on Neck Pain (Cote *et al.*, 2009) indicated that the prevalence of neck pain across occupations and populations varied substantially. Age also plays an important role in the development of work related neck pain (Cote *et al.*, 2009). According to Cote *et al*. (2009), neck pain was more prevalent in older workers in comparison to the younger workers. Mechanical factors contributing to MNP in the work place include: repetitive movements, uncomfortable position of the limbs and poor ergonomics (Ming, Narhi and Siivola, 2004). These mechanical factors result in development of muscle spasm and myofascial trigger points (MFTPs) causing MNP (Fernandez-de-las-Penas, Cleland and Huijbregts, 2011). MNP amongst students and workers has shown to correlate with the upsurge of computer usage on a daily basis (Brandt *et al*., 2004). Poor ergonomics associated with the use of computers have been identified amongst the contributory factors to MNP (Bruls, Bastiaenen and de Bie, 2013; Ming, Narhi and Siivola 2004). Poor posture and ergonomics may lead to overloading of the neck muscles and joints and hence the production of pain (Treaster *et al*., 2004; Ming, Narhi and Siivola 2004).

2.9.9 MUSCLE DYSFUNCTION AND SPASM CAUSING MNP

A muscle spasm occurs when one or more muscle groups undergo a sudden involuntary contraction (Moore and Dalley, 2006). A muscle spasm can be as a result of injury to the muscle itself (Middleditch and Oliver, 2005). A muscle can go into spasm as a protective mechanism, in the event of injury or inflammation to the surrounding structures in the neck (Moore and Dalley, 2006). Muscle spasm could also occur due to degeneration to the IVD with nerve root compression causing a decrease in the intervertebral space and hence produce paraspinal muscle spasm (Huguenin, 2004). Bergmann and Peterson (2011) suggest that hypolordosis may also contribute to muscle spasm in that more weight is shifted onto the vertebral body and discs which result in overloading of the posterior neck muscles and hence pain. Fernandez-de-las-Penas, Alonso-Blanco and Miangolarra (2007) have indicated that the reverse may also be true in that the muscle spasm of the local or intrinsic muscle could result in hyper/hypolordosis of the cervical spine. The study by Fernandez-de-las-Penas, Alonso-Blanco and Miangolarra (2007), also indicated that spasm of the global or extrinsic cervical muscles could result in restricted movement of the cervical spine and vice versa. Middleditch and Oliver (2005), suggest that asymptomatic muscle spasm could produce more compressive forces onto the IVD and other joints that may result in more pain.

2.10 RISK FACTORS FOR MECHANICAL NECK PAIN

The risk factors for mechanical neck pain can be categorised into various categories and sub-groups (Haldeman *et al*., 2008). The two categories are: work-related or non-work related risk factors and the sub-groups are: physical risks, psychosocial risks and individual risks (Dennison and Leal, 2011).

2.10.1 WORK-RELATED RISKS:

- Poor ergonomics
- Poor job satisfaction
- Repetitive work
- Stressful or high demanding jobs

2.10.2 NON-WORK RELATED RISKS:

- Age (approximately 35-50 years of age)
- Female gender
- Psychosocial factors

2.11 PROGNOSIS OF MECHANICAL NECK PAIN

The prognosis of MNP is variable and is dependant of a number of factors (Dennison and Leal, 2011). Poor prognostic variables include: a history of neck pain, poor coping mechanisms, middle-aged (35-59) and poor job satisfaction. A favourable prognosis may be attributed to: younger age, social support (support from family and friends) and good coping mechanisms such as stress relieving activities (Dennison and Leal, 2011; Haldeman *et al*., 2008).

2.12 ASSESSMENT OF MECHANICAL NECK PAIN

When a patient presents with neck pain, it is imperative to rule out both red and yellow flags prior to the diagnosis of MNP. Red flags (**Table 2.8**) are indicators of a serious underlying pathology causing the neck pain (Nordin *et al*., 2009) and yellow flags are considered patient indicators of their behavioural and cognitive clinical presentation (Dennison and Leal, 2011). It is also important to distinguish whether the MNP is chronic or acute in nature (Grieve, 1988).

Table 2.8: The Red Flags Indicating Serious Pathology

RED FLAG	Example
Pain	Constant, progressive , intractable pain, tenderness over vertebral body
Trauma	Fractures or major dislocations
SC compromise	Cervical myelopathy
Tumours/malignancy	Hx of cancer, unexplained weight loss, failure to respond to tx for one month
Infections	Night sweats, fever, malaise
Systemic diseases	Inflammatory arthritis, ankylosing spondylitis
Past medical history	Human Immunodeficiency Virus, Tuberculosis, Surgery

SC: Spinal cord; Hx: history; tx: Treatment

(Adapted from Nordin *et.al.*, 2009 ; Doherty, Lanyon and Ralston, 2002)

2.12.1 THE ASSESSMENT OF RESTRICTED JOINTS CAUSING JOINT DYSFUNCTION

Motion palpation of the cervical spine is used to locate restricted segments to indicate a joint dysfunction. A positive motion palpation finding indicating a symptomatic joint was defined as meeting three criteria (Plaugher, 1993):

- An end feel that is abnormal,
- The quality of resistance to motion is abnormal and
- Pain reproduction on motion palpation.

2.12.2 ORTHOPAEDIC TESTS TO MAKE A DIAGNOSIS OF CERVICAL FACET SYNDROME

Orthopaedic tests are used for diagnostic purposes. These tests can provide information as to whether there is compression of a nerve root or whether there is a joint dysfunction. Local tenderness is usually indicative of a joint dysfunction or facet syndrome and pain referred down the arm is indicative of a more serious pathology such as nerve compression (Magee, 2006). The tests are described as follows:

a. *Lateral Compression Test*: the patient is seated. The cervical spine is placed into lateral flexion and a vertical force is exerted at the top of the head.
b. *Cervical Compression Test*: Patient is seated and an axial force is exerted to the patient's head thus loading the cervical spine.

c. *Kemp's Test*: The Doctor stands behind the patient and places his fingers at the spinal level being tested in the patient. The Doctor then rotates the patient's head to the side being tested, extends their neck and then laterally flexes the neck to the side being tested.

2.12.3 SUBJECTIVE MEASURES

Self-assessment questionnaires, such as the reliable and valid Numerical Pain Rating Scales and the Neck Disability Index (NDI) are often given to patients complaining of neck pain. The answers to these questionnaires can provide the clinician with useful information as to how they can manage their patient as well as provide guidance to the prognosis of the patient (Haldeman *et al.,* 20008). These questionnaires are discussed as follows:

2.12.3.1 NUMERICAL PAIN RATING SCALES

The Numerical Pain Rating Scale (NRS) is used to measure the pain levels of the patient as it has high sensitivity to change and generates data that can be statistically analysed for audit purposes (Misailidou *et al*., 2010). NRS was shown to be reliable (Ferreira-Valente, Pais-Ribeiro and Jensen, 2011) and can be used during consultations to demonstrate the percentage decrease or increase of the patient's subjective pain over time. The Numerical Pain Rating Scale-101 (NRS-101) can be used to measure the patient's pain levels and to monitor any changes in pain indicating whether the outcome of the treatment is successful or unsuccessful. It is also effective in showing very small changes (Ferreira-Valente, Pais-Ribeiro and Jensen, 2011). The patient is expected to rate their pain when it is at its worst and when it is at its least. Cleland, Childs and Whitman (2008) suggest that the NRS-101 has a fair to moderate test-retest reliability in patients with MNP. The minimal clinically important difference (MCID) is noted at 20-25mm on a 100mm line (Ostelo and de Vet, 2005; Lee *et al*., 2003).

2.12.3.2 NECK DISABILITY INDEX (NDI)

According to Howell (2011), neck pain related disability and function needs to be measured to adequately assess and establish pre and post treatment outcomes. The CMCC (Canadian Memorial Chiropractic College) Neck Disability Index (NDI) is the most common region specific tool that is utilized for the measurement of neck related disability (Dennison and Leal, 2011), that resulted from neck pain. This questionnaire is designed to facilitate the clinicians understanding of how the patients' neck pain affects their ability to manage activities of daily life (Vernon, 2008). The NDI has 10 questions with six options ranked from zero to five. The scores are totalled out of 50 and converted into a percentage which indicates the patients' disability before and after the treatment. Vernon (2008) and Cleland, Childs and Whitman (2008) have indicated that the NDI is highly reliable on the "test-retest” reliability. The MCID of the NDI is said to be between 10 (Young *et al*., 2009) and 10.5 points (Pool *et al.*, 2007). There is a high degree of validity and internal consistency of the CMCC NDI (Vernon, 2008).

<u>2.12.4 OBJECTIVE MEASUREMENT TOOLS</u>

<u>2.12.4.1 ALGOMETER</u>

The Algometer (manufactured by Wagner instruments: P.O Box 1217, Greenwich T 06836) is a reliable measuring tool and is used to measure the pressure pain threshold of a patient (Livingston, Bernadi and Carroll, 1998). The pressure pain threshold (PPT) is defined as that point where the minimal amount of pressure first changes to pain (Mehdikhani and Okhovatian, 2012). According to Livingston, Bernadi and Carroll (1998), “algometers are designed to quantify and document levels of tenderness via pressure threshold measurement and pain sensitivity via pain tolerance measurement”. The minimal clinically important difference (MCID) is noted at 15% or $1.5kg/cm^2$ (O’Leary *et al*., 2007; Potter, McCarthy and Oldham, 2006; Paungmali, Vincenzino, and Smith, 2003).

<u>2.12.4.2 CERVICAL RANGE OF MOTION (CROM) GONIOMETER</u>

Active range of cervical ROM is part of a clinician’s routine assessment when assessing patients with neck pain (Howell, 2011). Rudolfsson *et al.*, (2012) suggest that there is a decrease in range of motion in patients experiencing neck pain. The Cervical Range of Motion (CROM–manufactured by Performance Attained Associates Model: 3600 Labore Road, Suite 6, St Paul, MN 5511041144) Goniometer is shown to be a reliable measurement tool (Youdas, Carey and Garret, 1991) and is used to measure all the ranges of motion within the cervical spine (i.e. flexion, extension, lateral flexion and rotation). Lee, Nicholson and Adams (2005) found a clinically significant difference in ROM between patients with and without neck pain. Their study revealed that patients with neck pain have far less range of motion in extension than patients without neck pain (Lee, Nicholson and Adams, 2005).

2.13 MANAGEMENT OF MECHANICAL NECK PAIN

A United States study revealed that the economic burden in the management of neck pain is second only to that of low back pain in the annual workers compensation costs (Munoz-Munoz *et al*., 2012).

2.13.1 DIAGNOSIS AND MANAGEMENT BASED ON A CLASSIFICATION SYSTEM

Evidence–based management and treatment-based classifications are becoming essential and provide added value to the adequate management of patients (Bergmann and Peterson, 2011). The underlying premise is that dividing or classifying patients with neck pain into subgroups based on management strategies is more beneficial and may improve the outcome of the physical therapy intervention (Dennison and Leal, 2011; Guzmann *et al*., 2008; Haldeman *et al*., 2008; Groenier, 2006; Buchbinder et *al*., 1996). Classifications that may be used are the pathological and non-pathological classification of neck pain (**Section 2.6.1** and **2.6.2)** as well as chronic versus acute conditions. Pathological causes need to be identified and understood so that patients can be referred to the respective specialist for medical care. The Neck Pain Task Force has developed a four grade classification system (**Table 2.9**) on the severity of neck pain (Haldeman *et al*., 2008). This classification is intended to provide a better understanding and interpretation of scientific evidence (Haldeman *et al*., 2008). The patient is categorized and treatment intervention is based according to the category in which the patient's symptoms match the diagnosis (Haldeman *et al*., 2008).

Table 2.9: The four grade classification system of neck pain

GRADE	DESCRIPTION	MANAGEMENT
I	No major structural pathology. Interference with activities of daily living are minor/absent	Likely to respond to minimal intervention such as reassurance and pain control. Does not require investigation or continuous treatment.
II	No major structural pathology There is major interference with activities of daily living	Requires early activation and pain relief. Treatment aimed at preventing long-term disability.
III	No major structural pathology Neurologic signs present: presence of weakness, reduced tendon reflexes, and/or sensory deficits.	Require investigation and sometimes more invasive Treatment options.
IV	Major structural pathology such as: fractures, neoplasms, myelopathy and systemic diseases	Requires prompt investigation and treatment.

(Adapted from Haldeman *et al*., 2008)

2.14 TREATMENT INTERVENTIONS FOR MECHANICAL NECK PAIN

There are several treatment options available for the treatment of MNP (Haldeman *et al*., 2008). According to Martinez-Segura *et al*. (2006), the aim of treating patients with MNP is to reduce neck pain and to restore normal range of motion of the cervical spine. Treatment options include invasive and non-invasive treatments (Haldeman *et al*., 2008; Rickards, 2006).

2.14.1 NON-INVASIVE TREATMENT OPTIONS:

- Acupressure,
- Cryotherapy,
- Electro-modalities (Transcutaneous Electro Nerve Stimulation (TENS), Ultrasound, Interferential therapy, Low-level laser),
- Exercise and stretching,
- Heat therapy,
- Ischaemic compression and /or
- Massage.

2.14.2 INVASIVE TREATMENT OPTIONS:

- Acupuncture and/or
- Dry needling for the treatment of MFTPs (Simons, Travell, Simons, 1999).

A study conducted by Bibby (2006) showed that acupuncture is often used at a later stage when other treatments have been shown to be ineffective. The results of the study conducted by Bibby (2006) should that the use of acupuncture had a favourable outcome and may be used in the early stages of treatment.

2.14.3 MANUAL THERAPY

Manual therapy is a non-invasive treatment and is divided into two subcategories, those that produce joint motion and those that do not produce joint motion (Vernon, Humpherys and Hagino, 2007). Treatment options that produce joint motion include: manipulation, mobilization and manual traction. There is a moderate to high rate of evidence to show that treatment of MNP with mobilization and manipulation reveals pain relief for six, 12 and up to 104 weeks (D'Sylva *et al*., 2010; Vernon Humpherys and Hagino, 2007). A study comparing the effects of mobilisation and manipulation on MNP revealed that both these treatments have an equal treatment effect as well as patient satisfaction in the treatment of MNP (Gross *et al*., 2010). Hurwitz *et al.* (2009) recommends that treatment could also be based on patient preferences, as a manual therapy that may have worked favourably, may provide a better outcome for the patient if used again. Jensen and Harms-Ringdahl (2007) suggests that a multimodal treatment, which includes manual therapy and exercise therapy is also effective. After a review of the current literature it was established that one of the commonly used manual techniques in the treatment of MNP is Muscle Energy Technique (MET).

2.15 MUSCLE ENERGY TECHNIQUE

MET is a type of manual therapy (Fryer, 2011). It involves the use of an isometric or isotonic contraction of a patients muscle in an accurately controlled direction against a counter-force applied by a manual therapist. This contraction is voluntary and controlled entirely by the patient (Chaitow, 2006). This causes the muscle to pull on its attachment to the bone, thus moving one bone in relation to the bone it articulates with; therefore restoring normal joint range of motion and reducing the cervical joint restriction. MET can be utilized adequately in the treatment of weakened muscles, lymph drainage, restricted joints, and shortened muscles (Fryer, 2011). As a result of the isometric contraction theory, there is indirect joint mobilization (Greenman, 1996; Edwards, 1993). The isotonic contraction is used to strengthen the physiologically weakened muscle and to improve elasticity and circulation. The underlying therapeutic action may involve a variety of neurological and biomechanical mechanisms, including hypoalgesia, altered proprioception, motor programming and control and change in tissue fluid (Fryer, 2011).

2.15.1 THE EFFECT OF MET

MET can be utilized in the (Greenman, 1996):

- Lengthening of a shortened or spastic muscle,
- Strengthening of a physiologically weakened group of muscles or even a muscle individually,
- Reduction of localized oedema which results in the relieving of passive congestion and hence reducing pain and / or
- Mobilization of an articulation with a restricted mobility.

2.15.2 PHYSIOLOGICAL MECHANISMS OF MUSCLE ENERGY TECHNIQUE

2.15.2.1 PAIN RELIEF

The voluntary contraction used in MET is an isometric contraction (Chaitow, 2006). MET is also believed to bring about joint movement that may aid in pain relief because it is also believed that a limited or decrease in range of motion may result in pain (Schenk, Adelman and Rousselle, 1994). It is purported that the joint motion and the isometric muscle contraction during the application of MET brings about stimulation of the joint and muscle proprioceptors (Fryer, 2011). This theory suggests that mechanoreceptor signals are carried through large diameter afferent fibers, the main role being to inhibit nociceptive signals at the dorsal horn of the spinal cord. This often results in the inhibition of pain (Kisner and Colby, 2002; Fryer, 2000).

MET may increase fluid drainage and augment hypoalgesia (Fryer, 2011). Muscle contraction is believed to increase muscle blood flow rates as well as cause an increase in lymph flow rates (Fryer, 2011). Mechanical forces that are acting on the fibroblasts within the connective tissues cause changes in the interstitial pressure and cause an increase in transcapillary blood flow (Fryer, 2011). The application of MET may relieve passive congestion that may have built up in the paraspinal muscles due to injury and hence aid in relieving the pain. MET may result in inflammatory cytokine reduction and peripheral nociceptors desensitization (Chaitow, 2006; Fryer, 2000).

2.15.2.2 MET AND PROPRIOCEPTION

Spinal pain is believed to affect motor programming, disturb proprioception and motor control and inhibit paraspinal or deep muscles and cause over activity of the superficial muscles of the spine causing them to overact to stimuli (Fryer, 2011). Since the application of MET produces joint motion while recruiting muscles, it is purported to affect proprioception feedback, motor control and motor learning (Fryer, 2011; Fryer, 2000). The theory behind this is that since MET cause’s recruitment of the deep segmental muscles it assists the central nervous system in producing co-ordination and movement in a region (Fryer, 2011; Fryer, 2000).

2.15.2.3 MET APPLIED TO SPINAL DYSFUNCTION

Acute spinal dysfunction is characterized by local pain and limited motion which is brought upon by zygapophyseal joint sprain and inflammation. Following the joint sprain and inflammation, nociceptive pathways may become activated and release neuropeptides which promote tissue inflammation. The central nervous system may also be affected and ultimately result in inhibition of the deep segmental muscles and cause excitation of the superficial muscles which affect the quality of motion. When MET is applied to acute spinal dysfunction, it is believed to aid in the promotion of fluid drainage, proprioception and hypoalgesia (Middleditch and Oliver, 2005; Fryer, 2000).

Chronic spinal dysfunctions are characterised by limited range of motion, thickened tissues and pain and tenderness that is localized (Fryer, 2011). The nociceptive pathways may be sensitized and therefore interfere with proprioception which additionally affects the segmental muscle control. MET applied to chronic spinal dysfunctions therefore have an influence on proprioception and muscle control (Fryer, 2011). An increase in range of motion and a decrease in pain may also be attributed to the stimulation of trans-synovial flow within the capsule of the zygapophyseal joint (Fryer, 2011; Chaitow, 2006; Fryer, 2000). Movement of the joint, which is brought about by the application of MET, may produce fluctuations in the intra-synovial pressure within the joint capsule (Fryer, 2011; Chaitow, 2006; Fryer, 2000). This subsequently results in the flow of trans-synovial fluid out of the joint that results in a decrease in effusion which contributes to a decrease in pain and an increase in range of motion (Fryer, 2011; Chaitow, 2006; Fryer, 2000).

2.15.2.4 MET APPLICATION FOR INCREASING THE MUSCLE LENGTH

Studies have shown MET to be effective in increasing muscle length (Ballantyne, Fryer and McLaughlin, 2003; Bandy and Irion, 1994). MET is also considered to reset the neurological resting length of muscles (Ballantyne, Fryer and McLaughlin, 2003). Bandy and Irion (1994) suggest that MET may increase the muscle length by influencing the creep and plastic changes within the muscle. The creep refers to the temporary elongation of the connective tissue due to its viscoelastic properties and plastic is defined as the micro-tearing and remodelling of the connective tissue fibers (Fryer, 2000). It is hypothesized that hypertonic muscles of the neck as well as joint locking may decrease range of motion within the cervical spine and that lengthening of these muscles may increase the overall physiologic range of motion within the cervical spine (Burns and Wells, 2006). According to Ehrenfeuchter (2000 cited in Burns and Wells, 2006), the relationship that exists between restricted joints and a decrease in motion may result in a reflex hypertonicity of the muscles crossing the dysfunctional joint. It is believed that an increase in the muscle tone may compress the joint surfaces and result in "locking" of the articulation (Fryer, 2011; Burns and Wells, 2006). It is further suggested that restoration of the joint articulation may result in restoration of the distorted joint with reflex relaxation of the previously hypertonic muscles (Burns and Wells, 2006).

When measuring the range of motion of a joint, it is imperative to consider the other structures that may influence the movement of the joint (Bergmann and Peterson, 2011). The related structures include tendons, skin, connective tissue, joint capsules, ligaments and muscles (Bergmann and Peterson, 2011; Moore and Dalley, 2006). According to Johns and Wright (1962 cited in Ballantyne, Fryer and McLaughlin, 2003), muscles comprise 41% of the torque required to move a joint so any dysfunctions in the muscle may cause a reduction in the movement of a joint. Lederman (2005) suggests that the viscoelastic properties of the muscles are responsible for the increasing muscle flexibility after the application of MET and that another suitable explanation would be that during the isometric contraction the muscle lengthens and stretching of the connective tissue elements occur which provides a reason for the increase in the range of motion. Ballantyne, Fryer and McLaughlin

(2003) concluded in their study on hamstring muscle flexibility that the reason for the increase in the muscle flexibility was due to an increase tolerance to stretch and not due to viscoelastic properties.

2.15.2.5 MET AND MUSCLE FATIGUE AND ENDURANCE

MET entails the use of an isometric contraction or an isotonic contraction (Chaitow, 2006). Research shows that patients with neck pain have decreased muscle endurance and may not be able to maintain the full duration of the isometric contraction that is required in the application of MET thus resulting in a poor outcome (Edmondston *et al.*, 2011; Lee, Nicholson and Adam, 2005; Gosselin, Rassoulian and Brown, 2004). Research suggests that patients experiencing neck pain may have decreased muscle endurance and are more likely to experience muscle fatigue (Edmondston *et al.*, 2011; Lee, Nicholson and Adam, 2005). During an investigation on endurance of the posterior cervical muscles of the neck, Lee, Nicholson and Adams (2005) found that patients with neck pain could not maintain the full duration of contraction. This suggested that individuals with neck pain have a significant reduction of neck muscle strength (Edmondston *et al.*, 2011; Lee, Nicholson and Adams, 2005).

Gosselin, Rassoulian and Brown (2004) conducted a study to ascertain whether neck pain had an effect on muscle endurance. The results of the study revealed that muscle fatigue occurred in the patients with neck pain following an isometric contraction into extension. The asymptomatic patients of that study were able to maintain the contraction for the full duration of the isometric contraction as opposed to patients with neck pain who could not maintain the resistance against the isometric contraction.

2.15.3 THE CONTRA-INDICATIONS OF MET

MET is generally a safe technique to utilise (Fryer, 2011; Chaitow, 2006). If there is an underlying pathology, such as arthritis or osteoporosis, it does not rule out the possibility of MET application. The manual therapist will simply have to change the dosage and application of the MET in terms of the repetitions and the force (Chaitow, 2006).

2.15.4 SIDE-EFFECTS OF MET

There have not been any serious adverse effects reported in the literature (Fryer, 2011). Greenman (1996) suggests that the patient may experience some muscle soreness after the first 12 to 36 hours after the application of MET. MET requires a certain degree of muscular effort from the patient which generally requires energy utilisation (Fryer, 2011; Chaitow, 2006). During muscle contraction waste products such as carbon dioxide and lactic acid are produced which sometimes results in the patient experiencing a small amount of pain after the treatment (Fryer, 2011). Chaitow (2006) further stated that there might be a small degree of stiffness and soreness after treatment, but that is a normal feature of most manual treatments.

2.16 COMPARATIVE STUDIES

MET is usually advocated in instances where the high-velocity, low-amplitude (HVLA) manipulation is contra-indicated (Greenman, 1996). The HVLA manipulation entails a rapid non-forceful thrust which sometimes produces an audible "pop" or crack (Hamilton, Boswell and Fryer, 2007). MET is often seen as a safer alternate to manipulation and has revealed a decrease in CMNP and an increase in cervical range of motion following its application (Greenman, 1996). According to Fryer (2000), pain may be inhibited by any technique that produces movement of the joints or joint capsule, which results in stimulation of the joint proprioceptors.

According to Fryer (2011), although MET is an effective form of manual therapy, it still remains largely understudied. He further suggests that evidence regarding its technique variations could be beneficial to the practitioner. While there is need for further investigation into the MET, available evidence supports the use of MET for the treatment of restricted mobility and spinal pain (Fryer, 2011). Schwerla *et al*. (2008) revealed a decrease in the pain intensity levels of patients suffering with CMNP following the application of MET. Schenk, Adelman and Rousselle *(*1994) conducted a study investigating the effects of a five-second MET on cervical range of motion in asymptomatic patients and discovered that after seven treatments over a four week period, all six ranges of motion (i.e. flexion, extension, right rotation, left rotation, left lateral flexion and right lateral flexion) increased. . In a South African study, Boodhoo (2002) demonstrated the efficacy of MET in the treatment of CMNP using a five-second contraction. The results of the study indicated that MET reduced the pain intensity and increased the cervical ranges of motion.

MET may be used to increase range of motion within a specific region (Schenk, Adelman and Rousselle, 1994). Lenehan, Fryer and McLaughlin (2003) conducted a study on trunk rotation which then supported the use of MET to increase the ROM within the thoracic spine. Schenk, Adelman and Rousselle (1994) and Lenehan, Fryer and McLaughlin (2003) both used a five-second MET contraction. Burns and Wells (2006) compared the effects of MET on cervical range of motion among young (18-35 years of age) to middle-aged (35-59 years of age) asymptomatic individuals with a control group who received sham manipulative therapy. A three- to five-second treatment duration was used in their study. The results of the study showed an increase in the overall active cervical range of motion in the treatment group when compared with the control group. The study further revealed a significant difference in the magnitude of change in all planes of movement with flexion and extension displaying the least amount of change. Roodt (2009) conducted a study on CMNP and found that following the application of a five-second MET, the results revealed an increase in the cervical range of motion, with rotation displaying the greatest improvement. The study also revealed a decrease in the pain levels of the participants and a subsequent decrease in the disability levels associated with the CMNP.

Ballantyne, Fryer and McLaughlin (2003) investigated effects of MET on hamstring muscle extensibility. The results of the study suggested that MET was effective in increasing the extensibility of the hamstring muscle. Viscoelastic and plastic changes in the myofascial connective tissue elements following MET are believed to be responsible for an increase in muscle extensibility (Lenehan, Fryer and McLaughlin, 2003).

Dearing and Hamilton (2008) conducted a study on the effects of MET on the upper trapezius muscles. The study was based on the pressure pain thresholds of the MFTPs in the upper trapezius muscle following the application of MET. The results of the study revealed a significant reduction in pain sensitivity. This was in accordance with Mehdikhani and Okhovatian (2013) who found similar results. Oliveira-Campelo *et al.* (2013) concluded that when MET was used to treat the trapezius muscle containing a MFTP, there was an increase in lateral flexion to the opposite side, rotation to the ipsilateral side and an increase in the pressure pain threshold of the MFTP.

Although MET is shown to be an effective treatment, there is much controversy as to the most suitable treatment contraction duration for effective treatment of CMNP. Greenman (2003) and Mitchell *et al.* (1979) recommend several seconds (three to seven seconds), just enough time for joint slack to be taken out. Chaitow (2006) recommends stretch contraction to be held for at least 30-60 seconds for the treatment of chronically shortened muscles. Ballantyne, Fryer and McLaughlin (2003) and Lenehan, Fryer and McLaughlin (2003) and Schenk, Adelman and Rousselle (1994) have utilized techniques using a contraction duration of five-seven seconds, until a new barrier was reached. However a 30-second (Bandy and Irion, 1994) and a 60-second (Feland *et al.,* 2001) contraction duration have shown to be more effective in increasing muscle extensibility.

Smith and Fryer (2008) conducted a study on the comparison of two MET techniques for increasing flexibility of the hamstring muscle group. In Group One, the researcher applied the MET with a 30-second stretch duration and in Group Two, the researcher applied MET with a three-second stretch duration. The findings of the study by Smith and Fryer (2008) suggested that both contraction durations appeared to be equally effective in increasing hamstring extensibility. A similar study was conducted by Fryer and Ruszkowski (2004), in which the influence of contraction duration of MET applied to the atlanto-axial joint in asymptomatic participants was investigated. The experiment was conducted over one day. In that study 52 asymptomatic participants were randomly allocated into one of the following three treatment groups: a control group (*n*=17), a five-second MET group (*n*=17) and a 20-second MET group (*n*=18).The results of the study showed that the application with the five-second MET was the most effective in increasing the active range of rotation motion.

Muscle Energy Technique has been shown to be an effective treatment protocol in increasing range of motion and in decreasing pain in individuals presenting with CMNP. Fryer and Ruszkowski (2004) conducted the study on asymptomatic participants which then failed to demonstrate the effects of the different MET contractions on decreasing pain in participants with CMNP. Fryer and Ruszkowski (2004) also limited their study to the atlanto-axial joint only therefore, providing no information on the effects of the study on the rest of the cervical spine. Boodhoo (2002) conducted his study on symptomatic patients and showed that MET decreases pain and increases the range of motion in the cervical spine. He did not, however, investigate the most effective contraction duration. The current study therefore aims to compare a long duration (45-second) MET contraction duration and a short duration (five-second) MET contraction duration in the management of chronic mechanical neck pain.

2.17 HAWTHORNE EFFECT

When interpreting the results of a study, it becomes imperative to consider the Hawthorne effect (Leonard and Masatu, 2006; Campbell, Maxey and Watson, 1995). The Hawthorne effect may bring about measurement bias that could influence the results of the study. It can be defined as a phenomenon of altered behaviour or performance that results from the awareness of being part of an experimental study (Leonard and Masatu, 2006; Campbell, Maxey and Watson, 1995). Berthelot, Le Goff and Maugars (2011) describe the Hawthorne effect as a distortion in the manner in which symptoms are expressed by participants or patients. This means that in a clinical or experimental setting, being observed by a healthcare worker can potentially alter the manner in which symptoms are expressed by a patient. In a clinical trial the Hawthorne effect may result in a decrease in pain scores as a result of the optimistic atmosphere of the trial or the desire to please the researcher (Berthelot, Le Goff and Maugars, 2011). The effect is much stronger when the patients are assessed and evaluated by a likeable healthcare worker as the patient may try harder to meet the perceived expectations of the researcher (Berthelot, Le Goff and Maugars, 2011). The opposite may also be a possibility as the patient could also exaggerate the severity of the pain at the onset of the study purely to meet the inclusion criteria of the study which will then provide a possible explanation for a rapid improvement in pain levels (Berthelot, Le Goff and Maugars, 2011). Although the Hawthorne effect is an important aspect to consider during clinical trials there has been a significant amount of critique regarding the validity of it in research (Leonard and Masatu, 2006; Campbell, Maxey and Watson, 1995). Numerous researchers argue that the positive effect observed during studies may be due to a number of other reasons other than the need to satisfy the researcher or altered behaviour during the study (Berthelot, Le Goff and Maugars, 2011; Leonard and Masatu 2006; Campbell, Maxey and Watson, 1995).

2.18 CONCLUSION

Upon the review of the available literature MET has been shown to be an effective treatment in the management of CMNP (Chaitow, 2006; Greenman, 2003; Boodhoo, 2002). However, there seems to be paucity of information in terms of the most effective contraction duration in the treatment method (Fryer, 2011). This research is aimed at comparing a short duration contraction and a long duration contraction to determine the most effective contraction duration of the MET in the treatment of CMNP.

CHAPTER THREE

MATERIAL AND METHODS

3.1 RESEARCH DESIGN

The design of this study was a quantitative, single blinded clinical trial. This study was conducted at the Chiropractic Day Clinic at the Durban University of Technology (DUT). Ethical clearance was obtained from the Institutional Research Ethics Committee (IREC). A clearance certificate **(Ethics Certificate Clearance Number: IREC 032/12 [Appendix A])** was issued prior to commencement of this study.

3.2 ADVERTISING

Posters (**Appendix B1**) were displayed in and around the DUT campus and Chiropractic Day Clinic at the DUT. Pamphlets **(Appendix B2)**, with the necessary information, were handed out to people and were made available in the waiting area at Chiropractic Day Clinic at DUT. However, a large number of the participants were recruited via word of mouth.

3.3 POPULATION

3.3.1. DEFINING POPULATION

A preliminary telephonic interview was conducted with some of the prospective participants that responded to the advertisement telephonically and a preliminary face to face interview to those that approached the researcher. This was done so as to ascertain whether they met the inclusion criteria for the study. The questions were asked in a specific order and the prospective participants had to answer according to an allocated answer. These questions and the expected responses are shown in **Appendix B3**. The population of the study was 59 and was determined using the inclusion and exclusion criteria.

3.3.2 INCLUSION AND EXCLUSION CRITERIA

3.3.2.1 INCLUSION CRITERIA

The inclusion criteria were applicable to both Groups A and B. Prospective participants were included in this study if:

- They complained of unilateral or bilateral neck pain, from the base of the skull to the base of the neck.
- They had neck pain of mechanical origin i.e. absent of pathologies or disease.
- They complained of persistent neck pain from which they had suffered for a period of more than six weeks indicating chronic neck pain (Grieve, 1988).
- They were between the ages of 18-40 years.
- They had read and signed the information sheet and informed consent letter **(Appendix C)**.
- They scored a pain rating from three to seven on the Numerical Pain Rating Scale or a rating from 30 to 70 on the Numerical Rating Scale-101 (Appendix I). This scoring was included in the study purely to increase the participants' homogeneity.
- They had at least one joint dysfunction in the cervical spine, located by means of motion palpation. A positive motion palpation finding indicating a symptomatic joint was defined as meeting three criteria (Plaugher, 1993): An abnormal end feel, abnormal quality to resistance of motion and local or referred pain that can be reproduced.
- A diagnosis of mechanical neck pain was made according to the following criteria (Bergmann and Peterson, 2011; Grieve 1988):
  1. Localized cervical spine pain that was with or without arm pain,
  2. Apposition of hypo-/hyper-mobile segments of the cervical spine,
  3. Asymmetrical neck pain that increased as the day progressed and was intensified by activities such as driving, repetitive lifting (especially of heavy or large objects), computer use and reading,
  4. Occipital pain and neck pain that was unilateral,
  5. Movements that are restricted and painful, especially rotation and lateral flexion of the neck towards the painful side and / or
  6. Myofascial trigger points or prominent neck muscles especially levator scapulae and the upper and middle fibers of the trapezius muscle.
- Two of the following three orthopaedic tests had to show a false positive. A false positive is defined as: local pain at the level being tested indicating a facet joint dysfunction.
  (Magee, 2006; Gatterman, 1998):

a. *Lateral compression test*: the patient is seated. The cervical spine is placed into lateral flexion and a vertical force is exerted at the top of the head.

b. *Cervical Compression test*: Patient is seated and an axial force is exerted to the patients' head thus loading the cervical spine.

c. *Kemp's Test*: The Doctor stands behind the patient and places their finger at the level being tested, rotates the patients head to the side being tested, extends the patients neck and then laterally flexes the neck to the side being tested (Magee, 2006).

3.3.2.2 EXCLUSION CRITERIA

The exclusion criteria were applicable to both Groups A and B. Prospective participants were excluded from the study if:

- Their neck pain was of non-mechanical origin i.e. organic causes (e.g. cancer and arthritis) (Binder, 2007).
- They displayed the contra-indications of MET (including but not limited to): tissue fragility, hypermobility, myositis, tumours (Fryer, 2011, Chaitow, 2006**).**
- The prospective participant had a positive orthopaedic test. A positive orthopaedic test would be if pain radiated down the participants arm as the researcher performed the orthopaedic tests.
- They recently had surgery or significant trauma to their neck within the previous three months (Michaleff *et al.*, 2009).
- They received treatment for their neck in the previous three months (Michaleff *et al*., 2009).
- They received other treatment to the neck during the course of the study.
- They were on medication such as anti-inflammatories and pain relief medication were excluded from the study unless they agree to undergo a "wash out" period of three days before they were included into the study (Seth, 1999).
- They had a previous Transient Ischaemic Attacks or a history of dizziness.

3.4 SAMPLING

3.4.1 SAMPLE STRATEGY

This study required a minimum of 48 participants, who were randomly allocated to one of two groups. Group A was the short duration MET (five-second) and had *n*=24 participants and Group B was the long duration MET (45-second) and comprised of *n*=24 participants.

Non-probability sampling was used to allocate the participants to each group via a computer generated random allocation table (Esterhuizen, 2012). This ensured that the researcher had no say and was unaware to which group each participant was allocated thus ensuring that the study was not manipulated to achieve the results that the researcher hoped to achieve.

3.4.2 SAMPLE

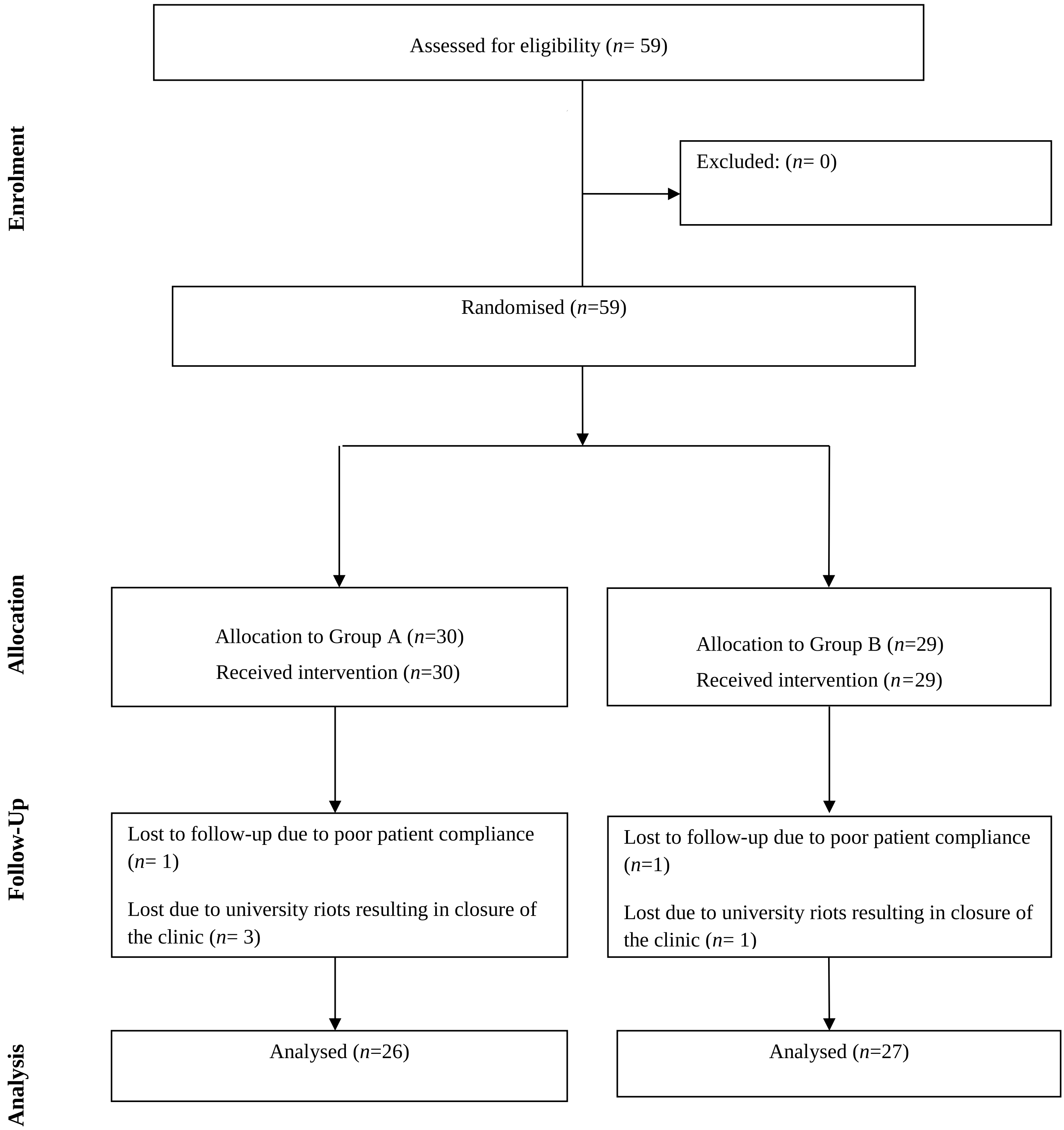
The study sample consisted of male and female participants between the ages of 18-40 from the eThekwini area.

3.4.3 SAMPLE SIZE

The statistician concluded that 48 participants were shown to be statistically sufficient with each group consisting of a minimum of 24 participants each (Esterhuizen, 2012).

Concealed allocation was used to ensure unpredictability of the allocation sequence. Concealed allocation occurs when the researcher is kept unaware of which group each participant falls into until a complete case history (**Appendix D),** physical examination (**Appendix E**) and cervical regional examination (**Appendix F**) has been done on the participant by the researcher thus ensuring that the participant fits into the inclusion criteria. An independent third person (**Appendix L**) was recruited only for the concealed allocation and was not involved in the participants' treatment. A randomization table (Esterhuizen, 2012) was used for the allocation of each participant into one of two groups. The group allocation was withheld from the researcher by the independent third person, who only relayed the information to the researcher once the participant had been clinically evaluated, included into the study and was ready for the treatment.

3.4.4 THE PROGRESS THROUGH THE RANDOMISED CLINICAL TRIAL OF GROUP A AND GROUP B TO MEET THE MINIMUM SAMPLE SIZE



3.5 RESEARCH PROCEDURE

If the participant was eligible for the study based on the preliminary interview (**Table 3.1**) an appointment was made by the researcher at the DUT Chiropractic Day Clinic.

3.5.1 FIRST CONSULTATION/ VISIT

At the initial consultation, the entire research process was explained to the participant, who were then given the opportunity to ask whatever questions they may have had at the time. Once the participants understood and agreed to be a part of the research, they then were asked to sign the Letter of Information and Informed Consent Form (**Appendix C**). The participants were advised that if they wished to withdraw from the study at any given time, they were free to do so, without any future repercussions. The participants that were excluded from the study or chose to be excluded from the study were given the opportunity to be treated as outpatients at the Chiropractic Day Clinic.

After the participants signed the Letter of Information and Informed Consent Form (**Appendix C**), a complete case history (**Appendix D),** physical examination **(Appendix E)** and cervical regional examination (**Appendix F)** were conducted on every new participant. A summary of the findings was then recorded (**Appendix G**).

The participants that met the inclusion criteria were then allocated via the computer generated random allocation randomized table (Esterhuizen, 2012) to one of two groups. There were 26 participants randomly allocated to Group A (short duration (five-second) MET) and 27 participants to Group B (long duration (45-second) MET).

An independent third person (**Appendix L**) was used for the concealed allocation. The researcher became privy to such information only once a complete assessment of the participant had been undertaken.

Each participant's name was assigned a specific code. This was to ensure that anonymity was maintained throughout the study as the participant's code was used in the recording, analysis and reporting of the data instead of their name.

Each participant was requested to fill out two questionnaires, the NRS-101(**Appendix I)** and the CMCC NDI (**Appendix J**).

Participants not eligible for the study (Both from telephonic and initial consultation screenings)

Participants that did not meet the inclusion criteria and were excluded from the study were given the opportunity to be treated at the Chiropractic Day Clinic as an out-patient and not as a research participant.

3.5.2 TREATMENT INTERVENTIONS FOR GROUP A (short duration (five-second) MET)

The researcher evaluated the cervical spine for joint dysfunctions using motion palpation (Bergmann and Peterson, 2011) and then applied the MET to those facet joint restrictions using the method outlined by Greenman (2003).

An example of MET applied to a typical vertebrae (e.g. C4-C5) is explained below. The technique was applied based on all restrictions found on motion palpation and which were found either in flexion, extension, lateral flexion or rotation. The duration of the isometric contraction was **five seconds** per restriction.

For example: If the participant had a *right lateral flexion* restriction, MET was applied as follows:

1. The participant was required to lie supine, with the researcher seated at the head of the bed.
2. The researcher then, with his/her right hand, palpated both the articular pillars of C5; this was the vertebra below the dysfunctional C4 vertebra.
3. The C5 vertebra was then stabilized, by the researcher's right hand, so that C4 could move on it.
4. The researcher's left hand was used to support the head and move it to the right, into right lateral flexion.
5. The researcher's right hand pushed C5 posteriorly toward the floor therefore imparting a degree of flexion to the cervical spine. The researcher's left hand then put the participant's neck into right lateral flexion until a restriction barrier was reached.
6. The participant was instructed to push their neck into left lateral flexion against the researcher's fixed resistance. Once the participant was placed in this position, the position was then maintained by the participant.
7. The participant was asked to hold the position for **five seconds** (Smith and Fryer, 2008; Fryer and Ruszkowski, 2004; Boodhoo, 2002).
8. The technique was repeated three times, with the researcher reaching a new restrictive barrier each time.

- The technique was applied in the same manner on both left and right restrictions. However, if the restriction were on the left (as opposed to their right side), then the researcher would use his or her right hand (as opposed to their left hand if it was the participant's right side that was problematic) to move the participant's cervical spine into the desired direction whilst the left hand stabilized the vertebra inferior to the dysfunctional vertebra.
- The method was also applied to rotation, flexion and extension restrictions by placing the cervical spine into the desired direction.

3.5.3 TREATMENT INTERVENTIONS FOR GROUP B (LONG DURATION (45-second) MET)

The researcher evaluated the cervical spine for joint dysfunctions using motion palpation (Bergmann and Peterson, 2011) and then applied the MET to those joint restrictions using the method outlined by Greenman (2003).

An example of MET applied to a typical vertebrae (e.g. C4-C5) is explained below. The technique was applied based on all restrictions found on motion palpation and which were found either in flexion, extension, lateral flexion or rotation. The duration of the isometric contraction was **45 seconds** per restriction.

For example: If the participant had a *right lateral flexion* restriction, MET was applied as follows:

1. The participant was required to lie supine, with the researcher seated at the head of the bed.
2. The researcher then, with his/her right hand, palpated both the articular pillars of C5; this was the vertebra below the dysfunctional C4 vertebra.
3. The C5 vertebra was then stabilized, by the researcher's right hand, so that C4 could move on it.
4. The researcher's left hand was used to support the head and move it to the right, into right lateral flexion.
5. The researcher's right hand pushed C5 posteriorly toward the floor therefore imparting a degree of flexion to the cervical spine. The researcher's left hand then put the neck into right lateral flexion until a restriction barrier was reached.
6. The participant then exerted a sub maximal isometric contraction against the researcher's resisting left hand. The participant was instructed to push their neck all the way into left lateral flexion against the researcher's restraint. Once the participant was placed in this position, the position was then maintained by the participant.
7. The participant was asked to hold the position for **45 seconds** (Chaitow, 2006).

8. The technique was repeated three times, with the researcher reaching a new restrictive barrier each time.

- The technique was applied in the same manner on both left and right restrictions. However, if the restriction were on the left (as opposed to their right side), then the researcher would use his or her right hand (as opposed to their left hand if it was the participant's right side was problematic) to move the participant's cervical spine into the desired direction whilst the left hand stabilized the vertebra inferior to the dysfunctional vertebra.
- The method was also applied to rotation, flexion and extension restrictions by placing the cervical spine into the desired direction.

Table 3.1 The muscles used in each direction of range of motion of the cervical spine

Motion	Muscles used to provide movement
RR	Right Levator Scapulae
	Left Upper Trapezius
	Right Posterior Cervicals
	Total
LR	Left Levator Scapulae
	Right Upper Trapezius
	Left Posterior Cervicals
	Total
LLF	Left Levator Scapulae
	Left Upper Trapezius
	Left Posterior cervicals
	Total
RLF	Right Levator Scapulae
	Right Upper Trapezius
	Right Posterior Cervicals
	Total

RR=Right Rotation, LR =Left Rotation, LLF=Left Lateral Flexion, RLF= Right Lateral Flexion

(Adapted from Standring, 2008; Moore and Dalley, 2006)

3.6 THE MEASUREMENTS

The objective and subjective measurements were collected and recorded on the data sheet **(Appendix H).** The objective and subjective data was collected on the first and third consultations before treatment was administered. The final data was collected on the fifth (final) visit. There was no treatment administered at the fifth visit.

3.6.1 BLINDING

The study was a blinded study. There were two blinded assessors used for the research for the sake of convenience. The blinded assessor was unaware of which group each participant fell into and was assigned to the research to record the objective measurements which were collected on a data sheet **(Appendix H).** The two blinded assessors (**Appendix M1**) had undergone a training workshop to ensure accurate usage of the measuring instruments (**Appendix M2).** This was done to ensure that the readings were taken in the similar and accurate manner.

3.6.2 SUBJECTIVE MEASUREMENTS

3*.6.2.1 Numerical rating scales*

The participant was asked to rate their pain on a scale of zero to ten. Only those participants with a rating of three to seven were included into the study to increase homogeneity of the study. The minimally clinically important difference (MCID) of the NRS is 4.3 points (Cleland, Childs and Whitman, 2008).

Once the participants were included into the study, the pain level of each participant was measured using the NRS-101**(Appendix I**). The NRS-101 is a questionnaire that has two scales from zero to 100. The zero indicates no pain and the 100 is an indication of excruciating pain. The two scales each have a question. One question is to rate your pain when it is at its worst. The second question is to rate your pain when it is at its least. The average of the two scores then provides an indication of the participant's pain intensity between treatments. The averaging of the two measurements are used in the data analysis as this is the preferred use of the NRS-101 (Yeomans, 2000). For the purpose of this study the NRS-101 was used as previous studies have indicated that it has high sensitivity, can detect small changes and can generate data that can be statistically analysed for audit purposes (Frampton and Hughes-Webb, 2011; Misailidou *et al*., 2010). The NRS-101 was shown to be reliable (Ferreira-Valente, Pais-Ribeiro and Jensen, 2011) and was used at the consultations to demonstrate the percentage decrease or increase of the participants' subjective pain over time. The MCID is noted at 20-25mm on a 100mm line (de Vet *et al*., 2007).

3.6.2.2 The CMCC Neck Disability Index (NDI) **(Appendix J)**

The CMCC NDI (Canadian Memorial Chiropractic College, Neck Disability Index) was used to assess the participant's disability, in terms of restrictions to their daily living that resulted from their MNP. This questionnaire is designed to promote an understanding of how a patient's neck pain affects their ability to manage everyday-life activities. The questionnaire consists of 10 sections, with six options each rated from zero to five. The participant was requested to tick one of the six blocks under each section. The participant was then given a score out of 50 which was multiplied by two to get a percentage. This percentage then indicated their perceived disability before and after the study. Vernon (2008) asserted that the NDI (**Appendix J**) tool is highly reliable on what is called "test-retest" reliability. There is a high degree of validity and internal consistency of the NDI (Vernon, 2008). Permission to use the NDI was gained from Vernon (2012) via email communication on the 20th June 2012 **(Appendix K)**. The MCID of the NDI is thought to be 10 points according to Young *et al.* (2009) and 10.5 points according to Pool *et al.* (2007).

3.6.3 OBJECTIVE MEASUREMENTS

3.6.3.1 RANGE OF MOTION

The Cervical Range of Motion (CROM) Goniometer (manufactured by Performance Attained Associates Model: 3600 Labore Road, Suite 6, St Paul, MN 5511041144) is a reliable tool (Williams *et al*., 2010; Jordan, 2000) and was used to measure all the ranges of motion of the cervical spine (i.e. flexion, extension, lateral flexion and rotation).

The use of the CROM Goniometer was followed as outlined in the manual and is explained as follows:

- The device was attached to the participants' head and secured with a strap.
- The participant was instructed to sit in the upright position with both feet placed firmly on the ground.
- The blinded assessor ensured that the device was zeroed prior to taking the measurements of each participant.
- The participant was then asked to move their neck to the end of range of motion in all directions. i.e. flexion, extension, right rotation, left rotation, right lateral flexion and left lateral flexion.

- Rotation (left and right): The participant was asked to look over their shoulder as far as they could on the left (left rotation) and then the right (right rotation).
- Flexion: The participant flexed their neck in the forward direction as far as possible.
- Extension: The participant was asked to look up at the ceiling and place their neck as far back as possible.
- Lateral flexion (left and right): The participant was asked to look forward and try and bring their ear down to their shoulder on either side.
- The measurements were then taken by the blinded assessor and written on the data sheet **(Appendix H).**
- The range of motion was measured at the first, third and fifth consultations

3.6.3.2 TENDERNESS

The Algometer (manufactured by Wagner instruments: P.O Box 1217, Greenwich T 06836) is a reliable and valid measuring tool and was used to measure the pain threshold of the participant. Livingston, Bernadi and Carroll *(*1998), suggests that "Algometers are designed to quantify and document levels of tenderness via pressure threshold measurement and pain sensitivity via pain tolerance measurement". The minimal clinically important difference is noted at 15% (Potter *et al*., 2006). The Algometer was used as follows:

- Four of the most tender trigger points were located within the muscles of the cervical spine (**Table 2.4**)
- tenderness readings were then taken, by the blinded assessor, of these four trigger points and recorded on the data sheet (**Appendix H**).
- The Algometer was placed on the trigger points with a gradual increase in pressure.
- The participant was then instructed to indicate when the pressure sensation turned into pain by saying the word "now".
- The points used for each participant was marked with a dye so that the exact location was used for the next pain measurement reading.

Table 3.2 Interventions and measurement frequency

WEEK	VISIT	GROUP A	GROUP B
1	1	Initial consultation The subjective and objective measurements were taken Short duration MET was administered	Initial consultation The subjective and objective measurements were taken Long duration MET was administered
	2	Short duration MET was administered	Long MET was administered
2	3	The subjective and objective measurements were taken Short duration MET was administered	The subjective and objective measurements were taken Long duration MET was administered
	4	Short duration MET was administered	Long duration MET was administered
3	5	The subjective and objective measurements were taken	The subjective and objective measurements were taken

3.7 STATISTICAL ANALYSIS

The raw data for statistical analysis was obtained from the NRS-101 scale, the NDI, the ROM readings and the tenderness readings. These readings and measurements were placed on an excel sheet. This excel sheet was then given to the statistician for the analysis of the data. The data of this study was analysed using the SPSS version 20 (IBM). The statistical analysis comprised of baseline comparisons of demographics between the groups, and intra and inter-group analyses. The demographics were compared between the two groups using Pearson's chi square tests where the demographic was measured as a binary or nominal variable, and using t-tests where a measured normally distributed variable was being compared. The statistically significant p value was noted as <0.05. The statistical analysis also comprised of an analysis of the intra and inter-groups. Repeated measures ANOVA testing was used to examine the effect on each outcome measure separately, of time (three time points: first, third and fifth visits) in the case of intra-group analyses (Objectives One and Two). To assess the effects of the intervention (five-second MET and 45-second MET) factorial two way two group by time (three time points) repeated measures ANOVA in the case of the inter-group analyses (Objective Three) was conducted. Profile plots were generated in order to assess direction and trend of the effect of the treatment. A Pearson's Correlation was done to establish if changes in the variables affected each other. The minimally clinically significant difference for the NDI, NRS-101 and the algometer readings were all determined to find the significance (Esterhuizen, 2013).

CHAPTER FOUR

RESULTS

4.1 INTRODUCTION

This chapter consists of the results of the study t. These results entail a demographic analysis as well as an analysis of the objective and subjective findings of the study. The results of the study are presented in the form of graphs and tables.

4.2 THE MYOFASCIAL TRIGGER POINTS AND RESTRICTIONS IN THE CERVICAL SPINE FOUND IN THE STUDY

Table 4.1 provides a description of each movement, the muscles used to bring about that neck movement and then the number of muscles that had trigger points in them for each group. Flexion and extension could not be examined in this manner as the muscles used for flexion and extension are paired and work together. Participants did not necessarily have matching trigger points in the posterior cervical muscles. The attachments for each muscle can be found in **Table 2.4.**

Table 4.1: Muscles used to produce the various ranges of motion along with the trigger points in each of these muscles

Motion	Muscle	No. of TP's in Group A	No. of TP's in Group B
RR	Right Levator Scapulae	23	29
	Left Upper Trapezius	16	9
	Right Posterior Cervicals	9	15
	Total	**48**	**53**
LR	Left Levator Scapulae	19	18
	Right Upper Trapezius	20	10
	Left Posterior Cervicals	17	17
	Total	**56**	**45**
LLF	Left Levator Scapulae	19	18
	Left Upper Trapezius	16	9
	Left Posterior cervicals	17	17
	Total	**52**	**44**
RLF	Right Levator Scapulae	23	29
	Right Upper Trapezius	20	10
	Right Posterior Cervicals	9	15
	Total	**52**	**54**

RR=Right Rotation, LR =Left Rotation, LLF=Left Lateral Flexion, RLF= Right Lateral Flexion, No. =Number TPs=Trigger points.

(Adapted from Standring, 2008; Moore and Dalley, 2006)

Table 4.2 provides information on the type and number of restrictions in the cervical spine that was diagnosed in each of the participants for each group and **Table 4.3** provides the number of restrictions at each cervical vertebral level per group.

Table 4.2: The type and number of cervical joint restrictions treated in each group

Restriction	Group A	Group B
F	1	1
E	10	6
RPA	41	26
LPA	20	22
LLF	2	3
RLF	14	7

F=Flexion, E=Extension, RPA=Right Posterior to Anterior,

LPA= Left Posterior to Anterior, LLF= Left Lateral Flexion, RLF= Right Lateral Flexion

Table 4.3: The number of cervical joint restrictions per level in each group

Level of restriction	No. of restrictions in Group A	No. of restrictions in Group B
C1	15	10
C2	28	20
C3	22	19
C4	14	15
C5	3	4
C6	5	3
C7	2	1

C= cervical vertebra, No. = Number of restrictions

4.3 DEMOGRAPHICS OF THE PARTICIPANTS

There were *n*=53 participants between the ages of 18 and 34 years, who were randomly allocated to one of two groups with Group A having *n*=26 participants and Group B having *n*=27 participants.

4.3.1 AGE

The participants' ages ranged from 18 to 34 years. The mean age of all the participants in the study is 21.7 years with a standard deviation of 3.4 years. In Group A, the mean age is 21.1 with a standard deviation of 3.1. The mean age of participants in Group B is 22.3 years with a standard deviation of

3.7. The results show that there was no statistically significant difference (*p*=0.211) in mean age between the two groups.

4.3.2 RACE

The distribution of both groups was similar. The comparison of the races in each group revealed no statistically significant results (*p*=0.438) and were therefore comparable. The Indian participants accounted for the highest percentage (75%) of the total sample. The number of participants of each race group is depicted graphically (**Figure 4.1**). The total percentage of each race per group in Group A is as follows; Coloured: 3.80%, Black: 11.50%, White: 15.40% and Indian: 69.20%. The percentage of each race group in Group B is as follows; Coloured: 7.40%, Black: 7.40%, White: 3.70% and Indian: 81.50%.

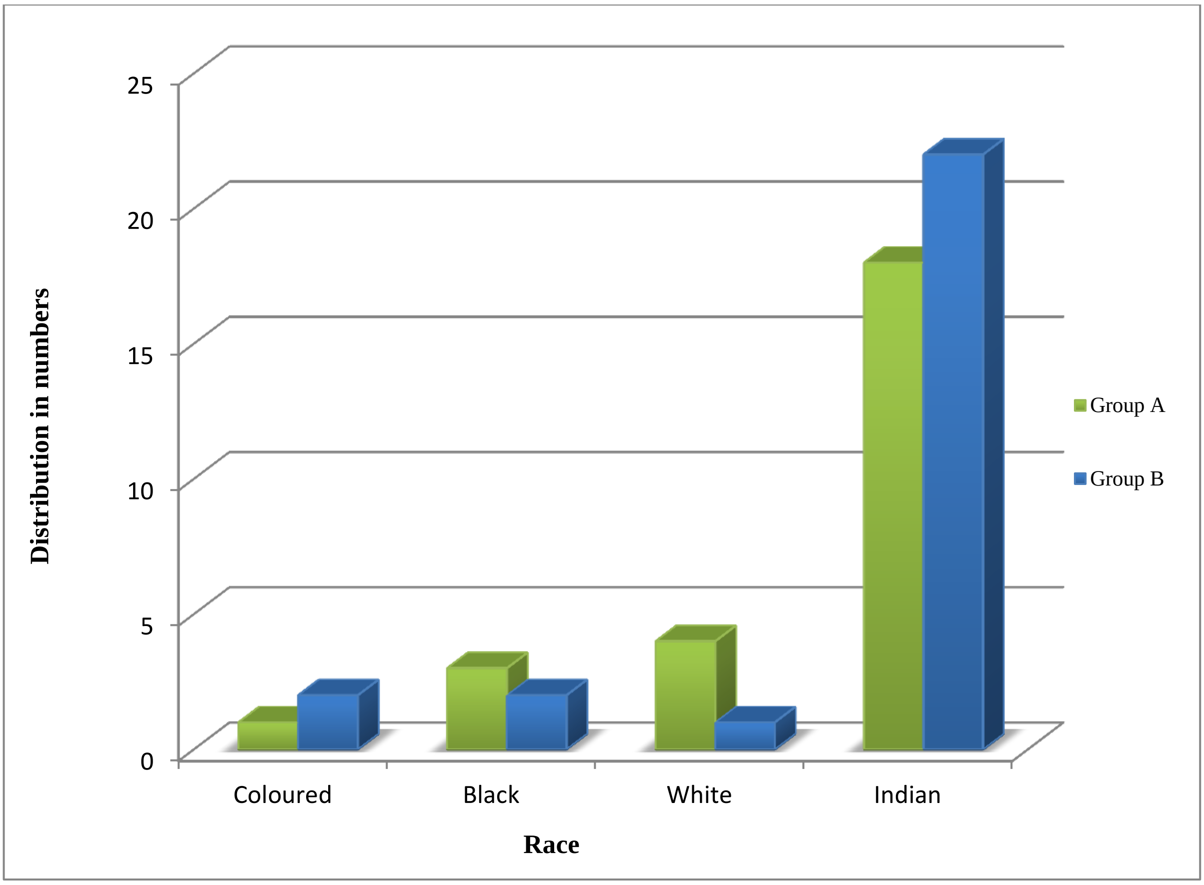


Figure 4.1: The distribution in numbers of the respective race groups of all participants in each Group (*n*=53)

4.3.3 BODY MASS INDEX (BMI)

The mean BMI of the two groups did not differ. The mean BMI was 22.7 kg/m^2 for Group A and 22.2 kg/m^2. The standard deviation was 4.4 for Group A and 4.3 for Group B.

4.3.4 GENDER

Figure 4.2 shows the distribution in numbers of both genders in each group The percentage of females was 59.30% for Group A and 40.70% in Group B. The percentage of males was 38.50% in Group A and 61.50% in Group B. The percentage of females in the study was only 1.8% higher than the percentage of male participants and hence not statistically significant.

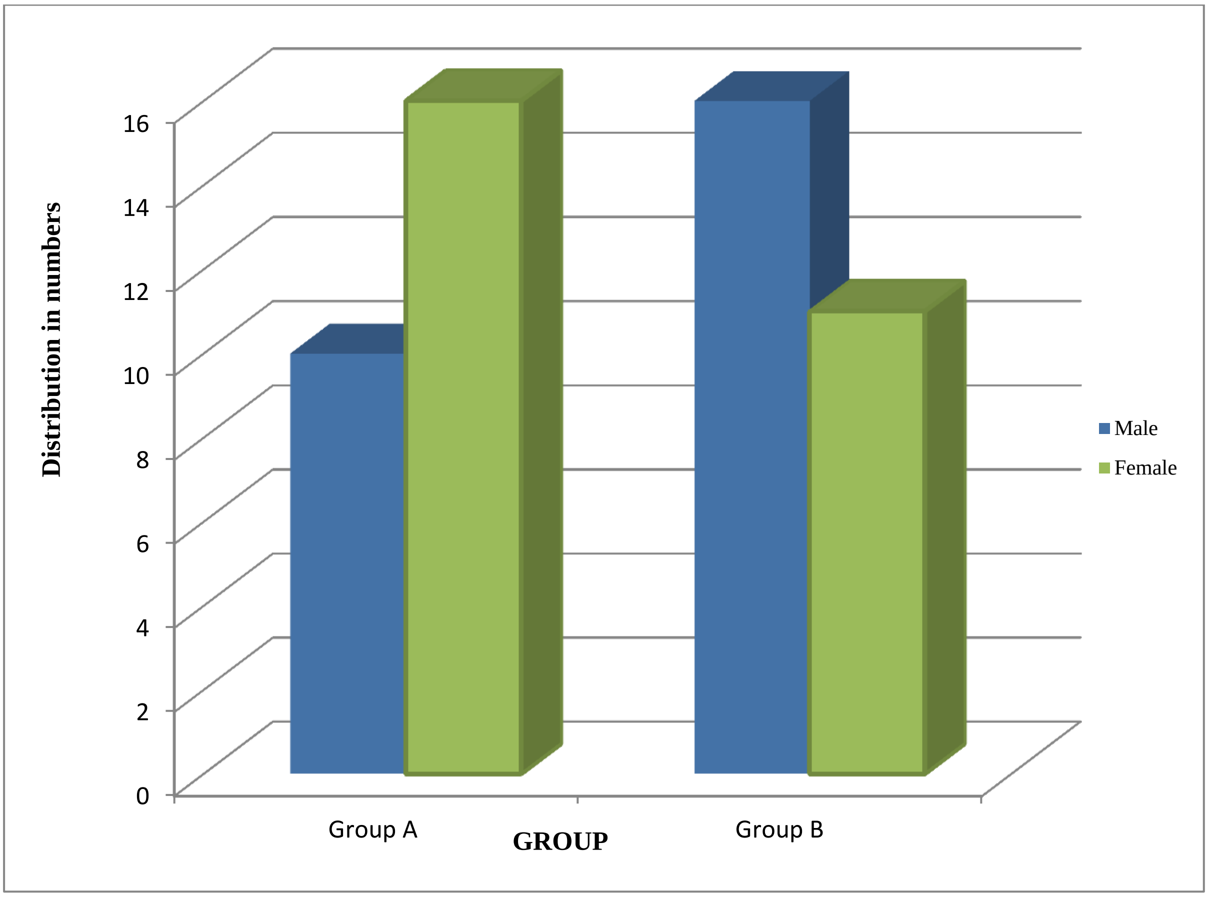


Figure 4.2: The distribution of gender in both Groups

4.3.5 OCCUPATION

For descriptive purposes, **Figure 4.3** graphically represents the distribution of the various occupations in each group with students being the highest in both groups. **Table 4.4** provides a breakdown of the students. The civil engineering students alone formed 42% of the 53 participants.

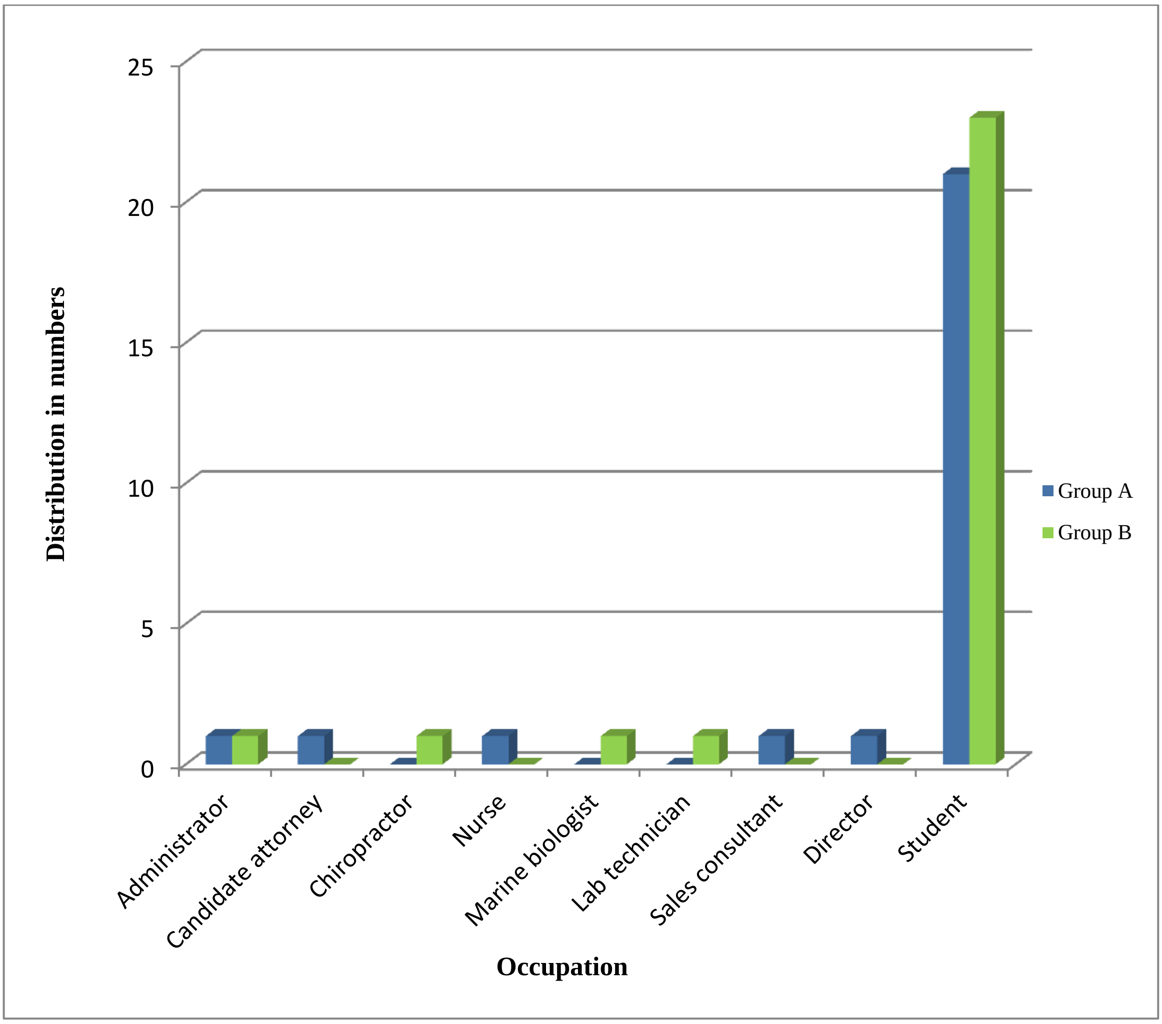


Figure 4.3: The distribution of occupation per Group (*n*=53)

Table 4.4: Student programme enrolment between the two groups

Student's qualification	Group A	Group B	Total
Engineering	8	14	22
Biomedical technology	0	1	1
Somatology	2	0	2
Radiography	2	1	3
Marketing	0	1	1
Chiropractic	2	2	4
Dental technology	1	1	2
Environmental health	3	1	4
Homeopathy	1	1	2
Information technology	1	0	1
B.Com accounting	0	1	1
Business management	1	0	1
Total	21	23	44

4.4 BASELINE SIMILARITIES AND DIFFERENCES BETWEEN THE TWO GROUPS

Testing for the baseline differences revealed that flexion was the only range of motion statistically different between the two groups (*p*=0.045) with Group A having higher values than Group B. **Table 4.2** displays the subjective and objective means between the two groups respectively.

Table 4.5: An independent t-test comparing baseline means between the two groups for the subjective and objective results

	GROUP	*n*	Mean	Std. Deviation	Std. Error Mean	P Value
NDI 1ST	Group A	26	24.46%	14.21%	2.79%	0.52
	Group B	27	22.11%	12.13%	2.34%	
NRS 1ST	Group A	26	31	10.323	2.024	0.773
	Group B	27	31.89	10.124	1.948	
F1	Group A	26	66.85	11.909	2.335	0.045
	Group B	27	59.37	14.436	2.778	
E1	Group A	26	67.88	15.201	2.981	0.215
	Group B	27	74.04	20.009	3.851	
RLF1	Group A	26	48.04	9.518	1.867	0.89
	Group B	27	48.44	11.64	2.24	
LLF1	Group A	26	48.27	10.536	2.066	0.844
	Group B	27	48.89	12.144	2.337	
RR1	Group A	26	70.27	16.533	3.242	0.986
	Group B	27	70.19	17.075	3.286	
LR1	Group A	26	67.88	16.938	3.322	0.968
	Group B	27	68.07	17.278	3.325	
TP 1 VISIT 1	Group A	26	3.58	2.043	0.401	0.614
	Group B	27	3.3	1.977	0.38	
TP 2 VISIT 1	Group A	26	3.85	1.953	0.383	0.82
	Group B	27	3.7	2.145	0.413	
TP 3 VISIT 1	Group A	26	4.08	2.189	0.429	0.595
	Group B	27	3.81	1.272	0.245	
TP 4 VISIT 1	Group A	26	3.73	1.845	0.362	0.892
	Group B	27	3.67	1.569	0.302	

***p* <0.05; repeated measures ANOVA**

4.5 SUBJECTIVE AND OBJECTIVE OUTCOME MEASURES FOR OBJECTIVE ONE

4.5.1 SUBJECTIVE OUTCOME MEASURES

Objective One: To determine the effectiveness of a short duration MET (Group A) in terms of subjective and objective measurements in the treatment of chronic mechanical neck pain.

The analysis of the intra-group testing was for the Neck Disability Index (NDI) and the Numerical Pain Rating Scale-101 (NRS-101).

4.5.1 .1 NECK DISABILITY INDEX (NDI):

The NDI scores in Group A showed a highly statistically significant decrease over time ($p<0.001$; Wilk's lambda=0.404). The results are illustrated graphically in **Figure 1** in **Appendix P**.

4.5.1.2. NUMERICAL PAIN RATING SCALE-101(NRS-101)

The NRS-101 scale was tested at the first, third and fifth visit thus giving three reading points. The NRS-101 score revealed a highly statistically significant decrease over time ($p<0.001$; Wilk's lambda=0.219). The results are shown on the graph in **Figure 2 (Appendix P).**

4.5.1.3 A SUMMARY OF THE SUBJECTIVE OUTCOME MEASURES IN GROUP A

Table 4.6 provides the mean subjective measures for Group A. There was a decrease in the mean scores from the first visit to the fifth (final) visit. The values for both subjective measures decreased to more than half of the initial score.

Table 4.6: The mean NDI and NRS-101 scores for Group A for each visit

	VISIT 1	VISIT 3	VISIT 5
NDI	24%	14%	10%
NRS-101	30.97	18.58	11.84

4.5.2 OBJECTIVE OUTCOME MEASURES

The objective outcome measures used for the analysis of the intra-group testing was the CROM Goniometer and the Algometer. The CROM Goniometer was used to measure the movements of flexion, extension, right lateral flexion, left lateral rotation, right rotation and left rotation of the cervical spine. The Algometer was used to determine the level of tenderness of four of the most painful trigger points of the neck.

4.5.2.1 CROM readings

4.5.2.1.1 Flexion (F)

There was no significant improvement of flexion over time (*p*=0.402; Wilk's lambda=0.927) as shown in **Figure 3 (Appendix P)**.

4.5.2.1.2 Extension (E)

There was a significant improvement in extension over time in Group A (*p*=0.015; Wilk's lambda=0.705) as shown in **Figure 4 (Appendix P)**.

4.5.2.1.3 Right Lateral Flexion (RLF)

There was no significant improvement in right lateral flexion over time in Group A (*p*=0.287; Wilk's lambda=0.901 as shown in **Figure 5 (Appendix P)**.

4.5.2.1.4 Left Lateral Flexion (LLF)

There was a significant improvement in left lateral flexion over time in Group A (*p*=0.010; Wilk's lambda=0.679) as shown in **Figure 6 (Appendix P)**.

4.5.2.1.5 Right Rotation (RR)

There was a significant improvement in right rotation over time in Group A (*p*=0.003; Wilk's lambda=0.620) as shown in **Figure 7 (Appendix P)**.

4.5.2.1.6 Left Rotation (LR)

There was no significant improvement in left rotation over time in Group A (*p*=0.086; Wilk's lambda=0.815 as shown in **Figure 8 (Appendix P).**

4.5.2.2 Tenderness readings

4.5.2.2.1 Trigger point One (TP1)

There was a statistically significant improvement in TP1 over time in Group A (*p*=0.004; Wilk's lambda=0.628) (**Figure 9, Appendix P**).

4.5.2.2.2 Trigger point two (TP2)

There was a statistically significant improvement in TP2 over time in Group A as seen in **Figure 10 (Appendix P)**. (*p*=0.003; Wilk's lambda=0.612).

4.5.2.2.3 Trigger point three (TP3)

There was a statistically significant improvement in TP3 over time in Group A as seen in **Figure 11 (Appendix P)**. (*p*=0.025; Wilk's lambda=0.734).

4.5.2.2.4 Trigger point four (TP4)

The results are shown in **Figure 12(Appendix P)**. There was a statistically significant improvement in TP4 over time in Group A (*p*=0.031; Wilk's lambda=0.748).

4.5.3 A SUMMARY OF THE OBJECTIVE OUTCOME MEASURES IN GROUP A

Table 4.7 provides a summary of the CROM and tenderness readings for Group A. All objective outcomes showed a significant improvement over time except for F, RLF and LR.

Table 4.7: A summary of the mean CROM and tenderness readings for Group A

		VISIT 1	VISIT 3	VISIT 5
CROM	F	67	63	64
	E	68	75	76
	RLF	48	49	52
	LLF	48	46	52
	RR	70	81	78
	LR	68	71	77
Tenderness	TP1	3.59	4.4	4.86
	TP2	3.88	4.81	5.16
	TP3	3.99	4.87	5.2
	TP4	3.74	4.13	4.61

CROM: Cervical Range of Motion

4.6 SUBJECTIVE AND OBJECTIVE OUTCOME MEASURES FOR OBJECTIVE TWO

Objective Two: To determine the effectiveness of a long duration (Group B) MET in terms of subjective and objective findings in the treatment of chronic mechanical neck pain.

4.6.1 SUBJECTIVE OUTCOME MEASURES

The analysis of the intra-group testing was for the Neck Disability Index (NDI) and the Numerical Pain Rating Scale-101 (NRS-101).

4.6.1.1 NECK DISABILITY INDEX (NDI):

The NDI scores in Group A showed a highly statistically significant decrease over time (p<0.001; Wilk's lambda=0.320). The results are illustrated graphically in **Figure 13 (Appendix P)**.

4.6.1.2 NUMERICAL PAIN RATING SCALE-101(NRS-101)

The NRS-101 measures were taken at the first, third and fifth visit thus giving three reading points. The NRS-101 score revealed a highly statistically significant decrease over time (p<0.001; Wilk's lambda=0.264). The results are shown on the graph below **Figure 14 (Appendix P)**

4.6.1.3 A SUMMARY OF THE SUBJECTIVE OUTCOME MEASURES OF GROUP B

Table 4.8 below provides a summary of the mean NDI and NRS-101 scores for Group B. The subjective measures both displayed a significant decrease in the scores.

Table 4.8: The mean subjective measures for Group B

	VISIT 1	VISIT 3	VISIT 5
NDI	22%	11%	7%
NRS-101	31.89	22.26	15.83

4.6.2 OBJECTIVE OUTCOME MEASURES

The objective outcome measures used for the analysis of the intra-group testing for Group B was the CROM Goniometer and the Algometer. The CROM Goniometer was used to measure the movements of flexion, extension, right lateral flexion, left lateral rotation, right rotation and left rotation of the cervical spine. The Algometer was used to determine the level of tenderness of four of the most painful trigger points of the neck.

4.6.2.1 CROM readings

4.6.2.1.1 Flexion (F)

There was no significant improvement of flexion over time (*p*=0.156; Wilk's lambda=0.862) (**Figure 15, Appendix P)**.

4.6.2.1.2 Extension (E)

There was no significant improvement in extension over time in Group B (*p*=0.852; Wilk's lambda=0.987) (**Figure 16, Appendix P)**.

4.6.2.1.3 Right Lateral Flexion (RLF)

There was no significant improvement in right lateral flexion over time in Group B (*p*=0.447; Wilk's lambda=0.938 as shown in **Figure 17 (Appendix P).**

4.6.2.1.4 Left Lateral Flexion (LLF)

There was a significant improvement in left lateral flexion over time in Group B (*p*=0.550; Wilk's lambda=0.953) as shown in **Figure 18 (Appendix P)**. There was a decrease in LLF from the third visit to the fifth visit.

4.6.2.1.5 Right Rotation (RR)

There was a significant improvement in right rotation over time in Group B (*p*=0.046; Wilk's lambda=0.78) as shown in **Figure 19 (Appendix P)**.

4.6.2.1.6 Left Rotation (LR)

There was a significant improvement in left rotation over time in Group B (*p*=0.006; Wilk's lambda=0.668 as shown in **Figure 20 (Appendix P).**

4.6.2.2 TENDERNESS READINGS

4.6.2.2.1 Trigger point One (TP1)

The results are shown in **Figure 21(Appendix P)**. There was a highly statistically significant improvement in TP1 over time in Group B (*p*<0.001; Wilk's lambda=0.522).

4.6.2.2.2 Trigger point two (TP2)

There was a highly statistically significant improvement in TP2 over time in Group B as seen in **Figure 22 (Appendix P)**. (*p*<0.001; Wilk's lambda=0.477).

4.6.2.2.3 Trigger point three (TP3)

The results are shown in **Figure 23 (Appendix P)**. There was a highly statistically significant improvement in TP3 over time in Group B (*p*<0.001; Wilk's lambda=0.539).

4.6.2.2.4 Trigger point four (TP4)

The results are shown in **Figure 24 (Appendix P)**. There was a statistically significant improvement in TP4 over time in Group B (*p*=0.001; Wilk's lambda=0.587).

4.6.3 A SUMMARY OF THE OBJECTIVE MEASURES FOR GROUP B

Table 4.9 provides a summary of the mean CROM and tenderness readings from the first visit to the fifth visit. All objective outcomes for Group B showed a significant improvement over time except for F, E, RLF, and LLF.

Table 4.9: A summary of the mean objective measures for each visit

		VISIT 1	VISIT 3	VISIT 5
CROM	F	59	61	64
	E	74	76	75
	RLF	48	50	52
	LLF	49	51	49
	RR	70	78	79
	LR	68	75	80
Algometer	TP1	3.25	3.9	4.23
	TP2	3.73	4.91	5.10
	TP3	3.76	4.76	5.06
	TP4	3.63	4.3	4.95

4.7 SUBJECTIVE AND OBJECTIVE OUTCOME MEASURES FOR OBJECTIVE THREE

Note for this section: Tables referred to in this section are available in **Appendix Q** should reference be needed to these data.

4.7. 1 SUBJECTIVE OUTCOME MEASURES

Objective Three: To compare a short duration (Group A) and a long duration (Group B) MET in terms of subjective and objective measures in the treatment of chronic mechanical neck pain.

4.7.1 .1 NECK DISABILITY INDEX (NDI):

Null Hypothesis: It is hypothesized that Group A would not show any difference in the degree of improvement of the NDI as Group B in the treatment of chronic mechanical neck pain. Utilizing the ANOVA testing and an alpha value of 0.05, the null hypothesis was not rejected (p=0.928; Wilk's lambda= 0.997) as both groups showed significant improvement (p<0.001).The effect of treatment on the NDI in both groups was the same as seen in **Figure 25 (Appendix P)** and **Table 1 in Appendix Q**. **Figure 25 (Appendix P)** illustrates that both groups had similar improvement scores on the NDI.

4.7.1 .2 NUMERICAL PAIN RATING SCALE-101 (NRS-101):

Null Hypothesis: It is hypothesized that Group A would not show any difference in the degree of improvement of the NRS-101 as Group B in the treatment of chronic mechanical neck pain. Utilizing the ANOVA testing and an alpha value of 0.05, the null hypothesis was not rejected (*p*=0.505; Wilk's lambda= 0.973). The effect of treatment on the NRS-101 revealed the same degree of improvement in both groups as seen in **Figure 26 (Appendix P)** and **Table 2 in Appendix Q**. **Figure 26 (Appendix P)** illustrates that both groups had a similar improvement in the NRS-101 measure with both slopes decreasing similarly having an almost parallel profile.

4.7.2 OBJECTIVE OUTCOME MEASURES

Objective Three: To compare a short duration (Group A) and a long duration (Group B) MET in terms of subjective and objective measures in the treatment of chronic mechanical neck pain.

4.7.2.1 CROM READINGS

4.7.2.1.1 Flexion (F)

Null Hypothesis: It is hypothesized that Group A would not show any difference in the degree of improvement of flexion as Group B in the treatment of chronic mechanical neck pain. Utilizing the ANOVA testing and an alpha value of 0.05 the null hypothesis cannot be rejected (*p*=0.226) as seen in **Table 3 (Appendix Q)**. **Figure 27 (Appendix P)** shows that Group A decreased between time 1 and 2 and then increased with both groups reaching the same level of improvement. These results need to be interpreted with caution as the baseline difference between the groups at the outset was significant (**Table 4.5**). This baseline difference may therefore have yielded potentially different outcomes had the groups been more homogenous in this measurement method.

4.7.2.1.2 Extension (E)

Null Hypothesis: It is hypothesized that Group A would not show any difference in the degree of improvement of extension as Group B in the treatment of chronic mechanical neck pain. Utilizing the ANOVA testing and an alpha value of 0.05 the null hypothesis cannot be rejected (*p*=0.223) as both groups improved (**Table 4, Appendix Q**). **Figure 28 (Appendix P)** demonstrates the improvement in both groups.

4.7.2.1.3 Right Lateral Flexion (RLF)

Null Hypothesis: It is hypothesized that Group A would not show any difference in the degree of improvement of right lateral flexion as Group B in the treatment of chronic mechanical neck pain.
Utilizing the ANOVA testing and an alpha value of 0.05 there was no statistically significant evidence for treatment effect and hence the null hypothesis is not rejected (*p*=0.822) as shown in **Table 5 (Appendix Q). Figure 29 (Appendix P)** shows that both groups improved over time.

4.7.2.1.4 Left Lateral Flexion (LLF)

Null Hypothesis: It is hypothesized that Group A would not show any difference in the degree of improvement of left lateral flexion as Group B in the treatment of chronic mechanical neck pain.
Utilizing the ANOVA testing and an alpha value of 0.05 there was statistically significant evidence for treatment effect for LLF and hence the null hypothesis is rejected (*p*=0.011) as seen in **Table 6 (Appendix Q)**. Group A showed an overall increase in scores while Group B's score did not change much from baseline values (**Figure 30, Appendix P**). Group A improved significantly in comparison to Group B.

4.7.2.1.5 Right Rotation (RR)

Null Hypothesis: It is hypothesized that Group A would not show any difference in the degree of improvement of right rotation as Group B's participants in the treatment of chronic mechanical neck pain. Utilizing the ANOVA testing and an alpha value of 0.05 both groups improved significantly, however, there was no treatment effect (*p*=0.372) as shown in **Table 7 (Appendix Q)** and hence the null hypothesis cannot be rejected. **Figure 31 (Appendix P)** illustrates that both groups show a great improvement from the first to second visit.

4.7.2.1.6. Left Rotation

Null Hypothesis: It is hypothesized that Group A would not show any difference in the degree of improvement of Left rotation as Group B in the treatment of chronic mechanical neck pain. Group A and Group B both showed an improvement (**Figure 32, Appendix P**). Utilizing the ANOVA testing and an alpha value of 0.05 **Table 8 (Appendix Q)** reveals that there was however no treatment effect (*p*=0.556) and hence the null hypothesis cannot be rejected for LR.

4.7.2.2 TENDERNESS READINGS

Null Hypothesis: It is hypothesized that Group A would not show any difference in the degree of improvement of tenderness as the participants in Group B in the treatment of chronic mechanical neck pain. **Figures 33-36 (Appendix P)** illustrate an improvement in the tenderness readings of all four trigger points in both groups with trigger point two (**Figure 34, Appendix P**) and trigger point three (**Figure 35, Appendix P**) showing an almost equal profile plot. Utilizing the ANOVA testing and an alpha value of 0.05 there was however, no treatment effect for all four trigger points (**TP1**: *p*=0.792; **TP2**: *p*=0.902; **TP3**: *p*=0.830 and **TP4**: *p*=0.571) as shown in **Tables 4.9-4.12 (Appendix Q)** and hence the null hypothesis cannot be rejected.

4.7.3 A SUMMARY OF THE MEAN OBJECTIVE AND SUBJECTIVE RESULTS

Table 4.10 provides the mean NDI and NRS-101 in both groups. These are the mean values taken at the first, third and fifth visits. Both groups displayed a decrease in the mean scores which suggested a decrease in the pain levels as well as the disability levels associated with the CMNP.

Table 4.10 A comparison of the subjective measures in both groups

	GROUP	VISIT 1	VISIT 3	VISIT 5
NDI	A	24%	14%	10%
	B	22%	11%	7%
NRS-101	A	30.97	18.58	11.84
	B	31.89	22.26	15.83

Table 4.11 provides a summary of the mean CROM and tenderness readings in both groups.

Table 4.11 A comparison of the objective measures in both groups

		VISIT 1		VISIT 3		VISIT 5	
	ROM	A	**B**	**A**	**B**	**A**	**B**
CROM	F	67	59	63	61	64	64
	E	68	74	75	76	76	75
	RLF	48	48	49	50	52	52
	LLF	48	49	46	51	52	49
	RR	70	70	81	78	78	79
	LR	68	68	71	75	77	80
Tenderness	TP1	3.59	3.25	4.4	3.9	4.86	4.23
	TP2	3.88	3.73	4.81	4.91	5.16	5.10
	TP3	3.99	3.76	4.87	4.76	5.20	5.06
	TP4	3.74	3.63	4.13	4.30	4.61	4.95

4.7.4 PEARSON'S CORRELATIONS BETWEEN THE CHANGES IN OUTCOME VARIABLES FOR GROUP A AND B

The tables below provide a summary of the negative and positive correlations that existed in both groups A and B individually.

4.7.4.1 PEARSON'S CORRELATIONS FOR GROUP A

Table 4.12: Pearson's correlation between changes in outcome variables in Group A (Five-second MET)

		Change in NDI	Change in NRS	Change in F	Change in E	Change in RLF	Change in LLF	Change in RR	Change in LR	Change in TP1	Change in TP2	Change in TP3	Change in TP4
Change in NDI	Pearson Correlation	1	.552**	.166	.189	-.065	.003	.035	.029	-.096	-.258	-.072	-.279
	Sig. (2-tailed)		.003	.418	.356	.751	.988	.867	.887	.642	.203	.725	.167
	N	26	26	26	26	26	26	26	26	26	26	26	26
Change in NRS	Pearson Correlation	.552**	1	-.130	.050	-.210	-.418*	.073	.064	-.076	-.294	-.410*	-.290
	Sig. (2-tailed)	.003		.526	.808	.302	.033	.723	.755	.712	.144	.037	.150
	N	26	26	26	26	26	26	26	26	26	26	26	26
Change in F	Pearson Correlation	.166	-.130	1	.222	.399*	.213	.275	-.124	.442*	.409*	.313	.315
	Sig. (2-tailed)	.418	.526		.275	.043	.297	.174	.546	.024	.038	.119	.117
	N	26	26	26	26	26	26	26	26	26	26	26	26
Change in E	Pearson Correlation	.189	.050	.222	1	.611**	.590**	.490*	-.141	.538**	.358	.372	.239
	Sig. (2-tailed)	.356	.808	.275		.001	.002	.011	.492	.005	.072	.062	.239
	N	26	26	26	26	26	26	26	26	26	26	26	26
Change in RLF	Pearson Correlation	-.065	-.210	.399*	.611**	1	.583**	.585**	.125	.417*	.419*	.325	.322
	Sig. (2-tailed)	.751	.302	.043	.001		.002	.002	.544	.034	.033	.106	.109
	N	26	26	26	26	26	26	26	26	26	26	26	26
Change in LLF	Pearson Correlation	.003	-.418*	.213	.590**	.583**	1	.418*	.271	.488*	.365	.290	.188
	Sig. (2-tailed)	.988	.033	.297	.002	.002		.034	.180	.011	.066	.151	.357
	N	26	26	26	26	26	26	26	26	26	26	26	26

		Change in NDI	Change in NRS	Change in F	Change in E	Change in RLF	Change in LLF	Change in RR	Change in LR	Change in TP1	Change in TP2	Change in TP3	Change in TP4
Change in RR	Pearson Correlation	.035	.073	.275	.490*	.585**	.418*	1	.143	.236	.239	.013	.141
	Sig. (2-tailed)	.867	.723	.174	.011	.002	.034		.487	.246	.239	.951	.494
	N	26	26	26	26	26	26	26	26	26	26	26	26
Change in LR	Pearson Correlation	.029	.064	-.124	-.141	.125	.271	.143	1	.078	-.068	-.259	-.289
	Sig. (2-tailed)	.887	.755	.546	.492	.544	.180	.487		.706	.743	.202	.153
	N	26	26	26	26	26	26	26	26	26	26	26	26
Change in TP1	Pearson Correlation	-.096	-.076	.442*	.538**	.417*	.488*	.236	.078	1	.500**	.382	.213
	Sig. (2-tailed)	.642	.712	.024	.005	.034	.011	.246	.706		.009	.054	.297
	N	26	26	26	26	26	26	26	26	26	26	26	26
Change in TP2	Pearson Correlation	-.258	-.294	.409*	.358	.419*	.365	.239	-.068	.500**	1	.359	.336
	Sig. (2-tailed)	.203	.144	.038	.072	.033	.066	.239	.743	.009		.072	.093
	N	26	26	26	26	26	26	26	26	26	26	26	26
Change in TP3	Pearson Correlation	-.072	-.410*	.313	.372	.325	.290	.013	-.259	.382	.359	1	.597**
	Sig. (2-tailed)	.725	.037	.119	.062	.106	.151	.951	.202	.054	.072		.001
	N	26	26	26	26	26	26	26	26	26	26	26	26
Change in TP4	Pearson Correlation	-.279	-.290	.315	.239	.322	.188	.141	-.289	.213	.336	.597**	1
	Sig. (2-tailed)	.167	.150	.117	.239	.109	.357	.494	.153	.297	.093	.001	
	N	26	26	26	26	26	26	26	26	26	26	26	26

****. Correlation is significant at the 0.01 level (2-tailed).**

***. Correlation is significant at the 0.05 level (2-tailed).**

(The significant correlations for Group A are highlighted in Table 4.12 above)

4.7.4.2 A SUMMARY OF THE POSITIVE AND NEGATIVE CORRELATIONS FOR GROUP A

Positive correlations:

- Positive correlations were found between the NDI and NRS-101 (*p*=.003). This suggests that when one variable increased, the other variable also showed an increase. When one variable decreased, the other variable also showed a decrease.
- Positive correlations were found between RLF and these variables; F (*p*=.043); E (*p*=.001) and TP1 (*p*=.034). This suggests that when RLF increased, there appeared to be an increase in the F, E and TP1 as well.
- LLF displayed a positive correlation with E (*p*=.002) and RLF (*p*=.002). This suggests that when the LLF increased, there was an increase in E and RLF as well.
- A positive correlation was found between RR and E (*p*=.011); RLF (*p*=.002) and LLF (*p*=.034). This suggests that when RR increased there was an increase in the RLF and LLF.
- A positive correlation was found between TP1 and these variables: F (*p*=.024); E (*p*=.005) and LLF (*p*=.011). This suggests that when the algometer readings increased (Indicating a decrease in the tenderness levels) there was an increase in the F, E and LLF ranges of motion.
- A positive correlation was found between TP2 and these two variables; RLF (*p*=.003) and TP1 (*p*=.009). This suggests that when TP2 readings increased (Indicating a decrease in tenderness) there was an increase in the RLF ROM and TP1.
- A positive relation was found between TP4 and TP3 (*p*=.001) suggesting that when TP4 increased , there was an increase in TP3 as well.

Negative correlations:

- Negative correlations were found between LLF and NRS-101 (*p*=.033). This suggests that when LLF increased or decreased there was an increase or decrease in the NRS-101 levels respectively suggesting that if the LLF ROM increased there was a decrease in the pain levels as reported by the participants.
- There was a negative correlation between TP3 and NRS-101 (*p*=.037) suggesting that when one variable increased the other decreased.

4.7.4.3 PEARSON'S CORRELATIONS FOR GROUP B

Table 4.13: Pearson's correlation between changes in outcome variables in Group B (45-second MET)

		Change in NDI	Change in NRS	Change in F	Change in E	Change in RLF	Change in LLF	Change in RR	Change in LR	Change in TP1	Change in TP2	Change in TP3	Change in TP4
Change in NDI	Pearson Correlation	1	.743**	-.195	-.093	-.091	-.279	-.148	-.404*	-.137	-.104	-.037	-.390*
	Sig. (2-tailed)		.000	.331	.645	.650	.159	.462	.036	.497	.605	.855	.044
	N	27	27	27	27	27	27	27	27	27	27	27	27
Change in NRS	Pearson Correlation	.743**	1	-.258	-.294	-.341	-.277	-.062	-.597**	-.252	.135	-.098	-.451*
	Sig. (2-tailed)	.000		.194	.137	.082	.162	.759	.001	.204	.503	.628	.018
	N	27	27	27	27	27	27	27	27	27	27	27	27
Change in F	Pearson Correlation	-.195	-.258	1	.035	.309	.204	.318	.219	-.200	-.548**	-.024	-.072
	Sig. (2-tailed)	.331	.194		.861	.117	.307	.106	.273	.316	.003	.906	.720
	N	27	27	27	27	27	27	27	27	27	27	27	27
Change in E	Pearson Correlation	-.093	-.294	.035	1	.174	.434*	.163	.144	-.059	-.112	-.017	-.081
	Sig. (2-tailed)	.645	.137	.861		.386	.024	.417	.474	.772	.579	.933	.688
	N	27	27	27	27	27	27	27	27	27	27	27	27
Change in RLF	Pearson Correlation	-.091	-.341	.309	.174	1	.411*	.049	.532**	.118	-.257	.134	.019
	Sig. (2-tailed)	.650	.082	.117	.386		.033	.808	.004	.557	.196	.505	.923
	N	27	27	27	27	27	27	27	27	27	27	27	27
Change in LLF	Pearson Correlation	-.279	-.277	.204	.434*	.411*	1	.179	.011	-.026	-.258	-.123	.060
	Sig. (2-tailed)	.159	.162	.307	.024	.033		.371	.958	.898	.194	.541	.768
	N	27	27	27	27	27	27	27	27	27	27	27	27
Change in RR	Pearson Correlation	-.148	-.062	.318	.163	.049	.179	1	.077	.071	-.014	.153	.006
	Sig. (2-tailed)	.462	.759	.106	.417	.808	.371		.702	.725	.947	.445	.977
	N	27	27	27	27	27	27	27	27	27	27	27	27

		Change in NDI	Change in NRS	Change in F	Change in E	Change in RLF	Change in LLF	Change in RR	Change in LR	Change in TP1	Change in TP2	Change in TP3	Change in TP4
Change in LR	Pearson Correlation	-.404*	-.597**	.219	.144	.532**	.011	.077	1	.357	-.128	.194	-.024
	Sig. (2-tailed)	.036	.001	.273	.474	.004	.958	.702		.067	.524	.333	.904
	N	27	27	27	27	27	27	27	27	27	27	27	27
Change in TP1	Pearson Correlation	-.137	-.252	-.200	-.059	.118	-.026	.071	.357	1	.557**	.345	.319
	Sig. (2-tailed)	.497	.204	.316	.772	.557	.898	.725	.067		.003	.078	.104
	N	27	27	27	27	27	27	27	27	27	27	27	27
Change in TP2	Pearson Correlation	-.104	.135	-.548**	-.112	-.257	-.258	-.014	-.128	.557**	1	.460*	.297
	Sig. (2-tailed)	.605	.503	.003	.579	.196	.194	.947	.524	.003		.016	.133
	N	27	27	27	27	27	27	27	27	27	27	27	27
Change in TP3	Pearson Correlation	-.037	-.098	-.024	-.017	.134	-.123	.153	.194	.345	.460*	1	.216
	Sig. (2-tailed)	.855	.628	.906	.933	.505	.541	.445	.333	.078	.016		.279
	N	27	27	27	27	27	27	27	27	27	27	27	27
Change in TP4	Pearson Correlation	-.390*	-.451*	-.072	-.081	.019	.060	.006	-.024	.319	.297	.216	1
	Sig. (2-tailed)	.044	.018	.720	.688	.923	.768	.977	.904	.104	.133	.279	
	N	27	27	27	27	27	27	27	27	27	27	27	27

****. Correlation is significant at the 0.01 level (2-tailed); *. Correlation is significant at the 0.05 level (2-tailed). (The significant correlations for Group B are highlighted in Table 4.13 above)**

4.7.4.4 A SUMMARY OF THE POSITIVE AND NEGATIVE CORRELATIONS FOR GROUP B

Positive correlations:

- There was a positive correlation between the NRS-101 and NDI (*p*=.000). This suggests that if the NRS-101 increased the NDI showed an increase and if the NRS-101 decreased the NDI also showed a decrease.
- A positive correlation was found with LLF and these variables; E (*p*=.024) and RLF (*p*=.033). This suggests that if the LLF increased or decreased, there appeared to be an increase or decrease in the other two variables respectively at the same time.
- A positive correlation was found between these two variables LR and RLF (*p*=.004). This suggests that changes in LR were matched by similar changes in RLF.
- A positive correlation was found between these two variables TP1 and TP3 (*p*=.003). This suggests that changes in TP1 were matched by similar changes in TP3.
- A positive correlation was found between these two variables TP2 and TP1 (*p*=.003). This suggests that changes in TP2 were matched by similar changes in TP1.
- A positive correlation was found between these two variables TP3 and TP2 (*p*=.016). This suggests that changes in TP3 were matched by similar changes in TP2.

Negative correlations:

- A negative correlation was found between LR and these two variables; NRS-101 (*p*=.001) and NDI (*p*=.036). This suggests that an increase in LR was matched by a decrease in the NRS-101 and the NDI. If the LR decreased then the NRS-101 and the NDI would has increased.
- There was a negative correlation between TP2 and F (*p*=.003) suggesting that when one variable increased the other decreased.
- A negative correlation was found between TP4 and these two variables; NDI (*p*=.044) and NRS-101 (*p*=.018). This suggests that when TP4 increased or decreased, the NDI andNRS-101 would do the opposite.

4.8 CONCLUSION

From the intra-group analysis of Group A, the results indicated that all outcomes showed a significant improvement over time except for F, RLF and LR. The intra-group analysis for Group B revealed that all outcome measures improved significantly over time except for F, E, RLF and LLF. The results of the inter-group analysis revealed that only LLF showed a significant treatment effect (p=0.011) where overall increase in scores was shown in Group A while Group B did not change much from baseline values. It can, therefore, be concluded that this study demonstrated that both treatment protocols are equally effective for all outcomes except for LLF where Group A seemed to show a more significant improvement than Group B.

CHAPTER FIVE

DISCUSSION OF RESULTS

5.1 INTRODUCTION

This chapter discusses the objective and subjective data that was stated in Chapter Four. The demographics as well as the three objectives of the study will also be discussed.

5.2 DEMOGRAPHICS

5.2.1 AGE

The age distribution in both groups was similar. The mean age of all participants was 21.7 years. A possible reason for this mean could be as a result of students forming 83% of the entire sample as the study was conducted at the Chiropractic Day Clinic situated at the Durban University of Technology (DUT). This location was easily accessible to DUT students. Another reason for the mean age of the study was because only prospective participants who were between the ages of 18-40 years were invited to participate in the study. This age group was selected to minimise the inclusion of participants with the onset of degenerative joint disease, osteoporosis or very young participants, thereby allowing homogeneity of the sample with regards to condition under study.

However, a point of note is that with such a young population, the degree of chronicity of the MNP would be dissimilar to those participants who are older and also have CMNP. Therefore, it is recognised that one of the limitations of this study is that the outcomes may only be limited to a younger population, who reports CMNP, and therefore it is recommended that a future study is considered with an older demographic or a stratified demographic to reduce the possible bias that the age of participants in this study represent.

5.2.2 RACE

The distribution of race was similar in both treatment groups and was not statistically significant (p=0.43). The groups were therefore comparable. The race represented highest in this study was the Indian population (**Figure 4.1**) with Group B having a slightly higher percentage of Indians than Group A. The Coloured race group formed the lowest percentage of only 5.7% of the overall number of participants. This could be attributed to the fact that Coloureds form only 2.5% of the total population in the eThekwini district with the Indian population being the second highest race group in eThekwini (16.7%) (Statistics South Africa, 2012).

5.2.3 BODY MASS INDEX (BMI)

The mean BMI in both groups were similar. Group A had only a slightly higher BMI than Group B. This was not statistically significant. The overall mean BMI of the participants was 22.4 kg/m^2 and was not comparable to the literature in which a South African study indicated that the mean BMI of the Indians with MNP was 24.8 kg/m^2 (Muchna, 2011). The current study had an Indian population of 75%. The mean BMI of the Indians is therefore higher than the results found in the study conducted by Muchna (2011). However, an American study conducted by Gerr *et al.* (2002) revealed that the highest percentage of neck pain in office workers was in individuals with a BMI of 18.5-24.9 kg/m^2. This may be comparable to the current study as the occupation demographic of the current study had jobs/activities that were consistent with office-like activity (e.g. Computer use, writing, forward flexed or laterally flexed head positions). It may be possible that the current study does not agree with Muchna (2011) because of the fact that the majority of the participants were students and therefore comply to a greater extent with Gerr *et al*. (2002) who conducted a study on office workers than Muchna's (2011) study that looked at the general population (which was not limited to office workers particularly as this relates to the use of a computer as is described further down under the discussion of occupation (**Section 5.2.5**).

5.2.4 GENDER

The male to female distribution revealed that Group A had more females than males whilst Group B had more males than females**.** However the overall male to female distribution of participants in each group was similar (p=0.130) and can be seen in **Figure 4.2**. The overall number of females in the study was, however, slightly higher than the males who participated in the study which is in accordance with the literature in which several studies indicate females to have a higher prevalence of neck pain (Skillgate *et al.*, 2012; Hoy, Protani and Buchbinder 2010; Leboeuf –Yde *et al*., 2009; Fejer *et al*., 2006; Brandt *et al*., 2004; Cote *et al*., 2004) as well as a higher incidence (Hoy, Protani and Buchbinder, 2010; Croft *et al.*, 2001) of neck pain than males.

5.2.5 OCCUPATION

Inferential statistic tests could not be done on the occupation groups as there were too many diverse occupations**. Figure 4.3** however illustrates that students formed the largest percentage of the 'occupation' demographic in the study. This finding could be attributed to the fact that the study was conducted at the Chiropractic Day Clinic situated at the DUT and as a university campus was therefore more readily accessible to students.

According to Kanchanomai *et al*. (2011) it is not uncommon to have a high prevalence and incidence of students with neck pain as research conducted on university students showed an incidence of 46% in the undergraduate students aged 18-25 years of age. Computer usage has been identified as the main contributing factor (Cote *et al*., 2008; Green *et al*., 2008; Sim *et al*., 2006; Schlossberg *et al*., 2004). It is also not infrequent for neck pain to appear in the various occupation groups of the study as majority of these groups have work activities that involve repeated lifting of heavy objects, head bent for prolonged periods of time (e.g. typing, studying) and working with arms at or above the level of the shoulder, all of which are contributing factors to a higher prevalence and incidence of acute and chronic mechanical neck pain (Sim *et al*., 2006; Ming, Narhi and Siivola, 2004). The engineering students alone formed a high percentage (42%) of the total student population for the current study (**Table 4.4**). This is comparable to a study conducted in the United States in which 64% of the engineering and computer science students presented with MNP (Schlossberg *et al*., 2004).

5.2.6 A SUMMARY OF THE DEMOGRAPHIC FINDINGS

The overall profile of Group A was a group of participants with a slightly higher BMI, slightly higher number of females, fewer students, fewer Indians and younger individuals. In comparison, Group B was the opposite with participants having a lower BMI; there were more males, more students and more Indians, and generally older participants.

5.3 BASELINE SIMILARITIES AND DIFFERENCES BETWEEN THE TWO GROUPS

An independent t-test comparing baseline means between the two groups for the subjective outcomes and for objective outcome measures were done. For the subjective outcome measures the NDI and NRS-101 were similar in both groups and where not statistically significant (NDI: p=0.520, NRS - 101: p=0.773) as shown in **Table 4.5.** The objective outcome measures (**Table 4.5**) were similar for all ranges of motion across both groups except for the flexion range of motion. Group A revealed a higher mean for Flexion when compared to Group B. Flexion was therefore considered statistically significant (p=0.045) at baseline. The mean range of motion at baseline (**Table 4.5**) was comparable to the mean range of motion of the age group 20-29 years as shown in the literature (**Table 5.1**). Flexion at baseline (66. 85°) was only slightly above the normal ranges found at the mean age of the study participants.

Table 5.1: The mean range of motion for previous age group studies comparable with the mean age of this study

ROM	AGE 20-29 years
Flexion	66°
Extension	57°
Left rotation	72°
Right rotation	71°
Left lateral flexion	44°
Right lateral flexion	45°

(Adapted from Feipel *et a*l., 1999)

The tenderness readings in both groups at baseline were similar. There was no statistical significance across all four TPs (TP1: p= 0.614; TP2: p= 0.820; TP3: p= 0.595 and TP4 p= 0.892) (**Table 4.5)**

The difference in the flexion ROM between the two groups may represent a significant variable that was not considered in this study and may have been influenced by the populations within each group. According to Quek *et al.* (2013) and Silva and Johnson (2013), this variable may point to forward head posture (FHP). With the slight increase in the BMI and more females in Group A; it is possible that a slight increase in FHP may have been present as FHP is seen to be associated with increased breast size, increased thoracic kyphosis and rounded shoulders, in the literature (Quek *et al*., 2013; Silva and Johnson, 2013; Ciesla and Polom, 2010; Szeto, Straker and Raine, 2002; Raine and Twomey, 1997). Therefore, when one considers that as FHP increases the degree to which a person is able to forward flex, but decreases the degree of extension (but to a lesser degree than flexion) (Raine and Twomey, 1997), it is possible that Group A may have been influenced to a greater degree based on its demographics. When looking at CMNP, the literature does not indicate that flexion may have specific precursors therefore controlling for flexion differences could not be done. Thus the presence of one or two outlier readings within this group may have affected the baseline norms, resulting in the significant difference obtained. However controlling for flexion statistically at baseline is possible.

5.4 DISCUSSION OF THE FINDINGS OF OBJECTIVE ONE

5.4.1 SUBJECTIVE OUTCOME MEASURES FOR GROUP A

5.4.1.1 NDI AND NRS-101 SCORES

The NDI (**Figure 1, Appendix P**) and NRS-101 scores (**Figure 2, Appendix P**) in Group A both displayed a statistically significant improvement (p<0.001). The minimally clinically important difference (MCID) of the NDI is between 10 (Young *et al*., 2009) and 10.5 points (Pool *et al.*, 2007) and the MCID for the NRS-101 is 20mm, therefore there was no clinical significance for the NDI or the NRS-101 for Group A as both had less changes than the MCID (**Table 4.6**). The NDI had a change of seven points only and the NRS-101 had a change of 19mm. It can also be noted that both the NDI and the NRS-101 have decreased to more than half from the mean scores seen at baseline to the final (fifth) visit (**Table 4.6**) further suggesting improvement in both subjective measures.

It is not uncommon to find these results as they are comparable to the literature which states that a decrease in neck pain will result in an increase in the ability to carry out activities or an improvement in function (Young *et al*., 2009). Fryer (2011), Chaitow (2006) and Fryer (2000) suggest that a possible reason for a decrease in pain following the application of MET may be attributed to the stimulation of trans-synovial flow within the capsule of the zygapophyseal joint. Movement of this joint, which is brought about by the application of MET, may produce fluctuations in the intra-synovial pressure within the joint capsule. This subsequently results in the flow of trans-synovial fluid out of the joint therefore resulting in a decrease in effusion. This reduction in effusion results in a decrease in pain (Chaitow, 2006) and hence a decrease in the disability associated with the CMNP (Fryer, 2011; Chaitow, 2006; Fryer, 2000).

5.4.2 OBJECTIVE OUTCOME MEASURES FOR GROUP A

5.4.2.1 CROM READINGS

Figures 4.6-4.11 graphically display the analysis of the CROM goniometer findings. A statistically significant (p<0.005) increase was only found in E, LLF and RR movement of the cervical spine. F, RLF and LR were not statistically significant. Flexion showed a steep decrease in the mean values from the first visit to the third visit. At baseline, flexion was slightly higher than the normal ranges found in the literature (**Table 2.6** and **Table 5.1**). At the end of the study flexion decreased but was now within the normal ranges of motion as found in the literature (**Table 2.6** and **Table 5.1)**.

When the changes in the range of motion above are read in the context of the data below, it becomes apparent that the effect of the short duration MET was as a result of:

- More extension restrictions than flexion restrictions as seen in **Table 4.2** which suggested that the extensors of the neck may have been tight or hypertonic indicating a dysfunctional joint (**Table 2.7**). According to Bergman, Peterson and Lawrence (1993), joint restrictions/dysfunctions are often associated with hypertonic muscles. It is worthy to note that the extension musculature hypertonicity may have been associated with inhibition via the reciprocal inhibition mechanism of the flexors of the neck as suggested by Chaitow (2006). This combination of muscle functioning or dysfunction is typical of FHP (Bergmann and Peterson, 2011) and may therefore serve to re-enforce the suggested reason for the significant difference between the Groups A and B at the baseline, with regards to the flexion range of motion. The flexor neck muscles may not have been treated sufficiently as there was only one flexion restriction treated in Group A (Table 4.2) Furthermore the results would seem to suggest that a short duration MET has an effect on reducing the hypertonicity in the smaller cervical spine extensor muscles and activate the smaller cervical spine flexors muscles (often referred to as postural muscles). This would have rectified the excess flexion range of motion in this study resulting in it decreasing over the period of the intervention.

- It should be considered that the flexion range of motion may not have improved, because there was only one flexion restriction to which MET was applied in Group A (**Table 4.2**). It however stands to reason that flexion would have had limited if any improvement over the course of the intervention as the range of motion present in Group A was already close to the end range of the normal range for the cervical spine (**Table 4.5 and Table 5.1**). Therefore, the application of treatment to improve flexion would most likely not have resulted in any change. Notwithstanding, this, future research may consider stratifying restrictions, in order to obtain equitable numbers in each of the treatment groups to avoid the presence of this as a possible confounding variable, particularly if this variable is not related to FHP.

Another possible reason for the changes seen in Group A may be linked to spinal coupled motions. Spinal coupled motion may provide an explanation for the patterns of range of motion. Type 1 coupled motion is described as contralateral coupling of rotation and lateral flexion and this occurs when the spine is in the neutral or closed-packed position (Fryer, 2011; Cook *et al.,* 2006). Cook *et al.* (2006) conducted a systemic review on the coupling behaviour of the cervical spine. The results of the study indicated that in the lower cervical spine, the spinal coupling is ipsilateral rotation and lateral flexion. Whilst this may be the case for the lower cervical spine, the study further indicated that the upper cervical spine displays variation in the spinal coupling motion and that contralateral rotation and lateral flexion may exist suggesting that an improvement in rotation to one side may also have an improvement in the contralateral lateral flexion. The results of Cook *et al.* (2006) may be used to authenticate the findings of the current study. This is possible in that in this study Group A:

- Showed a significant improvement in, LLF and RR whereas LR and RLF did not improve. Spinal coupling of contralateral rotation and lateral flexion may have existed in this group (Group A) and hence an improvement in right rotation displayed an improvement in the contralateral lateral flexion (LLF). The same principle may be used to give an explanation for the pattern of no improvement in LR and RLF.
- **Table 4.3** shows that there were very few Left PA restrictions treated in Group A when compared to the Right PA restrictions/ joint dysfunctions.
- Displayed cervical restrictions predominately in the upper cervical spine (**Table 4.3**) which meant that treatment was applied mostly to the upper cervical region.
- The postural muscles (small muscles of the cervical spine) as noted in the discussion on the changes in flexion and FHP) are also predominantly located in the upper cervical spine (Burgess-Limerick, Plooy and Ankrum, 1998).

Another consideration that needs to be given to this group is that MET was applied specifically to the restricted joints and not to the muscles. The number of MFTPs per muscle and collectively in each direction of movement is shown in **Table 4.1.** According to Simons, Travell and Simons (1999) a MFTP in a muscle could result in shortening of the muscle. Therefore, by default a stretch would have assisted in remedying the MFTPs in the respective muscles. The global muscles responsible for the various ranges of motion, all presented with MFTPs. Whilst the MET was applied specifically to the restricted joints in the neck, the muscles in the neck were not treated (at least not by a stretch) and could therefore explain a potential reason for F, RLF and LR not improving significantly as the muscles responsible for these actions, were not specifically isolated and treated. However, the effects of the MET on postural muscles or the small cervical muscles was neither recorded directly or via proxy measures, therefore it is suggested that these measures be included in future research to determine the presence of postural change with MET treatment and / or whether there are direct measures for the deep / small cervical muscles such as the cranio-cervical flexion tests (Burgess-Limerick, Plooy and Ankrum, 1998).

5.4.2.2 THE TENDERNESS READINGS

The results of the tenderness readings for Group A are shown in **Figures 4.12- 4.15**. There was no clinical significance for all the MFTPs as the mean scores for all these MFTPs were below the MCID of 1.5kg/cm^2 (O'Leary *et al.*, 2007; Potter, McCarthy and Oldham, 2006; Paungmali, Vincenzino and Smith, 2003) . There was, however, a statistically significant improvement in all MFTP readings in Group A. The tenderness readings increased from the first visit to the fifth visit (**Table 4.7**). This suggested that the pain levels experienced by the participants had decreased as they had less tenderness as measured with the use of the Algometer. The trigger points found in the study are shown in **Table 4.1**.

The changes in the tenderness readings, indicating a decrease in pain, concurs with the decrease in the NDI findings and the NRS-101 findings (**Figure 1 and Figure 2, Appendix P**) suggesting a large proportion of the pain that participants' experienced in their neck stemmed from the muscular component of their neck pain. According to Simons, Travell and Simons (1999) and Chaitow (2006) a MFTP in a muscle could result in shortening of the muscle, therefore, by default a stretch would have assisted in remedying the MFTPs in the respective muscles. This would be congruent with the assertions that the MET effects of potentially strengthening or toning the muscles (as would be the case in postural re-alignment), is also potentially responsible for decreasing the MFTPs present in the muscles by increasing their ability to ensure prolonged postures or alter postures to decrease the stressors placed on the muscles. These latter assertions require further testing and this is elaborated on in Chapter Six under recommendation from this study.

5.5 DISCUSSION OF THE FINDINGS OF OBJECTIVE TWO

5.5.1 SUBJECTIVE OUTCOME MEASURES FOR GROUP B

5.5.1.1 NDI AND NRS-101 SCORES

The NDI (**Figure 13, Appendix P**) and NRS-101 scores (**Figure 14, Appendix P**) in Group B both displayed a statistically significant improvement (p<0.001). However, the NDI for Group B was not clinically significant (**Table 4.8**) with a change of seven and a half points which is less than the MCID of 10-10.5 points (Young *et al*., 2009; Pool *et al*., 2007). The NRS-101 was also not clinically significant as it had a change of only 16mm (**Table 4.8**) which is less than the MCID of 20mm (Ostelo and de Vet, 2005; Lee *et al*., 2003).**Figure 14 (Appendix P)** that displays the NRS-101 results, showed a decrease in the mean NRS-101 scores from the first to fifth visit with the steepest descend seen from the first visit to the third visit thus indicating a greater decrease in the neck pain experienced by the participants. **Figure 13 (Appendix P)** that displays the NDI scores also showed a steep descent from visit one to visit three therefore indicating a decrease in the participants' disability levels associated with the neck pain. It was also noted that both the NDI and the NRS-101 decreased to more than half from the mean scores seen at baseline to the final (fifth) visit (**Table 4.8**) further suggesting improvement in both subjective measures. It is not uncommon to find these results as they are comparable to previous studies which states that a decrease in neck pain will result in an increase in the ability to carry out activities of daily living (Young *et al*., 2009).

5.5.2 OBJECTIVE OUTCOME MEASURES FOR GROUP B

5.5.2.1 CROM READINGS

Figures 4.18-4.23 graphically display the analysis of the CROM goniometer findings. A statistically significant (p<0.005) increase was only found in LR and RR movements of the cervical spine. F, E, LLF and RLF were not statistically significant. LLF (**Figure**: **4.21**) decreased from the third visit to the fifth visit. **Table 4.9** provides a summary of the objective measures. The extension movement may not have improved significantly as muscle fatigue could have set in as a result of the 45-second MET and that would have resulted in poor outcome. The contraction used in this MET treatment was an isometric contraction. These results may be comparable to the study conducted by Gosselin, Rassoulian and Brown (2004) in which muscle fatigue occurred in the patients with neck pain following an isometric contraction into extension. The asymptomatic patients of that study were able to maintain the contraction for the full duration of the isometric contraction as opposed to the neck pain patients who could not maintain the resistance against the isometric contraction. Lee, Nicholson and Adams (2005) also found that patients with neck pain could not maintain the full duration of a contraction for an investigation on endurance of the posterior cervical muscles of the neck and suggested that there is a significant reduction of neck extension in patients with neck pain.

The occupation statistics revealed that students formed the highest percentage of the 'occupation' demographic (**Figure 4.3**). The posture employed by students is one in which the head is in the forward flexed; left lateral flexion (Assuming that they are predominantly right handed) and rotated to the right (The individual tends to rotate the head toward the dominant hand) (Green, 2008; Sim, Lacey and Lewis, 2006; Schlossberg *et al*., 2004). This suggests that the left lateral flexors could have been shortened and stiff (Bergmann and Peterson, 2011; Middleditch and Oliver 2005). If RLF is controlled by the LLF muscles (Bergmann and Peterson, 2011; Middleditch and Oliver 2005). If these LLF muscles were already shortened at the onset and were not sufficiently treated then RLF may have been limited due to the stiff LLF flexors which are antagonists to the RLF. **Table 4.2** shows that there were indeed very few left lateral restrictions treated in both groups.

The effects of posture as noted in Group A, needs further investigation, as at this stage the contribution of this confounding variable cannot be determined by the measures utilised in this study and thus a recommendation is made that a future study more fully investigates this.

Flexion and Extension did not significantly improve in Group B and neither did LLF and RLF. This may be comparable to the study by Burns and Wells (2006) which investigated the effects of MET on gross cervical range of motion. The results of the study also revealed a significant improvement in rotation and also displayed a non-significant improvement in extension, flexion and lateral flexion to either side. The mean age of the current study was 21.7 years of age. This younger population is comparable with the study by Burns and Wells (2006). They suggest that the participants' age could have a possible role in the outcome in that younger individuals have a larger gross range of motion of the neck (**Table 5.1**) such that in Flexion and Extension movements and LLF and RLF movements are limited by anatomical barriers, as opposed to rotation which has no restrictive barriers (Burns and Wells, 2006) and could therefore account for the significant improvement in rotation only, in the current study (particularly in Group B, where the posture is closer to the optimum).

Additionally, as mentioned previously, MET was applied specifically to the restricted joints and not to the muscles. The number of MFTPs per muscle and collectively in each direction of movement is shown in **Table 4.1**. According to Simons, Travell and Simons (1999), a trigger point in a muscle could result in shortening of the muscle. The muscles responsible for the various ranges of motion, all presented with MFTPs (**Table 4.1**). Whilst the MET was applied specifically to the restricted joints in the neck, the muscles in the neck were not treated which could be a potential reason for the insignificant improvement of Flexion, Extension, LLF and RLF.

A further possible confounding variable in this group (Group B) is that of occupation, in that Group B had a higher percentage of students. Their right hand dominance as well as their continued lateral flexion to the left and rotation to the right (with right hand dominance, individuals tend to rotate their head towards that hand and laterally flex their necks away from the dominant hand), tight musculature of the right shoulder (including trapezius muscle and the levator scapula on the right), would have limited the degree of left rotation (by contracture or spasm), whilst allowing relatively normal (albeit slightly less) rotation to the right (Bergmann and Peterson, 2011). In addition this position is employed for several hours a day by the majority of students that are the largest contributor to this group. Therefore it is likely that these ROMs would have been the ones that would have increased the most of all the motion parameters tested, particularly when the posture of the Group B on the whole seems to have been better than that of Group A. This latter assertion however requires further evidence / support and therefore it is suggested that this research be repeated with emphasis on clinical as well as postural and muscular outcomes.

5.5.2.2 THE TENDERNESS READINGS

The results of the tenderness readings for Group B are shown in **Figures 4.24- 4.27**. There was no clinical significance for all the MFTPs as the means scores for all these TPs were below the MCID of the Algometer which is 1.5kg/cm^2 (O'Leary *et al*., 2007; Potter, McCarthy and Oldham, 2006; Paungmali, Vincenzino, and Smith, 2003). There was, however, a statistically significant improvement in all MFTP readings in Group B. The tenderness readings for all four MFTPs are shown in **Table 4.9**. The results show an increase from the first visit to the fifth visit. This suggested that the pain levels experienced by the participants had decreased as they had less tenderness. The MFTPs found in the study are shown in **Table 4.1**.

This concurs with the decrease in the NDI findings and the NRS-101 findings (**Figure 13 and Figure 14, Appendix P**) suggesting a large proportion of the participants' neck pain stemmed from the muscular or myofascial component of their neck pain. As previously mentioned, Simons, Travell and Simons (1999) suggest that a MFTP in a muscle could result in shortening of the muscle, therefore by default a stretch would have assisted in remedying the MFTPs in the respective muscles.

5.6 DISCUSSION OF THE FINDINGS OF OBJECTIVE THREE

Objective Three: To compare a short duration (Group A) and a long duration (Group B) MET in terms of subjective and objective measures in the treatment of CMNP.

5.6.1 SUBJECTIVE OUTCOME MEASURES

5.6.1.1 NDI AND NRS-101 SCORES

Both Group A and Group B displayed a significant decrease in the NDI and NRS-101 scores thus indicating a decrease in the disability and pain levels experienced by the patients. No group was superior to the other as both groups displayed a similar significant decrease in both the subjective measures. The mean decrease in the NDI value from the first visit to the fifth visit was seven points (14%) for Group A and seven and a half points (15%) for Group B (**Table 4.10**). These values are both lower than the MCID of 10-10.5 points (20%-21%) (Young *et al*., 2009; Pool *et al*., 2007), which indicates that there was no clinical significance obtained by both groups by the end of the study. This indicates that the short duration and long duration MET interventions were similar in their attaining significant statistical improvement however there was no clinical improvement over the time period of the study for both groups.

There are only a few studies that have used the NDI as a subjective measure before treating with MET. Roodt (2009) used the NDI as a subjective measure when treating with a three-five second MET. The results of that study showed that the NDI had a statistically significant (p=0.001) improvement as well as clinical significance of 14 points from the first to the seventh visit. The current study is comparable with this study in that there was a statistically significant improvement of the NDI over time following the treatment of CMNP with the application of MET.

The NRS -101 decreased significantly in both groups (**Figure 26, Appendix P**). Group A decreased from 31 to 12 (decreased by 19) and Group B decreased from 32 to 16 (decreased by 16) on the NRS-101 scale (**Table 4.10**). However, none of the groups revealed a minimal clinically important difference as the MCID is noted at 20-25mm on a 100mm line (Ostelo and de Vet, 2005; Lee *et al*., 2003).

There are also only a few studies that utilized the NRS-101 as a subjective measure. The results of the current study may be comparable to these studies that have used the NRS-101 when treating CMNP patients with MET. A study conducted by Boodhoo (2002), on the effects of MET on CMNP, revealed a statistically significant decrease (p< 0.05) in CMNP in the MET group when compared to the control group. Roodt (2009) also found a decrease in the NRS-101 score levels of 47 to 17 after the use of MET in the treatment of CMNP. Schwerla *et al*. (2008) conducted a study on the effects of MET on the pain intensity in patients suffering with CMNP. The study only had subjective measures taken. Although that study used the NRS 0-10 scale, it is still comparable to the current study as there was a significant decrease from 4.7- 2.2.

Based on the subjective outcome measures of this study, it can be concluded that MET is effective in reducing the pain levels in participants suffering with CMNP regardless of whether the five-second or 45-second MET was used. The NDI was used to measure the disability levels of the participant that was brought upon by the CMNP. This study clearly depicts that decreases in the pain levels brought about a decrease in the disability levels of the participants. It is not uncommon to find these results as they are comparable to the literature which states that a decrease in neck pain will result in an increase in the ability to carry out activities or an improvement in function (Young *et al*., 2009).

5.6.2 OBJECTIVE OUTCOME MEASURES

5.6.2.1 CROM GONIOMETER

Table 5.2 below provides a summary of the intra-group and inter-group analysis of the study. The intra-group analysis was done to investigate Objective One and Two and the inter-group analysis was done on Objective Three.

Table 5.2: A Summary of the Intra-Group and Inter-Group Analysis

ROM	Objective One (Group A)	Objective Two (Group B)	Objective Three	
			Group A	Group B
F	No Change	No Change	No Change	No Change
E	Increase	No Change	No Change	No Change
RR	Increase	Increase	No Change	No Change
LR	No Change	Increase	No Change	No Change
RLF	No Change	No Change	No Change	No Change

No Change: No Statistically significant increase; Increase: Statistically significant increase

The inter-group analysis of the CROM for both Groups is illustrated in **Figures 4.30-4.35** and **Tables 3-8 (Appendix Q).** There was no significant difference in the treatment effects of the two groups for Flexion, Extension, RLF, RR and LR in Objective Three. The only movement that displayed a difference was LLF (**Figure 30, Appendix P**) where there was statistically significant evidence for treatment effect (p=0.011). Group A showed a greater improvement than Group B for LLF. The results suggested that for both groups there was a significant increase in Extension, Flexion, RLF, RR and LR. No group was superior to the other for these movements. However, LLF seemed to reveal a greater improvement in Group A. Group B revealed an increase in LLF from visit one to three but then decreased by the fifth visit whereas Group A decreased from visit one to three but then increased exponentially by the fifth visit (**Figure 30, Appendix P).**

The null hypothesis was rejected as Group A had a significant improvement compared to Group B, in terms of LLF. The null hypothesis is not rejected for Extension, RLF, RR and LR as both groups improved equally. The findings for flexion need to be read with caution as there was a baseline difference between the groups at the outset. Therefore the lack of a significant difference and not rejecting the null hypothesis would fail to indicate that there is a need for further investigation in terms of the predisposing confounders that would have led to a difference between the groups and their effect on the outcome of the study.

The current study suggested that both the 45-second and five-second MET was effective in decreasing pain and increasing range of motion in all directions except for LLF in which the five-second MET proved to be more effective. A possible explanation would be that Group B had more students than Group A in the 'occupation' demographic (**Figure 4.3**). There were also more engineering students in Group B (**Table 4.4**) as well. The students reported that they were all in the middle of writing tests. The engineering students further reported having assignments and practical tests in addition to the tests. When writing tests, the posture requires one to have the head in the forward flexed and laterally bent to the left (assuming they are all right handed). The LLF would have shortened as a result (Bergmann and Peterson, 2011). This could potentially explain why the LLF decreased from the third visit to the fifth visit as the neck muscles were being aggravated by the posture acquired when writing tests.

Flexion and extension occurs primarily at C5-C6 level (Peterson and Bergmann, 2011). There was more extension restrictions in Group A that were treated than Group B (**Table 4.2**). This difference could explain why the results of the current study showed an improvement in the extension in Group A but not in Group B. Furthermore, treatment (45-second MET) of the extension restrictions in Group B may have resulted in muscle fatigue as previously discussed in **Section 5.5.2.1.**

5.6.2.2 THE TENDERNESS READINGS

The inter-group analyses of the tenderness readings for both groups are illustrated in **Figures 4.36-4.39** and **Tables 9-12 (Appendix Q).** Both Group A and Group B displayed an equal increase in the tenderness readings (**Table 4.11**). Although MET was applied to the restrictions and not the muscles, the application of MET does result in the use of muscles attached to the restrictions or facet dysfunctions in the cervical spine (Chaitow, 2006). As mentioned previously, Chaitow, 2006 and Simons, Travell and Simons (1999) suggest that a MFTP in a muscle could result in shortening of the muscle therefore by default a stretch would have assisted in remedying the MFTPs in the respective muscles. Neither group had a statistical significance over the other. This means that both groups improved but no one group was statistically better than the other. There was no clinical significance between the two groups as the changes from the first to the fifth visit were lower than the MCID of 1.5kg/m^2.

The results of the tenderness readings correspond with the findings of the NDI (**Table 1 (Appendix Q)** and **Figure 25 (Appendix P)**) and the NRS-101 (**Table 2 in Appendix Q** and **Figure 26, Appendix P**). These results suggest that a large portion of the CMNP may be attributed to the myofascial component in the cervical spine. As the participants developed a decrease in the tenderness levels, there was a related decrease in the NRS-101 and NDI scores indicating that the pain levels as reported by the participants had also decreased. The decrease in the NDI score indicates a decrease in the disability levels associated with neck pain. This finding is comparable to the literature which states that a decrease in neck pain may result in a decrease in the disability levels that was brought about as a result of the neck pain (Young *et al*., 2009). This further indicates that that there will also be an associated increase in function (Young *et al*., 2009).

5.6.2.3A DISCUSSION OF THE FINDINGS USING COMPARATIVE STUDIES

The results of the current study is comparable to the literature in which MET was shown to be an effective treatment for increasing the range of motion in the cervical spine.

Burns and Wells (2006) conducted an investigation on MET on the cervical spine of asymptomatic participants (*n*=18) and found that rotation increased significantly, whilst lateral flexion improved very slightly with flexion and extension remaining the same after treatment. The age (**Section 4.3.1**) and gender (**Figure 4.2**) demographics of the current study are comparable to that of the study by Burns and Wells (2006). The age range is from 18-40 years of age for the current study and 18-49 years of age for Burns and Wells (2006). Both studies had a higher percentage of females than males. It is however difficult to make a direct comparison between these two studies as Burns and Wells

(2006) only administered one treatment. The application of MET was also not specifically applied to restrictions as was the case with the current study.

Schenk, Adelman and Rousselle, (1994) also conducted a study on the cervical range of motion in and discovered that there was an increase in all six planes of movement following the application of MET. The treatment period was a duration of four weeks, in which six treatments were administered. The main difference between the current study and the study conducted by Schenk, Adelman and Rousselle, (1994) is that their study consisted of asymptomatic patients (*n*=18) and the current study consisted on symptomatic patients (*n*=53)

Boodhoo (2002) conducted his study on symptomatic individuals using a five-second MET. The results of the study were an increase in ranges of motion in all six planes and a decrease in neck pain. However, the current study differed from Boodhoo's (2002) study in that the age group demographic in that study was represented largely by participants between the ages of 38-60 years of age as opposed to the current study that was largely represented by participants in the age group of 20-30 years of age. This could however have been as a result of the inclusion criteria of the current study which only allowed for the inclusion of participants aged 18-40 years of age. The female to male ratio of the current study may be comparable to Boodhoo (2002) who also had a higher percentage of females than males. However, the ethnicity and occupation demographics were not studied in Boodhoo's (2002) study and could therefore not be compared to the current study.

The current study may also be comparable to Roodt (2009) who also discovered an increase in cervical range of motion with rotation producing the highest improvement in participants with CMNP following the use of MET. However the main difference between the two studies is that Roodt (2009) had administered six treatments using a five-second MET only whereas the current study administered four treatments comparing a five-second and a 45-second MET.

Very few studies have investigated the effects of duration of MET on the range of motion and pain in CMNP. Fryer and Ruszkowski (2004) conducted a comparative study on the influence of contraction duration of MET on the atlanto-axial joint in asymptomatic people. In this study 52 asymptomatic subjects were randomly allocated into one of the following three treatment groups: a control group (*n*=17), a five-second MET group (*n*=17) and a 20-second MET group (*n*=18). The results of the study showed that the application of the five-second MET was most effective in increasing the active range of rotation motion. The current study may only be comparable to Fryer and Ruszkowski (2004) for rotation range of motion as that study was conducted on asymptomatic people. The current study may also be comparable to Fryer and Ruszkowski (2004) in terms of the age demographic. The mean age of the participants in Fryer and Ruszkowski's (2004) study was 23.27 years when compared to the mean age of the current study of 21.7 years (**Section 4.3.1**). Fryer and Ruszkowski (2004) only had students in their study whereas the current study had different occupational groups, although, the percentage of students far exceeded the other occupations in this study.

5.7 BIOMECHANICAL AND PHYSIOLOGICAL MECHANISMS CAUSING THE CHANGES IN PAIN AND RANGE OF MOTION.

Chronic Spinal Dysfunctions are characterised by a decrease in range of motion, thickened tissues and pain and tenderness that is localised (Fryer, 2011). According to Fryer (2011), an increase in range of motion and a decrease in pain may be attributed to the stimulation of trans-synovial flow within the capsule of the zygapophyseal joint. Movement of the joint, which is brought about by the application of MET, may produce fluctuations in the intra-synovial pressure within the joint capsule. This subsequently results in the flow of trans-synovial fluid out of the joint which results in a decrease in effusion resulting in a decrease in pain (as noted by a decrease in the tenderness readings and the NRS-101 scores). A decrease in the disability associated with the pain (as noted in the changes of the NDI score) and an increase in range of motion (as noted by the changes in the CROM readings) (Fryer 2011; Chaitow 2006; Fryer 2000).

The increase in tenderness readings and the decrease in the NRS-101 indicated a decrease in tenderness and pain. MET is considered to bring about an increase in joint range of motion. The voluntary contraction used during the application of MET is an isometric contraction. It is purported that the joint motion and the isometric muscle contraction during the application of MET brings about stimulation of the joint which activates the mechanoreceptors. The Gate-Control theory may possibly provide an explanation for the pain relief (Fryer, 2011; Kisner and Colby, 2002). This theory suggests that mechanoreceptor signals are carried through large diameter axons, their aim being to; inhibit nociceptive signals at the dorsal horn of the spinal cord. This causes inhibition of pain (Kisner and Colby, 2002; Fryer, 2000). Furthermore MET may result in inflammatory cytokine reduction and peripheral nociceptor desensitization and hence bring about pain relief (Chaitow, 2006; Fryer, 2000).

Muscle Energy Technique did bring about an increase in the range of motion of the neck in both Groups (**Figures 4.30-4.35** and **Tables 3-8**). Burns and Wells (2006) suggest that hypertonic muscles, muscle spasms (Chaitow, 2006) of the neck as well as joint locking may decrease range of motion within the cervical spine and that lengthening of these muscles using Post-isometric MET may increase the overall physiologic range of motion within the cervical spine (Burns and Wells, 2006). According to Ehrenfeuchter (2000 in Burns and Wells, 2006), the relationship that exists between restricted joints and a decrease in motion may be as a result of reflex hypertonicity of the muscles crossing the dysfunctional joint. It is believed that an increase in the muscle tone may compress the joint surfaces and result in “locking” of the articulation. It is possible that the application of MET may have produced the restoration of the joint articulation thus resulting in “reseating” or restoration of the distorted joint with reflex relaxation of the previously hypertonic muscles which potentially increased the range of motion within the cervical spine. As previously stated an increase in ROM may result is related to a decrease in pain and hence an improvement in the tenderness readings and vice versa (Burns and Wells, 2006).

The Hawthorne effect that could have brought about measurement bias can be ruled out since the objective measures both increased over time, thus indicating a decrease in the pain levels and an increase in range of motion. Patients have very little influence on the objective measures and therefore the correlation between the objective and subjective measures ensures a greater uniformity and clinical consistency.

5.8 THE FINDINGS OF THE CORRELATION BETWEEN THE VARIABLES IN EACH GROUP.

5.8.1 THE CORRELATION OF THE SUBJECTIVE (NDI AND NRS-101) AND OBJECTIVE (CROM AND TENDERNESS) VARIABLES IN GROUP A

The discussion below refers to the findings in ***Table 4.12****.*

The results of **Table 4.12** reveal a positive correlation between the NDI and the NRS-101 (p=.003) suggesting that a decrease in pain was accompanied by a reduction in the disability levels experienced by the participants. Participants experienced an increase in the quality of life following a decrease in the pain levels. This is consistent with the literature that shows a decrease in reported pain is usually associated with an increase in function and decrease in disability (Young *et al*., 2009) and is consistent with the intra and inter-group analysis found in **Sections 5.4.1** and **5.6.1** respectively**.**

The positive relationship between RR and LLF (p=.034) suggests that if RR increases there is a corresponding increase in LLF and vice versa. This finding corresponds with the theory of Type one spinal coupled motion which states that spinal coupled motion exists with the contralateral rotation and lateral flexion (see **Section 5.4.2.1** on discussion of spinal coupled motion in relation to the findings in Group A). **Table 5.2** summarised the changes in ROM and revealed that RR and LLF both increased following the application of MET which is supported by the correlation statistics (**Table 4.12**). This suggests that the theory of spinal coupled motion could be used to provide a possible explanation as to why RR and LLF improved.

Additionally, TP1 showed a positive correlation with F (*p*=.024), E (*p*=.005) and LLF (*p*=.011). This suggests that an increase in the above mentioned ranges of motion were accompanied by an increase in the tenderness readings of TP1 indicating a decrease in the participants pain levels. This reinforces the findings that a decrease in pain may result in an increase in ROM and vice versa (see **Section 5.7** above on the discussion on the relationship between an increase in range of motion and Algometer measurements).

A negative relationship exists between LLF and NRS (*p*=.033). This suggests that an increase in one variable is accompanied by a decrease in the value of the other variable. **Figure 6 (Appendix P) and Table 5.2** both show that LLF had increased whilst **Figure 2 (Appendix P)** showed a decrease in the NRS-101 scores suggesting that with an increase in LLF range of motion, the participants experienced a decrease in pain. The reverse may also be true in that a decrease in pain may have resulted in an increase in the LLF ROM. This is consistent with the literature which states that an increase in ROM may result in a decrease in pain and vice versa (Fryer 2011; Chaitow 2006; Fryer 2000). **Section 5.7** provides a discussion on the biomechanical and physiological mechanisms involved in this relationship. A negative correlation also exists between TP3 and the NRS-101 (*p*=.037). This is not an unexpected finding as an increase in the TP3 (**Figure 11, Appendix P**) reading suggests that the participants' had an increase in the algometer measurement for tenderness due to a decrease in pain which would also result in a decrease in the NRS-101(**Figure 2, Appendix P**) score measurement as reported by the participant. This finding further supports the outcomes of the decreased NRS-101 score and its relationship with a decrease in disability (*p*=.003).

5.8.2 THE CORRELATION OF THE SUBJECTIVE (NDI AND NRS-101) AND OBJECTIVE (CROM AND TENDERNESS) VARIABLES IN GROUP B

*The discussion below refers to the findings in **Table 4.13**.*

The results of **Table 4.13** reveals a highly positive correlation between the NDI and the NRS-101 (*p*=.000) suggesting that a decrease in pain as measured by the NRS-101 was accompanied by a reduction in the disability levels experienced by the participants as measured by the NDI. This correlates with **Figure 13 (Appendix P)** displaying the NDI and **Figure 14 (Appendix P)** displaying the NRS-101 scores. Participants experienced an increase in the quality of life following a decrease in the pain levels. This is once again not an uncommon finding as this finding concurs with the current literature which supports this relationship (Young *et al.*, 2009). The intra- (**Section 5.5.1**) and inter-group (**Section 5.6.1**) analysis also supports these findings.

The results show a positive relationship between the TP readings. TP1 correlated with TP3 (*p*=.003) TP2 correlated with TP1 (*p*=.003) and TP3 correlated with TP2 (*p*=.016). This is not an uncommon finding and therefore suggests that most of the tenderness readings had increased indicating that there was a decrease in pain. This finding is supported by the positive correlation between NDI and the NRS-101 (*p*=.000) mentioned above which is the subjective measures or pain reported by the participants.

The results show a positive correlation between LR and RLF (*p*=.004). This suggests that an increase in one ROM is accompanied by an increase in the other. **Table 5.2** however, reveals that LR did increase but RLF did not. The theory of coupled spinal motion could, therefore, not be used to explain the changes in Group B.

A negative correlation was seen between the LR and the subjective measures NRS-101 (*p*=.001) and NDI (*p*=.036). This suggests that a decrease in one variable resulted in an increase in the other. **Table 5.2** shows that LR did increase. The NRS-101 and the NDI both decreased (**Section 5.5.1**). It can, therefore, be said that an increase in LR was accompanied by a decrease in pain (NRS-101) and disability (NDI) associated with the neck pain and vice versa.

The negative correlation between TP4 and NDI (*p*=.044) and NRS-101 (*p*=.018) suggests that an increase in one variable resulted in a decrease in the other. This correlates with **Figure 24 (Appendix P),** which shows an increase in the TP4 tenderness reading, which also correlates with the discussion in **Section 5.5.1** which reveals that both the NDI and the NRS-101 had decreased. These findings propose that an increase in TP4 tenderness reading was accompanied by a decrease in the NRS-101 and NDI therefore suggesting that there was a decrease in the pain levels of the participants. This negative correlation can be used to refute the suggestion made with regards to Hawthorne effect (see **Section 5.7** in terms of the Hawthorne effect in Group B) as the subjective and objective measures were evenly correlated.

5.9 CONCLUSION

The results of this study revealed that both the short duration MET (Group A) and the long duration MET (Group B) treatments are equally effective for all subjective and objective outcome measures except for Left lateral flexion where Group A seemed to show more improvement than Group B. The LLF showed a significant treatment effect (*p*= 0.011) where overall increase in scores were shown in Group A while Group B did not change much from baseline values.

CHAPTER SIX

CONCLUSION, RECOMMENDATIONS AND LIMITATIONS

6.1 CONCLUSION

This study was conducted to establish whether there was a difference between the contraction durations of MET in the treatment of chronic mechanical neck pain.

No group showed a better outcome than the other group for the subjective and objective measures except for LLF which displayed a statistically significant difference between the two groups with the five-second MET being more effective.

It can be concluded that MET may be used as a safe alternative in instances where manipulation is contra-indicated. The five-second MET displayed a significant improvement for all subjective and objective measures. It was also more comfortable for the participant as well as the researcher to maintain the five-second contraction. The five-second MET cuts down the treatment session and could be used effectively in a busy chiropractic practice.

6.2 RECOMMENDATIONS AND LIMITATIONS

- It is uncertain as to whether MET with the different time contractions may have had a different effect on each group. Group B could have also responded well to the five-second MET. It is recommended that a future study be conducted in which a cross-over can be done to see if the there is a specific profile that responds to MET treatment or whether it is the shorter duration of MET that was more effective. For this reason it is recommend that a cross-over study to determine whether sequencing of the different durations has an effect on the clinical outcomes for patients with CMNP.

- Some of the participants in the 45 second treatment group experienced a slight amount of discomfort during the treatment. It is recommended that future studies focus on the effects of discomfort using the 45 second contraction duration on the outcome of the treatment as the literature has not reported this clinical consequence.

- MET was only applied to the restrictions in the cervical spine and not the muscles. It would be interesting to see whether MET applied to the muscles would provide a better outcome than MET applied only to the restrictions.

- MET was shown to be an effective treatment protocol in instances where manipulation is contra-indicated. It is safe to use on patients with Degenerative joint disease (DJD). This study was conducted on participants aged 18-40 years and was designed as such to prevent the inclusion of participants older than 40 years of age with possible DJD. One of the limitations of this study is therefore that the outcome of the study may only be applicable to a younger population and not the older population. It is, therefore, recommended that a future study should be conducted in which the application MET is tested on older individuals to see the effects it has on their pain when manipulation is contra-indicated.

- The methodology of the study allowed for the participants to be treated twice within one week. Due to public holidays and weekends, appointments were purely made based on convenience. The follow-up periods therefore varied from participant to participant. To ensure consistency in future studies, the follow up periods should be at an exact amount of days following the last treatment for every participant.

- This study consisted of 53 participants (*n*=26 and *n*=27). It would be preferable to increase the sample size in future studies which would allow for parametric testing thus enabling the detecting of very subtle changes. With reference to the length of chronicity of the MNP and how this relates to age, it is uncertain as to whether MET with the different time contractions may have had a different effect on populations outside of the inclusion criteria in this study. Therefore, it is suggested that future studies stratify their participants or complete subgroup analyses of larger sample sizes.

- To promote homogeneity, each gender could be studied separately. Since males and females have different decrees of flexibility and strength, different contraction durations may be more suitable for a specific gender.

- It is a possibility that the flexion range of motion did not improve because there was only one flexion restriction to which MET was applied in Group A and Group B. Future research may consider stratifying restrictions, to obtain equitable numbers in each of the treatment groups to avoid the presence of this as a possible confounding variable, particularly if this variable is not related to forward head posture.

- The effects of the MET on postural muscles or the small cervical muscles was neither recorded directly or via proxy measures, therefore it is suggested that these measures be included in future research to determine the presence of postural change with MET treatment and / or whether there are direct measures for the deep / small cervical muscles such as the cranio-cervical flexion tests.

- Students formed the largest percentage of the participants in this study. The position employed by students, during hours of studying or writing, is that of forward head postures, rotation of the head toward the dominant hand and lateral flexion to the opposite side of the dominant hand (Green, 2008; Sim, Lacey and Lewis, 2006; Schlossberg *et al*., 2004). In addition this position is employed for several hours a day by the majority of students. Therefore it is likely that these ranges of motion would have been the ones that would have increased the most of all the motion parameters tested, particularly when the posture of the Group B on the whole seems to have been better than that of Group A. This latter assertion however requires further evidence / support and therefore it is suggested that this research be repeated with emphasis on clinical as well as postural and muscular outcomes.

- It is uncertain whether the participants' demographics influenced the baseline readings. The forward head posture in particular may have affected these readings. It is therefore suggested that future studies consider the forward head posture position of all participants (either through measurement of the cranio-vertebral angle or through limitations in the degree of flexion outside of the normal range).

- Consideration was also given to the use of a cross-over study (in this study) to determine the effect of the MET on the population in this study. It was however deemed unwise to set out on a cross-over study when it had not yet been determined which intervention (if at all) had superior clinical outcomes. Yet it does stand to reason that the differential effects of the MET (a short duration versus a long duration) may serve different functions in treating CMNP, therefore a subsequent study should consider a cross-over to determine whether sequencing of the different durations has an effect on the clinical outcomes for patients with CMNP.

- With reference to the length of chronicity of the MNP and how this relates to age, it is uncertain as to whether MET with the different time contractions may have had a different effect on populations outside of the inclusion criteria in this study. Therefore it is suggested that future studies stratify their participants or complete subgroup analyses of larger sample sizes.

REFERENCES

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.

Bandy, W.D. and Irion, J.M. 1994. The Effect of Time on Static Stretch on the Flexibility of the Hamstring Muscles. *Physical Therapy Journal,* 74(9)*:* 54-58.

Bergmann, T.F., Peterson, D.H. and Lawrence, D.J. 1993. *Chiropractic Technique, Principles and Procedures.* New York: Churchill Livingston.

Bergmann, T.F. and Peterson, D.H. 2011. *Chiropractic Technique: Principles and Procedures*. 3rd ed. Missouri: Elsevier Mosby.

Bennett, R. 2007. Myofascial pain syndromes and their evaluation. *Best Practices and Research Clinical Rheumatology*, 21(3): 427-445.

Berthelot, J., Le Goff, B. and Maugars, Y. 2011. The Hawthorne Effect: Stronger Than the Placebo Effect? *Joint Bone Spine,* 78: 335–336.

Bibby, P. 2006. The Management of Chronic Neck Pain –A Retrospective Survey of the Patient Journey Using in-Depth Semi-Structured Interviews, *Journal of Orthopaedic Nursing,* 10: 25–32.

Binder, A.L. 2007.Cervical Spondylosis and Neck Pain. *British Medical Journal,* 334: 527-531.

Bogduk, N. 2003. The Anatomy and Pathophysiology of Neck Pain. *Physical Medicine and Rehabilitation Clinics of North America*, 14: 455-472.

Boodhoo, V. 2002. The Efficacy of Muscle Energy Technique in the Treatment of Chronic Mechanical Neck Pain. M. Tech, Durban University of Technology.

Brandt, L.P.A., Andersen, J.H., Lassen, C.F., Kryger, A., Overgaard, E., Vilstrup, I. and Mikkelsen, S. 2004. Neck and Shoulder Symptoms and Disorders among Danish Computer Workers. *Scandinavian Journal of Work, Environment and Health,* 30(5): 399-409.

Brous, N. 2005. Muscle Energy Technique. In DiGiovanna, E.L., Schiowitz, S. and Dowling, D.J. *An Osteopathic Approach to Diagnosis and Treatment*. Philadelphia: Lippincott Williams and Wilkins.

Bruls, V.E.J., Bastiaenen, C.H.G. and de Bie, R.A. 2013. *Bio-Med Central Musculoskeletal Disorders,* 14(8): 1-8.

Buchbinder, R., Gael, V., Bombardier, C. and Hogg-Johnson, S. 1996. Classification Systems of Soft Tissue Disorders of the Neck and Upper Limb: Do They Satisfy Methodological Guidelines? *Journal of Clinical Epidemiology,* 49(2):141-149.

Burgees-Limerick, R., Plooy, A. and Ankrum, D.R. 1998. The Effect of Imposed and Self-Selected Computer Monitor Height on Posture and Gaze Angle. *Clinical Biomechanics,* 13: 584-592.

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.

Campbell, J.P., Maxey, V.A. and Watson, W.A. 1995. Hawthorne Effect: Implications for Pre-hospital Research. *Annals of Emergency Medicine,* 26: 590-594.

Carey, T.S., Freburger, J.K., Holmes, G.M., Jackman, A. Knauer, S., Wallace, A. and Darter, J. 2010. Race, Care Seeking, and Utilization for Chronic Back and Neck Pain: Population Perspectives. *The Journal of Pain,* 11(4): 343-350.

Carroll, J., Hogg-Johnson, S., Van der Velde, G., Haldeman, S., Holm S.W., Hurwitz, E.L., Cote, P., Nordin, M., Peloso, P.M., Guzman, J. and Cassidy, J.D. 2008. Course and prognostic factors for neck pain in the general population: Results of the Bone and Joint Decade 2000-2010 task force on neck pain. *Journal of Manipulative and Physiological Therapeutics,* 32(2S): S87-S96.

Chaitow, L.2006. *Muscle Energy Techniques*. London: Churchill Livingston.

Christensen, S.T. and Hartvigsen, J. 2008. A Systematic Critical Review of the Epidemiological Literature Dealing with Associations between Sagittal Spinal Curves and Health. *Journal of Manipulative and Physiological Therapeutics,* 31: 690-714.

Christensen, J.O. and Knardahl, S. 2010. Work and neck pain: A Prospective Study of Psychological, Social and Mechanical Risk Factors. *Pain*, 151: 162-173.

Ciesla, S. and Polom, K. 2010. The Effect of Immediate Breast Reconstruction with Becker-25 Prosthesis on the Preservation of Proper Body Posture in Patients After Mastectomy. *European Journal of Surgical Oncology,* 36: 625-631.

Cleland, J.A.., Childs, J.D. and Whitman, J.M. 2008. Psychometric Properties of the Neck Disability Index and Numeric Pain Rating Scale in Patients with Mechanical Neck Pain. *Archives of Physical Medicine and Rehabilitation,* 89(January): 69-74.

Cook, C., Hegedus, E., Showalter, C. and Sizer, P.S. 2006. Coupling Behavior of the Cervical Spine. *Journal of Manipulative and Physiological Therapeutics*, 29(7): 570-575.

Cote, P., Cassidy, D. and Carroll, L. 2003. The Epidemiology of Neck Pain: What We Have Learned From Our Population-Based Studies. *Journal of Canadian Chiropractic Association*, 47(4): 284-289.

Cote, P., Carroll, L., Cassidy, D. and Kristman, V. 2004. The Annual Incidence and Course of Neck Pain in the General Population: A Population-Based Cohort Study. *Pain*, 112: 267-273.

Cote, P., Van der Velde, G., Cassidy, D., Carroll, L., Hogg-Johnson, S., Holm, L.W., Carragee, E.J., Haldeman, S., Nordin, M., Hurwitz, E.L., Guzman, J. and Peloso, P.M. 2009. *Journal of Manipulative and Physiological Therapeutics*, 32(2S): S70-S86.

Croft, P.R., Lewis, M., Papageorgiou, A.C., Thomas, E., Jayson, M.V.C., Macfarlaned, G.J. and Silman, A.J. 2001. *Pain,* 93: 317-325.

de Vet, H.C.W., Ostelo, R.W.J.G., Terwee, C.B., van der Roer, N., Knol, D.L., Beckerman, H., Boers, M. and Bouter, L.M. 2007. Minimally Important Change Determined By a Visual Method Integrating an Anchor-Based and a Distribution-Based Approach. *Quality of Life Research*, 16: 131–142.

Dearing, J. and Hamilton, F. 2008. An Examination of Pressure-Pain Thresholds (PPT's) at Myofascial Trigger Points (MFTP's), Following Muscle Energy Technique or Ischaemic Compression Treatment. *Manual Therapy,* 13: 87–88.

Dennison, S.B. and Leal, M.H. 2011. Mechanical Neck Pain. In Fernandez-de-las-Penas, C.F., Cleland, J.A. and Huijbregts, P. *Neck and arm pain syndromes: Evidence informed screening, diagnosis and management*. China: Elsevier Ltd, Churchill Livingstone.

Doherty, M., Lanyon, P. and Ralston, S.H. 2002. Musculoskeletal Disorders. In Haslett, C. *Davidson's Principles and Practice of Medicine.* 19th ed. New York: Churchill Livingston.

DiGiovanna, E. 1991. *Osteopathic Diagnosis and Treatment*. Philadelphia: Lippincott.

Drews, E.R. 1994. A Demographic and Epidemiological Factors of Private Chiropractic Practices and a Chiropractic Teaching Clinic. M.Tech, Durban University of Technology

D'Sylva, J., Miller, J., Gross, A., Burnie, S.J., Goldsmith, C.H., Graham, N., Haines, T., Bronfort, G. and Hoving, J.L. 2010. Manual Therapy With or Without Physical Medicine Modalities for Neck Pain: A Systematic Review. *Manual Therapy*, 15: 415-433.

Edmondston, S., Björnsdóttir, G., Pálsson, T., Solgård, H., Kasper Ussing, Allison, G. 2011. Endurance and Fatigue Characteristics of the Neck Flexor and Extensor Muscles during Isometric Tests in Patients with Postural Neck Pain. *Manual Therapy,* 16: 332-338.

Edwards, S.L. 1993. *Manipulation and Mobilization: Extremity and Spinal Techniques.* USA: Mosby.

Esterhuizen, T (esterhuizent@ukzn.ac.za), 30 May 2012. Statistical Analysis. E mailed to K Naidoo (kerishan@yahoo.com). Accessed 30 May 2012.

Esterhuizen, T (esterhuizent@ukzn.ac.za), 21 May 2013. Statistical Analysis. E mailed to K Naidoo (kerishan@yahoo.com). Accessed 21 May 2013.

Feipel, V., Rondelet, B., Pallec, J.P. and Rooze, M. 1999. Normal Global Motion of the Cervical Spine: An Electrogoniometric Study. *Clinical Biomechanics*, 14: 462-470.

Fejer, R., Kyvik, K.O. and Hartvigsen, J. 2006. The Prevalence of Neck Pain in the World Population: A Systemic Critical Review of the Literature. *European Spine Journal*, 15: 834–848.

Feland, B.J., Myrer, W.J., Schulthie, S.S., Fellingham, G.W. and Meason, W.G. 2001. The Effect of Duration of Stretching of the Hamstring Muscle Group for Increasing Range of Motion in People Aged 65 Years or Older. *Physical Therapy*, 81(5): 1110-1117.

Fernandez-de-las-Penas, C. Alonso-Blanco, C. and Miangolarra, J.C. 2007. Myofascial Trigger Points in Subjects Presenting with Mechanical Neck Pain: A Blinded, Controlled Study. *Manual Therapy,* 12: 29-33.

Fernandez-de-las-Penas, C., Ge, H., Alonso-Blanco, C., Gonzalez-Iglesias, J. and Arendt-Nielsen, L. 2010. Referred Pain Areas of Active Myofascial Trigger Points in Head, Neck, and Shoulder Muscles, in Chronic Tension Type Headache. *Journal of Bodywork and Movement Therapies,* 14: 391-396.

Fernandez-de-las-Penas, C.F., Cleland, J.A. and Huijbregts, P.2011. *Neck and arm pain syndromes: Evidence informed screening, diagnosis and management*. China: Elsevier Ltd, Churchill Livingstone.

Ferreira-Valente, M.A., Pais-Ribeiro, J.L. and Jensen, M.P. 2011. Validity of four pain intensity rating scales. *Pain,* 152: 2399-2404.

Frampton, C.L. and Hughes-Webb, P. 2011. The Measurement of Pain. *Clinical Oncology*, 23: 381-386.
Fryer, G. 2000. Muscle Energy Concepts - A need for change. *Journal of Osteopathic Medicine,* 3(2): 54-59.

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.

Fryer. G 2011. Muscle Energy Technique. In Fernandez-de-las Penas, C.F., Cleland, J.A. and Huijbregts, P. *Neck and arm pain syndromes: Evidence informed screening, diagnosis and management*. China: Elsevier Ltd, Churchill Livingstone.

Gatterman, M.I. 1990. *Chiropractic Management of Spine Related Disorders*. Baltimore: William and Wilkins.

Gatterman, M.I. 1998. Chiropractic Management of Neck Pain of Mechanical Origin. In Giles, K. and Singer, K. *The Clinical Anatomy and Management of Back Pain Series, Volume 3: Clinical Anatomy and Management of Cervical Spine Pain.* Oxford: Butterworth-Heinemann.

Gerr, F., Marcus, M., Ensor, C., Kleinbaum, D., Cohen, S., Edwards, A., Gentry, E., Ortiz, D.J. and Monteilh, C. 2002. A Prospective Study of Computer Users: I. Study Design and Incidence of Musculoskeletal symptoms and Disorders. *American Journal of Industrial Medicine,* 41: 221-235.

Gibbons, P. and Tehan, P. 1998. Muscle Energy Concepts And Coupled Motion of the Spine. *Manual Therapy*, 3(2): 95-101.

Gosselin, G., Rassoulian, H., and Brown, I. 2004. Effects of Neck Extensor Muscles Fatigue on Balance. Clinical Biomechanics, 19: 473-479.

Green, B.N. 2008. A Literature Review Of Neck Pain Associated With Computer Use: Public Health Implications. *Journal of Canadian Chiropractic Association,* 52(3): 161–168.

Greenman, P. 1996. *Principles of Manual Medicine.* 2nd ed. Baltimore: Williams and Wilkins.

Greenman, P. 2003. *Principles of Manual Medicine.* 3rd ed. Philadelphia: Williams and Wilkins.

Grey, H. 1960. *A Cervical Vertebra* (image). Available: http://en.wikipedia.org/wiki/File:Gray84.png. (Accessed 7 January 2013). (Copyright expired)

Grey, H. 1960. *Second cervical vertebra, or epistropheus, from above* (image). Available: http://en.wikipedia.org/wiki/File:Gray87.png (Accessed 7 January). (Copyright has expired).

Grey, H. 1960. *Second cervical vertebra, epistropheus, or axis, from the side* (image). Available:http://en.wikipedia.org/wiki/File:Gray88.png. (Accessed 7 January 2013). (Copyright expired)

Grey, H. 1960. *Seventh cervical vertebra (vertebra prominens)* (image). Available: http://en.wikipedia.org/wiki/File:Gray89.png (Accessed 7 January 2013). (Copyright has expired).

Grey, H. 1960. *Side view of a typical cervical vertebra* (image). Available: http://en.wikipedia.org/wiki/File:Gray85.png. (Accessed 7 January 2013).

Grieve, G.P. 1988. *Common Vertebral Joint Problems*. 2nd ed. Edinburg: Churchill Livingston, Longman Group Limited.

Groenier, K.H., Winters, J.C., van Schuur, W.H., De Winter, A.F. and Meyboom-De Jonga,B. 2006. A Simple Classification System was Recommended for Patients With Restricted Shoulder or Neck Range of Motion. *Journal of Clinical Epidemiology,* 59: 599–607.

Gross, A., Miller, J., D'Sylva, J., Burnie, S. Goldsmith, C.H., Graham, N., Haines, T., Bronfort, G. and Hoving, J.L. 2010. Manipulation or Mobilisation for Neck Pain: A Cochrane Review. *Manual Therapy,* 15: 315-333.

Guzman, J., Hurwitz, E.L., Carroll, L.J., Haldeman, S., Cote, P., Carragee, E.J., Peloso, P.M., van der Velde, G., Holm, L.W., Hogg-Johnson, S. , Nordin, M. and Cassidy, D. 2008. **A New Conceptual Model of Neck Pain:** Linking Onset, Course, and Care: The Bone and Joint Decade 2000–2010 Task Force on Neck Pain and Its Associated Disorders. *European spine Journal*, 17: S14-S23.

Haldeman, S., Carroll, L., Cassidy, D., Schubert, J. and Nygren, A. 2008. The Bone and Joint Decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders. *Spine*, 33(4S): 55-57.

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: 42-49.

Henderson, M. and Bass, C. 2006. Chronic Pain: The Role of Psychosocial Factors in Common Musculoskeletal Disorders. *Psychiatry,* 5(2): 52-56.

Hogg-Johnson, S., Van der Velde, G., Carroll, L.J., Holm, L.W., Cassidy, J.D., Guzman, J., Cote, P., Haldeman, S. Ammendolia, C. Carragee, E., Hurwitz, E., Nordin, M. and Peloso, P. 2009. The Burden and Determinants of Neck Pain in the General Population Results of the Bone and Joint Decade 2000–2010 Task Force on Neck Pain and its Associated Disorders. *Journal of Manipulative and Physiological Therapeutics*, 32(2S): S47-S60.

Hoving, J.L., Koes, B, W.,Van Der Windht, D., Mameran, H., Deville, W., Scholten, R. and Bouter, L. 2002. Manual Therapy, Physical Therapy or Continued Care by a General Practitioner for Patients with Neck Pain. *Annals of Internal Medicine*, 136: 713-722.

Howell, E.R. 2011. The Association between Neck Pain, The Neck Disability Index And Cervical Ranges Of Motion: A Narrative Review. *Journal of Canadian Chiropractic Association*, 55(3): 211-221.

Hoy, D.G., Protani, M., De R, Buchbinder, R. 2010. *Best Practice and Research Clinical Rheumatology,* 24(6): 783-792.

Hoyle, J.A., Marras, W.S., Sheedy, J.E. and Hart, D.E. 2011. Effects of Postural and Visual Stressors on Myofascial Trigger Point Development and motor unit rotation during computer work. *Journal of Electromyography and Kinesiology,* 21: 41–48.

Huguenin, L.K., 2004. Myofascial trigger points: the current evidence. *Physical Therapy in Sport*, 5: 2-12.

Hurwitz, E.L., Carragee, E.J., Van der Velde, G., Carroll, L.J., Nordin, M., Guzman, J., Peloso, P.M., Holm, L.W., Cote, P., Hogg-Johnson, S., Cassidy J.D., Haldeman, S. 2009. Treatment of neck pain: Non-invasive interventions: Results of the Bone and Joint Decade 2000-2010 Task Force on neck pain and its associated disorders. *Journal of Manipulative and Physiological Therapeutics,* 32(2S): S141- S175.

Jensen, I. and Harms-Ringdahl, K. 2007. Neck Pain. *Best Practice and Research Clinical Rheumatology,* 21(1): 93-108.

Jordan, K. 2000. Assessment of Published Reliability Studies for Cervical Spine Range-of-Motion Measurement Tools. *Journal of Manipulative and Physiological Therapeutics*, 23(3): 180-195.

Kanchanomai, S., Janwantanakul, P., Pensri, P. and Jiamjarasrangsi, W. 2011. Risk factors for the Onset and Persistence of Neck Pain in Undergraduate Students: 1-year prospective cohort study. *Bio-Med Central, Public Health***,** 11:566.

Kanlayanaphotporn, R., Chiradejnant,A. and Vachalathiti, R. 2009. The Immediate Effects of Mobilization Technique on Pain and Range of Motion in Patients Presenting With Unilateral Neck Pain: A Randomized Controlled Trial. *Archives of Physical Medicine and Rehabilitation,* 90: 187-192.

Karels, C.H., Bierma-Zeinstra, S.M.A., Burdorf, A., Verhagen, A.P.. Nauta, A.P. and Koes, B.W. 2007. Social and Psychological factors influenced the course of arm, neck and shoulder complaints. *Journal of Clinical Epidemiology,* 60: 839-848.

Keijsers, E., Feleus, A., Miedema, H.S., Koes, B.W. and Bierma-Zeinstra, S.M.A. 2010. Psychosocial Factors Predicted Nonrecovery in Both Specific and Nonspecific Diagnoses at Arm, Neck, and Shoulder. *Journal of Clinical Epidemiology*, 63: 1370-1379.

Kirkaldy-Willis, W.H. 1992. The Three Phases in the Spectrum of Degenerative Diseases. In: Kirkaldy-Willis, W.H. and Burton, C.V. Managing low-back pain. 3rd ed. New York: Churchill Livingstone.

Kirpalani, D. and Mitra, R. 2008. Cervical facet joint dysfunction: A review. *Archives of Physical Medicine and Rehabilitation*, 89:770-774.

Kisner, C. and Colby, L.A. 2002. *Therapeutic Exercise: Foundation and Technique.* 4th ed. Philadelphia: F.A. Davis.

Leboeuf –Yde, C., Nielsen, J., O Kyvik, K., Fejer, R. and Hartvigsen, J. 2009. Pain in the lumbar, thoracic or cervical regions: do age and gender matter? A population-based study of 34,902 Danish twins 20–71 years of age. *Bio-Med Central Musculoskeletal Disorders*, 10(39): 1-12.

Lee, J.S., Hobden, E., Stiell, I.G. and Wells, G.A. 2003. Clinically important change in the visual analogue scale after adequate pain control. *Academy of Emergency Medicine*, 10(10): 1128-1130.

Lee, H., Nicholson, L.L. and Adams, R.D. 2005. Neck Muscle Endurance, Self-Report, and Range of Motion Data from Subjects with Treated and Untreated Neck Pain. *Journal of Manipulative and Physiological Therapeutics*, 28: 25-32.

Lederman, E. 2005. The Science and Practice of Manual Therapy. 2nd ed. United Kingdom: Elsevier Churchill Livingston.

Lenehan, K.L., Fryer, G. and McLaughlin, P. 2003. The Effect of Muscle Energy Technique on Gross Trunk Range of Motion. *Journal of Osteopathic Medicine*, 6(1): 13-18.

Leonard, K. and Masatu, M.C. 2006. Outpatient Process Quality Evaluation and the Hawthorne Effect. *Social Science and Medicine*, 63:2330–2340.

Liebenson, G. 1996. *Rehabilitation of the spine – A practitioner's manual.* Pennsylvania: Williams and Wilkins.

Livingston, T., Bernadi, D. and Carroll, M. 1998. *Algometer™ Commander and Digitrack™ Commander: User's Manual.* Journal of Tech Medical Industries.

Longmore, M., Wilkinson, I., Turmezei, T. and Cheung, C.K. 2007. *Oxford Handbook of Clinical Medicine*. 7th ed. United States: Oxford University Press.

Lord, S.M., Barnsley, L., Wallis, B.J., McDonald, G.J. and Bogduk, N. 1996. Percutaneous Radio-Frequency Neurotomy for Chronic Cervical Zygapophyseal-Joint Pain. *The New England Journal of Medicine*, 335(23): 1721- 1726.

Luime, J.J., Kuiper, J.I., Koes, B.W., Verhaar J.A.N., Miedema, H.S. and Burdorf, A. 2004. Work-Related Risk Factors for the Incidence and Recurrence of Shoulder and Neck Complaints among Nursing-Home and Elderly-Care Workers. *Scandinavian Journal of Work, Environment and Health*, 30(4):279-286.

Magee, D.J. 2006.*Orthopaedic Physical Assessment*. 4th ed. Missouri: Saunders Elsevier.

Manchikanti, L., Falco, F.J.E. Singh, V., Benyamin, R.M., Racz, G.B., Helm, A., Caraway, D.L. Calodney, A.K., Snook, L., Smith, H.S., Gupta, S., Ward, S., Grider, J.S. and Hirsch, J.A. 2013. An Update of Comprehensive Evidence-Based Guidelines for Interventional Techniques in Chronic Spinal Pain. Part I: Introduction and General Considerations. *Pain Physician,* 16:S1-S48.

Martınez-Segura, R., Fernandez-de-las-Penas, C., Ruiz-Saez, M., Lopez-Jimenez, C and Rodrıguez-Blanco, C. 2006. Immediate Effects on Neck Pain and Active Range of Motion after a Single Cervical High-Velocity Low-Amplitude Manipulation in Subjects Presenting With Mechanical Neck Pain: A Randomized Controlled Trial. *Journal of Manipulative and Physiological Therapeutics*, 29: 511-517.

McAviney, J., Schulz, D., Bock, R., Harrison, D.E. and Holland, B. 2005. Determining Relationship between Cervical Lordosis and Neck Complaints. *Journal of Manipulative and Physiological Therapeutics*, 28: 187-193.

Mehdikhani, R. and Okhovatian, F. 2012. Immediate effect of muscle energy technique on latent trigger point of upper trapezius muscle. *Clinical Chiropractic*, 15:112-120.

Meseguer, A.A., Fernandez-de-las-Penas, C., Navarro-Poza, J.L., Rodriguez-Blanco, C. and Gandia, J.J.B. 2006. Immediate Effects of the Strain/Counterstrain Technique in Local Pain Evoked By Tender Points in the Upper Trapezius Muscle. *Clinical Chiropractic,* 9: 112-118.

Michaleff, Z.A., Maher, C.G., Jull, G., Latimer, J., Connelly, L.B., Lin, C.C., Rebbeck, T. and Sterling, M. 2009. A Randomized Clinical Trial of a comprehensive exercise program for chronic whiplash: trial protocol. *BioMed-Central Musculoskeletal Disorders*, 10 (149): 1-7.

Middleditch, A. and Oliver, J. 2005. *Functional Anatomy of the Spine*. 2nd ed. China: Elsevier Butterworth Heinemann.

Ming, Z., Narhi, M. and Siivola, J. 2004. Neck And Shoulder Pain Related To Computer Use. *Pathophysiology,* 11: 51–56.

Misailidou, V., Malliou, P., Beneka, A., Karagiannidis, A. and Godolias, G. 2010. Assessment of patients with neck pain: a review of definitions, selection criteria, and measurement tools. *Journal of Chiropractic Medicine,* 9: 49-59.

Mitchell, F.L Jnr., Moran, P.S. and Pruzzo N.A. 1979. *An evaluation and treatment manual of osteopathic muscle energy procedures*. Missouri: Mitchell, Moran and Pruzzo Associates.

Moore, L.K. and Dalley, F.A. 2006. *Clinically Oriented Anatomy.* 5th ed. Philadelphia: Lippincott Williams and Wilkins.

Mouton, J. 1996. *Understanding Social Research*. Pretoria: J.L van Schaik Publishers.

Muchna. J.M. 2011. An epidemiological investigation into the risk factors associated with neck pain in the Indian population in the greater Durban area. M.Tech, Durban University of Technology.

Munoz-Munoz, S., Munoz-García, M.T., Alburquerque-Sendín, F., Arroyo-Morales, M. and Fernandez-de-las-Penas, C. 2012. Myofascial Trigger Points, Pain, Disability and Sleep Quality in Individuals with Mechanical Neck Pain. *Journal of Manipulative and Physiological Therapeutics,* 35(8): 608-613.

Ndlovu, P.Z. 2006. A Case-Control Study Investigating Factors Associated With Neck Pain in the Indigenous African Population in the Greater Durban Area. M. Tech, Durban University of Technology.

Nordin, M., Carragee, E.J., Hogg-Johnson,S., Weiner, S.S., Hurwitz, E.L., Peloso, P.M., Guzman, J., van der Velde, G., Carroll, L.J., Holm, L.W. Cote, P., Cassidy, D. and Haldeman, S. 2009. Assessment of Neck Pain and Its Associated Disorders: Results of the Bone and Joint Decade 2000–2010 Task Force on Neck Pain and Its Associated Disorders. *Journal of Manipulative and Physiological Therapeutics*, February: S117-S140.

Nordin, M. and Frankel, H. 2001. *Basic Biomechanics of the Musculoskeletal System. 3rd ed.* Baltimore: Lippincott Williams and Wilkins.

O'Leary, S., Falla, D., Hodges, P.W., Jull, G., and Vincenzino, B. 2007. Specific Therapeutic Exercise of the neck induces immediate local hypoalgesia. *The Journal of Pain*, 8(11): 832-839.

Oliveira-Campelo, N.M., de Melo, C.A., Alburquerque-Sendın, F. and Jorge P. Machado, J.P. 2013. *Journal of Manipulative and Physiological Therapeutics,* 36(5): 300-309.

Ostelo, R.W.J.G. and de Vet, H.C.W.2005. Clinically Important Outcomes in Low Back Pain. B*est practice research clinical rheumatology*, 19(4): 593-607.

O'Sullivan, P.B. 2005. 'Clinical Instability' of the Lumbar Spine: Its Pathological Basis, Diagnosis and Conservative Management. In: Jull, G.A. and Boyling, J.D. 3rd ed. *Grieve's Modern Manual Therapy*. Edinburgh: Churchill Livingstone.

Paungmali, A., Vincenzino, B. and Smith, M. 2003. Hypoalgesia induced by elbow manipulation in lateral epicondylalgia does not exhibit tolerance. *The Journal of Pain,* 4 (8): 448-454.

Plaugher, G. 1993. Textbook of Clinical Chiropractic - A Specific Biomechanical Approach. Baltimore: Williams and Wilkins, 80-217.

Plesh, O., Adams, S.H. and Gansky, S.A. 2012. Self- Reported Comorbid Pains in Severe Headaches or Migraines in a US National Sample. *Headaches,* 52(6): 946–956.

Pool, J., Ostelo, R., Hoving, J., Bouter, L. and de Vet, H. 2007. Minimal Clinically Important Change of the Neck Disability Index and the Numerical Rating Scale of Patients with Neck Pain, *Spine.* 32(26): 3047-3051.

Potter, L., McCarthy, C. and Oldham, J. 2006. Algometer Reliability in Measuring Pain Pressure Threshold over Normal Spinal Muscles to Allow Quantification of Anti-Nociceptive Treatment Effects. *International Journal of Osteopathic Medicine,* 9:113-119.

Quek, J., Pua, Y., Clark, R.A. and Bryant, L.A. 2013. Effects of thoracic kyphosis and forward head posture on cervical range of motion in older adults. *Manual Therapy*, 18: 65-71.

Quinn, K.P., and Winkelstein, B.A. 2007. Cervical facet capsular ligament yield defines the threshold for injury and persistent joint-mediated neck pain. *Journal of Biomechanics*, 40: 2299-2306

Raine, S. and Twomey, L.T. 1997. Head and Shoulder Posture Variations in 160 Asymptomatic Women and Men. *Archives of Physical Medicine and Rehabilitation,* 78: 1215-1223.

Rickards, L.D. 2006. The Effectiveness of Non-invasive Treatments for Active Myofascial Trigger Point Pain: A systematic review of the literature. *International Journal of Osteopathic Medicine,* 9:120-136.

Roodt, M.L.E. 2009. A Comparative Study of Three Different Types Of Manual Therapy Techniques in the Management of Chronic Mechanical Neck Pain. M.Tech, Durban University of Technology.

Rudolfsson, T., Bjorklund, M. and Djupsjobacka, M. 2012. Range Of Motion in the Upper and Lower Cervical Spine in People with Chronic Neck Pain. *Manual Therapy,* 17:53-59.

Ruiz-Saez, M., Fernández-de-las-Peñas, C., Alonso-Blanco, C.R., MartInez-Segura, R. and Rafael GarcIa-León, R. 2007. Changes in Pressure Pain Sensitivity in Latent Myofascial Trigger Points in the Upper Trapezius Muscle after a Cervical Spine Manipulation in Pain-Free Subjects, 30(8): 578-583.

Saayman, L., Hay, C. and Abrahamse, H. 2011. Chiropractic Manipulative Therapy and Low-Level Laser Therapy in the Management of Cervical Facet Dysfunction: A Randomized Controlled Study. *Journal of Manipulative and Physiological Therapeutics,* 34(3):153-163.

Schenk, R., Adelman, K. and Rousselle, J. 1994. The Effects of Muscle Energy Technique on Cervical Range of Motion. *Journal of Manual and Manipulative Therapy*, 2(4): 149-155.

Schlossberg, E.B., Morrow, S., Llosa, A.E., Mamary, E., Dietrich, P. and Rempel, D.M. 2004. Upper Extremity Pain and Computer Use among Engineering Graduate Students. *American Journal of Industrial Medicine,* 46: 297–303.

Schneider, G.M., Jull, G., Thomas, K. and Salo, P. 2012. Screening of Patients Suitable For Diagnostic Cervical Facet Joint Blocks E A Role for Physiotherapists. *Manual Therapy*, 17: 180-183.

Schwerla, F., Bischoff, A., Nürnberger, A., Genter, P., Guillaume, J. and Resch, K. 2008.Osteopathic Treatment of Patients with Chronic Non-Specific Neck Pain: A Randomized Controlled Trial of Efficacy. *Research in Complementary Medicine,* 15(3): 138-145.

Seth, S.D. 1999.*Textbook of Pharmacology.* 2nded. Edinburg: Churchill Livingston.

Silva, A.G. and Johnson, M.I. 2013. Does Forward Head Posture Affect Postural Control in Human Healthy Volunteers? *Gait and Posture,* 38: 352-353.

Sim, J., Lacey, R.J. and Lewis, M. 2006. The Impact of Workplace Risk Factors on the Occurrence of Neck and Upper Limb Pain: A General Population Study. *BioMed Central, Public Health,* 6(234): 1-10.

Simons, D.G., Travell, J.G. and Simons, L.S. 1999. *Travell and Simons Myofascial Pain and Dysfunction: The Trigger Point Manual. Vol. 1, Upper half of the body*. Baltimore: Williams and Wilkins.

Skillgate, E., Magnusson, C., Lundberg, M. and Hallqvist, J. 2012. The age- and sex-specific occurrence of bothersome neck pain in the general population – results from the Stockholm public health cohort. *BioMed Central Musculoskeletal disorders,* 13: 185.

Slabbert, W.N. 2010. An epidemiological investigation of neck pain in the White population in the greater Durban area. M. Tech, Durban University of Technology.

Smedley, J., Inskip, H., Trevelyan, F., Buckle, P., Cooper, C. and Coggon, D. 2003. Risk Factors for Incident Neck and Shoulder Pain in Hospital Nurses. *Occupational Environmental Medical,* 60: 864–869.

Smith, M. and Fryer, G. 2008. A Comparison of Two Muscle Energy Techniques for Increasing Flexibility of the Hamstring Muscle Group. *Journal of Bodywork and Movement Therapies,* 12: 312–317

Standring, S. 2008. *Gray's Anatomy: the Anatomical Basis of Clinical Practice*. 40th edition. Edinburgh. Churchill Livingstone/Elsevier.

Stemper, B.D., Yoganandan, N. and Pintar, F.A. 2003. Gender Dependent Cervical Spine Segmental Kinematics during Whiplash. *Journal of Biomechanics,* 36: 1281-1289.

Strimpakos, N. 2011. The Assessment of the Cervical Spine. Part 1: Range of Motion and Proprioception. *Journal of Bodywork and Movement Therapies,* 15: 114-124.

Statistics South Africa. 2012. *South African statistics*. Pretoria: Statistics South Africa.

Szeto, G.P.Y., Straker, L. and Raine, S. 2002. A field comparison of neck and shoulder postures in symptomatic and asymptomatic office workers. *Applied Ergonomics,* 33: 75-84.

Tortora, G.J. and Derrickson, B.2006. *Principles of Anatomy and Physiology.11th* ed. USA: John Wiley and Sons.

Treaster, D., Marras, W.S., Burr, D., Sheedy, J.E. and Hart, D. 2006. Myofascial Trigger Point Development from Visual and Postural Stressors during Computer Work. *Journal of Electromyography and Kinesiology,* 16: 115-124.

Tsai, Y.L., Weng, M.C., Chen, T.W., Hsieh, Y.L., Chen, C.S. and Huang, M.H. 2012. Correlation between the ossification of nuchal ligament and clinical cervical disorders. *Journal of Medical Sciences,* 28: 538-544.

Tsang, S.M.H., Szeto, G.P.Y. and Lee, R.W.Y. 2013. Normal Kinematics of the Neck: The Interplay between the Cervical and Thoracic Spines. *Manual Therapy,* 1-7.

Uhrenholt, L., Charles, A., Hauge, E. and Gregersen, M. 2009. Pathoanatomy of the Lower Cervical Spine Facet Joints in Motor Vehicle Crash Fatalities. *Journal of Forensic and Legal Medicine,* 16:253-260.

Venketsamy, Y. 2007. A Retrospective Cross-Sectional Survey of Cervical Cases Recorded at the Durban University of Technology (D.U.T) Chiropractic Day Clinic (1995-2005). M.Tech, Durban University of Technology.

Velly, A., Gornitsky, M. and Philippe, P. 2003 Contributing Factors to Chronic Myofascial Pain: A Case–Control Study. *Pain,* 104: 491-499.

Vernon, H., Humpherys, K. and Hagino, C. 2007. Chronic Mechanical Neck Pain in Adults Treated by Manual Therapy: A Systematic Review of Change Scores in Randomized Clinical Trials. *Journal of Manipulative and Physiological Therapies,* 30(3): 215-227.

Vernon, H. 1988. *Upper Cervical Syndrome: Chiropractic Diagnosis and Treatment.* Baltimore: Williams and Wilkins.

Vernon, H. 2008. The Neck Disability Index: State-of-the-Art, 1991-2008. *Journal of Manipulative and Physiological Therapeutics*, 31: 491-502.

Vincent, K., Maigne, J.Y., Fischhoff, C., Lanlo, O., and Dagenais, S. 2012. Systematic Review of Manual Therapies for Nonspecific Neck Pain. *Joint Bone Spine*, *1-8.*

Vizniak, N.A. 2010. *Quick Reference Evidence Based Muscle Manual.* Professional Health Systems Inc.

Vizniak, N.A. 2010. *Levator Scapulae muscles* (image). Professional Health Systems Inc.

Vizniak, N.A. 2010. *Posterior neck muscles* (image). Professional Health Systems Inc.

Vizniak, N.A. 2010. *Suboccipital muscles* (image). Professional Health Systems Inc.

Vizniak, N.A. 2010. *Trapezius muscles (Upper fibers)* (image). Professional Health Systems Inc.

Vos, T., Flaxman, A. and Naghavi, M., Lozano, R., Michaud, C., Ezzati, M., Shibuya, K., Salomon, J.A., Abdalla, S., Aboyans, V., Abraham, J., Ackerman, I., *et al*., 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. *Lancet*, 380: 2163-2196.

Wiegand, R. Kettner, N.W., Brahee, D. and Marquina, N. 2003. Cervical Spine Geometry Correlated to Cervical Degenerative Disease In A Symptomatic Group. *Journal of Manipulative and Physiological Therapeutics*, July/August: 341-346.

Wiegand, R. Kettner, N.W., Brahee, D. and Marquina, N. 2003. *The 5 geometric variables correlation with the development of degenerative disease in the cervical spine* (image). Cervical Spine Geometry Correlated to Cervical Degenerative Disease in a Symptomatic Group. *Journal of Manipulative and Physiological Therapeutics,* 341-346.

Williams, M.A., McCarthy, C.J., Chorti, A., Cooke, M.W. and Gates, S.M. 2010. A systematic review of reliability and validity studies of methods for measuring active and passive cervical range of motion. *Journal of Manipulative and Physiological Therapeutics*, 33 (2): 139-155

Yochum, T.R. and Rowe, L.J. 2005. *Essentials of Skeletal Radiology*. *3rd ed*. Philadelphia: Lippincott Williams and Wilkins.

Yeomans, S.G. 2000. The clinical application of outcomes assessment. United States of America: Appleton and Lange.

Yoon, S.H., Rah, U.W., Sheen, S.S. and Cho, K.H. 2009. Comparison Of 3 Needle Sizes For Trigger Point Injection In Myofascial Pain Syndrome Of Upper- And Middle-Trapezius Muscle: A Randomized Controlled Trial. *Archives of Physical Medicine and Rehabilitation*, 90:1332-1339.

Youdas, J., Carey, J. and Garret, T. 1991. Reliability of measurements of cervical range of motion- a comparison of three methods, *Physical Therapy*, 7(2): 98-104.

Young, B.A., Walker, M.J., Strunce, J.B., Boyles, R.E., Whitman, J.M. and Childs, J.D. 2009. Responsiveness of the Neck Disability Index in patients with mechanical neck disorders. *The Spine Journal,* 9: 802-808.

APPENDIX A

ETHICS CLEARANCE CERTIFICATE

DURBAN UNIVERSITY of TECHNOLOGY

INSTITUTIONAL RESEARCH ETHICS COMMITTEE (IREC)

3 September 2012

IREC Reference Number: **REC 43/12**

Ms K Naidoo
49/32nd Avenue
Umhlatuzuna
Durban
4092

Dear Ms Naidoo

A randomized controlled trial to determine the treatment duration effectiveness of Muscle Energy Technique in the treatment of mechanical neck pain

I am pleased to inform you that Full Approval has been granted to your proposal REC 43/12.

The Proposal has been allocated the following Ethical Clearance number **IREC 032/12**. Please use this number in all communication with this office.

Approval has been granted for a period of one year, before the expiry of which you are required to apply for safety monitoring and annual recertification. Please use the Safety Monitoring and Annual Recertification Report form which can be found in the Standard Operating Procedures [SOP's] of the IREC. This form must be submitted to the IREC at least 3 months before the ethics approval for the study expires.

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 SOP's. In addition, you will be responsible to ensure gatekeeper permission.

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

Yours Sincerely

[redacted]

Dr D F Naude
Chairperson: IREC

APPENDIX B1

POSTER

HAVE YOU BEEN SUFFERING FROM

NECK PAIN

for more than six weeks and are between the ages of 18-40?

Research is currently being conducted at the

CHIROPRACTIC CLINIC

Durban University of Technology

TREATMENT WILL BE MADE AVAILABLE FOR YOU,

Should you qualify for the study

For more information contact:

KERISHA NAIDOO

On: 031 3732205 / 071 7435282

APPENDIX B2

PAMPHLET

(Poster reduced to A5)

HAVE YOU BEEN SUFFERING FROM

NECK PAIN

for more than six weeks and are between the ages of 18-40?

Research is currently being conducted at the

CHIROPRACTIC CLINIC

Durban University of Technology

TREATMENT WILL BE MADE AVAILABLE FOR YOU,

Should you qualify for the study

For more information contact:

KERISHA NAIDOO

On: 031 3732205 / 071 7435282

APPENDIX B3

THE PRELIMINARY INTERVIEW

<u>Preliminary interview to determine if potential participants meet the inclusion criteria</u>

No.	Question	Expected Responses
1	Is it possible for me to ask you a few questions? (The participants consent was essential. If the participant agreed to this then the interview commenced)	YES
2	Are you on any pain medication? (If the participant answers yes to this, a "wash out" period of three days was required before they were included into the study (Seth, 1999)).	NO
3	Have you had treatment to your neck in the past three months?	NO
4	Have you had any recent trauma/surgery to your neck?	NO
5	Are you between the ages of 18- 40?	YES
6	Have you experienced neck pain for a period of longer than six weeks (Grieve, 1988)?	YES

APPENDIX C

LETTER OF INFORMATION AND INFORMED CONSENT FORM

INSTITUTIONAL RESEARCH ETHICS COMMITTEE (IREC)
LETTER OF INFORMATION

Title of the Research Study: *A Randomised Controlled Trial to Determine the Duration Effectiveness of Muscle Energy Technique in the Treatment of Chronic Mechanical Neck Pain.*

Principal Investigator/s/researcher: Kerisha Naidoo Contact number: 0738157561

Co-Investigator/s/supervisor/s: Dr. Charmaine Korporaal Contact number: 031 3732611
(**M.Tech: Chiropractic, CCFC, CCSP, ICSSD)**

Brief Introduction and Purpose of the Study: Muscle Energy Technique (MET) is a form of manual therapy and the purpose of this study is to determine which contraction duration of MET is more effective in the treatment of chronic neck pain. Each participant will be randomly allocated to one of two groups and will receive treatment based on the group in which they fall into.

Outline of the Procedures: The research will be conducted at the Chiropractic Day clinic at the Durban University of Technology. At the first consultation a consent letter has to be signed. You will then be screened to determine whether you will be included into the study. This is done via the inclusion/exclusion criteria, a case history, physical examination and cervical (neck) examination. If you are receiving any form of treatment for your neck or have in the past 3 months, you will be excluded from the study. If you are on any pain medication, a wash-out period of three days will be required of you, as the medication could have an effect on your symptoms. If you require further diagnostic evaluation or have any contra-indications to manual therapy, you will be excluded from the study. If you do not sign the consent letter you will also be excluded from the study.

Once you are included into the study, you will be required to fill in two questionnaires and measurements for range of motion and pain will be taken for statistical analysis. You will need to attend 4 treatments (two per week) and the fifth visit which will be for the final measurements. Measurements will be taken at the first, third and fifth visits. The first consultation is 2 hours and the follow up visits will last 30-45 minutes.

Risks or Discomforts to the Participant: The treatment given to you will be under the supervision of a qualified chiropractor at all times. MET is a non-invasive (i.e. non-surgical and no injectables) form of manual therapy and is considered to be a safe treatment. There are however instances where muscle stiffness lasting 1-2 days after treatment may occur as well as a short duration of post treatment soreness in a few cases. If you do have a history of dizziness it is important to provide this information to the researcher as there is a slight possibility of dizziness being experienced during the 45s treatment. If this does occur then the treatment will be stopped immediately and you will be excluded from the study and referred to an appropriate health facility .

Benefits: You will benefit from the study by receiving treatment for your neck pain and I, the researcher, will benefit by completing my dissertation.

Reason/s why the Participant May Be Withdrawn from the Study: Should you wish to withdraw from the study you are free to do so. If you are not compliant with what is expected of you during the course of the study, you will be withdrawn. You are free to withdraw from the study at any time. Withdrawal from the study does not prevent you from receiving further treatment at the chiropractic clinic at the normal clinic rates.

Remuneration: There will be no form of remuneration offered to you.

Costs of the Study: You are not expected to pay as the study is free. Once the study is complete, you will be expected to pay normal clinic rates should you wish to receive further treatment at the clinic.

Confidentiality: All patient information pertaining to the study will be coded to maintain confidentiality and will be stored in the Chiropractic Day Clinic. Results of the study will be made available at the Durban University of Technology library, without revealing any of the patients' details.

Research-related Injury: Should you experience any adverse reactions to the interventions in this study, you are free to cease further participation and withdrawal on this basis will not prevent you from receiving further treatment at the chiropractic clinic at the normal clinic rates. Should you wish to be referred to another health care facility, the researcher will facilitate this process for you.

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

Please contact the researcher (071 7435282), my supervisor (Dr. Charmaine Korporaal: Tel no. 031 3732611) or the Institutional Research Ethics administrator on 031 373 2900. Complaints can be reported to the DVC: TIP, Prof F. Otieno on 031 373 2382 or dvctip@dut.ac.za.

General:

Participation is completely voluntary. Should you wish to withdraw from the study at any given time, you are free to do so. If you still want treatment you can be treated at the clinic as a non-research patient.

INSTITUTIONAL RESEARCH ETHICS COMMITTEE (IREC)
CONSENT

Statement of Agreement to Participate in the Research Study:

- I hereby confirm that I have been informed by the researcher, Kerisha Naidoo, about the nature, conduct, benefits and risks of this study - Research Ethics Clearance Number: IREC 032/12,
- 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, Kerisha Naidoo, 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 D

CASE HISTORY

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 E

PHYSICAL EXAMINATION

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 F
CERVICAL REGIONAL EXAMINATION

DUT DURBAN UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF CHIROPRACTIC AND SOMATOLOGY

CHIROPRACTIC PROGRAMME

REGIONAL EXAMINATION – CERVICAL SPINE

Patient: .... File No: ....
Date: .... Student: ....
Clinician: .... Sign: ....

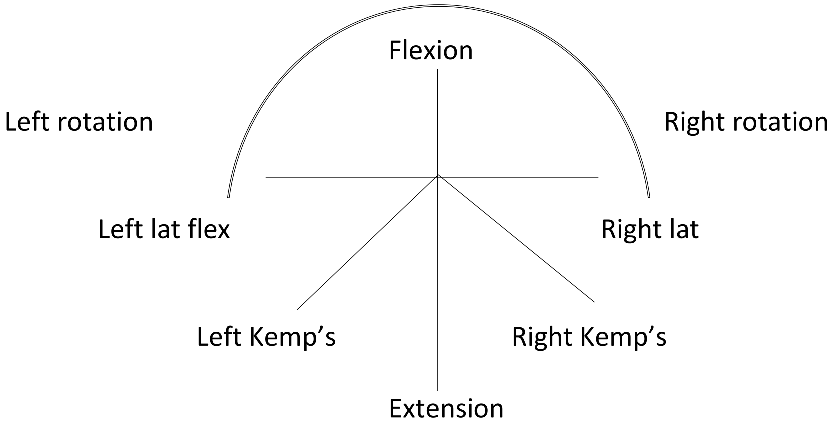
OBSERVATION:

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

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

RANGE OF MOTION:

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



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					

NEUROLOGICAL EXAMINATION:

Dermatones	**Left**	**Right**	**Myotomes**	**Left**	**Right**	**Reflexes**	**Left**	**Right**
C2			C1			C5		
C3			C2			C6		
C4			C3			C7		
C5			C4					
C6			C5					
C7			C6					
C8			C7					
T1			C8					
			T1					

Cerebellar tests:	Left	Right
Dysdiadochokinesis		

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

MOTION PALPATION & JOINT PLAY:

Left: Motion Palpation:
Joint Play:

Right: Motion Palpation:
Joint Play:

BASIC EXAM: SHOULDER:

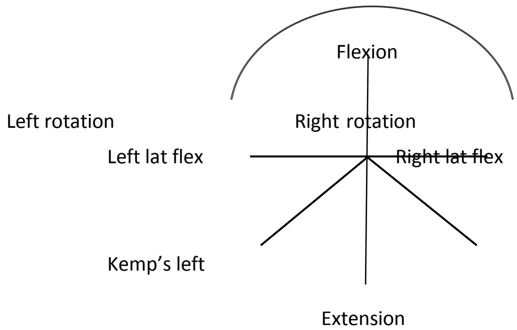
Case History:

ROM: Active:
Passive:
RIM:
Orthopaedic:
Neuro:
Vascular:
Kemp's right

BASIC EXAM: THORACIC SPINE:

Case History:

ROM:



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

APPENDIX G

SOAPE NOTE

CHIROPRACTIC PROGRAMME

DEPARTMENT OF CHIROPRACTIC AND SOMATOLOGY

DUT DURBAN UNIVERSITY OF TECHNOLOGY

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)* *Least* **0 1 2 3 4 5 6 7 8 9 10** *Worst* *Student Rating* ☐	**A:**
O:	**P:** **E:**
Special attention to:	**Next appointment:**

CHIROPRACTIC PROGRAMME

Patient Name:		**File number:**	**Page:**
Date:	**Visit:**	**Student:**	
Attending Clinician:		**Signature:**	
S: *Numerical Pain Rating Scale (Patient)* *Least* **0 1 2 3 4 5 6 7 8 9 10** *Worst* ☐ *Student Rating*		**A:**	
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:***

APPENDIX H

DATA SHEET

OBJECTIVE DATA COLLECTION SHEET

CROM DATA COLLECTION

PATIENT NAME: ____________________________
FILE NUMBER: _______________

<table>
<tr><td rowspan="6">DATE</td><td rowspan="6">VISIT 1</td><td>FLEXION</td><td></td></tr>
<tr><td>EXTENSION</td><td></td></tr>
<tr><td>RIGHT LATERAL FLEXION</td><td></td></tr>
<tr><td>LEFT LATERAL FLEXION</td><td></td></tr>
<tr><td>RIGHT ROTATION</td><td></td></tr>
<tr><td>LEFT ROTATION</td><td></td></tr>
<tr><td rowspan="6">DATE</td><td rowspan="6">VISIT 3</td><td>FLEXION</td><td></td></tr>
<tr><td>EXTENSION</td><td></td></tr>
<tr><td>RIGHT LATERAL FLEXION</td><td></td></tr>
<tr><td>LEFT LATERAL FLEXION</td><td></td></tr>
<tr><td>RIGHT ROTATION</td><td></td></tr>
<tr><td>LEFT ROTATION</td><td></td></tr>
<tr><td rowspan="6">DATE</td><td rowspan="6">VISIT 5</td><td>FLEXION</td><td></td></tr>
<tr><td>EXTENSION</td><td></td></tr>
<tr><td>RIGHT LATERAL FLEXION</td><td></td></tr>
<tr><td>LEFT LATERAL FLEXION</td><td></td></tr>
<tr><td>RIGHT ROTATION</td><td></td></tr>
<tr><td>LEFT ROTATION</td><td></td></tr>
</table>

ALGOMETER DATA COLLECTION

DATE	VISIT	TRIGGER POINT 1	TRIGGER POINT 2	TRIGGER POINT 3	TRIGGER POINT 4

APPENDIX I
NUMERICAL PAIN RATING SCALE-101
(NRS-101)

<u>Numerical Rating Scale – 101 Questionnaires</u>

Date: _____________ File no: ____________ Visit no: ___________

Patient name: ____

Please indicate on the line below, the number between 0 and 100 that best describes the pain you experience **<u>when it is at its worst.</u>** A zero (0) would mean "no pain at all'', and one hundred (100) would mean "pain as bad as it could be''.

Please write only **one** number.

0 ____ 100

Please indicate on the line below, the number between 0 and 100 that best describes the pain you experience **<u>when it is at its least.</u>** A zero (0) would mean "no pain at all'', and one hundred (100) would mean "pain as bad as it could be''.

Please write only **one** number.

0 ____ 100

APPENDIX J

CMCC NECK DISABILITY INDEX

(NDI)

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 care 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 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 K

PERMISSION TO USE NECK DISABILITY INDEX (NDI)

From: Howard Vernon [mailto:HVernon@cmcc.ca]
Sent: Wednesday, June 20, 2012 5:29 PM
To: Charmaine Maria Korporaal
Subject: RE: Dear Professors

Dear Dr. Korporaal,

Thanks so much for this message. I'm pleased that your student will use the NDI in their study. I'm also pleased that the version you provided is the correct one.

You have my permission for this use of the NDI.

Good luck with this work.

Howie Vernon

From: Charmaine Maria Korporaal [mailto:charmak@dut.ac.za]
Sent: June 20, 2012 10:23 AM
To: sgyeomans@charter.net; Howard Vernon; Silvano Mior
Cc: Kerisha Naidoo (kerishan@yahoo.com)
Subject: Dear Professors
Importance: High

Dear Professors,

One of my research students (Kerisha Naidoo) is currently having a proposal submitted to the Ethics committee at the Durban University of Technology for approval (the equivalent of IRB approval in the USA), with the title of :

The comparison of Short-phase Muscle Energy Technique versus Long-phase Muscle Energy Technique in the treatment of chronic mechanical neck pain.

As part of the study she is utilizing the attached questionnaire as one of her outcome measures.

In order for her to get Ethics approval she is required to have permission from the developers of the attached document. We have been given to understand that you have all three either reported on or played some part in the questionnaire development.

Would it therefore be possible to ask you

1. whether you would be in a position to give approval for Kerisha to utilize the questionnaire in the study and if so,

2. would you be willing to allow use of the questionnaire.

Thank you for your time in the above, we appreciate your response

Kind regards

Charmaine

Dr Charmaine Korporaal

M.Tech:Chiropractic, CCFC, CCSP, ICSSD

Senior lecturer and Clinic Director : Department of Chiropractic and Somatology

Durban University of Technology

P.O.Box 1334 Durban 4000 / 11 Ritson Road (by rear entrance)

Tel: 27 (0) 31 373 2611 Fax: 27 (0) 31 2023632 / (0) 866486360
Cell: 27 (0) 832463562 E-mail: charmak@dut.ac.za

Vice President : Chiropractic Association of South Africa

Secretary : Federation International Chiropractic Sport

National Internship Committee Chair ; Allied Health Professions Council

Member : Council Education Committee : Allied Health Professions Council

Member : ICRF steering committee

APPENDIX L

CONCEALED ALLOCATION CONTRACT

CONCEALED ALLOCATION AGREEMENT

I_______________________ (Concealed allocator) agree to do the concealed allocation for Kerisha Naidoo's study. The information regarding group allocation, will be kept hidden from Kerisha Naidoo, until the patient has been clinically evaluated. I will not share this information to anyone as I am aware of the importance of patient confidentiality.

Signature of Concealed allocator: __________________________

Date: _________

Signature of Researcher: ________________________

Date: _________

APPENDIX M1

BLINDED ASSESSORS CONTRACT

<u>AGREEMENT BETWEEN RESEARCHER AND BLIND ASSESSOR</u>

I______________________ (Blind assessor) agree to take the measurements for Kerisha Naidoo (Researcher) using the algometer and the CROM. I agree to undergo the training session to ensure I have a complete understanding of how the measurement instruments work. I have read up on the study and I am aware of the study design. I will not to divulge any information, be it of the readings or the patients' personal details, as this is to remain confidential at all times.

Signature of blinded assessor: _________________________

Date: ___________________

Signature of researcher: _____________________________

Date: ___________________

APPENDIX M2

BLINDED ASSESSORS TRAINING

BLINDED ASSESSOR TRAINING WORKSHOP

This is to confirm that I,______________________________(Blinded assessor), has undergone the training workshop held by Kerisha Naidoo (Researcher) on the ____________________(Date).

I agree that the following aspects about the CROM were covered in the workshop:

- How to place the CROM Goniometer on patients head.
- How to use the CROM
- How to recalibrate the CROM based on the magnetic fields
- How to explain the procedure to the patient
- How to read the measurements accurately
- Practiced using the CROM on patients to test my measuring skill
- Compared my measurements with that of the other blinded assessor

I agree that the following aspects about the algometer were covered in the workshop:

- How to use the Algometer
- How to place the Algometer on the patient
- Where exactly to place the algometer
- The instructions I should give the patient before placing the Algometer on the patient
- How to recalibrate the Algometer to obtain accurate measurements for the next reading
- How to read the measurements accurately
- Practiced using the Algometer on patients to test my measuring skill
- Compared my measurements with that of the other blinded assessor

Now that I have undergone the workshop training, I_______________________ (Blind assessor), am ready to take the objective measurements for Kerisha Naidoo (Researcher). I will take the measurements to the best of my ability and shall not divert from what I have learnt in this workshop.

Researcher: ____________________________________ Date: _________________

Blinded assessor: ___________________________________ Date: _________________

Supervisor: _____________________________________ Date: _________________

APPENDIX N

PERMISSION FOR USE OF IMAGE

ELSEVIER LICENSE
TERMS AND CONDITIONS

Oct 30, 2013

This is a License Agreement between Kerisha Naidoo ("You") and Elsevier ("Elsevier") provided by Copyright Clearance Center ("CCC"). The license consists of your order details, the terms and conditions provided by Elsevier, and the payment terms and conditions.

All payments must be made in full to CCC. For payment instructions, please see information listed at the bottom of this form.

Supplier	Elsevier Limited The Boulevard,Langford Lane Kidlington,Oxford,OX5 1GB,UK
Registered Company Number	1982084
Customer name	Kerisha Naidoo
Customer address	49/32nd avenue umhlatuzana
	Durban, KZN 4092
License number	3223610095949
License date	Sep 07, 2013
Licensed content publisher	Elsevier
Licensed content publication	Journal of Manipulative and Physiological Therapeutics
Licensed content title	Cervical spine geometry correlated to cervical degenerative disease in a symptomatic group
Licensed content author	Raymond Wiegand,Norman W Kettner,Deborah Brahee,Nelson Marquina
Licensed content date	July–August 2003
Licensed content volume number	26
Licensed content issue number	6
Number of pages	6
Start Page	341
End Page	346
Type of Use	reuse in a thesis/dissertation
Portion	figures/tables/illustrations
Number of figures/tables/illustrations	1
Format	both print and electronic
Are you the author of this Elsevier article?	No
Will you be translating?	No
Order reference number	
Title of your thesis/dissertation	A Randomized Controlled Trial to determine the

	treatment duration effectiveness of Muscle Energy Technique in the Treatment of Mechanical Neck Pain.
Expected completion date	Sep 2013
Estimated size (number of pages)	100
Elsevier VAT number	GB 494 6272 12
Permissions price	0.00 USD
VAT/Local Sales Tax	0.0 USD / 0.0 GBP
Total	0.00 USD
Terms and Conditions	

APPENDIX O

PERMISSION FOR USE OF MUSCLE IMAGES

Fw: Permission to use images

On Wednesday, September 4, 2013 4:37 PM, Charmaine Maria Korporaal <charmak@dut.ac.za> wrote:

Dear Nik

Thank you for your prompt response – it is greatly appreciated.

It would perhaps be easier for you to place a link to the DUT institutional repository and then highlight which of the dissertations have utilized your pictures.

I will ask Kerisha to put a reminder in her diary in order to provide you with the information when she is done with her research

Thank you

Charmaine

From: NIKITA VIZNIAK [mailto:contact@prohealthsys.com]
Sent: Wednesday, September 04, 2013 4:23 PM
To: Charmaine Maria Korporaal
Subject: RE: Permission to use images

Hi Charmaine,

No problem on the images – I would like to request permission to receive and post a copy of the dissertation on our website for reference

Thanks,

Nik

Dr. Nikita Vizniak

Chair, Physical Medicine BINM - www.binm.org

Director, Professional Health Systems - www.prohealthsys.com

6435 Marine Drive - Burnaby, BC, Canada - V3N 2Y5

E-mail: contact@prohealthsys.com

Tel: 604-521-5520   Fax: 604-521-5526

From: Charmaine Maria Korporaal [mailto:charmak@dut.ac.za]
Sent: September 3, 2013 9:50 PM
To: Tasha Murray & Nik Vizniak
Subject: FW: Permission to use images

Dear Dr Vizniak

I am sending this e-mail on behalf of a masters student – Ms Kerisha Naidoo – requesting permission to utilize the images as per the attached document.

Note that these images will be appropriately referenced to you in the text of her masters dissertation. This dissertation will be available in the DUT institutional repository about 2 months after Kerisha has qualified from the DUT. Therefore it will be accessible should you wish to verify the use of these images.

Please could you revert at your earliest convenience as to your decision

Kind regards

Charmaine

APPENDIX P

Figures showing the subjective and objective measures for objective one, two and three

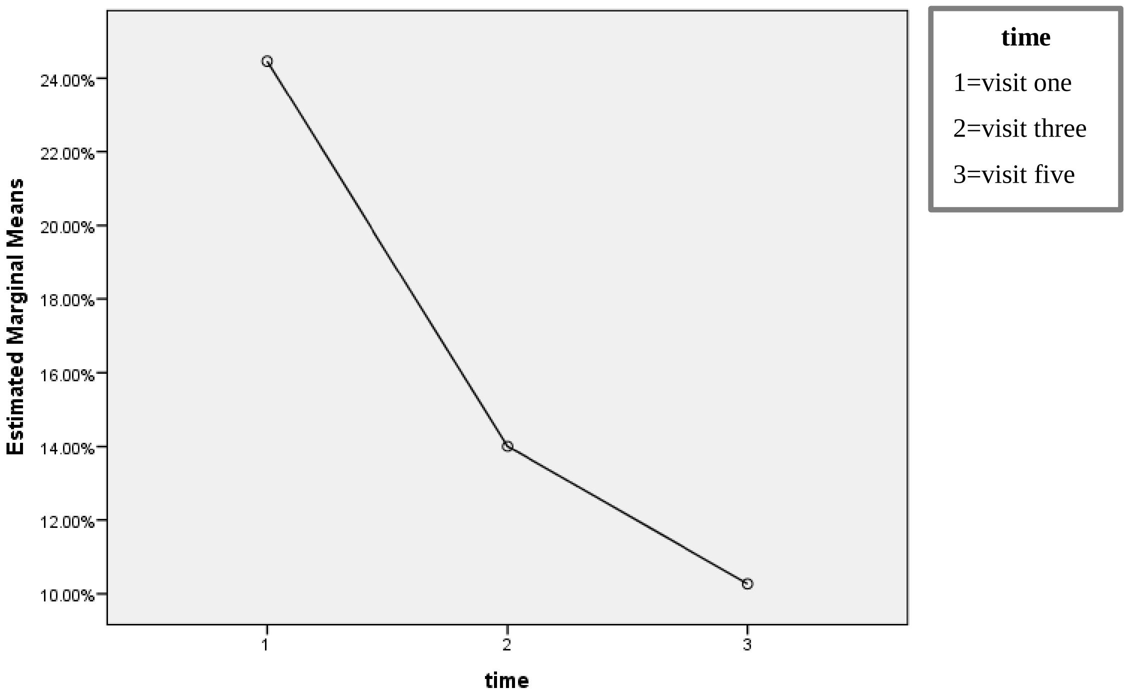


Figure 1: Profile plot of the mean NDI score over time of Group A

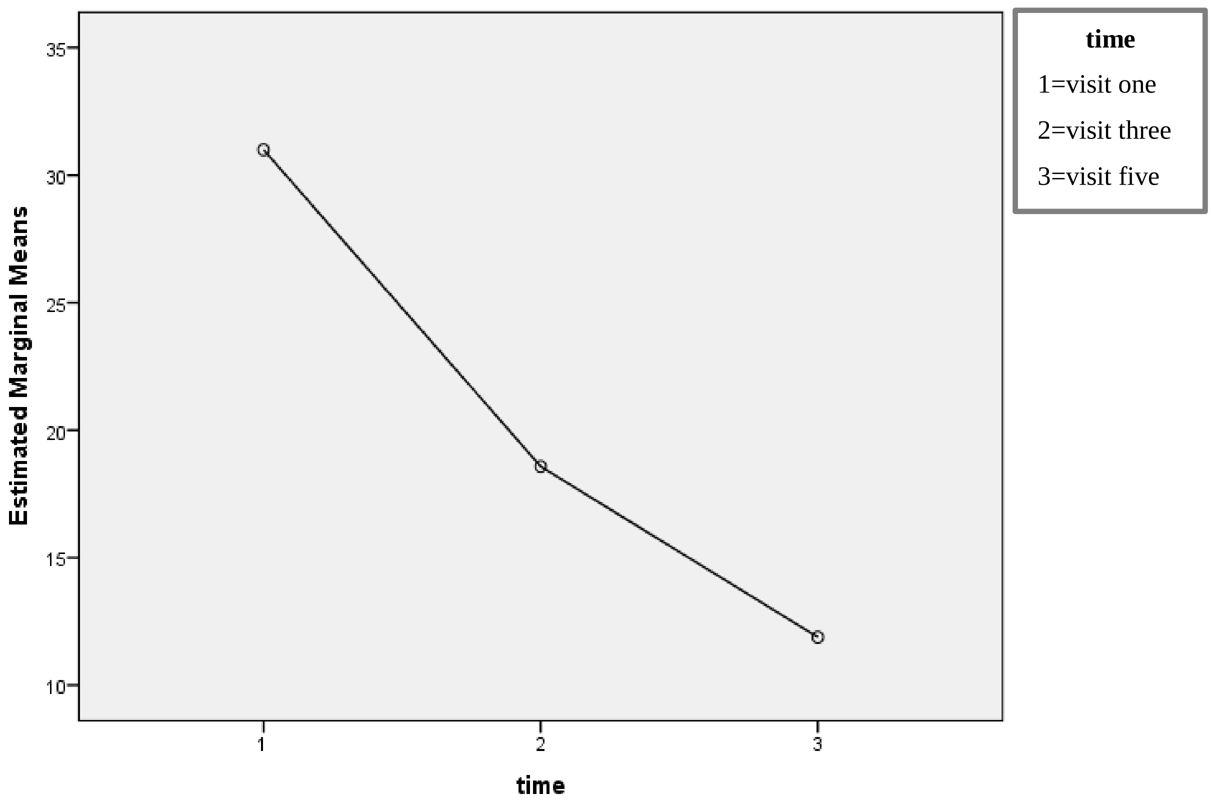


Figure 2: Profile plot of the mean NRS-101 score over time of Group A

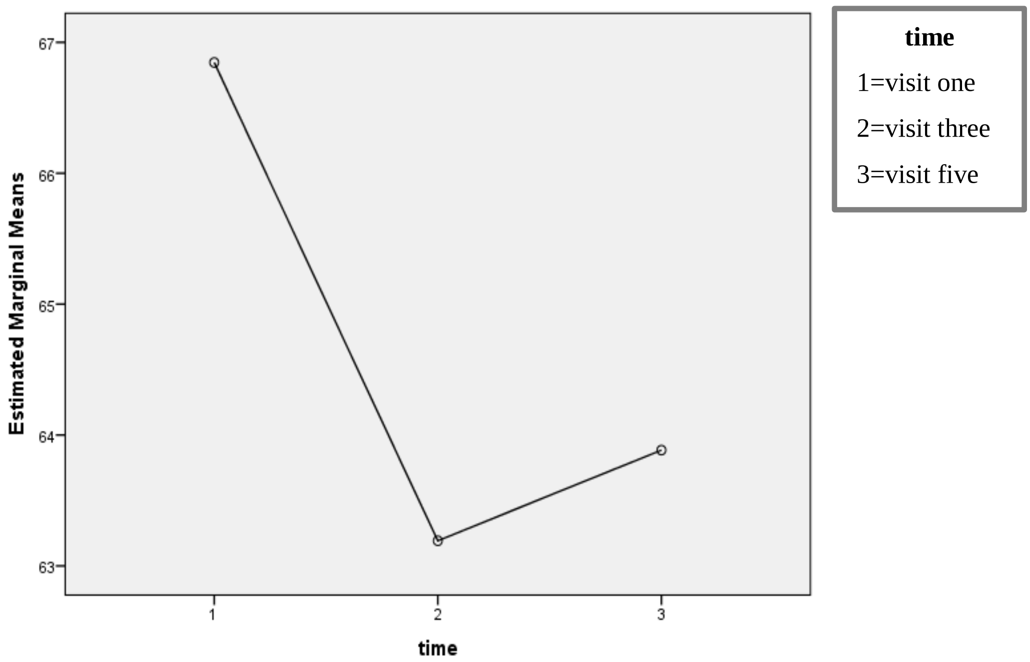


Figure 3: Profile plot of mean flexion over time of Group A

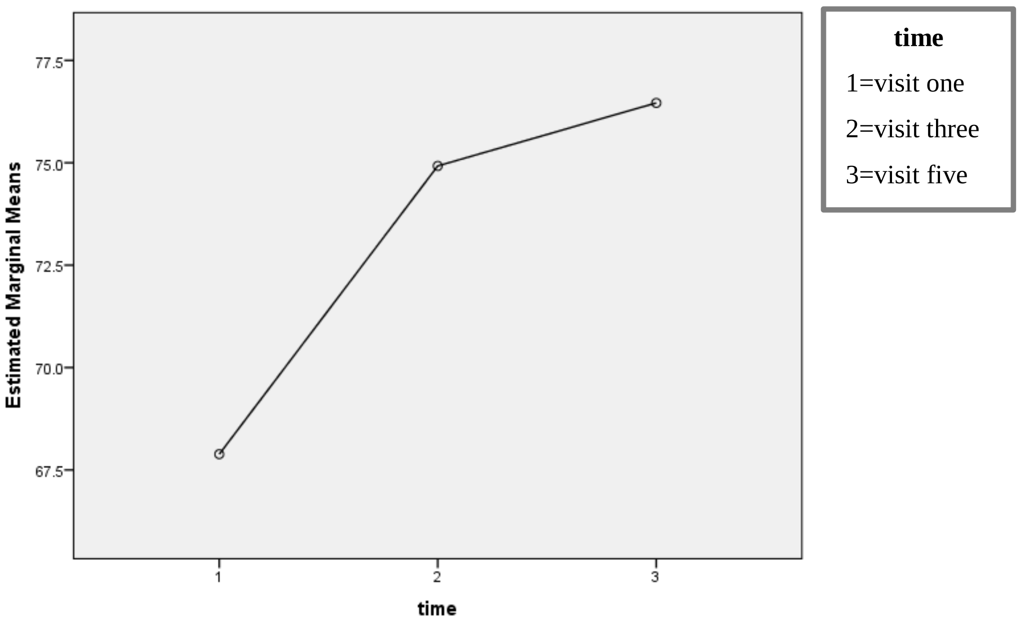


Figure 4: Profile plot of mean extension over time of Group A

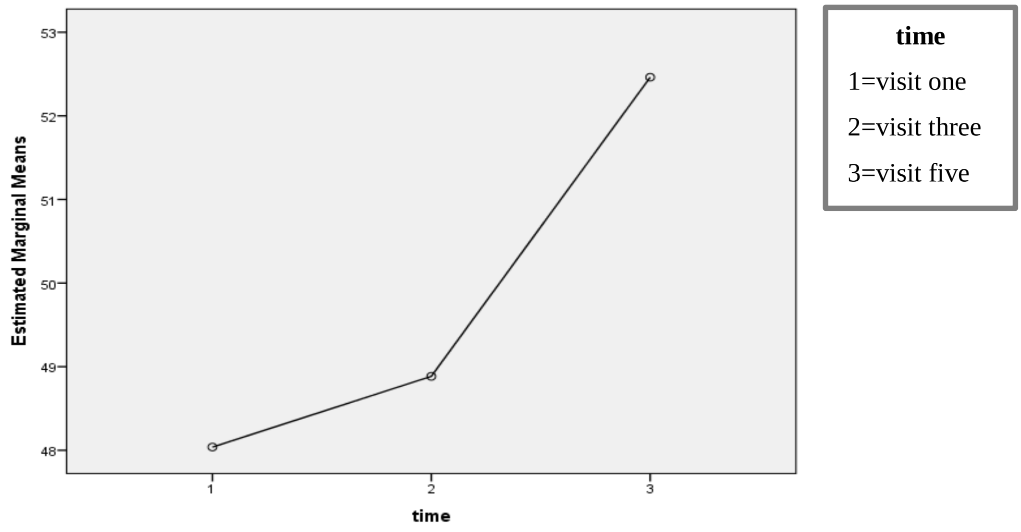


Figure 5: Profile plot of mean right lateral flexion over time of Group A

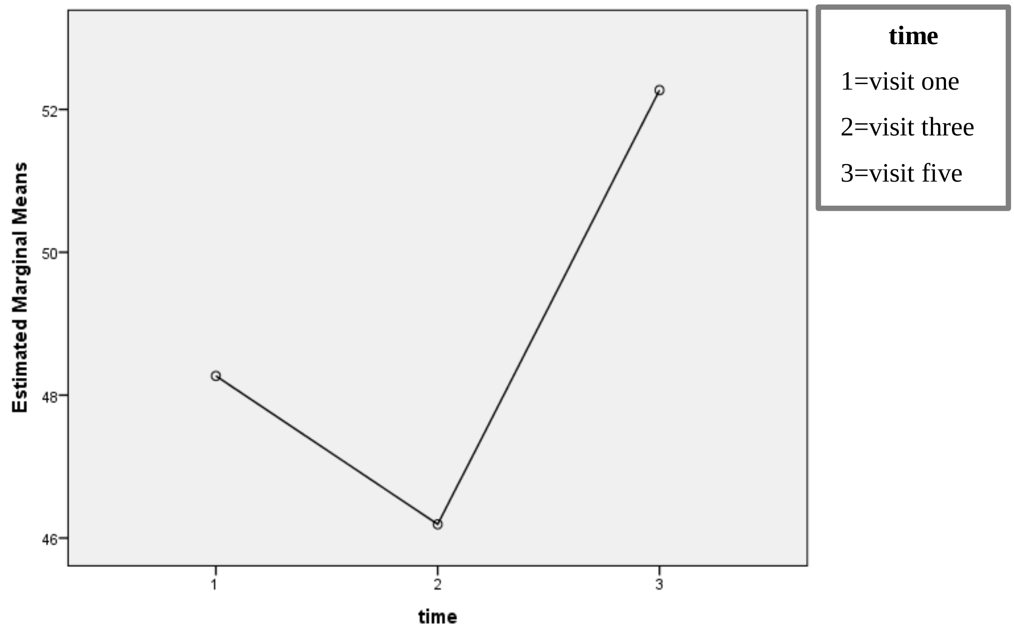


Figure 6: Profile plot of mean left lateral flexion over time of Group A

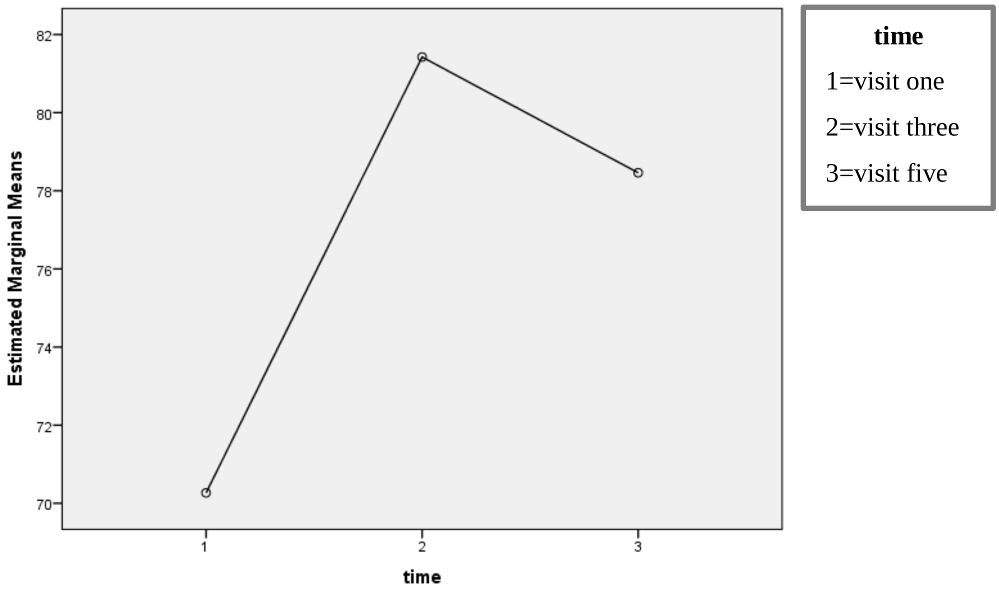


Figure 7: Profile plot of mean right rotation over time of Group A

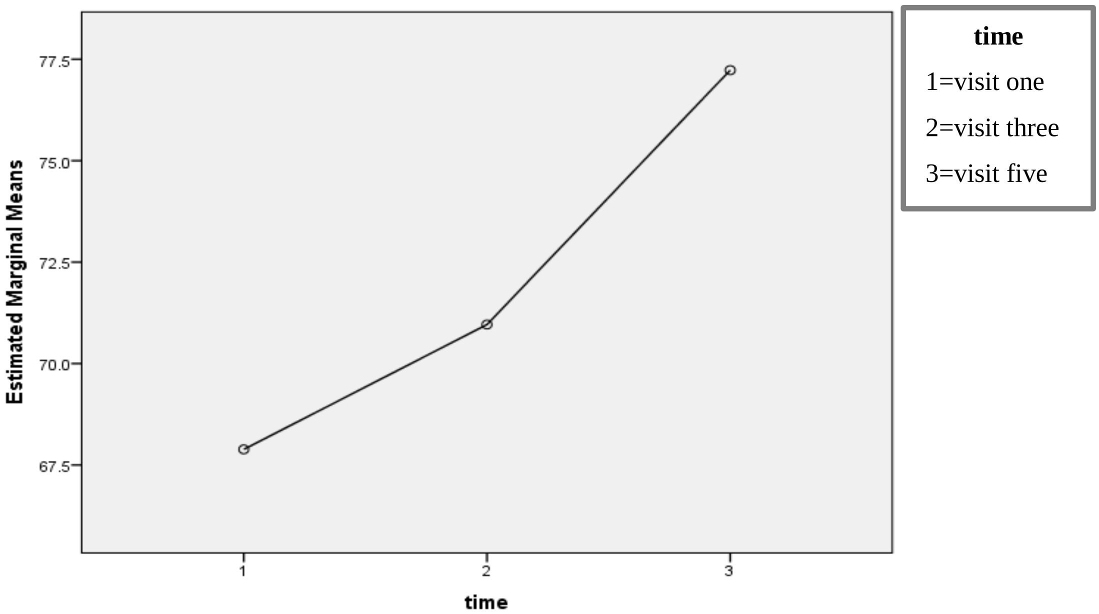


Figure 8: Profile plot of mean left rotation over time in Group A

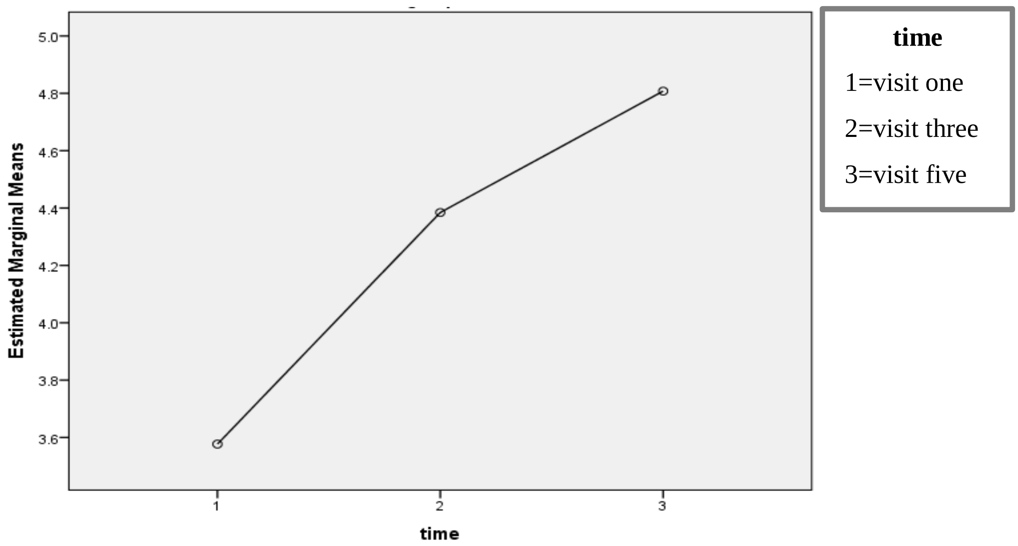


Figure 9: Profile plot of mean TP1 over time in Group A

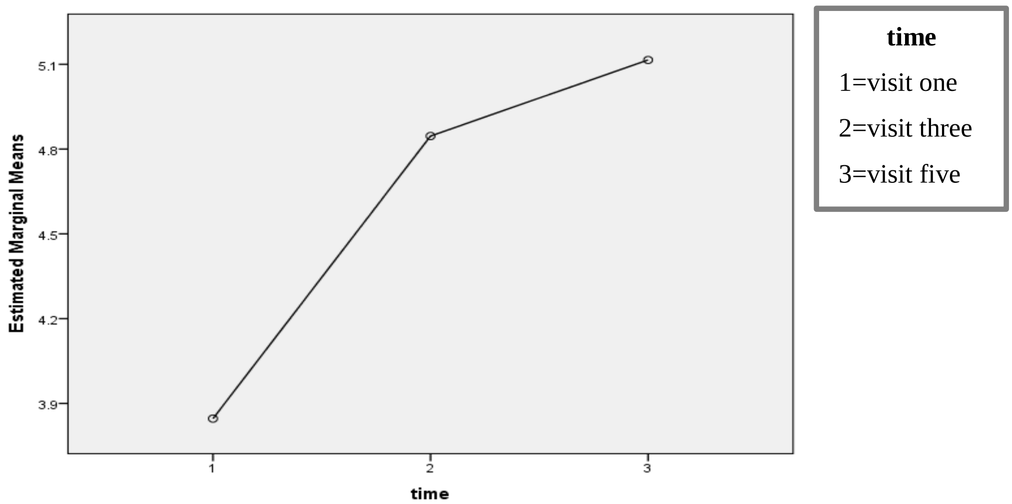


Figure 10: Profile plot of mean TP2 over time in Group A

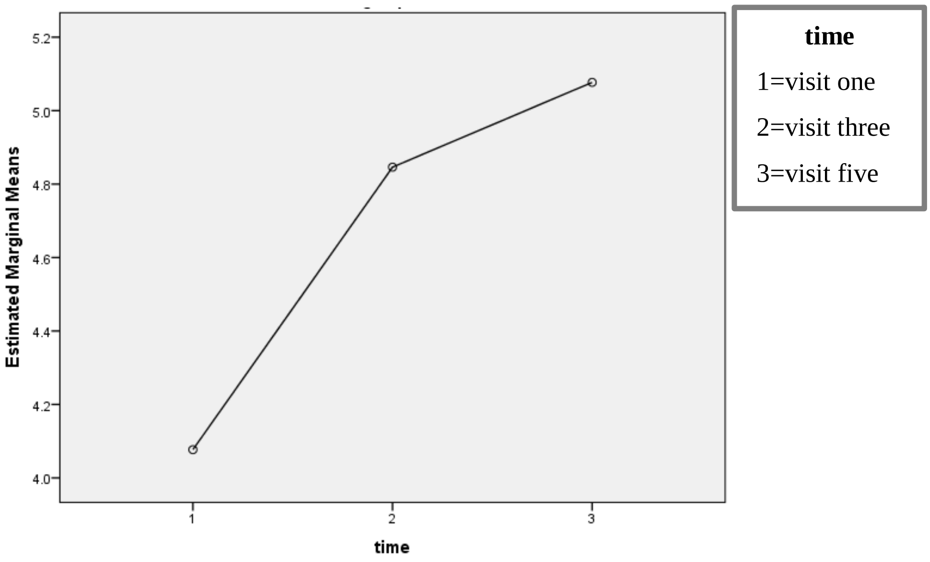


Figure 11: Profile plot of mean TP3 over time in Group A

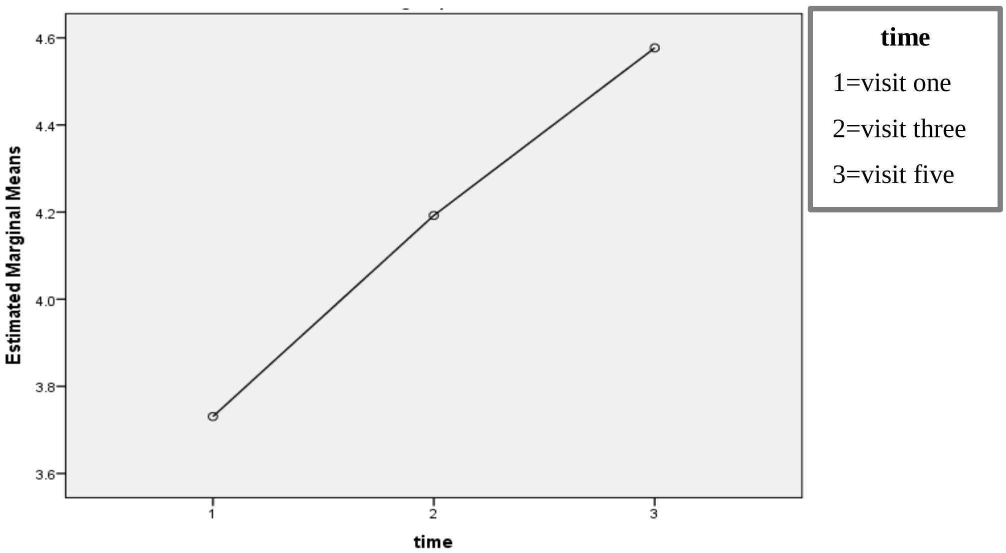


Figure 12: Profile plot of mean TP4 over time in Group A

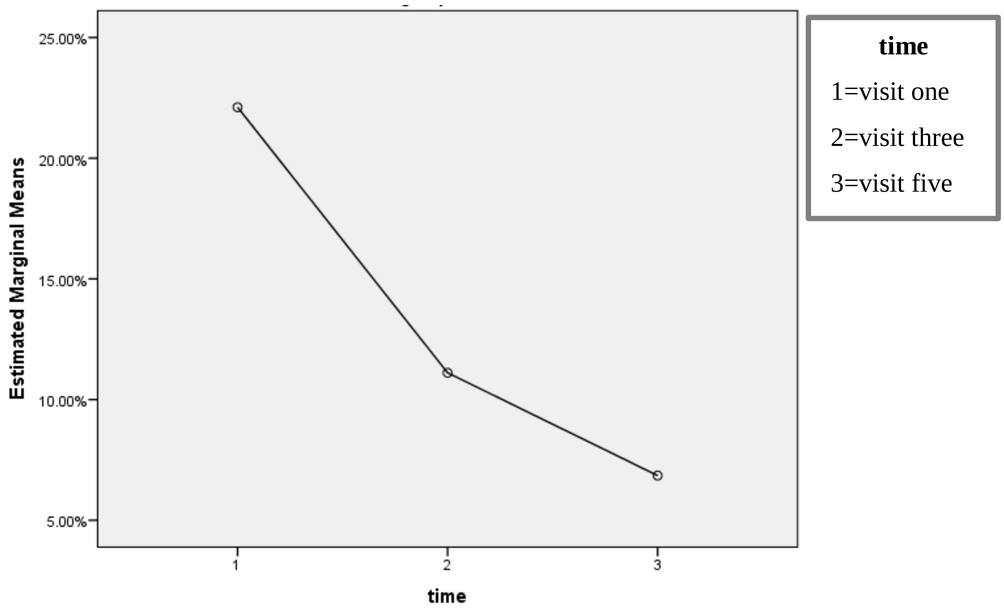


Figure 13: Profile plot of mean NDI over time in Group B

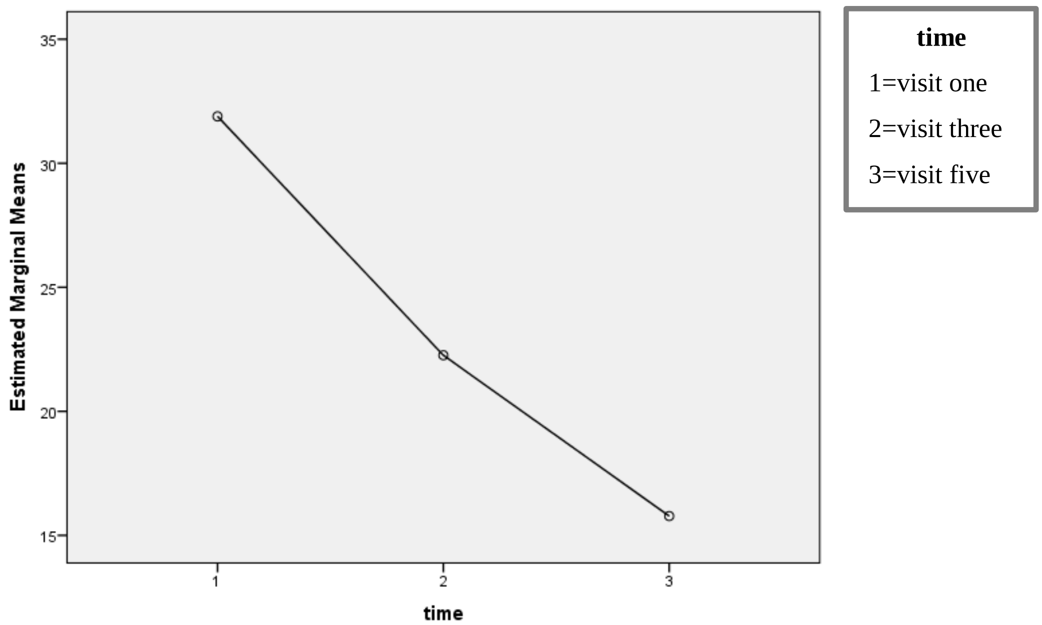


Figure 14: Profile plot of mean NRS-101 over time in Group B

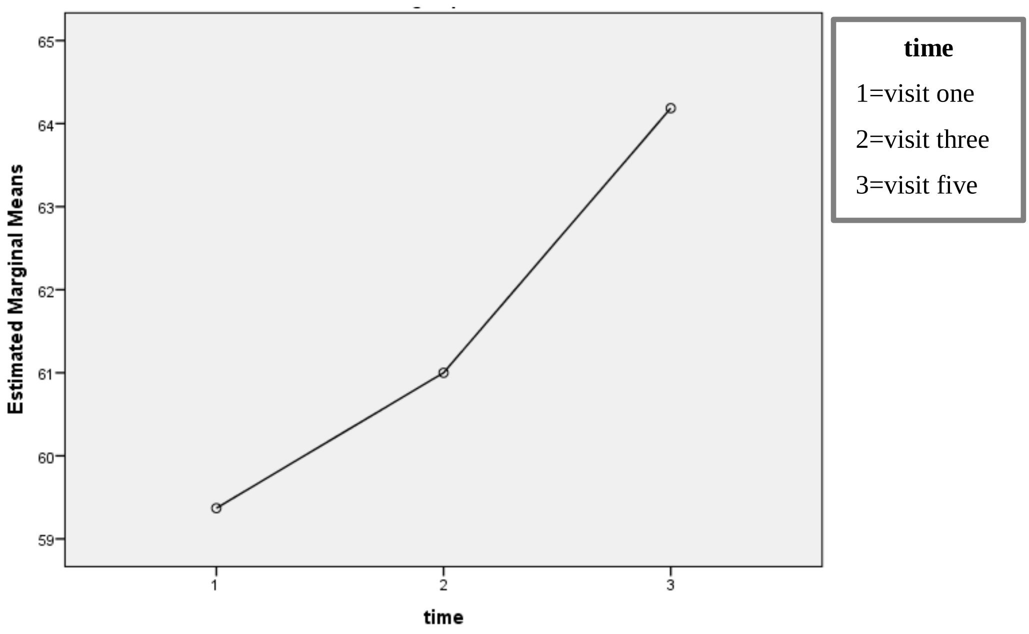


Figure 15: Profile plot of mean flexion over time in Group B

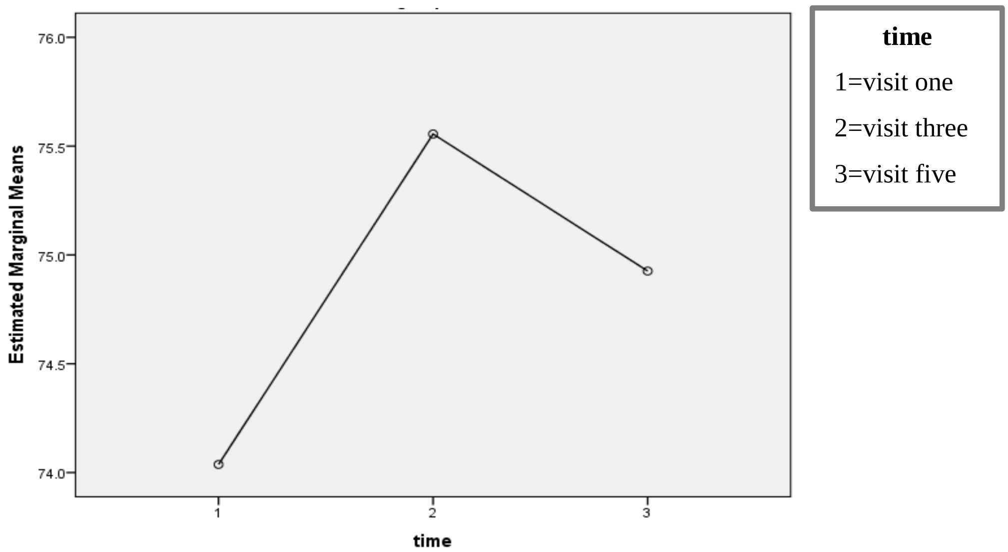
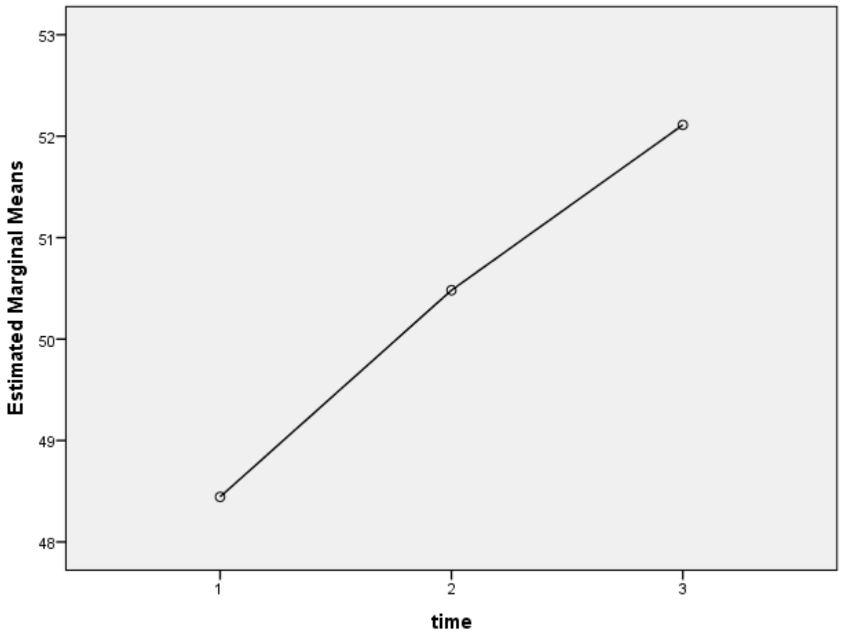


Figure 16: Profile plot of mean extension over time in Group B



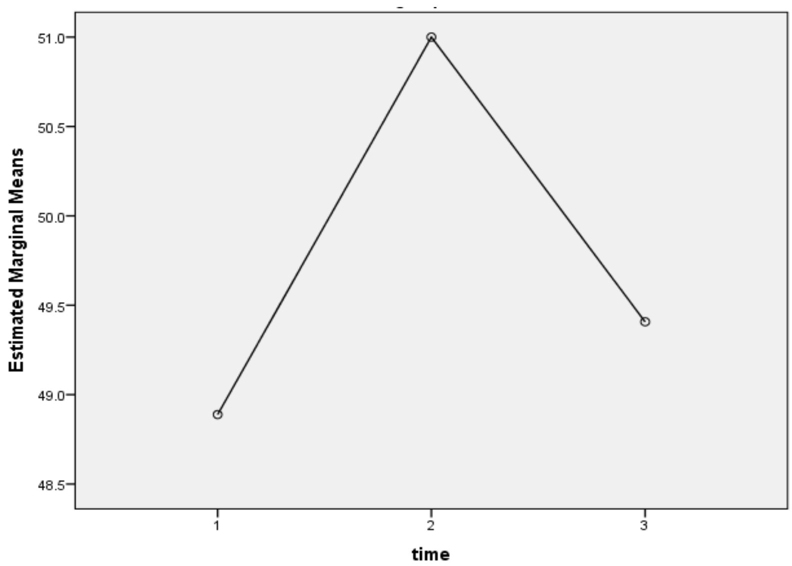
time

1=visit one

2=visit three

3=visit five

Figure 17: Profile plot of mean right lateral flexion over time in Group B



time

1=visit one

2=visit three

3=visit five

Figure 18: Profile plot of mean left lateral flexion over time in Group B

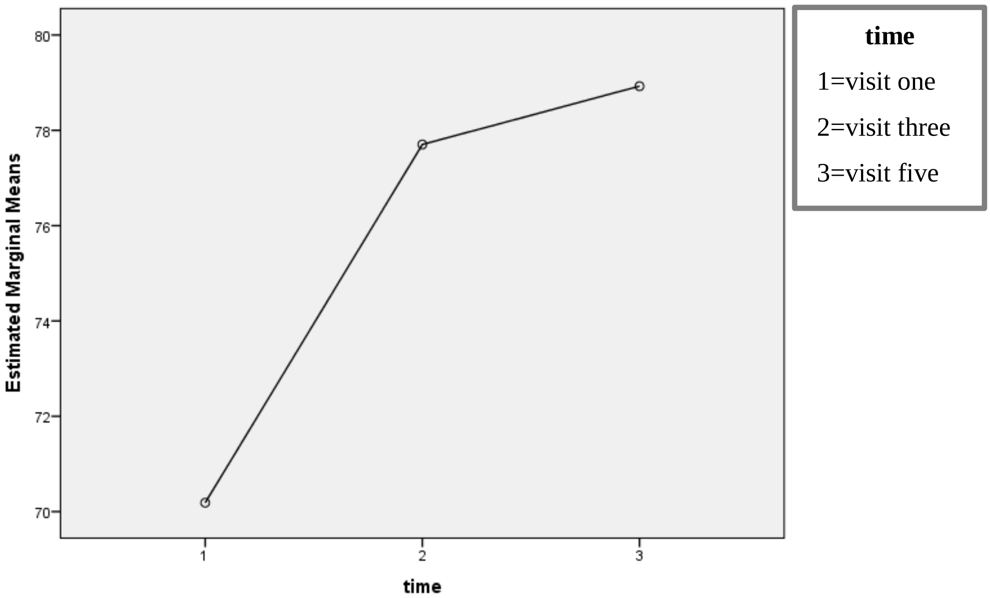


Figure 19: Profile plot of mean right rotation over time in Group B

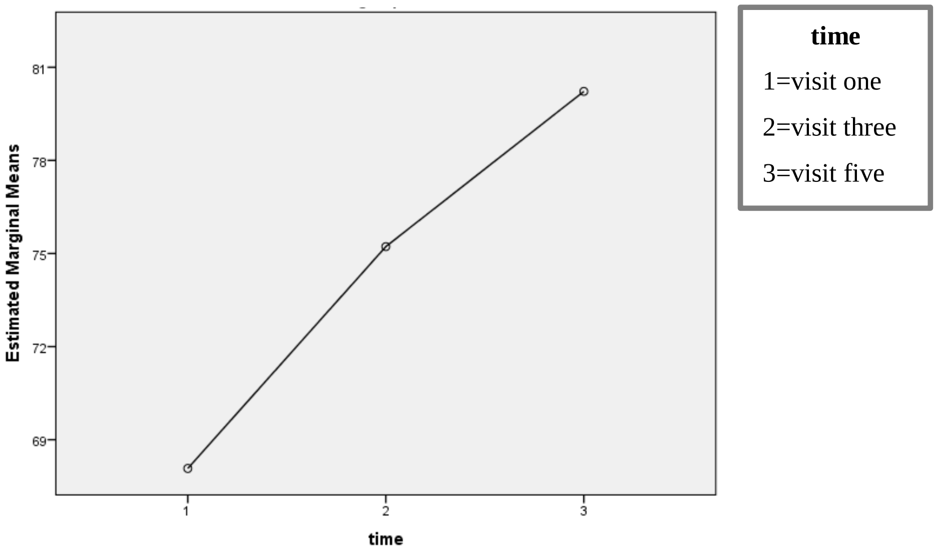


Figure 20: Profile plot of mean left rotation over time in Group B

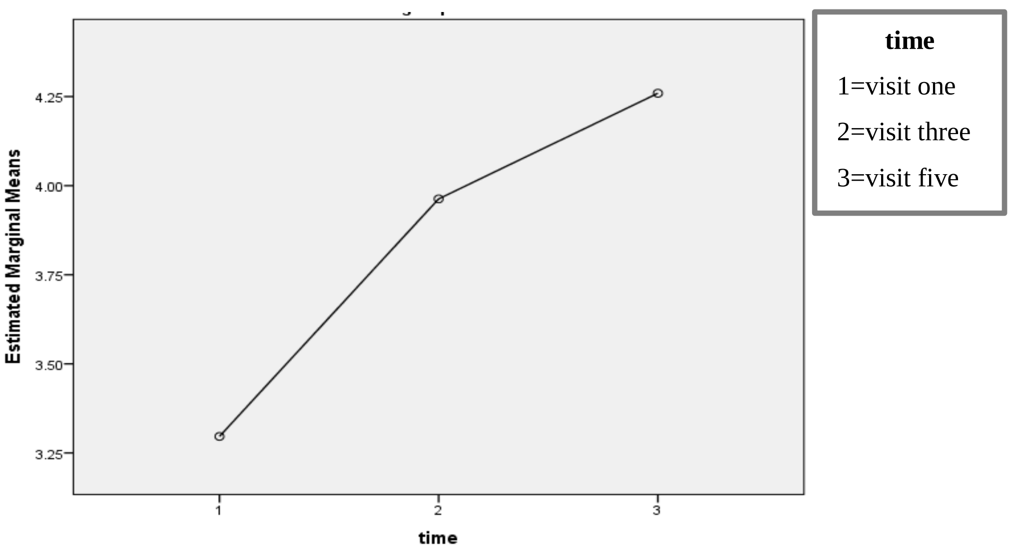


Figure 21: Profile plot of mean TP1 over time in Group B

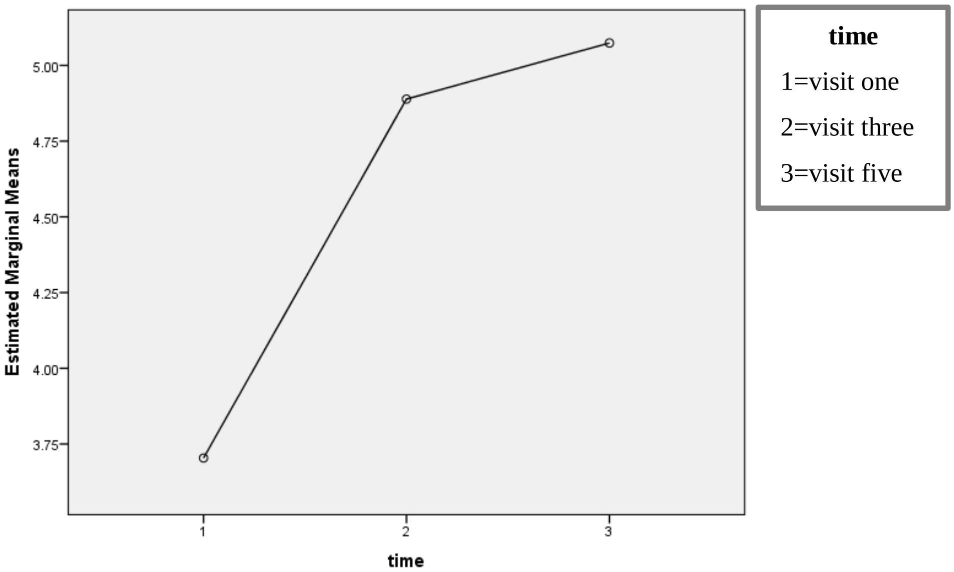
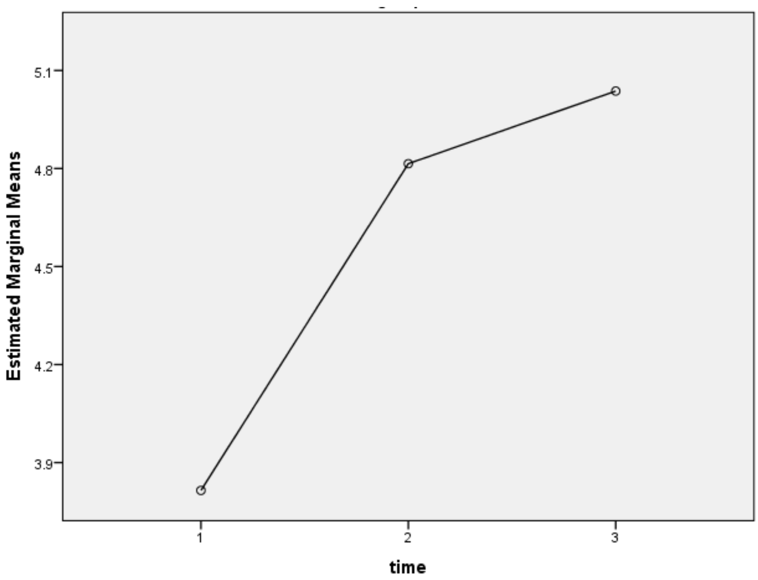
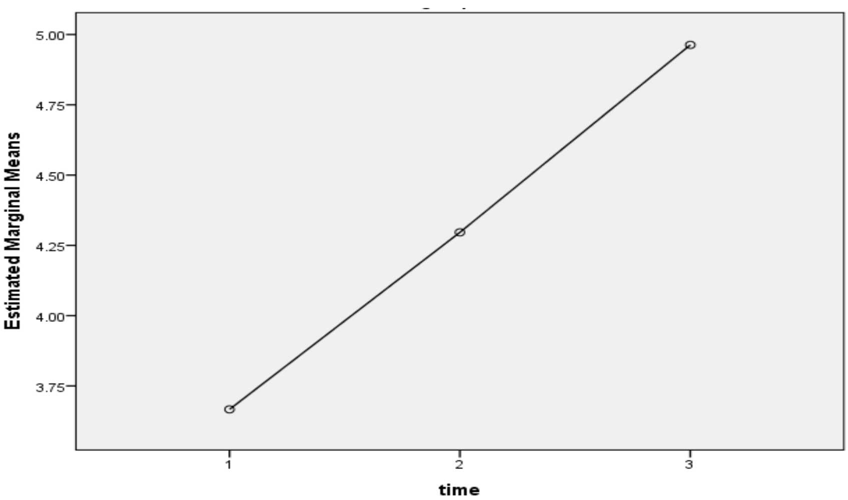


Figure 22: Profile plot of mean TP2 over time in Group B



time
1=visit one
2=visit three
3=visit five

Figure 23: Profile plot of mean TP3 over time in Group B



time
1=visit one
2=visit three
3=visit five

Figure 24: Profile plot of mean TP4 over time in Group B

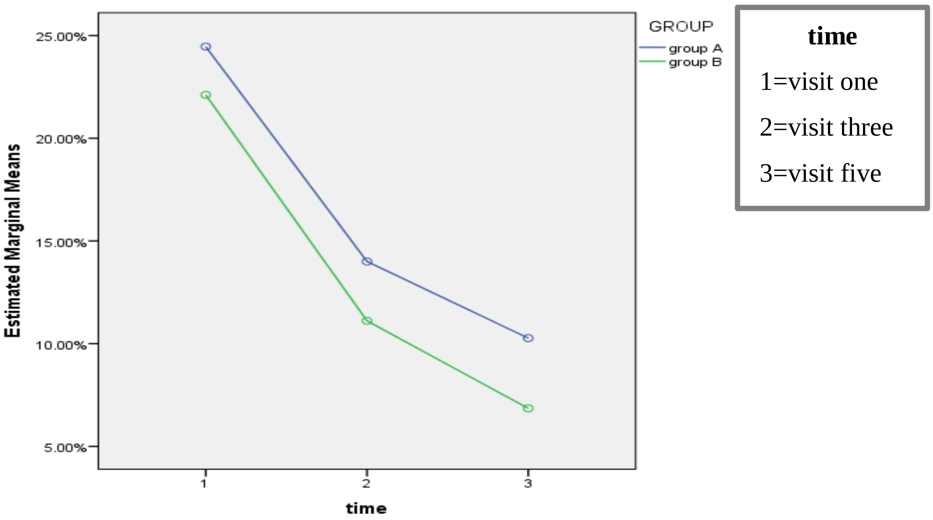


Figure 25: Profile plot of the mean NDI score by time and group

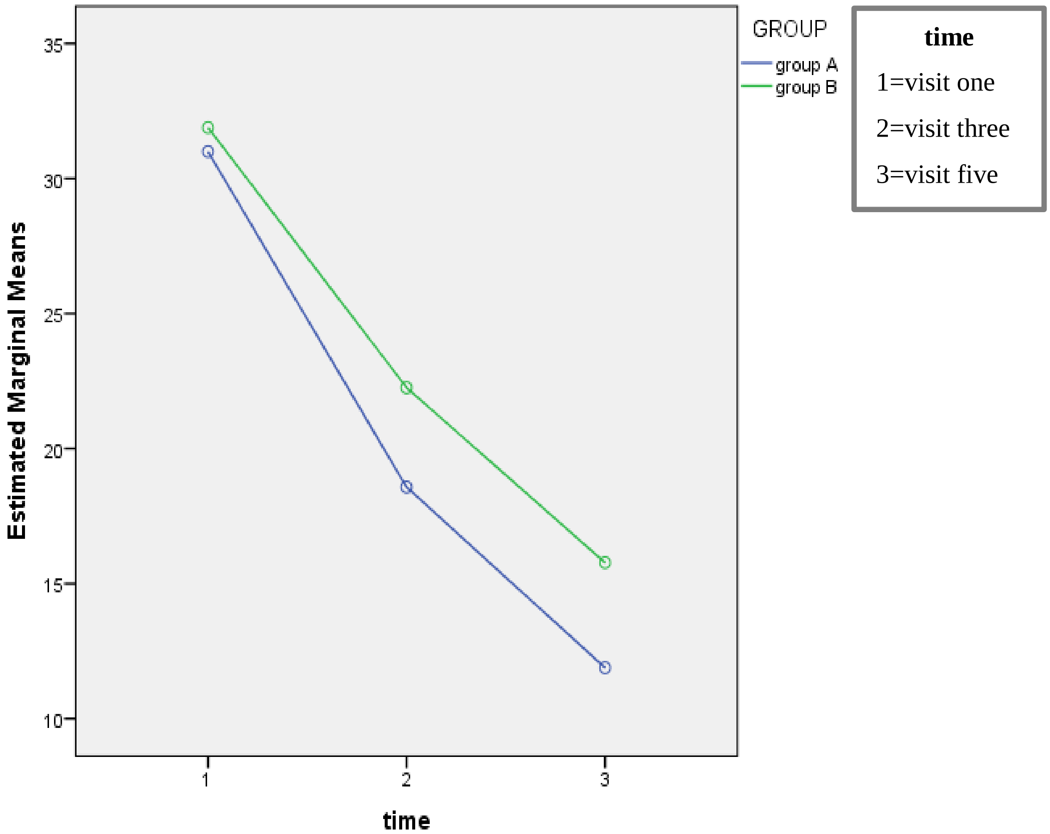


Figure 26: Profile plot of the mean NRS-101 by time and group

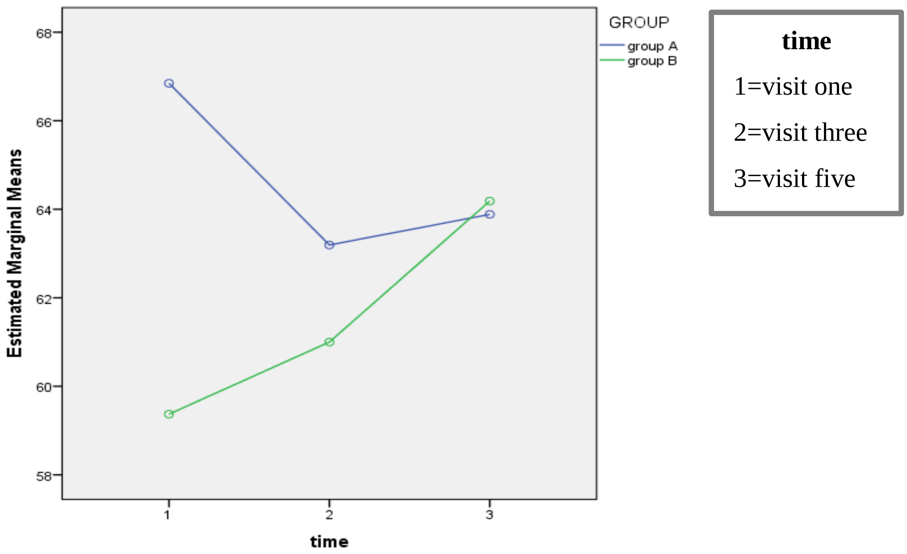


Figure 27: Profile plot of the mean flexion by time and group

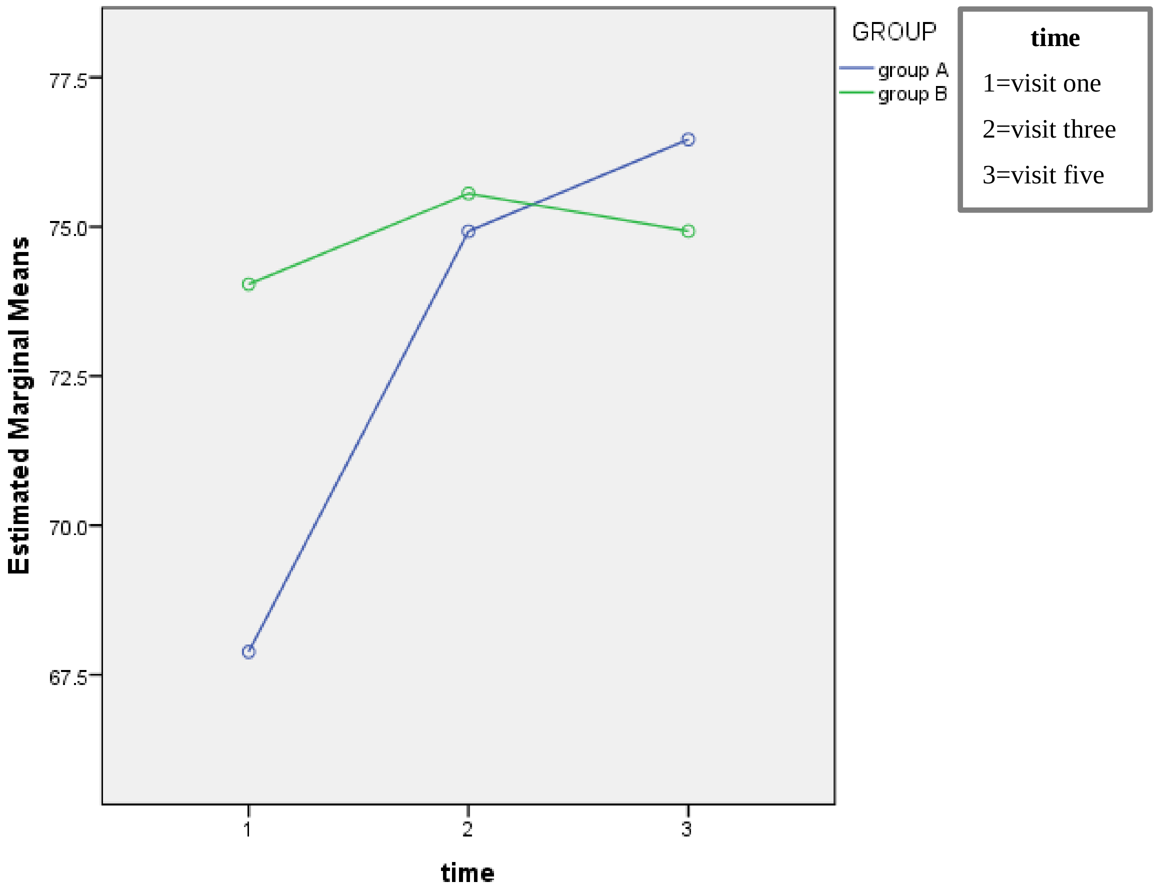


Figure 28: Profile plot of the mean extension by time and group

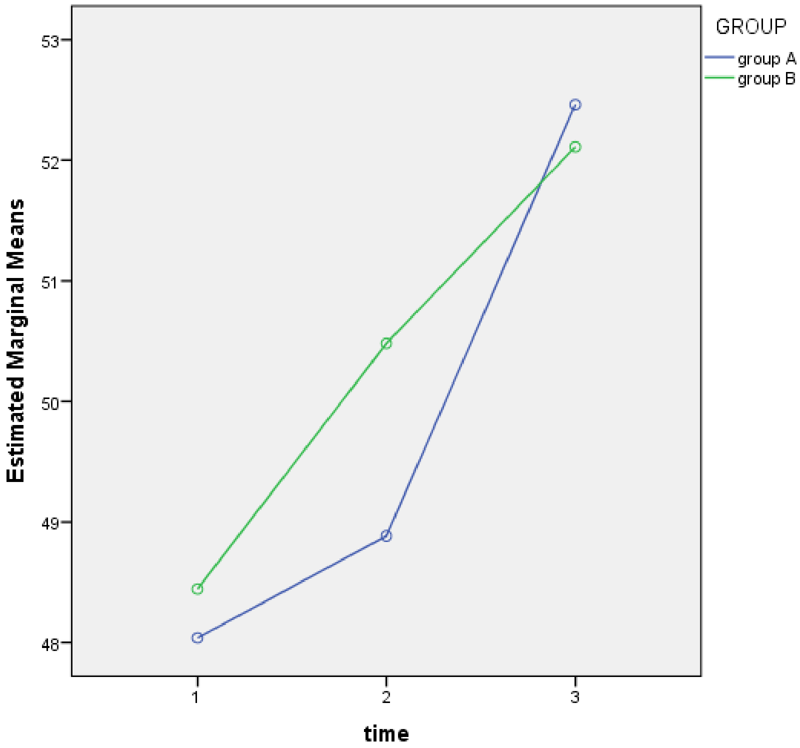


Figure 29: Profile plot of the mean right lateral flexion by time and group

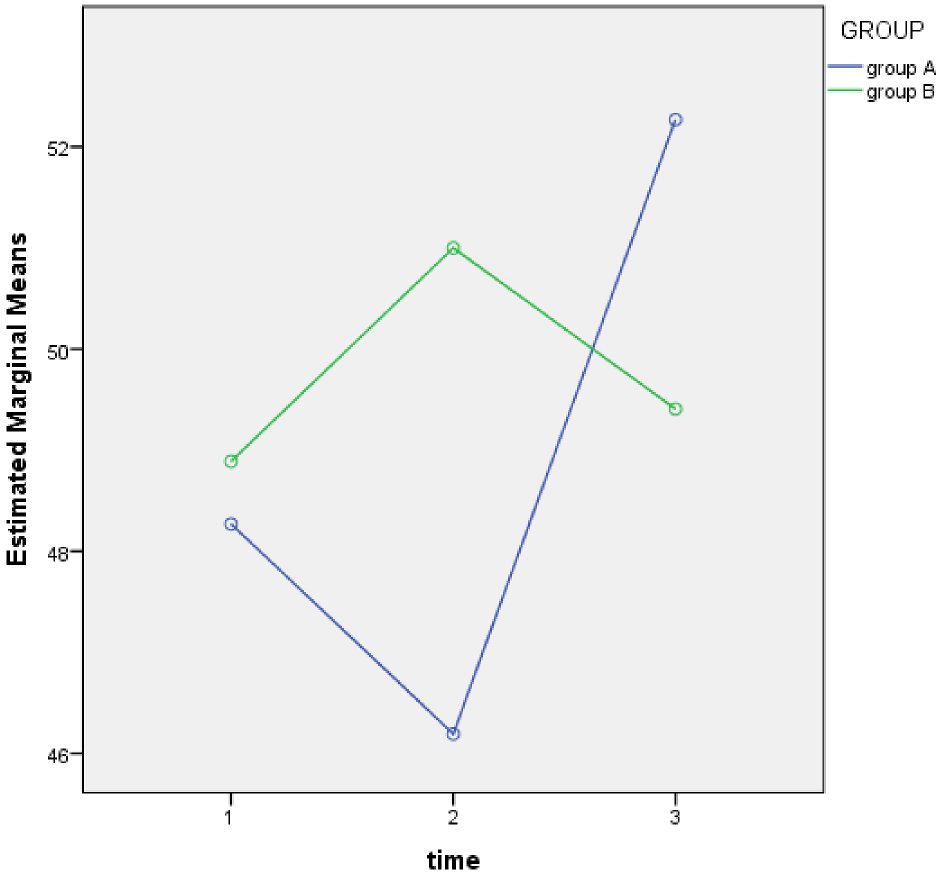
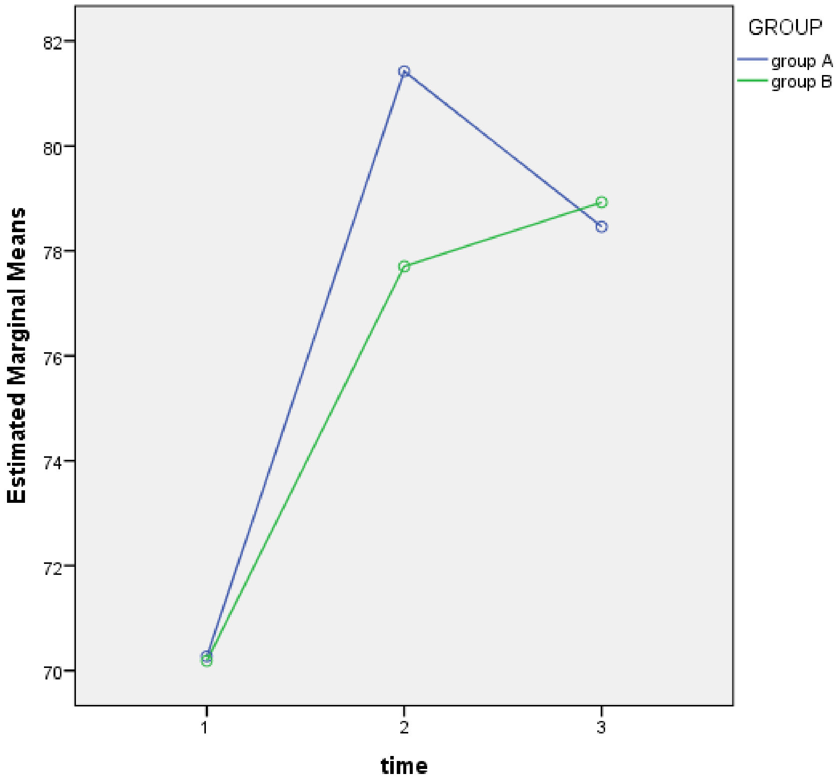


Figure 30: Profile plot of the mean left lateral flexion by time and group



time
1=visit one
2=visit three
3=visit five

Figure 31: Profile plot of the mean right rotation by time and group

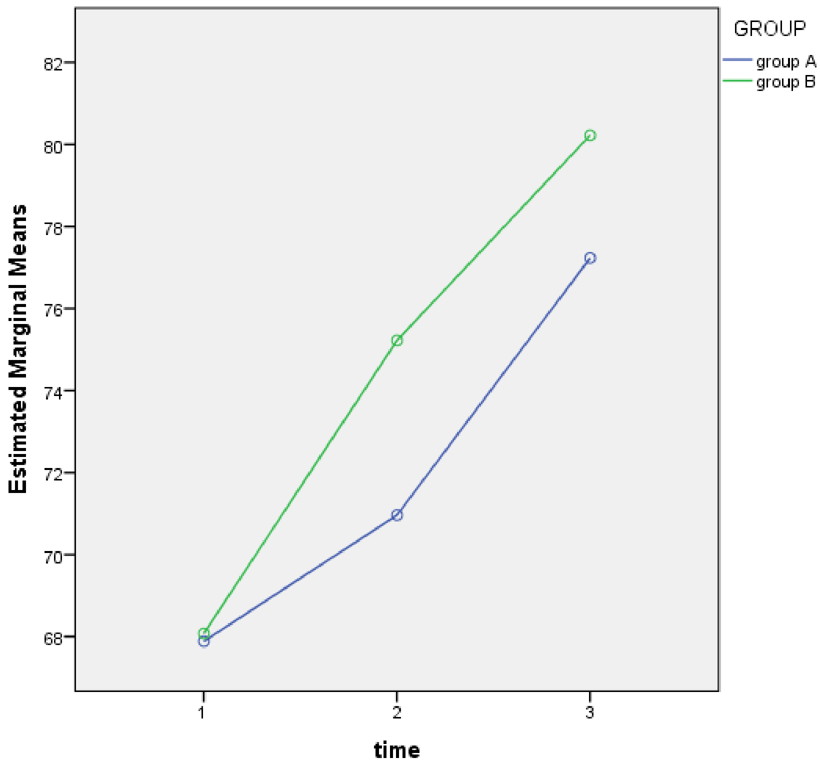


Figure 32: Profile plot of the mean left rotation by time and group

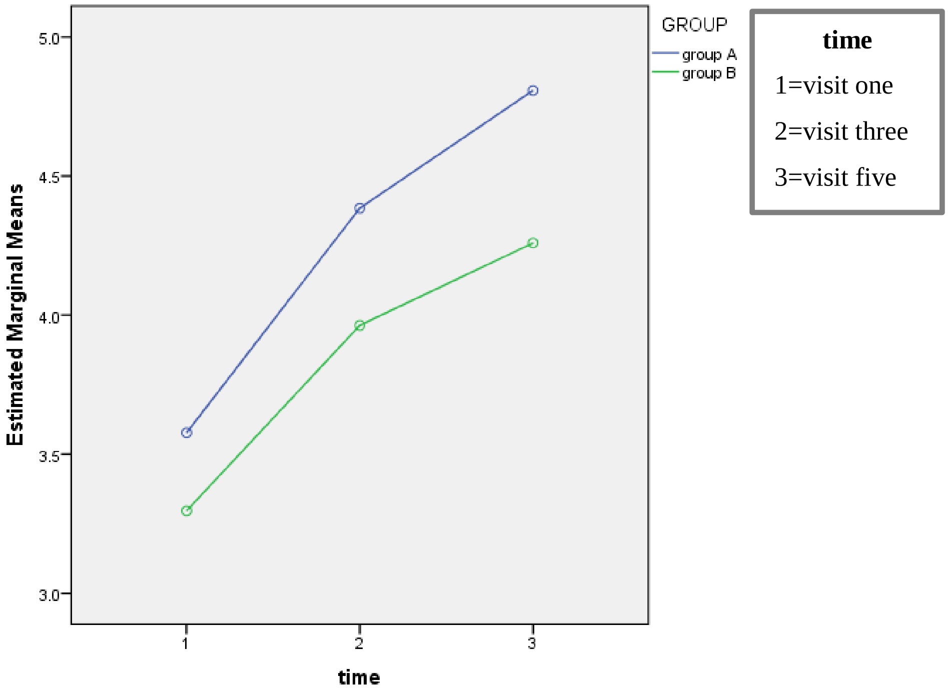


Figure 33: Profile plot of the mean Trigger point one by time and group

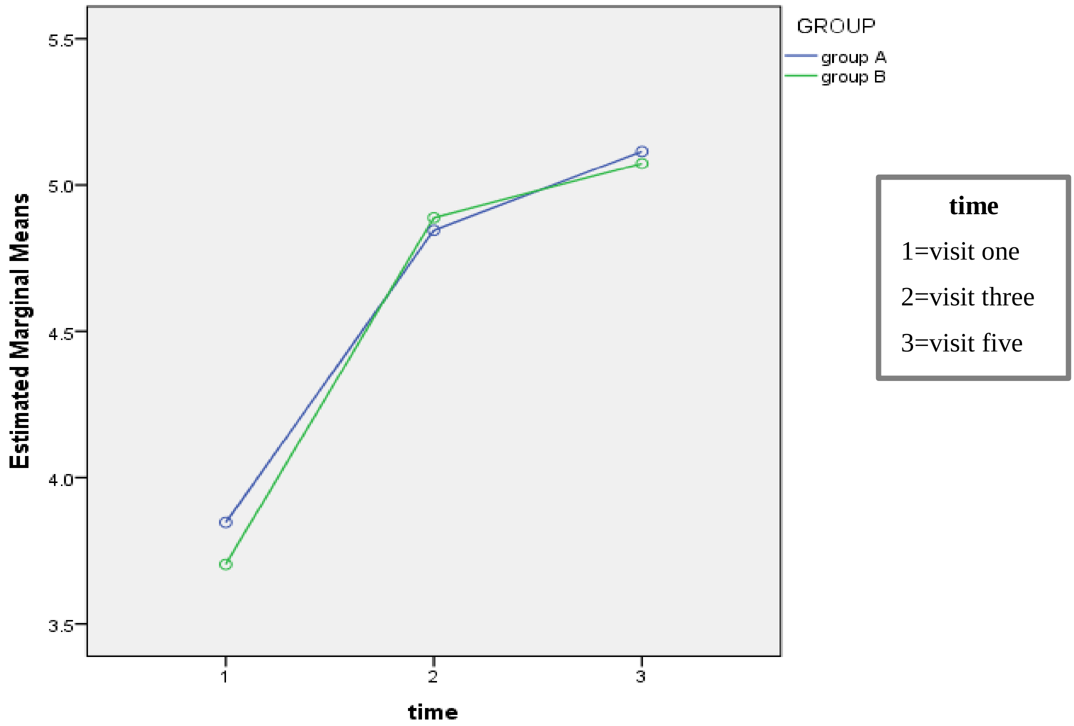


Figure 34: Profile plot of the mean trigger point two by time and group

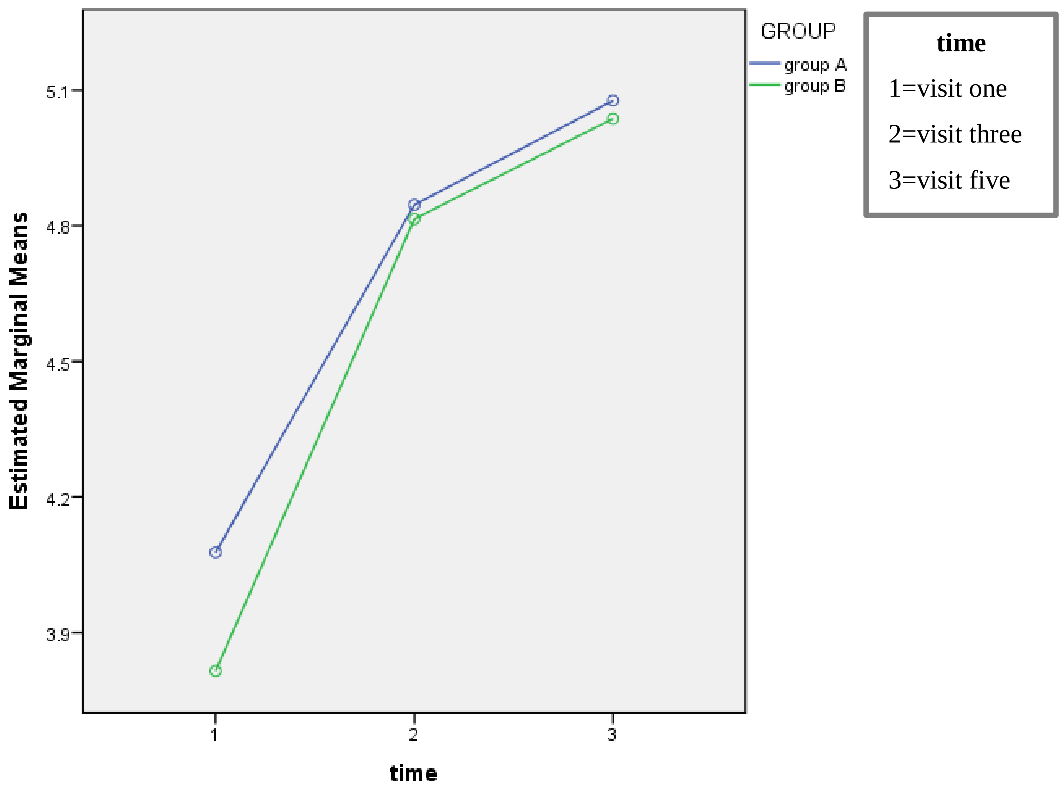


Figure 35: Profile plot of the mean trigger point three by time and group

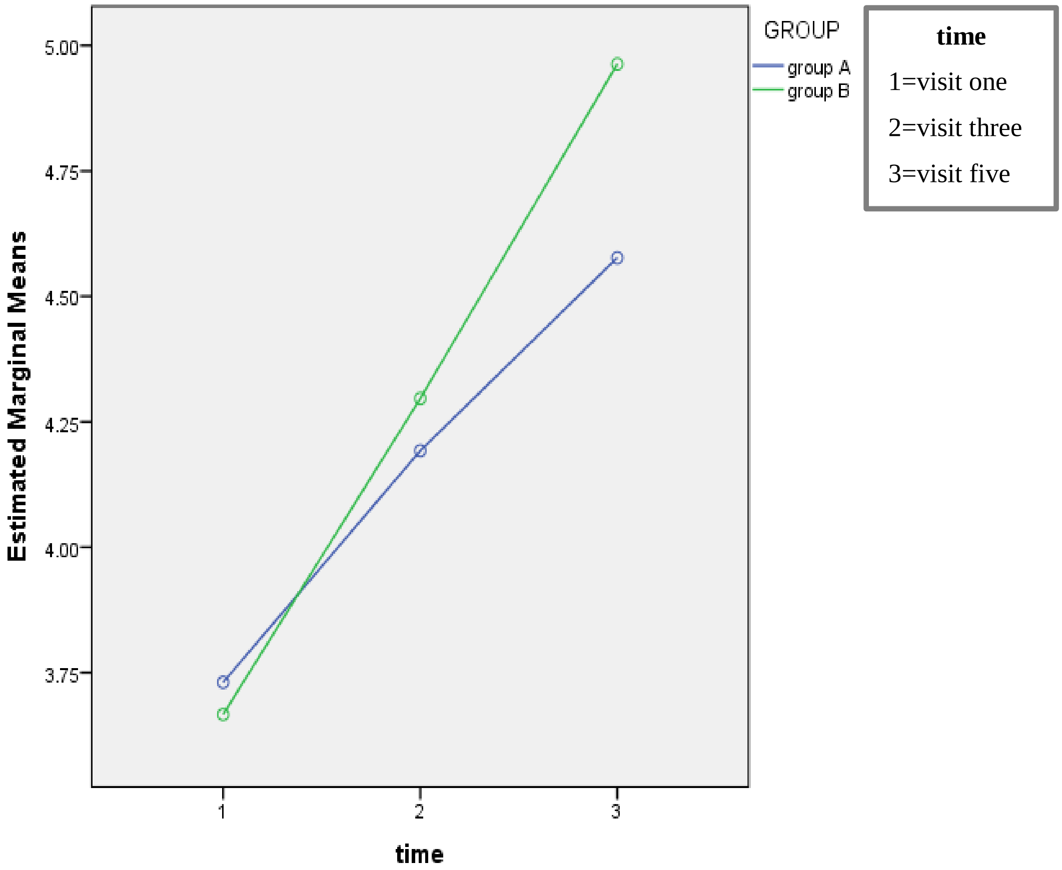


Figure 36: Profile plot of the mean trigger point four by time and group

APPENDIX Q

TABLES SHOWING THE TREATMENT EFFECTS WITHIN AND BETWEEN THE GROUPS WITH REFENCE TO CHAPTER FOUR

Table 1: Treatment effects within and between the groups for NDI

Effect	Statistic	*p* value
Time	Wilk's lambda=0.369	<0.001
Time x group	Wilk's lambda=0.997	0.928
Group	F=1.498	0.227

p **<0.05; repeated measures ANOVA**

Table 2: Treatment effects within and between the groups for NRS-101

Effect	Statistic	*p* value
Time	Wilk's lambda=0.242	<0.001
Time x group	Wilk's lambda=0.973	0.505
Group	F=1.435	0.237

p **<0.05; repeated measures ANOVA**

Table 3: Treatment effects within and between the groups for flexion

Effect	Statistic	*p* value
Time	Wilk's lambda=0.947	0.514
Time x group	Wilk's lambda=0.942	0.226
Group	F=1.83	0.182

p **<0.05; repeated measures ANOVA**

Table 4: Treatment effects within and between the groups for extension

Effect	Statistic	*p* value
Time	Wilk's lambda=0.906	0.085
Time x group	Wilk's lambda=0.942	0.223
Group	F=0.166	0.685

p **<0.05; repeated measures ANOVA**

Table 5: Treatment effects within and between the groups for right lateral flexion

Effect	Statistic	*p* value
Time	Wilk's lambda=0.921	0.129
Time x group	Wilk's lambda=0.922	0.822
Group	F=0.059	0.808

***p* <0.05; repeated measures ANOVA**

Table 6: Treatment effects within and between the groups for left lateral flexion

Effect	Statistic	*p* value
Time	Wilk's lambda=0.924	0.137
Time x group	Wilk's lambda=0.836	0.011
Group	F=0.128	0.722

***p* <0.05; repeated measures ANOVA**

Table 7: Treatment effects within and between the groups for right rotation

Effect	Statistic	*p* value
Time	Wilk's lambda=0.732	<0.001
Time x group	Wilk's lambda=0.961	0.372
Group	F=0.140	0.710

***p* <0.05; repeated measures ANOVA**

Table 8: Treatment effects within and between the groups for left rotation

Effect	Statistic	*p* value
Time	Wilk's lambda=0.752	0.001
Time x group	Wilk's lambda=0.977	0.556
Group	F=0.515	0.476

***p* <0.05; repeated measures ANOVA**

Table 9: Treatment effects within and between the groups for trigger point one.

Effect	Statistic	*p* value
Time	Wilk's lambda=0.602	<0.001
Time x group	Wilk's lambda=0.911	0.792
Group	F=0.513	0.477

p **<0.05; repeated measures ANOVA**

Table 10: Treatment effects within and between the groups for trigger point two

Effect	Statistic	*p* value
Time	Wilk's lambda=0.602	<0.001
Time x group	Wilk's lambda=0.911	0.792
Group	F=0.513	0.477

p **<0.05; repeated measures ANOVA**

Table 11: Treatment effects within and between the groups for trigger point three.

Effect	Statistic	*p* value
Time	Wilk's lambda=0.667	<0.001
Time x group	Wilk's lambda=0.993	0.830
Group	F=0.046	0.831

p **<0.05; repeated measures ANOVA**

Table 12: Treatment effects within and between the groups for trigger point four

Effect	Statistic	*p* value
Time	Wilk's lambda=0.665	<0.001
Time x group	Wilk's lambda=0.978	0.571
Group	F=0.093	0.762

p **<0.05; repeated measures ANOVA**

Journal Abstract

Title: Muscle energy technique for symptomatic chronic mechanical neck pain: an assessor-blinded, randomized, controlled clinical trial.

Objective: To compare two contraction durations of muscle energy technique in the treatment of chronic mechanical neck pain.

Design: An assessor-blinded, randomized, controlled clinical trial.

Setting: Chiropractic Day Clinic at the Durban University of Technology.

Participants: After IRB approval, 53 participants diagnosed with chronic mechanical neck pain were randomly allocated into one of two groups, a 5-second Muscle energy technique (MET) group (*n*=26) and a 45-second MET group (*n*=27).

Method: Participants in each group received four treatments over a period of two weeks. The objective measures were point tenderness and cervical range of motion which were measured using the algometer and CROM Goniometer respectively. The subjective measures were pain and neck disability as measured by the NRS-101 and CMCC Neck disability index respectively. The subjective and objective measures were taken on the first and third visit (before treatment was administered) and at the final follow-up visit (fifth visit). Data were analysed using the SPSS version 20 (IBM), with a statistically significant *p*-value set at <0.05. Repeated measures ANOVA testing determined the intragroup effects, where time versus treatment group interaction analyses was conducted for intergroup analyses. Profile plots assessed direction and trend of the effect of the treatment.

Results: Intragroup analysis of both groups showed significant improvement in all outcome measures (over time) except for Flexion, Right Lateral Flexion and Left Rotation in Group A and Flexion, Extension, Right Lateral Flexion and Left Lateral Flexion in Group B. The results of the inter-group analysis revealed that only Left Lateral Flexion showed a significant treatment effect (*p*=0.011) where increased scores were shown in Group A and not in Group B.

Conclusion: Both treatment protocols were equally effective over time (2 weeks) and for all outcome measures except for Left Lateral Flexion where the five-second MET, which seemed to show a greater degree of improvement than the 45-second MET. This therefore seems to support the use of

the shorter duration MET in clinical practice. A follow on study with a larger sample size should be conducted to verify the results of this study.

Key Words: neck pain, muscle contraction, neck muscles, therapeutics, intervention study, Muscle Energy Technique.

Article

Introduction

Neck pain (NP) has fast become a common problem and has a worldwide impact on an individual's daily activities, quality of life and productivity. As such, it is perceived as a healthcare challenge within the medical community. [1] In the general population studies have shown there to be an overall prevalence in NP ranging between 0.4% and 86.8 %.[2, 3] NP and its sequelae are associated with a substantial amount of disability in the general population. [4] Such NP disability forms an integral source of burden to society in that it has both a personal and economic impact. [1]

NP can be of an acute or chronic nature. [5] Chronic NP may be considered when the patient experiences NP for a period of six weeks or longer whereas acute NP may be defined as NP for a period of less than six weeks. [5] Mechanical neck pain (MNP) is a non-pathological type of NP and is of a multidimensional nature. [6] There appears to be wide variability in defining NP which may be attributed to physical and psychosocial contributing factors.[2, 7] In the context of this research, NP of mechanical origin has been described as any event or condition which lead to changes in the structure and functioning of a muscle as well as changes in the mechanics of the joint of patients. [8]

The aim of treating patients with MNP is to reduce NP and to restore normal range of motion of the cervical spine.[9] There are various conservative treatment options available in chiropractic practice for the treatment of chronic mechanical neck pain (CMNP).[3] Treatment options may include physical therapies and manual therapies. The physical therapies include: cryotherapy, electro-modalities, heat therapy, dry needling and acupuncture. [3, 10] By contrast, manual therapies may include: manipulation, mobilization and manual traction. [3, 10, 11] MET is included in the manual group of therapies and can be used when manipulation is contra-indicated.[14] Treatment using MET involves the voluntary contraction of a patient's muscle against a counter-force applied by the manual therapist.[12] When applied to the neck, MET causes the muscle to pull on its attachment to the bone, thus moving one vertebra in relation to its articulating counterpart. This technique is known to restore normal joint range of motion and decrease pain. [13, 14]

Several authors have demonstrated that MET does increase the ROM within the cervical spine[15- 20] and can also be effective in bringing about pain relief. [14, 15, 16, 19, 21] Although MET is shown to be an effective treatment in the management of CMNP, [14,16,17,19] the most suitable contraction time of MET remains an area of debate. Some authors recommend that a longer contraction duration (30-60 seconds)[17,22,23] is required when applying MET whilst other authors suggest that a shorter contraction duration (3-7 seconds) [12,14,20,24,25,] of MET is more effective in increasing cervical range of motion and decreasing neck pain. This study aimed to determine which contraction duration (5-second or 45-second) of MET was more effective in increasing cervical range of motion and decreasing CMNP and neck disability.

Methods

Study design

The design of the study was an assessor-blinded, randomized controlled, clinical trial.

Participants

Ethical clearance was obtained from the Institutional Research Ethics Committee (IREC) at the Durban University of Technology and an ethics clearance certificate was issued (IREC 032/12). Participants were included into the study if they were between the ages of 18-40 years and experienced unilateral or bilateral persistent NP [26] for a period of six weeks or longer [5] The NP had to be mechanical in origin and with no other clinical condition being the source of the participant's pain. [17, 27] Participants also had to have at least one joint dysfunction or restriction detected on motion palpation. [26]

Participants were excluded from the study if they presented with any contra-indications to MET application, recent surgery or significant trauma to the neck (having required surgery) in the past three months or had had any manual interventions for the NP in the three months prior to the study. [17, 28] Participants that were on medication such as anti-inflammatories and pain relief medication were required to undergo a "wash out" period of three days before they were included into the study. [29]

All prospective participants were given a letter of information and informed consent to read and sign (the latter if they agreed to participate in the study). They were also given the opportunity to ask any questions at that time. At the initial consult a complete case history, physical and cervical orthopaedic examinations were conducted. Once a diagnosis of CMNP was made, the 53 participants were randomly allocated to one of two groups via a computer generated randomization table (concealed allocation was utilised, as allocation was performed by an independent third party after participant inclusion had been determined).

The allocations resulted in Group A (*n*=26) [the 5-second MET] and Group B (*n*=27) [the 45-second MET], as outlined in Figure 1.

Outcome measures

All participants completed objective and subjective outcome measures at baseline.

- For the subjective measures the participants were asked to complete two questionnaires (viz. the CMCC Neck disability index (NDI) and the Numerical pain rating scale-101 (NRS-101)).
  The NRS-101 was used as previous studies have indicated that it has high sensitivity and can detect small changes. [30, 31] The NRS-101was used to demonstrate the percentage decrease or increase of the participants' subjective pain over time.
  The NDI has been shown to be highly reliable in "test-retest" reliability.[32] Additionally, there is a high degree of validity and internal consistency of the NDI. [32]
- For the objective measures the Cervical range of motion (CROM) Goniometer, which measured range of motion and the Algometer, which measured the point tenderness, were used.
- The CROM goniometer (manufactured by Performance Attained Associates Model: 3600 Labore Road, Suite 6, St Paul, MN 5511041144) is a reliable tool [33, 34] and is designed to measure all cervical ranges of motion (i.e. flexion, extension, lateral flexion and rotation). The Algometer (manufactured by Wagner instruments: P.O Box 1217, Greenwich T 06836) is a reliable measuring tool [35] and was used in this study to measure the pain threshold of the participants four most painful tender points (trigger points) in the neck.

All measures were taken by an independent, blinded assessor. Follow up outcome measures were taken at the third visit (prior to intervention) and at the fifth visit (last five).

Interventions

MET was administered to the participants by the researcher for four treatments over a period of two weeks. To achieve this, the researcher placed the affected joint into the desired position and then instructed the participant to contract against the unyielding force executed by the researcher. This contraction was an isometric contraction and in context of this study, caused the muscle to pull on its attachment to the vertebra, thus moving one vertebra in relation to its articulating counterpart. [14]

The participants in Group A were expected to maintain the contraction for five seconds, whereas the participants in Group B were expected to maintain the contraction for a period of 45 seconds and the procedure was repeated three times for each participant at each visit.

Statistical analysis

The data of this study was analysed using the SPSS version 20 (IBM). The statistically significant *p*-value was noted as <0.05. The statistical analysis comprised of an analysis of the intra and inter-groups. Repeated measures ANOVA testing was used to examine the effect on each outcome measure separately, of time (three time points: first, third and fifth visits) in the case of intra-group analyses. To assess the effects of the intervention (five-second MET and 45-second MET) a time versus treatment group interaction in the case of the inter-group analyses was conducted. Profile plots were generated in order to assess direction and trend of the effect of the treatment.

Results

The results of the intra-group analysis of Group A revealed that the NDI and NRS-101 scores both showed a significant decrease from the first to the fifth follow-up visits (Table 1) following the treatment of the participants with the five-second MET. Concurrently, the tenderness readings also showed a significant increase in the readings from the first follow-up visit to the fifth follow-up visit (Table 2). These results suggest that the NP and neck disability levels of the participants had decreased over time. Table 2 also reveals that the cervical ranges of motion revealed a significant improvement over time in all directions except for Flexion, Right lateral flexion and Left rotation.

Table 1 shows that the intra-group analysis for Group B revealed a significant improvement in the NDI and NRS-101 scores over time. Table 2 revealed a significant improvement over time for the algometer scores and the CROM readings except for Flexion, Extension, Right lateral flexion and Left lateral flexion.

The results of the inter-group analysis revealed that only Left lateral flexion showed a significant treatment effect (p=0.011) where overall increase in scores was shown in Group A while Group B did not change much from baseline values as seen in Figure 2. It can, therefore, be concluded that this study demonstrated that both treatment protocols are equally effective for all outcomes except for LLF where Group A seemed to show more improvement than Group B.

Table 1 displays the changes in the mean subjective measures over time for Group A and B. It can also be noted that both the NRS-101 and NDI have decreased to more than half from the mean scores seen at baseline to the fifth visit. The changes in these two outcome measures suggest that there was a decrease in the levels of NP and neck disability associated with the NP for one or both. Group A and Group B both displayed a statistically significant improvement for the NDI (p<0.001) and NRS-101 (p<0.001) scores. The minimally clinically important difference (MCID) of the NDI is between 10 points [36] and 10.5 points [37] and the MCID for the NRS-101 is 20mm, therefore there was no clinical significance for the NDI or the NRS-101 for Group A or Group B as both had less changes than the MCID.

In terms of the objective measures, Table 2 shows a significant increase in all the tenderness readings from the first visit to the fifth visit in both groups. The results of the tenderness readings for both groups showed no clinical significance for all the MFTPs as the mean scores for all these MFTPs were below the MCID of 1.5kg/cm [22, 38, 39, 40]

The CROM readings show a significant improvement in all ranges of motion except for Flexion, Right lateral flexion and Left rotation in Group A and Flexion, Extension, Right lateral flexion and Left lateral flexion. No MCIDs could be found for cervical range of motion with which to determine clinically significant improvement.

Discussion

From the results it can be seen that the pain levels experienced by the participants had decreased as they had less tenderness as measured with the use of the algometer. The changes in the tenderness readings, indicating a decrease in pain, concurs with the decrease in the NDI findings and the NRS-101 findings suggesting a large proportion of the pain that participants' experienced in their neck seemed to stem from a muscular component of their neck pain.

It is not uncommon to find these results as they are comparable to the literature which states that a decrease in NP will result in an increase in the ability to carry out activities or an improvement in function. [36] A decrease in pain may be attributed to the stimulation of trans-synovial flow within the capsule of the zygapophyseal joint. Movement of this joint, which is brought about by the application of MET, may produce fluctuations in the intra-synovial pressure within the joint capsule. This subsequently results in the flow of trans-synovial fluid out of the joint therefore resulting in a decrease in effusion. This reduction in effusion results in a decrease in pain and hence a decrease in the disability associated with the CMNP.[15, 17, 41]

In addition, the voluntary contraction used during the application of MET is an isometric contraction. [15, 17,] It is purported that the joint motion and the isometric muscle contraction during the application of MET brings about stimulation of the joint which activates the mechanoreceptors.[15] The Gate-Control theory may possibly provide an explanation for the pain relief. [15, 42] This theory suggests that mechanoreceptor signals are carried through large diameter axons, their aim being to inhibit nociceptive signals at the dorsal horn of the spinal cord. This causes inhibition of pain. [15, 42] Furthermore, MET may result in inflammatory cytokine reduction and peripheral nociceptor desensitization and hence bring about pain relief. [17, 41]

The only movement that displayed a significant difference was LLF (p=0.011), where Group A showed a greater improvement than Group B for LLF. When looking more closely at the LLF, Group B revealed an increase in LLF from visit one to three but then decreased by the fifth visit whereas Group A decreased from visit one to three but then increased exponentially by the fifth visit (Figure 2). A possible reason for this finding may be that the occupation statistics revealed that students formed the highest percentage of the ‘occupation’ demographic in Group B. The posture employed by students is one in which the head is in the forward flexed; left lateral flexion (right handedness) and rotated to the right.[43,44,45] This means that the left lateral flexors were potentially shorter, weaker and stiffer at the onset of the study. The left lateral flexor muscles may not have been sufficiently treated as MET was only applied to the joint dysfunctions found and no exercise was given to the participants between treatment sessions, therefore not remedying the weakness within the musculature. This would have maintained learned and abnormal muscle firing patterns and recruitment ratios, predisposing to decreased long term improvement. This latter discussion is however conjecture and requires further investigation.

In terms of the overall outcomes for the two groups in this study, very few studies have investigated the effects of contraction duration of MET on the range of motion and pain in CMNP. The current study may be comparable to a comparative study on the influence of contraction duration of MET on the atlanto-axial joint in asymptomatic people. In that study 52 asymptomatic subjects were randomly allocated into one of the following three treatment groups: a control group (n=17), a five-second MET group (n=17) and a 20-second MET group (n=18).The results of the study showed that the application of the five-second MET was most effective in increasing the active range of rotation motion. The current study may only be comparable to that study for rotation range of motion as that study was conducted on asymptomatic people. [18]

MET did bring about an increase in the range of motion of the neck in both Groups. It is hypothesized that hypertonic muscles of the neck as well as joint locking may decrease range of motion within the cervical spine and that lengthening of these muscles may increase the overall physiologic range of motion within the cervical spine. [46]

Conclusion

It can be concluded that MET may be used as a safe alternative in instances where manipulation is contra-indicated. The five-second MET displayed a significant improvement for all subjective and objective measures. It was also more comfortable for the participant as well as the researcher to maintain the five-second contraction. The five-second MET cuts down the treatment session and could be used effectively in a busy chiropractic practice.

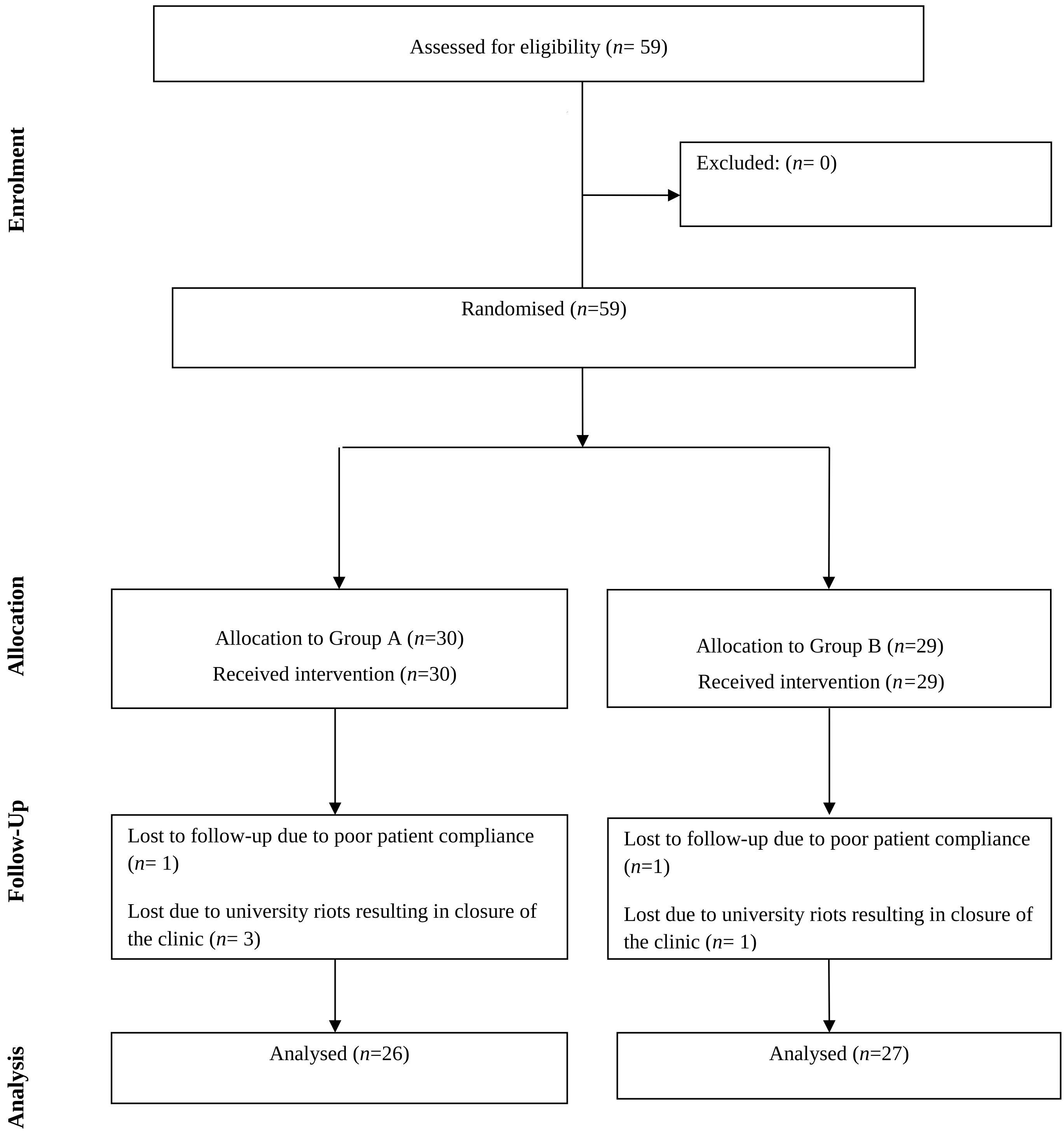


FIGURE 1: The Progress through the Randomized Clinical Trial of Group A and Group B

Table 1: The mean NDI and NRS-101 scores for Group A and Group B for each visit

	GROUP A			GROUP B		
	VISIT 1	VISIT 3	VISIT 5	VISIT 1	VISIT 3	VISIT 5
NDI	24%	14%	10%	22%	11%	7%
NRS-101	30.97	18.58	11.84	31.89	22.26	15.83

Table 2: A summary of the mean objective measures in Group A and Group B for each visit

		GROUP A			GROUP B		
		VISIT 1	VISIT 3	VISIT 5	VISIT 1	VISIT 3	VISIT 5
CROM Goniometer	**F**	67	63	64	59	61	64
	E	68	75	76	74	76	75
	RLF	48	49	52	48	50	52
	LLF	48	46	52	49	51	49
	RR	70	81	78	70	78	79
	LR	68	71	77	68	75	80
Algometer	**TP1**	3.59	4.4	4.86	3.25	3.9	4.23
	TP2	3.88	4.81	5.16	3.73	4.91	5.10
	TP3	3.99	4.87	5.2	3.76	4.76	5.06
	TP4	3.74	4.13	4.61	3.63	4.3	4.95

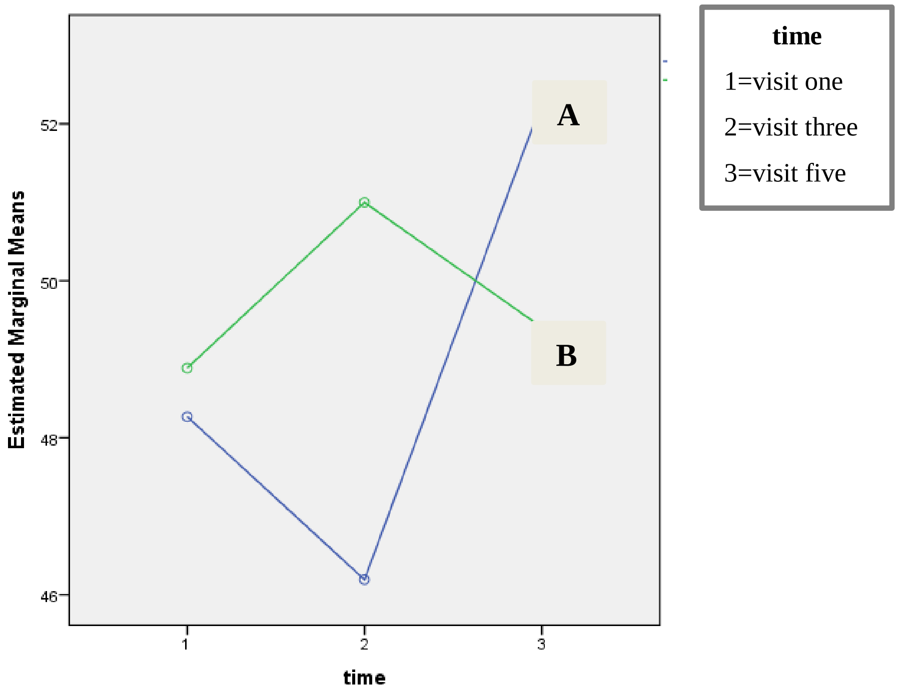


Figure 2: Profile plot of the mean left lateral flexion by time and group

References

1. Dennison, S.B. and Leal, M.H. Mechanical Neck Pain. In: Fernandez-de-las-Penas, C.F., Cleland, J.A. and Huijbregts, P. *Neck and arm pain syndromes: Evidence informed screening, diagnosis and management*. China: Elsevier Ltd, Churchill Livingstone; 2011
2. Hoy, D.G., Protani, M., De R, Buchbinder, R. *Best Practice and Research Clinical Rheumatology* 2010; 24(6): 783-792.
3. Haldeman, S., Caroll, L., Cassidy, D., Schubert, J., and Nygren, A. The Bone and Joint Decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders. *Spine* 2008; 33(45): 55-57.
4. Cote, P., Carroll, L., Cassidy, D. and Kristman, V. The Annual Incidence and Course of Neck Pain in the General Population: A Population-Based Cohort Study. *Pain* 2004 ; 112: 267-273.
5. Grieve, G.P. *Common Vertebral Joint Problems*. 2nd ed. Edinburg: Churchill Livingston, Longman Group Limited; 1988.
6. Jensen, I. and Harms-Ringdahl, K. Neck Pain. *Best Practice & Research Clinical Rheumatology* 2007; 21(1): 93-108.
7. Fejer, R., Kyvik, K.O. and Hartvigsen, J. The Prevalence of Neck Pain in The World Population: A Systemic Critical Review of the Literature. *European Spine Journal* 2006; 15: 834–848.
8. Bergmann, T.F., Peterson, D.H. and Lawrence, D.J. *Chiropractic Technique, Principles and Procedures.* New York: Churchill Livingston; 1993.
9. Martınez-Segura, R., Fernandez-de-las-Penas, C., Ruiz-Saez, M., Lopez-Jimenez, C and Rodrıguez-Blanco, C. Immediate Effects On Neck Pain And Active Range of Motion After A Single Cervical High-Velocity Low-Amplitude Manipulation In Subjects Presenting With Mechanical Neck Pain: A Randomized Controlled Trial. *Journal of Manipulative and Physiological Therapeutics* 2006; September: 511-517.
10. Rickards, L.D. The Effectiveness of Non-invasive Treatments for Active Myofascial Trigger Point Pain: A systematic review of the literature. *International Journal of Osteopathic Medicine* 2006; 9:120-136.
11. Hoving, J.L., Koes, B, W.,Van Der Windht, D., Mameran, H., Deville, W., Scholten, R. and Bouter, L. Manual Therapy, Physical Therapy or Continued Care by a General Practitioner for Patients with Neck Pain. *Annals of Internal Medicine* 2002; 136: 713-722.
12. Mitchell, F.L Jnr., Moran, P.S and Pruzzo N.A. *An evaluation and treatment manual of osteopathic muscle energy procedures*. Missouri: Mitchell, Moran and Pruzzo Associates; 1979.
13. Edwards, S.L. *Manipulation and Mobilization: Extremity and Spinal Techniques.* USA: Mosby; 1993.
14. Greenman, P. *Principles of Manual Medicine.*2nd edition. Baltimore: Williams and Wilkins; 1996.
15. Fryer. G. Muscle Energy Technique. In: Fernandez-de-las-Penas, C.F., Cleland, J.A. and Huijbregts, P. *Neck and arm pain syndromes: Evidence informed screening, diagnosis and management*. China: Elsevier Ltd, Churchill Livingstone; 2011.
16. Roodt, M.L.E. A Comparative Study of Three Different Types Of Manual Therapy Techniques in the Management of Chronic Mechanical Neck Pain. M.Tech, Durban University of Technology; 2009
17. Chaitow, L*Muscle Energy Techniques*. London: Churchill Livingston; 2006.
18. Fryer, G and Ruszkowski, W. The Influence of Contraction Duration in Muscle Energy Technique Applied to the Atlanto- Axial Joint. *Journal of Osteopathic Medicine* 2004; 7(2): 79-84.

19. Boodhoo, V. The Efficacy of Muscle Energy Technique in the Treatment of Chronic Mechanical Neck Pain. M. Tech, Durban University of Technology; 2002.
20. Schenk, R., Adelman, K. and Rousselle, J. The Effects of Muscle Energy Technique on Cervical Range of Motion. *Journal of Manual and Manipulative Therapy* 1994; 2(4): 149-155.
21. Schwerla, F., Bischoff, A., Nürnberger, A., Genter, P., Guillaume, J. and Resch, K..Osteopathic Treatment of Patients with Chronic Non-Specific Neck Pain: A Randomized Controlled Trial of Efficacy. *Research in Complementary Medicine* 2008*;* 15(3): 138-145.
22. Bandy, W.D. and Irion, J.M. The Effect of Time on Static Stretch on the Flexibility of Hamstring Muscles. *Physical Therapy Journal* 1994; 74(9)*: 54-58.*
23. Feland, B.J., Myrer, W.J., Schulthie, S.S., Fellingham, G.W. and Meason, W.G. The Effect of Duration of Stretching of the Hamstring Muscle Group for Increasing Range of Motion in People Aged 65 Years or Older. *Physical Therapy* 2001; 81(5): 1110-1117.
24. Ballantyne, F., Fryer, G. and McLaughlin. The Effect of Muscle Energy Technique On Extensibility: The Mechanism of Altered Flexibility Hamstring. *Journal of Osteopathic Medicine* 2003; 6(2): 59-63.
25. Lenehan, K.L., Fryer, G. and McLaughlin, P.. The Effect of Muscle Energy Technique on Gross Trunk Range of Motion. *Journal of Osteopathic Medicine* 2003*;* 5(1):13-18.
26. Plaugher, G.. Textbook of Clinical Chiropractic - A Specific Biomechanical Approach. Baltimore: Williams and Wilkins, 80-217; 1993.
27. Bergmann, T.F. and Peterson, D.H. . *Chiropractic Technique: Principles and Procedures*. 3rd ed. Missouri: Elsevier Mosby; 2011.
28. Michaleff, Z.A., Maher, C.G., Jull, G., Latimer, J., Connelly, L.B., Lin, C.C., Rebbeck, T. and Sterling, M. A Randomized Clinical Trial of a comprehensive exercise program for chronic whiplash: trial protocol. *BioMed-Central Musculoskeletal Disorders* 2009, 10 (149): 1-7.
29. Seth, S.D. *Textbook of Pharmacology.* 2ndedition. Edinburg: Churchill Livingston; 1999.
30. Frampton, C.L. and Hughes-Webb, P. The Measurement of Pain. *Clinical Oncology* 2011; 23: 381-386.
31. Misailidou, V., Malliou, P., Beneka, A., Karagiannidis, A. and Godolias, G. Assessment of patients with neck pain: a review of definitions, selection criteria, and measurement tools. *Journal of Chiropractic Medicine* 2010; 9: 49-59.
32. Vernon, H. The Neck Disability Index: State-of-the-Art. *Journal of Manipulative and Physiological Therapeutics* 2008; 31: 491-502.
33. Williams, M.A., McCarthy, C.J., Chorti, A., Cooke, M.W. and Gates, S.M. A systematic review of reliability and validity studies of methods for measuring active and passive cervical range of motion. *Journal of Manipulative and Physiological Therapeutics* 2010; 33: 139-155.
34. Jordan, K. Assessment of Published Reliability Studies for Cervical Spine Range-of-Motion Measurement Tools. *Journal of Manipulative and Physiological Therapeutics* 2000; 23(3): 180-195.
35. Livingston, T., Bernadi, D. and Carroll, M. *Algometer™ Commander & Digitrack™ Commander: User's Manual.* Journal of Tech Medical Industries; 1998.
36. Young, B.A., Walker, M.J., Strunce, J.B., Boyles, R.E., Whitman, J.M.and Childs, J.D. Responsiveness of the Neck Disability Index in patients with mechanical neck disorders. *The Spine Journal* 2009; 9: 802-808.

37. Pool, J., Ostelo, R., Hoving, J., Bouter, L., de Vet, H. Minimal Clinically Important Change of the Neck Disability Index and the Numerical Rating Scale of Patients with Neck Pain. *Spine* 2007; 32(26):3047-3051.
38. O'Leary, S., Falla, D., Hodges, P.W., Jull, G., and Vincenzino, B. Specific Therapeutic Exercise of the neck induces immediate local hypoalgesia. *The Journal of Pain* 2007; 8(11): 832-839.
39. Paungmali, A., Vincenzino, B., and Smith, M. Hypoalgesia induced by elbow manipulation in lateral epicondylalgia does not exhibit tolerance. *Journal of Pain* 2003; 4 (8): 448-454.
40. Potter, L., McCarthy, C. and Oldham, J. Algometer Reliability in Measuring Pain Pressure Threshold Over Normal Spinal Muscles to Allow Quantification of Anti-Nociceptive Treatment Effects. *International Journal of Osteopathic Medicine* 2006; 9:113-119.
41. Fryer, G. Muscle Energy Concepts - A need for change. *Journal of Osteopathic Medicine* 2000; 3(2): 54-59.
42. Kisner, C. and Colby, L.A. *Therapeutic Exercise: Foundation and Technique*. 4th ed. Philadelphia: F.A. Davis; 2002.
43. Green, B.N. A Literature Review Of Neck Pain Associated With Computer Use: Public Health Implications. *Journal Of Canadian Chiropractic Association* 2008; 52(3): 161–168.
44. Sim, J., Lacey, R.J. and Lewis, M. The Impact of Workplace Risk Factors on the Occurrence of Neck and Upper Limb Pain: A General Population Study. *BioMed Central, Public Health* 2006; 6:234.
45. Schlossberg, E.B., Morrow, S., Llosa, A.E., Mamary, E., Dietrich, P. and Rempel, D.M. Upper Extremity Pain and Computer Use Among Engineering Graduate Students. *American Journal of Industrial Medicine* 2004;, 46: 297–303.
46. Burns, D.K. and Wells, M.R.. 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* 2006*;* 106(3): 137-142.