THE RELATIVE EFFECTIVENESS OF USING PILATES EXERCISES TO OBTAIN SCAPULA STABILISATION AS AN ADJUNCT TO CERVICAL MANIPULATION IN THE TREATMENT OF CHRONIC MECHANICAL NECK PAIN.

By

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Dissertation submitted in partial compliance with the requirements for the Master's Degree in Technology: Chiropractic at the Durban University of Technology.

I, Carine Bernice Smit, do declare that this dissertation is representative of my own work in both conception and execution.

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Dedication

I dedicate this study to my parents, Ben and Bernice Smit. They have supported me throughout this journey, picked me up and pointed out the light at the end of the tunnel every time I stumbled and lost sight of it. The appreciation I feel towards you, is beyond words.

I love you.

ACKNOWLEDGEMENTS

A big thank-you to Dr. Nicki de Busser who helped me with this topic idea.

Very special thank you to Dr. Andrew Jones for supervising my work. You were always on the ball and made this process a lot simpler for me. I cannot tell you how many times you made my day!

Andri Marais your enthusiasm and positivity throughout this study was amazing. It was so motivational to both the participants and me. Without your help and dedication this topic would not have been possible. Thank you to you and your team at the Pilates House. It was an absolute pleasure working with you.

To the people I love thank-you for sharing this part of my life with me.
“Experience is not what happens to you; it’s what you do with what happens to you” (Unknown).

Mrs Twiggs, Mrs Van Den Berg and Mrs Ireland thank you for all the help and advice over the last couple of years.

All the participants, I thank you for your time and effort. It is much appreciated.

Abstract

Introduction:

It has been noted that in many recent research studies mechanical neck pain is a serious problem in the world today. There are epidemiological and statistical studies documenting the high incidence and prevalence of mechanical neck pain, which effects people's daily living (Drew, 1995; Ferrari and Russell, 2003; Cote *et al*., 2000, Venketsamy, 2007 and Haldeman *et al*., 2008).

Background:

Treatments for chronic neck pain, which are non-surgical, appear to be the most beneficial for patients (Haldeman, 2008). In brief, the presentation of chronic mechanical neck pain is defined as localised, asymmetrical neck pain with restricted range of motion and dysfunctional musculature (Grieve, 1988). The muscular dysfunction known as the upper cross syndrome is defined as tightness of the upper trapezius, pectoralis major and levator scapulae and weakness of rhomboids, serratus anterior, middle and lower trapezius and deep neck flexors. These muscles are responsible for stabilizing the scapula and the patient may present with rounded, elevated shoulders and anterior head carriage when diagnosed with this syndrome (Liebenson, 1996). Clinical trials conducted by Cassidy *et al*., (1992 a, b) concluded that spinal manipulative therapy (SMT) was highly effective in treating mechanical dysfunctions within the cervical spine. However, due to multi systemic involvement of the muscular, neural and passive systems in mechanical neck pain, the treatment may need to target all three of the subsystems of spinal stability to be most effective (Panjabi, 1992 a, b; Lee *et al*., 1998; Lee 2004 and Richardson et al., 2002). No research has been conducted on the effects and benefits of treatment directed on the cervical spine and upper cross syndromes. This research will compare scapula stabilization training and SMT to SMT in isolation, as a treatment for chronic mechanical neck pain.

Objectives:

The purpose of this study was to determine the effect that scapula stabilization had on chronic mechanical neck pain. Pilates exercises were used to strengthen and stabilize the scapula muscles (this included stretching out the hypertonic musculature of the upper cross syndrome). The aim was to improve posture as well as to decrease the mechanical stress on the neck. SMT was also concomitantly used to correct any cervical restrictions that were present. These results were then compared to the results of a group that only received spinal manipulative therapy. The null hypothesis was that the intervention group would not respond differently to the treatment protocol in terms of the subjective and objectives measurements.

Method:

This clinical trial was conducted on a sample population of 30 patients with chronic mechanical neck pain. Each patient was assigned to one of two groups (*n=15)* according to convenience sampling. Both groups received SMT to the cervical spine, while group B (intervention group) also received pilates classes twice weekly for four weeks, which retrained the scapula stabilization muscles to function optimally. The patients each underwent six spinal manipulative treatments over four weeks and a seventh consultation in the fifth week for data collection.

Both groups were evaluated in terms of subjective and objective clinical findings. Subjectively the assessment included 2 questionnaires (Numerical Pain Rating Scale and Canadian Memorial Chiropractic College [CMCC] neck disability index). Objective assessment included cervical motion palpation, Cervical Range Of Motion goniometer (CROM) measurements, scapula stabilization tests and a postural analysis with the use of digital photography. The statistics were completed under the guidance of a biostatistician, from the College of Health Science, University of KwaZulu – Natal, (Esterhuizen, 2008) who analyzed the captured data with the use of SPSS version 15. All outcome measures were quantitative. Repeated measures ANOVA testing was used to assess the presence of a different effect for each outcome measure over time between the two treatment groups. A statistically significant time by group effect would indicate a significant treatment effect. The minimum significance level was 0.05. The trends and direction of the effect were assessed via profile plots.

Result:

According to the statistical analysis, both groups showed improvements - subjectively and objectively - with regards to chronic mechanical neck pain, which is in keeping with the literature. In terms of the inter-group comparison the SMT group (Group A) showed a more constant improvement in range of motion, pain and disability indexes with the SMT only group while the SMT and pilates group (Group B) showed a greater effect in stabilizing the scapula and increasing the functionality of the surrounding musculature.

Conclusions and Recommendations:

The intervention treatment (Group B) did not have a greater effect on the short-term treatment of chronic mechanical neck pain than the reference group (Group A). It was also evident that the intervention group (Group B) often continued to improve when the SMT (Group A) only group often regressed at the follow up sessions. This improvement was either not significant enough or

the follow up session did not allow for enough time for a true reflection to be noted. It is recommended that more research be carried out to gain conclusive results indicating whether there is a more beneficial long term result to this treatment protocol.

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DEFINTIONS

Chronic Pain:

Chronic pain is defined as pain that lasts longer than 6 weeks. Acute pain becomes chronic pain when the period of pain exceeds 6 weeks and the healing process takes longer than the natural course of healing (Hansson, 2006).

Chiropractic:

Chiropractic is an alternative medicine that is concerned with the etiology, pathogenesis, diagnostics and treatment of functional disturbances within the neuromusculoskeletal systems. This includes pathomechanical states, pain syndromes and other neurophysiologic effects related to the spinal system and it's dependants (Schafer and Faye, 1990).

Contraindication:

Any condition, especially any disease condition, that renders one particular line of treatment improper or undesirable (Gatterman, 1990).

Pilates:

Pilates is an exercise discipline that is designed to condition the body as well as improve posture, muscle tone, alignment and provide flexibility by using exercises that stretch and strengthen selective muscles (Siler, 2000 and Worth, 2004).

Muscle imbalance:

Some muscles have become inhibited (underactive) for unknown reasons which weakens them. Often the antagonistic muscle compensates and becomes tight (hyperactive) and this will cause them to loose their extensibility (Liebenson, 1996).

Myofascial trigger points:

These are hyperirritable areas occurring in bands of muscle tissue. They are palpable, tender to compression and produce characteristic referred pain and autonomic phenomena (Travell et al., 1999).

Spinal manipulative therapy:

This is a manual procedure that utilizes controlled force, leverage, direction, amplitude and velocity, which is directed at a specific joint or anatomical region. The direct thrust moves the joint past the physiological range of motion, without exceeding the anatomical limitations of that joint (Chapman-Smith, 2000).

Abbreviations

ATP	- Adenosine Triphosphate
cm	- Centimeters
CNS	- Central Nervous System
CROM	- Cervical Range Of Motion goniometer
DUT	- Durban University of Technology
EAM	- External Auditory Meatus
LBP	- Low Back Pain
ROM	- Range Of Motion
SMT	- Spinal Manipulative Therapy

Chapter One

Introduction

1.1. The problem and its setting

The cervical spine is the most mobile section of the vertebral column (Vernon, 1988) and has adapted to allow for maximum mobility at the cost of stability. This makes it the most vulnerable part of the spine particularly to injuries (Magee, 2006).

According to Ferrari and Russell (2003) mechanical neck pain is the second most common complaint presenting to clinical practices (the first being low back pain). Haslett *et al*. (2002) proposes that this stems from either mechanical or degenerative problems. Any condition or event leading to altered joints or muscle structure and weakness (for example, incorrect posture, injury, aging, congenital abnormalities), can result in mechanical neck pain (Bergmann *et al*., 1993). If excessive stress is placed on any tissue, it will also lead to pain, inflammation, protective spasms and or neurological reflex patterns (Vernon, 1988) which will in turn cause neck pain. Haslett *et al.*, (2002) states that mechanical neck pain is frequently associated with asymmetrical restriction of the cervical range of motions and often has a history of abnormal posture or trauma. There is often no single cause for the pain and the pain is regularly just a symptom and not the diagnosis of the neck problem (Bergmann *et al*., 1993;Liebenson, 1996; Haslett *et al.*, 2002).

Daniel David Palmer founded chiropractic in 1895 (Chapman-Smith. 2000) and one of his first spinal manipulations on a patient was in the cervical region. The profession has progressed in the last 114 years and the goals of a chiropractic treatment today according to Chapman-Smith (2000) include the patient’s immediate needs (relief of pain), addressing the cause of the symptoms (restoring normal ranges of movement and function to the joints and muscles) and allowing the nervous system to function without interference (by optimising functioning of the musculoskeletal system).

Cassidy *et al*. (1992 a, b), performed randomised controlled studies, which concluded that spinal manipulation was effective in relieving pain of mechanical origin. Similarly researchers (Triano, 1992; Bergmann *et al*., 1993; Curl, 1994; Pooke, 2000) also found that there was a positive correlation between spinal manipulation and the surrounding musculature. Niemisto *et al*., (2003) conducted a clinical trial on chronic low back pain sufferers who received stabilisation exercises. One group received manipulations and stabilization exercises over a period of four weeks and the other only received a single consultation advising them to incorporate stabilisation exercises into their daily lives. Both groups showed significant improvement with the manipulation group showing a 20% decrease in both pain and disability of their low backs.

Every joint complex has multi systemic involvement: structural (joints), supportive (muscles and ligaments) neural elements and an emotional status (Panjabi, 1992b; Lee, 2004; Vleeming, 2006). When treating a spinal region it is apparent from the above researches, that the surrounding structures (muscles and joints) should also be addressed.

Liebenson (1996) stated that the upper cross syndrome is a dysfunction, which has both muscular hypertonicity (upper trapezius, pectoralis major and levator scapulae) and hypotonicity (rhomboids, serratus anterior, middle and lower trapezius and deep neck flexors). This according to Magee (2006) will reduce scapula stabilization and can cause an altered scapulo-humeral rhythm, which will lead to excessive postural stress on the cervical spine (Hammer, 1991).

Kendall et al., (1993) highlighted that a correlation was found between posterior cervical muscle dysfunction and poor posture i.e. anterior head carriage and rounded upper thoracic spine. These authors surmised that the abnormal posture led to compressive forces on the articulating facets and vertebral bodies, which led to facet syndromes. This suggests that treatment should be aimed at both postural correction and the mechanical neck restrictions.

Worth (2004) indicates that Pilates exercises concentrate on obtaining correct posture and alignment of the body. Every Pilates exercise focuses on training specific muscle groups to work optimally by stretching the hypertonic muscles out and simultaneously strengthening the weakened ones (Worth, 2004). Research has found that muscles can be divided into two subgroups: - local and global- and when both subgroups are functioning optimally, they work in tandem throughout the entire body and support the spine through any movement (Siler, 2000). With the presence of either pain, muscle imbalance or joint restrictions the movement patterns may be altered (Travell *et al.*, 1990; Hong, 1996; Liebenson, 1996) and the surrounding musculature tries to compensate. It appears that this compensation is the neural systems attempt to maintain spinal stability in the presence of any muscle dysfunction (O'Sullivan *et al.*, 1997 and Fryer *et al.*, 2004) Although the effects of Pilates exercises in stabilising the lumbar spine by addressing it's related musculature has been researched

(Herrington and Davies, 2003; Ferguson, 2006), the effect that stabilizing the scapula, with Pilates exercises, will have on the cervical spine has not been assessed.

Therefore the purpose of this study is to assess the effectiveness of using pilates exercises to obtain scapula stabilisation and in an attempt to improve cervical posture which will aid as an adjunct to cervical manipulation in patients who suffer from chronic mechanical neck pain. This was compared to patients who received spinal manipulation only.

1.2 The objectives and hypotheses of this study

As the evidence base of treatment benefits from using Pilates scapula stabilisation exercises to improve anterior head carriage and subsequently chronic mechanical neck pain is currently limited and literature supports spinal manipulation as a treatment for mechanic neck pain, the following objectives and non-directional null hypothesis were set prior to the initiation of this clinical trial to comparatively identify any improvements:

Objective one:

An inter-group analysis to determine the effectiveness of adjustments versus adjustments and pilates exercises in terms of subjective measurements:

i). Numerical Pain Rating Scale
ii). CMCC neck disability index

Null hypothesis one:

The null hypothesis is that the intervention group will not respond differently to the treatment protocol in terms of the subjective measurements.

Objective two:

An inter-group analysis to determine the effectiveness of adjustments versus adjustments and pilates exercises in terms of objective measurements: -

i). Motion palpation of cervical spine
ii). CROM cervical measurements
iii). Scapula stabilization orthopaedic test measurements
iv). Postural analysis (digital photographic images)

Null hypothesis two:

The null hypothesis is that the intervention group will not respond differently to the treatment protocol in terms of the objective measurements.

Objective three:

The third objective was to integrate the data obtained from objective one and two to determine the most effective treatment of chronic mechanical neck pain in this study. An inter-group comparison in terms of both the subjective and objective measurements.

Null hypothesis three:

The null hypothesis is that the intervention group will not respond differently to the treatment protocol in terms of the subjective and objectives measurements.

1.3 The Rationale

Mechanical neck pain is multifactorial in its aetiology. Haldeman *et al.*, (2008) recommended that more research on treatments that modify the direct risk factors should be direction for future investigations

Core strengthening and stabilisation have become a trend in rehabilitation (Ferguson, 2006) but stabilization of the scapula with the use of Pilates exercises has yet to be investigated as a means to improve chronic mechanical neck pain.

Although there are a number of treatment protocols for chronic mechanical neck pain as a single entity for example: - manipulation, mobilisation and physiotherapy. Upon review of the literature, there is a paucity of literature conducted on treatments aimed at mechanical neck pain and the upper cross syndrome musculature.

This research is aimed at determining the effectiveness of scapula stabilization exercises as an adjunctive treatment to spinal manipulative therapy for chronic mechanical neck pain and hence whether or not there is a need for chiropractors to incorporate the specific muscle training programme of scapula stabilization via Pilates exercises, in the treatment of chronic mechanical neck pain.

In the remaining chapters, the researcher will review the literature on chronic mechanical neck pain and treatment options (Chapter 2); describe in detail the methodology of this study (Chapter 3) and present the statistics (Chapter 4); results will be discussed in chapter 5 and chapter 6 will state the recommendations and conclusions of this study.

Chapter Two

Literature Review

2.1. Introduction

This chapter reviews the current literature and clinical trials conducted on the subject of chronic neck pain and its treatment protocols.

Particular focus is directed on the relationship between the muscles that stabilize the scapula, cervical posture and mechanical neck pain.

2.2. Epidemiology of neck pain

2.2.1. Incidence and prevalence of neck pain.

Borenstein *et al*., (1995) defined prevalence as the measure of people numbers within certain population groups that have a specific symptom or disease at a specific time. It was also stated that the rate at which people in a given population develop a disease or symptoms over a specific period of time, is the definition of incidence.

According to Ferrari and Russell (2003) on average ten percent of the Canadian population reported having neck pain for one week every month. These researchers also stated that neck pain of unspecified duration occurred in at least 80% of the population. Cote *et al*. (2000) conducted an epidemiological study and revealed that neck pain for longer than six months had 54.2 % incidence. This was lower than in Finland, Norway and Sweden where an incidence of 72% was found. In America, a survey on a twelve-month prevalence of neck pain ranged from 12.1% - 71.5% in the unemployed people and in workers it ranged from 27.1% - 47.8% (Haldeman *et al*., 2008).

In South Africa, an epidemiological study was carried out in both private chiropractic practices and a chiropractic teaching clinic over a 3 month period (February 1994- April 1994). One hundred and sixty two new patients answered the questionnaire within the teaching clinic during that three-month trial. The statistics revealed that 57.4 % of the patients that presented to private practices complained of neck pain and 54.6% of the patients at the chiropractic teaching clinic received treatment for neck pain (Drew, 1994). A retrospective study was done by Venketsamy (2007) at the Chiropractic Day Clinic, at the Durban University of Technology, to establish prevalence and demographics on neck pain. From 1996 - 2005 there was a significant increase in the prevalence of cervical complaints presenting to the teaching clinic, 17,4% to 20.61%. This prevalence is comparable to the results obtained by Drew (1994) in an unpublished study in which neck pain had 16.7% prevalence in the primary sample population.

2.3. Relevant Anatomy and Biomechanics of the cervical spine

2.3.1. Bones of the cervical spine

The spinal column consists of seven cervical vertebrae, twelve thoracic vertebrae and five lumbar vertebrae, which rest on the sacrum and pelvis (Moore and Dalley, 1999; Magee, 2006). The structure and function of each region of the spine is directly related to the demands that are placed on it anatomically and physiologically (Vernon, 1988).

Research has found that no other region of the spine shares the potential and influence on the human body like the cervical spine does (Vernon, 1988). C0-C2 provides information on balance, eye movements and the position of the cranium (Vernon, 1988). In adults the cervical spine has a mild lordosis that averages 34 degrees on lateral view (Harrison *et al.*, 1996). The lordosis extends from the atlas (C1) to the second thoracic vertebrae (Vernon, 1988; Hinwood and Richardson, 1991 and Moore and Dalley, 1999).

2.3.2. Cervical joints and movement patterns

The zygapophyseal joint or facet joint is formed by the junction between the superior and inferior facets of the articular processes, on one side, of two adjacent vertebrae. The facet joints in the cervical spine are diarthrodial synovial joints (Windsor *et al.*, 2005). The functions of the zygapophysial joints are to guide the movements between the vertebrae as well as protection. This is performed by restraining excessive movement between the vertebrae and discs (Giles and Singer, 1998). These joints are inclined at 45 degrees from the horizontal plane (Windsor *et al.*, 2005 and Panjabi and White, 1990) and 85 degrees from the sagittal plane (Windsor *et al.*, 2004). The lower the joint is in the cervical spine the more lax the joint capsule is to allow for increased gliding movements (Windsor *et al.*, 2004 and Panjabi *et al*., 1990). The movement at each vertebral level is primarily dictated by the orientation of the facets articulatory surfaces (Panjabi *et al.*, 1990).

The cervical spine allows for movement in all directions, namely: flexion, extension, rotation and lateral flexion (Moore and Dalley, 1999 and Magee, 2006). A normal, unhindered cervical spine can have a total of 130 degrees in flexion and extension; 75 degrees in lateral flexion and

160 degrees in rotation. These motions diminish in varying degrees in accordance with increasing age and disabilities (Giles *et al*., 1998).

According to Panjabi and White (1990) the mean range of cervical motion of the cervical spine at each level in degrees, is as follows:

Table 2.1 Normal Cervical Range of motion

LEVEL	FLEXION/ EXTENION	LATERAL FLEXION	ROTATION
C0 / C1	13	8	0
C1 / C2	10	0	47
C2 / C3	8	10	9
C3 / C4	13	11	11
C4 / C5	12	11	12
C5 / C6	17	8	10
C6 / C7	16	7	9
C7 / T1	9	4	8

These guidelines give researchers parameters to aim for when attempting to restore optimal range of motion to a dysfunctional cervical spine. There are coupled movements that occur in the cervical spine which are defined as a simultaneous rotation and lateral flexion around the respective axis (Jofe *et al.*, 1989). Panjabi and White (1990) asserts that at C2 there are two degrees of rotation for every three degrees of lateral flexion and at C7 there is one degree of rotation for every eight degrees of lateral flexion (Panjabi and White, 1990). They also suggested that there is a cephalocaudal decrease in the amount of coupling that occurs in the cervical spine which is thought to be due to the change in the orientation and incline of the facets.

There is a close relationship between the anatomical restraints of a vertebra and the muscles that control them (Panjabi and White, 1990; Moore and Dalley, 1999; Lee, 2004 and O'Sullivan, 2005). As each vertebra goes through its ranges of motion, its pattern of movement is directly determined by its structural design and soft tissue attachments (Jofe *et al*., 1989; Panjabi and White, 1990 and Moore and Dalley, 1999).

2.3.3. Muscles affecting the cervical spine

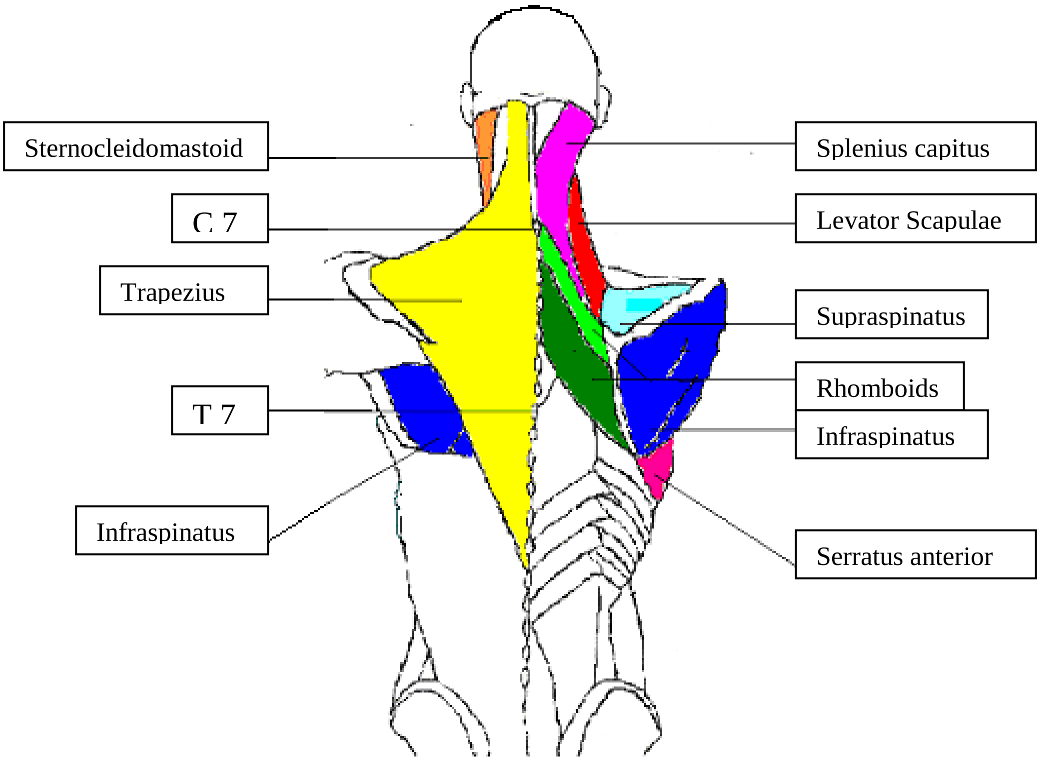

Figure 2.1: Posterior view: Upper cross muscles

(Adapted from Gray, 1918)

Out of the 5 spinal regions, the cervical spine is the most mobile section and therefore it has the most elaborate and specialised muscle system of the spine (Panjabi and White, 1990).

The body's musculature may be subdivided into local and global muscles. Local muscles are responsible for intersegmental stability and attach directly to the vertebrae. Global muscles consist of large torque producing muscles. They have the responsibility of regional stability and act on the spine without attaching directly to it (Lee, 2004 and O'Sullivan, 2005). Balancing and evenly distributing external load stress, is part of the global muscles job description (Giles and Singer, 1998). The function of the local muscles is to control segmental stiffness independently of the global muscles (Giles and Singer, 1998). Lee (2004) also commented that there is a "neurophysiological difference" in the timing of the initiations of the muscle contractions within these two groups during movement. It also appears that certain parts of some muscles may belong to both sub-divisions (Lee, 2004). How muscles interact and function together is equally as important as the individual functions of the muscles. Lee (2004) states that both are crucial to understanding spinal biomechanics (stability and mobility).

According to Liebenson (1996) muscles are the medium through which the compensatory effects from the central nervous system are channelled. Also, when a specific joint is injured or is dysfunctional, a certain muscle or group of muscles will react in accordance and vice versa (Liebenson, 1996). Liebenson's (1996) ideas emphasized that when a joint or muscle is not functioning optimally it will cause compensatory changes in its functional partner and identifies the three-way link between the central nervous system (CNS), the muscles and the joints. Lee (2004) has extended on this idea and depicted that any muscle contraction (due to the joint or neural stimulation) produces a force that not only affects that muscle but also will extend beyond the anatomical confines of that muscle. It is transmitted to surrounding muscles, tendons, ligaments and bones, which are either directly (anatomically) or indirectly (neurologically) related. Therefore, a muscle that is hyperactive will be relaying stress onto the surrounding joints and tissues. The following functional chains have been documented: the nerves and joints of the cervical spine from C3- T3 effect the sternocleidomastoid, levator scapulae, upper, middle and lower trapezius, cervical erector spinae, scaleni and serratus anterior (Liebenson, 1996).

2.3.3.1. Trapezius

This is a superficial muscle of the back and attaches the pectoral girdle to the skull and spinal column. Superiorly it is attached to the medial third of the nuchal line, external occipital protuberance, ligamentum nuchae and C7-T12 spinous processes. Inferiorly it attaches to the lateral third of the clavicle, acromion as well as the spine of the scapula. The spinal root of the accessory nerve and C3 and C4 nerves innervates this muscle. The trapezius's main action is elevation (superior fibers), retraction (middle fibers) and rotation (inferior fibers) of the scapula (Moore and Dalley, 1999). Tightness of the upper fibers in this muscle will cause scapula elevation. This will generally be linked with concomitant weak lower and middle fibers (indicative of upper cross syndrome) and lead to rounding of the upper thoracic spine (Liebenson, 1996).

2.3.3.2. Levator Scapulae

True to its name, this muscle's function is to elevate and rotate the scapula. It also aids in lateral flexion of the neck. It attaches cephaladly to the transverse processes of C1-C4 and caudally to the superior portion of the medial border of the scapula. It is innervated by the dorsal scapular nerve (C5) and the C3 and C4 nerves (Moore and Dalley, 1999). Dysfunction of this muscle will lead to aberrant scapula movement as well as decreased movement of the cervical spine (Moore and Dalley, 1999).

2.3.3.3. Sternocleidomastoid

This is a broad strap-like muscle that has two heads. It attaches superiorly to the lateral surface of the mastoid process and to the lateral half of the nuchal line. Inferiorly the sternal head attaches to the anterior surface of the manubrium and the clavicular head attaches to the superior surface of the medial third of the clavicle. It derives its innervation from the spinal root of the accessory nerve as well as C2 and C3. When acting unilaterally it causes lateral flexion and rotation of the head and when acting bilaterally it causes flexion of the head (Moore and Dalley, 1999). Hypertonicity of this muscle will lead to anterior head carriage and a loss of lordosis in the cervical spine (Magee, 2006).

2.3.3.4. Serratus Anterior

This muscle is one of the most powerful muscles of the pectoral girdle and is a very strong protractor of the scapula. It attaches to the external surfaces of the lateral area of the first to eighth rib. Distally, it attaches to the anterior surface of the medial border of the scapula. The long thoracic nerve innervates it and its main function is to protract the scapula and hold it firmly against the thoracic wall. It also aids in rotation of the scapula (Moore and Dalley, 1999). When this muscle is not functioning optimally winging of the scapula is seen. When the arm is raised, the medial inferior border of the scapula is pulled markedly away from the thoracic wall. The arm will also not manage to elevate more than the horizontal position, as the serratus anterior is not rotating the glenoid cavity superiorly to allow for complete abduction (Moore and Dalley, 1999 and Magee, 2006).

2.3.3.5. Pectoralis Major

This is a large fan shaped muscle. Proximally it has two attachments; the clavicular head - attaching to the anterior surface of the medial half of the clavicle and the sternal head – attaching to the anterior part of the sternum and the superior six costal cartilages. Distally it attaches to the lateral lip of the intertubecular groove of the humerus. Both the lateral and medial pectoral nerves as well as C5, C6 (clavicular head), C7, C8 (sternal head) innervate this muscle (Moore and Dalley, 1999). The main action is to adduct the arm, medially rotate the humerus and draw the scapula anteriorly and inferiorly. Over active pectoralis major muscles cause rounding of the shoulders and subsequently increase the kyphosis of the thoracic spine. Protraction of the scapula is also indicative of hyperactive pectoral muscles (Magee, 2006).

2.4. Mechanical neck pain

Neck pain is an experience that most people can expect to deal with at some point in their lives, although the majority will not have it interfering with the normal activities of their daily living (Haldeman *et al*., 2008). Neck pain is multifactorial in aetiology, with numerous risk factors. Some risk factors are nonmodifiable and these include age, gender and genetics (Haldeman *et* *al*., 2008). Neck pain has the potential to originate from a variety of sources as bone, discs, ligaments, joints, muscles and fascia are all innervated by pain fibers (nociceptors) (Panjabi *et al*., 1990). Regularly there is not a single cause for neck pain but rather a combination of factors that cause it, with pain being a symptom of these factors (Liebenson, 1996).

2.4.1. Aetiology of mechanical neck pain in the general population

Any condition or event leading to altered joints or muscle structure and function (for example, incorrect posture, injury and or aging) can result in mechanical neck pain (Bergmann *et al*., 1993). There is often not a single cause for the pain and any tissue that is placed under excessive stresses will lead to pain, inflammation, protective spasms and or neurological reflex patterns (Vernon, 1988).

Vernon (1988) describes abnormal mechanical function as “pathomechanics”. This was classified into four different subsections that included congenital factors, ligamentous instability, muscular dysfunction and neurological abnormality. Therefore, dysfunctions of the joints or muscles or any aberrant patterns of movement due to muscle inhibitions are all “pathomechanical” and can lead to mechanical neck pain due to alterations to the normal biomechanics of the cervical spine.

Grieve (1988) suggested that in the absence of trauma and major injury, one of the greatest causes of neck pain is poor posture. Later, Gatterman (1990) elaborated on this and described the most common cause of mechanical neck pain to be when zygophyseal joints are placed under stress and this leads to the locking of these joints and reciprocal muscle strain on the cervical musculature. Alterations in normal muscle tone are also cited as one of the earliest causes of abnormal biomechanics and are then the reason for further changes in active and passive range of motion (Vernon, 1988). Grieve (1988) agreed that a plausible reason for the joint fixations was because of the muscle imbalances and asymmetrical soft tissue contractures. Kendall *et al.*, (1993) found a correlation between posterior cervical muscle dysfunction, anterior head carriage and round upper back posture. The above authors all hypothesized that poor posture resulted in compressive forces on the articulating facets and posterior vertebral bodies leading to zygophyseal syndromes with associated strain on the surrounding musculature (Vernon, 1988; Grieve, 1988; Kendall *et al.*, 1993) Liebenson (1996) emphasised the three way link between the joints, muscles and CNS and therefore we can conclude that muscular dysfunction will lead to poor posture, which will cause additional strain on the cervical zygophyseal joints and subsequently mechanical neck pain (Grieve, 1988; Gatterman, 1990; Kendall, 1993 and Liebenson, 1996).

2.4.2. Diagnosis of mechanical neck pain.

Patients suffering from mechanical neck pain may exhibit any or all of the symptoms which include increased spinal stiffness, localised muscle and joint pain and reduced range of motion at the sites of the cervical dysfunctions (Humphreys *et al*., 2004). According to Kirkaldy-Willis (1992) the term dysfunction implies that at a specific anatomical level the components of the joint are not functioning normally.

The presenting features of chronic mechanical neck pain are, according to Grieve (1988), local chronic cervical pain with or without arm pain, asymmetrical neck pain that worsens as the day progresses and is aggravated by, for example, driving and reading, unilateral occipital pain and neck pain, restricted and painful cervical rotation and lateral flexion to the painful side and prominent upper and middle trapezius and levator scapulae muscles.

There are five diagnostic criteria for joint dysfunction in mechanical neck pain (Bergmann *et al*., 1993) comprising of pain and or tenderness, which is produced by the palpation of the dysfunctional osseous and soft tissue; asymmetry, identified on postural analysis or during palpation of the vertebral segments; range of motion abnormalities that are noted during active and passive motioning; the tone and texture changes of the tissues noted during examination. Orthopedic tests have also been designed to help diagnose mechanical pain for example Kemps test[1]. Haslett *et al*. (2002) also stated that mechanical neck pain from the upper joint dysfunctions often refers pain to the occiput, temple or face and from the lower joint dysfunctions to the scapula, shoulder and arm.

2.5. Muscle pain

Muscles often are overlooked as a cause of pain and spinal joints and intervertebral discs joints are favoured (Liebenson, 1996). Overloading of any muscle leads to disrupted muscle tone or muscle spasm. This will lead to altered neural stimulation that will cause pain (Gattereman, 1990; Liebenson 1996; Travell *et al*., 1999 and Lee 2004)

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[1]Kemps test is an orthopedic test that is performed in the following manner: The doctor stands behind the patient and with his indifferent hand he laterally flexes and extends the patient over the side that is being tested. This position causes maximum stress on the facet joints and narrowing of the intervertebral foramen on the side that is being tested. A true positive for this test would be localised pain and discomfort and the following differential diagnoses may be ascertained from this test: radiculopathy, facet syndrome or meniscoid entrapment (Vizniak, 2002 and Magee, 2004).

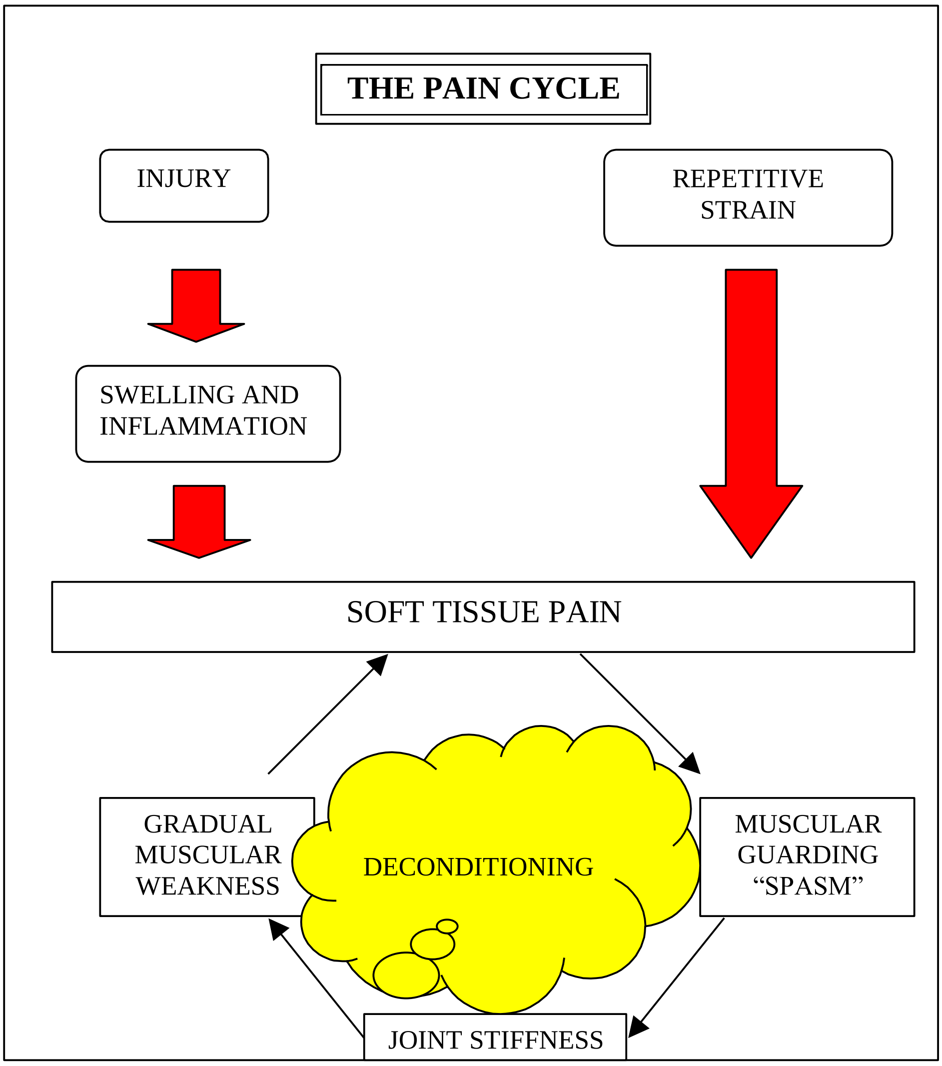

Figure 2.2: The Pain Cycle

(Adapted from Liebenson, 1996)

2.5.1. A possible cause of pain due to muscle dysfunctions

The energy crisis theory is one of the earliest explanations of trigger point formation (Hong, 1996 and Travell *et al.*, 1999). The theory is based on what happens when muscles either undergo macrotrama (e.g. whiplash), recurrent microtrauma (e.g. poor posture) or an increase in the demands placed on them (e.g. increased neural input) (Gatterman, 1990 and Travell *et al.*, 1999). It is theorised that the above will lead to an increase of calcium from the sarcolemma. This increase will in turn prolong the shortening of the sarcomeres. The prolonged shortening subsequently compromises the circulation and will thus reduce the oxygen supply to the cell. With reduced oxygen the cells are unable to produce enough adenosine triphosphate (ATP) to activate the process of relaxation. To add to this, there is an accumulation of metabolites due to the depleted energy source and the sub-optimally functioning calcium pump. These include lactate, seratonins, kinins, and prostogladins. This increased concentration will trigger the firing of the muscle nociceptors and result in pain (Travell *et al.*, 1990 and Hong, 1996).

2.5.2. Effects of Muscle Pain on Joints

The surrounding joint musculature increases the compression forces within a joint (Lee, 2004) and this function has been classified as force closure and relies directly on the optimal working of the muscles. Force closure reduces the size of the joints neutral zone and controls shear forces between the two joint surfaces (Lee, 2004). It has been proposed that when paraspinal muscles become overactive and painful because of abnormally increased or sustained contractions, it interferes with the normal joint motion which becomes identifiable with palpation (Fryer *et al*., 2004). The receptors of a joint can facilitate or inhibit surrounding muscles (Liebenson, 1996). Liebenson (1996) noted that inhibition of muscles surrounding a joint could be due to overloading of that joint or pain with in that joint. Fryer *et al*., (2004) agrees and suggested that spinal pain seems to suppress the activation of the deep musculature. This highlights the direct link between joints and their surrounding musculature (Fryer *et al*., 2004 and Liebenson, 1996).

2.5.3. Effects of muscle Pain on Movement patterns

Posture and movement are directly related to the musculature of the back. The musculature has two functions: to support the spinal column and supply force that is needed for movement (Giles and Singer, 1998). The presence of pain, muscle imbalance, trigger points and or joint dysfunctions can alter the performance of certain movement patterns (Travell *et al.*, 1990; Hong, 1996 and Liebenson, 1996). Once the movement patterns have been distorted the activation sequences of the related muscles is also altered. For example global muscles may be recruited late and the local muscles try to substitute for them and then become hyperactive themselves and this also works in the reverse (Liebenson, 1996; O'Sullivan *et al*., 1997 and Fryer *et al*., 2004). It appears that this compensation is the neural systems attempt to maintain spinal stability in the presence of any muscle dysfunction (O'Sullivan *et al*., 1997 and Fryer *et al*., 2004). This will in turn lead to postural changes and joint stress (Liebenson, 1996).

2.5.4. Effects of muscle pain and movement patterns on posture.

As the bipedal form is so unstable, most humans will have to adjust if an additional stress is added, in order to maintain balance. These adjustments include altering the gait cycles as well as posture and the curvature of the spine (Orloff and Raff, 2004). With spinal adjustments, the postural muscles increase their rigidity to continue supporting the spine in the new altered posture (Orloff and Raff, 2004). The passive tissues (according to Panjabi, 1992a,b) are thus placed under stress with the compromised posture (Giles and Singer, 1998). Any anterior head carriage is related to a loss of lordosis and often even associated with a kyphosis in the cervical spine, which will cause an increase in the load placed on the vertebral bodies and discs. This head position will require increased extensor muscle activation in the attempt to maintain equilibrium (Orloff and Raff, 2004).

Poor posture with anterior head carriage and a kyphotic upper thoracic spine is indicative of an upper cross syndrome (Magee, 2006). Hammer (1991) stated that when there is hypertonicity of Levator Scapulae muscle there is a loss of cervical lordosis and an increased occurrence of degeneration to the vertebrae. Normal spinal position can thus be considered as a treatment outcome because theoretically by returning the spine to its optimum position one would be eliminating the aberrant forces and will minimize any deforming forces placed on the ligaments, muscles and joints and thus decrease the activation of nociceptors (Harrison *et al*., 1996).

A clinical trial was conducted with the use of three different pillows as treatments to establish the affect on postural neck pain (Lavin *et al*., 1997) testing the theory that during the day patients would guard against excessive movements or postures that would cause neck pain. If at night there was poor head and neck support this would lead to poor neck and head posture and the patient may awaken experiencing more pain. One out of the three pillows showed improvements however it was concluded that further research was necessary (Lavin *et al*., 1997).

An investigation into the postural alterations that occur during upper limb movement has been conducted (Davey *et al*., 2002). The results asserted that the trunk muscles are involved in keeping the center of mass over the supporting structures i.e. lower limbs. The musculature surrounding the arm is needed to generate the movement forces and the upper spinal musculature (cervical) is essential in counter-acting this force (movement) and stabilising the spine (Davey *et al*., 2002). Therefore, poor scapula stabilization or an altered scapulo-humeral rhythm will lead to excessive stress on the cervical spine (Hammer, 1991). This outlines the cervical involvement in the movement of the scapula (Hammer, 1991 and Davey *et al*., 2002).

2.6. Upper cross syndrome and its effects

A syndrome is defined as unique combination of symptoms or signs which form a distinct "clinical entity". The elements of a syndrome may be effects of a common cause, or the relationship is one of observed association and the direct link is not fully understood (Youngson, 2004). Dr Vladimir Janda specialised in rehabilitation medicine and was very interested in the functional role of muscles. He identified crossed syndromes of muscle imbalances for upper and lower extremities based on the patterns and recruiting times of specific muscles in relation to limb movements in 1979 (Moore, 2004).

The upper cross syndrome is defined as tightness of the upper trapezius, pectoralis major and levator scapulae muscles and weakness of rhomboids, serratus anterior, middle and lower trapezius and deep neck flexors (Liebenson, 1996). Tight pectoralis muscles and weakened or lengthened lower trapezius and serratus anterior cause increased protraction of the scapula and thus lack of scapula stabilization (Magee, 2006). Other postural signs of upper cross syndrome include rounded shoulders (due to shortened pectoral muscles), anterior head carriage (occurs with kyphosis of the upper thoracic spine) and elevated shoulders (as a result of shortened upper trapezius and levator scapulae and weak lower and middle trapezius muscles) (Liebenson, 1996). All of these lead to deviation from the correct spinal posture and thus place mechanical strain on the vertebral joints.

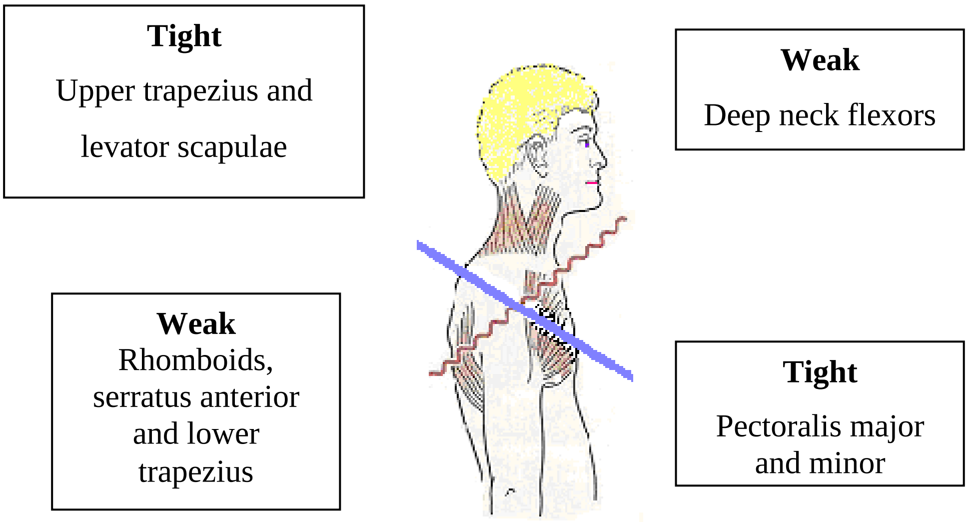

Figure 2.3: Upper Cross Syndrome

Adapted from Magee (2006)

Magee (2006) describes the loss of scapula control as being comprised of:

a) Altered scapula-humeral rhythm. The definition of Scapula-humeral rhythm is: - During 180˚ of abduction, there is a 2:1 ratio of movement of the humerus to the scapula, 120˚ of movement occurs at the glenohumeral joint and 60˚ at the scapulathoracic joint (Magee, 2006).

b) Scapula protraction along the chest wall, especially under load.

Tight pectoralis muscles and weakened or lengthened lower trapezius and serratus anterior cause increased protraction of the scapula (Magee, 2006).

c) Early contraction of the upper trapezius muscle on abduction of the upper limb. When the lower trapezius muscle is weak there is an increased depression of the scapula and to counteract this fault the upper trapezius fibers have to contract early to elevate the scapula for further movement (Magee, 2006).

On inspection of the interscapular space and the positioning of the scapulae, the quality and functionality of the scapula stabilisers can be identified by the distance and symmetry of the above two aspects (Liebenson, 1996). If there is a dysfunction in the stabilizers (neurological or muscular) often winging of the scapula can be observed (Moore and Dalley, 1999).

Hammer (1991) said that poor scapula stabilization or an altered scapulo-humeral rhythm would lead to excessive stress on the cervical spine. When there is hypertonicity of levator scapulae muscle (as occurs in the upper cross syndrome) there is also a loss of cervical lordosis and an increased occurrence of cervical degeneration (Hammer, 1991). Minor alterations in head posture have been shown to change the cervical curve when viewed on lateral radiographs (Hinwood and Richardson, 1991). Kendal (1993) stated that any deviation from normal posture, in which there is minimal additional stress, is capable of causing adverse strain and subsequently pain in the spinal structures.

2.7. Spinal stabilization systems with the human body

Spinal instability allows for an abnormally large amount of movement to occur within vertebral segments (Panjabi, 1992b). This increased movement causes compression and stretching of the neural components as well as deformation of the ligaments and joint capsules, which will fire the nociceptors and induce pain (Panjabi and White, 1990). When referring to the spine the description of stability according to Giles and Singer (1998) is:

"*The ability of the spine under physiological loads to limit patterns of displacement so as not to damage or irritate the spinal cord or nerve roots and, in addition, to prevent incapacitating deformity or pain due to structural changes*".

The neutral zone is defined as the range of motion that a vertebral body has, starting from a neutral position up to the start of resistance offered by the joint (Panjabi and White, 1990). Panjabi (1992a) noted that within this neutral zone, there is low muscle stiffness and it is imperative to achieve and maintain satisfactory stability of the spine, theses stabilising muscles must be in good tone and function uninhibitedly. The superficial and deep spinal muscles form a corset-type structure around the spine that helps maintain the neutral zone of the spine (Panjabi, 1992b). An increase in the neutral zone size will indicate spinal instability (Panjabi, 1992b). Thus, by focussing treatments on reducing the size of the neutral zone, it should increase the spinal stability and ensure adequate functioning of all the surrounding components (Boden, 2002).

The spine is recognized to be "inherently unstable" (Panjabi and White, 1990; Panjabi, 1992b and Lee, 2004). The muscles and their controls (CNS) need to provide stability of the spine in any given posture and to produce optimum movements during activities (Panjabi and White, 1990). An effective model of spinal stabilization was developed and introduced by Panjabi (1992a). This model links three subsections together: Passive (osseous and ligamentous structures), Active (spinal muscles and their force producing capabilities) and Neural (CNS which controls the other two groups via sensory feedback). Each of these is interdependent and work together to efficiently maintain stability and harmonious functioning of the musculoskeletal system. If any one of the subsystems shows discrepancies to the normal, the other two subsystems may adapt and compensate accordingly (Panjabi, 1992a). This model was later updated by Lee and Vleeming (1998) and a second model was formed which included a fourth component: The emotional state of the patient. This was called the integrated model of function (Lee and Vleeming, 1998). The separate entities include form closure, force closure, motor control and emotions.

According to Lee and Vleeming (1998) form closure is the structure and shape of the joints articulation surfaces, the orientation of the articular surfaces and how these articular surfaces influence the stability and mobility of that specific joint. Every joint has a close-pack position where maximum congruency occurs between the joint surfaces and minimal movement is experienced. This is the position of maximum joint stability (Magee, 2006). If the joint were to stay in this position all the time no movement would occur across the joint. Each joint has a variable amount of congruency between the two articulating surfaces and this will dictate how much force closure is needed in the joint (Lee and Vleeming, 1998 and Lee, 2004) thus the lower the levels of congruency, the higher the degree of force closure needed at that joint to allow for optimum functioning.

Force closure is the degree of compression formed across a joint by the surrounding musculature that allows loading of the joint at specific times(Lee and Vleeming, 1998 and Lee, 2004). In the closed pack position the joint capsule and the surrounding ligaments are maximally taut and distraction forces do not easily separate the joint surfaces (Magee, 2006). The responsibility of allowing movement and supplying adequate compression across a joint belongs to the surrounding ligaments, muscles and fascia. By engaging these structures and maximising the tension within them, the friction between the articular surfaces of the joint will increase. This will not cause any deformation to any component of the joint but rather allow for safe loading of the joint (Lee and Vleeming, 1998 and Lee, 2004).

Motor control is the sequence in which muscles are activated. For every movement to be adequately performed different muscles need to work in co-ordination with one another. This will ensure that the stability of the joint is maintained while each motion is carried out unhindered (Lee 2004 and Vleeming, 2006).

Emotional states (fight, flight or freeze) are physically expressed through movements. This is accomplished by muscle action. If any response is maintained for a long period of time it will affect the muscles tone. When muscles are hypertonic there is a subsequent increase in force on the joints that the muscle attaches to and those that are indirectly affected by it as well (Lee, 2004).

Therefore in summary, with these two stabilisation models in mind, all treatments should incorporate all components of each model.

2.8. Treatment protocols

Treatments for neck pain, which are non-surgical, appear to be the most beneficial for patients (Haldeman, 2008). A variety of active treatments including manipulative therapy and exercises were included in this category. When these treatments are focused on restoring optimum functioning of the body, the most favourable outcomes were achieved (Haldeman, 2008).

2.8.1. Spinal Manipulative therapy

This therapy is mainly used in treating articular dysfunctions with the use of a manipulation (Liebenson, 1996). A manipulation is defined as:

> *" A manual procedure that involves a directed thrust to move a joint past the physiological range of motion, without exceeding the anatomical limits."* Chapman-smith (2000) p58

This form of treatment is now used on many dysfunctions in most structures and tissues of the musculoskeletal system (Liebenson, 1996). SMT is thought to have therapeutic effects due to two mechanisms: neuromechanical and stimulation of the autonomic nervous system (Curl, 1994). As with most treatments, there are also cases of adverse reactions. A third to half of chiropractic treated patients have reported to have transient unpleasant reactions such as discomfort, increased pain and or stiffness as well as headaches and fatigue (Hurwitz *et al*., 2005) after SMT.

A clinical trial was conducted by Cassidy *et al.,* (1992b) on fifty patients to establish the effect of manipulation of the cervical spine on pain and range of motion. The study entailed pre-manipulation testing and post-manipulation testing screens for pain and range of motion. All subjects received a single rotation manipulation to the painful side from a chiropractor. One of the objectives was to also determine to what extent the relationship between pain and range of motion existed. The results suggested that SMT administered to the cervical spine had an immediate effect of increasing range of motion and decreasing pain (Cassidy *et al*., 1992b). From these results we can conclude that SMT has a favourable response on pain as well as range of motion, as an increase in range of motion is inversely proportional to pain levels.

Cassidy *et al*., (1992a) performed a randomised control study comparing the immediate effects of SMT to mobilization in 100 patients suffering from mechanical neck pain. Fifty-two patients received SMT and forty-eight received mobilization. The results of this study indicated that there was an 85% improvement in the SMT group and 69% in the group who received mobilization. There was a decrease in pain intensity and both groups showed an increase in cervical range of motion in all three planes, with the manipulation group experiencing a greater improvement. According to the results of this research, it can be concluded that the SMT is to a large percentage effective in treating mechanical neck pain (Cassidy *et al*., 1992a,b), however there was no follow up on this study to evaluate the duration of its effectiveness.

With the knowledge that spinal manipulative therapy is effective in relieving cervical pain of mechanical origin (Cassidy *et al*., 1992 a,b) and that the musculature not only ensures stability of the joint but may also alter the posture and functioning of the joint (Hammer, 1991; Panjabi, 1992a; Liebenson, 1996 and Lee, 2004), research on combining treatments for both joints and muscles to reach a single goal can proceed.

2.8.2. Myofascial pain syndromes and Manipulative therapy.

Triano (1992) and Pooke (2000) have researched treating myofascial pain syndromes via SMT. Triano (1992) investigated the biomechanical effects of the spinal manipulation and found that high velocity spinal manipulations performed on the cervical spine also had a reflex response in the neck musculature. According to unpublished research done by Pooke (2000), spinal manipulation to the primary segmental area of innervation to a muscle had similar improvements as dry needling of the trigger points in the muscle. Levator scapulae, rhomboids, supraspinatous, infraspinatous and deltoids were the muscles researched in this study. Both treatments showed a reduction in terms of pain and a decrease in disability. SMT, thus has a reciprocal effect on the muscles (Pooke, 2000).

With this knowledge in mind the connection between the cervical spine and the muscles involved in the upper-cross syndrome can be highlighted. The muscles, according to Liebenson (1996), and their innervations (Moore and Dalley, 1999) are illustrated in the Table 2.2 below:

Table 2.2 Muscles and their Innervation

MUSCLE	INNERVATION
Trapezius	Spinal root of the accessory nerve and C3 and C4 nerves
Levator scapulae	Dorsal scapula nerve (C5) and cervical nerves C3, C4
Pectoralis Major	Lateral and medial pectoral nerves and spinal nerves C5-T1
Serratus Anterior	Long thoracic nerve (C5-C6)
Rhomboids	Dorsal scapula nerve (C5)

This depicts the interlinking of the cervical joints and nerves from C3 to T1 and the muscles that are primarily involved in the upper cross syndrome.

2.8.3. Exercise and spinal manipulation

2.8.3.1. Theory behind exercise

The spine with all its ligaments attached but devoid of its muscles is a very unstable structure (Panjabi and White, 1990). This is because the muscles and their controls are required to provide stability of the spine in any given posture and to produce movements. The models according to Panjabi (1992a,b) and Lee and Vleeming (1998) identify that if there is a weakening of the muscles there will be a negative implication on spinal stability. This is because muscles are responsible for maintaining stability (Panjabi, 1992 a,b; Liebenson, 1996; Lee and Vleeming, 1998; Moore and Dalley, 1999; Richardson et al., 2002 and Lee, 2004).

Panjabi (1992) stated that if there was an increased passive neutral zone – which may, for example, be due to degeneration or trauma – then the muscles would have the potential capability to decrease the neutral zone to within normal values, thus reducing the instability (Lee and Vleeming, 1998; Richardson *et al*., 2002; Lee 2004).

Muscles therefore need to be in an optimal functioning capacity at all times to prevent instability and as a protective device if abnormal loads are intermittently added to the joints (Panjabi, 1992 a,b; Lee and Vleeming, 1998 and Lee, 2004). The purpose of any exercise is to isolate the correct muscle action and strengthen it, thus allowing this action to be applied in all daily movements as well as developing the muscles ability to maintain this position for a period of time without having detrimental effects on the surrounding joints and nervous tissue (Richardson & Jull, 1995).

2.8.3.2. Research on exercise treatments

In an unpublished study by Boden (2002), comparing the effectiveness of SMT versus SMT in conjunction with core stabilizing exercises in low back pain (LBP) patients, it was found that training core-stabilizing muscles had a definite effect on the endurance of the stabilizing muscles. Sixty patients participated in this study and were randomly assigned to each group. Measurements were recorded using the algometer (assessing the tenderness of the joints), orthopedic tests, the Oswestry low back pain disability questionnaire and the biopressure feedback unit (which measured the endurance of transverses abdominus). The findings validated that SMT is effective in treating LBP however there was not sufficient evidence to conclude whether SMT and stabilisation was more effective than manipulation alone (Boden, 2002).

Further research conducted on the effects of stabilisation exercises, was done on 204 chronic LBP sufferers by Niemisto *et al*., (2003). The participants were randomly assigned to either a manipulative treatment group or a consultation group. Both groups received a booklet on basic anatomy and physiology of the spine, ideal ergonomics for LBP patients and instructions on how to perform the stabilization exercises. The treatment group included four sessions of manipulation and stabilizing exercises, aiming to correct the lumbopelvic rhythm, over a period of four weeks. The stabilization exercises were taught to the participants by asking them to draw their stomachs in towards their spines. Simultaneously, the pressure change was measured with a biofeedback meter placed under the lower lumbar spine while the patient was in the prone position. The patients were educated on how to incorporate these isometric exercises during their daily activities. The consultation group had a single consultation, where the booklet was explained and they were advised to incorporate the activities into their lives. There was a follow up at five months as well as at twelve months. The results showed that there was a greater reduction in both pain and disability within the treatment group, in comparison to the consultation group. Both groups however, showed significant improvements. At the commencement of this study, 58% of the consultation treatment group reported daily LBP and 62% of the consultation group. This decreased at the twelve month follow up to 37% and 39% respectively. Incorporating stabilization exercises into treatments has been found to aid in LBP however to this researchers knowledge no research has been done on stabilizing the scapulae and it’s effects on the cervical spine.

McKenzie who suggested that anterior head carriage is clinically significant, developed "neck retraction exercises" that are meant to decrease patient's symptoms and improve their posture (Harrison *et al*., 1996). The exercises use a loading strategy that concentrates on the centralisation phenomenon which was defined as a change of pain location from a distal position to a more proximal position in relation to the spine (Rathore, 2003). The McKenzie method is based on the classification of conditions derived from the patients' symptoms and their responses to specific initial assessment procedures. The classifications include: Postural syndromes, Derangement syndromes and Dysfunction syndromes (Rathore, 2003). The exercises include chin retraction and cervical extensions in a supine position. The exercises are progressive in nature and as the patient achieves improvement, added resistance or traction by the practitioner, can advance the exercises (Rathore, 2003). The goal of the McKenzie Method is to teach patients suffering from neck pain how to treat themselves and manage their own pain for life using exercise techniques (Harrison *et al*., 1996). The effectivity of the McKenzie exercises was researched by Rathore (2003) in the treatment of cervical radicular pain and it was found to be effective as a short term treatment. McKenzie exercises however do not address causes of mechanical neck pain such as lack of scapula stabilisation. More research is needed into the effectiveness of these exercises with differing neck conditions (Rathore, 2003).

A case study was documented of a 56 year old man who suffered from cervicogenic headaches and was diagnosed with an upper cross syndrome. The treatment that he received included SMT and interferential myofascial release three times a week for the first two weeks. It progressed on to stretching exercises, Mckenzie retraction exercises and a physioball for proprioception which were performed daily. He was treated for seven months returning to the clinic fortnightly for SMT. The patient found relief from his chronic headaches threw this combination treatment. The treatment was defined as "low-tech rehabilitation treatment protocol" which addressed the cause, the associated dysfunctions as well as the symptoms and favourable results were achieved (Moore, 2004). With cases such as the above, further investigations into specific exercise training of specific muscles is needed to aid in the treatment of syndromes and their associated dysfunctions.

Authors such as Siler (2000), Worth (2004) and Ferguson (2006) have identified pilates as a form of exercise that promotes stabilisation and rehabilitation. Ferguson (2006) compared 3 groups of females (sedentary lifestyle, moderately active and regular Pilates attendees) and found that 83% of the Pilates group was able to isolate their transverse abdominus muscle (lumbar spine deep stabilizing muscle) when tested but only 33% of the other two groups combined achieved this. When lumbopelvic stability was tested, the Pilates group had a 42% pass rate, while both the moderately active and sedentary groups had a 0% pass rate. This supports the claims that Pilates trains the individual to locate and strengthen the muscles supporting the spine as well as focuses on correct posture. No research has yet assessed how stabilizing the scapula and retraining the upper thoracic musculature to allow for correct upper spine posture with the use of Pilates exercises, affects the cervical spine.

2.8.4 Pilates

Pilates is a system designed to condition the body as well as improve posture, muscle tone, alignment and provide flexibility by using exercises that stretch and strengthen selective muscles (Siler, 2000 and Worth, 2004). Pilates is designed as a programme that will work in conjunction with other exercise programmes to strengthen, rebalance and realign the body. Pilates trains the individuals to identify their own musculoskeletal strengths and weaknesses and equips them with the knowledge to correct and rebalance their entire body mechanics (Worth, 2004) thus, focus is also placed on improving personal body awareness which further decreases the risks of strain or injury that can occur with imbalances (Worth, 2004). This became a popular method of rehabilitation in the 1990's among practitioners dealing with orthopaedic, geriatric and chronic pain patients. This popularity of pilates may be due to it's potential to change the shape of an individuals body with very little impact on their joints (Worth, 2004). Pilates is aimed at challenging the neuromusculoskeletal system and it is progressive by design so that both beginners and advanced candidates will benefit equally (Anderson and Spector, 2000).

When a specific site demonstrates a "motor control 'weak link' ", the muscles are thus functioning insufficiently. Movement patterns can be retrained to reduce the deficit in performance and control (Comerford, 2007). Local muscles work in tandem with the more superficial global muscles and together they support the spine and any movement (Siler, 2000). With this improved posture and stability one is able to use the body more effectively and efficiently while taking part in daily activities, due to the muscles being strengthened and lengthened (Worth, 2004).

Participants may see immediate changes within their body's alignment and positioning but on average most people notice improvements in their posture, strength and flexibility within 6-10 sessions of Pilates (Worth, 2004).

There are advantages and disadvantages to all exercises. With Pilates, Worth (2004) has outlined the following:

Benefits of Pilates	
1	Improves mind and body awareness
2	Improves balance and increases strength
3	Focuses on correct body alignment
4	Improves stability, flexibility and joint mobility
5	Exercises muscles without causing pain, risking muscle tears or jarring of joints
6	Enhances muscle control
7	Stretches and lengthens shortened and dysfunctional muscles
Disadvantages of Pilates	
1	It is costly to take lessons at a Pilates studio
2	Not much focus is paid to the extremities as these exercises specialise on the spine and trunk
3	Not sufficient cardiovascular exercise on its own. Further exercise regimes need to be incorporated into participants lives.

2.9. The Conclusion

There is a large of body of evidence supporting the interlinking of subsystems: muscle, joints, nerves and emotions (Lee and Vleeming, 1998 and Lee, 2004). Researchers (Lee and Vleeming, 1998; Panjabi and White, 1990; Lee, 2004) have stated that when mechanical neck pain is present one or more components of the stabilising system are affected, as pain is merely a symptom of a dysfunction (Liebenson, 1996).

Muscles are the stabilisers of the spine (Panjabi and White, 1990). Muscles also have the potential capacity to reduce any instability (Lee and Vleeming, 1998 and Lee, 2004). Incorporating the strengthening of the stabilisers into the treatment is highly suggested. Weakened scapula stabilisers, as in the upper cross syndrome, cause anterior head carriage and poor posture (Magee, 2006). Grieve (1988) and Hammer (1991) commented that one of the greatest causes of neck pain was poor posture. The neurological link between the cervical spine and the scapula muscles is anatomically (Moore and Dalley, 1999) and clinically demonstrated (Pooke, 2000). Muscles are a key component to correct posture and thus mechanical stress and as the authors: Boden, 2002; Niemisto *et al*., 2003 and Ferguson, 2006 have shown, exercise is effective in stabilising the spine and decreasing mechanical stress.

Pilates is a system designed to improve posture, muscle tone, and alignment as well as provide flexibility (Siler, 2000 and Worth, 2004). Pilates has been demonstrated to aid in lumbar spine stability and low back pain (Ferguson, 2007). This, along with the successful results achieved in strengthening of the low back stabilisers in patients suffering from chronic LBP (Boden, 2002; Niemisto *et al*., 2003 and Ferguson, 2007) warrants an investigation into how stabilising the scapula with the use of pilates exercises affects mechanical neck pain.

Chapter Three

Materials and Methods

3.1. Introduction

This chapter gives a detailed description of the methods employed in the data collection from the subjects and the interventions utilized, as well as the methods of statistical analysis and the process by which the data was evaluated.

3.2. Study Design

This study was a quantitative clinical trial comparing SMT (spinal manipulative therapy) alone to SMT and the use of scapula stabilization through pilates exercises (Appendix K) conducted on 30 chronic mechanical neck pain patients.

3.3. Advertising

Participants were sourced for the purpose of this study by means of advertisements (Appendix A), which were posted and handed out around the DUT campus and placed at local Pharmacies and Libraries – with permission of the respective authorities.

3.4. Subjects

3.4.1. Sampling

This study utilized the convenience sampling technique as the pilates classes were allocated two specific time slots (10:30 am – 11:30am, Monday and Wednesdays) weekly which posed a restraint for the sample population. A total of thirty participants formed the sample group for the study, which were divided into two groups, A and B. Both groups received six spinal manipulative treatments over a period of four weeks (Haldeman *et al.*, 1993). The treatments were scheduled twice a week for the first two weeks and then once a week for the following two weeks. The cervical joints to be manipulated at each consultation were determined by motion palpation. Group B attended two pilates classes a week (for four weeks, commencing the week of the initial consultation) concomitantly. These classes taught scapula stabilization exercises to correct the upper cross syndromes. All subjects volunteered as per prevailing ethical requirements, and two withdrew from the study after being unable to adhere to the follow up consultation times as stipulated in the Information Letter (Appendix B) provided at the start of the study. These participants were replaced promptly so that the requirements of the study were met.

3.4.2. Subject Screening

The participant evaluation and selection process began with an initial telephonic interview where pertinent questions were asked to determine eligibility for the study and into which sub-group the participant would be included. These questions included:

► *How old are you?*
Participants had to be between the ages of 18-45 years. This avoided the need for parent or guardian consent (if under the age of 18) (Giles and Singer, 1998) and spondylosis and or osteopenia (Yochum and Rowe, 2005; Magee, 2006).

►*Where is the pain?*
The pain needed to be primarily in the cervical region and/or upper trapezius muscle.

►*How long have you experienced this pain?*
The participant had to have experienced this pain consistently or intermittently for more that 50 days (7 weeks) for it to be classed as a chronic condition according to Quebec scheme of classification (Haldeman *et al.,* 1993).

►*Have you experienced any recent trauma, suffer from arthritis or any known metabolic disorders?*
This would have helped to rule out any patients contraindicated to manipulation identified by Gatterman (1990).

If the candidate was successful at the telephonic interview, an initial consultation with the researcher was then scheduled where further evaluations were performed in order to determine whether the remainder of the inclusion criteria were fulfilled.

3.4.3. Inclusion Criteria

The following inclusion criteria were adhered to in order to increase homogeneity in the study and ensure all participants accepted into the study suffered from chronic mechanical neck pain:

1) The participants were between the ages of 18-45 years
2) The participants were diagnosed with chronic (more than 7 weeks) mechanical neck pain.
3) The participants needed a numerical pain rating scale score between 3-8 (Bolton and Wilkinson, 1998) as only moderate pain candidates were used to help homogenous the group.
4) The participants were diagnosed with upper cross syndrome (Liebenson, 1996) i.e. they presented with anterior head carriage, hypertonic and hypotonic muscle imbalances and weak scapula stabilisers.
5) The participants had read the Information Sheet and signed the Informed Consent Form.
6) The participants had to be able to attend the scheduled pilates classes (Group B).

3.4.4. Exclusion Criteria

Individuals were excluded from this study if

1) The participants were younger than 18 or older than 45 years
2) The participants neck pain was not of a mechanical origin e.g. trauma
3) The participants had experienced any recent trauma (within 3 months of the initial consultation)
4) The participant's primary complaint was that of headaches or facial pain.
5) If suffering from dizzy spells
6) Any contra-indication to manipulations were found (Gatterman, 1990)
   - vertebral malignancy
   - vertebral-basilar insufficiency
   - bone infections
   - fractures
   - joint hypermobility
   - clotting disorders
   - osteopenia
   - spondlyoarthropathies
7) Any contra-indications to pilates were found: pregnancy, hypertension,

osteoporosis and spinal tumors.

8) If the participant had any sort of structural abnormality e.g. Scoliosis or had a positive Adams test[2].
9) Any participants who were taking anti-inflammatory or muscle relaxant medication had to have a three day "wash out" period before participating in the study (Seth, 1999).
10) Any participants who failed to comply with the Consent Form was excluded.
11) Participants were not to receive any other form of treatment for the entire duration of the study, and if there were any major lifestyle changes (e.g. rigorous exercise) while they were involved with the study, that participant was excluded from the study.

This study's participants had no further limitations e.g. ethnicity, race or occupation.

3.5. Intervention

Once the participant had been accepted and met the inclusion criteria an initial consultation was arranged. At the initial consultation the participant received an Information Sheet describing the nature and purpose of this clinical trial and signed an Informed Consent Form (Appendix B) prior to the initial treatment, thus ensuring an understanding of the involvement in this study. The initial consultation included a full case history, physical examination and cervical regional examination.

The measurements for this study were recorded onto data sheets (Appendix I and J) at the three measurement intervals (First, sixth and seventh consultation). The patients completed the Numerical Pain Rating Scale (Appendix G) at all seven consultations and the CCMC neck Disability Index (Appendix H) at the first, sixth and seventh consultation. Active range of motion of the cervical spine was measured with the use of the CROM (Youdas *et al*., 1991; Rheult *et al.*, 1992). One digital photograph was taken in an anatomically lateral view at three measurement intervals. The reliability of this method has not bee researched. The following

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[2]Adams Test is an orthopedic test that is used to differentiate a functional scoliosis from a structural scoliosis. The doctor stands behind the patient as they bend forward to touch the floor and observes the levels of the rib cage. A true positive is indicated by a rib hump, which is indicative of a structural scoliosis. The rib hump disappears in a functional scoliosis with the change in position (Vizniak, 2002 and Magee, 2004).

scapula stabilization tests were used to identify improvements in the target muscles: The Lennie test and Lateral Scapula Slide test evaluated the symmetry and position of the scapula and the Scapula Squeeze test tested the endurance of the muscles. Although these are reputable tests (Magee, 2006) the reliability and use within research have not been researched and the researcher, for the purpose of this study, sourced these tests.

Motion palpation was performed during the cervical regional exam and at each consultation in order to determine the levels and sides of vertebral restrictions. The diagnostic criterion for mechanical neck pain according to Bergmann (1993) was used to identify the joint fixations and to deduce the direction of decreased motion. SMT was administered to dysfunctional cervical joints that presented at each consultation.

Group A received SMT treatments six times over a period of four weeks (twice for the first two weeks and once a week for the third and fourth weeks). Group B received the same SMT treatment as well as concurrent pilates exercise (Appendix K) training twice a week for four weeks to teach scapula stabilization.

The patients were informed that, if at any stage they wished to leave the study they were free to do so. All patient information was confidential and no patients were co-erced into participating in the study.

3.6. Treatments

3.6.1. Spinal Manipulative Therapy (SMT)

This therapy is mainly used in treating articular dysfunctions with the use of a manipulation (Liebenson, 1996). Both groups received SMT after motion palpation and the dysfunctional joints were identified (Bergmann, 1993). The manipulation treatment protocol was in accordance to Haldeman *et al*., (1993) for chronic mechanical neck pain, which states that over a four to six week period, six to eight treatments should be scheduled.

The participants were generally supine for manipulative therapy. Manipulations were administered to the presenting fixated joints only.

3.6.2. Pilates

The specific pilates exercises that were incorporated into the retraining of the scapula stabilizers are outlined in Appendix K (Marais, 2008). The Pilates classes were held at Pilates House, Silverton Road, administered by an advanced Pilates instructor, trained in the classical (New York) method. All appointments and lessons were scheduled and given to the participant at the first consultation for the duration of their research participation. If the patient had an adverse reaction to the manipulative therapy, pilates exercises or any other part of the study, they were excluded from the clinical trial and managed accordingly i.e. referred to another student within the clinic or referred to a more relevant practitioner.

3.7. Measurements

3.7.1. Frequency

The data collected comprised of both objective and subjective measurements and was documented at three measurement intervals: prior to the first SMT at the initial consultation in the first week, after the sixth SMT consultation in the fourth week and at the follow up consultation in the fifth week of the research. These were recorded on data collection sheets (Appendix I and J)

3.7.2. Objective measurements

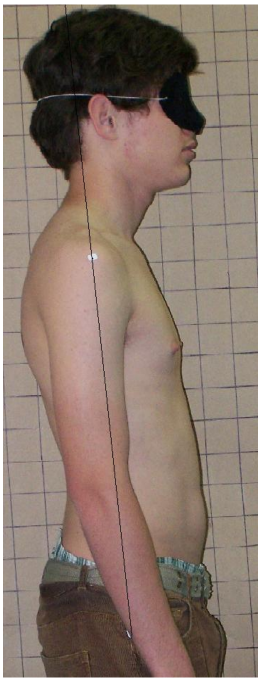
3.7.2.1. Cervical Range of Motion (CROM) Goniometer

Active range of motion in the cervical spine was measured using the CROM goniometer. This instrument was chosen as it has been demonstrated to be reliable in measuring cervical range of motion in both intra and inter-examination scales (Rheult *et al.*, 1992). This device measures active movements of the cervical spine in all three planes.

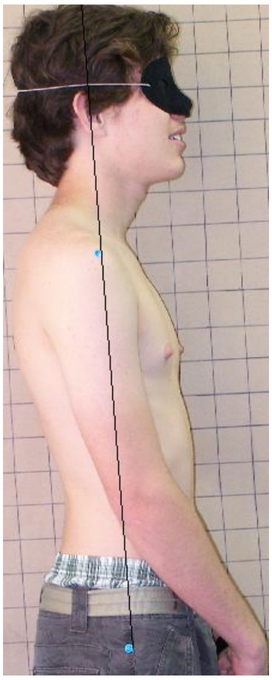
While taking measurements the participant needed to be seated in a straight back chair with their back pressed against the back of the chair (Youdas *et al*., 1991). The CROM was then fastened to the participant's head and the magnets were placed around the neck. The participant was then asked to move the head and neck in one direction only (the participants shoulders and body were to remain stationary) as far as possible without experiencing discomfort. Measurements were then taken in degrees for each one of the six directions of movement and recorded on the data sheet (Appendix I) and then later transferred on to spreadsheets for further statistical analysis.

3.7.2.2. Postural Analysis via Digital photography

The ideal standing position viewed from the side is a plumb line that passes through the ear lobe, midway through the shoulder joint, midway through the trunk, through the greater trochanter and slightly anterior to the midpoint of the knee, as well as slightly anterior to the lateral malleoli (Kendall, 1993). Photographs were taken at the stated intervals to assess the improvements in the patient’s posture. A lateral view of the patient was taken and the measurements recorded on the data sheet (Appenidx J).



Poor posture with
anterior head carriage
(Initial)



Improved posture
with a more centered plumb line
(Follow –up)

The measurements included the distance between the external auditory meatus (EAM) and the plum line and the angle formed at the point of the shoulder, between the EAM and the plum line. The patients were placed in the same place in a specific room, identified prior to the research commencing. A line drawn on the floor was used to position the patient so as to obtain the same position in each measurement session. The camera was placed on a tripod in the same position for each image and the tripod remained in a constant position throughout the research. Female participants were asked to wear tight fitting clothing (ski pants, tight fitting tops and a unitard was available should their clothing not have been appropriate). The male participants were asked to remove their shirts for the postural analysis photograph so that measurement points were not obscured. The participants were given an eye mask to cover the eyes in the photographs and thus maintain anonymity. A 5cm by 5cm grid pattern was placed behind the patients in the photographs and used for measurement scales when analysing the pictures. Drawing a perpendicular line from the EAM to the plumb line and calculating the distance, with the use of the scale of the photograph, measured the distance between the EAM and the plumb line. When working out the angle between the EAM and the plumb line from the point of the shoulder, a trigonometry formula was used:

Tan θ = opposite over adjacent.

Θ = the angle between the EAM and the plumb line

Opposite = the distance between the EAM and the plumb line

Adjacent = the distance between the point of the shoulder and where the perpendicular from the EAM bisects the plumb line.

This method of calculation has not been validated.

3.7.2.3. Scapula stabilisation tests

The stability of the scapula and muscular stabilisers are directly related to the cervical spine (Hammer, 1991; Kendal, 1993 and Liebenson, 1996). These tests assess the relative weakness of certain muscles involved in the upper cross syndrome by measuring distances between specific anatomical land marks and comparing left and right as well as comparing any distance changes. The stability of the scapula was tested with the use of the following special tests according to Magee (2006) at the three measurement intervals:

3.7.2.3.1. The Lennie test

This test measured the position of each scapula and compared the left to the right. Three horizontal measurements were taken in centimetres, one from the superior angle of the scapula to the spinous process of T2; the second from the root of the spine of the scapula to T4 and lastly from the inferior angle of the scapula to T7. This test measured the symmetrical positioning of each scapula in comparison to the thoracic spine. If there was unilateral weakening or nerve dysfunction, winging of the scapula would have been found and with that a difference in the distance between the spine and the left and right scapula (Moore and

Dalley, 1999). Any difference between left and right measurements greater than one cm was considered significant and the scapulae were considered to be asymmetrical (Magee, 2006).

This was a comparative test of left and right positioning of each scapula in the individual participant and there was no control against which to compare, as the measures would vary according to differences in body conformation.

3.7.2.3.2. Lateral scapular slide test

The stability of the scapula during abduction of the upper limb is measured by this test (Magee, 2006). The definition of Scapula-humeral rhythm is: - During 180˚ of abduction, there is a 2:1 ratio of movement of the humerus to the scapula, the first 120˚ of movement occurs at the glenohumeral joint and the last 60˚ at the scapulothoracic joint (Magee, 2006). The test begins with the arms next to the patients' sides (resting) and the distance between the base of the spine of the scapula and T4 and the distance between the inferior angle of the scapulae and T7 are noted on the data sheets while the patient is seated. This was the control measurement as the measures varied according to differences in body conformation. The patient was then asked to raise one arm (abduction) to 45 degrees and the same two measurements were then taken. The measures were repeated at 90 degrees and at 120 degrees of arm abduction, bilaterally. Beyond 120 degrees the scapula would start to move, as the abduction would be occurring at the scapulothoracic joint (Moore and Dalley, 1999 and Magee, 2006). There should not have been a discrepancy of more than one cm from the first measurement in the resting position to any of the abduction measurements (Magee, 2006). The scapula should have remained stationary against the thoracic cage if the stabilising muscles (trapezius, rhomboids and serratus anterior) were functioning optimally (Magee, 2006). Therefore, this test measured whether the stabilising muscles were functioning optimally and allowing minimal movement to occur at the scapula within the first 120 degrees of arm abduction.

3.7.2.3.3. Scapular Isometric Pinch test

The patient was asked to stand and to actively retract their scapulae together as hard as possible (pinching the scapulae together). The arms were not permitted to assist in the "pinching" and were to remain at the participants' sides. The scapula retraction muscles, which include the middle and lower fibers of the trapezius, rhomboids and serratus anterior (Liebenson, 1996), were being tested for endurance and point of fatigue. Magee (2006) stated that this contraction should be held for 15-20 seconds without the patient experiencing burning pain or obvious muscle fatigue. The researcher timed the patient, with the use of a stop watch, from the point of the contraction initiation to the point were the participant mentioned muscle burning or discomfort. The researcher was also aware of any muscle fatiguing signs and the recruitment of other muscles to help with the pinch and stopped timing if any of these signs were observed. This test was performed at all three measurement intervals to observe improvements in the muscles endurance.

3.7.3. Subjective Measurements

3.7.3.1. Numerical pain rating scale (NRS)

A number of subjective and objective measurement methods have been devised to measure pain (Van der Merwe, 2008). Subjective methods appear to be more satisfactory than objective methods as pain perception differs from participant to participant (Liggins, 1982). Several methods of subjective measurement have been reviewed.

This scale was used to measure the subjective pain rating of the participant with their interpretation of the pain intensity being given a numerical rating. The NRS scale consists of a 0-10 scale with numbers being allocated in ascending order according to reported pain intensity and had the advantage that it is relatively easy for the patient to understand and use (Appendix G) (Liggins, 1982).

This scale was compared to five other methods of rating the intensity of clinical pain and they all yielded similar results within each of the participants (Jenson *et al*., 1986). Thus implying that this was an accurate means of assessment for clinical pain.

3.7.3.2. CMCC Neck Disability Index.

This specifically designed index fulfils the need for a measurement tool that subjectively measures “reduced activities of daily living in patients with neck pain” (Liebenson, 1996). Vernon and Moir (1991), who were the designers of this measuring index, demonstrated that there was a high degree of validity and internal consistency with the CMCC neck disability index. It consists of 10 sections, which each contains six options, that have rating scores ranging from zero (for the first option) to five (for the last option) (Appendix H). The participant answered this questionnaire and received a total score out of fifty and this score was calculated as a percentage. This percentage then reflected the patients' disability at the varied measuring intervals.

This questionnaire is applicable to a wide age range and is unaffected by gender or ethnicity (Vernon and Moir, 1991). The results of this questionnaire, which were answered at all three measurement intervals, were recorded and placed on spreadsheets for statistical analysis.

3.8. Statistical Analysis

Statistically measurements were drawn from both objective and subjective tests.

The statistical analysis was completed under the guidance of a statistician from the University of KwaZulu-Natal Medical School, Mrs Tonya Esterhuizen. The subjective data was obtained using the Numerical Pain Rating Scale (Appendix G) and the CMCC Neck Disability Scale (Appendix H). The objective data was obtained using the CROM, Postural analysis and Scapula Stabilisation tests and documented on the data collection sheets (Appendix I and J). Data collection was of numerical value from which statistics were developed and the conclusions were drawn.

Data was entered and analysed in SPSS version 15 (SPSS Inc. Chicago, Ill, USA). All outcome measures were quantitative. Repeated measures ANOVA was used to assess the presence of a treatment effect. Repeated measures ANOVA testing was used to assess the presence of a different effect for each outcome measure over time between the two treatment groups.

A statistically significant time*group effect indicated a significant treatment effect. The minimum significance level was 0.05. The trends and direction of the effect were assessed via profile plots.

Chapter Four

Statistical methods and Results

4.1. Introduction to Statistical methodology

SPSS version 15.0 (SPSS Inc., Chicago, Illinois, USA) was used to analyse the data. A *p* value < 0.05 was considered as statistically significant.

Both inter and intra group comparisons were completed. Repeated measures ANOVA testing was used to assess the effects of time (3 time points: first, sixth and seventh) in the intra-group analyses. To assess the effect of the intervention (chiropractic and Pilates relative to chiropractic alone) a time by group interaction effect in the inter-group analyses was used. This was performed on subjective and objective quantitative outcomes respectively. The direction and trend of the treatment effect was assessed using profile plots.

4.2. Results

The patients participating in Group A, were the reference group and received SMT only. Patients participating in Group B received SMT as well as four weeks of pilates scapula stabilisation exercise training (the intervention group).

4.2.1. Demographics

Thirty participants were subdivided into two groups of 15 respectively. As this was not a randomised study and participants were allocated to groups according to convenience, differences in the demographics may have existed and influenced the outcome measures of this study. Therefore, the demographics (Table 4.1) are comparatively tabulated in accordance to each treatment group as well as the total within the study. There are a statistically significant different proportion of males and females in the two groups ($p = 0.028$), with the chiropractic and pilates group being female predominant and the chiropractic only group being male predominant. Ethnic distribution was the same in each group ($p = 0.363$) and so was age ($p = 0.761$). The mean age for the study was 27.7 years with a range of 19 - 44 years of age.

There were a variety of occupations in each group, the most common being students. These were not compared statistically since there were too many categories with to few responses.

Table 4.1: Demographic characteristics of the treatment groups and total sample.

		Chiropractic Group A		Chiropractic + Pilates Group B		Total		p value
		Count	Column %	Count	Column %	Count	Column %	
Gender	Female	5	33.3%	11	73.3%	16	53.3%	
	Male	10	66.7%	4	26.7%	14	46.7%	0.028
Ethnicity	Black	1	6.7%	0	.0%	1	3.3%	
	Coloured	0	.0%	2	13.3%	2	6.7%	
	Indian	3	20.0%	2	13.3%	5	16.7%	
	White	11	73.3%	11	73.3%	22	73.3%	0.362
Age		27.3 (7.1)		28.1(7.2)		27.7 (7.0)		0.761
Occupation	Accountant	1	6.7%	0	.0%	1	3.3%	
	Administrator	1	6.7%	0	.0%	1	3.3%	
	Beautician	0	.0%	1	6.7%	1	3.3%	
	Broker	1	6.7%	0	.0%	1	3.3%	
	Hair dresser	1	6.7%	0	.0%	1	3.3%	
	homeopath	0	.0%	1	6.7%	1	3.3%	
	House wife	0	.0%	2	13.3%	2	6.7%	
	Lawyer	1	6.7%	0	.0%	1	3.3%	
	Manager	1	6.7%	0	.0%	1	3.3%	
	Musician	1	6.7%	1	6.7%	2	6.7%	
	Sales manager	2	13.3%	0	.0%	2	6.7%	
	Self employed	1	6.7%	0	.0%	1	3.3%	
	Shop keeper	0	.0%	1	6.7%	1	3.3%	
	Student	4	26.7%	5	33.3%	9	30.0%	
	Surveyor	1	6.7%	0	.0%	1	3.3%	
	Teacher	0	.0%	2	13.3%	2	6.7%	
	Waitron	0	.0%	2	13.3%	2	6.7%	

4.2.2. Numerical Pain Rating Scale (NRS)

The Numerical Pain Rating Scale (NRS) was tested at each chiropractic consultation and thus gave seven reading points. There was a highly significant decrease in pain in Group A ($p < 0.001$) over the seven time points.

Table 4.2: Within - subjects effects for NRS for Group A

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.038	< 0.001

There was a highly significant decrease in pain in Group B ($p < 0.001$) as well over the 7 time points.

Table 4.3: Within - subjects effects for NRS for Group B

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.096	< 0.001

Both groups showed similar responses in terms of pain levels. The general direction of response in both groups was a decrease and the slopes of the lines were similar. Chiropractics and pilates (intervention) did not have a greater effect than chiropractic alone (reference), in terms of subjective pain ($p = 0.650$).

Table 4.4: Within and Between - subjects effects for NRS

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.142	< 0.001
Time*Group	Wilk's lambda = 0.854	0.650
Group	F = 4.09	0.053

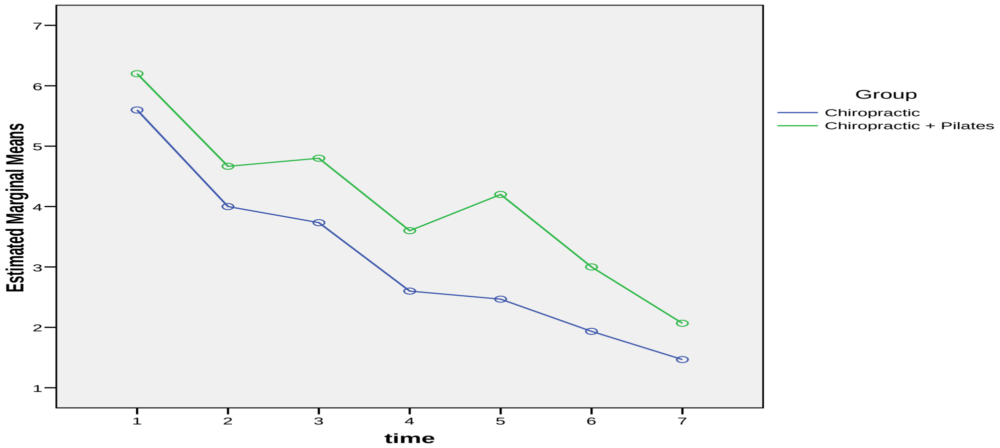


Figure 4.1: Profile plot of mean NRS by time and group

4.2.3 CMCC Neck Disability Index

The CMCC neck disability readings were taken at the three time measurement intervals: first, sixth and seventh consultations. There was a highly significant decrease in CCMC score over time in Group A ($p < 0.001$). Figure 4.2 shows that the initial decease between treatment one and treatment six was steeper than the slope between the sixth consultation and the seventh. Consideration also has to be granted to the fact that the first time interval was a period of four weeks and the last was a period of one week.

Table 4.5: Within - subjects effects for CCMC for Group A

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.224	< 0.001

There was a highly significant decrease in CCMC score over time in Group B as well ($p < 0.001$). Group B showed a decrease in the subjective ratings of CMCC with the last interval not indicating as steep as the treatment period.

Table 4.6: Within - subjects effects for CCMC for Group B

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.216	< 0.001

Table 4.7: Within and Between - subjects effects for CCMC

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.226	< 0.001
Time*Group	Wilk's lambda = 0.983	0.789
Group	F = 2.132	0.155

Both groups showed similar responses in neck disability. Both groups had slopes that decreased similarly. Chiropractics and pilates (intervention) did not have a greater effect than chiropractic alone (reference), in terms of subjective pain ($p = 0.789$).

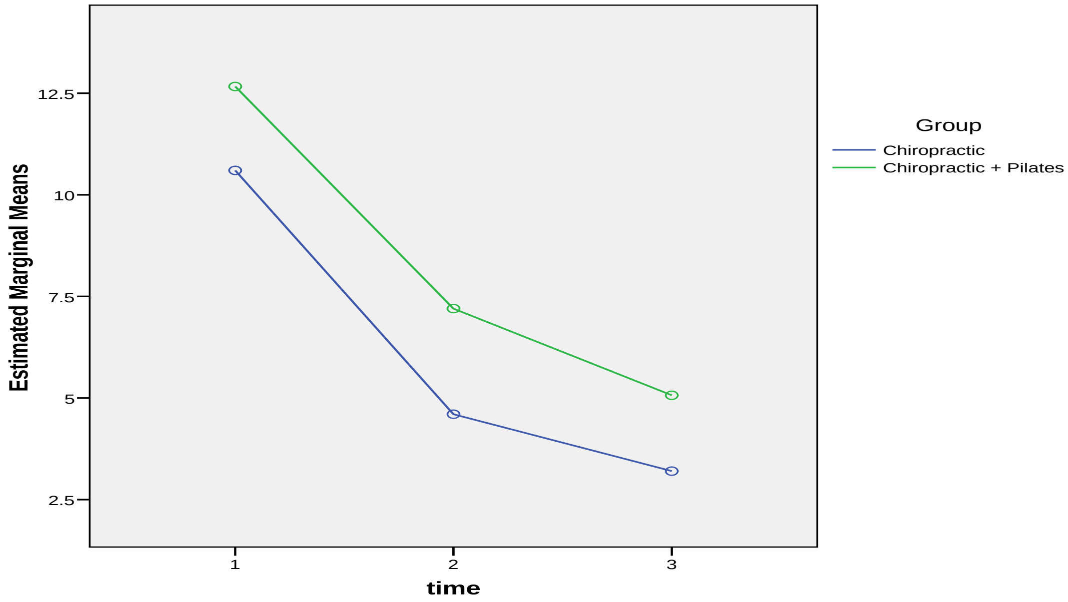


Figure 4.2: Profile plot of mean CCMC by time and Group

4.2.4. Postural Analysis

4.2.4.1. Distance from the external auditory meatus to the plumb line.

This measurement was used to assess the effects that each treatment had on anterior head carriage and subsequently assess its effect on neck pain and disability. The greater the distance between the external auditory meatus (EAM) and the plumb line is, the greater the anterior head carriage in that individual is.

There was a significant decrease in distance over time in Group A (p = 0.001). Figure 4.3 shows that the initial decrease was very steep, but after treatment there was little change.

Table 4.8: Within - subjects effects for Distance for Group A

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.346	0.001

There was an insignificant decrease in distance over time in Group B (p = 0.105). Figure 4.3 shows that the initial decrease was very steep, but it did not decrease numerically as much as Group A. Between the second and third measurement intervals there was little change in the slope.

Table 4.9: Within - subjects effects for Distance for Group B

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.707	0.105

There was no intervention (chiropractics and pilates) effect for this outcome ($p = 0.366$). Figure 4.3 shows that both groups showed a decrease over time, but the rate of decrease was significantly faster in the reference group.

Table 4.10: Within and Between - subjects effects for Distance

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.557	< 0.001
Time*Group	Wilk's lambda = 0.928	0.366
Group	F = 2.153	0.153

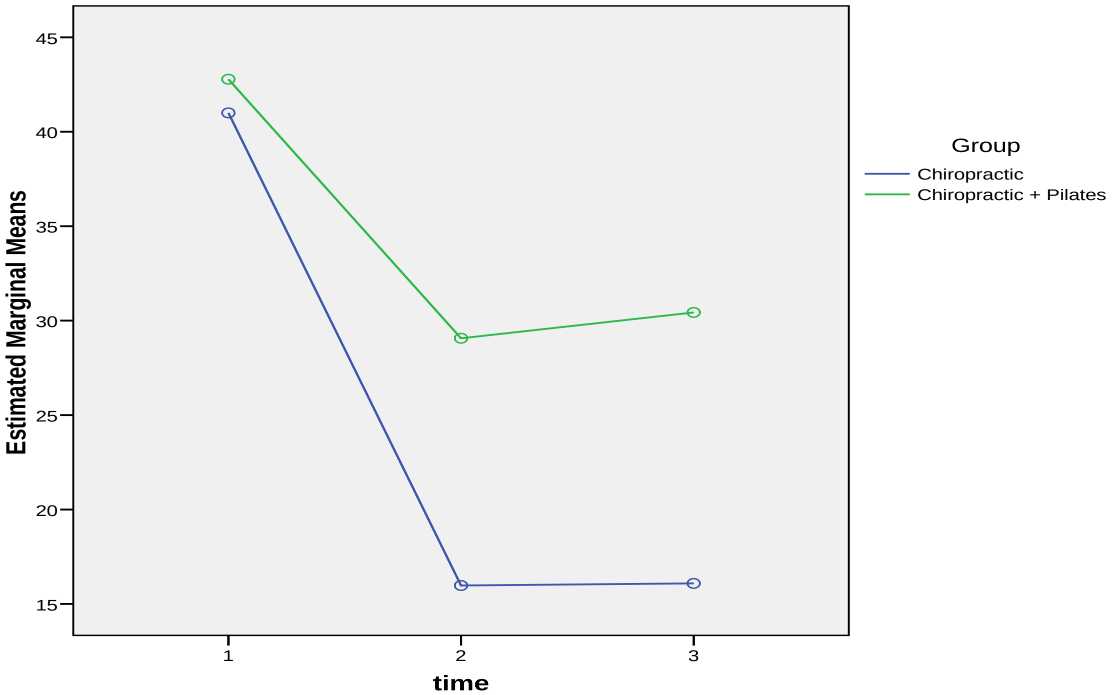


Figure 4.3: Profile plot of mean Distance by time and Group

4.2.4.2. The angle formed at the point of the shoulder between the EAM and the plumb line.

This angle was measured to give an indication of the degree of anterior head carriage and how the angle changed according to the two different treatment protocols. The greater the angle the greater the anterior head carriage disability is in that individual.

There was a significant decrease in angle over time in Group A (*p* = 0.009). Figure 4.4 shows that the initial decrease was very steep, and that there was a slight increase after measurement two during the follow up period.

Table 4.11: Within - subjects effects for Angle for Group A

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.482	0.009

There was a slight change in angle over time in Group B (*p* = 0.280). Figure 4.4 shows that the initial decrease was steep, and there was a further slight decrease after the treatment, which was, measured at the third measurement interval.

Table 4.12: Within - subjects effects for Angle for Group B

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.822	0.280

There was no intervention effect for this outcome (*p* = 0.480). Figure 4.4 shows that both groups showed a decrease over time, but the rate of decrease was faster in the reference group (chiropractics) than the intervention group (chiropractics and pilates) during treatment.

Table 4.13: Within and Between - subjects effects for Angle

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.658	0.004
Time*Group	Wilk's lambda = 0.947	0.480
Group	F = 1.56	0.222

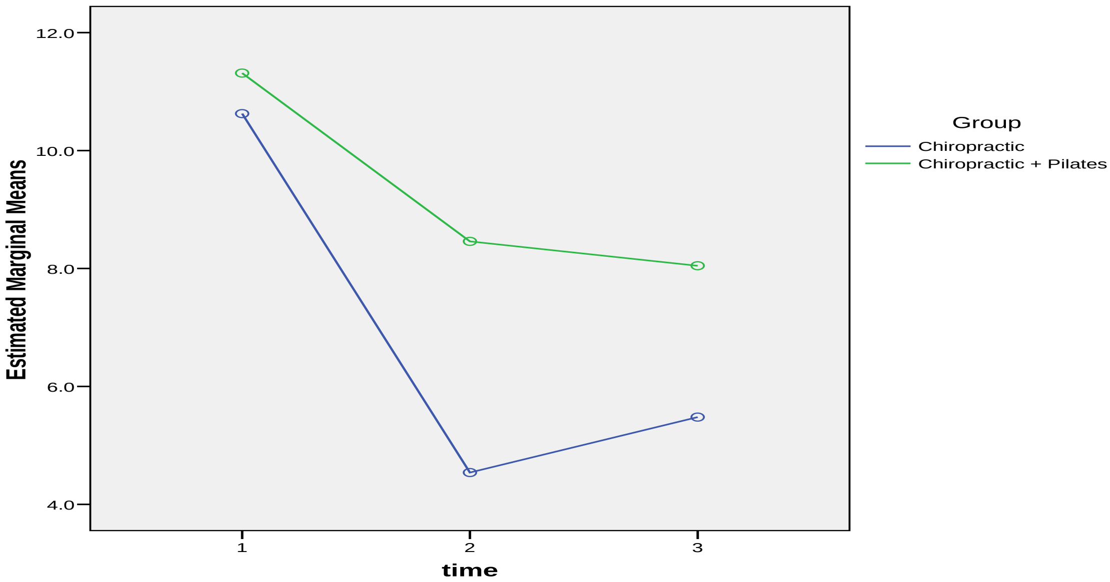


Figure 4.4: Profile plot of mean Angle by time and Group

4.2.5. Range of motion of the cervical spine

Cervical range of motion was measured in six directions: flexion, extension, left rotation, right rotation, left lateral flexion and right lateral flexion. This was measured using the CROM.

4.2.5.1. Flexion

There was a significant increase in flexion over time in Group A (p = 0.008). Figure 4.5 shows that the initial increase was very steep, and there was a slight decrease after the treatment period.

Table 4.14: Within - subjects effects for Flexion for Group A

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.477	0.008

There was a significant increase in flexion over time in Group B (p=0.022). Figure 4.5 shows that the initial increase was very steep and, it is important to note, that there was still a slight increase after the treatment period, which was measured at the third follow up interval.

Table 4.15: Within - subjects effects for Flexion for Group B

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.557	0.022

There was no intervention effect for this outcome (*p* = 0.264). Figure 4.5 shows that both groups showed an increase in range of flexion over time, but the rate of increase was faster in the reference group between measurement one and two. However, the intervention group continued to improve after treatment while the reference group decreased in motion. At measurement 3 both groups ended up with the same mean value.

Table 4.16: Within and Between - subjects effects for Flexion

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.540	< 0.001
Time*Group	Wilk's lambda = 0.906	0.264
Group	F = 0.454	0.506

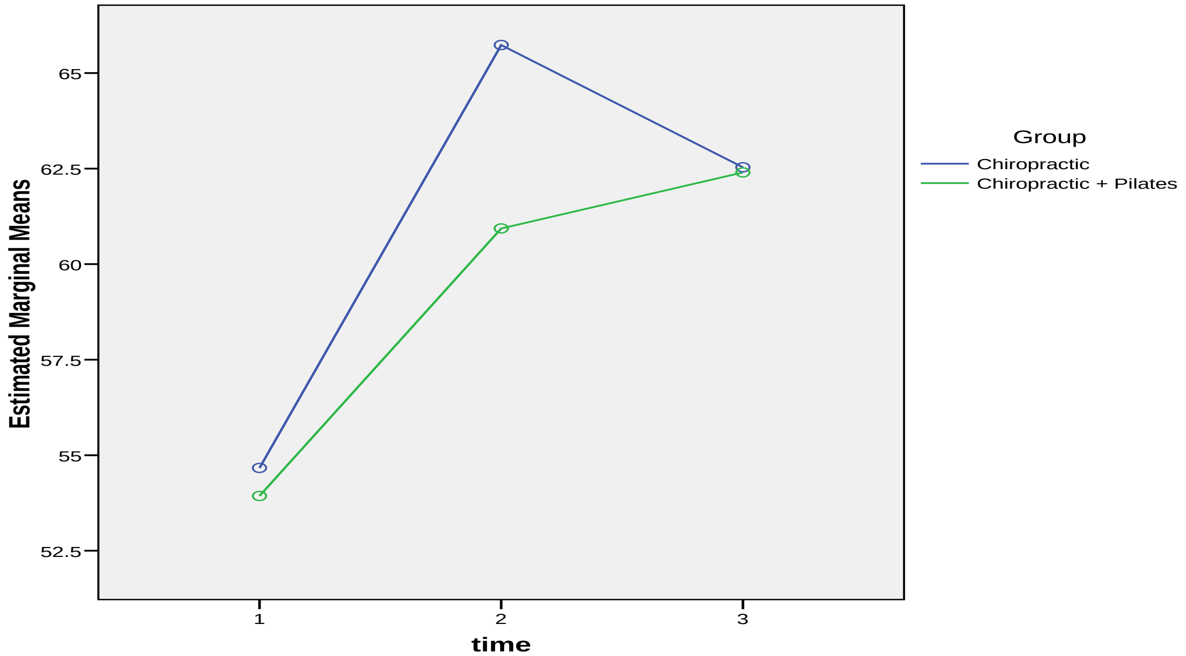


Figure 4.5: Profile plot of mean Flexion by time and Group

4.2.5.2. Extension

There was a significant increase in extension over time in Group A ($p < 0.001$). Figure 4.6 shows that the initial increase was very steep, and there was a slight decrease after the treatment period.

Table 4.17: Within - subjects effects for Extension for Group A

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.273	< 0.001

There was a significant increase in extension over time in Group B ($p = 0.012$). Figure 4.6 shows that the initial increase was very steep, and there was a slight decrease after the treatment period.

Table 4.18: Within - subjects effects for Extension for Group B

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.505	0.012

There was no significant intervention effect for this outcome ($p = 0.256$). Figure 4.6 shows that both groups showed an increase over time, but the rate of improvement was faster in the reference group during the treatment period. However, the reference group showed a faster decline after treatment than the intervention group.

Table 4.19: Within and Between - subjects effects for Extension

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.382	< 0.001
Time*Group	Wilk's lambda =0.904	0.256
Group	F = 0.299	0.589

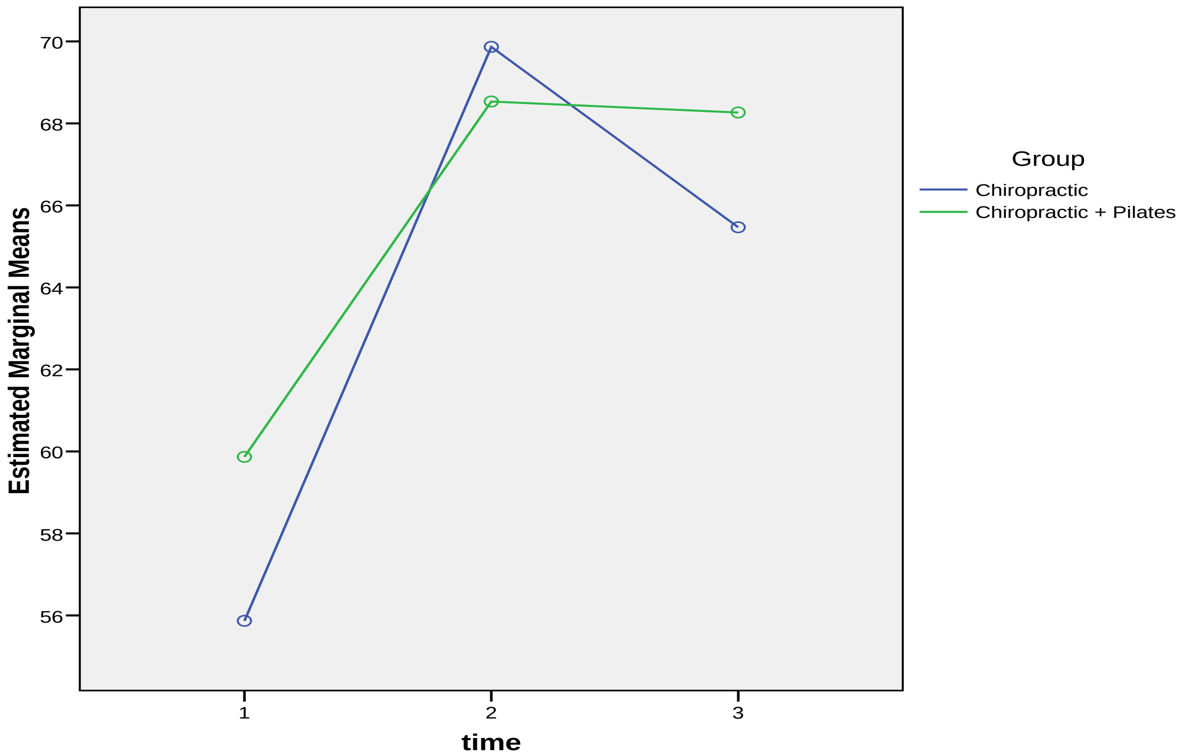


Figure 4.6: Profile plot of mean Extension by time and Group

4.2.5.3. Right rotation

There was a significant increase in right rotation over time in Group A ($p < 0.001$). Figure 4.7 shows that the initial increase was very steep, and there was a slight decrease after treatment at measurement 3.

Table 4.20: Within - subjects effects for Right rotation for Group A

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.288	< 0.001

There was a significant increase in right rotation over time in Group B ($p < 0.001$). Figure 4.7 shows that the initial increase was very steep (over 10 degrees), but there was a decrease after treatment, which did not receed to baseline value.

Table 4.21: Within - subjects effects for Right rotation for Group B

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.262	< 0.001

There was a marginally significant intervention effect for this outcome ($p = 0.047$). Figure 4.7 shows that both groups showed an increase over time, but the rate of increase was faster in the reference group than the intervention group.

Table 4.22: Within and Between - subjects effects for Right rotation

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.318	< 0.001
Time*Group	Wilk's lambda = 0.798	0.047
Group	F = 0.038	0.847

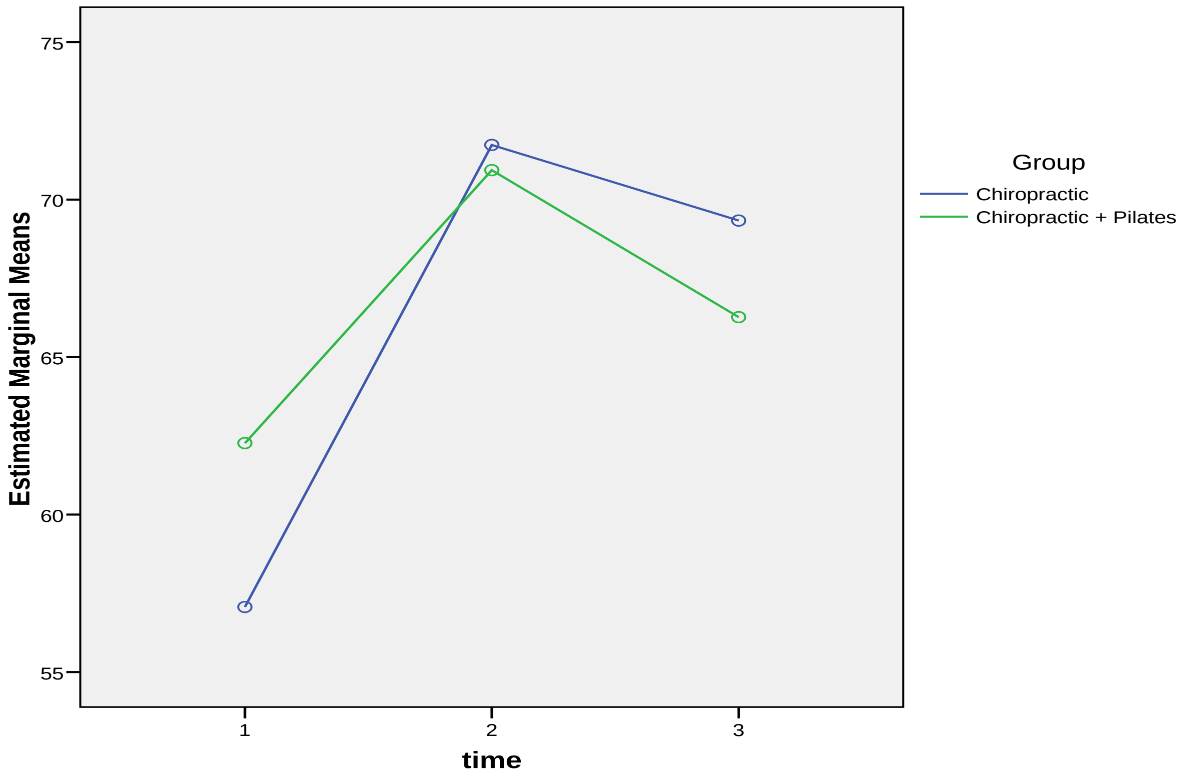


Figure 4.7: Profile plot of mean Right rotation by time and Group

4.2.5.4. Left rotation

There was a significant increase in left rotation over time in Group A ($p < 0.001$). Figure 4.8 shows that the initial increase was very steep, and there was a slight decrease after treatment at measurement three.

Table 4.23: Within - subjects effects for Left rotation for Group A

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.081	< 0.001

There was a significant increase in left rotation over time in Group B ($p<0.001$). Figure 4.8 shows that the initial increase was very steep, and there was a further slight decrease after treatment at measurement three.

Table 4.24: Within - subjects effects for Left rotation for Group B

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.276	< 0.001

There was no significant intervention effect for this outcome ($p = 0.747$). Figure 4.8 shows that both groups showed an increase over time, and the rate of increase was similar, thus the slopes of the lines were almost parallel.

Table 4.25: Within and Between - subjects effects for Left rotation

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.204	< 0.001
Time*Group	Wilk's lambda = 0.979	0.747
Group	F = 0.825	0.371

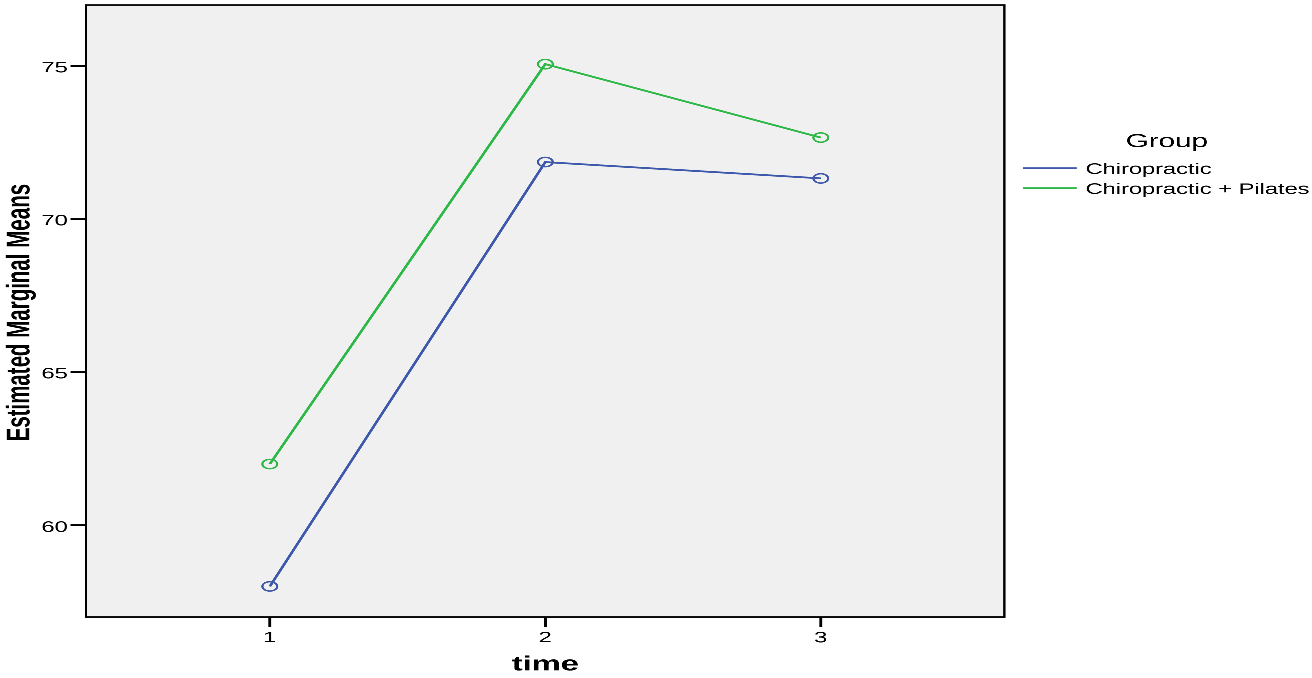


Figure 4.8: Profile plot of mean Left rotation by time and Group

4.2.5.5. Right lateral flexion

There was a significant increase in right lateral flexion over time in Group A (p < 0.001). Figure 4.9 shows that the initial increase was very steep, and there was a slight decrease after treatment at measurement three.

Table 4.26: Within - subjects effects for Right lateral flexion for Group A

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.227	< 0.001

There was also a significant increase in right lateral flexion over time in Group B (p = 0.005). Figure 4.9 shows that the initial increase was very steep, and there was a slight increase after treatment at measurement three.

Table 4.27: Within - subjects effects for Right lateral flexion for Group B

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.437	0.005

There was no intervention effect for this outcome (*p* = 0.387). Figure 4.9 shows that both groups showed an increase over time, and the rate of increase was similar, thus the slopes of the lines were almost parallel.

Table 4.28: Within and Between - subjects effects for Right lateral flexion

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.349	< 0.001
Time*Group	Wilk's lambda = 0.932	0.387
Group	F = 0.827	0.371

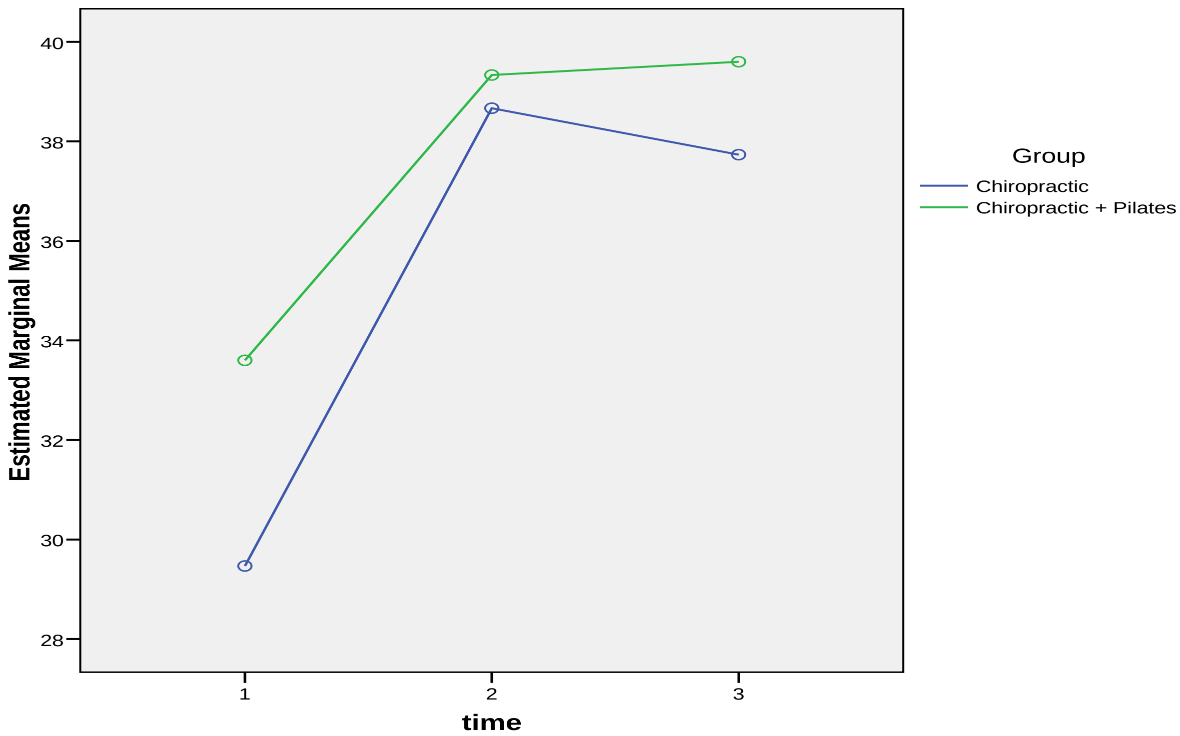


Figure 4.9: Profile plot of right lateral flexion by time and Group

4.2.5.6. Left lateral flexion

There was a significant increase in left lateral flexion over time in Group A ($p < 0.001$). Figure 4.10 shows that the initial increase was very steep, and there was a plateau after treatment at measurement three.

Table 4.29: Within - subjects effects for Right lateral flexion for Group A

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.258	< 0.001

There was minimal change in left lateral flexion over time in Group B (*p* = 0.234). Figure 4.10 shows the trend of a slight increase over time.

Table 4.30: Within - subjects effects for Right lateral flexion for Group B

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.800	0.234

There was a non-significant intervention effect for this outcome (*p* = 0.371). Figure 4.10 shows that both groups showed an increase over time, and the rate of increase was similar, thus the slopes of the lines were almost parallel and they concluded on the same mean values at measurement three.

Table 4.31: Within and Between - subjects effects for Right lateral flexion

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.602	< 0.001
Time*Group	Wilk's lambda = 0.929	0.371
Group	F = 0.215	0.647

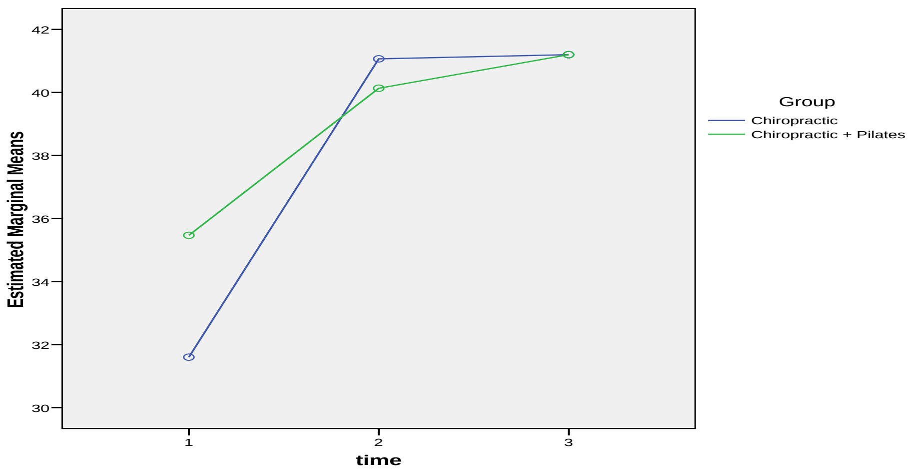


Figure 4.10: Profile plot of left lateral flexion by time and Group

4.2.6. Scapula stabilisation tests

Lennie test

The Lennie test is used to measure the position of the scapulae. It compares left to right on an individual checking for the symmetry of the scapulae. Three horizontal measurements are taken from specific spinous processes to the scapula. Symmetry in posture from left to right is optimal.

4.2.6.1. Lennie test T2

The difference in measurement between the left and right side at each time point at T2 was used in this analysis. The closer the difference was to 0 the better the outcome. There was no significant change over time in Group A (p = 0.234). Figure 4.11 shows that the difference initially decreased and then increased to above the original difference, which was closer to 0 but not significantly so.

Table 4.32: Within - subjects effects for Lennie test T2 for Group A

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.800	0.234

There was no significant change over time in Group B (p = 0.981). Figure 4.11 shows that the difference initially decreased and then levelled off.

Table 4.33: Within - subjects effects for Lennie test T2 for Group B

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.997	0.981

There was a non-significant intervention effect for this outcome (p = 0.418). Figure 4.11 shows that the groups showed slightly different trends over time but the difference was not significant.

Table 4.34: Within and Between - subjects effects for Lennie test T2

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.926	0.356
Time*Group	Wilk's lambda = 0.937	0.418
Group	F = 0.921	0.346

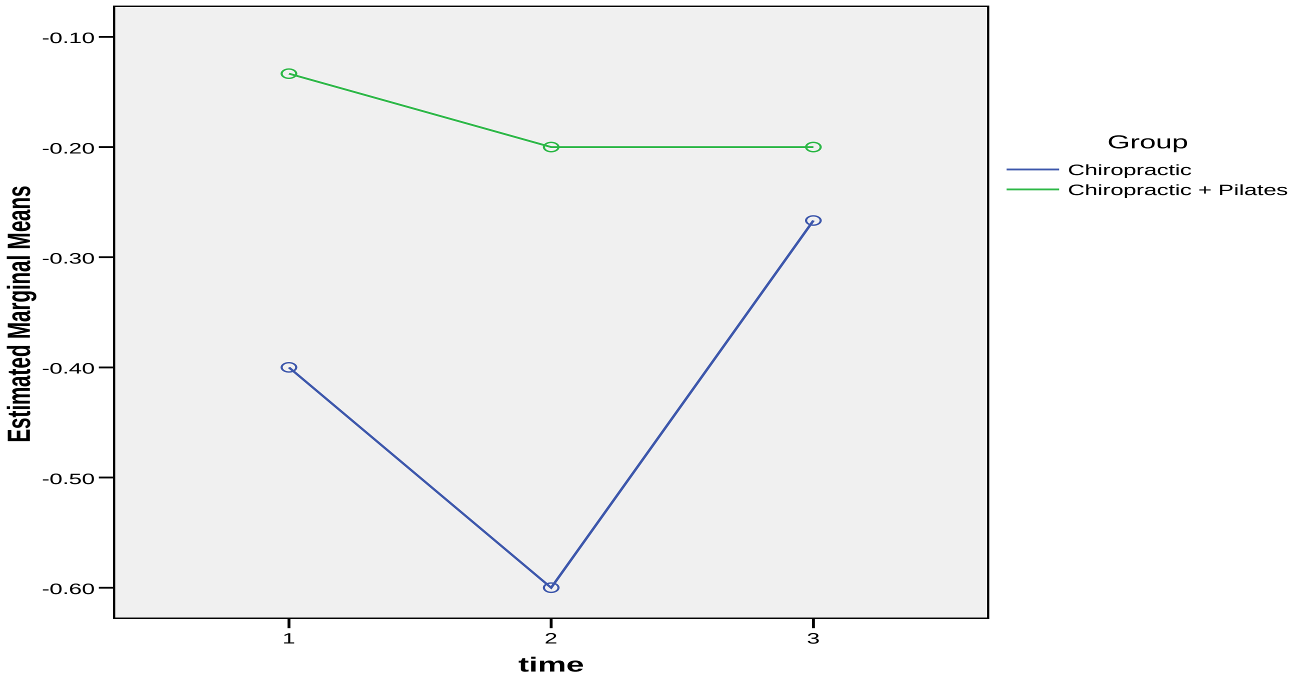


Figure 4.11: Profile plot of Lennie test T2 by time and Group

4.2.6.2. Lennie test T4

There was no significant change over time in Group A ($p = 0.861$). Figure 4.12 shows that the difference increased during treatment, which was opposite to the desired effect and returned to the baseline measurement after treatment.

Table 4.35: Within - subjects effects for Lennie test T4 for Group A

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.975	0.861

There was no significant change over time in Group B (p = 0.235). Figure 4.12 shows that the difference initially decreased then slightly increased after treatment at measurement three.

Table 4.36: Within - subjects effects for Lennie test T4 for Group B

Effect	Statistic	p value
Time	Wilk's lambda = 0.786	0.235

There was a non-significant intervention effect for this outcome (p = 0.418). Figure 4.12 shows that the groups showed slightly different trends over time. The intervention group showed an increase up to almost 0 while the reference group showed a slight increase in the distance during treatment but overall did not change much. Therefore the trends suggest that the intervention was more effective than the reference for this outcome.

Table 4.37: Within and Between - subjects effects for Lennie test T4

Effect	Statistic	p value
Time	Wilk's lambda = 0.986	0.668
Time*Group	Wilk's lambda = 0.933	0.418
Group	F = 4.019	0.056

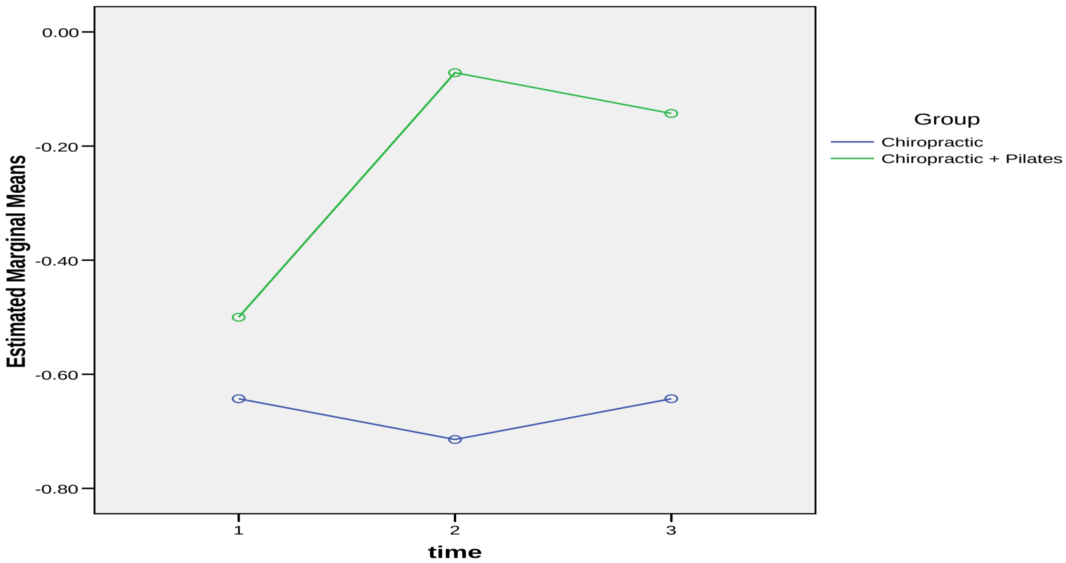


Figure 4.12: Profile plot of Lennie test T4 by time and Group

4.2.6.3. Lennie test T7

There was no significant change over time in Group A (*p* = 0.905). Figure 4.13 shows that the difference initially decreased during treatment then increased before measurement three but was still below the baseline difference and was slightly closer to 0 but not significantly so.

Table 4.38: Within - subjects effects for Lennie's test T7 for Group A

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.985	0.905

There was a marginally significant change with time in Group B (*p* = 0.047). Figure 4.13 shows that the difference initially decreased steeply during treatment and then almost levelled off to close to 0 before measurement three.

Table 4.39: Within - subjects effects for Lennie's test T7 for Group B

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.625	0.047

There was a non-significant intervention effect for this outcome (*p* = 0.214). Figure 4.13 shows that the intervention group decreased steeply up to almost 0 while the reference group did not change much. Therefore this trend suggests that the intervention was more effective than the reference for this outcome.

Table 4.40: Within and Between - subjects effects for Lennie's test T7

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.857	0.125
Time*Group	Wilk's lambda = 0.892	0.214
Group	F = 0.414	0.525

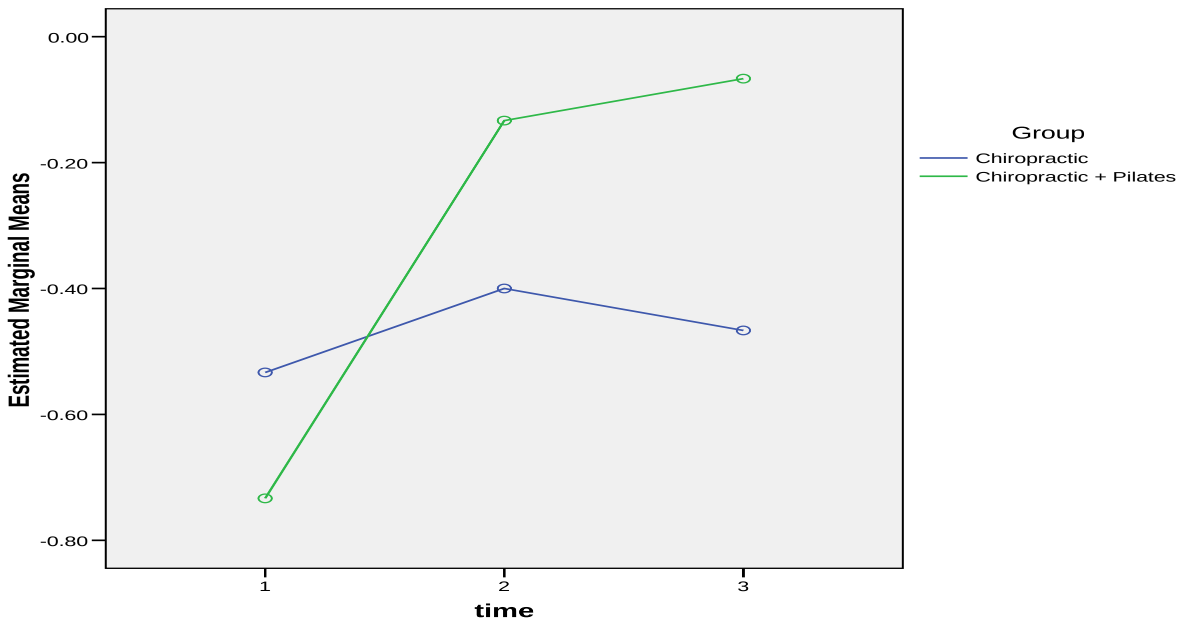


Figure 4.13: Profile plot of Lennie's test T7 by time and Group

Lateral Scapula Slide test

This test measured the stability of the scapula during glenohumeral joint movements. The patient was seated and horizontal measurements were taken from specific spinous processes to the scapula with the arm in three different positions: 45, 90 and 120 (Magee, 2006).

4.2.6.4. Scapula slide T4 45^o

There was no significant difference over time for this outcome, on the left side (*p* = 0.361). There was a statistically significant difference over time for this outcome, on the right side (*p* = 0.009). Figure 4.14 shows that there was a general decrease in the amount of movement that occurred at T4 over time. The scale of this decrease was small on the left hand side (Figure 4.14) with a fairly constant decrease on the right hand side (Figure 4.15).

Table 4.41: Within - subjects effects for Scapula slide T4 45^o for Group A

Effect	Statistic	*p* value
Left hand side		
Time	Wilk's lambda = 0.855	0.361
Right hand side		
Time	Wilk's Lambda = 0.481	0.009

There was no significant difference over time for this outcome for group B bilaterally: Left (*p* = 0.809) and right (*p* = 0.687). Figure 4.14 shows that there was an initial decrease in the distance during treatment however in the follow up there was an increase up to baseline level for group A on the left hand side. The scale of the change was small.

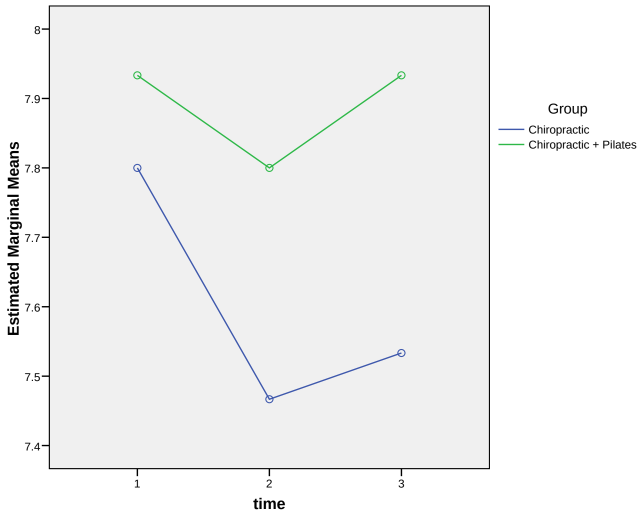
Table 4.42: Within - subjects effects for Scapula slide T4 45^o for Group B

Effect	Statistic	*p* value
Left side		
Time	Wilk's lambda = 0.968	0.809
Right side		
Time	Wilk's lambda = 0.944	0.687

There was a non-significant intervention effect for this outcome bilaterally: left (*p* = 0.796) and right (*p* = 0.369). Figure 4.14 shows that the intervention group did not change much during treatment or in the follow up on the left, while the reference group showed more of a decrease over the treatment period with a slight increase in the follow up on the left hand side. Figure 4.15 shows that both groups decreased over time on the right, but the rate of decrease was slightly faster in the reference group.

Table 4.43: Within and Between - subjects effects for Scapula slide T4 45^o

Effect	Statistic	*p* value
Left side		
Time	Wilk's lambda = 0.943	0.451
Time*Group	Wilk's lambda = 0.983	0.796
Group	F = 0.594	0.447
Right side		
Time	Wilk's lambda = 0.795	0.045
Time*group	Wilk's lambda = 0.929	0.369
Group	F = 1.016	0.322



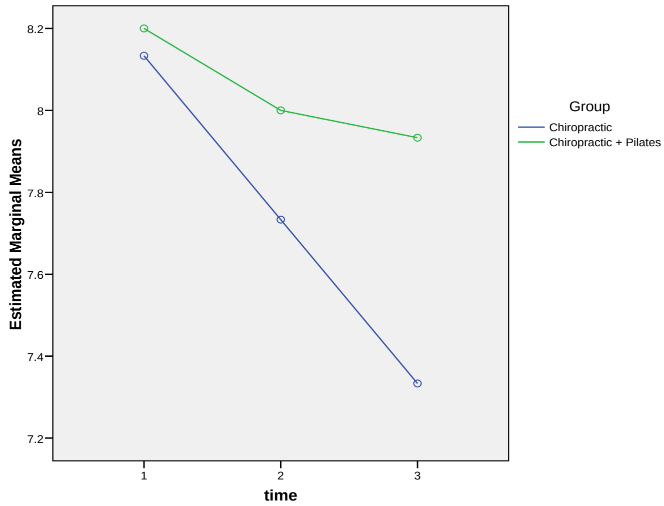


Figure 4.14: Profile plot of Scapula slide T4 T4 Left 45° by time and Group

Figure 4.15: Profile plot of Scapula slide right45° by time and Group

4.2.6.5. Scapula slide T4 90°

There was no significant difference over time for this outcome bilaterally: left (p = 0.632) and right (p = 0.226). Figure 4.16 shows that there was an initial decrease during treatment time, followed by a greater increase in the follow up measurement on the left. Figure 4.17 shows that there was an initial decrease over time, followed by a slight increase on the right hand side.

Table 4.44: Within - subjects effects for Scapula slide T4 90° for Group A

Effect	Statistic	*p* value
Left side		
Time	Wilk's lambda = 0.932	0.632
Right side		
Time	Wilk's lambda = 0.796	0.226

There was no significant difference over time for this outcome in group B bilaterally: left *(p* = 0.661) and right (p = 0.759). Figure 4.16 shows that there was a gradual increase in distance over time on the left hand side. Figure 4.17 shows that there was an initial increase in distance during treatment, followed by a slight decrease in the distance at the follow up measurement on the right.

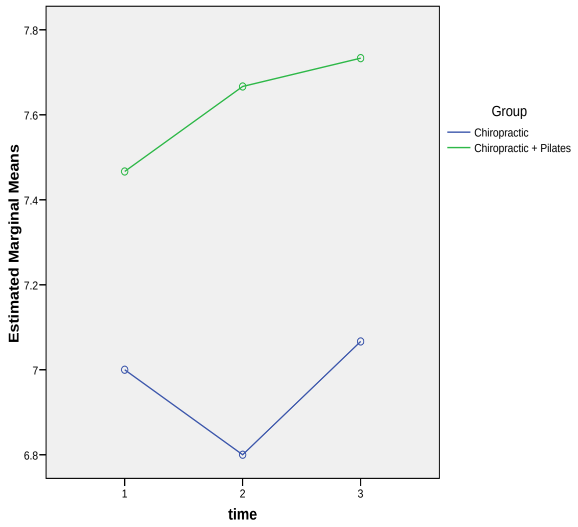
Table 4.45: Within - subjects effects for Scapula slide T4 90^o for Group B

Effect	Statistic	*p* value
Left side		
Time	Wilk's lambda = 0.938	0.661
Right side		
Time	Wilk's lambda = 0.958	0.759

There was a non-significant intervention effect for this outcome bilaterally: left (p = 0.574) and right (p = 0.228). Figure 4.16 shows that the intervention group increased slightly over time whilst the reference group decreased slightly during the treatment period and then increased at the follow and ended up not changing the distance much on the left. Figure 4.17 shows that each group was changing in a different direction. The intervention group increased over time while the reference group decreased. The difference in both slopes over time was, however, relatively minor and not statistically significant.

Table 4.46: Within and Between - subjects effects for Scapula slide T4 90^o

Effect	Statistic	*p* value
Left side		
Time	Wilk's lambda = 0.964	0.612
Time*Group	Wilk's lambda = 0.960	0.574
Group	F = 4.529	0.042
Right side		
Time	Wilk's lambda = 0.996	0.946
Time*Group	Wilk's lambda = 0.912	0.228
Group	F = 4.6	0.041



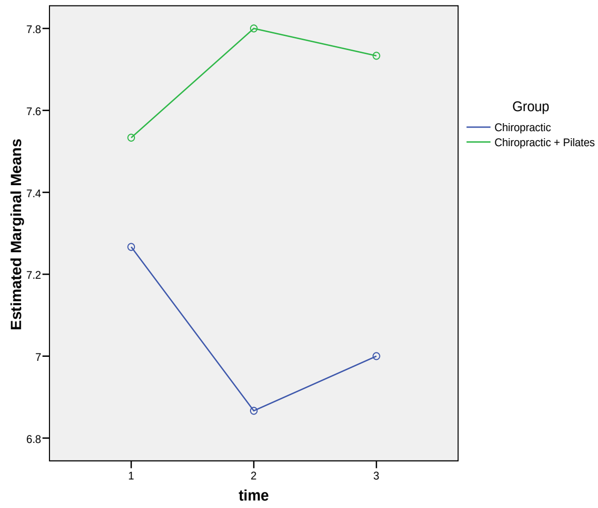


Figure 4.16: Profile plot of Scapula slide T4 Left 90° by time and Group

Figure 4.17: Profile plot of Scapula slide T4 Right 90° by time and Group

4.2.6.6. Scapula slide T4 120°

There was no significant difference over time for this outcome in Group A on the left (p = 0.356). There was a significant change on the right hand side (p = 0.018). Figure 4.18 shows that there was an initial decrease during the treatment period, followed by a further more gradual decrease at the follow up measurement on the left. On the right hand side (Figure 4.19) there was a general decrease over time, which was steeper during treatment than at the follow up measurement.

Table 4.47: Within - subjects effects for Scapula slide T4 120° for Group A

Effect	Statistic	*p* value
Left side		
Time	Wilk's lambda = 0.853	0.356
Right side		
Time	Wilk's lambda = 0.541	0.018

There was no significant difference over time for this outcome in group B bilaterally. Figure 4.18 and 4.19 shows that there was an initial increase during treatment, followed by a small decrease at the follow up.

Table 4.48: Within - subjects effects for Scapula slide T4 120^o for Group B

Effect	Statistic	*p* value
Left side		
Time	Wilk's lambda = 0.852	0.354
Right side		
Time	Wilk's lambda = 0.866	0.393

Figures 4.18 and 4.19 show that each group was changing in different directions. The intervention group increased in distance during treatment bilaterally while the reference group decreased. There was a large group effect meaning that irrespective of time, the two groups values were significantly different.

Table 4.49: Within and Between - subjects effects for Scapula slide T4 120^o

Effect	Statistic	*p* value
Left side		
Time	Wilk's lambda = 0.993	0.912
Time*Group	Wilk's lambda = 0.855	0.112
Group	F = 8.25	0.008
Right side		
Time	Wilk's lambda =0.989	0.866
Time*Group	Wilk's lambda =0.772	0.030
Group	F= 6.53	0.016

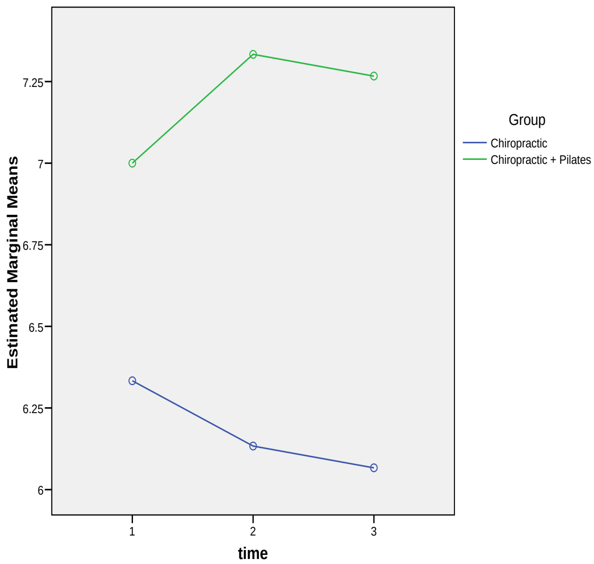


Figure 4.18: Profile plot of Scapula slide T4 Left 120^o by time and Group

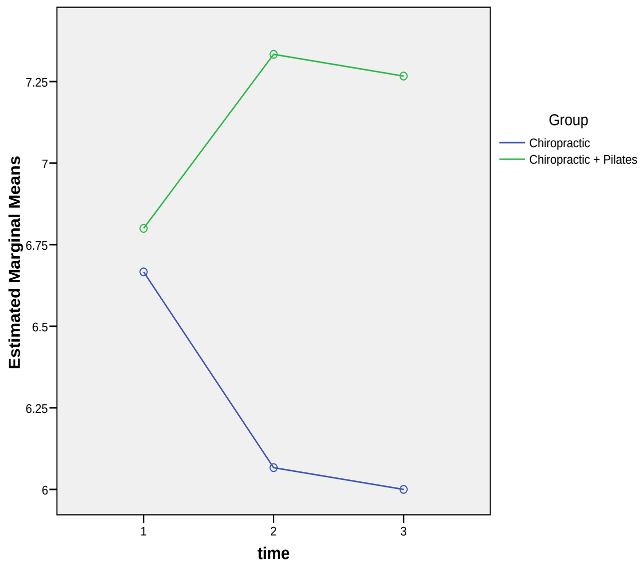


Figure 4.19: Profile plot of Scapula slide T4 Right 120^o by time and Group

4.2.6.7. Scapula slide T7 45^o

There was no significant difference over time for this outcome in group A bilaterally. Figure 4.20 and 4.21 both show that there was an initial decrease over time, followed by a slight increase.

Table 4.50: Within - subjects effects for Scapula slide T7 45^o for Group A

Effect	Statistic	*p* value
Left side		
Time	Wilk's lambda = 0.770	0.183
Right side		
Time	Wilk's lambda = 0.273	0.121

There was no favourable difference over time for this outcome in group B on the left hand side. Figure 4.20 shows that there was a general increase over time. There was a significant difference over time for this outcome in group B on the right hand side (p = 0.027). Figure 4.21 shows that there was an initial decrease during treatment, followed by a slight increase at the follow up.

Table 4.51: Within - subjects effects for Scapula slide T7 45° for Group B

Effect	Statistic	*p* value
Left side		
Time	Wilk's lambda = 0.858	0.369
Right side		
Time	Wilk's lambda = 0.575	0.027

There was a non-significant intervention effect for this bilateral outcome. Figure 4.20 shows that while the intervention group increased during treatment and at the follow up, the reference group decreased during treatment on the left. Figure 4.21 shows that the rate of change in both groups was constant and the slopes of the two lines were almost parallel on the right.

Table 4.52: Within and Between - subjects effects for Scapula slide T7 45°

Effect	Statistic	*p* value
Left side		
Time	Wilk's lambda = 0.962	0.591
Time*Group	Wilk's lambda = 0.846	0.105
Group	F=3.23	0.083
Right side		
Time	Wilk's lambda = 0732	0.015
Time*Group	Wilk's lambda = 0.974	0.698
Group	F = 2.79	0.106

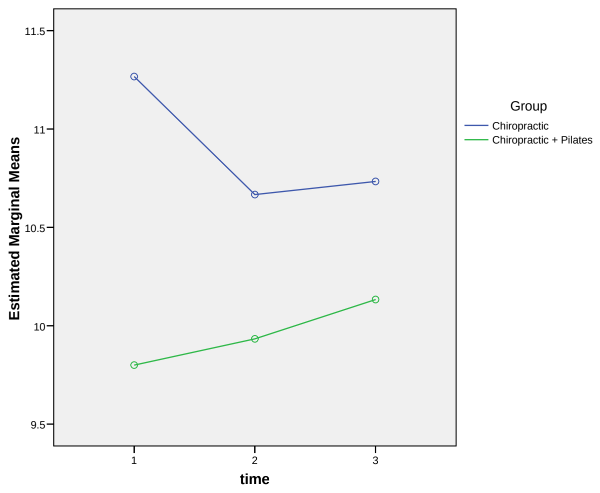


Figure 4.20: Profile plot of Scapula slide T7 Left 45° by time and group

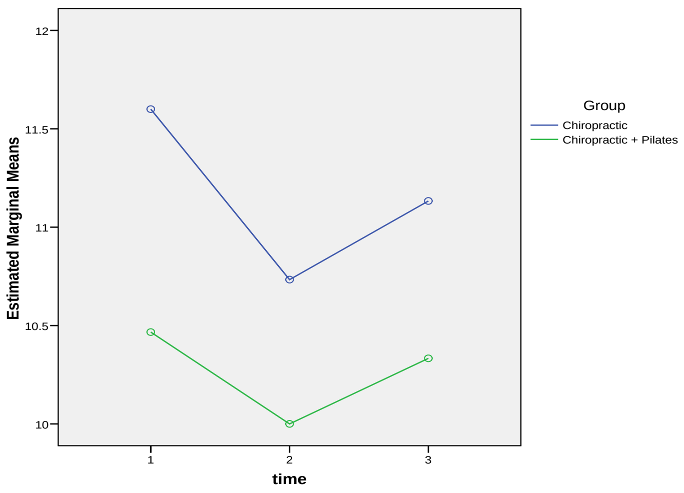


Figure 4.21:Profile plot of Scapula slide T7 Right 45° by time and group

4.2.6.8. Scapula slide T7 90^o

There was no significant difference over time for this outcome in group A (bilaterally). Figure 4.22 and 4.23 both show that there was an initial decrease during treatment time, followed by a slight increase at the follow up with the right hand side almost reaching baseline.

Table 4.53: Within - subjects effects for Scapula slide T7 90^o for Group A

Effect	Statistic	*p* value
Left side		
Time	Wilk's lambda = 0.796	0.226
Right side		
Time	Wilk's lambda = 0.760	0.167

There was no difference over time for this outcome in group B on the left (p = 0.331). Figure 4.22 shows that there was a decrease during treatment, followed by a slight increase in the distance at the follow up. There was a significant difference over time for this outcome in group B on the right (p = 0.008). Figure 4.23 shows that there was a decrease during treatment, followed by a small increase at the follow up.

Table 4.54: Within - subjects effects for Scapula slide T7 90^o for Group B

Effect	Statistic	*p* value
Left side		
Time	Wilk's lambda = 0.843	0.331
Right side		
Time	Wilk's lambda = 0.473	0.008

There was no intervention effect for this outcome bilaterally. Figures 4.22 and 4.23 both show that the rate of change in both groups was constant and the slopes of the two lines were almost parallel. The right hand side (figure 4.23) had a larger effect.

Table 4.55: Within and Between - subjects effects for Scapula slide T7 90^{o}

Effect	Statistic	*p* value
Left side		
Time	Wilk's lambda = 0.820	0.068
Time*Group	Wilk's lambda = 0.994	0.921
Group	F=7.496	0.011
Right side		
Time	Wilk's lambda = 0.698	0.008
Time*Group	Wilk's lambda = 0.867	0.146
Group	F = 4.144	0.051

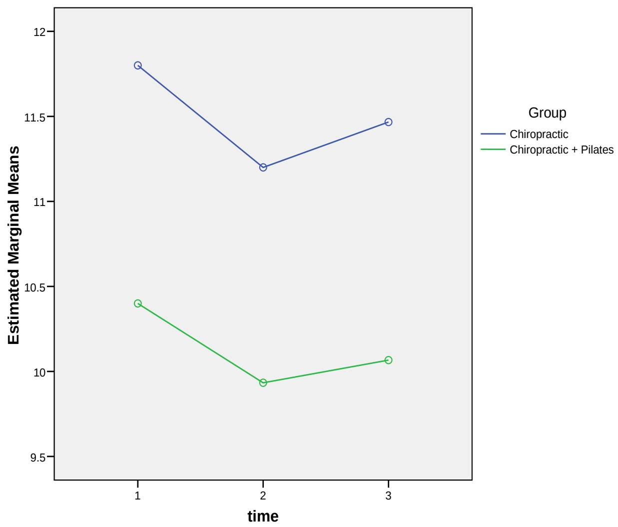


Figure 4.22: Profile plot of Scapula slide T7 Left 90^{o} by time in Group B

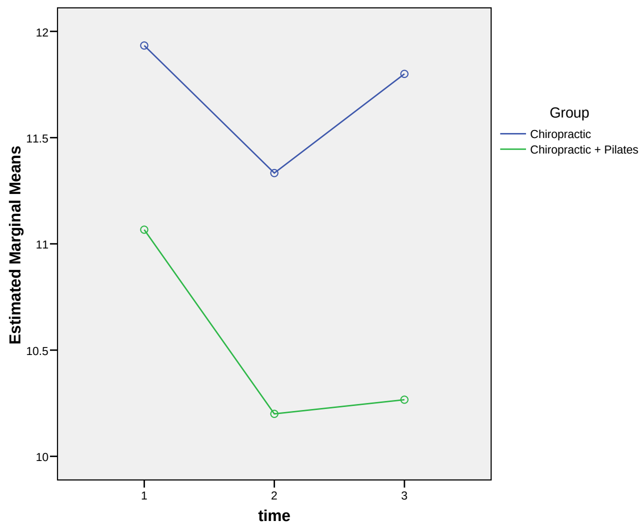


Figure 4.23: Profile plot of Scapula slide T7 Right 90^{o} by time in Group B

4.2.6.9. Scapula slide T7 120^{o}

There was a difference over time for this outcome in group A bilaterally. Figure 4.24 and 4.25 both show that there was an initial decrease over time, followed by a larger increase to above baseline level on the left.

Table 4.56: Within - subjects effects for Scapula slide T7 120^{o} for Group A

Effect	Statistic	*p* value
Left side		
Time	Wilk's lambda = 0.573	0.027
Right side		
Time	Wilk's lambda = 0.868	0.399

There was a significant difference over time for this outcome in group B bilaterally. Figure 4.24 shows that there was a linear decrease over the treatment time and follow up on the left. Figure 4.25 shows that there was an initial decrease during treatment followed by a slight increase at the follow up on the right.

Table 4.57: Within - subjects effects for Scapula slide T7 120^{o} for Group B

Effect	Statistic	*p* value
Left side		
Time	Wilk's lambda = 0.526	0.015
Right side		
Time	Wilk's lambda = 0.562	0.024

There was a statistically significant intervention effect for this outcome (p = 0.008) on the left. Figure 4.24 shows that the rate of change in both groups was different. The intervention group decreased during treatment and further decreased at the follow up while there was an overall increase in the reference group. There was no intervention effect for this outcome on the right however (p = 0.201). Figure 4.25 shows that the rate of change in both groups was similar with a slightly greater decrease occurring during treatment in the intervention group (B).

Table 4.58: Within and Between - subjects effects for Scapula slide T7 120°

Effect	Statistic	*p* value
Left side		
Time	Wilk's lambda = 0.939	0.428
Time*Group	Wilk's lambda = 0.700	0.008
Group	F = 11.491	0.002
Right side		
Time	Wilk's lambda = 0.768	0.028
Time*Group	Wilk's lambda =0.888	0.201
Group	F = 9.487	0.005

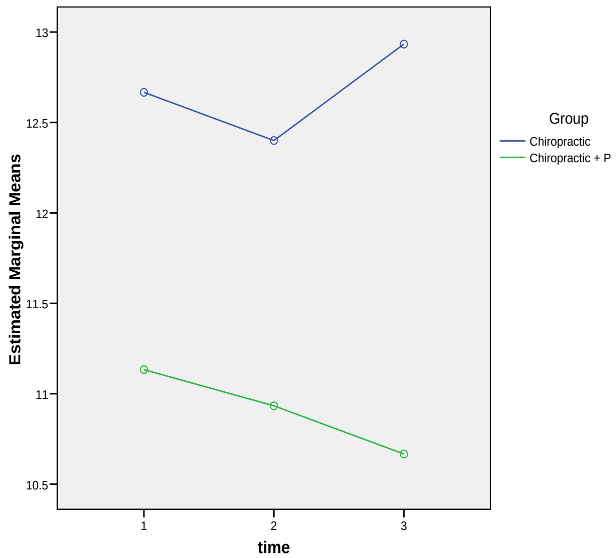


Figure 4.24: Profile plot of Scapula slide T7 Left 120° by time and Group

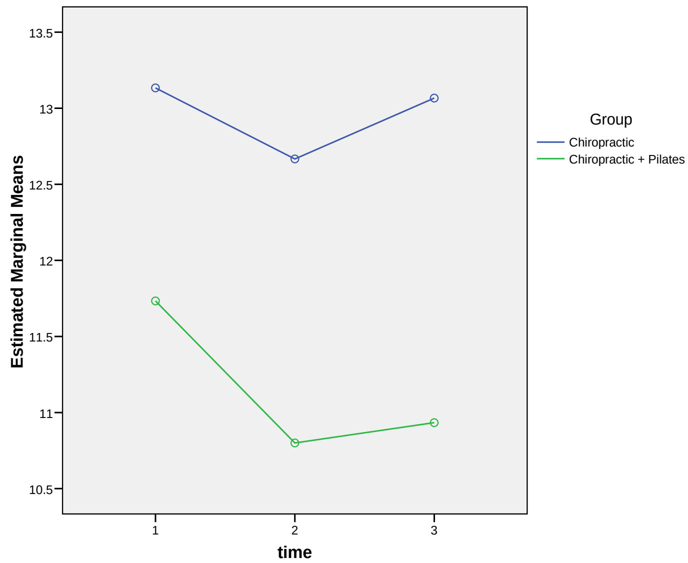


Figure 4.25: Profile plot of Scapula slide T7 Right 120° by time and Group

Scapula isometric Pinch or squeeze test (seconds)

This test measures the endurance of the scapula retraction muscles (rhomboids, middle and lower trapezius and anterior serratus) at maximum contraction.

4.2.6.10. Scapula Squeeze test

There was no difference over time for this outcome (*p* = 0.795). Figure 26 shows that there was an initial slight increase over time, followed by a larger decrease to well below baseline level.

Table 4.59: Within - subjects effects for Scapula Hold for Group A

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.965	0.795

There was a highly significant difference over time for this outcome in group B (p = 0.001). Figure 4.26 shows that there was a generally steep increase over time.

Table 4.60: Within - subjects effects for Scapula Hold for Group B

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.314	0.001

There was a highly statistically significant intervention effect for this outcome ($p < 0.001$). Figure 4.26 shows that the rate of change in both groups was different. The intervention group increased steeply over time while the reference group remained relatively constant with a slight decrease at the follow up. Thus the intervention was effective for this outcome.

Table 4.61: Within and Between - subjects effects for Scapula Hold

Effect	Statistic	*p* value
Time	Wilk's lambda = 0.518	<0.001
Time*Group	Wilk's lambda = 0.496	<0.001
Group	F = 1.64	0.211

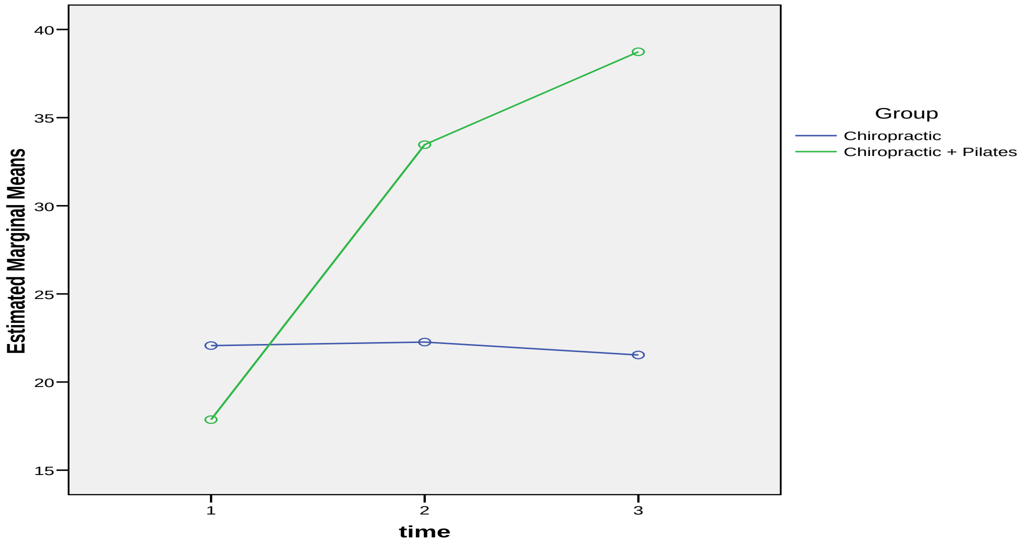


Figure 4.26: Profile plot of Scapula Hold by time and Group

4.3. Summary and conclusion

The intervention was significantly more beneficial than the reference for the following outcomes: Right rotation, scapula slide T4 right 120^{o}, scapula slide T7 Left 120^{o}, and scapula hold. The other outcomes did not show statistically significant intervention effects.

Chapter Five

Discussion of results

5.1. Introduction

The aim of this study was to investigate the effectiveness of scapula stabilization exercises as an adjunctive treatment to spinal manipulative therapy for chronic mechanical neck pain. This researcher understands, from the literature, that the achievement of increased stability and decreased stress on the cervical spine joints can be obtained by ensuring adequate operation of the surrounding musculature (Panjabi and White, 1990; Panjabi, 1992a, b; O'Sullivan *et al.*, 1997; Fryer *et al.*, 2004; Lee, 2004). By aiming a treatment protocol at incorporating all structures related to the pain (joints, muscles and nerves), this would allow for the source of the problem to be identified and treated along with the symptoms. Therefore, by stabilizing the scapula and addressing the upper cross syndrome this researcher hypothesised that it could aid in rectifying abnormal cervical posture and decrease mechanical neck pain. Although the immediate effects of the SMT are desirable, the goal of a chiropractic treatment should also include long-term relief. By combining these aspects together, it will aid in management of the dysfunction and alleviate the recurrent incidents of chronic mechanical neck pain.

This chapter is a discussion of the subjective and objective data presented in chapter four, with reference to the aim of the study. There was an intra-group and inter-group comparison performed to identify the most optimum treatment intervention.

5.2. Demographic Data

All participants in this study were diagnosed with chronic mechanical neck pain. As this was not a randomized study and participants were allocated to groups according to convenience, significant differences in the demographics existed and would have influenced the outcome measures of this study if they were taken into consideration.

There were a statistically significant different proportion of males and females in the two groups ($p = 0.028$), with the chiropractic and Pilates (Intervention Group) group being female predominant and the chiropractic only (Reference Group) group being male predominant. As a generalisation, this could possibly be due to the fact that females may be more attuned to this type of exercise as well as the males possibly having jobs with less flexible hours i.e. they are less adaptable to the set morning Pilates appointments. Racial distribution was the same in each group ($p = 0.363$) and so was age ($p = 0.761$). The mean age for the study was 27.7 years with a range of 19 - 44 years. There were a variety of occupations in each group, students being the most common in both Group A and Group B ($n = 9$). As the research was being based at a tertiary education institute, and the flexible hours and available time that a student has, could also have contributed to more students responding to the advertisements. This enabled them to adhere to the six chiropractic appointments as well as to attend eight morning classes of Pilates.

As many variables were permitted within the demographics, the occupations were not compared statistically, as the number of categories was too large with too few responses.

5.3. Numerical Pain Rating Scale (NRS)

The NRS was one of the two subjective scales that were used. It was completed at each of the chiropractic consultations thus resulting in seven readings being captured. It was utilized to establish from the participants, the degree of neck pain at the first consultation and whether or not there was an improvement as the treatments progressed.

The reference group showed a steady decrease in the pain levels during treatment with minimal pain fluctuations ($p < 0.001$). Although the intervention (Group B) also showed a similar decrease ($p < 0.001$) in pain, fluctuations at the third and fifth were evident in this group during treatment (Figure 4.1). Possibly the reason for these pain level increases were due to the participants experiencing muscle pain from the Pilates exercises that were being performed, as dysfunctional muscles were being recruited and this necessitated physiological adaptation to the exercises. Another consideration was that the muscles that were now being expected to perform were being placed under mechanical stress during the exercises. When muscles are placed under stress, this effect is relayed to both joints and nerves that are related to it (Panjabi, 1992 a b; Lee and Vleeming, 1998; Lee, 2004). As the Pilates exercises were challenging dysfunctional muscles, transient muscle stiffness was acceptable. Thus, dysfunction and pain within the muscle due to the Pilates exercises performed may have caused dysfunctions within the cervical spine, accentuating neck pain that caused the episodic increases in the pain rating scales.

5.4. CMCC Neck Disability Index

The CMCC Neck Disability Index was used as the second subjective measure. This evaluated the restrictions within the patients' daily life caused by the mechanical neck pain. This was documented at three intervals: prior to the first SMT treatment, after the sixth SMT treatment and at the follow up consultation.
The intra-group graphs show a considerable decrease in disability in both groups (Group A and Group B: $p < 0.001$). This can be partly attributed to both receiving sufficient SMT for the chronic cervical dysfunctions as it has been demonstrated to be a successful treatment protocol (Cassidy *et al*., 1992 a, b).

There was no significant treatment effect for chiropractic and Pilates compared to chiropractic alone, in terms of CCMC score ($p = 0.789$). Both groups showed similar responses as the general direction, in both groups, was a decrease and the slopes of the linear graphs were similar. Thus, the intervention did not have a greater effect in terms of subjective disability. Figure 4.2 shows the almost parallel slopes of the lines. A possible explanation for this is that both groups were suffering from mechanical dysfunctions within their cervical spine and these were successfully treated by the SMT (Cassidy *et al*., 1992 a, b). This may have been the primary cause of the daily limitations and not specifically the dysfunctions within the muscles. Consequently, by treating the primary problem (joint dysfunctions) there was an obvious decrease in disability (Group A and Group B: $p < 0.001$).

There were steeper gradients to the graphs during the treatment period (between measurement one and two) than the follow up period (between measurement two and three). It has to be considered that the treatment period (between one and two) was four weeks long in comparison to the follow up period (between two and three), which was one week long. Therefore a greater decrease in pain may be expected over the longer time span had this trend continued.

It must be noted that both groups showed a continued decrease in disability, in both subjective tests (NRS and CMCC), during the follow up period. This may have been attributed to either the common treatment of SMT or the improvement of the muscular dysfunction at the follow up consultation by the Pilates exercises (Group B) and the neurological effect that the SMT had on the related musculature (Triano, 1992; Curl, 1994; Pooke, 2000) (Group A).

5.5. Postural Analysis

As the main postural assessment within this study was the extent of anterior head carriage, as this places excessive stress on the cervical spine (Grieve, 1988; Gatterman, 1990; Kendall, 1993; Liebenson, 1996), only a lateral view assessment was taken into consideration. Digital photographs allowed the measurements to be taken initially and compared with the improved posture after the treatment. Only the cervical spine postural changes were assessed during this study to identify the effect the treatments had on the anterior head carriage.

5.5.1. Distance from the external auditory meatus to the plumb line.

This evaluation measured the distance from the EAM to the plumb line as the greater the distance between the EAM and the plumb line, the further away from the plumb line the head is held and the greater the anterior head carriage in that individual is (Orloff and Raff, 2004; Magee, 2006).

Group A showed a marked decrease in the distance between the EAM and the plumb line during treatment but no further changes during the follow-up stages ($p = 0.001$). This change in posture because of SMT may be due to the neural effect that an adjustment has on the muscles (Pooke, 2000) i.e. relieving dysfunctions such as trigger points or due to the fact that the muscles may have been inhibited by the joint receptors due to pain or discomfort within the joints (Liebenson, 1996). Another possibility is that there is an improvement in the biomechanics of the cervical spine after SMT, which would allow for the facet joints to glide on one another without causing impingements and pain.

Group B showed less of a decrease during treatment and had a minimal increase in the distance during the follow up period ($p = 0.105$). The inter group comparison graph (Figure 4.3) showed that there was a greater improvement in the reference group and the intervention was not as successful in decreasing the distance between the EAM and the plumb line therefore there was no intervention effect ($p = 0.366$). The Pilates exercises used are specifically directed at improving the scapula position and it was hypothesized that this would then improve the cervical posture. It is a possibility that these exercises improved the scapula position but did not address the position of the head. This may even lead to an increase in the distance between the plumb line and the EAM. The plumb line will be shifted more centrally due to the change in the shoulder position but the EAM would remain constant with the lack of change in the head position.

5.5.2. The angle formed at the point of the shoulder between the EAM and the plumb line.

The angle formed at the point of the shoulder between the EAM and the plumb line should be zero in when the participant is standing with correct posture and no anterior head carriage. In contrast, the greater the angle, the greater the indication of poor posture is. With this measurement the correct positioning of the shoulders and scapulae play a role too, because with anterior head carriage a rounded thoracic spine is common (Kendall *et al.,* 1993). But if the EAM and the shoulder point were both not lined up with the plumb line, a greater angle was formed.

The reference group (Group A) showed a significant postural improvement during treatment with a slight increase in angle during the follow-up period (p =0.009). Group B also had a decrease in the angle during treatment but they showed a slight continuation in improvement at the follow up period ($p = 0.280$). This continued improvement may be due to the fact that the muscles had been taught a new functioning position and were now beginning to engage in this correct position. Had the follow up period been a greater time span, possibly further decreases may have been seen within this group. The decrease was larger in the reference group (group A) than in the intervention group and thus there was no significant intervention effect for this outcome ($p = 0.480$).

It can be confirmed from the results of this study, that SMT does have a positive effect on the degree of anterior head carriage.

Using digital photography as a means of objectively measuring the change in anterior head carriage held a high level of subjectivity in terms of accurately forming the plumb line. How the patient stood, the arm position and head position for the photograph were directly related to the plumb line and how the assessor joined up the specific points was also open to subjectivity. This means of measurement did not carry enough validity and credibility.

5.6. Range of motion of the cervical spine

For right rotation there was a significant treatment effect according to the statistical analysis ($p < 0.001$). There was a steep increase in the degrees of rotation during treatment with a slight decrease in both groups during the follow up period (Figure 4.7) however; the rate of increase was greater in the intervention group.

For flexion, extension, right lateral flexion and left lateral flexion the intervention group (Group B) did not have as great an improvement during the treatment period as Group A (reference) did. Group B however, continued to improve after the treatment, and during the follow-up period while the SMT group was decreasing. Dysfunctions within the neck equate to mechanical neck pain and restricted movements (Grieve, 1988; Bergmann *et al*., 1993) which when treated by SMT will improve considerably (Cassidy *et al*., 1992 a, b). This could be a possible reason as to why Group A (reference) had improved results. The intervention group received this treatment however they were also dealing with the effects of teaching their muscles “new functioning”. Muscle dysfunctions (pain, inhibition) may cause a decrease in range of motion (ROM) (Grieve, 1988; Gatterman, 1990; Kendall, 1993 and Liebenson, 1996). Therefore the intervention group did not have as great an improvement during treatment but continued to show improvement post treatment protocol, as the muscles were now no longer allowing a possible cause of the mechanical neck pain to occur i.e. rounded shoulders, anterior head carriage and the upper cross syndrome (Grieve, 1988; Gatterman, 1990; Kendall *et al*., 1993; Liebenson, 1996; Humphreys *et al*., 2004). This may have alleviated further dysfunctions, maintain or even improved range of motion further had a longer follow up period occurred.

For flexion ($p = 0.008$), extension ($p < 0.001$), right rotation ($p < 0.001$), left rotation ($p < 0.001$), right lateral flexion ($p < 0.001$) and left lateral flexion ($p < 0.001$), SMT had significant improvements in the degree of movement during the treatment period. This decreased slightly in the follow up period though. The improvement may be attributed to the possible therapeutic effects of manipulation through two mechanisms:

- neuro-mechanical. This includes stimulation of the mechanoreceptors, muscle spindle stretching and the break down of articular adhesions resulting in an increase in active and passive joint motion (Curl, 1994).
- Stimulation of the autonomic nervous system. This will result in a reflex inhibition of pain and muscle spasms (Curl, 1994). This is supported by Bergmann *et al*., (1993) who described the effects of SMT resulting in decreased muscle spasm, increased soft tissue flexibility, decrease in muscle fatigue and increase in passive and active range of motion.

The Intervention group (Group B) in general, continued to improve or maintain the improvement (with bilateral rotation being the exception) during the follow up period. It is a possibility that as the time period within the follow up duration was only a week there was no significant improvement in the ROM and had this period been longer the outcomes may have been different.

An age limit was placed on the sample population to avoid informed consent forms needed in minors and to avoid degenerative conditions occurring after forty-five (Yochum and Rowe, 2005; Magee, 2006). The cervical ranges of motions diminish in varying degrees in accordance with increasing age (Giles and Singer, 1998). Possibly by homogenizing the sample population and having a smaller age window more accurate results may have been concluded with respect to ROM.

As females are often more flexible than males this may also attribute to differences within ROM. Group A had a male predominance and Group B had a female predominance which may explain the fact that Group B had a greater ROM at the initial consultations in five out of the six directions (the exception being flexion). By having equal gender percentages in each group, may have resulted in more valid and creditable measurements.

5.7. Scapula stabilisation tests

These tests focused on the improvement of the shoulder girdle musculature.

5.7.1. Lennie test

The Lennie test compares the distance of the scapulae from the spine. The rhomboids and trapezius affect this distance and if they are weakened, it would lead to a greater distance between the spine and the scapula (Liebenson, 1996). This test was an objective test to compare left and right symmetry of the scapula and whether or not there was an improvement in the positioning in either of the two treatments. Three different distances from the scapulae to the spine were measured.

The T2 distance changes showed different graph slopes in Figure 4.11. The reference group showed a larger decrease in this measurement but during the follow up period, increased beyond its starting point. A possible reason for this could be that the control treatment (SMT) was treating the pain but not addressing the primary cause and thus once treatment was terminated the improvements regressed. The neural stimulation from the SMT (Triano, 1992; Curl, 1994; Pooke, 2000), may have influenced the muscles and the functioning thus during treatment there was an improvement in the muscular positioning of the scapulae. The intervention group showed a less gradual decrease in the distance between the scapulae and the spine. However this group maintained the improvement during the follow up period. The more gradual delay in the intervention group may be attributed to the acceptable occurrence of muscle tenderness post exercise. The maintenance was possibly due to the improvement in the muscles performance due to the Pilates exercises that were specifically directed at enhancing them and correcting any dysfunctions.

T4 showed a positive improvement, as there was a decrease in the Intervention Group (Group B) distances ($p = 0.235$) between the scapula and the spine, as well as improved symmetry between left and right. This was an optimal response as it meant that the scapulae were being drawn back and decreasing the kyphosis of the upper thoracic spine, which could cause anterior head carriage and mechanical neck pain (Kendall *et al.*, 1993). This demonstrated that the second null hypothesis was incorrect as the Intervention group (Group B) had a more significant response.

T7 had the greatest improvement out of the three measurements. This may be related to the fact that this level would have the largest distance if there was a kyphotic thoracic spine, as the scapulae would be protracted or if a lack of scapulae stabilization was evident, this level also has the largest amount of abduction away from the spine in comparison to the other two levels (Moore and Dalley, 1999). The larger the initial distance, the larger the extent of improvement may be as minimal movement is optimal. The intervention group (Group B) had a positive response ($p = 0.047$) and then continued to improve during the follow up period. This indicated that the muscles continued to improve after the treatment. Group A improved slightly but was unable to maintain the improvement ($p = 0.905$). This confirms that the Pilates scapula stabilization exercises were effective in improving the positioning and symmetry of the scapula of the patients.

5.7.2. Lateral Scapula Slide test

The scapula slide test measures the ability of the serratus anterior, trapezius and rhomboids to hold the scapula still against the thoracic wall during the first 120 degrees of arm abduction, which occurs at the glenohumeral joint (Magee. 2006). The greater the stability of the scapula is, the less movement that occurs during the first 120 degrees at the scapulothoracic junction. This test was measured at 3 different degrees of arm abduction (45, 90 and 120 degrees) and at two different levels (T4 and T7) and it was conducted bilaterally.

At the level of T4, a slight decrease in bilateral movement was shown in both groups at 45 degrees of arm abduction with both having an increase in distance at the follow up period. There was a non-significant intervention effect for this outcome bilaterally: left ($p = 0.796$)

and right (p = 0.369). There may not be enough movement that occurs at this level and at this degree of abduction for an effect to be observed. At 90 degrees the reference Group (Group A) showed a decrease in movement that became a slight increase in the follow up period. This decrease may be due to the SMT, which was administered to the primary segmental area of innervation to these muscles and had a corresponding positive effect of the muscles (Triano, 1992; Curl, 1994; Pooke, 2000). The Intervention Group (Group B) showed a slight increase in distance bilaterally which was followed by a decrease during the follow up period. This increase during treatment may be due to the muscles incorrect activation sequence being altered and the correct muscles that had not been functioning optimally were not engaging at the correct point. Once they had begun to stabilize the scapula and engage correctly after the four weeks of Pilates classes, the decrease in the measurement was seen. However there was a non-significant intervention effect for this outcome bilaterally: left (p = 0.574) and right (p = 0.228). The measurements at 120 degrees also showed a similar bilateral response. Group A showed a decrease followed by a slight increase and Group B showed an initial increase followed by a slight decrease. Figures 4.18 and 4.19 show that each group was changing in different directions. The intervention groups increased in distance during treatment bilaterally while the reference group decreased. There was a large group effect meaning that irrespective of time, the two groups values were significantly different. A possible explanation for this may be that the Intervention Group were being taught to disengage muscles that were compensating for dysfunctional stabilizers during movements (Liebenson, 1996; O'Sullivan *et al*., 1997; Fryer *et al*., 2004; Magee, 2006) and the stabilizers were not yet engaging in the correct sequence in the four week treatment period. This was the opposite effect to what was hypothesized. The second null hypothesis stated that there would be an equal improvement between the two groups in terms of objective measurements.

T7 was again expected to render greater movement than T4 as the inferior angle of the scapula will move more than the spine of the scapula in abduction of the arm. At 45 and 90 degrees of movement there was a similar response between the two groups bilaterally. There was a decrease in the movement during treatment, which was a positive response and implied that the SMT was having a similar effect as the intervention treatment. Both groups were unable to maintain the improvement during the follow-up period (Figure 20 and Figure 21). This may be because the muscles treated for a long enough duration or possibly that the primary cause of the instability had not been addressed. During 120 degrees of motion there was a slightly different effect between the left and right hand sides of the patients but the general trend was that there was a significant decrease in the distance in the Intervention Group (Group B) (left: p = 0.015 and right: p = 0.024) when compared to the reference group (left: p = 0.027 and right: p= 0.399) and the intervention continued to improve on the left hand side with a minimal increase on the right hand side of the patients (Figure 4.24 and Figure 4.25). Therefore, there was a statistically significant intervention effect for this outcome (p = 0.008) on the left hand side. This may be attributed to the larger extent of movement that occurs at this level and that there is more muscle that has an effect on this levels movement. Thus as the Intervention Group had more muscular treatment incorporated into it's protocol it was more successful in stabilizing the scapulae.

From graphs in Figure 4.20- Figure 4.25 it can be deduced that SMT had a positive effect on the muscles in Group B. We can confirm that the Intervention Group had a large degree of improvement during 120 degrees of abduction (p = 0.008). However, the reference group had a greater influence on the movement that occurred at T4 (p =0.018). This may be attributed to the fact that the cervical joints that were manipulated are directly linked to the nerves that innervate these muscles and thus had an effect on the muscles that directly attached to the region around the spine of the scapula. This is in comparison to the inferior angle of the scapula, which has muscles attaching within this region that are not innervated from the cervical roots (Triano, 1992; Curl, 1994; Moore and Dalley, 1999; Pooke, 2000). The Intervention Group (Group B) focused on muscles that affect both the spine of the scapula and the inferior angle of the scapula and this may have been the reason for the greater improvement in Group B at the inferior angle during 120 degrees of movement.

There was often a large starting measurement difference between the two groups. A possible cause for this difference may be due to the different gender predominance within the groups. This may have caused a problem in identifying whether or not there was a significant improvement by the intervention group. It is difficult to differentiate between statistical significance and clinical significance, as the latter is hard to quantify. By having a more homogenized group this may have been avoided.

There was also often a greater improvement on the right hand side than the left. This is thought to be due to the fact that most participants were right hand dominant and these muscles were possibly worked harder.

5.7.3. Scapula Isometric Pinch or Squeeze test

The third test (Scapular pinch test) was used to measure which treatment had a greater effect on the functioning ability of the relevant muscles. This was tested by the muscles endurance. If there was a significant change in the time that the muscles could hold the squeeze, an improvement had occurred in that muscle's strength, endurance and functioning capacity, due to the treatment protocol. This test was measured in seconds, as it was the increase in functional muscle contraction time that was measured.

Group A (reference) showed a slight increase in the muscle endurance but on average managed to maintain a constant degree of endurance during treatment and at the follow-up consultation. As this group's treatments were not directly focusing on improving muscle strength this can be expected here. The SMT may have corrected any vertebral dysfunctions but it has not been shown to improve the strength and endurance of a muscle. The Intervention Group (Group B) on the other hand had a significant increase in the time measurement (p = 0.001). The time measurement more than doubled during the treatment time and continued to increase during the follow-up period (Figure 4.26). This continued increase may be due to the fact that the participants were now using their muscles correctly in everyday life and continued to strengthen because of these activities (as a result of the Pilates classes). Although the SMT had positive effects on posture and the stabilization of the scapula it did not improve the performance of a muscle or enhance its functioning ability. Therefore the muscles themselves were positively enhanced in Group B.

5.8. Conclusion

There were mixed results as to whether or not the intervention was successful.

There was a subjective improvement in both treatment groups. The first null hypothesis was demonstrated to be valid. Objectively there was an improvement in the functioning of the muscles that stabilized the scapula (which also showed improved positioning of the scapula) within the Intervention Group but this did not improve the anterior head carriage. The reference Group had improvements in anterior head carriage as well as range of motion and some scapula stabilizing tests. This demonstrated that the second null hypothesis was not applicable. These results indicate that by improving the anterior head carriage less mechanical neck pain is experienced. However it does not indicate whether the Pilates exercises that taught scapula stabilization, were able to have a positive effect on improving posture and decreasing chronic mechanical neck pain within the time period allowed. Thus, the third null hypothesis was demonstrated to hold no credibility.

Chapter Six

Recommendations and Conclusions

This chapter includes the conclusion of this study from both the subjective and objective data that was obtained and recommendations pertinent to this study and future studies along this line.

6.1. Conclusion

This study aimed at investigating the relative effectiveness of using pilates exercises to obtain scapula stabilization as an adjunct to cervical manipulation in the treatment of chronic mechanical neck pain. There was a one week follow up treatment after six SMT consultations over four weeks of treatment. A group of 30 participants took part in the study.

The hypothesis was that both groups would improve due to the SMT received. However it was also hypothesised, that by improving the stability of the scapulae and cervical posture of the patient with Pilates exercises, the spine would undergo less direct mechanical stress and thus experience a further decrease in pain and restricted range of motion.

The results comparing the two groups showed that for right rotation ROM, Lennie test at T4 and T7, scapula slide test T4 and T7 at 120^{o}, and scapula squeeze test, the intervention treatment was more effective. The reference group had a greater statistically significant improvement in: flexion, extension, right lateral flexion, left lateral flexion and with the Scapular Slide test at T4 bilaterally. There was an equal improvement in both the NRS and CMCC, by both groups.

There was a more constant improvement in ROM, pain and disability indexes with the SMT only group. The SMT and Pilates groups showed a greater effect in stabilizing the scapula and increasing the functionality of the surrounding musculature. However there was no association with the Pilates scapula stabilization exercises and improving posture of cervical ROM. This treatment intervention did not have a greater effect on the short-term treatment of chronic mechanical neck pain though.

As this was one of the first postural assessment and scapular stabilization clinical trials performed at the Durban University of Technology, further investigation is needed involving a better study design and a longer period of investigation, which may yield more conclusive results. There are a number of recommendations:

6.2. Homogenity

More closely defined parameters with regards to using matching pairs within the groups with respect to age, gender, ethnicity, occupation and extent of pain and disability would greatly enhance the strength of this study. This would allow for a more accurate comparison of whether or not the pilates was an effective intervention.

6.3. Sample Size

A larger sample size would increase the validity, as this would improve the statistical power of the study. It may be difficult to enroll more people who would be willing to sacrifice the amount of time needed for this research and also a greater expense in enrolling a greater number of participants into pilates classes with regards to this particular research topic.

6.4. Follow-up consultation

There was no long-term follow up consultation performed in this study. A longer follow-up period may have shown a greater effect of the Pilates and SMT group with the possibility of continued improvement, in comparison to the SMT group who tended to "relapse" after the treatment period. A clause could possibly have been inserted indicating that these participants may be contacted a few weeks after the research was concluded by a second researcher who would do a follow up study to see the long-term effects of the intervention. This would have promoted the validity and credibility of this research.

6.5. Treatment period

By increasing the treatment period to six weeks, instead of four, more significant results could have been obtained by both groups (longer time to learn the Pilates exercises and also more SMT). Therefore by allowing for a longer learning period as well as a possible maintenance period by increasing the number of Pilates classes from 8-12 over 6 weeks, may have been more affective.

6.6. Differentiating between muscle pain and joint pain

An explanation of the difference between muscle pain and joint pain needs to be established with the participants in such a study. It was acknowledged by this researcher that there was often a misunderstanding between the two and the participants muscle pain experienced by the Pilates exercises was often perceived as cervical joint pain and upper thoracic spine pain. Possibly by using the algometer as another objective finding in future studies would assess the difference between muscle tenderness versus joint tenderness.

6.7. Additional regional

As the thoracic spine was directly linked to anterior head carriage and rounding of the shoulders (thoracic kyphosis), treatment to this region may have been beneficial in this study.

With regards to the postural analysis, the entire spine should be taken into consideration in future studies and not only the cervical spine. The reason being that an exaggerated lumbar lordosis, leads to a more kyphotic thoracic spine and subsequently affects the cervical spine lordosis and anterior head carriage (Moore and Dalley, 1999; Orloff and Raff, 2004; Vleeming, 2006).

6.8. Third group

The improvement in the ROM and decreased pain in both groups was presumed to be due to the SMT. A third group that received Pilates classes only as a treatment protocol, would possibly be beneficial to conclusively identify whether it was indeed the SMT that was alleviating the pain.

6.9. Muscle Testing

A more in depth investigation into the dysfunctional muscles may render a more sound conclusion to the treatment benefits. Specific testing of muscles using an EMG machine is advised in future researches to allow for absolute results. This will allow for specific improvements to be documented and will reinforce the manual muscle testing techniques such as motion palpation or the algometer.

6.10 Further Research

The paucity of literature in the topics addressed in this research topic highlighted the need for future investigations into the relationships between:

1) Upper cross syndrome and neck pain
2) Anterior head carriage and neck pain
3) The percentage of people in the general population who exhibit the features of upper cross syndrome, yet have no clinical problems.

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APPENDIX A


Research in Chiropractic
Have you been suffering from
NECK PAIN
for more than 7 weeks and
are between the ages of 18-45 years?
Research is currently being carried out by the
Chiropractic Department
Durban University of Technology
Should you qualify to take part in the study
FREE TREATMENT
is available for you.
For more information contact
CARINE SMIT
on:
031 – 3732205/2512
083 999 27 28
DURBAN UNIVERSITY of TECHNOLOGY
A Leading University of Technology in Africa

APPENDIX B

Letter of Information and consent form

Title of the research:

The relative effectiveness of using pilates exercises to obtain scapula stabilisation as an adjunct to cervical manipulation in the treatment of chronic mechanical neck pain.

Name of supervisor: Dr. A. Jones, M.Dip.C, CCST, CCFC. (031-9034467)

Name of Research student : Carine Bernice Smit (031- 3732205)

The purpose of this study will be to determine the relative effectiveness of retraining and strengthening muscles that stabilize the scapula along with spinal manipulation when treating chronic mechanical neck pain. There will be 2 sample groups. Both groups shall receive spinal manipulative therapy for four weeks, and group B will attend classes of pilates exercises to help retrain muscles involved in stabilizing the scapula. The patients will each undergo six chiropractic treatments in four weeks (twice for the first two weeks and then once a week for the following two) and a seventh consultation shall be scheduled in their fifth week of the study for data collection.

The data will be collected via both objective and subjective measurements:
1) Numerical pain rating scale (NRS)
2) CMCC neck disability index
3) CROM (Cervical Range of Motion)
4) Scapula stabilization tests
5) Postural analysis – will be done with the use of digital photography in front of a grid to measure postural changes. The photographs will be used to obtain measurements and will not be in any of the publications.

Risks or discomforts to you as a participant:
There is the likelihood of transient muscle pain within the first two weeks for the group attending pilates classes, as well as a possibility of tenderness in the cervical region, the day after a manipulation.

Benefits to you as a participant:
The hypothesis is that there shall be an improvement in neck pain and posture.

Reasons why you may be withdrawn from the study:
If you are unable to comply with the treatment protocol or do not return to the chiropractic day clinic in the fifth week for your follow-up consultation you will be excluded from the study. If you do not meet the inclusion criteria you will not be admitted into this research. If at any stage you wish to withdraw from the research you are free to do so and you shall not suffer any adverse consequences.

Remuneration and costs:
Treatment for the duration of the research programme will be free of charge. Subjects taking part in the study will not be offered any other form of remuneration for taking part in this study.

Confidentiality:
All patient information is confidential. The results of the study will be made available in the Durban University of Technology library in the form of a mini- dissertation

Persons to contact in the event of any problems:
Researcher: Carine Bernice Smit (031 373 2205 / 083 999 2728)
Supervisor: Dr. Andrew Jones (031 9034467)
HOD : Dr Charmaine Korporaal

Statement of Agreement to Participate in the Research Study:
I, …………………………………………………(Full name and Surname),
ID number…………………………… have read this document in its entirety and understand its contents. Where I have had any questions or queries, these have been explained to me by ……………………………..to my satisfaction. Furthermore, I fully understand that I may withdraw from this study at any stage without any adverse consequences and my future health care will not be compromised. I, therefore, voluntarily agree to participate in this study. I here by indemnify the researcher, the supervisor and DUT from any harm that may occur during the research.

Participants name :………………………………………
Signature: ………………………………………………..
Date:……………………………………………………

Researchers name: ……………………………………..
Signature:………………………………………………
Date:……………………………………………………

Witness name:…………………………………………..
Signature:………………………………………………...
Date:……………………………………………………

Supervisor name:…………………………………………..
Signature :………………………………………………
Date:…………………………………………………………

APPENDIX C

DURBAN INSTITUTE OF TECHNOLOGY
CHIROPRACTIC DAY CLINIC
CASE HISTORY

Patient: ______________________ Date: __________

File # : __________ Age: __________
Sex : __________ Occupation: ______________________

Intern 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:

<u>Intern's Case History:</u>

1. **Source of History:**

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

3. **Present Illness:**

	Complaint 1	Complaint 2
■ Location ■ Onset : Initial: Recent: (1) 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
- Hospitalisations

6. **Current health status and life-style:**

- Allergies

- Immunizations
- Screening Tests incl. xrays
- Environmental Hazards (Home, School, Work)
- Exercise and Leisure
- Sleep Patterns
- Diet
- Current Medication
  Analgesics/week:
- Tobacco
- Alcohol
- Social Drugs

7. Immediate Family Medical History:

- Age
- Health
- Cause of Death
- DM
- Heart Disease
- TB
- Stroke
- Kidney Disease
- CA
- Arthritis
- Anaemia
- Headaches
- Thyroid Disease
- Epilepsy
- Mental Illness
- Alcoholism
- Drug Addiction
- Other

8. Psychosocial history:

- Home Situation and daily life
- Important experiences
- Religious Beliefs

9. Review of Systems:

- ☐ General
- ☐ Skin
- ☐ Head
- ☐ Eyes
- ☐ Ears
- ☐ Nose/Sinuses
- ☐ Mouth/Throat
- ☐ Neck
- ☐ Breasts
- ☐ Respiratory
- ☐ Cardiac
- ☐ Gastro-intestinal
- ☐ Urinary
- ☐ Genital
- ☐ Vascular
- ☐ Musculoskeletal
- ☐ Neurologic
- ☐ Haematologic
- ☐ Endocrine
- ☐ Psychiatric

APPENDIX D

Durban Institute of Technology

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 E

DURBAN UNIVERSITY OF TECHNOLOGY
REGIONAL EXAMINATION - CERVICAL SPINE

Patient: .... File No: ....

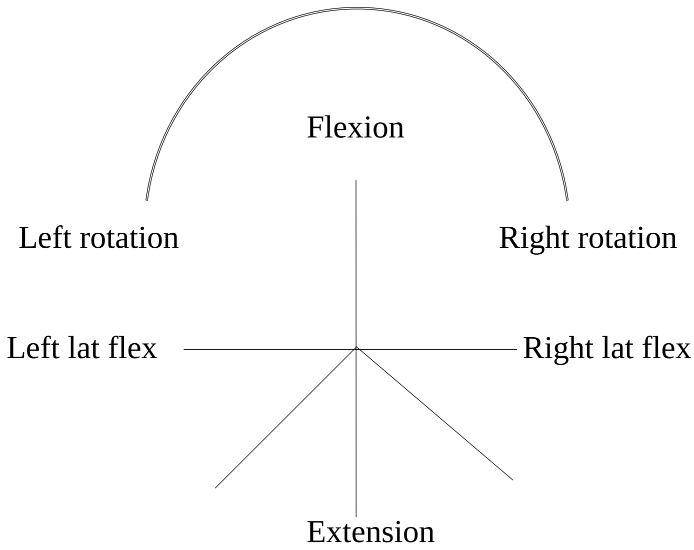
Date: .... Student: ....

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):
Flexion (45º):



PALPATION:
Lymph nodes
Thyroid Gland
Trachea

ORTHOPAEDIC EXAMINATION:

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

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

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:

<u>BASIC EXAM: SHOULDER:</u>

Case History:

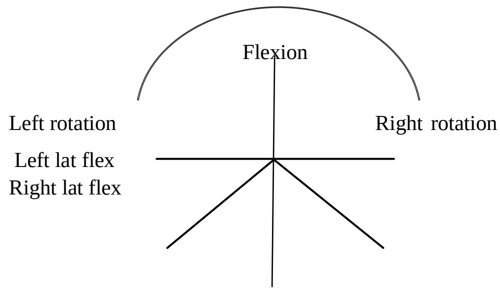
ROM: Active:
Passive:
RIM:

Orthopaedic:
Neuro:
Vascular:

<u>BASIC EXAM: THORACIC SPINE:</u>

Case History:

ROM:



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

APPENDIX F

DURBAN UNIVERSITY OF TECHNOLOGY

Patient Name: ***File #:***
Page:

Date: ***Visit:*** ***Intern:***
Attending Clinician: ***Signature:***

S: ***Numerical Pain Rating Scale (Patient)*** ***Intern 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:*** ***Intern:***
Attending Clinician: ***Signature:***

S: ***Numerical Pain Rating Scale (Patient)*** ***Intern 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:*** ***Intern:***
Attending Clinician: ***Signature***

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

O: ***P:***

E:

Special attention to: ***Next appointment:***

APPENDIX G

NRS Pain Rating Scale

Patient Name:

Date:

Pain Severity Scale:

Rate your usual level of pain today by checking one box on the following scale:

0	1	2	3	4	5	6	7	8	9	10

No pain pain **Excruciating**

Bolton and Wilkinson, 1998 : 1-7

APPENDIX H

CMCC NECK DISABILITY INDEX

Patient Name:______________________________ File no.:______________ Date:______________

This questionnaire has been designed to give the doctor information as to how your back pain has affected your ability to manage everyday life. Please answer every section and mark in each section only ONE box as it applies to you. We realize you may consider that two of the statements in any one section could relate to you, but please just mark the box which most closely describes your problem.

Section 1 - Pain Intensity

- ☐ I have no pain at the moment. (0)
- ☐ The pain is very mild at the moment. (1)
- ☐ The pain is moderate at the moment. (2)
- ☐ The pain is fairly severe at the moment. (3)
- ☐ The pain is very severe at the moment. (4)
- ☐ The pain is the worst imaginable at the moment. (5)

Section 2 - Personal Care (Washing, Dressing ...)

- ☐ I can look after myself normally without causing extra pain. (0)
- ☐ I can look after myself normally but it causes extra pain. (1)
- ☐ It is painful to look after myself and I am slow and careful. (2)
- ☐ I need some help but manage most of my personal care. (3)
- ☐ I need help every day in most aspects of self care. (4)
- ☐ I do not get dressed, I wash with difficulty and stay in bed. (5)

Section 3 - Lifting

- ☐ I can lift heavy weights without extra pain. (0)
- ☐ I can lift heavy weights but it gives extra pain. (1)
- ☐ Pain prevents me from lifting heavy weights off the floor, but I can manage if they are conveniently positioned, for example on a table. (2)
- ☐ Pain prevents me from lifting heavy weights, but I can manage light to medium weights if they are conveniently positioned . (3)
- ☐ I can lift only very light weights. (4)
- ☐ I cannot lift or carry anything at all. (5)

Section 4 - Reading

- ☐ I can read as much as I want to without pain in my neck. (0)
- ☐ I can read as much as I want to with slight pain in my neck. (1)
- ☐ I can read as much as I want with moderate pain in my neck. (2)
- ☐ I cannot read as much as I want because of moderate pain in my neck. (3)
- ☐ I can hardly read at all because of severe pain in my neck. (4)
- ☐ I cannot read at all. (5)

Section 5 - Headaches

- ☐ I have no headaches at all. (0)
- ☐ I have slight headaches which come infrequently. (1)
- ☐ I have moderate headaches which come infrequently. (2)
- ☐ I have moderate headaches which come frequently. (3)
- ☐ I have severe headaches which come frequently. (4)
- ☐ I have headaches almost all the time. (5)

Section 6 - Concentration

- ☐ I can concentrate fully when I want to with no difficulty. (0)
- ☐ I can concentrate fully when I want to with slight difficulty. (1)
- ☐ I have fair degree of difficulty in concentrating when I want to. (2)
- ☐ I have a lot of difficulty in concentrating when I want to. (3)
- ☐ I have a great deal of difficulty in concentrating when I want to. (4)
- ☐ I cannot concentrate at all. (5)

Section 7 - Work

- ☐ I can do as much work as I want to . (0)
- ☐ I can do only my usual work, but no more. (1)
- ☐ I can do most of my usual work, but no more. (2)
- ☐ I cannot do my usual work. (3)
- ☐ I can hardly do any work at all. (4)
- ☐ I cannot do any work at all. (5)

Section 8 - Driving

- ☐ I can drive my car without any neck pain. (0)
- ☐ I can drive my car as long as I want with slight pain in my neck. (1)
- ☐ I can drive my car as long as I like with moderate pain in my neck. (2)
- ☐ I cannot drive my car as long as I want because of moderate pain in my neck. (3)
- ☐ I can hardly drive at all because of severe pain in my neck. (4)
- ☐ I cannot drive at all. (5)

Section 9 - Sleeping

- ☐ I have no trouble sleeping. (0)
- ☐ My sleep is slightly disturbed (<1 hour sleep loss). (1)
- ☐ My sleep is mildly disturbed (1-2 hours sleep loss). (2)
- ☐ My sleep is moderately disturbed (2-3 hours sleep loss). (3)
- ☐ My sleep is greatly disturbed (3-5 hours sleep loss). (4)
- ☐ My sleep is completely disturbed (5-7 hours sleep loss). (5)

Section 10 - Recreation

- ☐ I am able to engage in all my recreation activities with no neck pain at all. (0)
- ☐ I am able to engage in all my recreation activities, with some pain in my neck. (1)
- ☐ I am able to engage in most, but not all of my usual recreation activities because of pain in my neck. (2)
- ☐ I am able to engage in a few of my usual recreation activities because of pain in my neck. (3)
- ☐ I can hardly do any recreation activities because of pain in my neck. (4)
- ☐ I cannot do any recreation activities at all. (5)

Scores (out of 50): 0–4 No disability
5–14 Mild disability
15–24 Moderate disability
25–34 Severe disability
>35 Complete disability

(Modified from Vernon, H, and S, Mior : The neck disability index: A study of reliability and validity. J. Manip. Physio. Ther. 14:411, 1991.)

APPENDIX I

Data Collection Sheet

Patient Name : …………………………..   File Number:……………………

CROM GONIOMETER				
Date				
Treatment	1 (Before)	6 (After)	Follow Up	Total Difference
Flexion				
Extension				
Right Rotation				
Left Rotation				
R Lateral Flexion				
L Lateral Flexion				

Scapula Stabilization:

Lennie Test

	T2	T6	T7
Treatment 1			
Treatment 6			
Follow Up			
Total Difference			

Lateral scapula

Slide test:

	T2	45˚	90˚	120˚	T7	45˚	90˚	120˚
Tx 1								
Tx 6								
F / U								
Total Diff.								

Scapular Isometric Pinch Test

	Tx 1	Tx6	F/U	Difference
Time				

APPENDIX J

Patient Name:………………………………..
File number:…………………………………

POSTURAL ANALYSIS		
Measurement	Distance between plumb-line and ext. auditory meatus	Angle between ext. aud. Meatus and plumb-line @ point of shoulder
Treatment 1 **Date:**		
Treatment 6 **Date:**		
Follow Up **Date:**		
Total difference:		

APPENDIX K

Pilates Exercises for scapula stabilisation

1) Supine lying on mat (i)

- Correct neck alignment (use pillows if needed)
- Engage shoulder blades, triceps, small of back and base of skull into mat.
- Do breathing but stay connected.

2) Supine lying on mat (ii)

- Arm circles (both directions) staying anchored on the mat.
- use strong ribcage breathing to connect into scapula.

3) Diamond Press (i)

- Lie prone on a mat, using the inferior traps and serratus to slide shoulder blades out and down. Move into slight back extension maintaining this position.

4) Diamond Press(ii)

- Repeat above but add lateral arm movement to the back extension.

5) 90˚ arm slides

- Lie supine on mat arms bent at 90˚, thumbs on floor. Engage lats and serratus to slide elbows on floor towards waistline. Repeat with baby fingers on floor. Keep correct neck alignment at all times.

6) Arm circles on small barrel

- Lie supine with head and neck resting over the barrel. Open chest and connect scapula into barrel. Remain in this position and do arm circles.

Cue to engage TA for stability.

7) Chest expansion- chair

-Sit on mat, back towards chair. Place hands on stepper, open chest, stabilize scapula, traps soft and down. Pump arms up and down.

8) Pumping arms on chair

- Lie prone on Wunda chair. Heels of hands connected into stepper. Stabilizing scapula, pump arms up and down. Cue to engage TA for lower back stability.

9) Chest expansion – straps

- Kneel on mat, face wall and hold onto handle of theratubing. Pull tubing to open chest, using upper back muscles. Maintain alignment and let tubing go. Repeat adding 90˚ lateral rotation of the head right and left.

10) Peripheral vision arms

- Sit on reformer with legs crossed. Hands into handles, 1 spring. Pull straps up and slightly forward to peripheral vision. Soft traps, no contraction of pectorals, no winging of scapula. Soften and let down.

11) Kneeling plank on swiss ball

-Kneel on mat, place barrels on ball in front of you. Correct posture to plumbline requirements. Engage and allow ball to roll forward, keep alignment and fall forward diagonally. Use TA and shoulder stabilizers to return keeping exact alignment.

APPENDIX L

THE PILATES HOUSE

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11 June 2008

To Whom It May Concern:

This serves to confirm that I have consulted with Carine Smit on her research and give permission for the classes to be held at The Pilates House and that I will instruct the classes on her behalf.

Yours sincerely,

ANDRI MARAIS

....
CARINE SMIT

....
WITNESS

....
SUPERVISOR