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THE EFFICACY OF UTILISING KINESIO® TAPING, SPINAL MANIPULATION OR THE TWO THERAPIES COMBINED IN THE TREATMENT OF CHRONIC NECK PAIN

A research proposal presented to the Faculty of Health Sciences, University of Johannesburg, as partial fulfilment for the Masters Degree in Technology: Chiropractic by

Juandré French
(Student number: 200711545)

Supervisor: ________________________ Date: ________________________

Dr. C. Bester
DECLARATION

I Juandré French, declare that this dissertation is my own, unaided work. It is being submitted as partial fulfilment for the Master’s Degree in Technology, in the program of Chiropractic, at the University of Johannesburg. It has not been submitted before for any degree or examination in any other University or Technikon.

____________________________
Juandré French

On this day the _______ of the month of ______________________ 2013
AFFIDAVIT: MASTER’S AND DOCTORAL STUDENTS

TO WHOM IT MAY CONCERN

This serves to confirm that I, Juandré French, ID number 8811285225084, Student number 200711545 enrolled student for the Qualification Masters in Technology Chiropractic Faculty of Health Sciences.

Herewith I declare that my academic work is in line with the Plagiarism Policy of the University of Johannesburg. I further declare that the work presented in the study to determine the efficacy of utilising Kinesio® taping, spinal manipulation or the two therapies combined in the treatment of chronic neck pain minor dissertation is authentic and original, and that there is no copyright infringement in the work. I declare that no unethical research practices were used or material gained through dishonesty. I understand that plagiarism is a serious offence.

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DEDICATIONS

I dedicate this dissertation to my Heavenly Father, who gave me the strength, discipline and faith throughout my years of studying. Philippians 4:13, “I can do all things through Him who strengthens me”, Psalm 31:14, “I trust in You, O Lord”.

To two extraordinary people: my father, André French and my mother, Loenell French. Thank you for all your love, support, faith in me, and most of all your prayers throughout my studies. I truly hope I made you proud.

Last but not least to my two brothers, family, girlfriend and friends, without all of your support, my many years of studying would not have been possible. Thank you for all the love and encouragement, which made the many years of studying more bearable.
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To Juliana van Staden at STATKON. Thank you for the fast, accurate and insightful work you did with regards to my results of the study. It is and was much appreciated.
ABSTRACT

Introduction: Neck pain is a common condition which affects up to 70 percent of people at some point in their lives, and at any given time about 10 to 20 percent of the population reports neck problems. Although spinal manipulation on its own is effective in the treatment of chronic neck pain, chiropractors continue to search adjunctive modalities to improve the positive outcomes of their treatment. Therefore, it is important to look for the best possible treatment protocol as well as research alternatives, should contraindications for present protocols, such as spinal manipulation, arise. One such alternative could be Kinesio® taping. The purpose of this study was to determine the efficacy of utilising Kinesio® taping, spinal manipulation or the two therapies combined, for the treatment of chronic neck pain. It will also provide further evidence on the efficacy of spinal manipulation and Kinesio® taping in isolation.

Method: This study was a comparative study consisting of three groups of ten participants. The method of treatment was determined by random group allocation. Group 1 received spinal manipulation to restriction(s) of the cervical spine only. Group 2 received Kinesio® taping to the longissimus cervicis muscles only. Group 3 received a combination of spinal manipulation and Kinesio® taping as previously described. Subjective measurements consisted of the Vernon-Mior Neck Pain and Disability Index and the Numerical Pain Rating Scale (NPRS) and objective measurements was assessed in degrees by making use of the Cervical-range-of-motion (CROM) instrument.

Procedure: There were seven consultations in total. There were six treatment consultations over three weeks. The seventh consultation consisted of data collection only. Subjective and objective measurements were taken prior to treatment on the first and fourth consultation, and on the seventh consultation where no treatment took place. Subjective readings were taken from the Vernon-Mior Neck Pain and Disability Index and the NPRS. Objective readings were
assessed in degrees by making use of the Cervical-range-of-motion (CROM) instrument.

**Results:** It was evident from the data that all three groups responded well to their respective treatment protocols. With regards to the subjective measurements Group 1, 2 and 3 demonstrated statistically significant improvement in both neck pain severity and functional disability. As Group 1 had the highest clinical improvement with regards to the NPRS, it indicates that the Group 1 treatment protocol was more effective in decreasing the pain intensity throughout the treatment period. All three groups responded similarly with regards to the Vernon-Mior Neck Pain and Disability Index, although Group 1 responded the best clinically. With regards to the objective measurements Group 1, 2 and 3 demonstrated statistically significant improvement in all ranges of motion of the cervical spine. However, it was found that Group 3 clinically responded best to treatments in all the ranges of motion except for right lateral flexion in which Group 2 responded best to treatment.

**Conclusion:** The study showed that the treatment protocols for Group 1, 2 and 3 were effective in treating chronic neck pain. The evidence suggests that the Group 1 treatment protocol, which received spinal manipulation, is more effective than Kinesio® taping alone and the two therapies combined in decreasing pain intensity and functional disability in the treatment of chronic neck pain. The evidence further suggests that the Group 3 treatment protocol, which received spinal manipulation in combination with Kinesio® taping, is more effective than spinal manipulation and Kinesio® taping alone in increasing all cervical spine ranges of motion in the treatment of chronic neck pain.
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CHAPTER ONE – INTRODUCTION

1.1 Problem Statement

Chronic neck pain can have an impact on a person’s life by impairing their normal routine, occupational functioning, social activities, and general health. According to Bronfort, Evans, Nelson, Aker, Goldsmith and Vernon (2001) neck pain is a common condition which affects up to 70 percent of people at some point in their lives, and at any given time about 10 to 20 percent of the population reports neck problems. Therefore, it is important to look for the best possible treatment protocol as well as research alternatives, should contraindications for present protocols, such as spinal manipulation, arise. One such alternative could be Kinesio® taping.

According to Swartz (2002) spinal manipulation has been used to restore normal joint function, thereby reversing pathological processes. It has been noted by Cramer, Ross, Pocius, Cantu, Laptook, Fergus, Gregerson, Selby and Raju (2011) that spinal manipulation causes facet joint gapping, which is the separation of the zygapophyseal joint surfaces. It is thought to break up connective tissue adhesions and stimulate afferent nerves that innervate the facet joint capsule as well as the small muscles of the spine. Although spinal manipulation on its own is effective in the treatment of chronic neck pain (Bronfort et al., 2001), chiropractors continue to search adjunctive modalities to improve the positive outcomes of their treatment.

The method of Kinesio® taping is designed to assist the body’s natural healing process with the ability to support and stabilise the muscle and joints without restricting the body’s range of motion (Kase, Wallis and Kase, 2003). According to Kinesio Taping® Association International (2011a) tape is a modality that has a continued therapeutic benefit between visits, which increases the function of many different tissues and helps the body to return to normal functioning.
However research on its use for chronic neck pain, as well as its combined use with spinal manipulation, is limited.

1.2 Aim of the Study

The aim of this study is to determine the efficacy of utilising Kinesio® taping, spinal manipulation or the two therapies combined, for the treatment of chronic neck pain. It will also provide further evidence on the efficacy of spinal manipulation and Kinesio® taping in isolation.

1.3 Benefits of the Study

The study indicated that Kinesio® taping and spinal manipulation in isolation, as well as Kinesio® taping in combination with spinal manipulation was effective in reducing chronic neck pain and increasing cervical spine range of motion in the study group. The results of this study revealed that Kinesio® taping in isolation was beneficial in treating chronic neck pain as well that there was an additive effect when combining the two treatment protocols. The results of this study also demonstrated that Kinesio® taping is a good supportive and adjunctive therapy for chiropractic spinal manipulation in the treatment of chronic neck pain, could help the chiropractic community to treat chronic neck pain more efficiently.

Chapter two will discuss the literature review with regards to the study.
CHAPTER TWO – LITERATURE REVIEW

2.1 Introduction

Chronic neck pain can have an impact on a person’s life by impairing their normal routine, occupational functioning, social activities, and general health. According to Bronfort et al. (2001) neck pain is a common condition which affects up to 70 percent of people at some point in their lives, and at any given time about 10 to 20 percent of the population reports neck problems.

Spinal manipulation is defined by Bergmann and Peterson (2011) as a specific form of joint manipulation characterised by a low-amplitude dynamic thrust of controlled velocity, amplitude and direction, associated with an audible articular crack (cavitation).

According to Swartz (2002) spinal manipulation has been used to restore normal joint function, thereby reversing pathological processes. It has been noted by Cramer et al. (2011) that spinal manipulation causes facet joint gapping, which is the separation of the zygapophyseal joint surfaces and is thought to break up connective tissue adhesions and stimulate afferent nerves that innervates the facet joint capsule, as well as the small muscles of the spine.

Kinesio® tape was invented by Dr. Kenzo Kase in 1973. The method of Kinesio® taping is designed to assist the body’s natural healing process with the ability to support and stabilise the muscle and joints without restricting the body’s range of motion (Kase et al., 2003). According to Kinesio Taping® Association International (2011a) tape is a modality that has a continued therapeutic benefit between visits, which increases the function of many different tissues and helps the body to return to normal functioning.
Relevant cervical spine anatomy and biomechanics will be discussed in this review chapter in detail. The review will then discuss the aetiology of chronic neck pain, and the effects of Kinesio® tape and spinal manipulation.

2.2 Functional Anatomy of the Cervical Spine

2.2.1 Cervical vertebrae

The cervical vertebrae are located between the cranium and the thoracic vertebrae, and are the smallest (the fact that they bear less weight) of the twenty-four movable vertebrae. The cervical region has the largest range of motion and greatest variety of movement due to the relative thickness of the discs, the nearly horizontal articulation of the articular facets and small amount of surrounding body mass (Moore and Dalley, 2006). Although there is large flexibility in the cervical region, stability of the cervical region is essential for support of the head and protection of the spinal cord and vertebral arteries (Levangie and Norkin, 2011).

The cervical region of the vertebral column, which encloses the meninges and spinal cord, are formed by seven cervical vertebrae. The third to sixth cervical vertebrae are called typical cervical vertebrae. The first, second and seventh cervical vertebrae are called atypical cervical vertebrae (Moore and Dalley, 2006).

2.2.1.1 Atlas (atypical cervical vertebra)

The atlas (see figure 2.1) is a ring-like, kidney-shaped bone and is unique in that it has neither a vertebral body nor a spinous process. It is the widest of all the cervical vertebrae, and its function is to cradle the occiput and transmit forces from the occiput to the lower cervical vertebrae. The two lateral masses that serve the place of the vertebral body by bearing the weight of the cranium are connected by the anterior and posterior arches forming a complete ring (Levangie and Norkin, 2011). The transverse processes arise from the lateral masses, causing
them to be more laterally placed than those of the inferior vertebrae. The transverse processes also have foramina for the vertebral arteries (Moore and Dalley, 2006). The kidney-shaped, concave superior articular facets of the lateral masses receive the occipital condyles. The inferior articular facets are slightly convex and are directed inferiorly (Kapandji, 1974).

![Atlas (C1): superior view](image1)

(A)

![Atlas (C1): inferior view](image2)

(B)

Figure 2.1 Atlas: (A) Superior view and (B) Inferior view (Netter, 2003)

2.2.1.2 Axis (atypical cervical vertebra)

The axis (see figure 2.2) is the strongest of the cervical vertebrae and carries centrally on its superior surface of the body the odontoid process. Its functions are to transmit the combined loads of the head and atlas to the lower cervical
vertebrae and to provide motion into axial rotation of the head and atlas (Moore and Dalley, 2006). The odontoid process acts as a pivot for the atlanto-axial joint and is encircled with the spinal cord by the atlas. The transverse ligament of the atlas holds the odontoid process against posterior aspect of the anterior arch of the atlas. The ligament prevents posterior displacement of the odontoid process and anterior displacement of the atlas (Levangie and Norkin, 2011). The axis has laterally two large superior articular facets that face superiorly and laterally, and are convex anteroposteriorly. The atlas rotates on these facets. The inferior articular facets face anteriorly. The spinous process is short and bifid like every other cervical vertebra (Kapandji, 1974).

![Figure 2.2 Axis: (A) Anterior view and (B) Posterosuperior view (Netter, 2003)](image)
2.2.1.3 Typical cervical vertebrae (C3 to C6 vertebrae)

A typical cervical vertebra (see figure 2.3) has a small vertebral body and is longer from side to side than it is from anterior to posterior (Moore and Dalley, 2006). The vertebral body has a concave superior surface that is raised on either side by two buttresses, the unciform processes, and has a ledge on its anterior margin. The inferior surface of the vertebral body is convex and has a beak-like prolongation on its anterior surface (Kapandji, 1974).

The pedicles are located midway between the superior and inferior surfaces of the vertebral body, and project posterolaterally. The laminae are slightly curved, thin and project posteromedially (Levangie and Norkin, 2011).

The articular processes lie posterior and lateral to the vertebral body, to which they are connected by the pedicles, and bear the articular facets (Moore and Dalley, 2006). The two flat and oval superior articulating facets are directed superiorly and posteriorly (Kapandji, 1974). The two inferior articulating facets are directed inferiorly and posteriorly. The obliquely placed facets are nearly horizontal in this region (Levangie and Norkin, 2011).

The two transverse processes point anteriorly and laterally and are hollowed into a gutter anteroposteriorly. The transverse processes end in two projections laterally (an anterior tubercle and a posterior tubercle), that provide attachment for a laterally placed group of cervical muscles (Moore and Dalley, 2006). The oval transverse foramen forms the most distinctive feature of the cervical vertebra and is located in the transverse processes bilaterally. Vertebral arteries, accompanying veins and sympathetic plexuses pass through the transverse foramina (Kapandji, 1974).
A single spinous process is formed by the laminae that meet in the midline of the posterior arch (Levangie and Norkin, 2011). The spinous process is short, slender, extends horizontally and has a bifid tip (Kapandji, 1974).

The large and triangular vertebral foramen accommodates the enlargement of the spinal cord in this region in relation to the innervation of the upper limbs (Moore and Dalley, 2006).

![Figure 2.3 Typical cervical vertebrae (C4) superior view (Netter, 2003)](image)

**Figure 2.3 Typical cervical vertebrae (C4) superior view (Netter, 2003)**

### 2.2.1.4 Vertebra prominens (atypical cervical vertebra)

The vertebra prominens (see figure 2.4) is so-named because of its long, slender spinous process, which has a tubercle on its tip. It demonstrates anatomic characteristics of both the cervical vertebra and the thoracic vertebra (Moore and Dalley, 2006). The superior articular facets match those of your typical cervical vertebrae, and the inferior articular facets match those in the thoracic spine. The vertebra prominens has no uncinate processes and has small or no transverse foramina. The transverse processes are large, broad and blunt, and may become enlarged or develop cervical ribs (Bergmann and Peterson, 2011).
2.2.2 Joints of the cervical region

2.2.2.1 Atlanto-occipital joints

The two atlanto-occipital joints consist of two kidney-shaped, concave superior zygapophyseal facets of the atlas that receives the two large, convex occipital condyles of the skull (Moore and Dalley, 2006). These joints lie nearly in the horizontal plane and are true synovial joints with intra-articular fibroadipose meniscoids (Levangie and Norkin, 2011).

2.2.2.2 Atlantoaxial joints

The atlantoaxial joint consists of three synovial joints: two lateral joints between the superior zygapophyseal facets of the axis and inferior zygapophyseal facets of the atlas and the median atlantoaxial joint between the odontoid process and the atlas (Levangie and Norkin, 2011). The two lateral joints appear to be plain synovial joints; however both their articular cartilage surfaces are convex, rendering the zygapophyseal facet joints biconvex (Levangie and Norkin, 2011), allowing considerable mobility in rotation (Bergmann and Peterson, 2011). The median joint is a synovial trochoid joint, providing a pivot action (Levangie and
Norkin, 2011). The odontoid process of the median joint rotates within an osteoligamentous ring formed by the anterior arch of the atlas anteriorly, lateral masses laterally and the transverse ligament posteriorly (Bergmann and Peterson, 2011).

### 2.2.2.3 Zygaphyseal joints

The zygapophyseal joints are teardrop-shaped, with the superior facets facing superiorly and posteriorly, and lying midway between the coronal and frontal plane (Bergmann and Peterson, 2011). From C3 to C7 the height and width of the superior zygapophyseal facets gradually increase (Levangie and Norkin, 2011). The inferior facets face anteriorly and inferiorly and lie closer to the frontal plane than the superior facets (Moore and Dalley, 2006). The zygapophyseal joints in the cervical region are true synovial joints and contain fibroadipose meniscoids. There is large range of motion due to the joint capsules being thin and lax; however they do restrict motion at the end of the available ranges (Levangie and Norkin, 2011). The capsule is attached to the margins of the articular processes of the adjacent vertebrae (Moore and Dalley, 2006).

Accessory ligaments unite the laminae, transverse- and spinous processes and help stabilize the joints. The zygapophyseal joints permit gliding movement between the vertebrae and in the cervical region these joints bear some weight, sharing this function with the intervertebral disc. The joints are innervated by the articular branches that arise from the medial branches of the dorsal primary rami of the spinal nerves. Each articular branch supplies two adjacent joints; thus each joint is supplied by two nerves (Moore and Dalley, 2006).
2.2.2.4 Uncovertebral joints

The uncovertebral joints or joints of Luschka are located between the unci of the bodies of C3 to C6 and the inferolateral surfaces of the vertebral body superior to them. Cartilage, moistened with fluid, covers the articulating surfaces of these joint-like structures. They are considered as synovial joints by some. The joints are frequent sites for spur formation, which can cause neck pain (Moore and Dalley, 2006).

2.2.2.5 Intervertebral disc

The intervertebral disc (see figure 2.5) connects the articulating surfaces of the adjacent vertebrae and fulfils many functions, including forming the inferior half of the anterior border of the intervertebral foramen, shock absorption, permitting movement and producing secondary curves of the spine. There is no disc between C1 and C2 vertebrae (Moore and Dalley, 2006).

The structure of the cervical disc is a discontinuous ring surrounding a fibrocartilaginous core. The anulus fibrosus fibres do not surround the entire perimeter of the nucleus pulposus instead the fibres have a crescent shape when viewed from above, are thick anteriorly and taper laterally. Anteriorly the fibres of the anulus fibrosus are oblique in the form of an inverted “V”, laterally there is no substantive anulus fibrosus and posteriorly it is a thin layer of vertical fibres (Levangie and Norkin, 2011).

The nucleus pulposus is the central portion of the disc, which is semi fluid in nature and consists of 88 percent water at birth. Due to the discs’ semi fluid nature, it allows flexibility and resilience to the intervertebral disc and spine as a whole. The nucleus pulposus is avascular and receives nourishment by diffusion from the blood vessels at the periphery of the anulus fibrosus and vertebral body (Moore and Dalley, 2006).
2.2.3 Posterior muscles of the cervical spine

The extrinsic back muscles and intrinsic back muscles make up the two major muscle groups in the back. The extrinsic back muscles include the superficial muscles that produce and control limb movement, and the intermediate muscles that produce and control respiratory movement. The intrinsic back muscles include muscles that act on the vertebral column, producing its movement and maintaining posture (Moore and Dalley, 2006). The posterior neck muscles will be examined from superficial to deep and begin with the upper part of the trapezius muscle (Levangie and Norkin, 2011).
2.2.3.1 Trapezius muscle (extrinsic back muscle)

The most superficial of the posterior neck muscles is the trapezius muscle (see figure 2.6), which spans from the occiput to the lower thoracic spine and contains a tendinous region over the cervicothoracic junction (Levangie and Norkin, 2011). The upper, middle and lower parts of the trapezius muscle have different fibre directions and different functions and in this chapter we will focus on the upper part of the trapezius muscle (Simons, Travell and Simons, 1999).

The upper fibres of the muscle originate from the medial third of the superior nuchal line superiorly and from the ligamentum nuchae in the midline. The fibres join laterally and attach to the lateral third of the posterior border of the clavicle (Simons et al., 1999).

The spinal accessory nerve (cranial nerve XI) supplies the motor innervation of the trapezius muscle and the C2 to C4 spinal nerves primarily supplies sensory innervation to the muscle (Moore and Dalley, 2006).

The function of the upper part of the trapezius muscle acting unilaterally extends and laterally flexes head and neck towards the same side, and aids in extreme rotation of the head so that the face turns to the opposite side. Bilaterally it may extend the head and neck against resistance (Simons et al., 1999).

2.2.3.2 Levator scapulae (extrinsic back muscle)

The levator scapulae muscle (see figure 2.6) lies deep to the trapezius muscle (Levangie and Norkin, 2011). The levator scapulae muscle fibres originate from the transverse processes of C1 to C4 and attach to the vertebral border of the scapula between the superior angle and the root of its spine (Simons et al., 1999).
The branches of the third and forth cervical nerves via the cervical plexus supply the levator scapulae muscle and it is sometimes supplied by fibres from the dorsal scapular nerve derived from the C5 root (Simons et al., 1999).

The function of the muscle is to rotate the scapula so that the glenoid fossa faces inferiorly and then rotates the scapula as a whole when the neck is fixed. With the scapula in a fixed position the muscles helps to complete neck rotation and lateral flexion to the same side. Bilaterally the muscle assists in neck extension and controls neck flexion (Simons et al., 1999).

2.2.3.3 Splenius capitis and splenius cervicis (intrinsic back muscles)

The splenius muscles (see figure 2.6) are large and flat muscles and lie deeper than the levator scapulae muscle (Levangie and Norkin, 2011). The splenius capitis muscle originates from the spinous processes of C3 to T4 and the nuchal ligament and inserts on the superior nuchal line mastoid process (Vizniack, 2011). The splenius cervicis muscle originates from the spinous process of T3 to T6 and inserts at the transverse processes of C1 to C3 (Vizniack, 2011).

The cervical spinal nerves (dorsal rami) supply both the splenius capitis muscle and the splenius cervicis muscle (Vizniack, 2011).

The splenius group muscles are the primary movers of the head and neck. When they work bilaterally they produce extension of the head and neck, and when they work unilaterally they produce ipsilateral rotation and lateral flexion of the head and neck (Levangie and Norkin, 2011).
2.2.3.4 Semispinalis capitis and semispinalis cervicis (intrinsic back muscles)

The semispinalis group muscles (see figure 2.6) are deeper than the splenius group muscles (Levangie and Norkin, 2011). The semispinalis capitis muscle originates from the occiput between the superior and inferior nuchal line and inserts at the articular processes of the C4 to C6 vertebrae (Simons et al., 1999). The semispinalis cervicis muscle originates from the thoracic transverse processes of T1 to T5 and inserts at the spinous processes of the lower cervical spine (Levangie and Norkin, 2011).

The branches of the posterior primary division of the first four or five cervical spinal nerves supply the semispinalis capitis muscle. The third to sixth cervical spinal nerves supply the semispinalis cervicis muscle (Simons et al., 1999).

The function of the semispinalis capitis muscle is primarily to produce extension of the head and functions in antigravity control of the head when one leans forward. The function of the semispinalis cervicis muscle is mainly to extend the neck and rotate it to the opposite side (Simons et al., 1999).

2.2.3.5 Longissimus capitis and longissimus cervicis (intrinsic back muscles)

The longissimus capitis and longissimus cervicis muscles (see figure 2.6) are lateral and deeper to the semispinalis group of muscles (Levangie and Norkin, 2011) and also forms part of the erector spinae muscles of the cervical spine (Simons et al., 1999). The longissimus capitis muscle originates from the articular processes of the last three or four cervical vertebrae and transverse processes of the first four or five thoracic vertebrae, and inserts at the skull along the posterior margin of the mastoid process (Simons et al., 1999). The longissimus cervicis muscle originates from the transverse processes of the first four to five thoracic vertebrae and articular processes of the last four cervical vertebrae, and inserts at the transverse processes C2 to C6 vertebrae (Kinesio Taping® Association International, 2011a).
The lateral branches of the posterior primary divisions of the cervical spinal nerves supply both the longissimus capitis muscle and the longissimus cervicis muscles (Simons et al., 1999).

The function of the longissimus capitis muscle is to produce extension of the head as well as rotation and lateral flexion to the same side (Simons et al., 1999). The function of the longissimus cervicis muscle is to extend the spine bilaterally and is also a postural stabiliser (Kinesio Taping® Association International, 2011a).
Figure 2.6 Illustration of the posterior muscle layers of the cervical spine: (A) Superficial layer, (B) Intermediate layer and (C) Deep layer (Netter, 2003)

2.2.4 The integumentary system

The integumentary system is the body’s first line of defence against the external environment and plays an integral part in the functioning of the human body. The system consists of two major components, the cutaneous membrane (skin) and the accessory structures (Martini, Ober, Garrison, Welch and Hutchings, 2006).

The skin is a complex organ (largest of the body) and not merely just a passive protective mantle (Kumar, Abbas, Fausto and Mitchell, 2007). The skin consists of two components, the epidermis which forms the outermost layer and the dermis which lies between the epidermis and the subcutaneous layer. The accessory structures include the nails, exocrine glands and hair which are located in the dermis and protrude through the epidermis to the skin surface (Martini et al., 2006).
The integumentary system functions with, and is supported by a large network of blood vessels and nerves that run within the subcutaneous layer of the skin. Martini et al. (2006) stated that the general functions of the skin and subcutaneous layer include:

- Protection of underlying tissues and organs
- Excretion of waste products
- Maintenance of normal body temperature
- Synthesis of vitamin D
- Storage of nutrients
- Detection of touch, pressure, temperature and pain

The receptors of the skin will be discussed in detail, due to the relevance of the study.

### 2.2.4.1 Innervation of the skin

The peripheral nervous system (PNS) and central nervous system (CNS) are anatomically and operationally continuous with each other. The PNS sensory fibres convey neural impulses from the sense organs and sensory receptors in various parts of the body which includes the skin. The PNS nerves are either cranial nerves or spinal nerves (Moore and Dalley, 2006).

Spinal nerves arise from the spinal cord as rootlets which converge to form either a ventral root (motor fibres) or a dorsal root (sensory fibres) as figure 2.7 illustrates. The ventral and dorsal roots unite to form a mixed spinal nerve, which divides into two primary rami: a ventral ramus and a dorsal ramus. The dorsal ramus splits into a medial and lateral branch. The dorsal rami supply nerve fibres to the synovial joints of the vertebral column, deep muscles of the back and the overlying skin in a segmental pattern (Moore and Dalley, 2006).
The skin is filled with sensory receptors and anything that comes into contact with it initiates a nerve impulse that can reach our conscious awareness (Martini et al., 2006). Guyton and Hall (1997) stated that there are five types of sensory receptors: nociceptors, mechanoreceptors, thermoreceptors, electromagnetic receptors and chemoreceptors. Nociception or pain perception is mostly relayed by the free nerve endings in the skin. Thermo or temperature receptors are also free nerve endings found in the skin and skeletal muscles and transmit change in temperature to the nervous system (Martini et al., 2006).

Mechanoreceptors are sensitive to stimuli that distort their cell membranes. These cell membranes contain mechanically regulated ion channels that respond to stretching, twisting or compression of the membrane (Martini et al., 2006). According to Martini et al. (2006) there are three classes of mechanoreceptors:

- Tactile receptors that provide sensations of touch, pressure and vibration
- Baroreceptors that detect pressure changes in the walls of the blood vessels
- Proprioreceptors that detect positional changes in the joints.

**Figure 2.7 Spinal cord, grey matter, spinal roots and spinal nerves (Netter, 2003)**
Tactile receptors (see figure 2.8) are further divided into fine touch and pressure receptors and crude touch and pressure receptors. Fine touch receptors provide detailed information about a source of stimulation, including the exact location, shape, size, texture and movement. These receptors have very high sensitivity, but small receptive field. The crude touch receptors provide poor localisation of stimuli, due to the large receptive field of the receptor (Martini et al., 2006).

Martini et al. (2006) stated that tactile receptors range in complexity, from free nerve endings to specialised sensory complexes with supporting structures, and that there are six types of tactile receptors:

1. Free nerve endings (sensitive to touch and pressure) are situated between epidermal cells
2. Nerve endings of the root hair plexus (monitor distortions and movements across the body surface)
3. Merkel discs (fine touch and pressure receptors)
4. Meissners’ corpuscles (perceive sensation of fine touch, pressure and low-frequency vibration)
5. Pacinian corpuscles (sensitive to deep pressure and most sensitive to pulsing or high-frequency vibrating stimuli) are located throughout the dermis
6. Ruffini corpuscles (sensitive to deep pressure and skin distortion) are located in the reticular dermis
Chemoreceptors detect small changes in the concentration of specific chemicals or compounds. In general they respond only to water-soluble and lipid-soluble substances dissolved in surrounding fluid and exhibit peripheral adaptation over a period of seconds (Martini et al., 2006).

2.3 Biomechanics of the Cervical Spine

Levangie and Norkin (2011) stated that the cervical spine is designed for a large amount of movement and moves almost six hundred times every hour whether we are awake or asleep. Flexion, extension, rotation and lateral flexion are permitted in the cervical region, accompanied by translations. The predominant translation occurs in the sagittal plane during flexion and extension. The cervical region is subjected to axial compression, tension, bending, torsion and shear stresses, but differs from the other regions in that it is more mobile and bears less weight (Levangie and Norkin, 2011).

The discs at atlanto-occipital and atlantoaxial joints are absent and therefore the compressive load must be transferred directly through the atlanto-occipital joint to articular facet of the axis. The pedicles and laminae of the axis transfer these

Figure 2.8 Skin with its tactile receptors (Martini et al., 2006)
forces to the inferior surface of the vertebral body and to the two inferior zygapophyseal articular processes, which transfer the forces to the adjacent inferior disc. The laminae in the axis are large and therefore adapted to transmit these compressive loads (Levangie and Norkin, 2011).

In the lower cervical spine the compressive loads are transmitted by three parallel columns: a single anterocentral column formed by the vertebral bodies, and two posterolateral columns formed by the left and right zygapophyseal joints. The compressive forces are primarily transmitted by the vertebral bodies and the intervertebral discs. During erect sitting and standing postures the compressive loads are low, and are high during at end ranges of flexion and extension (Levangie and Norkin, 2011).

2.3.1 Atlanto-occipital joint

The primary movement that occurs at the atlanto-occipital joints is flexion and extension. The combined range of motion for flexion-extension ranges from 10 to 30 degrees. In flexion, the occipital condyles roll forward and slide backward while the occipital bones separate from the posterior arch of the atlas. In extension, the occipital condyles roll backward and slide forward while the occipital bones approximate to the posterior arch (Bergmann and Peterson, 2011). A few degrees axial rotation and lateral flexion are available at this segment, but is extremely limited by tension in the joint capsules (Levangie and Norkin, 2011).

2.3.2 Atlantoaxial joint

The primary movement that occurs at the atlantoaxial joint is axial rotation. The segmental range of motion for rotation ranges from 40 to 45 degrees to each side, or a total of about 90 degrees. The joint contributes approximately 55 to 58 percent of the total rotation in the cervical spine (Levangie and Norkin, 2011). During rotation the articular surfaces slide posteriorly on the side of rotation and anteriorly on the side opposite to rotation. This motion occurs about a centrally
located axis within the odontoid process and is limited by the alar ligaments (Bergmann and Peterson, 2011). Other motions at the joint include flexion, extension and lateral flexion (Levangie and Norkin, 2011).

### 2.3.3 Lower cervical spine

The primary movement that occurs at the lower cervical spine is flexion and extension. The combined range of motion for flexion-extension averages 15 degrees per segment and is greatest at the C5-6 motion segment (Bergmann and Peterson, 2011). During flexion the cranial vertebra tilts anteriorly which is coupled with anterior translation (Levangie and Norkin, 2011), stretches the facet joints and posterior disc, and compresses the anterior disc (Bergmann and Peterson, 2011). During extension the cranial vertebra tilts posteriorly which is coupled with posterior translation (Levangie and Norkin, 2011), stretches the anterior disc and compresses the posterior disc (Bergmann and Peterson, 2011). Flexion and extension occur around an axis located in the subjacent vertebra and combine sagittal plane rotation with sagittal plane translation. The net effect of these two forces is to limit shifting of the nucleus pulposus during flexion, extension and lateral flexion (Bergmann and Peterson, 2011).

Other movements of the lower cervical spine include rotation and lateral flexion which both decrease significantly at the cervicothoracic junction. Lateral flexion exhibits greater movement than rotation (Bergmann and Peterson, 2011). These movements are coupled motions as movement of either alone would cause the zygapophyseal joints to abut one another and prevent motion (Levangie and Norkin, 2011).

Lateral flexion has a range of motion of 10 degrees to each side in the midcervical segments, which decreases towards the caudal segments. During lateral flexion the facets on the side of lateral flexion slide together as the inferior facet slides inferomedially due to the coupled rotation. On the opposite side, the facets distract and the inferior facet slides superiorly (Bergmann and Peterson, 2011).
Rotation has an average range of motion slightly less than those of lateral flexion which also decreases towards the caudal segments. During rotation on the side of cervical rotation (posterior body rotation), the inferior facet of the superior vertebra glides posteroinferiorly as the contralateral facet glides anterosuperiorly (Bergmann and Peterson, 2011).

### 2.4 Chronic Neck Pain

Chronic pain is defined by Verhaak, Kerssens, Dekker, Sorbi and Bensing (1998) as the persistence of pain for one month or longer. Bronfort et al. (2001) reported that painful zygapophyseal joints and weak neck muscles are common in patients with chronic neck pain.

Bogduk (2003) defined neck pain as a pain that is perceived to arise in a region bounded inferiorly by an imaginary line running through the spinous process of T1, laterally by the margins of the neck and superiorly by the superior nuchal line. Neck pain according to Bogduk (2003) can be caused by nerve injuries, radiculopathy, postural disorders and soft tissue injuries. Gerwin (2001) reported that neck pain is also caused by extensor cervical muscle trigger points and weakness, which includes longissimus cervicis muscle. Fernández de las Penas, Cleland and Huijbregts (2011) further stated that pathological conditions such as malignancy, cervical myelopathy, fracture, systemic disease and arterial dysfunction can also cause neck pain.

A systemic review of literature done by Fejer, Kyvik and Hartvigsen (2006) indicated that neck pain of one year duration was found in 37.2 percent of the population. According to SaAvedar-Hernadez, Castro-Sanchez, Arroyo-Morales, Cleland, Lara-Palomo and Fernandez-De-La-Penas (2012) the best possible treatment protocol for patients with neck pain remains a priority for researchers as it results in substantial disability and costs.
Fernandez-de-las-Penas, Palomeque-del-Cerro, Rodriguez-Blanco, Gomez-Conesa and Miangolarra-Page (2007) stated that spinal manipulation is commonly used in the treatment of chronic neck pain. Furthermore, spinal manipulation aimed at the cervical spine is very effective intervention in patients with chronic neck pain (Fernandez-de-las-Penas et al., 2007).

2.5 Spinal Manipulation

2.5.1 The chiropractic hypothesis

Bergmann and Peterson (2011) stated that the broad chiropractic model of health care is one of holism. This model views the human being as a dynamic, integrated and complex living thing who has an innate capacity for self-healing and to maintain homeostatic balance. The human body is perceived as being charged with an innate ability to respond to the environment (Bergmann and Peterson, 2011).

Chiropractic focuses on the treatment and evaluation of neuromusculoskeletal disorders and does not disregard the many potential causes of ill health and the complex nature of health maintenance. Paramount to the chiropractic principle is the significant role the nervous system plays in the human being as it influences all the other systems in the body and therefore helps with health and disease. Spinal manipulation is the most specialised and distinct therapy used by chiropractors to enhance the body’s ability to self-regulate through its effects on the nervous system and hence, all other systems (Bergmann and Peterson, 2011).

According to Haldeman (1993) spinal manipulation improves the musculoskeletal system’s function, which affects the nervous system, which in turn may have positive effects on the other neuromusculoskeletal tissues, organ dysfunction, tissue pathologies or symptom complexes.
2.5.2 Vertebral subluxation

Bergmann and Peterson (2011) stated that D.D Palmer, the founder of chiropractic, defined the vertebral subluxation as a partial or incomplete separation, one in which the articulating surfaces remain in partial contact. Gatterman and Hansen (1994) further defined a vertebral subluxation as a motion segment in which alignment, movement integrity, or physiology is altered, although the contact between the two joint surfaces remains in contact. This causes an alteration in the biomechanical or neurophysiological reflections of these articular structures or body systems that may be directly or indirectly affected by them (Bergmann and Peterson, 2011).

2.5.3 The Vertebral Subluxation Complex (VSC)

The VSC is central to the philosophy, science and practice of chiropractic, and is defined as a motion segment in which the movement, alignment and/or the physiological function is altered, although contact between the joint surfaces stays intact (Lantz, 1995). According to Lantz (1995) the VSC is a model of motion segment dysfunction from a chiropractic clinic perspective. Any form of kinesiological dysfunction is central to Lantz’s concept of subluxation.

The kinesiopathology component is placed at the apex of the VSC, because restoration of motion is the chiropractor’s central goal (Lantz, 1995). Movement is affected by muscle (myologic component) that is guided, limited and stabilized by connective tissue which is controlled by the nervous system accordingly, while the vascular system provides nutrition, acts as a cleansing source and largely mediates the inflammatory response. The coordinated function of all the tissue components of the VSC (kinesiological, mycological, connective tissue, inflammatory and vascular) is in turn controlled by the nervous system and they are responsible for permitting and sustaining adequate segmental motion. Any disturbance of these components is perceived to have inevitable effects on all the other components (Lantz, 1995).
According to Esposito and Philipson (2005) the primary responses to the VSC are muscle spasm, pain, sympathetic hyperactivity/vasomotor change and altered mobility. Esposito and Philipson (2005) further stated that altered mobility causes mechanical and biomechanical dysfunction which leads to abnormal range of motion which sets up neural receptor irritation and altered muscle dysfunction, perpetuating the basic loop of dysfunction.

Lantz (1995) concluded that the vertebral subluxation complex allows for every aspect of chiropractic care to be incorporated into a single conceptual model. Each diagnostic procedure can be mapped into one or more of the components and the effects of spinal manipulation can be assigned to specific tissue components or their elements.

2.5.4 Vertebral adjustment

Vertebral subluxations of the cervical spine can have an impact on a person’s life by impairing their normal routine, occupational functioning, social activities, and general health. Haneline (2005) stated that spinal manipulation is the basis of chiropractic practice and is the most focused and important therapy used by chiropractors. The diversified techniques are the most commonly taught and used manipulative methods in chiropractic and include a number of manipulative approaches that are applied to all spinal and most peripheral joints (Haneline, 2005).

According to Swartz (2002) spinal manipulation has been used to restore normal joint function, thereby reversing pathological processes. Spinal manipulation is characterised by a low-amplitude dynamic thrust of controlled velocity, amplitude, direction and is commonly associated with a cavitation. Spinal manipulation commonly affects joint and neurophysiologic function (Bergmann and Peterson, 2011).
It has been noted by Cramer et al. (2011) that spinal manipulation causes facet joint gapping, which is the separation of the zygapophyseal joint surfaces and is thought to break up connective tissue adhesions, stimulate afferent nerves that innervate the facet joint capsule as well as the small muscles of the spine and initiate the recovery process. Fernández de las Penas et al. (2011) suggested that spinal manipulation is effective in immediately improving cervical spine range of motion and decreasing neck pain.

2.5.5 Reflex theories of spinal manipulation

Gillette (2002) stated that spinal manipulation may induce a short-lived phasic response triggered by the stimulation of both deep and superficial mechanoreceptors. A longer lived tonic response may also be initiated, which is triggered by the noxious stimulation of nociceptive receptors.

Stimulus-produced analgesia is bolstered by research that implies that spinal manipulation induces sufficient force to simultaneously activate both superficial and deep somatic mechanoreceptors, proprioceptors and nociceptors. This stimulation produces a barrage of strong afferent sensory impulses capable of inhibiting the central transmission of pain (Bergmann and Peterson, 2011).

According to Fernandez-de-las-Penas et al. (2007) the neurophysiologic mechanisms by which spinal manipulation is effective in decreasing pain are not completely understood. There are two possible mechanisms. One mechanism could be that spinal manipulation may induce a reflex inhibition of pain or reflex muscle relaxation by modifying the discharge of proprioceptive group one and two afferents. A second mechanism might be a presynaptic inhibition of segmental pain pathways and the activation of the endogenous opiate system. These two mechanisms would explain local effects of spinal manipulation (Fernandez-de-las-Penas et al., 2007).
Martinez-Segura, Fernandez-de-las-Penas, Ruiz-Saez, Lopez-Jimenez and Rodriguez-Blanco (2006) suggested that another possible mechanism can be that spinal manipulation causes mechanical stimulation of joint capsule proprioceptors and muscle spindles and induces a reflex inhibition of pain and improves mobility. Nevertheless, it seems that more than one mechanism likely explains the effects of spinal manipulation (Fernandez-de-las-Penas et al., 2007).

Haldeman (1993) stated that spinal manipulation has been shown to produce a consistent reflex from a multi-receptor origin, resulting in clinical observed benefits, which include pain reduction and decreased muscle hypertonicity.

2.6 Taping Techniques

2.6.1 Sports taping

There are many therapy choices to address problems involving athletes and patients, such choices include devices that give direct stabilization and support to the affected area. These devices do a good job of temporarily decreasing pain and symptoms (Kase et al., 2003). Kinesio Taping® Association International (2011a) recognises three main taping techniques within the therapeutic communities: Prophylactic Athletic Taping, McConnel® Taping Technique and the Kinesio® Taping Method.

2.6.1.1 Athletic taping technique

Its primary function is to limit or assist joint movement for acute injuries or injury prevention. The tape applies a compressive force to the skin, joints and muscles and requires pre-tape or an adhesive spray prior to application. The tape has limited wear time and is applied immediately prior to activity and taken off immediately thereafter. Skin irritation may be due to moisture entrapment, latex content, skin compression, joint compression and muscle compression (Kinesio Taping® Association International, 2011a).
2.6.1.2 McConnell® taping technique

McConnell Taping is a bracing or strapping technique using a extremely rigid tape placed over a cotton mesh tape (Leukotape® over Endura-Tape®) and is widely accepted by the medical community. The tape is meant to affect the biomechanics of a patient, limit pathological movement and should not be left on for more than eighteen hours to prevent skin reactions. Skin irritation may be due to moisture entrapment, latex content, skin compression, joint compression and muscle compression. Primarily the tape helps with neuromuscular re-education (Kase et al., 2003).

Yasukawa, Patel and Sisung (2006) stated that the non-stretch rigid tape is used to protect and support a joint structure or to limit unwanted joint movement. However Bragg, Macmahon, Overom, Yerby, Matheson and Carter (2002) found that athletic tape after 15-20 minutes of exercise loses its ability to restrict joint movement and has a poor adhesive quality when wet. Therefore according to Simoneau, Degner, Kramper and Kittleson (1997) the effects of taping may be due to cutaneous stimulation of the proprioceptive and sensorimotor systems.

2.6.1.3 Kinesio® taping method

The method of Kinesio® taping is designed to assist the body’s natural healing process with the ability to support and stabilise the muscle and joints without restricting the body’s range of motion. The tape activates neurological and circulatory systems, promotes venous and lymphatic flow, reduces inflammation and provides stability to injured joints (Kase et al., 2003). Kinesio® tape also causes an increase in proprioception through increased stimulation of the cutaneous mechanoreceptors by applying pressure to, and stretching the skin (Halseth, McChesney, DeBeliso, Vaughn and Lien, 2004). According to Kinesio Taping® Association International (2011a) the tape is a modality that has a continued therapeutic benefit between visits, which increases the function of many different tissues and helps the body to return to normal functioning.
SaAvedar-Hernadez et al. (2012) states that the tape is waterproof, porous, adhesive, has a width of 5 cm and a thickness of 0.5 mm. Kinesio® tape is constructed of 100 percent cotton and elastic fibres, stretches along the longitudinal axis only and its adhesive is 100 percent medical grade, acrylic, heat-activated and has no medicine. The thickness and weight of the tap is similar to skin and its wave like adhesive pattern mimics that of a fingerprint allowing the skin to breathe (Thelen, Dauber and Stoneman, 2008). The tape allows normal range of motion and may stay on the skin for 3-5 days with good skin tolerance. Cotton fibres wrap the elastic strands which allow for evaporation and quick drying so it can be worn in the shower or while swimming (Kase et al., 2003). Lastly, prescribed wear time for one application is usually three to four days (Thelen et al., 2008).

The Kinesio® taping method is applied on the skin over muscles and joints to reduce pain and inflammation, relax overused muscles and to support muscles and joints while maintaining normal range of motion (Thelen et al., 2008). According to Kinesio Taping® Association International (2011a) the tape is used to treat patients with: muscle imbalances, postural insufficiency, circulatory and lymphatic conditions, neurological conditions, ligament injuries, tendon injuries, joint injuries, fascial adhesions and scars.

The five major physiological systems affected by Kinesio® Tex Tape was found by Kinesio Taping® Association International (2011a) to be the skin and its receptors, superficial fascia, circulatory and lymphatic systems, muscles and the joints.

The application of Kinesio® Tex Tape changes the tension elements in tissues. Because the body is hierarchical, self-organizing and load distributing the tissues react and compensate for these changes in tension (Kinesio Taping® Association International, 2011a). The taping method for applying the tape differs depending on the goal: increasing active range of motion, relieving pain, adjusting misalignments or increasing lymphatic circulation (Kase et al., 2003).
When the taping method is followed correctly the tape effects muscle by facilitating a weakened muscle or relaxing an overused muscle, decreasing pain and fatigue and increasing tissue recovery. Kinesio® tape affects the joints biomechanics by balancing agonist and antagonist, decreasing muscle guarding and pain, supporting ligament and tendon function and increasing kinaesthetic awareness (Kinesio Taping® Association International, 2011a). Pain reduction occurs due to the mechanical stimulation that the tape has on the skin. The tape provides a prolonged stimulation of the mechanoreceptors in the skin by compressive forces or decompressive forces that unload the mechanoreceptors by decreasing inflammation. Either of these forces relieves pain (Kase et al., 2003).

SaAvedar-Hernandez et al. (2012) stated that Kinesio® taping decreases neck pain and disability in individuals with mechanical neck pain. A possible mechanism by which Kinesio® taping induces these changes may be related to the neural feedback provided to the individuals, which can facilitate their ability to move the cervical spine with a reduced mechanical irritation on the soft tissues. In addition SaAvedar-Hernadez et al. (2012) stated that the tape may create tension in soft tissue structures that provide afferent stimuli, facilitating a pain-inhibitory mechanism and thereby reducing the pain levels.

Chapter 3 will discuss the method in which the study was done.
CHAPTER THREE – METHODOLOGY

3.1 Introduction

This chapter will discuss the method in which the research was performed. It outlines the treatment protocols and the measurement techniques used for the different groups during the study.

3.2 Participant Recruitment

Thirty participants with neck pain for one month or more (chronic neck pain) were included into the study. Participants were recruited via “word of mouth” advertising by students and participants, and an advertisement (Appendix A) was placed on the notice board in the Chiropractic clinic.

3.3 Sample Selection and Size

The study consisted of three groups of ten participants, who was examined and accepted according to the inclusion and exclusion criteria. The grouping was determined by random group allocation. The study did not discriminate against demographics such as gender and race. The participants needed to comply with the inclusion and exclusion criteria to ensure validity. All participants were requested to read the information sheet (Appendix B) and sign the consent form (Appendix C) specific to this study.

3.4 Inclusion Criteria

Participants had to:

- Present with neck pain of one month or longer
- Not use pain or anti-inflammatory medication during this study
- Have joint restriction(s) of the cervical spine as determined by motion palpation
• Be between ages 18-50. This was to limit the risk of degenerative changes having occurred in the cervical spine (Carnes and Vizniack, 2010)

3.5 Exclusion Criteria

Participants may not:

• Have had contraindications to spinal manipulation (Appendix D)
• Have had history of cervical surgery
• Have had contraindications to Kinesio® tape (Appendix E)

3.6 Group Allocation

The grouping was determined by random group allocation. The participants had the opportunity to select a card from an envelope, which either had Group 1, Group 2 or Group 3 written on it. In this way participants were placed in their respective groups. This ensured the random allocation of the participants into the three treatment groups. Group 1 received spinal manipulation to restriction(s) of the cervical spine only. Group 2 received Kinesio® taping to longissimus cervicis muscles only. Group 3 received a combination of spinal manipulation and Kinesio® taping.

3.7 Treatment Protocol

The venue for the treatment was in the Chiropractic clinic on the University of Johannesburg’s Doornfontein campus. All the treatments were performed by the researcher under the supervision of the clinician on duty. There were seven consultations in total. There were six treatment consultations over three weeks, with two treatments being performed per week. The seventh and final consultation was for data collection only.
3.7.1 Initial consultation

The first consultation consisted of:

- All participants were requested to read the information sheet (Appendix B) and sign the consent form (Appendix C) for this study.
- A full case history (Appendix F) and physical examination (Appendix G) of each participant was performed by the researcher.
- Cervical spine regional examination (Appendix H) and cervical spine motion palpation were performed.
- A summary of these forms were included on a SOAP note (Appendix I) and signed by the clinician on duty.
- The participants completed the Vernon-Mior Neck Pain and Disability Index (Appendix J) and NPRS (Appendix K).
- The researcher measured the range of motion of the cervical spine of the participant with the CROM instrument and recorded the measurements.
- Treatment was performed as per participant’s group allocation.
- Group 1 received spinal manipulation to restriction(s) of the cervical spine only.
- Group 2 received Kinesio® taping to longissimus cervicis muscles only.
- Group 3 received a combination of spinal manipulation and Kinesio® taping.

3.7.2 Follow-up consultation

The follow-up consultations consisted of:

- Subjective and objective data were collected prior to treatment on the fourth consultation and at the seventh/final consultation, where no treatment took place as described previously.
- Each group received the respective treatment protocol as per group allocation.
- In the groups where Kinesio® tape was applied, a new application of the tape was done at each treatment.
3.8 Motion Palpation

Motion palpation was used to detect joint dysfunction and the direction of motion restriction in the cervical spine of the participants. It was noted by Humphreys, Delahaye and Peterson (2004) that motion palpation is a valid and reliable diagnostic tool which is employed by many practitioners to detect major spinal fixations in the cervical spine.

The cervical spine was palpated for the loss in motion in the following directions:

- Flexion
- Extension
- Lateral flexion
- Rotation

3.9 Chiropractic Manipulation

The rotary cervical index contact spinal manipulation technique was used in the study (Esposito and Philipson, 2005). The participant was supine with the head resting on a pillow and the cervical spine in neutral. The index finger made contact over the posterior-lateral aspect of the zygapophyseal joint, whilst the participant’s head was cradled with the other hand. Ipsilateral lateral flexion and contralateral rotation was applied to the cervical spine until tension was felt at the contact point. At tension a high-velocity, low-amplitude spinal manipulation was applied upward and medially (SaAvedar-Hernadez et al., 2012).

3.10 Application Method of Kinesio® Tape to Longissimus Cervicis

The Kinesio® tape was pre cut by the researcher into 15cm X 5cm pieces with a longitudinal cut of 11cm along the middle of the length of the tape to produce a Y-strip of tape with two tails. All the corners of the tape were rounded, to prevent the corners of the tape catching on to clothes.
The Kinesio® taping was performed as described by SaAvedar-Hernadez et al. (2012) as follows:

- The Kinesio® consisted of a beige Y-strip, and was applied to the longissimus cervicis muscles with the participant in the seated position
- The tape was first anchored below the T4 spinous process with no stretch applied (Figure 3.1)
- The participant forward flexed and rotated the head and neck away from the side being taped (Figure 3.2)
- Each tail (beige Y-strip, two tailed), with a stretch of 15 to 25 percent applied to it was placed over the longissimus cervicis muscles (Kinesio Taping® Association International, 2011a) (Figure 3.3)
- Once both the tails of the beige Y-strip were placed correctly, the tape was rubbed to activate the adhesive layer of the tape
- The participant was asked to sit upright, and the application was checked for proper adhesion (Figure 3.4)
- The participant was instructed to keep the tape on for two to three days, until new taping would be applied in the following consultation
3.11 Subjective Data Collection

3.11.1 Numerical Pain Rating Scale (NPRS)

The participant was asked to complete the NPRS (Appendix K) which has been shown by SaAvedar-Hernadez et al. (2012) to be a valid and reliable tool. The participant chose a number on the scale, which included numbers from zero representing no pain to ten representing the maximum pain, which best represented their pain at that moment. The number was noted in the file.

3.11.2 The Vernon-Mior Neck Pain and Disability Index

It was used to measure the participant’s functional level of disability due to chronic neck pain. The participant was asked to answer the questionnaire, which consisted of ten sections and each with six possible answers (scoring 0-5), by marking the statement under each unit that best describes the level of disability the participant was feeling at that moment. The first section rated the pain intensity and the following nine rated the effect that pain had on their daily activities such as: personal care, lifting, reading, headaches, concentration, work, driving, sleeping and recreation. The score was recorded accordingly.
Scoring of the Vernon-Mior Neck Pain Disability Index is shown in the table below:

**Table 3.1: Vernon-Mior Neck Pain and Disability Index scores and their meanings**

<table>
<thead>
<tr>
<th>Score Range</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 10</td>
<td>Normal</td>
</tr>
<tr>
<td>11 - 20</td>
<td>Mild disability</td>
</tr>
<tr>
<td>21 – 30</td>
<td>Moderate disability</td>
</tr>
<tr>
<td>31 – 40</td>
<td>Severe disability</td>
</tr>
<tr>
<td>41 – 50</td>
<td>Complete/exaggerated disability</td>
</tr>
</tbody>
</table>

The Vernon-Mior Neck Pain and Disability Index (Appendix J) was shown to be a valid and reliable questionnaire by McCarthy, Grevitt, Silcocks and Hobbs (2007).

**3.12 Objective Data Collection**

The CROM instrument accurately measures the sagittal, coronal and horizontal range of motion movements that can be performed by the cervical spine in degrees. It eliminates location errors, initial head position errors and tracking errors by using a mainframe which is positioned over the nose bridge and to the ears, whilst in an upright position (http://www.spineproducts.com).

The participant was seated on a chair with both feet flat on the ground, knees and hips flexed to 90 degrees and buttocks against the back of the chair. The CROM mainframe was positioned appropriately on top of the participant’s head as described previously. The participants were asked to move their heads as far as their pain would allow them to in normal fashion (flexion, extension, right lateral flexion, left lateral flexion, right rotation, and left rotation). A reading was taken after each movement.
Normal cervical spine ranges of motion are shown in the table below:

Table 3.2: Normal range of motion of the cervical spine (Vizniak, 2010)

<table>
<thead>
<tr>
<th>Flexion</th>
<th>Extension</th>
<th>Lateral Flexion</th>
<th>Rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>60°</td>
<td>60°</td>
<td>45°</td>
<td>80°</td>
</tr>
</tbody>
</table>

To ensure validity and accuracy, the researcher used the CROM instrument throughout the research to measure cervical spine range of motion as it is has been shown by SaAvedar-Hernadez et al. (2012) to be a valid and reliable tool.

3.13 Data Analysis

Both subjective and objective data (Appendix L) was analysed by statisticians located at the University of Johannesburg Kingsway campus at STATKON.

A statistician analysed the data using exploratory data analysis to determine normality and equal variances. Once the exploratory data analysis was completed, either parametric or non-parametric testing was employed. If outliers were found in the data, non-parametric testing was used. If the data displayed normality and equal variances, parametric testing was used. The assumptions of normality and equal variances did not hold true therefore non-parametric testing was utilised. In this study the non-parametric test, the Kruskal-Wallis test, was used and if positive the Mann-Whitney test was used for the inter-group analysis. In this study the non-parametric test, the Friedman test, was used and if positive the Wilcoxon signed rank test was used for the intra-group analysis.
3.14 Ethical Considerations

The consent form (Appendix C) was read and signed by each participant prior to data collection. The name of the researcher, purpose of the study and benefits of partaking in the study, participant assessment and treatment procedure was outlined in the information sheet (Appendix B) and consent form (Appendix C). Risks, benefits and discomforts caused by the treatments were discussed and the participant’s safety was a priority at all times.

The privacy of the participant was protected. The only people in the treatment room were the researcher, participant and clinician. The participant’s information was converted into data, meaning anonymity was ensured. Standard doctor/patient confidentiality was adhered to at all times. Participants participated on a voluntary basis and they were free to withdraw from the study at any stage. Any questions by the participants were explained by the researcher, whose contact details were made available. All participants were requested to sign the information sheet (Appendix B) and consent form (Appendix C), indicating that they understood all that was required of them for this study. The results of the study were made available on request to the participants.

With regards to this particular study, there were risks, benefits and discomforts that the participant could experience. Spinal manipulations were normally done as part of routine chiropractic care and present a slight risk of discomfort. Manipulation may have resulted in post-manipulation stiffness. There was also a slight possibility of pain. Kinesio® taping could cause skin irritation due to the tape’s adhesive glue, and should have been removed immediately if it did so. The participant’s protection was that experienced personnel performed the manipulations and taping under observation of a qualified chiropractor. The study was investigational and there may have been other risks or side effects which were unforeseen or unknown. The participant should have immediately contacted the researcher if any side effects were perceived by the participant’s participation
in this study. No participants suffered any adverse effects to any of the treatment modalities during this study, thus no participants had to be referred.

The benefit regarding this study was a possible decrease in neck pain which would improve a person’s life by improving their normal routine, occupational functioning, social activities, and general health. It would also benefit to determine the efficacy of utilising Kinesio® taping in isolation or in combination with spinal manipulation, in the treatment of chronic neck pain and provide further evidence on the efficacy of spinal manipulation.

Chapter four will discuss the results of the study that were obtained during the clinical trial of this study.
CHAPTER FOUR – RESULTS

4.1 Introduction

This chapter presents the results that were obtained during the clinical trial of this study. This study was a comparative study consisting of three groups of ten participants, who were examined and accepted according to the inclusion and exclusion criteria.

The method of treatment was determined by random group allocation. Group 1 received spinal manipulation to restriction(s) of cervical spine only. Group 2 received Kinesio® taping to the longissimus cervicis muscles only. Group 3 received a combination of spinal manipulation and Kinesio® taping as previously described.

Both subjective and objective data was analysed by statisticians located at the University of Johannesburg Kingsway campus at STATKON.

In this study the Shapiro-Wilk test was used with regards to the tests of normality. This was due to the group sizes being under fifty participants. The assumptions of normality and equal variances did not hold true therefore non-parametric testing was utilised. In this study the non-parametric test, the Kruskal-Wallis test, was used and if positive the Mann-Whitney test was used for the inter-group analysis. In this study the non-parametric test, the Friedman test, was used and if positive the Wilcoxon signed rank test was used for the intra-group analysis.

The results represent a small group of subjects and therefore no assumptions can be made with respect to the population as a whole. The p-value for all tests was set at 0.05 and represented the level of significance of the results. Therefore a p-value that was ≤ 0.05 was statistically significant.
With regards to the clinical analysis of the subjective measurements, a decrease percentage of the mean over the treatment period was determined by the following method:

- Step 1: \( \frac{\text{Visit 7 mean}}{\text{Visit 1 mean}} \times 100 = x\% \)
- Step 2: 100\% - x\% = Decrease percentage over treatment time

Clinical analysis of the objective measurements determined an increase percentage of the mean over the treatment period by the following method:

- Step 1: \( \frac{\text{Visit 1 mean}}{\text{Visit 7 mean}} \times 100 = x\% \)
- Step 2: 100\% - x\% = Increase percentage over treatment time

The data analysis included:

- Demographic data analysis consisting of age and gender
- Subjective measurements consisting of the NPRS and the Vernon-Mior Neck Pain and Disability Index
- Objective measurements consisting of readings from a CROM instrument which included cervical spine flexion, extension, rotation and lateral flexion

### 4.2 Demographic Data Analysis

#### Table 4.1: Demographic data

<table>
<thead>
<tr>
<th>DATA</th>
<th>Group 1 (spinal manipulation)</th>
<th>Group 2 (Kinesio® taping)</th>
<th>Group 3 (Combination treatment)</th>
<th>Combined Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>19 – 27</td>
<td>19 – 46</td>
<td>19 – 35</td>
<td>19 – 46</td>
</tr>
<tr>
<td>Mean age</td>
<td>± 24 years</td>
<td>± 25 years</td>
<td>± 24 years</td>
<td>± 24 years</td>
</tr>
<tr>
<td>Gender distribution</td>
<td>7 males</td>
<td>4 males</td>
<td>3 males</td>
<td>14 males</td>
</tr>
<tr>
<td></td>
<td>3 females</td>
<td>6 females</td>
<td>7 females</td>
<td>16 females</td>
</tr>
</tbody>
</table>
The participants recruited for this study were between 19 and 46 years of age, with a mean age of 24 years. The combined sample group consisted of 14 male and 16 female participants.

The participants allocated to Group 1 were between 19 and 27 years of age, with a mean age of 24 years. Group 1 consisted of 7 male and 3 female participants.

The participants allocated to Group 2 were between 19 and 46 years of age, with a mean age of 25 years. Group 2 consisted of 4 male and 6 female participants.

The participants allocated to Group 3 were between 19 and 35 years of age, with a mean age of 24 years. Group 3 consisted of 3 male and 7 female participants.

4.3 Subjective Data Analysis

4.3.1 The NPRS

Table 4.2: Group 1 column statistics for cervical spine NPRS

<table>
<thead>
<tr>
<th>Visit</th>
<th>Mean</th>
<th>Std Deviation</th>
<th>Std Error</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.40</td>
<td>1.51</td>
<td>0.48</td>
<td>5.00</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>3.60</td>
<td>1.84</td>
<td>0.58</td>
<td>3.00</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>7</td>
<td>0.80</td>
<td>0.79</td>
<td>0.25</td>
<td>1.00</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>
Table 4.3: Group 2 column statistics for cervical spine NPRS

<table>
<thead>
<tr>
<th>Visit</th>
<th>Mean</th>
<th>Std Deviation</th>
<th>Std Error</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.70</td>
<td>2.00</td>
<td>0.63</td>
<td>6.00</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td>3.60</td>
<td>1.71</td>
<td>0.54</td>
<td>3.50</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>1.50</td>
<td>1.72</td>
<td>0.54</td>
<td>1.00</td>
<td>0</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 4.4: Group 3 column statistics for cervical spine NPRS

<table>
<thead>
<tr>
<th>Visit</th>
<th>Mean</th>
<th>Std Deviation</th>
<th>Std Error</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6.40</td>
<td>1.08</td>
<td>0.34</td>
<td>6.00</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>3.70</td>
<td>2.11</td>
<td>0.67</td>
<td>4.00</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>1.60</td>
<td>2.32</td>
<td>0.73</td>
<td>0.00</td>
<td>0</td>
<td>6</td>
</tr>
</tbody>
</table>

4.3.1.1 Clinical analysis

Figure 4.1 Changes in the NPRS mean value
Figure 4.1 illustrates the NPRS mean values measured at the first, fourth and seventh visit. At the first visit Group 1 had a mean value of 5.40, Group 2 had a value of 5.70 and Group 3 had a value of 6.40. At the forth visit Group 1 had a mean value of 3.60, Group 2 had a value of 3.60 and Group 3 had a value of 3.70. At the seventh visit Group 1 had a mean value of 0.80, Group 2 had a value of 1.50 and Group 3 had a value of 1.60. This indicates that the mean decrease in the NPRS value for Group 1 was 85.19%, for Group 2 was 73.68% and for Group 3 was 75.00%.

4.3.1.2 Statistical analysis

Intra-group analysis

Table 4.5: Friedman test for changes in the NPRS readings

<table>
<thead>
<tr>
<th>Friedman Test</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>p = 0.000</td>
<td>p = 0.000</td>
<td>p = 0.000</td>
<td></td>
</tr>
<tr>
<td>Thus</td>
<td>Thus</td>
<td>Thus</td>
<td></td>
</tr>
<tr>
<td>p &lt; 0.05</td>
<td>p &lt; 0.05</td>
<td>p &lt; 0.05</td>
<td></td>
</tr>
</tbody>
</table>

The Friedman test was used to check for changes over time within the three groups, and was statistically significant (p < 0.05) in all three the groups. Group 1, 2 and 3 all had p-values of 0.000. The Wilcoxon signed rank test was used for the within group analysis to demonstrate where these changes occurred.
Table 4.6: Wilcoxon signed rank test for changes in the NPRS readings

<table>
<thead>
<tr>
<th>Visit</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – 4</td>
<td>p = 0.007</td>
<td>p = 0.007</td>
<td>p = 0.011</td>
</tr>
<tr>
<td></td>
<td>Thus p &lt; 0.05</td>
<td>Thus p &lt; 0.05</td>
<td>Thus p &lt; 0.05</td>
</tr>
<tr>
<td>4 – 7</td>
<td>p = 0.005</td>
<td>p = 0.007</td>
<td>p = 0.011</td>
</tr>
<tr>
<td></td>
<td>Thus p &lt; 0.05</td>
<td>Thus p &lt; 0.05</td>
<td>Thus p &lt; 0.05</td>
</tr>
<tr>
<td>1 – 7</td>
<td>p = 0.005</td>
<td>p = 0.005</td>
<td>p = 0.007</td>
</tr>
<tr>
<td></td>
<td>Thus p &lt; 0.05</td>
<td>Thus p &lt; 0.05</td>
<td>Thus p &lt; 0.05</td>
</tr>
</tbody>
</table>

The non-parametric Wilcoxon signed rank test was used to determine where the changes occurred between visits in Group 1, 2 and 3. What can be seen from table 4.6 is that there was a statistically significant difference noted on intra-group analysis, via the Wilcoxon signed rank test of Group 2 and Group 3 between all the visits in and Group 1 between visit 1-4 and visit 1-7 terms of the NPRS over the time of the treatment. A non-statistically significant difference was noted in Group 1 between visit 4-7.

Analysis of Group 1 indicated that a statistically significant difference (p < 0.05) was found between visit 1-4 (p = 0.007), visit 4-7 (p = 0.005) and visit 1-7 (p = 0.005).

Analysis of Group 2 indicated that a statistically significant difference (p < 0.05) was found between visit 1-4 (p = 0.007), visit 4-7 (p = 0.007) and visit 1-7 (p = 0.005).
Analysis of Group 3 indicated that a statistically significant difference \((p < 0.05)\) was found between visit 1-4 \((p = 0.011)\), visit 4-7 \((p = 0.011)\) and visit 1-7 \((p = 0.007)\).

**Inter-group analysis**

**Table 4.7: Inter-group comparison at the first, fourth and seventh visit for NPRS of the three groups**

<table>
<thead>
<tr>
<th>Visit</th>
<th>Mean/p-value</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mean</td>
<td>5.40</td>
<td>5.70</td>
<td>6.40</td>
</tr>
<tr>
<td></td>
<td>p-value</td>
<td>(p = 0.322) thus (p &gt; 0.05)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Mean</td>
<td>3.60</td>
<td>3.60</td>
<td>3.70</td>
</tr>
<tr>
<td></td>
<td>p-value</td>
<td>(p = 0.999) thus (p &gt; 0.05)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Mean</td>
<td>0.80</td>
<td>1.50</td>
<td>1.60</td>
</tr>
<tr>
<td></td>
<td>p-value</td>
<td>(p = 0.778) thus (p &gt; 0.05)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Upon inter-group analysis, table 4.7 shows that the baseline reading of the p-value at visit 1 \((p = 0.322)\) started at greater than \(0.05\) and therefore the groups started off comparable. However the p-value remained greater than \(0.05\) at visit 4 \((p = 0.999)\) and visit 7 \((p = 0.778)\) and therefore there was no statistical significant difference \((p > 0.05)\) noted between the three groups.
4.3.2 Vernon-Mior Neck Pain and Disability Index

Table 4.8: Group 1 column statistics for Vernon-Mior Neck Pain and Disability Index

<table>
<thead>
<tr>
<th>Visit</th>
<th>Mean</th>
<th>Std Deviation</th>
<th>Std Error</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9.60</td>
<td>4.14</td>
<td>1.31</td>
<td>9.50</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>4</td>
<td>5.30</td>
<td>3.02</td>
<td>0.96</td>
<td>5.00</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>7</td>
<td>2.30</td>
<td>1.95</td>
<td>0.62</td>
<td>2.00</td>
<td>0</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 4.9: Group 2 column statistics for Vernon-Mior Neck Pain and Disability Index

<table>
<thead>
<tr>
<th>Visit</th>
<th>Mean</th>
<th>Std Deviation</th>
<th>Std Error</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6.90</td>
<td>4.04</td>
<td>1.23</td>
<td>8.00</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>6.00</td>
<td>4.71</td>
<td>1.49</td>
<td>5.50</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>7</td>
<td>2.80</td>
<td>3.36</td>
<td>1.06</td>
<td>1.00</td>
<td>0</td>
<td>9</td>
</tr>
</tbody>
</table>

Table 4.10: Group 3 column statistics for Vernon-Mior Neck Pain and Disability Index

<table>
<thead>
<tr>
<th>Visit</th>
<th>Mean</th>
<th>Std Deviation</th>
<th>Std Error</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>11.10</td>
<td>6.14</td>
<td>1.94</td>
<td>11.00</td>
<td>3</td>
<td>26</td>
</tr>
<tr>
<td>4</td>
<td>4.90</td>
<td>3.60</td>
<td>1.14</td>
<td>5.00</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>7</td>
<td>2.70</td>
<td>3.43</td>
<td>1.09</td>
<td>1.50</td>
<td>0</td>
<td>10</td>
</tr>
</tbody>
</table>
4.3.2.1 Clinical analysis

Figure 4.2 Changes in Vernon-Mior Neck Pain and Disability Index mean values

Figure 4.2 illustrates the Vernon-Mior Neck Pain and Disability Index mean values measured at the first, fourth and seventh visit. At the first visit Group 1 had a mean value of 9.60, Group 2 had a value of 6.90 and Group 3 had a value of 11.10. At the forth visit group 1 had a mean value of 5.30, Group 2 had a value of 6.00 and Group 3 had a value of 4.90. At the seventh visit Group 1 had a mean value of 2.30, Group 2 had a value of 2.80 and Group 3 had a value of 2.70. This indicates that the mean decrease in the Vernon-Mior Neck Pain and Disability Index value for Group 1 was 76.04%, for Group 2 was 59.42% and for Group 3 was 75.68%.
4.3.2.2 Statistical analysis

Intra-group analysis

Table 4.11: Friedman test for changes in the Vernon-Mior Neck Pain and Disability Index

<table>
<thead>
<tr>
<th>Friedman Test</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>p = 0.000</td>
<td></td>
<td>p = 0.009</td>
<td>p = 0.000</td>
</tr>
<tr>
<td>Thus</td>
<td></td>
<td>Thus</td>
<td>Thus</td>
</tr>
<tr>
<td>p &lt; 0.05</td>
<td></td>
<td>p &lt; 0.05</td>
<td>p &lt; 0.05</td>
</tr>
</tbody>
</table>

The Friedman test was used to check for changes over time within the three groups, and was statistically significant (p < 0.05) in all three the groups. Group 1 and 3 had p-values of 0.000 and Group 2 had a p-value of 0.009. The Wilcoxon signed rank test was used for the within group analysis to demonstrate where these changes occurred.
Table 4.12: Wilcoxon signed rank test for changes in the Vernon-Mior Neck Pain and Disability Index

<table>
<thead>
<tr>
<th>Visit</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – 4</td>
<td>p = 0.005</td>
<td>p = 0.325</td>
<td>p = 0.008</td>
</tr>
<tr>
<td></td>
<td>Thus p &lt; 0.05</td>
<td>Thus p &gt; 0.05</td>
<td>Thus p &lt; 0.05</td>
</tr>
<tr>
<td>4 – 7</td>
<td>p = 0.018</td>
<td>p = 0.057</td>
<td>p = 0.015</td>
</tr>
<tr>
<td></td>
<td>Thus p &gt; 0.05</td>
<td>Thus p &gt; 0.05</td>
<td>Thus p &lt; 0.05</td>
</tr>
<tr>
<td>1 – 7</td>
<td>p = 0.005</td>
<td>p = 0.011</td>
<td>p = 0.005</td>
</tr>
<tr>
<td></td>
<td>Thus p &lt; 0.05</td>
<td>Thus p &lt; 0.05</td>
<td>Thus p &lt; 0.05</td>
</tr>
</tbody>
</table>

The non-parametric Wilcoxon signed rank test was used to determine where the changes occurred between visits in Group 1, 2 and 3. What can be seen from table 4.12 is that there was a statistically significant difference noted on intra-group analysis of Group 1 between visit 1-4 and visit 1-7, Group 2 between visit 1-7 and Group 3 between all the visits. A non-statistically significant difference was noted in Group 1 between visit 4-7 and Group 2 between visit 1-4 and visit 4-7.

Analysis of Group 1 indicated that a statistically significant difference (\(p < 0.05\)) was found between visit 1-4 (\(p = 0.005\)) and visit 1-7 (\(p = 0.005\)), and a non-statistical significant difference (\(p > 0.05\)) was found between visit 4-7 (\(p = 0.018\)).

Analysis of Group 2 indicated that a statistically significant difference (\(p < 0.05\)) was found between visit 1-7 (\(p = 0.011\)), and a non-statistical significant difference (\(p > 0.05\)) was found between visit 1-4 (\(p = 0.325\)) and visit 4-7 (\(p = 0.057\)).
Analysis of Group 3 indicated that a statistically significant difference ($p < 0.05$) was found between visit 1-4 ($p = 0.008$), visit 4-7 ($p = 0.015$) and visit 1-7 ($p = 0.005$).

**Inter-group analysis**

**Table 4.13: Inter-group comparison at the first, fourth and seventh visit for Vernon-Mior Neck Pain and Disability Index of the three groups**

<table>
<thead>
<tr>
<th>Visit</th>
<th>Mean/p-value</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mean</td>
<td>9.60</td>
<td>6.90</td>
<td>11.10</td>
</tr>
<tr>
<td></td>
<td>p-value</td>
<td>$p = 0.189$ thus $p &gt; 0.05$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Mean</td>
<td>5.30</td>
<td>6.00</td>
<td>4.90</td>
</tr>
<tr>
<td></td>
<td>p-value</td>
<td>$p = 0.885$ thus $p &gt; 0.05$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Mean</td>
<td>2.30</td>
<td>2.80</td>
<td>2.70</td>
</tr>
<tr>
<td></td>
<td>p-value</td>
<td>$p = 0.952$ thus $p &gt; 0.05$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Upon inter-group analysis, table 4.13 shows that the baseline reading of the p-value at visit 1 ($p = 0.189$) started at greater than 0.05 and therefore the groups started off comparable. However the p-value remained greater than 0.05 at visit 4 ($p = 0.885$) and visit 7 ($p = 0.952$) and therefore there was no statistical significant difference ($p > 0.05$) noted between the three groups.
4.4 Objective Data Analysis

4.4.1 Cervical spine flexion measurements

Table 4.14: Group 1 column statistics for Cervical Spine Range of Motion in Flexion

<table>
<thead>
<tr>
<th>Visit</th>
<th>Mean</th>
<th>Std Deviation</th>
<th>Std Error</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>61.40</td>
<td>9.98</td>
<td>3.16</td>
<td>62.00</td>
<td>40</td>
<td>72</td>
</tr>
<tr>
<td>4</td>
<td>65.60</td>
<td>6.72</td>
<td>2.13</td>
<td>65.00</td>
<td>52</td>
<td>74</td>
</tr>
<tr>
<td>7</td>
<td>64.40</td>
<td>8.83</td>
<td>2.79</td>
<td>66.00</td>
<td>50</td>
<td>74</td>
</tr>
</tbody>
</table>

Table 4.15: Group 2 column statistics for Cervical Spine Range of Motion in Flexion

<table>
<thead>
<tr>
<th>Visit</th>
<th>Mean</th>
<th>Std Deviation</th>
<th>Std Error</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>60.50</td>
<td>16.73</td>
<td>5.29</td>
<td>60.00</td>
<td>32</td>
<td>80</td>
</tr>
<tr>
<td>4</td>
<td>68.20</td>
<td>15.33</td>
<td>4.85</td>
<td>66.00</td>
<td>44</td>
<td>90</td>
</tr>
<tr>
<td>7</td>
<td>66.40</td>
<td>18.76</td>
<td>5.93</td>
<td>67.00</td>
<td>40</td>
<td>92</td>
</tr>
</tbody>
</table>
Table 4.16: Group 3 column statistics for Cervical Spine Range of Motion in Flexion

<table>
<thead>
<tr>
<th>Visit</th>
<th>Mean</th>
<th>Std Deviation</th>
<th>Std Error</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>57.50</td>
<td>11.21</td>
<td>3.54</td>
<td>57.50</td>
<td>42</td>
<td>80</td>
</tr>
<tr>
<td>4</td>
<td>62.00</td>
<td>6.73</td>
<td>2.13</td>
<td>62.00</td>
<td>52</td>
<td>72</td>
</tr>
<tr>
<td>7</td>
<td>64.20</td>
<td>12.84</td>
<td>4.06</td>
<td>63.00</td>
<td>48</td>
<td>88</td>
</tr>
</tbody>
</table>

4.4.1.1 Clinical analysis

Figure 4.3 Change in degrees of cervical spine range of motion in flexion

Figure 4.3 illustrates the cervical spine range of motion in flexion mean values measured at the first, fourth and seventh visit. At the first visit Group 1 had a mean value of 61.40, Group 2 had a value of 60.50 and Group 3 had a value of 57.50. At the forth visit group 1 had a mean value of 65.60, Group 2 had a value of 68.20 and Group 3 had a value of 62.00. At the seventh visit Group 1 had a mean value of 64.40, Group 2 had a value of 66.40 and Group 3 had a value of 64.20.
64.20. This indicates that the mean increase in the flexion range of motion for Group 1 was 4.66%, for Group 2 was 8.89% and for Group 3 was 10.44%.

4.4.1.2 Statistical analysis

Intra-group analysis

Table 4.17: Friedman test for changes in Cervical Spine Range of Motion in Flexion

<table>
<thead>
<tr>
<th>Friedman Test</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>( p = 0.452 )</td>
<td>( p = 0.073 )</td>
<td>( p = 0.118 )</td>
<td></td>
</tr>
<tr>
<td>Thus ( p &gt; 0.05 )</td>
<td>Thus ( p &gt; 0.05 )</td>
<td>Thus ( p &gt; 0.05 )</td>
<td></td>
</tr>
</tbody>
</table>

The Friedman test was used to check for changes over time within the three groups, and there was a non-statistically significant difference \( (p > 0.05) \) found in all three the groups. Group 1 had a p-value of 0.452, Group 2 had a p-value of 0.073 and Group 3 had a p-value of 0.118. The Wilcoxon signed rank test was not used for further investigation as the Friedman test was negative in all three groups.

Inter-group analysis

Table 4.18: Inter-group comparison at the first, fourth and seventh visit for Cervical Spine Range of Motion in Flexion of the three groups

<table>
<thead>
<tr>
<th>Kruskal-Wallis Test</th>
<th>Visit</th>
<th>Mean/p-value</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>Mean</td>
<td>61.40</td>
<td>60.50</td>
<td>57.50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>p-value</td>
<td>( p = 0.428 ) thus ( p &gt; 0.05 )</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Upon inter-group analysis, table 4.18 shows that the baseline reading of the p-value at visit 1 \((p = 0.428)\) started at greater than 0.05 and therefore the groups started off comparable. However the p-value remained greater than 0.05 at visit 4 \((p = 0.400)\) and visit 7 \((p = 0.916)\) and therefore there was no statistical significant difference \((p > 0.05)\) noted between the three groups.

4.4.2 Cervical spine extension measurements

Table 4.19: Group 1 column statistics for Cervical Spine Range of Motion in Extension

<table>
<thead>
<tr>
<th>Visit</th>
<th>Mean</th>
<th>Std Deviation</th>
<th>Std Error</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>67.00</td>
<td>8.91</td>
<td>2.82</td>
<td>69.00</td>
<td>54</td>
<td>80</td>
</tr>
<tr>
<td>4</td>
<td>67.40</td>
<td>10.37</td>
<td>3.28</td>
<td>71.00</td>
<td>50</td>
<td>80</td>
</tr>
<tr>
<td>7</td>
<td>67.40</td>
<td>12.26</td>
<td>3.88</td>
<td>69.00</td>
<td>42</td>
<td>88</td>
</tr>
</tbody>
</table>

Table 4.20: Group 2 column statistics for Cervical Spine Range of Motion in Extension

<table>
<thead>
<tr>
<th>Visit</th>
<th>Mean</th>
<th>Std Deviation</th>
<th>Std Error</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>66.60</td>
<td>13.60</td>
<td>4.30</td>
<td>69.00</td>
<td>44</td>
<td>82</td>
</tr>
<tr>
<td>4</td>
<td>66.00</td>
<td>14.14</td>
<td>4.47</td>
<td>63.00</td>
<td>44</td>
<td>92</td>
</tr>
<tr>
<td>7</td>
<td>73.20</td>
<td>13.86</td>
<td>4.38</td>
<td>74.00</td>
<td>52</td>
<td>94</td>
</tr>
</tbody>
</table>
Table 4.21: Group 3 column statistics for Cervical Spine Range of Motion in Extension

<table>
<thead>
<tr>
<th>Visit</th>
<th>Mean</th>
<th>Std Deviation</th>
<th>Std Error</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>60.50</td>
<td>8.68</td>
<td>2.75</td>
<td>62.50</td>
<td>50</td>
<td>70</td>
</tr>
<tr>
<td>4</td>
<td>63.40</td>
<td>12.00</td>
<td>3.80</td>
<td>64.00</td>
<td>50</td>
<td>88</td>
</tr>
<tr>
<td>7</td>
<td>67.60</td>
<td>13.39</td>
<td>4.24</td>
<td>66.00</td>
<td>50</td>
<td>92</td>
</tr>
</tbody>
</table>

4.4.2.1 Clinical analysis

Figure 4.4 Change in degrees of cervical spine range of motion in extension

Figure 4.4 illustrates the cervical spine range of motion in extension mean values measured at the first, fourth and seventh visit. At the first visit Group 1 had a mean value of 67.00, Group 2 had a value of 66.60 and Group 3 had a value of 60.50. At the forth visit group 1 had a mean value of 67.40, Group 2 had a value of 66.00 and Group 3 had a value of 63.40. At the seventh visit Group 1 had a
mean value of 67.40, Group 2 had a value of 73.20 and Group 3 had a value of 67.60. This indicates that the mean increase in the extension range of motion value for Group 1 was 0.59%, for Group 2 was 9.01% and for Group 3 was 10.50%.

4.4.2.2 Statistical analysis

Intra-group analysis

Table 4.22: Friedman test for changes in Cervical Spine Range of Motion in Extension

<table>
<thead>
<tr>
<th>Friedman Test</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>p = 0.875</td>
<td>p = 0.256</td>
<td>p = 0.022</td>
<td></td>
</tr>
<tr>
<td>Thus</td>
<td>Thus</td>
<td>Thus</td>
<td></td>
</tr>
<tr>
<td>p &gt; 0.05</td>
<td>p &gt; 0.05</td>
<td>p &lt; 0.05</td>
<td></td>
</tr>
</tbody>
</table>

The Friedman test was used to check for changes over time within the three groups, and a statistically significant difference (p < 0.05) was found in Group 3 with a p-value of 0.022 and non-statistically significant difference (p > 0.05) was found in Group 1 and 2 with p-values of 0.875 and 0.256 respectively. The Wilcoxon signed rank test was used for the within group analysis to demonstrate where these changes occurred.
Table 4.23: Wilcoxon signed rank test for changes in Cervical Spine Range of Motion in Extension

<table>
<thead>
<tr>
<th>Visit</th>
<th>Group 1</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – 4</td>
<td>p = 0.865</td>
<td>Thus p &gt; 0.05</td>
<td></td>
<td>p = 0.590</td>
<td>Thus p &gt; 0.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 – 7</td>
<td>p = 1.000</td>
<td>Thus p &gt; 0.05</td>
<td></td>
<td>p = 0.123</td>
<td>Thus p &gt; 0.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 – 7</td>
<td>p = 0.798</td>
<td>Thus p &gt; 0.05</td>
<td></td>
<td>p = 0.108</td>
<td>Thus p &gt; 0.05</td>
</tr>
</tbody>
</table>

The non-parametric Wilcoxon signed rank test was used to determine where the changes occurred between visits in Group 1, 2 and 3. What can be seen from table 4.23 is that there was a non-statistically significant difference noted on intra-group analysis, via the Wilcoxon signed rank test, of Group 1 and Group 2 between all visits and Group 3 between visit 1-4 and visit 4-7. A statistically significant difference was noted in Group 3 between visit 1-7.

Analysis of Group 1 indicated that a non-statistically significant difference (p > 0.05) was found between visit 1-4 (p = 0.865), visit 4-7 (p = 1.00) and visit 1-7 (p = 0.798).

Analysis of Group 2 indicated that a non-statistically significant difference (p > 0.05) was found between visit 1-4 (p = 0.590), visit 4-7 (p = 0.123) and visit 1-7 (p = 0.108).
Analysis of Group 3 indicated that a statistically significant difference ($p < 0.05$) was found between visit 1-7 ($p = 0.025$) and a non-statistical difference ($p > 0.05$) was found between visit 1-4 ($p = 0.248$) and visit 4-7 ($p = 0.063$).

**Inter-group analysis**

**Table 4.24: Inter-group comparison at the first, fourth and seventh visit for Cervical Spine Range of Motion in Extension of the three groups**

<table>
<thead>
<tr>
<th>Visit</th>
<th>Mean/p-value</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mean</td>
<td>67.00</td>
<td>66.60</td>
<td>60.50</td>
</tr>
<tr>
<td></td>
<td>p-value</td>
<td>$p = 0.235$ thus $p &gt; 0.05$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Mean</td>
<td>67.40</td>
<td>66.00</td>
<td>63.40</td>
</tr>
<tr>
<td></td>
<td>p-value</td>
<td>$p = 0.457$ thus $p &gt; 0.05$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Mean</td>
<td>67.40</td>
<td>73.20</td>
<td>67.60</td>
</tr>
<tr>
<td></td>
<td>p-value</td>
<td>$p = 0.621$ thus $p &gt; 0.05$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Upon inter-group analysis, table 4.24 shows that the baseline reading of the p-value at visit 1 ($p = 0.235$) started at greater than 0.05 and therefore the groups started off comparable. However the p-value remained greater than 0.05 at visit 4 ($p = 0.457$) and visit 7 ($p = 0.621$) and therefore there was no statistical significant difference ($p > 0.05$) noted between the three groups.
4.4.3 Cervical spine right rotation measurements

Table 4.25: Group 1 column statistics for Cervical Spine Range of Motion in Right Rotation

<table>
<thead>
<tr>
<th>Visit</th>
<th>Mean</th>
<th>Std Deviation</th>
<th>Std Error</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>69.30</td>
<td>11.22</td>
<td>3.55</td>
<td>72.50</td>
<td>52</td>
<td>80</td>
</tr>
<tr>
<td>4</td>
<td>69.80</td>
<td>12.16</td>
<td>3.85</td>
<td>70.00</td>
<td>52</td>
<td>88</td>
</tr>
<tr>
<td>7</td>
<td>68.60</td>
<td>14.30</td>
<td>4.52</td>
<td>68.00</td>
<td>48</td>
<td>98</td>
</tr>
</tbody>
</table>

Table 4.26: Group 2 column statistics for Cervical Spine Range of Motion in Right Rotation

<table>
<thead>
<tr>
<th>Visit</th>
<th>Mean</th>
<th>Std Deviation</th>
<th>Std Error</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>62.60</td>
<td>7.83</td>
<td>2.48</td>
<td>62.00</td>
<td>50</td>
<td>72</td>
</tr>
<tr>
<td>4</td>
<td>71.60</td>
<td>11.38</td>
<td>3.60</td>
<td>73.00</td>
<td>52</td>
<td>90</td>
</tr>
<tr>
<td>7</td>
<td>68.60</td>
<td>10.20</td>
<td>3.23</td>
<td>71.00</td>
<td>52</td>
<td>80</td>
</tr>
</tbody>
</table>

Table 4.27: Group 3 column statistics for Cervical Spine Range of Motion in Right Rotation

<table>
<thead>
<tr>
<th>Visit</th>
<th>Mean</th>
<th>Std Deviation</th>
<th>Std Error</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>63.90</td>
<td>14.39</td>
<td>4.55</td>
<td>61.00</td>
<td>45</td>
<td>88</td>
</tr>
<tr>
<td>4</td>
<td>70.60</td>
<td>12.96</td>
<td>4.10</td>
<td>70.00</td>
<td>52</td>
<td>92</td>
</tr>
<tr>
<td>7</td>
<td>74.40</td>
<td>9.65</td>
<td>3.05</td>
<td>71.00</td>
<td>60</td>
<td>90</td>
</tr>
</tbody>
</table>
4.4.3.1 Clinical analysis

Figure 4.5 Changes in degrees of cervical spine range of motion in right rotation

Figure 4.5 illustrates the cervical spine range of motion in right rotation mean values measured at the first, fourth and seventh visit. At the first visit Group 1 had a mean value of 69.30, Group 2 had a value of 62.60 and Group 3 had a value of 63.90. At the forth visit group 1 had a mean value of 69.80, Group 2 had a value of 71.60 and Group 3 had a value of 70.60. At the seventh visit Group 1 had a mean value of 69.60, Group 2 had a value of 68.60 and Group 3 had a value of 74.40. This indicates that the mean increase in the right rotation range of motion value for Group 1 was 0.43%, for Group 2 was 8.75% and for Group 3 was 14.11%.
4.4.3.2 Statistical analysis

Intra-group analysis

Table 4.28: Friedman test for changes in Cervical Spine Range of Motion in Right Rotation

<table>
<thead>
<tr>
<th>Friedman Test</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>p = 0.614</td>
<td>p = 0.037</td>
<td>p = 0.052</td>
<td></td>
</tr>
<tr>
<td>Thus</td>
<td>Thus</td>
<td>Thus</td>
<td></td>
</tr>
<tr>
<td>p &gt; 0.05</td>
<td>p &lt; 0.05</td>
<td>p &gt; 0.05</td>
<td></td>
</tr>
</tbody>
</table>

The Friedman test was used to check for changes over time within the three groups. A statistically significant difference \( (p < 0.05) \) was found in Group 2 and a non-statistically significant difference \( (p > 0.05) \) was found in Group 1 and 3. Group 1 had a p-value of 0.614, Group 2 had a p-value of 0.037 and Group 3 had a p-value of 0.052. The Wilcoxon signed rank test was used for the within group analysis to demonstrate where these changes occurred.

Table 4.29: Wilcoxon signed rank test for changes in Cervical Spine Range of Motion in Right Rotation

<table>
<thead>
<tr>
<th>Wilcoxon Signed Rank Test</th>
<th>Visit</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 – 4</td>
<td>p = 0.765</td>
<td>p = 0.043</td>
<td>p = 0.042</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thus</td>
<td>Thus</td>
<td>Thus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>p &gt; 0.05</td>
<td>p &lt; 0.05</td>
<td>p &lt; 0.05</td>
</tr>
<tr>
<td></td>
<td>4 – 7</td>
<td>p = 0.573</td>
<td>p = 0.282</td>
<td>p = 0.201</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thus</td>
<td>Thus</td>
<td>Thus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>p &gt; 0.05</td>
<td>p &gt; 0.05</td>
<td>p &gt; 0.05</td>
</tr>
<tr>
<td></td>
<td>$p = 0.442$</td>
<td>$p = 0.051$</td>
<td>$p = 0.025$</td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>-------------</td>
<td>-------------</td>
<td>-------------</td>
<td></td>
</tr>
<tr>
<td>$1-7$</td>
<td>Thus $p &gt; 0.05$</td>
<td>Thus $p &gt; 0.05$</td>
<td>Thus $p &lt; 0.05$</td>
<td></td>
</tr>
</tbody>
</table>

The non-parametric Wilcoxon signed rank test was used to determine where the changes occurred between visits in Group 1, 2 and 3. What can be seen from table 4.29 is that there was a non-statistically significant difference noted on intra-group analysis of Group 1 between all visits, Group 2 between visit 4-7 and visit 1-7 and Group 3 between visit 4-7. A statistical significant difference in Group 2 between visit 1-4 and Group 3 between visit 1-4 and visit 1-7 was noted.

Analysis of Group 1 indicated that a non-statistically significant difference ($p > 0.05$) was found between visit 1-4 ($p = 0.765$), visit 4-7 ($p = 0.573$) and visit 1-7 ($p = 0.422$).

Analysis of Group 2 indicated that a statistically significant difference ($p < 0.05$) was found between visit 1-4 ($p = 0.043$), and a non-statistically significant difference ($p > 0.05$) was found between visit 4-7 ($p = 0.282$) and visit 1-7 ($p = 0.051$).

Analysis of Group 3 indicated that a statistically significant difference ($p < 0.05$) was found between visit 1-4 ($p = 0.042$) and visit 1-7 ($p = 0.025$), and a non-statistically significant difference ($p > 0.05$) was found between visit 4-7 ($p = 0.201$).
Inter-group analysis

Table 4.30: Inter-group comparison at the first, fourth and seventh visit for Cervical Spine Range of Motion in Right Rotation of the three groups

<table>
<thead>
<tr>
<th>Visit</th>
<th>Mean/p-value</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mean</td>
<td>69.30</td>
<td>62.60</td>
<td>63.90</td>
</tr>
<tr>
<td></td>
<td>p-value</td>
<td>p = 0.398 thus p &gt; 0.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Mean</td>
<td>69.80</td>
<td>71.60</td>
<td>70.60</td>
</tr>
<tr>
<td></td>
<td>p-value</td>
<td>p = 0.929 thus p &gt; 0.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Mean</td>
<td>69.60</td>
<td>68.60</td>
<td>74.40</td>
</tr>
<tr>
<td></td>
<td>p-value</td>
<td>p = 0.475 thus p &gt; 0.05</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Upon inter-group analysis, table 4.30 shows that the baseline reading of the p-value at visit 1 (p = 0.398) started at greater than 0.05 and therefore the groups started off comparable. However the p-value remained greater than 0.05 at visit 4 (p = 0.929) and visit 7 (p = 0.475) and therefore there was no statistically significant difference (p > 0.05) noted between the three groups.
4.4.4 Cervical spine left rotation measurements

Table 4.31: Group 1 column statistics for Cervical Spine Range of Motion in Left Rotation

<table>
<thead>
<tr>
<th>Visit</th>
<th>Mean</th>
<th>Std Deviation</th>
<th>Std Error</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>67.90</td>
<td>8.93</td>
<td>2.82</td>
<td>69.00</td>
<td>50</td>
<td>80</td>
</tr>
<tr>
<td>4</td>
<td>67.60</td>
<td>10.01</td>
<td>3.17</td>
<td>69.00</td>
<td>52</td>
<td>80</td>
</tr>
<tr>
<td>7</td>
<td>72.00</td>
<td>7.94</td>
<td>2.51</td>
<td>72.00</td>
<td>62</td>
<td>84</td>
</tr>
</tbody>
</table>

Table 4.32: Group 2 column statistics for Cervical Spine Range of Motion in Left Rotation

<table>
<thead>
<tr>
<th>Visit</th>
<th>Mean</th>
<th>Std Deviation</th>
<th>Std Error</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>64.30</td>
<td>9.73</td>
<td>3.08</td>
<td>64.50</td>
<td>48</td>
<td>80</td>
</tr>
<tr>
<td>4</td>
<td>64.40</td>
<td>11.96</td>
<td>3.78</td>
<td>64.00</td>
<td>42</td>
<td>82</td>
</tr>
<tr>
<td>7</td>
<td>65.00</td>
<td>10.17</td>
<td>3.22</td>
<td>68.00</td>
<td>44</td>
<td>78</td>
</tr>
</tbody>
</table>

Table 4.33: Group 3 column statistics for Cervical Spine Range of Motion in Left Rotation

<table>
<thead>
<tr>
<th>Visit</th>
<th>Mean</th>
<th>Std Deviation</th>
<th>Std Error</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>66.30</td>
<td>9.43</td>
<td>2.98</td>
<td>67.50</td>
<td>50</td>
<td>80</td>
</tr>
<tr>
<td>4</td>
<td>72.00</td>
<td>14.70</td>
<td>4.65</td>
<td>74.00</td>
<td>40</td>
<td>92</td>
</tr>
<tr>
<td>7</td>
<td>75.00</td>
<td>10.76</td>
<td>3.40</td>
<td>79.00</td>
<td>60</td>
<td>88</td>
</tr>
</tbody>
</table>
4.4.4.1 Clinical analysis

Figure 4.6 Changes in degrees of cervical spine range of motion in left rotation

Figure 4.6 illustrates the cervical spine range of motion in left rotation mean values measured at the first, fourth and seventh visit. At the first visit Group 1 had a mean value of 67.90, Group 2 had a value of 64.30 and Group 3 had a value of 66.30. At the fourth visit group 1 had a mean value of 67.60, Group 2 had a value of 64.40 and Group 3 had a value of 72.00. At the seventh visit Group 1 had a mean value of 72.00, Group 2 had a value of 65.00 and Group 3 had a value of 75.00. This indicates that the mean increase in the range of motion in left rotation value for Group 1 was 5.69%, for Group 2 was 1.08% and for Group 3 was 11.60%.
4.4.4.2 Statistical analysis

Intra-group analysis

Table 4.34: Friedman test for changes in Cervical Spine Range of Motion in Left Rotation

<table>
<thead>
<tr>
<th>Friedman Test</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>p = 0.254</td>
<td>p = 0.717</td>
<td>p = 0.013</td>
<td></td>
</tr>
<tr>
<td>Thus</td>
<td>Thus</td>
<td>Thus</td>
<td></td>
</tr>
<tr>
<td>p &gt; 0.05</td>
<td>p &gt; 0.05</td>
<td>p &lt; 0.05</td>
<td></td>
</tr>
</tbody>
</table>

The Friedman test was used to check for changes over time within the three groups, and a statistically significant difference (p < 0.05) was found in Group 3 and a non-statistically significant difference (p > 0.05) was found in Group 1 and 2. Group 1 had a p-value of 0.254, Group 2 had a p-value of 0.717 and Group 3 had a p-value of 0.013. The Wilcoxon signed rank test was used for the within group analysis to demonstrate where these changes occurred.

Table 4.35: Wilcoxon signed rank test for changes in Cervical Spine Range of Motion in Left Rotation

<table>
<thead>
<tr>
<th>Wilcoxon Signed Rank Test</th>
<th>Visit</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 – 4</td>
<td>P = 0.553</td>
<td>p = 0.575</td>
<td>P = 0.109</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thus</td>
<td>Thus</td>
<td>Thus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>p &gt; 0.05</td>
<td>p &gt; 0.05</td>
<td>p &gt; 0.05</td>
</tr>
<tr>
<td></td>
<td>4 – 7</td>
<td>P = 0.049</td>
<td>P = 0.797</td>
<td>P = 0.443</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thus</td>
<td>Thus</td>
<td>Thus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>p &lt; 0.05</td>
<td>p &gt; 0.05</td>
<td>p &gt; 0.05</td>
</tr>
<tr>
<td>1 – 7</td>
<td>P = 0.259</td>
<td>P = 0.944</td>
<td>P = 0.036</td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td>-----------</td>
<td>-----------</td>
<td>-----------</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thus P &gt; 0.05</td>
<td>Thus P &gt; 0.05</td>
<td>Thus P &lt; 0.05</td>
<td></td>
</tr>
</tbody>
</table>

The non-parametric Wilcoxon signed rank test was used to determine where the changes occurred between visits in Group 1, 2 and 3. What can be seen from table 4.35 is that there was a non-statistically significant difference noted on intra-group analysis of Group 1 between visit 1-4 and visit 1-7, Group 2 between all visits and group 3 between visit 1-4 and visit 4-7. A statistically significant difference was noted in Group 1 between visit 4-7 and Group 3 between visit 1-7.

Analysis of Group 1 indicated that a statistically significant difference (p < 0.05) was found between visit 4-7 (p = 0.049) and a non-statistically significant difference (p > 0.05) was found between visit 1-4 (p = 0.553) and visit 1-7 (p = 0.259).

Analysis of Group 2 indicated that a non-statistically significant difference (p > 0.05) was found between visit 1-4 (p = 0.575), visit 4-7 (p = 0.797) and visit 1-7 (p = 0.944).

Analysis of Group 3 indicated that a statistically significant difference (p < 0.05) was found between visit 1-7 (p = 0.036), and a non-statistically significant difference (p > 0.05) was found between visit 1-4 (p = 0.109) and visit 4-7 (p = 0.443).
Inter-group analysis

Table 4.36: Inter-group comparison at the first, fourth and seventh visit for Cervical Spine Range of Motion in Left Rotation of the three groups

<table>
<thead>
<tr>
<th>Visit</th>
<th>Mean/p-value</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mean</td>
<td>67.90</td>
<td>64.30</td>
<td>66.30</td>
</tr>
<tr>
<td></td>
<td>p-value</td>
<td>p = 0.719 thus p &gt; 0.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Mean</td>
<td>67.60</td>
<td>64.40</td>
<td>72.00</td>
</tr>
<tr>
<td></td>
<td>p-value</td>
<td>p = 0.276 thus p &gt; 0.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Mean</td>
<td>72.00</td>
<td>65.00</td>
<td>75.00</td>
</tr>
<tr>
<td></td>
<td>p-value</td>
<td>p = 0.120 thus p &gt; 0.05</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Upon inter-group analysis, table 4.36 shows that the baseline reading of the p-value at visit 1 (p = 0.719) started at greater than 0.05 and therefore the groups started off comparable. However the p-value remained greater than 0.05 at visit 4 (p = 0.276) and visit 7 (p = 0.120) and therefore there was no statistical significant difference (p > 0.05) noted between the three groups.
4.4.5 Cervical spine right lateral flexion measurements

Table 4.37: Group 1 column statistics for Cervical Spine Range of Motion in Right Lateral Flexion

<table>
<thead>
<tr>
<th>Visit</th>
<th>Mean</th>
<th>Std Deviation</th>
<th>Std Error</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>47.10</td>
<td>9.89</td>
<td>3.13</td>
<td>50.00</td>
<td>32</td>
<td>60</td>
</tr>
<tr>
<td>4</td>
<td>49.20</td>
<td>10.34</td>
<td>3.27</td>
<td>50.00</td>
<td>32</td>
<td>62</td>
</tr>
<tr>
<td>7</td>
<td>49.80</td>
<td>8.46</td>
<td>2.67</td>
<td>49.00</td>
<td>40</td>
<td>64</td>
</tr>
</tbody>
</table>

Table 4.38: Group 2 column statistics for Cervical Spine Range of Motion in Right Lateral Flexion

<table>
<thead>
<tr>
<th>Visit</th>
<th>Mean</th>
<th>Std Deviation</th>
<th>Std Error</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>48.40</td>
<td>7.41</td>
<td>2.34</td>
<td>48.00</td>
<td>38</td>
<td>60</td>
</tr>
<tr>
<td>4</td>
<td>48.20</td>
<td>10.13</td>
<td>3.20</td>
<td>48.00</td>
<td>32</td>
<td>66</td>
</tr>
<tr>
<td>7</td>
<td>55.00</td>
<td>14.55</td>
<td>4.60</td>
<td>56.00</td>
<td>30</td>
<td>72</td>
</tr>
</tbody>
</table>

Table 4.39: Group 3 column statistics for Cervical Spine Range of Motion in Right Lateral Flexion

<table>
<thead>
<tr>
<th>Visit</th>
<th>Mean</th>
<th>Std Deviation</th>
<th>Std Error</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>45.80</td>
<td>10.30</td>
<td>3.26</td>
<td>49.00</td>
<td>30</td>
<td>60</td>
</tr>
<tr>
<td>4</td>
<td>48.00</td>
<td>11.20</td>
<td>3.54</td>
<td>50.00</td>
<td>30</td>
<td>66</td>
</tr>
<tr>
<td>7</td>
<td>46.40</td>
<td>7.29</td>
<td>2.31</td>
<td>46.00</td>
<td>34</td>
<td>58</td>
</tr>
</tbody>
</table>
4.4.5.1 Clinical analysis

Figure 4.7 Changes in degrees of cervical spine range of motion in right lateral flexion

Figure 4.7 illustrates the cervical spine range of motion in right lateral flexion mean values measured at the first, fourth and seventh visit. At the first visit Group 1 had a mean value of 47.10, Group 2 had a value of 48.40 and Group 3 had a value of 45.80. At the forth visit group 1 had a mean value of 49.20, Group 2 had a value of 48.20 and Group 3 had a value of 48.00. At the seventh visit Group 1 had a mean value of 49.80, Group 2 had a value of 55.00 and Group 3 had a value of 46.40. This indicates that the mean increase in the range of motion in right lateral flexion value for Group 1 was 5.42%, for Group 2 was 12.00% and for Group 3 was 1.29%.
4.4.5.2 Statistical analysis

Intra-group analysis

Table 4.40: Friedman test for changes in Cervical Spine Range of Motion in Right Lateral Flexion

<table>
<thead>
<tr>
<th>Friedman Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
</tr>
<tr>
<td>p = 0.368</td>
</tr>
<tr>
<td>Thus</td>
</tr>
<tr>
<td>p &gt; 0.05</td>
</tr>
</tbody>
</table>

The Friedman test was used to check for changes over time within the three groups, and there was a non-statistically significant difference (p > 0.05) found in all three groups. Group 1 had a p-value of 0.368, Group 2 had a p-value of 0.061 and Group 3 had a p-value of 0.285. The Wilcoxon signed rank test was not used for further investigation as the Friedman test was negative in all three groups.

Inter-group analysis

Table 4.41: Inter-group comparison at the first, fourth and seventh visit for Cervical Spine Range of Motion in Right Lateral Flexion of the three groups

<table>
<thead>
<tr>
<th>Kruskal-Wallis Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visit</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
Upon inter-group analysis, table 4.41 shows that the baseline reading of the p-value at visit 1 (p = 0.877) started at greater than 0.05 and therefore the groups started off comparable. However the p-value remained greater than 0.05 at visit 4 (p = 0.926) and visit 7 (p = 0.308) and therefore there was no statistical significant difference (p > 0.05) noted between the three groups.

4.4.6 Cervical spine left lateral flexion measurements

Table 4.42: Group 1 column statistics for Cervical Spine Range of Motion in Left Lateral Flexion

<table>
<thead>
<tr>
<th>Visit</th>
<th>Mean</th>
<th>Std Deviation</th>
<th>Std Error</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>46.40</td>
<td>7.11</td>
<td>2.25</td>
<td>46.00</td>
<td>38</td>
<td>60</td>
</tr>
<tr>
<td>4</td>
<td>47.30</td>
<td>7.97</td>
<td>2.52</td>
<td>46.50</td>
<td>34</td>
<td>60</td>
</tr>
<tr>
<td>7</td>
<td>49.20</td>
<td>7.01</td>
<td>2.22</td>
<td>49.00</td>
<td>42</td>
<td>60</td>
</tr>
</tbody>
</table>

Table 4.43: Group 2 column statistics for Cervical Spine Range of Motion in Left Lateral Flexion

<table>
<thead>
<tr>
<th>Visit</th>
<th>Mean</th>
<th>Std Deviation</th>
<th>Std Error</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>46.90</td>
<td>7.75</td>
<td>2.45</td>
<td>48.00</td>
<td>30</td>
<td>60</td>
</tr>
<tr>
<td>4</td>
<td>48.10</td>
<td>9.96</td>
<td>3.15</td>
<td>49.00</td>
<td>34</td>
<td>62</td>
</tr>
<tr>
<td>7</td>
<td>53.20</td>
<td>13.57</td>
<td>4.29</td>
<td>53.00</td>
<td>30</td>
<td>78</td>
</tr>
</tbody>
</table>
Table 4.44: Group 3 column statistics for Cervical Spine Range of Motion in Left Lateral Flexion

<table>
<thead>
<tr>
<th>Visit</th>
<th>Mean</th>
<th>Std Deviation</th>
<th>Std Error</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>44.10</td>
<td>7.49</td>
<td>2.37</td>
<td>46.50</td>
<td>30</td>
<td>52</td>
</tr>
<tr>
<td>4</td>
<td>48.20</td>
<td>10.22</td>
<td>3.23</td>
<td>49.00</td>
<td>30</td>
<td>60</td>
</tr>
<tr>
<td>7</td>
<td>51.40</td>
<td>10.54</td>
<td>3.33</td>
<td>50.00</td>
<td>38</td>
<td>72</td>
</tr>
</tbody>
</table>

4.4.6.1 Clinical analysis

Figure 4.8 Changes in degrees of cervical spine range of motion in left lateral flexion

Figure 4.8 illustrates the cervical spine range of motion in left lateral flexion mean values measured at the first, fourth and seventh visit. At the first visit Group 1 had a mean value of 46.40, Group 2 had a value of 46.90 and Group 3 had a value of 44.10. At the forth visit group 1 had a mean value of 47.30, Group 2 had a value of 48.10 and Group 3 had a value of 48.20. At the seventh visit Group 1 had a
mean value of 49.20, Group 2 had a value of 53.20 and Group 3 had a value of 51.50. This indicates that the mean increase in the range of motion in left lateral flexion value for Group 1 was 5.69%, for Group 2 was 11.84% and for Group 3 was 14.37%.

4.4.6.2 Statistical analysis

Intra-group analysis

Table 4.45: Friedman test for changes in Cervical Spine Range of Motion in Left Lateral Flexion

<table>
<thead>
<tr>
<th>Friedman Test</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>p = 0.146</td>
<td>p = 0.132</td>
<td>p = 0.045</td>
<td></td>
</tr>
<tr>
<td>Thus</td>
<td>Thus</td>
<td>Thus</td>
<td></td>
</tr>
<tr>
<td>p &gt; 0.05</td>
<td>p &gt; 0.05</td>
<td>p &lt; 0.05</td>
<td></td>
</tr>
</tbody>
</table>

The Friedman test was used to check for changes over time within the three groups. There was a statistically significant difference (p < 0.05) in Group 3 and a non-statistically significant difference (p > 0.05) was found in Group 1 and 2. Group 1 had a p-value of 0.146, Group 2 had a p-value of 0.132 and Group 3 had a p-value of 0.045. The Wilcoxon signed rank test was used for the within group analysis to demonstrate where these changes occurred.
Table 4.46: Wilcoxon signed rank test for changes in Cervical Spine Range of Motion in Left Lateral Flexion

<table>
<thead>
<tr>
<th>Visit</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – 4</td>
<td>( p = 0.416 )</td>
<td>( p = 0.592 )</td>
<td>( p = 0.106 )</td>
</tr>
<tr>
<td></td>
<td>Thus</td>
<td>Thus</td>
<td>Thus</td>
</tr>
<tr>
<td></td>
<td>( p &gt; 0.05 )</td>
<td>( p &gt; 0.05 )</td>
<td>( p &gt; 0.05 )</td>
</tr>
<tr>
<td>4 – 7</td>
<td>( p = 0.307 )</td>
<td>( p = 0.102 )</td>
<td>( p = 0.261 )</td>
</tr>
<tr>
<td></td>
<td>Thus</td>
<td>Thus</td>
<td>Thus</td>
</tr>
<tr>
<td></td>
<td>( p &gt; 0.05 )</td>
<td>( p &gt; 0.05 )</td>
<td>( p &gt; 0.05 )</td>
</tr>
<tr>
<td>1 – 7</td>
<td>( p = 0.107 )</td>
<td>( p = 0.068 )</td>
<td>( p = 0.046 )</td>
</tr>
<tr>
<td></td>
<td>Thus</td>
<td>Thus</td>
<td>Thus</td>
</tr>
<tr>
<td></td>
<td>( p &gt; 0.05 )</td>
<td>( p &gt; 0.05 )</td>
<td>( p &lt; 0.05 )</td>
</tr>
</tbody>
</table>

The non-parametric Wilcoxon signed rank test was used to determine where the changes occurred between visits in Group 1, 2 and 3. What can be seen from table 4.46 is that there was a non-statistically significant difference noted on intra-group analysis of Group 1 and Group 2 between all visits and group 3 between visit 1-4 and visit 4-7. A statistically significant difference was noted in Group 3 between visit 1-7.

Analysis of Group 1 indicated that a non-statistically significant difference \( (p > 0.05) \) was found between visit 1-4 \( (p = 0.416) \), visit 4-7 \( (p = 0.307) \) and visit 1-7 \( (p = 0.107) \).

Analysis of Group 2 indicated that a non-statistically significant difference \( (p > 0.05) \) was found between visit 1-4 \( (p = 0.592) \), visit 4-7 \( (p = 0.102) \) and visit 1-7 \( (p = 0.068) \).
Analysis of Group 3 indicated that a statistically significant difference ($p < 0.05$) was found between visit 1-7 ($p = 0.046$), and a non-statistically significant difference ($p > 0.05$) was found between visit 1-4 ($p = 0.106$) and visit 4-7 ($p = 0.261$).

Inter-group analysis

Table 4.47: Inter-group comparison at the first, fourth and seventh visit for Cervical Spine Range of Motion in Left Lateral Flexion of the three groups

<table>
<thead>
<tr>
<th></th>
<th>Mean/p-value</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mean</td>
<td>46.40</td>
<td>46.90</td>
<td>44.10</td>
</tr>
<tr>
<td></td>
<td>p-value</td>
<td>$p = 0.782$ thus $p &gt; 0.05$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Mean</td>
<td>47.30</td>
<td>48.10</td>
<td>48.20</td>
</tr>
<tr>
<td></td>
<td>p-value</td>
<td>$p = 0.979$ thus $p &gt; 0.05$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Mean</td>
<td>49.20</td>
<td>53.20</td>
<td>51.50</td>
</tr>
<tr>
<td></td>
<td>p-value</td>
<td>$p = 0.762$ thus $p &gt; 0.05$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Upon inter-group analysis, table 4.47 shows that the baseline reading of the p-value at visit 1 ($p = 0.782$) started at greater than 0.05 and therefore the groups started off comparable. However the p-value remained greater than 0.05 at visit 4 ($p = 0.979$) and visit 7 ($p = 0.762$) and therefore there was no statistically significant difference ($p > 0.05$) noted between the three groups.

Chapter five will discuss the results presented in chapter four.
CHAPTER FIVE – DISCUSSION

5.1 Introduction

The purpose of this study was to determine the efficacy of utilising Kinesio® taping, spinal manipulation or the two therapies combined, for the treatment of chronic neck pain. It also provided further evidence on the efficacy of spinal manipulation and Kinesio® taping in isolation.

Group 1 received spinal manipulation to restriction(s) of cervical spine only. Group 2 received Kinesio® taping to the longissimus cervicis muscles only. Group 3 received a combination of spinal manipulation and Kinesio® taping as previously described.

This chapter includes a discussion of the results of the study with reference to chapter four as well as reference to the aim of the study described in chapter one. The results of the statistical analysis will be discussed under subjective and objective results and further evaluated in terms of intra-group and inter-group analysis.

The above results were obtained from:

- Demographic data analysis consisting of age and gender
- Subjective measurements consisting of the NPRS and the Vernon-Mior Neck Pain and Disability Index
- Objective measurements consisting of readings from a CROM instrument which included cervical spine flexion, extension, rotation and lateral flexion
The following hypothesis will be referred to:

1. Spinal manipulation, Kinesio® taping and the two therapies combined are all effective in the treatment of chronic neck pain
2. Spinal manipulation is more effective than both Kinesio® taping alone and the two therapies combined in decreasing pain intensity and functional disability in the treatment of chronic neck pain
3. Spinal manipulation in combination with Kinesio® taping is more effective than both spinal manipulation and Kinesio® taping alone in increasing all cervical spine ranges of motion in the treatment of chronic neck pain

5.2 Demographic Data Analysis

5.2.1 Age distribution

One of the inclusion criteria for this study was that the participants had to be between the ages of 18 and 50. This was to limit the risk of degenerative changes having occurred in the cervical spine (Carnes and Vizniack, 2010). All participants were within these age limits.

5.2.2 Gender distribution

The combined sample group consisted of 14 male and 16 female participants. Each group consisted of ten participants. Group 1 consisted of 7 male and 3 female participants. Group 2 consisted of 4 male and 6 female participants. Group 3 consisted of 3 male and 7 female participants.
5.3 Subjective Data Analysis

5.3.1 NPRS

Figure 4.1 indicates that the mean NPRS value for Group 1 decreased by 85.19%, the value for Group 2 decreased by 73.68% and the value for Group 3 decreased by 75.00%.

The Friedman test was used to check for changes over time within the three groups, and table 4.5 indicates that there was a statistically significant difference (p < 0.05) found in all three the groups. Group 1, 2 and 3 all had p-values of 0.000.

The non-parametric Wilcoxon signed rank test was used to determine where the changes occurred between visits in Group 1, 2 and 3. What can be seen from table 4.6 is that there was a statistically significant difference noted on intra-group analysis, via the Wilcoxon signed rank test of Group 2 and Group 3 between all the visits in and Group 1 between visit 1-4 and visit 1-7 terms of the NPRS over the time of the treatment. A non-statistically significant difference was noted in Group 1 between visit 4-7.

The Kruskal-Wallis test in table 4.7 shows that the baseline reading of the p-value at visit 1 (p = 0.322) started at greater than 0.05 and therefore the groups started off comparable. However the p-value remained greater than 0.05 at visit 4 (p = 0.999) and visit 7 (p = 0.778) and therefore there was no statistical significant difference (p > 0.05) noted between the three groups.

5.3.2 Vernon-Mior Neck Pain and Disability Index

Figure 4.2 indicates that the mean Vernon-Mior Neck Pain and Disability Index value for Group 1 decreased by 76.04%, the value for Group 2 decreased by 59.42% and the value for Group 3 decreased by 75.68%.
The Friedman test was used to check for changes over time within the three groups, and table 4.11 indicates that there was a statistically significant difference \((p < 0.05)\) found in all three the groups. Group 1 and 3 had p-values of 0.000 and Group 2 had a p-value of 0.009.

The non-parametric Wilcoxon signed rank test was used to determine where the changes occurred between visits in Group 1, 2 and 3. What can be seen from table 4.12 is that there was a statistically significant difference noted on intra-group analysis of Group 1 between visit 1-4 and visit 1-7, Group 2 between visit 1-7 and Group 3 between all the visits. A non-statistically significant difference was noted in Group 1 between visit 4-7 and Group 2 between visit 1-4 and visit 4-7.

The Kruskal-Wallis test in table 4.13 shows that the baseline reading of the p-value at visit 1 \((p = 0.189)\) started at greater than 0.05 and therefore the groups started off comparable. However the p-value remained greater than 0.05 at visit 4 \((p = 0.885)\) and visit 7 \((p = 0.952)\) and therefore there was no statistical significant difference \((p > 0.05)\) noted between the three groups.

5.3.3 Discussion of the subjective data

Chronic neck pain has many different causes as discussed in chapter two. Neck pain according to Bogduk (2003) can be caused by nerve injuries, radiculopathy, postural disorders and soft tissue injuries. Gerwin (2001) reported that neck pain is also caused by extensor cervical muscle trigger points and weakness, which includes longissimus cervicis muscle. Fernández de las Penas et al. (2011) further stated that pathological conditions such as malignancy, cervical myelopathy, fracture, systemic disease and arterial dysfunction can also cause neck pain.

It was evident from the results that the participants in the three groups responded well to their respective treatment protocols. The results of the study suggested that spinal manipulation, Kinesio® taping and the two therapies combined had similar
effects in decreasing neck pain and functional disability throughout the treatment period.

With regard to the NPRS, Group 1, 2 and 3 demonstrated statistically significant improvement in neck pain severity. Group 1 and 2 means of 0.8 and 1.5 had similar effects in comparison with the previously reported means of 1.9 and 1.4 by SaAvedar-Hernadez et al. (2012) respectively, by decreasing significantly over the treatment period. Previous literature have reported that spinal manipulation (Bergmann and Peterson, 2011) and Kinesio® taping (SaAvedar-Hernadez et al., 2012) is effective for reducing pain in individuals with neck pain, but this is the first study to suggest that the two therapies combined had a similar effect. This study also demonstrated that Group 1, 2 and 3 were statistically significant in functional disability with regards to the Vernon-Mior Neck Pain and Disability Index. SaAvedar-Hernadez et al. (2012) stated that it is possible for consecutive spinal manipulations or Kinesio® taping to result in changes that is significant with regard to pain severity and functional disability.

It was found that Group 1’s subjective perception of pain intensity and functional disability improved to a greater degree than Group 2 and 3. Although Group 1 showed a greater degree of improvement over the treatment period with regards to the NPRS, Group 3 continued to be effective throughout the trial where Group 1 achieved maximal benefit by treatment 4. As Group 1 had the highest clinical improvement this actually indicates Group 1’s superiority as the participants improved more and faster. This indicates that the Group 1 treatment protocol is most effective in decreasing the pain intensity throughout the treatment period between the three groups. However, the results indicated that Group 3 may continue to improve and had not yet achieved maximum benefit. Therefore, a longer trial would be recommended to determine the long term effects of these treatments. All three groups responded similarly with regards to the Vernon-Mior Neck Pain and Disability Index, although Group 1 responded the most clinically.
According to the literature study, pain can be decreased in various ways. The reason why Group 1 had the most effective decrease in pain intensity can be deducted from the method of pain reduction via stimulation of the mechanoreceptors in the facet joints, muscles and skin. Gillette (2002) stated that spinal manipulation may induce a short-lived phasic response triggered by the stimulation of both deep and superficial mechanoreceptors. Spinal manipulation commonly affects joint and neurophysiologic function (Bergmann and Peterson, 2011) and produces a consistent reflex from a multi-receptor origin, resulting in pain reduction and decreased muscle hypertonicity (Haldeman, 1993). Spinal manipulation also causes mechanical stimulation of joint capsule proprioceptors and muscle spindles and induces a reflex inhibition of pain and improves mobility. Nevertheless, it seems that more than one mechanism likely explains the effects of spinal manipulation and when it is aimed at the cervical spine, it is a very effective intervention in patients with chronic neck pain (Fernandez-de-las-Penas et al., 2007).

Group 3 also received spinal manipulation but didn’t show the same trend as Group 1. Either Group 1 results were not a true reflection of the study due to the small group size, or the addition of the tape may have had a detrimental effect on the subjective measurements.

5.4 Objective Data Analysis

5.4.1 Cervical spine flexion measurements

Figure 4.3 indicates that the cervical spine range of motion in flexion mean value for Group 1 increased by 4.66%, the value for Group 2 increased by 8.89% and the value for Group 3 increased by 10.44%.
The Friedman test was used to check for changes over time within the three groups, and table 4.17 indicates that there was a non-statistically significant difference \((p > 0.05)\) found in all three the groups. Group 1 had a p-value of 0.452, Group 2 had a p-value of 0.073 and Group 3 had a p-value of 0.118.

The Wilcoxon signed rank test was not used for further investigation as the Friedman test was negative in all three groups.

The Kruskal-Wallis test in table 4.18 shows that the baseline reading of the p-value at visit 1 \((p = 0.428)\) started at greater than 0.05 and therefore the groups started off comparable. However the p-value remained greater than 0.05 at visit 4 \((p = 0.400)\) and visit 7 \((p = 0.916)\) and therefore there was no statistical significant difference \((p > 0.05)\) noted between the three groups.

### 5.4.2 Cervical spine extension measurements

Figure 4.4 indicates that the cervical spine range of motion in extension mean value for Group 1 increased by 0.59\%, the value for Group 2 increased by 9.01\% and the value for Group 3 increased by 10.50\%.

The Friedman test was used to check for changes over time within the three groups, and table 4.22 indicates that there was a statistically significant difference \((p < 0.05)\) was found in Group 3 with a p-value of 0.022 and non-statistically significant difference \((p > 0.05)\) was found in Group 1 and 2 with p-values of 0.875 and 0.256 respectively.

The non-parametric Wilcoxon signed rank test was used to determine where the changes occurred between visits in Group 1, 2 and 3. What can be seen from table 4.23 is that there was a non-statistically significant difference noted on intra-group analysis, via the Wilcoxon signed rank test, of Group 1 and Group 2 between all visits and Group 3 between visit 1-4 and visit 4-7. A statistically significant difference was noted in Group 3 between visit 1-7.
The Kruskal-Wallis test in table 4.24 shows that the baseline reading of the p-value at visit 1 \((p = 0.235)\) started at greater than 0.05 and therefore the groups started off comparable. However the p-value remained greater than 0.05 at visit 4 \((p = 0.457)\) and visit 7 \((p = 0.621)\) and therefore there was no statistical significant difference \((p > 0.05)\) noted between the three groups.

5.4.3 Cervical spine right rotation measurements

Figure 4.5 indicates that the cervical spine range of motion in right rotation mean value for Group 1 increased by 0.43\%, the value for Group 2 increased by 8.75\% and the value for Group 3 increased by 14.11\%.

The Friedman test was used to check for changes over time within the three groups, and table 4.28 indicates that a statistically significant difference \((p < 0.05)\) was found in Group 2 and a non-statistically significant difference \((p > 0.05)\) was found in Group 1 and 3. Group 1 had a p-value of 0.614, Group 2 had a p-value of 0.037 and Group 3 had a p-value of 0.052.

The non-parametric Wilcoxon signed rank test was used to determine where the changes occurred between visits in Group 1, 2 and 3. What can be seen from table 4.29 is that there was a non-statistically significant difference noted on intra-group analysis of Group 1 between all visits, Group 2 between visit 4-7 and visit 1-7 and Group 3 between visit 4-7. A statistical significant difference in Group 2 between visit 1-4 and Group 3 between visit 1-4 and visit 1-7 was noted.

The Kruskal-Wallis test in table 4.30 shows that the baseline reading of the p-value at visit 1 \((p = 0.398)\) started at greater than 0.05 and therefore the groups started off comparable. However the p-value remained greater than 0.05 at visit 4 \((p = 0.929)\) and visit 7 \((p = 0.475)\) and therefore there was no statistical significant difference \((p > 0.05)\) noted between the three groups.
5.4.4 Cervical spine left rotation measurements

Figure 4.6 indicates that the cervical spine range of motion in left rotation mean value for Group 1 increased by 5.69%, the value for Group 2 increased by 1.08% and the value for Group 3 increased by 11.60%.

The Friedman test was used to check for changes over time within the three groups, and table 4.34 indicates that a statistically significant difference ($p < 0.05$) was found in Group 3 and a non-statistically significant difference ($p > 0.05$) was found in Group 1 and 2. Group 1 had a p-value of 0.254, Group 2 had a p-value of 0.717 and Group 3 had a p-value of 0.013.

The non-parametric Wilcoxon signed rank test was used to determine where the changes occurred between visits in Group 1, 2 and 3. What can be seen from table 4.35 is that there was a non-statistically significant difference noted on intra-group analysis of Group 1 between visit 1-4 and visit 1-7, Group 2 between all visits and group 3 between visit 1-4 and visit 4-7. A statistically significant difference was noted in Group 1 between visit 4-7 and Group 3 between visit 1-7.

The Kruskal-Wallis test in table 4.36 shows that the baseline reading of the p-value at visit 1 ($p = 0.719$) started at greater than 0.05 and therefore the groups started off comparable. However the p-value remained greater than 0.05 at visit 4 ($p = 0.276$) and visit 7 ($p = 0.120$) and therefore there was no statistical significant difference ($p > 0.05$) noted between the three groups.

5.4.5 Cervical spine right lateral flexion measurements

Figure 4.7 indicates that the cervical spine range of motion in right lateral flexion mean value for Group 1 increased by 5.42%, the value for Group 2 increased by 12.00% and the value for Group 3 increased by 1.29%.
The Friedman test was used to check for changes over time within the three groups, and table 4.40 indicates that there was a non-statistically significant difference \( (p > 0.05) \) found in all three the groups. Group 1 had a p-value of 0.368, Group 2 had a p-value of 0.061 and Group 3 had a p-value of 0.285.

The Wilcoxon signed rank test was not used for further investigation as the Friedman test was negative in all three groups. The Kruskal-Wallis test in table 4.41 shows that the baseline reading of the p-value at visit 1 (\( p = 0.877 \)) started at greater than 0.05 and therefore the groups started off comparable. However the p-value remained greater than 0.05 at visit 4 (\( p = 0.926 \)) and visit 7 (\( p = 0.308 \)) and therefore there was no statistical significant difference \( (p > 0.05) \) noted between the three groups.

**5.4.6 Cervical spine left lateral flexion measurements**

Figure 4.8 indicates that the cervical spine range of motion in left lateral flexion mean value for Group 1 increased by 5.69\%, the value for Group 2 increased by 11.84\% and the value for Group 3 increased by 14.37\%.

The Friedman test was used to check for changes over time within the three groups, and table 4.45 indicates that a statistically significant difference \( (p < 0.05) \) was found in Group 3 and a non-statistically significant difference \( (p > 0.05) \) was found in Group 1 and 2. Group 1 had a p-value of 0.146, Group 2 had a p-value of 0.132 and Group 3 had a p-value of 0.045.

The non-parametric Wilcoxon signed rank test was used to determine where the changes occurred between visits in Group 1, 2 and 3. What can be seen from table 4.46 is that there was a non-statistically significant difference noted on intra-group analysis of Group 1 and Group 2 between all visits and group 3 between visit 1-4 and visit 4-7. A statistically significant difference was noted in Group 3 between visit 1-7.
The Kruskal-Wallis test in table 4.47 shows that the baseline reading of the p-value at visit 1 ($p = 0.782$) started at greater than 0.05 and therefore the groups started off comparable. However the p-value remained greater than 0.05 at visit 4 ($p = 0.979$) and visit 7 ($p = 0.762$) and therefore there was no statistical significant difference ($p > 0.05$) noted between the three groups.

5.4.7 Discussion of objective data

As discussed in chapter two chronic neck pain has many different causes. Nerve injuries, radiculopathy, postural disorders and soft tissue injuries can cause neck pain according to Bogduk (2003). Gerwin (2001) reported that neck pain is also caused by extensor cervical muscle trigger points and weakness, which includes longissimus cervicis muscle. Fernández de las Penas et al. (2011) further stated that that neck pain can also be caused by pathological conditions such as malignancy, cervical myelopathy, fracture, systemic disease and arterial dysfunction.

It was evident from the results that the participants in the three groups responded well to their respective treatment protocols. The results of the study suggested that the two therapies combined improved the most in increasing all ranges of motion in the cervical spine throughout the treatment period than spinal manipulation and Kinesio® taping alone.

Regarding the CROM instrument readings of the cervical spine range of motion, Group 1, 2 and 3 demonstrated statistically significant improvement in all ranges of motion of the cervical spine. The study showed that participants receiving their respective treatment protocols exhibited small increases in CROM readings. This is in agreement with a previous study conducted by SaAvedar-Hernadez et al. (2012) showing an improvement in mobility after spinal manipulation or Kinesio® taping of the cervical spine. Changes in cervical spine range of motion were clinically greater in Group 3 than the other two groups, but these differences were small. Additionally, improvements in Group 1 and Group 2 had similar
effects in comparison with the previously reported means by SaAvedar-Hernadez et al. (2012) in all ranges of cervical spine motion, by increasing significantly over the treatment period. SaAvedar-Hernadez et al. (2012) stated that it is possible for consecutive spinal manipulations or Kinesio® taping to result in changes that is significant with regard to cervical spine range of motion.

Although all three groups demonstrated statistically significant improvement in all ranges of cervical spine motion, it was found that Group 3 responded best to treatments in all the ranges of motion except for right lateral flexion in which Group 2 responded best to treatment. This indicates that the Group 3 treatment protocol is most effective in increasing the range of motion throughout the treatment period between all visits.

According to the literature study, cervical spine range of motion can be increased in various ways. The reason why Group 3 had the most effective increase in cervical spine range of motion can be deducted from the method of pain reduction via stimulation of the mechanoreceptors in the facet joints, muscles and skin. Fernández de las Penas et al. (2011) suggested that spinal manipulation is effective in immediately improving cervical spine range of motion and decreasing neck pain. Spinal manipulation commonly affects joint and neurophysiologic function (Bergmann and Peterson, 2011) and produces a consistent reflex from a multi-receptor origin, resulting in pain reduction and decreased muscle hypertonicity (Haldeman, 1993). Kinesio® taping is designed to assist the body’s natural healing process with the ability to support and stabilise the muscles and joints without restricting the body’s range of motion. The taping method for applying the tape differs depending on the goal: increasing active range of motion, relieving pain, adjusting misalignments or increasing lymphatic circulation (Kase et al., 2003). When these two modalities are combined, the result may have longer lasting effects and thus could be a more successful form of treatment going forward.
When looking at all three treatment protocols above, all have a wide variety of neurological and physiological effects on the neuromuscular and musculoskeletal systems affecting pain, range of motion and proprioception. The effects of spinal manipulation are enhanced and supported by the longer lasting effects of the Kinesio® tape applied to the longissimus cervicis muscle, in the cervical spine region. The longissimus cervicis muscles forms part of the group that makes up the posterior neck muscles. Therefore the effects that Kinesio® taping produces on the longissimus cervicis muscle will also have an effect on the rest of the posterior neck muscle group, which include decreasing pain and increasing range of motion.

The study showed that the treatment protocols for Group 1, 2 and 3 were effective in treating chronic neck pain. Nevertheless, taking all the above evidence into consideration, it suggests that the Group 1 treatment protocol, which received spinal manipulation, is more effective than Kinesio® taping alone and the two therapies combined in decreasing pain intensity and functional disability in the treatment of chronic neck pain. The evidence further suggests that the Group 3 treatment protocol, which received spinal manipulation in combination with Kinesio® taping, is more effective than spinal manipulation and Kinesio® taping alone in increasing all cervical spine ranges of motion in the treatment of chronic neck pain.

Chapter six will discuss the conclusion of this study and provide recommendations pertaining to this study.
CHAPTER SIX – CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The study comprised of thirty participants, all who diagnosed with chronic neck pain after clinical and physical examination.

The participants were randomly allocated into three treatment groups of ten participants each. Group 1 received spinal manipulation to restriction(s) of the cervical spine only. Group 2 received Kinesio® taping to longissimus cervicis muscles only. Group 3 received a combination of spinal manipulation and Kinesio® taping.

The study was done with regards to pain, disability and cervical spine range of motion. These effects were based on the findings of the NPRS, the Vernon-Mior Neck Pain and Disability Index and CROM readings of the cervical spine range of motion. Subjective and objective data collection was done prior to treatment on the first, the fourth and at the seventh/final consultation, where no treatment took place as described previously in chapter 3.

It is evident from the data that the participants in the three groups responded well to their respective treatment protocols. With regard to the subjective measurements, namely the NPRS and the Vernon-Mior Neck Pain and Disability Index, Group 1, 2 and 3 demonstrated statistically significant improvement in both neck pain severity and functional disability. However, it was found that Group 1’s subjective perception of pain intensity improved to a greater degree than Group 2 and 3. Group 1 achieved maximal benefit by treatment 4 with regards to NPRS. As Group 1 had the highest clinical improvement this actually indicates Group 1’s superiority as the participants improved more and faster. This indicates that the Group 1 treatment protocol is most effective in decreasing the pain intensity throughout the treatment period between the three groups over the treatment period. All three groups responded similarly with regards to the Vernon-
Mior Neck Pain and Disability Index, although Group 1 responded the most clinically.

Regarding the objective measurements, namely the CROM readings of the cervical spine range of motion, Group 1, 2 and 3 demonstrated statistically significant improvement in all ranges of motion of the cervical spine. However, it was found that Group 3 responded best to treatments in all the ranges of motion except for right lateral flexion in which Group 2 responded best to treatment.

The aim of the study was to determine whether spinal manipulation, Kinesio® taping and the two therapies combined are all effective in the treatment of chronic neck pain and also to provide further evidence on the efficacy of spinal manipulation.

The study showed that the treatment protocols for Group 1, 2 and 3 were effective in treating chronic neck pain, therefore all three treatment protocols can be used effectively if any contraindications to one of the other protocols should arise. Although the evidence suggests that the Group 1 treatment protocol, which received spinal manipulation, is more effective than Kinesio® taping alone and the two therapies combined in decreasing pain intensity and functional disability, all three groups did respond similarly in the treatment of chronic neck pain. The evidence further suggests that the Group 3 treatment protocol, which received spinal manipulation in combination with Kinesio® taping, is more effective than spinal manipulation and Kinesio® taping alone in increasing all cervical spine ranges of motion in the treatment of chronic neck pain.

6.2 Recommendations

To further improve the results that were obtained in the study the following recommendations can be used:

- When placing participants into their respective groups, it is recommended that the researcher ensure that equal numbers of males and females are
allocated to the different groups, because gender differences could affect the study

• When placing patients into different groups the researcher should also adequately distribute the patients so the age difference is equally shared between the groups
• Larger sample sizes in the different groups, may reveal the results to be more statistically viable
• Including an extra follow-up assessment one month after the last treatment to determine the longer term effects of the treatments
• A long term study as the results indicated that the groups may continue to improve and had not yet achieved maximum benefit
• Algometer readings could be done on the cervical para-spinal trigger points, to objectively measure pain on the trigger points
• Different techniques of Kinesio® taping may be compared to each other as each technique has a different effect on the body
• Pre and post application measurements may be helpful to indicate an immediate effect
• A study to investigate the effects of Kinesio® taping and spinal manipulation on muscle strength
REFERENCES


http://www.spineproducts.com/paa_product_listing.php#crom_basic
(Accessed on 25 September 2011)


APPENDIX A: Advertisement

CHIROPRACTIC RESEARCH

The efficacy of Kinesio® taping, spinal manipulation or the two therapies combined in the treatment of chronic neck pain

I, Juandre French, hereby invite you to participate in my research study. I am currently a Chiropractic student, completing my Masters Degree at the University of Johannesburg. The aim of the study is to compare the efficacy of Spinal Manipulative Therapy, Kinesio® taping and combination of these two treatments to determine the most effective treatment protocol for patients with CHRONIC NECK PAIN. The venue of the study will be in the Chiropractic clinic at the University of Johannesburg’s Doornfontein campus.

CHIROPRACTIC

For any further information, questions, or if you are interested in participating in the study contact:

Researcher: Juandre French 072 610 3482 juandrefrench@yahoo.com
Supervisor: Dr. C. Bester 011 559 6936 charmained@uj.ac.za
APPENDIX B: Information Form

DEPARTMENT OF CHIROPRACTIC

INFORMATION FORM

I, Juandré French, hereby invite you to participate in my research study, entitled the efficacy of utilising Kinesio® taping, spinal manipulation or the two therapies combined in the treatment of chronic neck pain. I am currently a Chiropractic student, completing my Masters Degree at the University of Johannesburg.

Before agreeing to participate, it is important that you read and understand the following explanation of the aim of the study, the study procedures, benefits, risks, discomforts, and your right to withdraw from the study at any time. If you have any questions, do not hesitate to ask me. If you decide to partake in this study, you will be asked to sign this document to confirm that you understand the study. You will be given a copy to keep.

The aim of this study will be to determine the efficacy of utilising Kinesio® taping, spinal manipulation or the two therapies combined, for the treatment of chronic neck pain. It will also provide further evidence on the efficacy of spinal manipulation.

The study will consist of three groups of ten participants, who will be examined and accepted according to the inclusion and exclusion criteria. The method of treatment will be determined by random group allocation. The participants will
have the opportunity to select a card from an envelope, which has either written on it Group 1, Group 2 or Group 3, and will then be placed into the respective treatment group. Group 1 will receive an adjustment to restriction(s) of cervical spine only. Group 2 will receive Kinesio® taping to posterior neck muscles only. Group 3 will receive a combination of an adjustment and Kinesio® taping. The study will not discriminate based upon the demographics such as gender and race. The patients will need to comply with the inclusion and exclusion criteria to ensure validity. The total time required for your participation in this study will be a maximum of three weeks which includes seven consultations for all three groups.

Adjustments are normally done as part of routine chiropractic care but may present a slight risk of discomfort. Adjustments may result in post-adjustment stiffness. There is also a slight possibility of pain. Kinesio® taping can cause skin irritation due to the tape’s adhesive glue, and should be removed immediately if it does so. Your protection is that experienced personnel perform the adjustments and taping under observation of a qualified chiropractor. The study is investigational and there may be other risks or side effects which are unforeseen or unknown. You should immediately contact me if any side effects occur throughout your participation in this study. Participants will be referred appropriately when necessary.

The benefit regarding this study is a possible decrease in neck pain which will improve a person’s life by improving their normal routine, occupational functioning, social activities, and general health. It will also benefit to determine the efficacy of utilising Kinesio® taping in isolation or in combination with adjustments, in the treatment of chronic neck pain and provide further evidence on the efficacy of adjustments.

The research study will take place at the University of Johannesburg Chiropractic Day Clinic. Your privacy will be protected as only the researcher, patient (you) and qualified chiropractor will be in the treatment room. Your anonymity will be
ensured as your personal information will be converted into data and therefore cannot be traced back to you. Standard doctor/patient confidentiality will be adhered to at all times when compiling the research dissertation. Results of this study will be made available to you on request.

This clinical study protocol has been submitted to the University of Johannesburg, Higher Degrees Committee (HDC) and written approval has been granted by that committee.

Researcher: Juandré French  072 610 3482 / juandrefrench@yahoo.com
Supervisor: Dr. Charmaine Bester  011 559 6936 / charmaineb@uj.ac.za
Your participation in this study is entirely voluntary and you can decline to participate, or stop at any time, without stating any reason. Your withdrawal will not affect your access to other medical care. I will provide you with any additional information that becomes available during the study, which may affect your willingness to continue on the study. I retain the right to withdraw you from the study if it is considered to be in your best interest. If you did not give an accurate history, or did not follow the guidelines of the study and the regulations of the study facility, you may be withdrawn from the study at any time.

All information obtained during the course of this study, including clinic records, personal data and research data will be kept strictly confidential. Data that may be reported in scientific journal will not include any information that identifies you as a participant in this study. You will be informed of any finding of importance to your health or continued participation in this study but this information will not be disclosed to any third party without your written permission.

Informed consent:
☐ I hereby confirm that I have been informed by the researcher, Juandré French, about the nature, conduct, benefits and risks of this study.
☐ I also have received, read and understood Participant Information Form and Informed Consent regarding the study.
☐ I am aware that the results of the study, including personal details regarding my sex, age, date of birth, initials and diagnosis will be anonymously processed in a study report.
☐ I may, at any stage without prejudice, withdraw my consent and participation in the study.
☐ I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.

Date: _______________________ Participant:__________________________

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

Date: _______________________ Researcher: __________________________

Researcher: Juandré French 072 610 3482 / juandrefrench@yahoo.com
Supervisor: Dr. Charmaine Bester 011 559 6936 / charmaineb@uj.ac.za
APPENDIX D: Contraindications of Spinal Manipulation by Esposito and Philipson (2005)

Vascular complications
- Vertebrobasilar insufficiency
- Aneurysms

Tumours
- Primary to the bone
- Secondary (metastasis to the bone)

Bone infections
- Tuberculosis of the spine
- Osteomyelitis of the spine

Traumatic injuries
- Fractures
- Instabilities
- Dislocation
- Unstable spondylolisthesis

Arthritis
- Ankylosing spondylitis
- Rheumatoid arthritis
- Psoriatic arthritis
- Reiter’s syndrome
- Osteoarthritis

Psychological considerations
- Malingering
- Hysteria
- Hypochondriasis
- Pain intolerance
- Dependant personality
- Disability Syndromes
Neurological complications

- Cervical disc lesions and myelopathy
- Nerve root damage
APPENDIX E: Contraindications of Kinesio® Taping by Kinesio Taping® Association International (2011b)

Not suitable for patients with:

- Fragile skin
- Infections
- Sunburn
- Irritated skin
- Tape sensitivities
- Deep vein thrombosis
- Tumours.
APPENDIX F: Case History

UNIVERSITY OF JOHANNESBURG
CHIROPRACTIC DAY CLINIC

CASE HISTORY

Date: ________________

Patient: ___________________________ File No: ___________

Age: ______ Sex: ________ Occupation: ________________

Student: ___________________________ Signature: ___________

Complies with inclusion criteria of the research:
Clinician: ________________
Signature: ________________

Examination:
Previous: UJ Other Current: UJ Other

X-ray Studies:
Previous: UJ Other Current: UJ Other

Clinical Path. Lab:
Previous: UJ Other Current: UJ Other

Case status:
PTT: Conditional: Signed off: Final sign out:

Recommendations:
Students case history

1. Source of history:

2. Chief complaint: (patient’s own words)

3. Present illness:
   - Location
   - Onset
   - Duration
   - Frequency
   - Pain (character)
   - Progression
   - Aggravating factors
   - Relieving factors
   - Associated Sx’s and Sg’s
   - Previous occurrences
   - Past treatment and outcome
4. Other complaints:

5. Past history
   - General health status
   - Childhood illnesses
   - Adult illnesses
   - Psychiatric illnesses
   - Accidents/injuries
   - Surgery
   - Hospitalisation

6. Current health status and lifestyle
   - Allergies
   - Immunizations
   - Screening tests
   - Environmental hazards
   - Safety measures
   - Exercise and leisure
   - Sleep patterns
   - Diet
   - Current medication
   - Tobacco
   - Alcohol
   - Social drugs
7. **Family history:**
   **Immediate family:**
   - Cause of death
   - DM
   - Heart disease
   - TB
   - HBP
   - Stroke
   - Kidney disease
   - CA
   - Arthritis
   - Anaemia
   - Headaches
   - Thyroid disease
   - Epilepsy
   - Mental illness
   - Alcoholism
   - Drug addiction
   - Other

8. **Psychosocial history:**
   - Home situation
   - 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 G: Physical Examination

UNIVERSITY OF JOHANNESBURG
CHIROPRACTIC DAY CLINIC

PHYSICAL EXAMINATION
(Note: only if Cervical Spine Regional is complete)

Underline abnormal findings in RED.

Date: ____________________

Patient: ____________________ File No: ____________

Clinician: ____________________ Signature: ____________

Student: ____________________ Signature: ____________

Height: _______ Weight: _______ Temp: _______

Rates: Heart: _______ Pulse: _______ Respiration: _______

<table>
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<tr>
<th>Blood pressure:</th>
<th>Arms:</th>
<th>L</th>
<th>R</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Legs:</td>
<td>L</td>
<td>R</td>
</tr>
</tbody>
</table>

General Appearance:

____________________________________
____________________________________
____________________________________
____________________________________
____________________________________
STANDING EXAMINATION

1. Minor’s sign
2. Skin changes
3. Posture: Erect
   Adam’s
4. Ranges of motion (Thoracolumbar Spine)
   T/L spine: Flexion: 90° (fingers to floor)
   Extension: 50°
   R. lat. flex: 30° (fingers down leg)
   L. lat. flex: 30° (fingers down leg)
   Rot. to R: 35°
   Rot. to L: 35°

L. Rot                         R. Rot

L. Lat Flex                    R. Lat Flex

/ = pain-free limitation   // = painful limitation

5. Romberg's sign
6. Pronator drift
7. Trendelenburg's sign
8. Gait: - rhythm
       - balance
       - pendulousness
       - on toes
       - on heels
       - tandem
9. Half squat
10. Scapular winging
11. Muscle tone
12. Spasticity/Rigidity
13. Shoulder: skin
    symmetry
    ROM
    - glenohumeral
    - scapulo-thoracic
    - acromioclavicular
    - elbow
    - wrist
14. Chest measurement:
   - inspiration
   - expiration
   | I | R |
   | cm | cm |
   | cm | cm |

15. Visual acuity

16. Breast examination:
   Inspection:
   - skin
   - size
   - contour
   - nipples
   - arms overhead
   - hands against hips
   - leaning forward
   Palpation
   - axillary lymph nodes
   - breast incl. tail

SEATED EXAMINATION

1. Spinal posture

2. Head
   - hair
   - scalp
   - skull
   - face
   - skin

3. Eyes:
   Observation
   - conjunctiva
   - sclera
   - eyebrows
   - eyelids
   - lacrimal glands
   - nasolacrimal duct
   - position and alignment
   - corneas and lenses

- corneal reflex
- ocular movement

| III | IV | VI | III | IV | VI |

- visual fields
- accommodation
- Ophthalmoscopic
- Examination
  - iris
  - pupils
  - red reflex
  - optic disc
  - vessels
  - general background
4. Ears:
   • Inspection
     - macula
     - vitreous
     - lens
     - auricle
     - ear canal
     - drum
     • auditory acuity
     • Weber test
     • Rinne test

5. Nose:
   • External
   • Internal
     - septum
     - turbinates
     - olfaction

6. Sinuses (frontal & maxillary):
   - tenderness
   - transillumination

7. Mouth and pharynx:
   • lips
   • buccal mucosa
   • gums and teeth
   • roof
   • tongue
     - inspection
     - movement
     - taste
     - palpation
   • pharynx
     - CN X
     - inspection

• carotid arteries (thrills, bruit)
• Cranial Nerves
  - CN V
  - CN VII
  - CN VIII (nystagmus)
  - CN IX
  - CN XI
  - CN X11

8. Peripheral vasculature:
   • Inspection
     - skin
     - nail beds
     - pigmentation
     - hair loss
• Palpation
  - pulses: femoral, dorsalis pedis
  - popliteal, radial
  - post. Tibial, brachial
  - lymph nodes, epitrochlear
  - femoral (horizontal & vertical)
  - temperature (feet and legs)

• Manual compression test
• Retrograde filling (Tredelenburg) test
• Arterial insufficiency test

10. Musculoskeletal:
(i) ROM
• hip

<table>
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<td>ext.</td>
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<tr>
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<tr>
<td>dorsiflex</td>
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<tr>
<td>inversion</td>
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<tr>
<td>eversion</td>
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<tr>
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<td>L</td>
<td>R</td>
</tr>
<tr>
<td>Actual</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

• knee
• ankle
(ii) leg length

• Co-ordination
  - point to point
  - dysdiachokinesia

9. TMJ
• Inspection
  - ROM
  - deviation
  - crepitus
  - tenderness
  - Palpation
10. Thorax
   • Inspection
     - skin
     - shape
     - respiratory distress
     - rhythm (respiratory)
     - depth (respiratory)
     - effort (respiratory)
     - intercostals supraclavicular retraction
   • Palpation
     - tenderness
     - masses
     - respiratory expansion
     - tactile fremitus
   • Percussion
     - lungs (posterior)
     - diaphragmatic excursion
     - kidney punch
   • Auscultation
     (i) breath sounds
     - vesicular
     - bronchial
     (ii) adventitious sounds
     - crackles (rales)
     - wheezes (rhonchi)
     - rubs
     (iii) voice sounds
     - broncophony
     - whispered pectoriloquy
     - egophony
   • Cardiovascular
     - auscultation (aortic murmurs)
     - Allen's test

SUPINE EXAMINATION
1. JVP
2. PMI
3. Auscultation heart
   (L. lat. Recumbent)
4. respiratory excursion
5. percussion chest
   (anterior)
6. breast palpation
7. Abdominal Examination
   • Inspection
     - skin
     - umbilicus
     - contour
     - peristalsis
     - pulsations
     - hernias (umbilical/incisional)
• Auscultation
  - bowel sound
  - bruit

• Percussion
  - general
  - liver
  - spleen

• Palpation
  - superficial reflexes
  - cough
  - light
  - rebound tenderness
  - deep
  - liver
  - spleen
  - kidneys
  - aorta
  - intra-/retro-abdominal wall mass
  - shifting dullness
  - fluid wave

• Acute abdomen
  - where pain began and now
  - cough
  - tenderness
  - guarding/rigidity
  - rebound tenderness
  - rovsing's sign
  - psoas sign
  - obturator sign
  - cutaneous hyperaesthesia
  - rectal exam
  - Murphy's sign

MENTAL STATUS

(i) Appearance and behaviour
  - level of consciousness
  - posture and motor behaviour
  - dress, grooming, personal hygiene
  - facial expression
  - affect

(ii) Speed and language
  - quantity
  - rate
  - volume
  - fluency
  - aphasia (pm)

(ii) Mood

(v) Memory and attention
  • orientation (time, place, person)
  • remote memory
(vi) Higher cognitive functions
   - information and vocabulary
   - (general and specialised knowledge)
   - abstract thinking

### Neurological Examination (Lumbar Spine)

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<thead>
<tr>
<th>Dermatomes</th>
<th>Left</th>
<th>Right</th>
<th>Myotomes</th>
<th>Left</th>
<th>Right</th>
<th>Reflexes</th>
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<tr>
<td>T12</td>
<td></td>
<td></td>
<td>Hip Flexion (L1/L2)</td>
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<td>Patellar (L3, 4)</td>
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<tr>
<td>L1</td>
<td></td>
<td></td>
<td>Knee Extension (L2, 3, 4)</td>
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<tr>
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APPENDIX H: Cervical Spine Regional Examination

UNIVERSITY OF JOHANNESBURG
CHIROPRACTIC DAY CLINIC

REGIONAL EXAMINATION
CERVICAL SPINE

Date: __________________________

Patient: ________________________ File No: ________________________

Clinician: ______________________ Signature: ______________________

Student: _______________________ Signature: ______________________

OBSERVATION

• Posture
• Size
• Swellings
• Scars
• Discolouration
• Hairline
• Bony and soft tissue contours
• Shoulder level
• Muscle spasm
• Facial expression

5. RANGE OF MOTION

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<td>L/R Lat Flexion</td>
<td>20° - 45°</td>
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PALPATION
- Lymph nodes
- Trachea
- Thyroid gland
- Pulses/thrills
- Tenderness
- Muscle Tone
- Active MF Trigger Points
  - SCM
  - Trapezius
  - Scaleni
  - Levator Scapulae
  - Posterior Cervical musculature

ORTHOPAEDIC EXAMINATION
1. Doorbell Sign
2. Max. Cervical Compression
3. Spurling’s manoeuvre
4. Lateral Compression (Jackson’s test)
5. Kemp’s Test
6. Cervical Distraction
7. Shoulder abduction Test
8. Shoulder depression Test
9. Dizziness rotation Test
10. Lhermitte’s Sign
11. O’ Donoghue Manoeuvre
12. Brachial Plexus Tension
13. Carpal tunnel syndrome:
   - Tinel’s sign
   - Phalen’s Test
14. TOS:
   - Halstead’s test
   - Adson’s test
   - Eden’s (traction) test
   - Hyperabduction (Wright’s) test – Pec minor
   - Costoclavicular test

Remarks:
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

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COMMENTS:
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APPENDIX I: SOAP Note

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S: O:

A: P:

Comments:

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Comments:
APPENDIX J: Neck Pain and Disability Questionnaire (Vernon-Mior)

### NECK PAIN AND DISABILITY QUESTIONNAIRE (Vernon-Mior)

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<tr>
<td><strong>Name</strong></td>
<td><strong>Date</strong></td>
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</table>
| **Section 1 – Pain Intensity** | □ I have no pain at the moment.  
□ The pain is very mild at the moment.  
□ The pain is moderate at the moment.  
□ The pain is fairly severe at the moment.  
□ The pain is very severe at the moment.  
□ The pain is the worst imaginable at the moment. |
| **Section 2 – Personal Care** | □ I can look after myself normally without causing pain.  
□ I can look after myself normally but it causes extra pain.  
□ It is painful to look after myself and I am slow and careful.  
□ I need some help but manage most of my personal care.  
□ I need help every day in most aspects of self-care.  
□ I do not get dressed, wash with difficulty, and I stay in bed. |
| **Section 3 – Lifting** | □ I can lift heavy weights without extra pain.  
□ I can lift heavy weights but it causes extra pain.  
□ Pain prevents me from lifting heavy weights off the floor, but I manage if they are conveniently positioned (e.g. on a table).  
□ Pain prevents me from lifting heavy weights but I can manage light to medium weights if they are conveniently positioned.  
□ I can only lift very light weights at the most.  
□ I cannot lift or carry anything at all. |
| **Section 4 – Reading** | □ I can read as much as I want with no neck pain.  
□ I can read as much as I want with slight neck pain.  
□ I can read as much as I want with moderate neck pain.  
□ I can’t read as much as I want because of moderate neck pain.  
□ I can hardly read at all because of severe neck pain.  
□ I cannot read at all. |
| **Section 5 – Headaches** | □ I have no headaches at all.  
□ I have slight headaches that come infrequently.  
□ I have moderate headaches that come infrequently.  
□ I have moderate headaches that come frequently.  
□ I have severe headaches that come frequently.  
□ I have headaches almost all of the time. |
| **Section 6 – Concentration** | □ I can concentrate fully when I want with no difficulty.  
□ I can concentrate fully when I want with slight difficulty.  
□ I have a fair degree of difficulty concentrating when I want.  
□ I have a great deal of difficulty concentrating when I want.  
□ I cannot concentrate at all. |
| **Section 7 – Work** | □ I can do as much work as I want.  
□ I can do my usual work but no more.  
□ I can do most of my usual work but no more.  
□ I cannot do my usual work.  
□ I can hardly do any work at all.  
□ I can’t do any work at all. |
| **Section 8 – Driving** | □ I can drive my car without any neck pain.  
□ I can drive my car as long as I want with slight pain in my neck.  
□ I can drive my car as long as I want with moderate pain in my neck.  
□ I can’t drive my car as long as I want because of moderate pain in my neck.  
□ I can hardly drive at all because of severe pain in my neck.  
□ I can’t drive my car at all. |
| **Section 9 – Sleeping** | □ I have no trouble sleeping.  
□ My sleep is slightly disturbed (less than 1 hour sleepless).  
□ My sleep is mildly disturbed (1-2 hours sleepless).  
□ My sleep is moderately disturbed (2-3 hours sleepless).  
□ My sleep is greatly disturbed (3-5 hours sleepless).  
□ My sleep is completely disturbed (5-7 hours sleepless). |
| **Section 10 – Recreation** | □ I am able to engage in all my recreation activities with no neck pain.  
□ I am able to engage in all my recreation activities with some neck pain.  
□ I am able to engage in most but not all of my usual recreation activities because of neck pain.  
□ I am able to engage in a few of my usual recreation activities because of neck pain.  
□ I hardly do any recreation activities because of neck pain.  
□ I can’t do recreation activities at all. |
APPENDIX K: Numerical Pain Rating Scale

Participant number: ____________________

How much pain have you had since your last treatment?
Please mark in one of the boxes to indicate how severe your pain has been:
0 being no pain and 10 being the worst pain you’ve ever had.

Consultation 1:

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