DRY NEEDLING VERSUS CERVICAL SPINE MANIPULATION COMBINED WITH DRY NEEDLING IN THE TREATMENT OF SUBSCAPULARIS MYOFASCIAL TRIGGER POINTS

A dissertation presented to the Faculty of Health Sciences, University of Johannesburg, as partial fulfilment for the Masters degree in Technology, Chiropractic by

Nicole Oosthuizen
200906708

Supervisor: ______________________ Date:

Dr. C. Yelverton

DECLARATION

I, Nicole Oosthuizen do hereby declare that this is my own unaided work except where otherwise indicated in the text. This dissertation is being submitted for the degree of Masters Degree in Technology at the University of Johannesburg. It has not been previously submitted for any degree or examination at any other Technikon or University.

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Signature

On this ______ day of _________________ 2016

DEDICATION

To my parents, Andre and Sylvia, without you, I would never have been the person I am today. Thank you for all the help and support throughout my student life. Thank you for the guidance, love and for always believing in me. I would never have been able to do this alone and for that I am forever grateful. Thank you for always supporting me and never doubting my capabilities. Thank you for all the prayers through the rough times as well as the good times. Thank you.

To my brother, Melcom, thank you for your support and for being there when I needed you. I never would have been able to do this without you. Thank you for your assistance and patience during my dissertation, without you, this dissertation would not have been possible. I am forever thankful and happy to have you as my brother and my best friend. Thank you to Mena, my sister in law for being so patient and helping me through the many difficult nights of working.

To my best friends, Jared, Corlè, Andriani, Tasmyn, Lauren, Kirsty and Gillian. I thank you all from the bottom of my heart. You were all there for me from the start. Thank you for all the love, support, encouragement and most of all the friendship. Through all the rough times and through all the good times. You helped me through it all and I cannot thank you enough for always making me smile.

Lastly, thank you to God. Without his strength, love and guidance, I would not have been able to do this and be the lady I am today.

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"*You never know how far reaching something you think, say, or do will affect the lives of millions tomorrow.*"

BJ Palmer

ABSTRACT

PURPOSE: Shoulder pain is one of the most common disorders that patients present with in practice. The most common cause of shoulder pain is a musculoskeletal problem that is chronic and recurrent. It is considered to be the main contributor towards non-traumatic upper limb pain. One of the identifiable causes of shoulder pain is myofascial pain syndrome which is caused by myofascial trigger points and produces symptoms similar to other shoulder pain syndromes. The subscapularis muscle is the largest of the rotator cuff muscles and is subjected to a large amount of biomechanical strain as well as neuromuscular tension. The aim of this study was to compare the effectiveness of treating shoulder pain with either dry needling the subscapularis muscle or with a combination treatment of dry needling the subscapularis muscle as well as cervical spine manipulations in order to determine which of the two treatment protocols are more effective.

METHODS: This study was a comparative study consisting forty participants between the ages of 18 and 40 years old with shoulder pain that were divided into 2 groups. Prior to becoming a participant in this study, individuals were assessed according to the inclusion and exclusion criteria. A Numerical Pain Rating Scale, clinical case history, full physical examination, cervical spine regional, shoulder regional and pressure algometer readings were completed. The method for treatment for each participant was determined by random group allocation. Group 1 received dry needling of the subscapularis muscle and group 2 received a combination treatment of subscapularis muscle dry needling and cervical spine manipulations. Subjective and objective readings were based on the above mentioned treatments. All participants received six treatments over a period of three weeks.

MEASUREMENTS: Subjective measurements were obtained by the Numerical Pain Rating Scale and the objective measurements were obtained using the hand-held pressure algometer. The data was collected on the initial, fourth and seventh consultations.

OUTCOME: With the subjective readings, the intragroup analysis of the Numerical Pain Rating Scale for the both treatment groups showed improvement. Group 1 had a **92.44%** improvement and group 2 had a **93.18%** improvement. No statistically significant differences were noted for the intergroup analysis. With regards to the objective measurements, the intragroup analysis of the pressure algometer readings indicated an improvement for both the groups. Group 1 had a **33.06%** improvement and group 2 had a **26.84%** improvement. No statistically significant differences were noted for the intergroup analysis.

CONCLUSION: The results showed that both treatment groups protocols were effective in the treatment of subscapularis myofascial trigger point dysfunction. Although both treatment protocols have shown to be effective and have shown improvement, intergroup analysis indicates that statistically there is no treatment protocol that is seen to be more effective in treating subscapularis myofascial trigger points.

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CHAPTER 1: INTRODUCTION

1.1 The Problem and its Setting

A common musculoskeletal disorder is shoulder pain. Pain and stiffness that causes shoulder movement restrictions can cause substantial disability and affect a person's ability to do normal daily activities and work. Musculoskeletal pain is the third most common cause of consultation in primary care (Mitchell, Adebajo, Hay and Carr, 2005). Shoulder pain is the main contributor to non-traumatic upper limb pain, in which reoccurrence of symptoms is common (Bron, de Gast, Dommerholt, Stegenga, Wensing and Oostendorp, 2011).

The most common cause of persistent pain is often a myofascial related pain. The presence of one or more hyperirritable sites within a muscle, known as myofascial trigger points, is characterised as myofascial pain syndrome (Rachlin, 2002). Muscles in the shoulder consisting of myofascial trigger points, produce symptoms that are similar to other shoulder pain syndromes. As a result, myofascial trigger points in musculoskeletal pain are accepted in the medical literature due to their role (Bron *et al.*, 2011).

The rotator cuff muscles, consisting of supraspinatus, infraspinatus, teres minor and subscapularis, stabilize the glenohumeral joint by compressing and depressing the humeral head into the glenoid cavity. These muscles work along with the scapulothoracic muscles to control scapular movements, thereby allowing a large range of motion for the shoulder; this is referred to as scapulohumeral rhythm (Thurner, Donatelli, Bascharon, 2013). A disruption to this relationship may often occur due to muscle imbalance thereby altering the kinematics and causing compensatory movement patterns to occur (Ludewig and Reynolds, 2009). Hidalgo-Lozanzo, Fernandez-de-las-Penas, Alonso-Blanco, Ge, Arendt-Nielson and Arroyo-Morales (2010), found that the muscles most commonly affected by trigger points in the shoulder are supraspinatus, infraspinatus and subscapularis muscle. There is a limited amount of research with regards to treating trigger points to minimize shoulder pain.

Thurner *et al.,* (2013) proposed that trigger points within the subscapularis muscle may cause sensitization of adjacent muscles of the shoulder girdle and present as satellite trigger points which potentially lead to a heightened sensitization of pain and motion restrictions of the shoulder complex.

Myofascial trigger points create sensory symptoms which take on a variety of forms and are not limited to the sense of pain. Symptoms such as muscle stiffness, weakness, nausea, oedema, dizziness and postural disturbances are even more diverse (Davies, 2004).

Severe pain at rest and during motion of the upper limb may be caused by subscapularis muscle trigger points. Pain referral from trigger points in the subscapularis muscle is along the posterior aspect of the shoulder overlying scapula, extending down the posterior aspect of the arm to the elbow and it often causes a strap like area of referred pain and tenderness around the wrist (Simons, Travell and Simons, 1999).

Trigger points found within the subscapularis muscle are activated by unusual repetitive exertion requiring forceful medial rotation, adduction with forceful overhead lifting, reaching back at shoulder level to arrest a fall, shoulder dislocation, tear of the shoulder joint capsule, proximal humeral fracture and prolonged immobilization (Simons *et al.*, 1999).

Dry needling has been used by practitioners to treat and manage myofascial pain syndrome. Dry needling is most effective, when the needle is inserted deep within the myofascial trigger point, causing a local twitch response to be elicited (Dommerholt and Fernandez-de-las-Penas, 2013). Targeting the needle at maximum tenderness within the taut band, the aim of dry needling is to break up the trigger point (Yap, 2007).

As another possible avenue for the effective treatment and management of symptoms associated with myofascial pain syndrome, the chiropractic manipulation has been effective. Mechanically, a chiropractic manipulation has been proposed to restore optimal functioning to joint motion. The chiropractic manipulation may also manifest changes in the dynamics of the supporting capsule-ligamentous tissue around the joint and it may also affect the tone and strength. Neurologically, chiropractic manipulations have been proposed to have the ability to restore and improve spinal and peripheral nerve conduction. This in turn manifests in a reduction in pain through stimulation of mechanoreceptors within the synovial joint. Furthermore, the chiropractic manipulation may alter both motor and sensory functioning within the body and also influence the regulation of the autonomic nervous system (Gatterman, 2005).

1.2 Aim of the Study

The aim of the study was to compare the effectiveness of treating shoulder pain with either dry needling subscapularis muscle or cervical spine manipulations combined with dry needling of subscapularis muscle trigger points, to determine which of the two treatment protocols were more effective.

1.3 Possible Outcomes of the Study

The study, through assessment of myofascial trigger points, overall may provide valuable insight into possible mechanisms involved in myofascial pain dysfunction. Additionally, by treating with cervical spine manipulation combined with trigger point dry needling versus a dry needling treatment alone, a better understanding of which treatment approach is provided. Subsequently providing clarity on which treatment regime is the most effective in treating the clinical presentation of subscapularis muscle myofascial trigger points.

The possible outcome of this study might provide additional value to the formation of treatment protocols when patients present with shoulder pain. The outcome could determine the most effective treatment for shoulder pain. It may give healthcare professionals a new insight into the treatment of shoulder pain and also to provide them with a better understanding of treatment of subscapularis muscle trigger points.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

In this chapter, all aspects involved with the subscapularis muscle and subscapularis myofascial pain syndrome will be discussed as thoroughly as possible. It will address the anatomy of subscapularis muscle, focusing more specifically on the trigger points. Myofascial pain syndrome will also be discussed, covering the etiology and clinical presentation of myofascial pain syndrome. The treatment of myofascial pain syndrome will be explained, focusing specifically on trigger point dry needling as well as emphasis on the effect of the chiropractic manipulation on myofascial pain syndrome. The basis of this research and its aims will be better understood at the end of this chapter.

2.2 Functional Organisation of Skeletal Muscle

Skeletal muscle is composed primarily of skeletal muscle tissue, but it also contains connective tissue, nerves and blood vessels.

There are six functions of skeletal muscle (Martini and Nath, 2009):

- Store nutrient reserves
- Maintain posture and body position
- Support soft tissues
- Skeletal movement
- Maintain body temperature
- Guard entrances and exits

Skeletal muscle fibers contain hundreds of nuclei internal to the plasma membrane, therefore making them enormous.

A muscle fibers sarcolemma, surrounds the sarcoplasm of the muscle fiber. Myoglobin, mitochondria, lysosomes, lipid vacuoles and glycogen are contained within the myocyte sarcoplasm (Kumar, Abbas and Fausto, 2010).

Myofibrils are cylindrical structures that are situated inside the muscle fiber and are encircled by branches of the transverse tubules (refer to figure 2.1) (Martini and Nath, 2009). Myofibrils consist of sarcomeres, myosin and Z-bands (Kumar *et al.*, 2010). Protein filaments are found in myofibrils called myofilaments. There are two types of myofilaments found:

- Thin filaments (Primarily made up of actin)
- Thick filaments (Primarily made up of myosin)

When actively shortened, myofibrils cause skeletal muscle contraction. Myofibrils at each end of the skeletal muscle fiber are anchored to the inner surface of the sarcolemma. The sarcolemma is attached to the collagen fibers of the tendon. Pulling on the tendon is caused by the myofibril which contracts and shortens the entire cell (Martini and Nath, 2009).

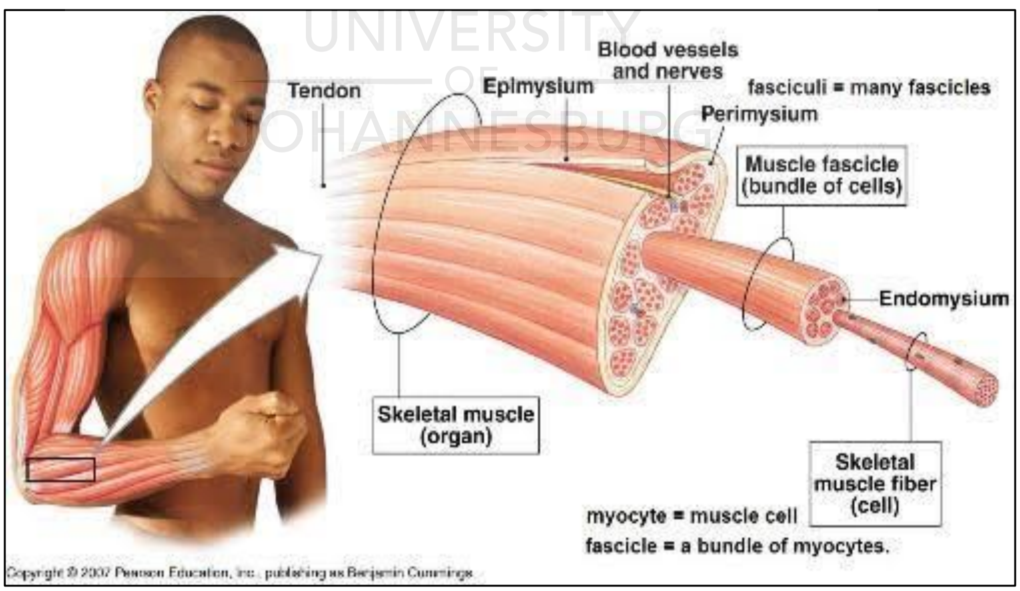

Figure 2.1: Structure of skeletal muscle (Martini and Nath, 2009)

Multinucleate skeletal muscle fibers are formed during embryonic development by myoblasts (groups of embryonic cells) which fuse. Myosatellite cells develop when some of the myoblasts do not fuse with developing skeletal muscle tissue. These cells remain in adult skeletal muscle tissue. When an injury occurs, the satellite cells increase in size, divide and fuse with the muscle fibers that are damaged. This assists the repairing process after an injury (Martini and Nath, 2009).

According to Martini and Nath (2009), muscle contraction requires a large amount of energy; therefore extensive vascular networks deliver oxygen and nutrients and carry away metabolic waste products that are generated by the active skeletal muscle.

Any muscle in the human body may develop pain and dysfunction (Yap, 2007).

2.3 The Subscapularis Muscle

2.3.1 The Anatomy and Function of the Subscapularis Muscle

a. Origin and Insertion

The rotator cuff muscles are made up of four scapulohumeral muscles namely; teres minor, supraspinatus, infraspinatus and subscapularis muscle (Figure 2.2). They are known as the rotator cuff muscles because of the musculotendinous cuff that they form around the glenohumeral joint (Moore, Dalley and Agur, 2010).

Forming part of the posterior wall of the axilla and lying on the costal surface of the scapula, the subscapularis muscle is a thick, triangular muscle. The subscapularis muscle crosses the anterior aspect of the humerus, on its way to the attachment site of the humerus (Moore *et al.*, 2010).

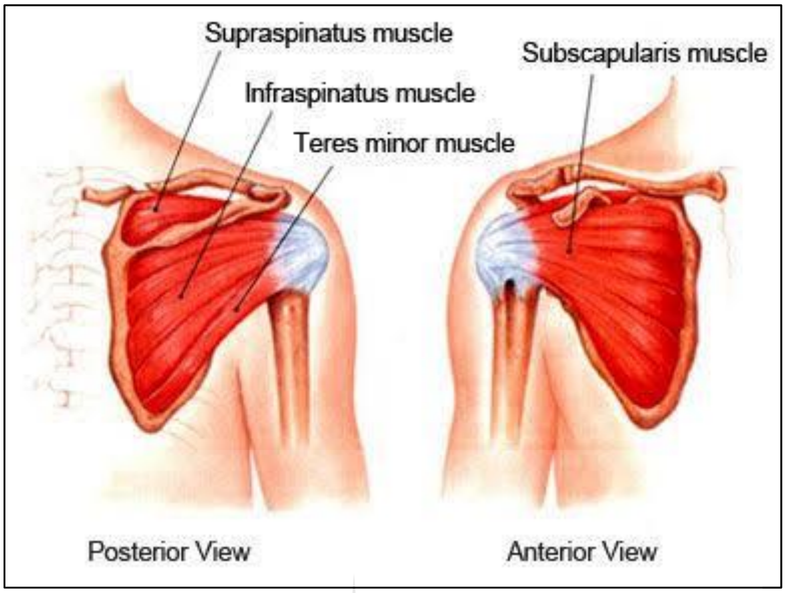

Figure 2.2: Subscapularis muscle (Moore *et al.*, 2010)

The subscapularis muscle originates in the subscapular fossa of the scapula and inserts on the lesser tubercle of the humerus (Vizniak, 2011). The subscapularis muscle is the largest of the four rotator cuff muscles with nearly three times the physiological cross sectional area as the remaining three posterior cuff muscles combined (Thurner *et al.*, 2013).

b. Innervation and Blood supply

The subscapularis muscle is innervated through the posterior cord of the brachial plexus from spinal nerves C5 and C6 which make up the superior and inferior subscapularis nerves. Entering more distally, the inferior subscapularis nerve enters the more distal part of the subscapularis muscle and ends in the teres major muscle. The superior subscapularis nerve enters the more superior, horizontal part of the subscapularis muscle (Simons *et al.*, 1999).

The subscapularis muscle, which forms part of the rotator cuff muscles, is supplied by the subscapular artery. The subscapular artery is the largest branch of the axillary artery; it descends on the lateral border of the subscapularis muscle and terminates by dividing into the thoracodorsal and circumflex artery. The subscapular artery course is continued by the thoracodorsal artery; it continues to the scapulas inferior angle and supplies the muscles adjacent to it (Bain, Itoi, Du Giacomo and Sugay, 2015 and Moore *et al.*, 2010).

c. Function

Glenohumeral joint stability is maintained by the subscapularis muscle by helping to maintain the head of the humerus in the glenoid fossa. The subscapularis muscle also prevents displacement of the humeral head anteriorly.

The subscapularis muscle acts as the primary medial rotator and adductor of the arm. Joining the subscapularis muscle, the other rotator cuff muscles help hold the head of the humerus in the glenoid cavity during all movements of the glenohumeral joint, thereby offering stability to the joint (Moore *et al.*, 2010). The rotator cuff muscles also stabilize the glenohumeral joint by depressing the humeral head within the glenoid concavity. Allowing for optimal length-tension relationships of the rotator cuff musculature, the scapulothoracic muscles control scapular movements by properly aligning the glenoid concavity relative to the humeral head. This allows the scapula and humerus to move in a complex but coordinated fashion together and is referred to as scapulohumeral rhythm (Reinold, Escamilla and Wilk, 2009).

2.4 The Cervical Spine

2.4.1 The Cervical Spine Anatomy

Forming the skeleton of the neck, the cervical spine is located between the cranium and the thoracic vertebrae. The transverse foramen, in the transverse process, is the most distinctive feature of each cervical vertebrae. The vertebral artery and accompanying veins pass through the transverse foramen, except in C7 which transmits only small accessory veins, therefore C7 has a smaller foramen compared to the other cervical vertebrae (Moore *et al.*, 2010).

According to Moore *et al.* (2010), the cervical vertebrae transverse processes end in two lateral projections; namely the anterior and the posterior tubercles.

The vertebrae of C3 to C7 have large vertebral foramen and are therefore known as the typical cervical vertebrae. The large vertebral foramen allows the cervical enlargement of the spinal cord as a consequence of this regions role in the innervation of the upper limbs (Moore *et al.*, 2010).

The body of the cervical vertebrae is smaller and wider from side to side than it is anteroposteriorly, the concave superior surface has the uncus as the body and the inferior surface is convex. The articular processes superior facets are directed superioposteriorly, while the articular processes inferior facets are directed inferoanteriorly (Moore *et al.*, 2010).

The first and second cervical vertebrae are the atypical vertebrae of the cervical spine. Vertebra C1 is also known as the atlas and is unique as it does not have a body or a spinous process. The ring shaped atlas has paired lateral masses that serve the place of the body by bearing the weight of the cranium. Originating from the lateral masses, the transverse processes are more laterally placed. This specific feature makes the atlas the widest of the cervical vertebrae, which allows for increased leverage for attached muscles (Moore *et al.*, 2010).

The C2 vertebra is also known as the axis and is the strongest of the cervical vertebrae. The C1 vertebra carries the cranium and also rotates on vertebra C2. The axis has a blunt tooth-like projection, which projects superiorly from the body and is known as the dense. The dens is found anterior to the spinal cord and acts as a pivot, so that rotation of the head can occur around it. The dens is held in place by the transverse ligament, which extends between the lateral masses of the atlas (Moore *et al.*, 2010).

2.4.2 The Neuroanatomy of the Cervical Spine

A spinal nerve branches off from the spinal cord at each segment of the spine and courses through the intervertebral foramina of each cervical vertebral segment. Comprised of a ventral and dorsal rootlet, each spinal nerve then unite into ventral and dorsal roots, which occurs in the intervertebral foramina, this then forms the spinal nerves. Almost immediately dividing, the spinal nerve forms the dorsal and ventral ramus. The primary division comes from the dorsal ramus and the anterior primary division comes from the ventral ramus (Crame and Darby, 2014).

Exiting laterally to the intervertebral foramina, the dorsal ramus is much smaller than the ventral ramus. It then courses posteriorly close to the articular pillars anterolateral aspect. At the level of C5, the dorsal ramus courses through a groove on the lateral aspect of the articular pillars of the above mentioned vertebrae. Once the dorsal ramus reaches the posterolateral aspect of the superior articular process, it divides into a lateral and medial branch. The lateral branch of the dorsal ramus innervates superficial muscles of the neck as well as the back regions. The medial branch of the dorsal ramus innervates the deeper segmentally orientated muscles, the zygapophyseal joints and the interspinous ligaments.

However, the dorsal ramus of C6 does not divide into a lateral and medial branch. It only consists of a deep medial branch (Cramer *et al.*, 2014).

The ventral ramus exits the spine posteriorly to the vertebral artery, coursing its way between the anterior and posterior inter-tranversarii muscles. The ventral ramus makes a very important contribution to the brachial plexus. The brachial plexus innervates the upper extremities and the anterior neck (Cramer *et al.*, 2014).

Spinal nerves associated with vertebral levels C5 and C6, ventral ramis contribute to the roots of the brachial plexus. They unite to form the superior trunk of the brachial plexus, which then give rise to anterior and posterior divisions (Cramer *et al.*, 2014).

Branching from the superior trunk is the lower and upper subscapular nerves. The upper subscapular nerve branches from the posterior cord and passes posteriorly and enters the subscapularis muscle directly, innervating the muscle superiorly. Also a branch of the posterior cord, the lower subscapular nerve passes inferolaterally, deep to the subscapular vein and artery and innervates the subscapularis muscle inferiorly (Moore *et al.*, 2010).

2.5 Myofascial Pain Syndrome

2.5.1 Introduction

Myofascial pain is a major cause of incidence in modern society (Yap, 2007). According to Gatterman (2005), deep muscular pain referred from hypersensitive trigger points in muscle bellies is a common characteristic of myofascial pain.

According to Raj and Paradise (2004), a pain syndrome is defined as neurogenic, musculoskeletal, sympathetic, visceral or psychogenic in origin. Myofascial pain syndrome consists of pain, muscle stiffness and decreased range of motion (Patrick, Stevens, Walker and Zempsky, 2013).

Myofascial pain syndrome is a common disorder that presents with a persistent aching pain. The aching pain, from the trigger point which is in one or more muscles in that region, is referred to a localised area of the body (Baldry, 2001; Rudin, 2003). A myofascial trigger point is said to be the hallmark finding of this syndrome (Gerwin, Shannon, Hong, Hubbard and Gervitz, 1997).

Myofascial pain syndrome often remains unrecognised and untreated, even though it has a high prevalence (Yap, 2007).

2.5.2 Myofascial Trigger Points

According to Rudin (2003) myofascial trigger points are hypersensitive tender areas in skeletal muscle contained within taut palpable bands. This is the characteristic finding of myofascial pain syndrome. The trigger point is painful during compression; stretching and periods of overload (Fernandez-De-Las-Penas, Alonso-Blanc and Miangolarra-Page, 2007).

According to Raj *et al.* (2004), a trigger point has the following clinical properties:

- Palpable taut band
- Focal spot tenderness in the taut band
- Restricted and painful range of motion
- Referred pain to a regional site once activation of the trigger point occurs
- Recognition of the pain by pressure on the tender nodule
- Reproducibility of pain pattern
- Visual or tactile identification of a local twitch response on activation of the trigger point
- Muscle weakness with absence of muscle atrophy
- Altered sensation or pain during compression of the muscle
- Symptoms of autonomic dysfunction

2.5.3 Location and Referral of Trigger Points in the Subscapularis Muscle

There are three common trigger points in the subscapularis muscle (Simons *et al.*, 1999):

- The first trigger point is the most accessible. Found within the vertical fibers on the ventral aspect and lie inside the lateral border of the scapula
- Trigger point two lies superior to the first trigger point and is harder to reach. It is found within the horizontal bundle of fibers as they extend across the scapula

- Trigger point three is located along the scapulas vertebral border, where the subscapularis muscle attaches to the medial border of the scapula (Figure 2.3)

Trigger points in the subscapularis muscle cause severe referred pain at rest as well as on motion of the upper limb. The pain referral of the subscapularis muscle is generally over the posterior axillary fold and medial border of the arm. The pain may also extend down the arm posteriorly, skipping the forearm, to a band of pain around the wrist. The pain may also extend medially over the mid deltoid and medially over the scapula (Vizniak, 2011).

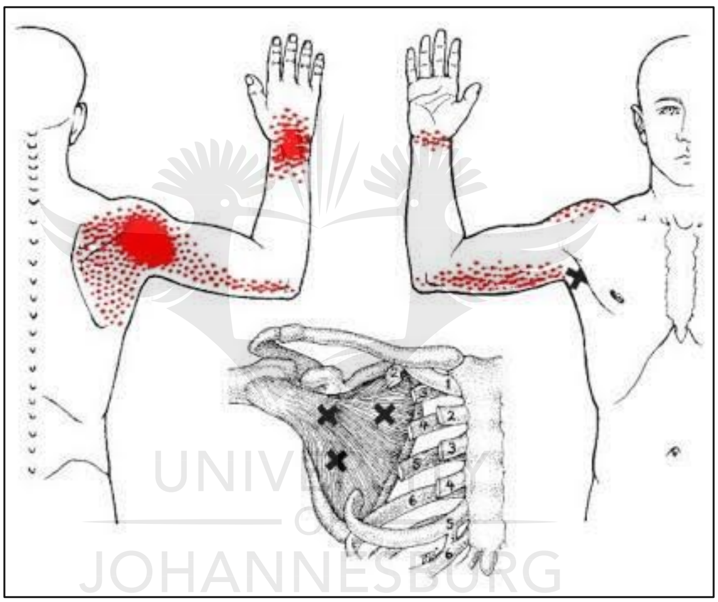

Figure 2.3: Subscapularis muscle referral patterns (Simons *et al.*, 1999).

a. Observation of Active Trigger Points in the Subscapularis muscle

A marked limitation of abduction or lateral rotation of the arm at the glenohumeral joint is identified as the involvement of subscapularis muscle. An even greater restriction of a combined movement of abduction and lateral rotation is seen in patients with subscapularis muscle trigger points (Simons *et al.*, 1999).

b. Activation and Perpetuation of Subscapularis Trigger Points

There are six ways that subscapularis trigger points are activated:

- While exerting strong abduction during overhead lifting
- To arrest a fall, by reaching back suddenly at shoulder level to arrest a fall
- Unusual repetitive exertion requiring forceful medial rotation, when the subject is out of condition
- Prolonged immobilization of the shoulder joint in adduction and medial rotation
- Tear of the shoulder joint capsule
- Fracture of the proximal humerus

The subscapularis muscle trigger points are perpetuated by movements requiring medial rotation of the humerus (Simons *et al.*, 1999).

2.5.4 Myofascial Trigger Point Examination

A trigger point is located by means of tender spots within the muscle involved and a loss of range of motion over the joint. Active trigger points are identified as they cause the patient to recognise the pain they have been experiencing when pressure is applied to the trigger point directly. Pain that is unrecognisable and occurs once pressure is applied to a trigger point is known as a latent trigger point (Simons *et al.*, 1999).

Muscles must be completely relaxed while they are being examined for trigger points, otherwise distinction between the slack muscle fibers and adjacent tense bands is diminished (Simons *et al*, 1999).

The presence of exquisite tenderness at a nodule in a taut band is the most reliable diagnostic feature of trigger point examination. Among the normally pliable fibers, a taut band feels like a palpable cord of tense muscle fibers (Simons *et al.*, 1999).

Skilled palpation is the key element to identifying trigger points. Location of the muscle is found, using anatomical landmarks by visual observation and manual palpation. Once the muscle has been positioned optimally, the examiner uses either pincer grip or flat palpation techniques to determine where the trigger point is (Dommerholt *et al.*, 2013).

Flat palpation is one of the two types of palpation described by Simons *et al.* (1999), and is the most relevant to this study. Flat palpation is the use of fingertips to allow the mobility of the subcutaneous tissue to slide the patients' skin across the muscle fibers.

2.5.5 Pathogenesis of Myofascial Trigger points

Introduction

The development of trigger points is explained by numerous hypotheses. The etiology of trigger points is unclear but the energy crises theory and the motor endplate hypothesis is the two most widely accepted theories. Combining these theories provide a plausible explanation (Huguenin, 2004).

a. Energy Crisis Theory

The theory suggests that due to repetitive macrotrauma and microtrauma, there is an increase demand on the muscle, this leads to an increased release of calcium from the sarcolemma which in turn causes shortening of the sarcomeres (Huguenin, 2004). This pathophysiological process could account for:

- Muscle overload affects the trigger points
- The trigger points taut band has an absence of motor unit potential
- Nociceptors sensitisation in the trigger point
- Restoring the muscles full stretch length with any therapeutic technique (Simons *et al.*, 1999).

An increase in calcium also results in an increase in acetylcholine from the motor endplate (Simons *et al.*, 1999). Acetylcholine acts as a neurotransmitter to activate muscles, by binding to acetylcholine receptors on the skeletal muscle (Martini *et al.*, 2009). Depolarisation of the post-synaptic membrane is abnormal and occurs due to the increase in the acetylcholine from a dysfunctional motor endplate. The action potential absence within the motor unit is due to the sustained shortening of the taut band (Simons *et al.*, 1999).

Within the myofascial trigger points, low oxygen levels were found. Shortening of the actin and myosin is due to the traumatic release of calcium that occurs at the sarcoplasmic reticulum or from a failure to restore adenosine triphosphate. This is a vital part that is required for normal functioning of the calcium pump and for the normal release of actin and myosin complexes. Local muscle contractures and taut bands are due to the shortage of adenosine triphosphate. Activation of actin and myosin filaments is caused by the elevated intercellular calcium concentration due to the impaired calcium pump.

As seen in Figure 2.4, local energy crisis occurs due to the decreased oxygen and blood supply. By stimulating the production of vasoactive products, the energy crisis causes sensitization of the local nociceptors (Simons *et al.*, 1999). The direct stimulation of sensory nerves which produce pain is stimulated by the release of bradykinin, histamine and prostaglandins (Huguenin, 2004).

The increased contractile activity is only temporary, because the trauma to the sarcolemma and sarcoplasmic reticulum is mostly short term (Simons *et al.*, 1999).

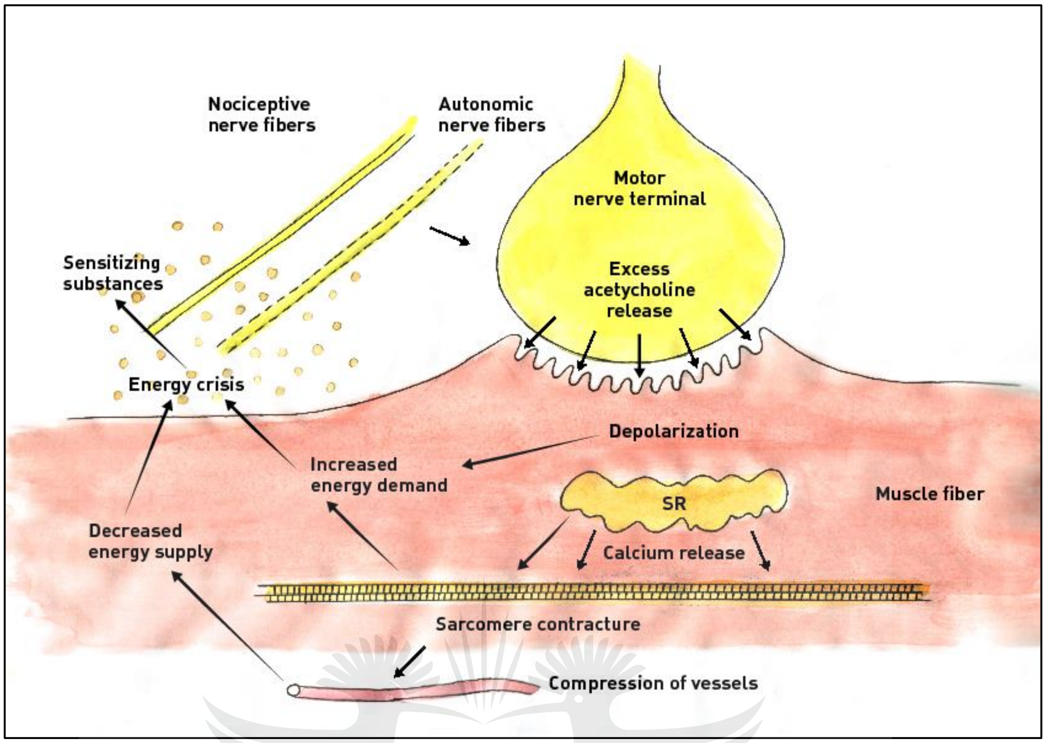

Figure 2.4 A Schematic drawing demonstrating the energy crisis theory (Simons *et al.*, 1999).

b. Motor Endplate Dysfunction Hypothesis

Identifying dysfunctions in the region of the motor endplates as a major cause of myofascial trigger points is known as the motor endplate dysfunction hypothesis.

According to Simons *et al.* (1999), this hypothesis refers to dysfunction of the motor endplate as the foundation for myofascial trigger point formation. The term endplate refers to the physical structure and the neuromuscular junction refers to the functional significance of the structure therefore these terms are used interchangeably.

Various mechanisms can cause a trigger point to exist when a motor endplate becomes dysfunctional. Reduction of the axoplasmic transport of molecules that cause acetylcholine release inhibition is caused by compression of the local sensory nerves by the sustained muscle contraction (Hohmann and Herkenham, 1999; Gessa, Casu and Carta, 1998).

There is a reduction in the oxygen supply to the muscles due to the compression of the blood vessels by the sustained muscle contraction. The decreased blood supply coupled with the increased metabolic supply cause a rapid depletion of adenosine triphosphate (Simons *et al.*, 1999).

According to Hugeuenin (2004) the energy crisis theory and motor endplate dysfunction hypothesis can co-exist, due to the synaptic junction which is present between the muscle cell and motor endplate.

c. Integrated Trigger Point Theory

This is a combination of the two theories. Indicated by this theory is that many dysfunctional endplates in a region forms a trigger point. Each dysfunctional endplate is associated with a section of muscle fibre that is maximally contracted (Simons *et al.*, 1999).

It was shown with needle electromyography (EMG), that minute loci within the myofascial trigger point produces characteristic electrical activity. The active loci are found in clusters within the motor endplate (Hubbard and Berkhoff, 1993).

Characteristics of active loci within trigger points are seen by the spontaneous spikes in electrical activity and are recognised on electromyographs as normal endplate potentials. Physiological experiments done by Simons *et al.* (1999) showed that these potentials are not normal, but instead they are due to a grossly abnormal increase in acetylcholine release at the nerve terminal. Located at an endplate, it can be seen that the contracted knot is the cause of endplate dysfunction (Simons *et al.*, 1999).

The endplate potentials are caused by the abnormal increase of the acetylcholine released by the nerve (Simons *et al.*, 1999). The increased rate of release of the acetylcholine from the nerve terminal is observed as the electromyography noise. A small amount of muscle activity is capable of propagating action potentials a small distance from the cell membrane of the muscle. This small degree of muscle shortening is due to the activation of contractile elements (Huguenin, 2004).

A decrease in the flexibility of the muscle, a decrease in range of motion and eventually general disability develops from the painful muscle condition (Gatterman, 2005).

A relationship between the dysfunctional endplate and the contracted knot was proposed by this hypothesis. The hypothesis provided a model that can be used to design critical experiments that refine, refute or verify the hypothesis (Simons *et al.*, 1999).

The hypothesis is based on the excessive release of acetylcholine into the synaptic cleft from the dysfunctional motor nerve. The effect is caused by the impaired cholinesterase function. Activation of the acetylcholine receptors in the post-junctional membrane is activated by the excess acetylcholine and this produces an increased number of small endplate potentials (Simons *et al.*, 1999).

As these potentials are so numerous, they superimpose to produce partial depolarisation of the post-junctional membrane and endplate noise. An increase in energy demand is caused by the excessive demand of acetylcholine in the motor nerve terminal due to its excessive demand for production. An additional local energy demand is caused by the increased activity of the postjunctional membrane and sustained depolarisation. There have been increased numbers of abnormal mitochondria and subsarcolemma mitochondria that have been noted in past studies, this mechanism is said to be responsible for the presence of many ragged red fibers in the muscles that are compatible characteristically with the presence of myofascial trigger points (Simons *et al.*, 1999).

The sarcoplasmic reticulum occurs releases the calcium from the voltage gated calcium channels resulting in the depolarisation of the T tubules at the triad where the T tubules communicate with the sarcoplasmic reticulum (Simons *et al.*, 1999).

The T-tubule is part of the same sarcoplasmic membrane that forms the post-junctional membrane. One mechanism that might account for the tonic increase in the release of calcium from the sarcoplasmic reticulum is the sustained depolarisation of the membrane. This produces local sarcomere contractures of the contraction knots. Clinicians describe a palpable nodule at the trigger point and it is said to be due to the increase in volume occupied by the contraction knot. This contraction process is said to occur in the immediate area of the endplate. An increase in the energy demand of the calcium pumps that return the calcium into the sarcoplasmic reticulum is due to the sustained release of calcium from the sarcoplasmic reticulum. The contracture of the sarcomeres is sustained within the contraction knot and this greatly increases the local energy and oxygen demand (Simons *et al.*, 1999).

Sensitizing and modifying the function of sensory and autonomic nerves in the region, is due to the release of neuroactive substances by the energy crisis in the vicinity of the endplate. The motor nerve is part of the neurovascular bundle that includes the sensory and autonomic nerves as well as the small blood vessels. Sensitization of these local nociceptors explains the tenderness and referred pain originating at the trigger point and the origin of the local twitch response. Evidence suggests that the abnormal release of acetylcholine from the nerve terminal, modulated by the autonomic nervous system activity completes what then becomes a self-sustaining vicious cycle (Simons *et al.*, 1999).

2.6 Management of Myofascial Pain Syndrome

2.6.1 Introduction

Relief of pain and inflammation, reducing spasm, improving circulation, correcting abnormal postures, and prevention of further injury are the primary aims of treating myofascial pain syndrome (Harden, 2007). The central feature of myofascial pain syndrome is to remove the myofascial trigger point. It is critical for the relief of pain and to restore normal function that the trigger point is eliminated (Gerwin, 1999).

Myofascial pain syndrome treatment is focused around interrupting the reflexive pain cycle. This pain cycle is created by the trigger point and interrupting it is accomplished through one of several modalities (Raj *et al.*, 2004):

a. Stretch and Spray

Consisting of passive stretching of the target muscle, stretch and spray is a non-invasive modality used to eliminate trigger points (Raj *et al.*, 2004). Vapo- coolant is applied to a muscle while the muscle is gradually stretched until the maximum stretch or a barrier is reached (Gerwin, 1999).

b. Intramuscular Injections

Myofascial pain reduction is reached by using precision needling, local anaesthetic and anti-inflammatory agents to reach the trigger point with an injection. Mechanical disruption of the trigger point occurs using this technique and an anti-inflammatory agent is used to inhibit prostaglandin E2 build up (Partanen, Ojala and Arokoski, 2010).

According to Raj *et al.* (2004) the injections consist of either 0.5% procaine, 0.25% to 0.5% lidocaine, or 0.125% to 0.25% bupivacaine.

c. Myofascial Dry Needling

Referred to as intermuscular stimulation, dry needling is an invasive technique in which an acupuncture needle is inserted into the skin and muscle (Dommerholt *et al*, 2013). The aim of myofascial trigger point dry needling is to break up trigger points mechanically (Yap, 2007).

The needle is targeted at the point of maximum tenderness, penetrates the trigger point and disrupts the taut band. The trigger point disappears once the muscle responds with a local twitch response (Yap, 2007).

According to Dommerholt *et al.* (2013) dry needling is most effective when the needle is placed deep within the trigger point and a local twitch response is elicited. To break up the trigger point is the main aim of dry needling. The needle is targeted at maximum tenderness within the taut band (Yap, 2007).

As myofascial dry needling is the treatment used in this study, it will be discussed in more detail later.

d. Ischaemic Compression

This technique is performed by applying an increasing digital pressure to the myofascial trigger point until the sensation of pressure is that of pain and pressure. Until the pressure and pain eases by 50%, which is indicated by the patient, the pressure is maintained. Once the pain and pressure eases by 50%, the pressure is increased until discomfort is felt again (Fernandez-de-las-Penas *et al.*, 2006). Each myofascial trigger point pressure palpation is held, until there is pain relief which therefore indicates that the trigger point has been inactivated (Raj *et al.*, 2004).

e. Ultrasound

Ultrasound treatment is the application of high-frequency sound waves applied to inactivate trigger points. The predominant theory behind ultrasound is that the high frequency acoustic energy produces non-thermal and thermal effects on tissues to aid in the healing process. Reducing the pain mediators by increasing blood flow, decreasing inflammation and changing nerve conduction, causes a reduction in the pain which may also resolve the trigger point (Harris and Clauw, 2002).

f. Pharmacological Management

Prolonging of myofascial pain syndrome may occur due to sleep disturbances and inadequate analgesia, therefore using medications alongside other modalities is indicated for any myofascial pain syndrome treatment protocol (Raj *et al.*, 2004). During the treatment phase, analgesics play a role in producing comfort. Antidepressant drugs offer the same potential pain relief for myofascial pain syndrome as it does for any other pain syndrome (Gerwin, 1999).

2.7 Myofascial Dry Needling

2.7.1 Introduction

According to Tekin, Akarsu, Durmus, Cakar, Dincer and Kiralp (2013), dry needling is one of the most effective treatments for myofascial pain syndrome. It is also referred to as intramuscular stimulation (Dommerholt *et* al., 2013). Once palpation is used to locate the trigger point, a very fine solid filament needle is inserted into the muscle. According to Dommerholt *et al.* (2013), dry needling is an invasive technique in which a needle is used for the treatment of pain and dysfunction of many body tissues.

Dry needling is divided into two categories namely; superficial dry needling and trigger point dry needling (Dommerholt, *et al.*, 2013). When a needle is inserted into an active trigger point, using the trigger point dry needling technique, it will cause a local twitch response. Inserting a needle into the superficial tissues overlying the trigger point is known as superficial dry needling (Baldry, 2002). It was stated by Dommerholt *et al.* (2013), that some authors have found dry needling to be very effective in the *treatment* of patients with shoulder pain.

2.7.2 Myofascial Trigger Point Dry Needling

According to Dommerholt *et al.* (2013), dry needling is an invasive procedure in which an acupuncture needle is directed at the trigger point and inserted into the skin and muscle.

Dry needling is most effective when the needle is placed deeply within the trigger point and a local twitch response is elicited (Dommerholt *et al.*, 2013). A local twitch response is elicited in the muscle when the taut band has been disrupted as the needle penetrates the trigger point. The main aim of trigger point dry needling, according to Yap (2007), is to break down the trigger point and this is done by targeting the needle at maximal tenderness within the taut band.

Eliciting a local twitch response with trigger point dry needling is a painful procedure therefore post needling soreness may last one to two days. This pain is easily distinguished from the original pain complaint, by the patient (Dommerholt *et al.*, 2013).

2.7.3 Effects of Dry Needling on Myofascial Trigger Points

The needle is inserted into the trigger point of the muscle and stimulates the mechanoreceptors. Mechanoreceptors are large in diameter and this in turn gives a large diameter afferent input into the spinal cord via the dorsal horn. There is a gate-like effect that occurs by, blocking the intra dorsal horn passing the information passed by the myofascial trigger point nociceptors and it therefore causes myofascial pain relief (Baldry, 2002).

Dry needling disrupts contraction knots, stretches contractured sarcomere assemblies and reduces the actin and myosin filaments overlap. Since trigger points have dysfunctional motor endplates, when the needle penetrates the trigger point, it is thought that it causes destruction of the motor endplates and this in turn causes distal axon denervations. Dry needling causes an increase in the flow of blood to the area of the trigger point; it then flushes the excess calcium from the area and decreases the sustained muscle contraction (Simons *et al.*, 1999).

2.8 The Chiropractic Vertebral Subluxation Complex

The theoretical model that describes dysfunction of a motion segment is known as the chiropractic vertebral subluxation complex (VSC). It includes the pathological changes in nerves, muscles, ligaments, local blood supply and connective tissue complex interactions. Although, this is a contrast to the mechanistic view that the chiropractic subluxation as a static misalignment of the articular facets (Gatterman, 2005). A subluxation is also referred to as a motion segment where the alignment, physiological functions and movement integrity has been altered (Peterson *et al.*, 2002).

This subluxation complex encompasses pathological changes with regards to spinal biomechanics, biochemistry, physiology and anatomy and that it generates symptoms such as pain and visceral or autonomic symptoms (Gatterman, 2005).

a. Theoretical components

There are five theoretical components to the VSC. Each represents a distinct pathophysiological process and is interactive with one another and that contributes to the overall picture (Gatterman, 2005):

- Neuropathophysiology is the muscle hypertonia, increased sympathetic facilitation and sensory dysaesthesias, or muscle atrophy, sympathetic atonia and anaesthesia associated with the neural consequences of the subluxation (Gatterman, 2005).
- Kinesiopathology encompasses articular hypomobility, hypermobility or loss of joint play due to the disordered movement component of the VSC (Gatterman, 2005). This functional imbalance may result in altered stress distribution within the vertebral motion segment. Due to the mechanical irritation that ensues, it may result in neurogenic and non-neurogenic pain. Individual structural elements (facet, muscle, disc, ligaments or nerve) may experience concentration of local stresses within functional consequences and tissue-specific symptom production. There is a state of dysfunction that can lead to local inflammatory or biomechanical changes. If neural elements become inflamed or compromised, the remote symptoms may also appear in the peripheral distribution of the nerve (Triano, 2001).

- Myopathology may be a postural compensatory mechanism or secondary to the neuropathophysiology component of the VSC, which may manifest as muscle hypertonicity (Gatterman, 2005).
- A histopathology component refers to the cellular flow associated with the inflammatory process. Oedema may accumulate within the confines of the intervertebral foramen impeding the flow of circulating fluids, compounding the neuropathophysiology component of the subluxation complex (Gatterman, 2005).
- Biochemically, prostaglandin E-2, histamine, bradykinin, potassium ions, leukotriene B-4, 5-hydroxytryptamine and cytokines will accumulated in stressed tissue (Gatterman, 2005).

Mechanical and chemical irritants stimulates local nociceptors with a resultant abundance of afferent input to the spinal cord through the dorsal horn, resulting in somato-autonomic and somato-somatic reflexes via the autonomic and motor nervous system. Myofascial trigger points, muscle imbalance and spinal muscle deconditioning are hypothesised to result from reflex stimulation of the anterior and lateral horn cells of the spinal cord, resulting in reflex muscle spasm and sympathetic hyperactivity respectively (Gatterman, 2005).

It is furthermore proposed that an effective treatment protocol of the myopathological component of the subluxation complex in the form of active trigger points in the subscapularis muscle should therefore include the restoration of the segmental mobility (kinesiopathological component) at the innervating segments within the cervical spine (Gatterman, 2005).

2.9 The Chiropractic Manipulation

The primary treatment tool of a chiropractor is known as the chiropractic manipulation. A dysfunction of the joint, joint locking and joint blockage is referred to as a movement restriction (Leach, 2004; Gatterman, 2004).

A chiropractor focuses their treatment on reducing interference and restoring nerve function. They therefore stimulate the body to heal itself. There are a variety of adjunct techniques used as a treatment procedure; such as joint manipulation which is a high velocity, low amplitude adjustment. Another technique is mobilisation which is a low velocity adjustment combined with modalities such as soft tissue massage, orthotic devices as well as patient ergonomics (Cooperstein and Gebberzon, 2004).

A chiropractic manipulation has the ability to elicit a reflex response in the body. This may be in the form of reflex inhibition of spastic muscles, reduction in pain and temporary activation of the skeletal musculature of the upper and lower extremities as well as the back (Herzog, 2000).

Designed to move a joint beyond its physiological limit into the paraphysiological space without passing anatomic integrity and motion limit, the chiropractic manipulation is the application of a high velocity, low amplitude thrust (Erikson, 2004; Gatterman, 2005).

Joint manipulation is also described as any procedure where the hands are used to mobilise, manipulate, apply traction or influence the joints of the body, aiming to influence the patient's health (Peterson *et al.*, 2002). The main purpose of a chiropractic manipulation is to improve function and thereby improve health by alleviation of musculoskeletal pain, abnormal function and joint alignment. The chiropractic manipulation affects the joint dysfunction, periarticular fibrosis, adhesions and muscle spasms (Peterson and Bergmann, 2002).

The audible release heard during a manipulation occurs when the joint is moved into the paraphysiological space, past the elastic barrier of resistance. Movement of the joint past the physiological barrier will result in injury to the ligaments and joint capsule (Peterson *et al.*, 2002).

Three events occur when the joint passes the elastic barrier of resistance (Peterson *et al.*, 2002):

- Joint surface separation
- A cracking sound that is audible
- A radiolucent space presence within the joint

2.9.1 Neurophysiological Effects from stimulation of C5-C6 Nerve Roots via Cervical Spine Manipulations on Myofascial Trigger Points

The subscapularis muscle is innervated by the upper and lower subscapular nerves. These are branches from the superior trunk of the brachial plexus, which is the convergence of C5 and C6 ventral rami (Moore, 2010; Cramer *et al.*, 2014).

Moderately strong evidence was showed by Fernandez-de-Las-Penas (2009) that stated the spinal manipulation reduces pain caused by myofascial trigger points. Muscle spasms and trigger points have a strong relationship with hypomobility (subluxation) of the joint that is related to the muscles innervations. Evidence shows that there is a decrease in the myofascial trigger point sensitivity after spinal manipulation. An abnormal sensory input from a hypomobile joint, which in this case is C5/C6, can trigger the formation of trigger points in the subscapularis muscle.

Internal toxins and chemicals and external environmental toxins are irritants that stimulate the nociceptors and pain receptors within the subscapularis muscle creating a reflex mechanism, which sends signals along the afferent spindle pathway. Entering the spinal column via the dorsal roots and through interneuronal connections, these signals are transmitted to various spinal levels, specifically C5 and C6. These signals are then transmitted to alpha motor neurons and efferent pathways to the motor units located within the subscapularis muscle. This results in muscle contraction and spasm (Herzog, 2000).

Mechanoreceptors found within the spinal facet joint at specific segments as well as pain receptors, cutaneous receptors and the proprioceptors of the subscapularis muscle, which include the golgi tendon organs and the muscle spindles are all stimulated by the chiropractic manipulation (Herzog, 2000). This may interrupt and reverse the reflex mechanism of the subscapularis muscle and may cause relaxation of the muscle. This could reduce the number of trigger points located within the subscapularis muscle and thereby restore motion (Plaugher, 1993).

a. The Nerve Compression Theory of the Chiropractic Manipulation

The strengths and weaknesses of each proposed neurological effect of the chiropractic manipulation was examined by Haldeman (2000). The primary effect of the manipulation as proposed by the nerve compression theory is to correct a chiropractic subluxation. The subluxation is a change in relationship between the vertebrae, which in turn cause spinal nerve root compression and that results in abnormal nerve root function.

There was no evidence found to suggest that the change in relation of the adjacent vertebra could result in nerve root and spinal cord compression. There was also little evidence to support that the chiropractic manipulation had the ability to relieve any existing compression of the nerve root. It was therefore concluded that the chiropractic manipulation might not be considered to have an effect on the reduction of the nerve root compression (Haldeman, 2000).

Very little evidence suggests that the 'bone out of place' theory of subluxation can compromise neural tissue in the intervertebral foramen (Gatterman, 2005). The intervertebral foramen encroachment theory with subsequent nerve compression furthermore possessed a simple appeal. There are unusual anatomical properties that the spinal nerve roots in the intervertebral foramen possess as they have less connective tissue to protect and support them compared to the peripheral nerves (Pickar, 2002).

There is substantial evidence that the axons of the peripheral nerves are less susceptible to mechanical compression than the dorsal root ganglia. Distal neurological effects are associated with increased neural activity. By restoring normal biomechanical movement of the vertebral segment, the chiropractic manipulation is suggested to thereby reduce pressure within the intervertebral foramen, relieving dysfunction of the dorsal root ganglion (Gatterman, 2005).

b. The Reflex Theory of the Chiropractic Manipulation

The reflex theory of the chiropractic manipulation is of particular interest to this study. Considered as a biomechanical abnormality, is the chiropractic subluxation within a vertebral motion segment. It is proposed that such a relationship should stimulate sensory receptors in the spinal and paraspinal structures. These structures include muscles, ligaments, facet joint capsules and the impulses of which presumably activate neural reflex centres of higher centres within the spinal cord. These receptors respond to inflammatory (pain), mechanical (position, motion and tissue tension) and changes in temperature. Somato-somatic responses result in muscle spasm, or somato-visceral responses in sympathetic and parasympathetic nerves result in autonomic phenomena due to the impulses generated from these receptors (Haldeman, 2000; Bergmann *et al.*, 2011).

These reflexes according to Haldeman *et al.* (2000), activate specific somato-somatic reflexes and central reflex pathways in experimental animals. A chiropractic manipulation at the spinal level has been demonstrated to bring about these reflexes. However, minimal evidence remains that these reflexes persist for correct amount of time to bring long-term relief (Haldeman, 2000).

A theory of a particular interest to this study is reflex relaxation of hypertonic muscles by sudden stretching. Attribute to the stimulation of inhibitory afferents to the dorsal horn from mechanoreceptors, it can be believed that manipulations can normalise abnormal muscle tone

(Evans, 2002). However, the evidence reveals that the chiropractic manipulation effect on somatomotor activity causes both excitatory and inhibitory effects (Pickar, 2002).

A study by Fryer, Morris and Gibbons (2004), appeared to provide evidence that the chiropractic manipulation produces a decrease in resting paraspinal electromyographic (EMG) activity. In the majority of cases, immediately after receiving a chiropractic manipulation to the associated vertebral dysfunction, the resting EMG activity levels within the tight muscle bundles decreased.

A different view is that sudden stretch of musculature produced by a manipulation will excite the motor neuron rather than inhibit it. Studies have been performed where the facet joints of anaesthetised cats at level C3/C4 were distracted and an increase in the EMG activity of cervical and upper limb musculature was recorded. This is likely due to the facet capsule mechanoreceptors and affected by the muscles and elicited by way of the reflex arcs. A synergy of the passive capsule-ligamentous and active muscular joint restraints are therefore achieved. It is therefore reasonable to suggest that a similar synergistic relationship occurs in humans, due to the facet capsules being so richly innervated (Evans, 2002).

A study conducted by De Vocht, Pickar and Wilder (2005), showed that central motor excitability was additionally increased after spinal manipulations in four cases in the study, whereas resting EMG was higher after delivering a chiropractic manipulation, although this increase was small in three of the four cases.

To support motor excitatory effect of the chiropractic manipulation was demonstrated with further evidence, by transcranial magnetic stimulation activation of descending tracts. This resulted in the gastrocnemius muscle showing large motor activity when preceded by a lumbar spine chiropractic manipulation. This is once more, presumably that the mechanism is reflexive in nature (De Vocht *et al.*, 2005).

Lastly, an excitatory effect of C5/C6 chiropractic manipulations on the motor activity of the biceps brachii muscle which is not attached to the spine at its origin or insertion was demonstrated by Dunning *et al.* (2008). The segmental innervation of the biceps brachii muscle corresponds to the C5/C6 segment. The resting EMG activity ipsilateral to the side of the application of the chiropractic manipulation was higher than the contralateral side, but EMG increases from the resting state were observed bilaterally. These studies indicated that spinal manipulation can both decrease the inflow of sensory information from the muscle spindles as well as cause an increase in the excitability of motor pathways in the spinal cord (Pickar, 2002).

c. The Pain Relief Theory of the Chiropractic Manipulation

By stimulation of the spinal structures, the pain relief theory proposes that chiropractic manipulation can bring hypoalgesia, which then reduces muscular pain thresholds via central facilitation. Even though there is no evidence to suggest that patients who receive chiropractic treatment in the form of spinal manipulation therapy may describe a type of pain relief that may exceed the same pain relief obtained and described with other treatment methods, however the changes observed may also be due to psycho-physiological mechanisms and may not be due to the effects of the manipulation on spinal pain (Haldeman, 2000).

Investigations of the immediate effect of a single cervical spine manipulation on the pressure pain threshold of latent trigger points by Ruiz-Saez, Fernandez-de-Las-Penas, Blanco, Martinez-Seguraand Garcia-Leon (2007), were done. The control group received a sham manipulation and the treatment group received an actual manipulation. The treatment group showed an increase in pressure pain threshold and the control group showed a decrease in pressure pain threshold levels.

Measuring changes in pain threshold after spinal manipulations using the pressure algometer was investigated by Vernon, Aker, Burns, Vilijakaanen and Short (1990). The case study revealed that a spinal manipulation increased the average pain threshold of six tender spots in the region by approximately 50% (Pickar, 2002).

2.10 Conclusion

In this chapter we have discussed the literature that is the most pertinent to this study. The emphasis of this chapter was on the anatomy and physiology of skeletal muscle; the anatomy of the cervical spine; myofascial trigger points of the subscapularis muscle; myofascial pain syndrome.

The benefits of chiropractic manipulations as well as dry needling therapy have been discussed previously. This justifies the use of chiropractic manipulations as part of the treatment protocol for subscapularis myofascial trigger points. Chiropractic manipulations have a positive effect on the structures directly related to the joints causing an increase in joint mobility, improved blood circulation, reduction in the perception of pain, improvement of muscle hypertonicity and a decrease in trigger point severity. Motor dysfunction is a characteristic feature of myofascial trigger points (Dommerholt *et al.*, 2004).

The theory behind this study is that the cervical spine manipulation to C5/C6 vertebrae could inhibit or block the nociceptive afferent fibers from the subscapularis myofascial trigger point and thereby reduce the pain caused by the trigger point. If the trigger point formation is due to the joint hypomobility, cervical spine manipulation to the segment could restore normal mobility to the joint and in turn remove the cause of the trigger point formation (Fernandez-de-Las-Penas, 2009).

In this chapter, dry needling has been discussed with regards to effects and mechanism of use on myofascial trigger points. Dry needling therapy is a technique in which an acupuncture needle breaks up the trigger point by inserted it into the skin and muscle (Dommerholt *et al.*, 2006, Yap, 2007).

This research study will give a better understanding of the effectiveness of treating with dry needling versus cervical spine manipulations combined with dry needling in the treatment of subscapularis muscle myofascial trigger points.

CHAPTER 3: METHODOLOGY

3.1 Introduction

This chapter is a detailed explanation on how this study was conducted and carried out.

3.2 Study Design

The study was a comparative study with random group allocation.

3.2.1 Sample Size and Selection

The sample group consisted of forty participants who suffer from shoulder pain. Participants between the ages of 18 to 40, who met the inclusion criteria, were randomly divided into two groups of twenty participants each. Participants used for this study were recruited by advertisements (Appendix A) that were placed at the University of Johannesburg Doornfontein campus. The study took place at the Chiropractic Day Clinic at the University of Johannesburg.

Before taking part of this study, the potential participants had to undergo an examination done by the researcher. The examination included a full case history (Appendix B), a full physical exam (Appendix C), a cervical regional (Appendix D), a shoulder regional (Appendix E), pressure algometer readings (Appendix F) and the completion of the Numerical Pain Rating Scale (Appendix G).

3.2.2 Inclusion Criteria

Participants had to comply with the following inclusion criteria, in order to be a participant of this study:

- Either gender

- Between the ages of 18 and 40 years old as the subscapularis muscle is the most frequently injured shoulder structure in people under 40 years of age (Benjamin, 2011)
- Patients with a BMI below 25 as there might be difficulty locating subscapularis trigger points in patients with a high BMI
- Diagnostic criteria for the Subscapularis muscle myofascial trigger point (Simons *et al.*, 1999):

- The presence of a hyperirritable palpable nodule within the subscapularis muscle
- Spot tenderness over the palpable trigger point
- When pressure is applied over spot tenderness, characteristic referral pain will arise
- Referral pain over the posterior shoulder, covering the scapula and extending posteriorly down to the elbow
- Subscapularis trigger points are often caused by strong adduction with repeated overhead lifting and reaching back at the shoulder level

3.2.3 Exclusion Criteria

Participants were not allowed to take part in this study if they had the following:

- Participants where on history, physical and regional examinations, evidence that Chiropractic manipulation is contra-indicated (Appendix H)
- Participants where on history, physical and regional examination, dry needling is contra-indicated (Appendix I)
- Participants in other forms of treatment (during the duration of the study), which may interfere with the study, for example the use of muscle relaxants.

3.2.4 Random Group Allocation

Participants who met the inclusion criteria were randomly allocated to Group 1 or Group 2 by picking a number, i.e. 1 or 2, out of a hat. This number would identify the group selected by the participant. The forty participants were divided into two groups of 20 participants each.

Participants in Group 1 received dry needling of the subscapularis muscle. Participants in Group 2 received a combination treatment, which involved a chiropractic manipulation delivered to restrictions of the cervical spine together with dry needling of the subscapularis trigger points.

3.3 Treatment Approach

3.3.1 First and Follow Up Visits

Each group's participants were treated six times. There were a total of seven visits over a period of three weeks. The seventh visit was used as a data collection visit. Each participant was treated twice a week with at least two days between treatments, for a period of three weeks. The last week of treatment consisted of three visits with the last visit used only for data collection.

a. First (Initial) Visit

Figure 3.1 illustrates that on the first visit the participant was given the participant information form (Appendix J) and were required to sign the consent form (Appendix K). Once suitability for the study was confirmed, the participant was required to complete the Numerical Pain Rating Scale (Appendix G). A full case history (Appendix B), a full physical examination (Appendix C), a cervical regional (Appendix D), a shoulder regional (Appendix E) and motion palpation of the facet joints of the cervical spine were performed, after which the SOAP note (Appendix L) was completed. The pressure algometer was used to determine the severity of the subscapularis muscle trigger points (Appendix F).

Participants in the first group received dry needling of the subscapularis muscle. Participants in group two received a combination treatment of dry needling the subscapularis muscle as well as cervical spine manipulations to the segments that innervated the subscapularis muscle.

b. Follow-Up Visits

During follow-up visits (visits 2 to 6), the cervical spine restrictions were reassessed via motion palpation and corrected with chiropractic manipulative therapy on the second to sixth visits for participants in the second group. Myofascial trigger points were further reassessed with digital palpation and dry needling was done to the subscapularis muscle on the second to sixth visits for participants in the first and second group.

On the fourth treatment, participants were required to complete the Numerical Pain Rating Scale (Appendix G) to determine if there was an improvement. The pressure algometer (Appendix F) was also used to determine the pain pressure at that visit.

On the seventh visit, no treatment took place. The participants were required to complete the Numerical Pain Rating Scale (Appendix G) and the pressure algometer (Appendix F) was used to reassess the pain pressure.

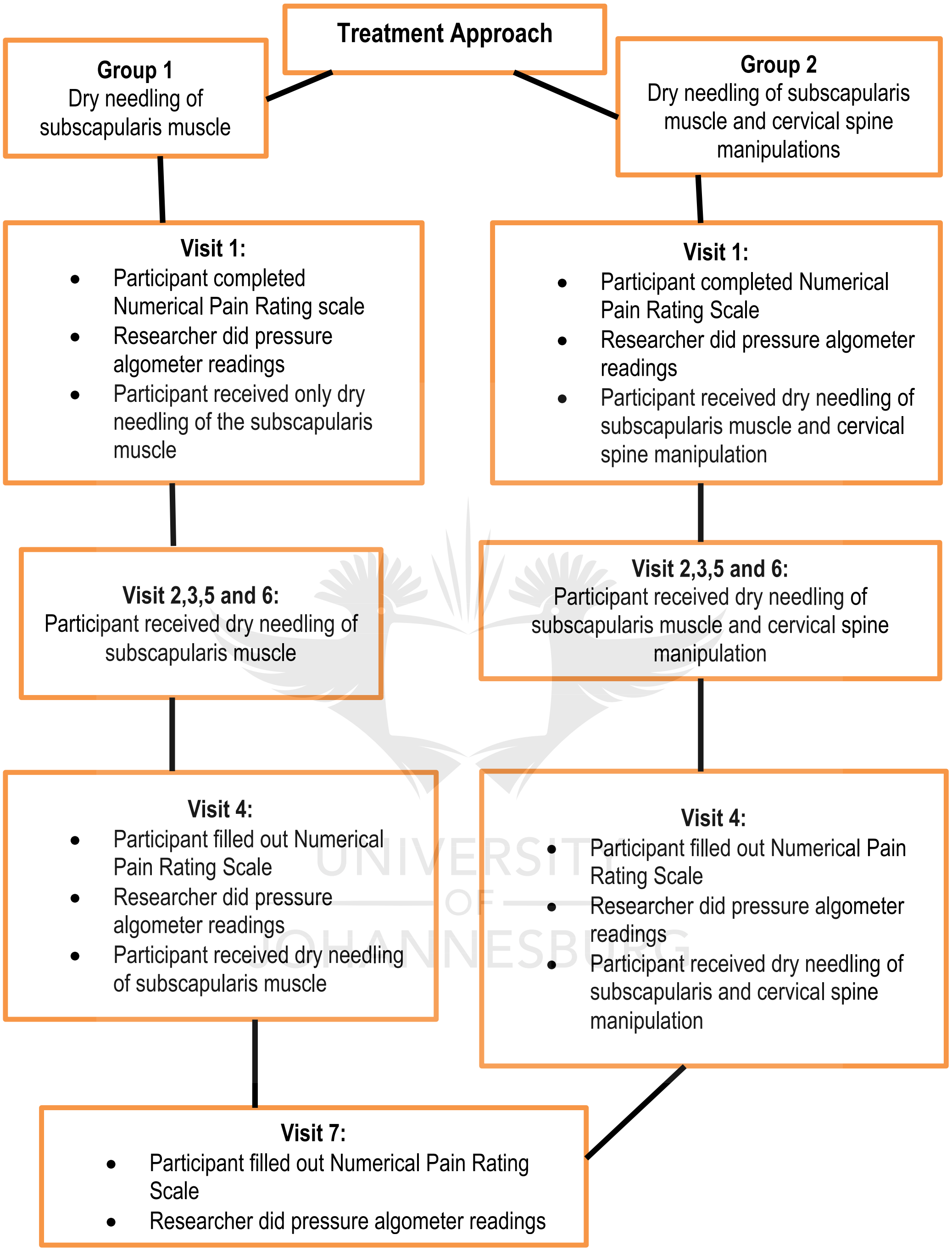

Figure 3.1: Flow diagram representing the outline of treatment

3.4 Subjective Data

3.4.1 The Numerical Pain Rating Scale

Intensity of pain can be identified as the severity or magnitude of pain perceived by an individual. Within a clinical setting, as it is the primary target pain treatment, the preferred measurement of pain is pain intensity (Jansen, 2011). Pain intensity is influenced by the duration at which it is expected to last for as well as the patients' interpretation of the pain. External factors such as an individual's beliefs and attitude as well as emotional factors such as anxiety, depression and fear are many contributing factors to the way an individual experiences pain (Williamson and Hoggart, 2005).

The Numerical Pain Rating Scale (Appendix G) is used to determine the participants' pain level from 0-10. The Scale was completed before the treatment on the first and fourth visits and on the seventh data collection visit. Participants were asked to grade their pain level experienced at that particular moment on a scale of 0 to 10. Zero indicates "no pain" and 10 indicates "worst imaginable pain". Due to its simplicity and low failure rate, the Numerical Pain Rating Scale is used (Williamson *et al.*, 2005). The Numerical Pain Rating Scale is considered valid and reliable in its measure of a patients pain intensity (Bolton and Wilkinson, 1998; Yeomans, 2000; Ferreira-Valente, Pais-Ribiero and Jensen, 2011).

The Numerical Pain Rating Scale was used to verify any subjective changes in the participant's observation regarding their shoulder pain specifically during this research study. Scores of the Pain Rating Scale remained confidential. The participants' scores were not given to them nor did they see their answers from the previous scale before answering the next.

3.5 Objective Data

The objective data was measured using the hand-held pressure algometer (Appendix F). Objective data was collected before treatment on visit 1 and visit 4 as well as during the data collection visit on the seventh day. The pressure algometer measures the minimum pressure that causes pain (Rachlin, 1994).

3.5.1 The Pressure Algometer

The pressure algometer (Figure 3.2) is known as the pressure threshold meter that has a rubber disc of $1cm^2$ and is calibrated in kg/cm^2. The pressure algometer is a force gauge, spring operated plunger. The pressure algometer is designed to determine the pressure threshold and tissue compliance (Fischer, 1988). The threshold of pressure is the minimum pressure needed to cause pain (Rachlin, 1994). To determine the severity of a muscle trigger point in practice, the pressure algometer is used and proven to be valid and reliable by Fischer (1988) when a comparison of corresponding muscles on opposite sides failed to elicit significant differences. The pressure algometer is proven to be useful in the diagnosis and management of myofascial pain syndrome and collectively in the clinical management of pain (Haussler and Erb, 2003).

In this study, the researcher located the active subscapularis myofascial trigger points using flat palpation. The researcher then placed the pressure algometer perpendicular to the skin on the myofascial trigger point and gradually applied pressure. The measurements were then recorded in kilograms of pressure per centimetre squared (kg/cm^2). This was taken from the point at which the participant first perceived the pain and indicated discomfort verbally. The measurement was repeated three times on the trigger point and the readings were recorded and the average was noted.

With regards to intraclass correlation coefficients (ICC), pressure algometry has been proven to have a good repeatability. It has a good validity through assessments by pain and disability questionnaires and has demonstrated intra and inter- rater reliability (Azavedo, de Lima Pires, de Souza Andrade and McDonell, 2008; Ylinen, 2007; Goolkasian, 2002).

Figure 3.2 The Pressure Algometer (www.sciencedirect.com)

3.6 Patient Assessment

A myofascial trigger point examination of the subscapularis muscle had to be performed on each participant. Participants in group two also received motion palpation of the cervical spine to assess for restrictions specifically located at the level of C5/C6.

3.6.1 Flat Palpation of the Subscapularis Muscle

There are three trigger points found in the subscapularis muscle. Trigger point one is located within the vertical fibers on the ventral aspect and lie inside the lateral border of the scapula. Trigger point two lies superior to the first one and is in the horizontal bundle of fibers as they extend across the scapula. Trigger point three is located at the point of attachment on the medial border of the scapula (Simons *et al.*, 1999).

The participant was placed in a position to allow the subscapularis muscle to lengthen to a point of observable increase in resistance to movement. The position that the participant was placed in was supine, with arm abducted to 90 degrees and externally rotated, the participants hand was placed behind their head. Cross fibre palpation was used by the researcher to identify any taut bands within the subscapularis muscle, this fibre examination was through flat palpation. If the taut band was identified, palpation along the taut band was used to search for the focal point and, once this point was identified the participant was asked if the point was tender under pressure and whether it reproduced the pain (Simons *et al.*, 1999).

3.6.2 Dry Needling the Subscapularis Muscle

The participant was placed in the supine position with arm abducted to 90 degrees and externally rotated with their arm placed behind their head. Comfort of the participant was also ensured. Due to dry needling being such an invasive technique; great care was taken while performing it to ensure safety and hygiene and to prevent infection, bruising, internal tissue damage, pneumothorax and bleeding.

The scapula was brought more laterally to optimize access to the subscapularis muscle. The skin over the subscapularis muscle was cleaned using an alcohol swab to ensure the area was clean and dry. The needle was inserted parallel to the rib cage and perpendicular to the scapula. The needle was directed away from the rib cage to prevent a pneumothorax. After 6 to 10 minutes the needle was removed using an alcohol swab to ensure a hygienic environment (Dommerholt *et al.*, 2013).

3.6.3 Motion Palpation of the Cervical Spine

Motion palpation was performed by the researcher on participants in the second group, to locate cervical spine restrictions, specifically at the level of C5/C6. Cervical spine motion palpation was performed in the following manner (Bergmann and Peterson, 2011):

- The palmer surface of the middle finger of the researcher was placed over the cervical spine articular pillars;
- For rotation, the researcher passively rotated the participants head away from the side of evaluation, at the end of passive rotation, the joint was sprung passively along the facet planes from a posterior to anterior direction to assess the joint play motion;

- For lateral flexion, the participants head was passively laterally flexed by the researcher towards the side of evaluation, at the end of passive rotation, additional overpressure was applied towards the midline to assess the joint play motion.

3.6.4 Diversified Manipulation of the Cervical Spine

After motion palpation had been performed, restrictions were found in the cervical spine and were recorded. Group 1 participants received dry needling of the subscapularis muscle. Group 2 participants received a combination treatment of dry needling the subscapularis muscle as well as manipulations to the cervical spine segments C5/C6.

The cervical spine manipulations were performed in the following way (Bergmann *et al*, 2011):

- The participant was in the supine position;
- The researcher stood at the head of the table, on the side of the restriction, angled at a 45 to 90 degree angle to the participant;
- With a ventrolateral contact of the distal index finger, the researcher contacted the posterior articular pillar of the superior vertebrae of the participants' restricted segments, using the hand corresponding to the side of the segmental contact. The thumb or thenar aspect of the researchers hand rested on the participants cheek;
- Cradling the participants head, supporting the contralateral occiput and upper cervical spine, the researcher used their indifferent hand;
- The researcher rotated the head away from the side of dysfunction;
- The manipulation is administered in a different way, depending on the type of restriction;
- For a rotary restriction, the head was rotated away from the dysfunction side while laterally flexing the head towards the side of the contact, ensuring minimal lateral flexion so as to avoid compressing and locking the joint being distracted. Once the point of tension was reached, the thrust was delivered through the wrists and forearms in a clockwise or anti-clockwise direction along the planes of the facet joint;

- For a lateral flexion restriction, the participants head was laterally flexed towards the side of contact, ensuring minimal rotation and the thrust was delivered in a medioinferior direction.

3.7 Statistical Analysis

The subjective and objective data was collected by the researcher during the study. The results were given to the statisticians at STATKON department at the University of Johannesburg. The statistician used the Shapiro-Wilk test to determine normality per group. Inter-group analysis (comparison between groups) was performed using the independent T-test for normality. If normality was not met, a Mann-Whitney U-test was performed, to establish where the difference occurred. Intra-group analysis (comparison within the groups over time) was assessed with the one way repeated ANOVA test. The Friedman test was used if the data was not normally distributed. Wilcoxon Signed Rank test determined where the differences were noted.

3.8 Ethical Considerations

All participants that partook in this particular study received a participant information form (Appendix J) and were requested to read and sign the participant consent form (Appendix K) specific to this study. The information and consent form outlined the details of the researcher, the purpose and benefits of this study as well as all the necessary participant assessment and treatment procedures relevant to this study. Participants' safety was ensured by explaining the risks, discomforts and benefits of the treatment involved to the participant (prevention of harm). The information and consent form also explained that the participant's privacy was protected by ensuring their anonymity (no names or data) and confidentiality (standard doctor confidentiality) while compiling the research dissertation.

The participants' files were stored in a strong room at the Chiropractic Day Clinic at the University of Johannesburg. The participants were informed that their participation was voluntary and that they were free to withdraw from the study at any stage. If the participant had any further questions, they were answered by the researcher. Results of the study were made available on request. The study was conducted as originally approved by the Faculty of Health Sciences Higher Degrees Committee (Appendix M) and Research Ethics Committee (Appendix N).

With regards to this particular study, benefits included a decrease in shoulder pain, a decrease in the muscle spasm found within the subscapular musculature. Some participants may have experienced slight pain or discomfort in cervical spine due to the chiropractic manipulation or in the shoulder due to the dry needling, which was normal.

Dry needling is an invasive technique; therefore great care was taken while performing the technique to ensure safety and hygiene to prevent infection, bruising, internal tissue damage, pneumothorax and bleeding.

Participants were referred to a specialist if any problems arose.

According to the University of Johannesburg's strict plagiarism guidelines, this study was submitted to Turnitin in order to generate an originality report (Appendix O).

CHAPTER 4: RESULTS

4.1 Introduction

This chapter's purpose is to present the results obtained during the research trial of this study. To determine whether there were any statistically significant improvements in any of the two groups and between the two groups, all the objective and subjective data was statistically analysed and plotted on line graphs. The efficacy of the treatment protocol was also determined by the degree to which there was a significant difference in the subjective findings. The subjective data was measured in the two groups using the Numerical Pain Rating scale, the efficacy was determined by the degree to which the participants' disability percentage differed during the treatment time.

The objective data of this study was the handheld pressure algometer, this was used to determine the pain threshold that causes pain in the participant over the subscapularis trigger point at the end of each treatment protocol.

No assumptions can be made with respect to the population as a whole with regard to this study as the results represented a small group of participants.

The statistical analysis was conducted on a 95 percent confidence level. The probability level (p-value) was set at $p \leq 0,05$. If the p-value is $\leq 0,05$, a statistical significant finding is observed. If the p-value is $\geq 0,05$, it can be stated that there is no statistically significant difference.

The Bonferroni correction technique was added to the intragroup analysis. This test was used to determine the smallest p-value of each variable against a significant level of $0.05 \div 3 = 0.017$ and the largest p-value against a significance level of $0.05 \div 1 = 0.05$. The Bonferroni correction is used to lower the p-value in order to prevent data from incorrectly appearing significant, as well as to ensure accuracy of the data.

4.2 Demographic Data Analysis

Table 4.1 Age distribution within the sample of 40 participants

Group	Mean age in years
Dry needling	25.45
Combination	26.95

4.2.1 Age Tests

Participants in this study were between the ages of 18 and 40 years old. Equal age ratios were ensured in each group with the mean age of participants in the dry needling group being 25.45 years old and the mean age for the combination group being 26.95.

The differences between the ages in the groups were not statistically significant because $p = 1.00$ ($p > 0.05$).

Table 4.2 Gender distribution within the two groups

Group	Male	Female
Dry Needling	6	14
Combination	4	16

4.2.2 Gender Distribution

The dry needling group consisted of 6 males and 14 females and the combination group consisted of 4 males and 16 females. The unequal gender distribution can be attributed to the random grouping of participants and the availability of participants who met the inclusion criteria.

4.3 Subjective Data Analysis

The Numerical Pain Rating Scale was the subjective data of this study.

For the intragroup analysis, to form a comparison of each group individually over time, the Friedman test was used. If the values indicated a statistically significant difference, further intragroup analysis was required and this was done using the Wilcoxon Signed Rank test.

To determine whether there was normal distribution between the two groups, the Mann-Whitney U test was used.

4.3.1 Numerical Pain Rating Scale

a. Intragroup analysis of the Numerical Pain Rating Scale

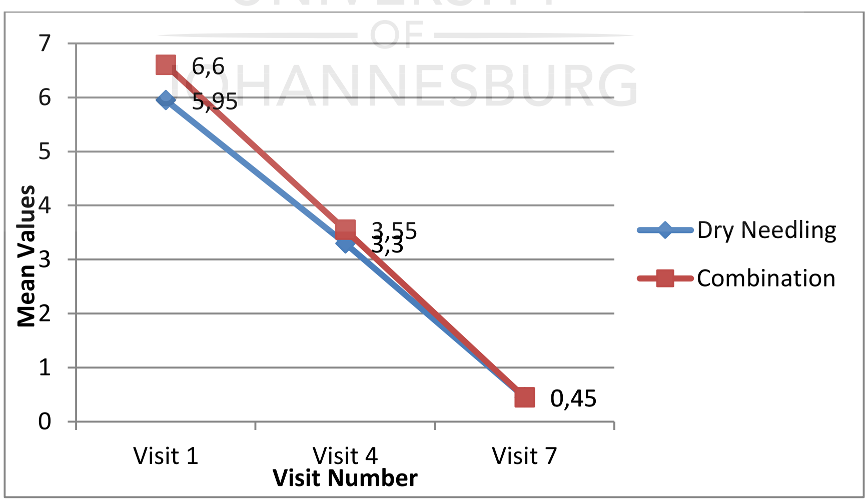

Figure 4.1 Line graph representing the mean value for the Numerical Pain Rating Scale for both groups

Illustrated by Figure 4.1 are the mean values for the dry needling and the combination groups for the Numerical Pain Rating Scale. The dry needling group had a mean value of **5.95** at reading one, **3.30** at reading two and **0.45** at reading three. This indicated a **92.44%** improvement between visit 1 and visit 7. The p-value for the dry needling group was **0.000** which is less than 0.005, therefore indicating a statistically significant difference.

The combination group had a mean value of **6.60** at reading one, **3.55** at reading two and **0.45** at reading three. A **93.18%** improvement was indicated between visit 1 and visit 7. The p-value for the combination group was **0.000** which is less than **0.005** and this indicated a statistically significant difference.

As there were statistically significant changes within the two groups, it was therefore necessary to establish when these changes occurred. The non-parametric Wilcoxon Signed Ranks Test was used to determine if the changes occurred during the first (visit 1) and second (visit 4) readings, during the second (visit 4) and third (visit 7) readings or during the second (visit 4) and third (visit 7) readings.

Table 4.3 Non-Parametric Wilcoxon Signed Rank Test for Intragroup Analysis of Numerical Pain Rating Scale

Non-Parametric Wilcoxon Signed Ranks Test with Bonferroni correction		
Visit Number	**Dry Needling**	**Combination**
p-value between visit 4 and visit 1	0.000 thus p ≤ than 0.017	0.000 thus p ≤ than 0.017
p-value between visit 7 and visit 1	0.000 thus p ≤ than 0.017	0.000 thus p ≤ than 0.017
p-value between visit 7 and visit 4	0.000 thus p ≤ than 0.017	0.000 thus p ≤ than 0.017

Table 4.3 indicates that the two groups showed statistical significant differences for the Numerical Pain Rating Scale. The p-values for the dry needling group between visit 1 and visit 4 were **0.000** (**p ≤ 0.017**), between visit 1 and 7 were **0.000** (**p ≤ 0.017)** and between visit 4 and 7 were **0.000** (**p ≤ 0.017**). This indicates a statistically significant difference between all the visits for the dry needling group.

The p-values for the combination group **0.000** (**p ≤ 0.017**), between visit 1 and 7 were **0.000** (**p ≤ 0.017**) and between visit 4 and 7 were **0.000** (**p ≤ 0.017**) which indicated there was a statistically significant difference between all the visits for the combination group.

b. Intergroup Analysis of the Numerical Pain Rating Scale

Table 4.4 Non-Parametric Mann-Whitney U Test for Intergroup Analysis of Numerical Pain Rating Scale

Non-Parametric Mann-Whitney U Test			
Reading Number	**Mean Rank/ p-value**	**Dry needling**	**Combination**
Visit 1	Mean Rank	17.45	23.55
	p-value 0.086 thus p ≥ 0.05		
Visit 4	Mean Rank	19.73	21.28
	p-value 0.661 thus p ≥ 0.05		
Visit 7	Mean Rank	20.23	20.78
	p- value 0.863 thus p ≥ 0.05		

Table 4.4 illustrates the p-values at the initial visit (**p = 0.085**) and the final visit (**p = 0.863**) when both groups were compared with each other, the Mann Whitney U test was used to

detect between group differences for the Numerical Pain Rating Scale. There were no statistically significant differences between the groups (**$p > 0.05$**).

4.4 Objective Data Analysis

The objective data for this study was obtained using the pressure algometer.

4.4.1 The Pressure Algometer

a. Intragroup Analysis of the Pressure Algometer Readings

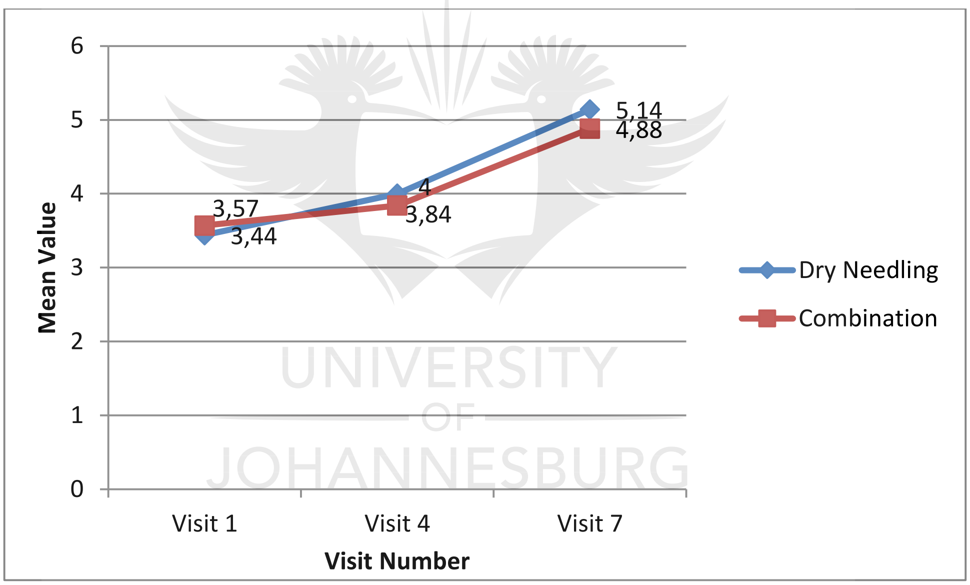

Figure 4.2 Line graph representing the pressure algometer readings of both groups

Figure 4.2 illustrates readings for the pressure algometer at visit 1, 4 and 7. The Friedman test was used when comparing the pressure algometer readings.

The dry needling groups mean value at visit 1 was **3.44 kg/cm^2**, **4.00 kg/cm^2** at visit 4 and **5.14 kg/cm^2** at visit 7. There was a **33.07%** improvement between visit one and visit seven.

The p-value was **0.000** (**$p \leq 0.05$**), which indicates a statistically significant difference between the first and seventh visit.

The combination groups mean value at visit 1 was **3.57 kg/cm^2**, **3.84 kg/cm^2** at visit 4 and **4.88 kg/cm^2** at visit 7. This indicates **a 26.84%** improvement between visit one and visit seven. The p-value was **0.000** (**$p \leq 0.05$**), which indicates a statistically significant difference and therefore an improvement between the first and seventh visits.

Due to these statistical significant changes occurring within both the groups, it is necessary to establish when these changes occurred within each of the groups.

The non-parametric Wilcoxon Signed Ranks Test was used to determine whether these changes occurred during the first (visit 1) and second (visit 4) readings, between the second (visit 4) and third (visit 7) reading or between the first (visit 1) and third (visit 7) reading.

Table 4.5 Non-Parametric Wilcoxon Signed Ranks Test for the Intragroup Analysis of the Pressure Algometer

Non-Parametric Wilcoxon Signed Ranks Test with Bonferroni correction		
Visit Number	**Dry Needling**	**Combination**
p-value between visit 4 and visit 1	0.000 thus $p \leq 0.017$	0.000 thus $p \leq 0.017$
p-value between visit 7 and visit 4	0.000 thus $p \leq 0.017$	0.000 thus $p \leq 0.017$
p-value between visit 7 and visit 1	0.000 thus $p \leq 0.017$	0.000 thus $p \leq 0.017$

Table 4.5 illustrates that the two groups showed statistically significant differences for the pressure algometer readings between visit one and visit four, with the p-values being **0.000** (**p**

≤ 0.17) for the dry needling group, and **0.000** (**p ≤ 0.017**) for the combination group. The p-value between visit 4 and visit 7 for the dry needling group was **0.000** (**p ≤ 0.017**) and for the combination group **0.000** (**p ≤ 0.017**). The p-value for the dry needling group between visit 1 and 7 was **0.000** (**p ≤ 0.017**) and the combination group was **0.000** (**p ≤ 0.017**). All the p-values are less than **0.05**, thus indicating statistically significant differences.

b. Intergroup Analysis of the Pressure Algometer Readings

Table 4.6 Non-Parametric Mann-Whitney U test for the Intergroup Analysis of the Pressure Algometer readings

Non-Parametric Mann-Whitney U test			
Reading	**Mean Rank/ p-value**	**Dry Needling**	**Combination**
Visit 1	Mean Rank	19.25 kg/cm^2	21.75 kg/cm^2
	p-value 0.499 thus $p \geq 0.05$		
Visit 4	Mean Rank	22.65 kg/cm^2	18.35 kg/cm^2
	p-value 0.244 thus $p \geq 0.05$		
Visit 7	Mean Rank	22.45 kg/cm^2	18.55 kg/cm^2
	p-value 0.291 thus $p \geq 0.05$		

Table 4.6 illustrates the p-values at the initial visit (**p = 0.499**) and at the final visit (**p = 0.291**) when both groups were compared with each other using the Mann- Whitney U test to detect between group differences for the pressure algometer readings. There were no statistically significant differences between the groups (**p < 0.05**).

CHAPTER 5: DISCUSSION

5.1 Introduction

With references to the aim presented in Chapter 1, this chapter deals with the discussion of the demographic data, subjective data, as well as the objective data obtained in this research study. The subjective data consisted of the Numerical Pain Rating Scale and the objective data consisted of pressure algometry readings (pressure-pain threshold).

5.2 Demographic Data

The largest percentages of participants in this study were between 18 and 40 years of age. The mean age for the participants in the dry needling group were 25 years and the mean age for the combination group were 27 years. This is due to the fact that the majority of participants were recruited from the University of Johannesburg, Doornfontein campus. The study is comparable to a study conducted by Hutchinson, Yelverton and Whelan (2014), where the mean ages for the groups were 24 and 25 years respectively. This is comparable to this study as it was a study pertaining to myofascial trigger point dysfunction.

Participants in this study were mainly female, according to a similar study by Cloete and Bester (2012), this is because females are more likely to suffer from shoulder pain due to trigger points than males. According to Van der Windt, Koes, de Jong and Bouter (1995), there is a higher incidence of shoulder complaints in females than there are in men.

5.3 Subjective Data

The subjective data consisted of the Numerical Pain Rating scale. This was used to record what the patient was experiencing with regard to subscapularis myofascial trigger points.

5.3.1 The Numerical Pain Rating Scale

According to Williamson *et al.* (2004), pain rating scales have a fundamental place in clinical practice. It suggests that patients are able to use the scales to communicate their pain experience and their response to treatment.

a. Intragroup Analysis

Dry needling Group

Figure 4.1 illustrates that the initial mean value for the dry needling group was **5.95** and the final mean value was **0.45**. This showed a **92.44%** reduction in the pain intensity. The Friedman test was used to detect within group changes and the p-value determined was 0.000. Further analysis using the Wilcoxon Signed Rank test showed a p-value of **0.000**. Therefore there was a statistically significant difference within the dry needling group (**$p \leq 0.05$**). It has been reported to be clinically significant with a 2-point change on the Numerical Pain Rating Scale (20%) (Farrar, Young, LaMareaux, Werth and Poole, 2001).

This may be compared to a study by Glanz, Moodley and Yelverton (2006), whereby the Numerical Pain Rating Scale was also used, as a subjective tool to measure the effectiveness of deep dry needling versus superficial dry needling for myofascial trigger points in the trapezius muscle. The results revealed a 48% decrease in pain according to the Numerical Pain Rating Scale for the dry needling group.

This improvement is confirmed by Simons *et al.* (1999), who stated that the therapeutic effect of dry needling is to mechanically disrupt the trigger point. Due to trigger points having a dysfunctional motor end plate, it is conceivable that dry needling damages or destroys the motor endplates and causes axon denervations distally when the needle hits the trigger point. This is said to trigger specific changes in the cholinesterase and acetylcholine at the endplate as part of the normal muscle regeneration process (Dommerholt *et al.*, 2013).

Combination Group

The initial mean value for the combination group was **6.60** and the final mean value was **0.45**. This showed a **93.18%** reduction in pain intensity. The Friedman test was used to detect within the group changes and showed the p-value was **0.000**. Further analysis using the Wilcoxon Signed Rank test showed a p-value of **0.000**. Therefore there were statistically significant differences within the combination group (**$p \leq 0.05$**).

This proves to be statistically significant because comparing it to a similar study exploring the effectiveness of Longs manipulation on patients presenting with chronic mechanical neck pain, the study found in statistical analysis that the Numerical Pain Rating Scale had a p-value of 0.002 immediately after treatment was administered. The p-value was 0.040 after a three month follow up treatment. The statistical significant p-value was set at less than 0.05. (Hua-Lin, Shen, Chi Keung Chung and Tai Wing Chiu, 2013).

An analgesic effect is postulated to occur in the subscapularis muscle (Gatterman, 2005). The results obtained are similar to a study by Oliviera-Cambelo *et al.* (2010), the analgesic effect is obtained with applying chiropractic manipulations to the innervation segment of the subscapularis muscle. Oliviera-Cambelo, Rubens-Rebelatto, Vallejo, Alburquerque-Sendi and Fernandez-de-Las-Penas (2010), demonstrated atlanto-occipital manipulations immediate analgesic effects on masticatory muscle pain in the distribution of the trigeminal nerve as measured by the Numerical Pain Rating Scale.

It is hypothesized that the myofascial trigger point nociceptors and the facet nociceptors sensory pathways share the same pathway in the spinal cord or to the higher centre. There is believed to be suppression of myofascial trigger point pain at the same time as suppression of the facet pain within the cervical spine. Therefore chiropractic manipulations administered to the innervation segment of the subscapularis muscle has the ability to relieve the myofascial trigger point pain within the subscapularis muscle (Hong, 2006).

The analgesic effect for the combination group may be attributed to the chiropractic manipulations ability to modify the central and peripheral pain process (Vernon, Humphreys and Hagino, 2007).

b. Intergroup Analysis

There was no evidence statistically at the conclusion of treatment (**p = 0.863**) to suggest that chiropractic manipulations combined with dry needling the subscapularis muscle is a better treatment protocol than only dry needling the subscapularis muscle, in terms of reducing the shoulder pain intensity due to active subscapularis myofascial trigger points. It is therefore not possible to draw any statistical conclusions as to the most appropriate treatment.

Both the dry needling and the combination group showed an overall statistical and clinical improvement throughout the study with regards to the Numerical Pain Rating Scale. The participants therefore felt a reduction in pain for both groups. These overall results were expected as dry needling has already proven to help resolve trigger points. Dry needling is said to cause an increase of blood flow to the area of the trigger point which then flushes the area of excess calcium and that in turn decreases the sustained muscle contraction therefore decreasing pain experienced (Simons *et al.*, 1999).

The combination group in this study was expected to have a better result than the dry needling group, as spinal manipulations are expected to have an additive effect to dry needling. The results may have been skewed due to a small sample size. Tough, White, Cummings, Richards and Campbell (2009), did a study to see the current information available on dry needling in the management of myofascial trigger points, they concluded that there was a limited sample size and that this was causing poor quality studies.

This may be compared to a study conducted by Cloete and Bester (2012), consisting of two groups; group 1 received dry needling of the infraspinatus muscle and cervical spine manipulations and group 2 received only dry needling of the infraspinatus muscle There were no statistical significant differences between the two groups with regards to the Numerical Pain Rating Scale and it was said to be due to the small sample size of the study.

A study investigating the chiropractic research and management of upper limb conditions was conducted by McHardy, Hoskins, Pollard, Onley and Windsham (2008) and indicated that there is a very small amount of chiropractic research into upper limb conditions and that there is a need for future research to be directed at a higher-level of incidence and due to the limited sample size and research this was causing poor quality studies.

It is evident that both the dry needling and combination treatment groups improved in a similar way with regards to the Numerical Pain Rating Scale, but it could be due to the small sample size that there were no statistically significant findings between the two groups.

5.4 Objective Data

5.4.1 Pressure Algometer

The minimal pressure which induces pain and is measured using the pressure algometer, is known as pressure threshold. According to a study done by Chesterton, Sim, Wright and Foster (2007), the pressure algometer provides highly reliable measurements of pressure pain threshold.

a. Intragroup Analysis

Dry Needling Group

Figure 4.2 illustrates the initial mean value for pain threshold for the dry needling group was **3.44 kg/cm^2** and the final mean value was **5.14 kg/cm^2**, this showed a **33.07%** increase in pain threshold. The Friedman test was used to detect within group changes and further analysis using the Wilcoxon Signed Rank test showed the p-value was **0.000**. Therefore there was a statistically significant difference within the dry needling group (**$p \leq 0.05$**).

It was proposed that the primary cause of injections were mechanical stimulation of a trigger point with the needle. Since then, for the treatment of myofascial trigger points dry needling has been widely used (Lewit, 1979). Resolving the build-up of histamine that causes the pain, tightness and inflammation characterised by the myofascial trigger points, dry needling deactivates the hyperirritable spot within the taught band of voluntary skeletal muscle (Lavelle, Lavelle and Susti, 2007). Most effective when dry needling therapy elicits a local twitch response, this is probably due to the rapid depolarisation of the involved muscle fibers, which then manifests as local twitches. Once the muscle has finished twitching the spontaneous electrical activity subsides, and dysfunction and pain decrease dramatically (Simons *et al.*, 1999).

A study conducted by Cloete *et al.* (2012), on the effectiveness of dry needling infraspinatus myofascial trigger points versus cervical spine manipulations combined with dry needling of infraspinatus myofascial trigger points, showed that pressure pain threshold increased between visit 4 and visit 7 which means that trigger point dry needling therapy is effective for treating myofascial trigger points. According to Simons *et al.* (1999), dry needling causes an increased blood flow to the area of irritability, which in turn cause the flushing out the excess calcium and causes the muscle to relax and decreases the pain felt.

Combination Group

Figure 4.2 illustrates the initial mean value for pain threshold for the combination group was **3.57** kg/cm^2 and the final mean value was **4.88** kg/cm^2, this indicates a **26.84%** increase in pain threshold. The Friedman test was used to detect within group changes and the Wilcoxon Signed Rank test was used for further analysis and showed a p-value of **0.000**. Therefore there was a statistically significant difference with the combination group (**$p \leq 0.05$**).

In a recent study conducted, the pain threshold was evaluated and the effects on pain pressure by means of spinal manipulations delivered to the thoracic spine were determined. The results showed, at a statistical significant level set at $p \leq 0.05$, the pain pressure threshold to have a p-value of 0.002 over the treatment period, it showed that a statistical significance was present within the group receiving the spinal manipulations to the thoracic spine. This finding suggested that the doctor of chiropractic could rely on the pain pressure threshold as a pre-treatment indicator of segmental dysfunction. It also suggests that pain pressure threshold measurements immediately following chiropractic manipulations may be utilized by the chiropractor to determine treatment efficacy. The findings of the latter study may easily be compared to the current study (Ezell, Hoffman and Holmes, 2012).

A study by Fernandez-de-Las-Penas, Perez-de-Heredia, Berea-Riviera and Miangolorra-Page (2007), testing the immediate effect of cervical spine manipulations on pressure pain threshold over the lateral elbow region, showed that there was an immediate increase in pressure pain threshold over the lateral epicondyle of both elbows. This could indicate an attribution to group 2 showing clinical and statistical improvements which was expected.

It has been hypothesized that a chiropractic manipulation administered to the innervation segment has the ability, by modifying the proprioceptive afferents, to induce a reflex muscle relaxation. It also has the ability to induce reflex muscle relaxation by activating the segmental inhibitory pathways and the central descending inhibitory pathway activation mechanism. Furthermore, a central hypoalgesic effect occurs by activating the periaqueductal gray substance. Therefore a chiropractic manipulation has been demonstrated to evoke changes in pain-pressure sensitivity in myofascial trigger points when administered to the cervical segment responsible for the innervation of the subscapularis muscle (C5/C6). Similarly, it is compared to a research study that explored changes in pressure pain sensitivity in latent myofascial trigger points in the upper trapezius muscle after cervical spine manipulations in pain free subjects (Ruiz-Saez *et al.*, 2007).

b. Intergroup Analysis

There is no statistical evidence at the conclusion of treatment (**p = 0.291**) to suggest that chiropractic manipulations combined with dry needling of the myofascial trigger points of the subscapularis muscle is superior to only dry needling the subscapularis muscle in terms of reducing shoulder pain intensity due to active subscapularis myofascial trigger points. It is therefore not possible to draw any statistical conclusions as the most appropriate treatment.

Both the dry needling and the combination group showed an overall statistical and clinical improvement throughout the study with regards to the pressure algometer. The participants therefore felt a reduction in pain for both groups. These overall results were expected as dry needling has already proven to help resolve trigger points.

It was expected in this study that the combination group would have a greater improvement, as it has been proven in other studies that spinal manipulation to the innervation segment on its own can resolve myofascial trigger points. Therefore the additive effect of spinal manipulations to dry needling was expected to have a better effect on the pressure pain threshold.

In a study conducted by Hutchinson *et al.* (2014), the pain pressure threshold was evaluated and the effects of cervical spine manipulations on infraspinatus myofascial trigger points. The study showed that pressure pain threshold increased by 21.7%.The findings showed that the manipulation to the innervation segment decreased the intensity of the shoulder pain and also improved the pressure pain threshold.

A study conducted by Fernandez-de-Las-Penas in 2009 showed that spinal manipulations inactivate myofascial trigger points and cause immediate pain relief. It was concluded that there is a change in muscle sensitivity in a muscle trigger point after spinal manipulation, which suggests that chiropractic practitioners should include treatment of joins hypomobility in the management of trigger points.

As there was a clinical and statistical decrease in pain for both groups, it indicates that both these treatments are helpful and useful for chiropractors to use in practice in the treatment of subscapularis myofascial trigger points.

5.5 Conclusion

In conclusion, the results showed that, dry needling subscapularis muscle and the combination group of dry needling subscapularis muscle and cervical spine manipulations, both showed significant improvements with regards to the Numerical Pain Rating Scale and the pressure algometer.

It has been shown that both groups in this study have therapeutic effects in the treatment of subscapularis myofascial trigger points, however there are no conclusive statistical evidence that proves that one treatment has a greater therapeutic effect compared to the other or that spinal manipulations had an additive effect to the dry needling.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The aim of this research study was to compare dry needling combined with spinal manipulations to dry needling, to see which treatment protocol was more effective and which treatment had the most desirable therapeutic effect on subscapularis myofascial trigger points.

The outcome of the clinical and statistical findings for this particular study, suggest that the chiropractic profession can treat shoulder pain effectively with dry needling myofascial trigger points. However according to statistical analysis no group was proven to provide a more desirable therapeutic effect but both groups did indeed show improvement. The clinical decrease in pain and increase in pain tolerance can be attributed to the dry needling, as both groups received dry needling.

This indicated that any one of the treatment protocols can be used in the treatment of shoulder pain due to subscapularis myofascial trigger points provided there are no contra-indications present. The chiropractic manipulation and process of dry needling both have a positive effect on the suppression of pain and disability symptoms, when it is applied to the treatment of shoulder pain due to myofascial trigger points. According to Cumming and White (2001), dry needling is an effective treatment in decreasing pain and pain threshold and therefore is an effective way of treating myofascial trigger points. A study conducted by Lehman (2012), showed that there are changes in muscle activity in upper limb muscles when spinal joints are manipulated. This could indicate that cervical spine manipulations do assist with myofascial trigger point treatment, but this was not statistically evident due to a small sample group size.

In conclusion, as dry needling the subscapularis muscle or a combination of dry needling subscapularis muscle and cervical spine manipulations have both shown to decrease pain in the participant, there is no superior treatment protocol for shoulder pain due to myofascial trigger points of the subscapularis muscle. This study has given the chiropractic profession two different treatment protocols which are both effective protocols for patients suffering with shoulder pain due to myofascial trigger points in the subscapularis muscle.

6.2 Recommendations

The following recommendations should be considered for future research regarding the treatment of subscapularis myofascial trigger points:

- Providing more information and relevance to the general population, therefore using a larger sample size.
- Comparing the long term effects, a follow up visit can be scheduled for both treatments.
- Three groups within the trial and the third group consists of only cervical spine manipulations to the innervation segment.
- Including shoulder manipulations or mobilizations to determine the mechanical effects of the manipulation on the subscapularis myofascial trigger point.
- Having two sample groups; one receiving cervical spine manipulations and dry needling of the subscapularis muscle trigger points. Another group receiving cervical spine manipulations and ischaemic compression of the subscapularis muscle trigger points. This will provide a comparison between two common treatment protocols currently used.
- Focusing on the immediate effect of dry needling and innervation segment manipulations may also be performed and may have a different result from the current study performed when assessing a treatment protocol for myofascial trigger points of the subscapularis muscle.

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APPENDIX A: ADVERTISEMENT

DO YOU SUFFER FROM SHOULDER PAIN??

RESEARCH STUDY PROVIDING CHIROPRACTIC TREATMENT!!

DRY NEEDLING VERSUS CERVICAL SPINE MANIPULATION COMBINED WITH DRY NEEDLING OF SUBSCAPULARIS MYOFASCIAL TRIGGER POINTS

If you are between the ages of 18 and 40 years come take part in a research project involving the treatment of shoulder pain

Treatment will be conducted at the University of Johannesburg Doornfontein Campus, Gate 7, Sherwell Road.

If you are interested in receiving treatment contact:

Nicole Oosthuizen: 061 226 3766

UJ Ethics clearance number: REC-01-234-2015

APPENDIX B: CASE HISTORY

UNIVERSITY OF JOHANNESBURG

CHIROPRACTICDAY CLINIC

CASE HISTORY

Date: __________

Patient: __________________________ **File No: ________**

Age: _______ **Sex: ________** **Occupation: _________**

Student: _________________________ **Signature:__________________**

Complies with Inclusion criteria of the research:

Clinician: __________________

Signature: _________________

Examination:

Previous: UJ Current: UJ

Other Other

X-ray Studies:

Previous: UJ Current: UJ

Other Other

Clinical Path. Lab:

Previous: UJ Current: UJ

Other 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 & 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 pattern

Diet

Current medication

Tobacco

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. *Psychological 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

Neurological

Haematological

Endocrine

Psychiatric

APPENDIX C: PHYSICAL EXAMINATION

RESEARCH

UNIVERSITY OF JOHANNESBURG

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:**_____________

Blood pressure:	**Arms:**	**L**	**R**
	Legs:	**L**	**R**

General Appearance:

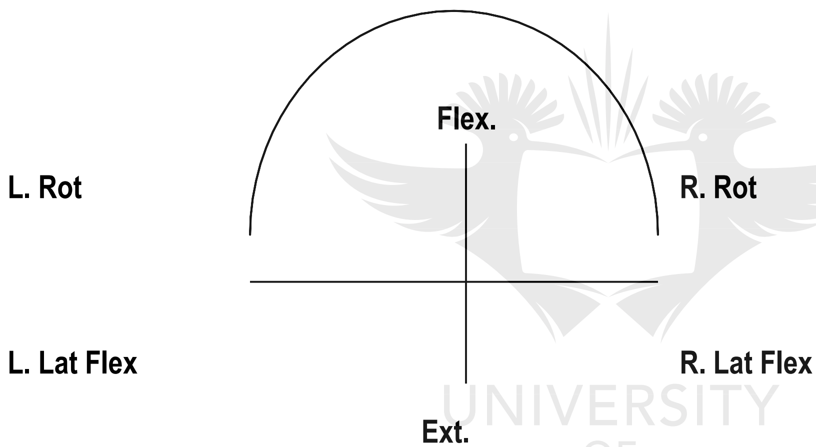
____

____

____

STANDING EXAMINATION

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



/ = 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:

	L	R
- Inspiration	cm	cm
- expiration	cm	cm

15. Visual acuity

16. Breast examination:
Inspiration:
- 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

L			R		
III	**IV**	**VI**	**III**	**IV**	**VI**

- visual fields
- accommodation
- Opthalmoscopic
- Examination
  - iris
  - pupils
  - red reflex
  - optic disc
  - vessels
  - general background
  - macula
  - vitreous
  - lens

4. Ears:

- Inspection
  - 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 - CNX

  - inspection
- carotid arteries (thrills, bruit)
- Cranial Nerves
  - CNV
  - CNVII
  - CNVIII (nystagmus)
  - CNIX
  - CNXI
  - CNX11

8. Peripheral vasculature:
- Inspection
  - skin
  - Nail beds
  - pigmentation
  - hair loss

- Palpation
  - pulses:
    - femoral
    - popliteal
    - post. Tibial
    - dorsalis pedis
    - radial
    - 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

	L	R
flex. 90/120		
ext. 15		
abd. 45		
add. 30		
int rot 40		
ext rot 45		
	L	**R**
flex. 130		
ext. 0/15		
	L	**R**
plantar Flex 45		
dorsiflex 20		
inversion 30		
eversion 20		

	L	R
Apparent		
Actual		

- knee
- ankle

(ii) leg length

- Co-ordination
  - point to point
  - dysdiachokinesia

10. TMJ

- Inspection
  - ROM
  - deviation
- Palpatation
  - crepitus
  - tenderness

11. 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)
  - diaphgragmatic excursion
  - kidney punch
- Auscultation
  - (i) breath sounds
  - vesicular
  - bronchial
  - (ii) adventitious sound
  - crackles (rales)
  - wheezers (rhonchi)
  - rubs
  - (iii) voice sounds
  - broncophony
  - whispered pectoriloquey
  - egophony
- Cardiovascular
  - auscultation (aortic murmors)

- 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)

(iii) Mood

(iv) Memory and attention

- orientation (time, place, person)
- remote memory
- recent memory
- new learning ability

(v) Higher cognitive functions

- Information and vocabulary
- (general and specialised knowledge)
- Abstract thinking

NEUROLOGICAL EXAMINATION (LUMBAR SPINE)

DERMATOMES	Left	Right	MYOTOMES	Left	Right	REFLEXES	Left	Right
T12			**Hip Flexion (L1/L2)**			Patellar (L3, 4)		
L1			**Knee Extension (L2, 3,4)**			Medial Hamstring (L5)		
L2			**Knee Flexion (L5/S1)**			Lateral Hamstring (S1)		
L3			**Hip Int. Rot (L4/L5)**					
L4			**Hip Ext. Rot (L5/S1)**					
L5			**HipAdduction (L2, 3,4)**					
S1			**HipAbduction (L4/5)**					
S2			**AnkleDorsiflexion (L4/L5)**					
S3			**Hallux Extension (L5)**					
			AnklePlantar Flexion (S1/S2)					
			Eversion (S1)					
			Inversion (L4)					
			Hip Extension (L5/S1)					

APPENDIX D: CERVICAL SPINE REGIONAL

RESEARCH

UNIVERSITY OF JOHANNESBURG
CHIROPRACTIC DAY CLINIC

REGIONAL EXAMINATION CERVICAL SPINE

Date: ________________________

Patient: ______________________________ File No:____________________

Clinician: ______________________________ Signature:__________________

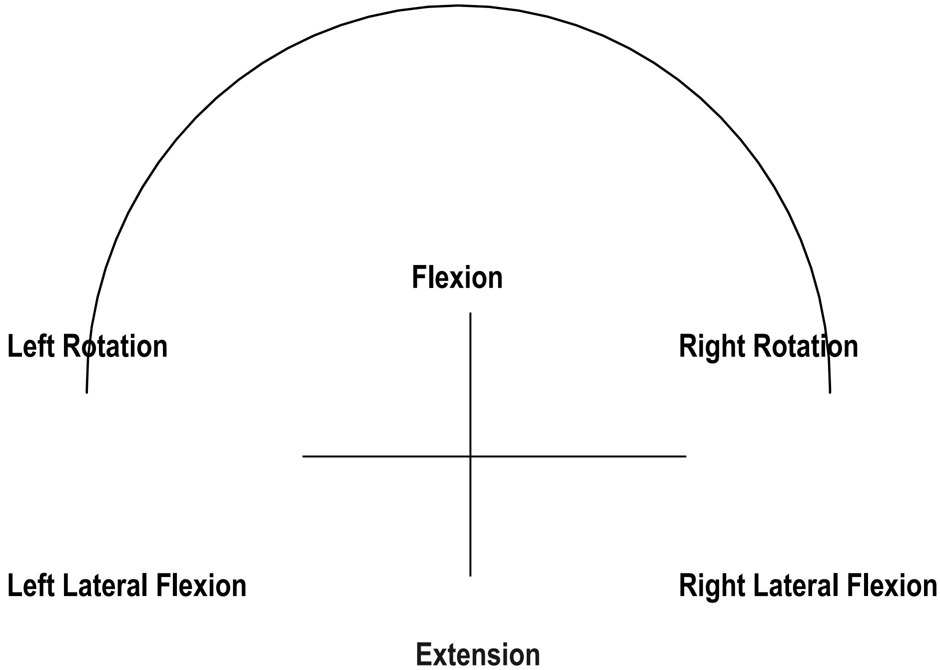
Student: ______________________________ Signature:__________________

OBSERVATION

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

5. RANGE OF MOTION

Flexion	=	45º-90º
Extension	=	55º-70º
L/R Rotation	=	70º-90º
L/R Lat Flexion	=	20º-45º



/ =Pain free limitation

// = Painful limitation

<u>PALPATION</u>

- Lymph nodes
- Trachea
- Thyroid gland
- Pulses/thrills
- Tenderness
- Muscle Tone
- Active MF Trigger Points
  - -SCM
  - -Trapezius
  - -Scaleni
  - -Levator Scapulae
  - -Posterior Cervical musculature

<u>ORTHOPAEDIC EXAMINATION</u>

1. Doorbell Sign
2. Max. Cervical Compression
3. Spurling's manoeuvre
4. Lateral Compression(Jackson's test)
5. Kemp'sTest

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'sTest

14. TOS:
- Halstead's test
- Adson's test
- Eden's (traction) test
- Hyperabduction (Wright's) test–Pec minor
- Costoclavicular test

REMARKS:

VASCULAR	**LEFT**	**RIGHT**
BLOOD PRESSURE		
CAROTIDS		
SUBCLAVIAN ARTERIES		
WALLENBERG'STEST		

COMMENTS:

MOTION PALPATION

Jt. Play			Left					Right				Jt. Play		
P/A	Lat	Fle	Ext	LF	AR	PR		Fle	Ext	LF	AR	PR	P/A	Lat
							C1							
							C2							
							C3							
							C4							
							C5							
							C6							
							C7							
							T1							
							T2							
							T3							
							T4							

NEUROLOGICAL EXAMINATION

DERMA TOMES	Left	Right	MYOTOMES	Left	Right	REFLEXES	Left	Right
C2			**Neck Flexion C1/2**			Biceps C5		
C3			**Lat. Neck Flexion C3**			Brachioradialis C6		
C4			**Shoulder Elevation C4**			Triceps C7		
C5			**Shoulder Abduction C5**					
C6			**ElbowFlexion C5**					
C7			**ElbowExtension C7**					
C8			**ElbowFlexion at90º C6**					
T1			**Forearm Pronation C6**					
			Forearm Supination C6					
			Wrist Extension C6					
			Wrist Flexion C7					
			Finger Flexion C8					
			Finger Abduction T1					
			Finger Adduction T1					

APPENDIX E: SHOULDER EXAMINATION

RESEARCH

UNIVERSITY OF JOHANNESBURG
CHIROPRACTIC DAY CLINIC

REGIONAL EXAMINATION

THE SHOULDER GIRDLE

Date: ______________________________

Patient: ______________________ **File No:** ______________

Clinician: ______________________ **Signature:** ______________

Student: ______________________ **Signature:** ______________

OBSERVATION

- Posture
- Skin
- Congenital deformities (e.g. Sprengel's)
- Developmental deformities (e.g. winging of scapula)
- Traumatic deformities (e.g. step, sulcus, disilocation)
- Asymmetry

REMARKS:

____

____

____

____

____

____

PALPATION

ANTERIOR STRUCTURES

- Clavicle
- Coracoid
- Sternum
- Humerus
- Sternoclavicular joint
- Acromioclavicular joint
- Ribs and costal cartilages
- Rotator cuff muscles
- Axilla

POSTERIOR STRUCTURES

- Scapula
- Spine of Scapula
- Triceps tendon
- Spinous processes of the lower cervical
- And upper cervical spines

REMARKS:

ACTIVE MOVEMENTS

	LEFT	RIGHT
Elevation through abduction (170 – 180 degrees)		
Painful arc with abduction		
Elevation through forward flexion (160 – 180 degrees)		
Elevation through scapula plane (170 – 180 degrees)		
Lateral rotation (80 – 90 degrees)		
Medial rotation (60 – 100 degrees)		
Extension (50 – 60 degrees)		
Adduction (50 – 75 degrees)		
Apley's Scratch Text (lat. Rot/abd. – med. Rot/add)		
Horizontal adduction/abduction (130 degrees)		
Circumduction (200 degrees)		

REMARKS:

____

____

____

____

PASSIVE MOVEMENTS (determine range and end feel)

	LEFT	**RIGHT**
Elevation through forward flexion		
Elevation through abduction		
Lateral rotation		
Medial rotation		
Extension		
Abduction		
Horizontal adduction		
Horizontal abduction		

RESISTED ISOMETRIC MOVEMENTS

	LEFT	RIGHT
Forward flexion of the shoulder		
Extension of the shoulder		
Adduction of the shoulder		
Abduction of the shoulder		
Medial rotation of the shoulder		
Lateral rotation of the shoulder		
Flexion of the elbow		
Extension of the elbow		

REMARKS:

____

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SPECIAL TESTS

Tests for Anterior Shoulder Instability

- Rockwood Test
- Apprehension (Crank) Test

Tests for Posterior Shoulder Instability

- Norwood Stress Test
- Posterior Apprehension Test
- Push-Pull Test

Tests for Inferior and Multi directional Instability

- Feagin Sign
- Sulcus Sign

Tests for Muscle Tendon Pathology

- Speed's Test (Bicipital Tendinitis)
- Drop Arm Test (Rotator Cuff)

- Ludington's Test (Biceps Tendon)
- Supraspinatus Test
- Pectoralis Major Contracture Test

Tests for Neurological Function

- Brachial Plexus Tension
- Tinel's Sign
- Phalen's

Tests for Other Shoulder Joints

- Acromioclavicular Shear Test

REFLEXES AND CUTANEOUS DISTRIBUTION

REFLEXES	LEFT	RIGHT
Biceps (C5 – C6)		
Triceps (C7 – C8)		
Pectoralis Major – Clavicular Portion (C5 – C6)		
Pectoralis Major – Sternocostal Portion (C7 – C8 and T1)		

Dermatomes

C4 ________________________________

C5 ________________________________

C6 ________________________________

C7 ________________________________

C8 ________________________________

T1 ________________________________

T2 ________________________________

T3 ________________________________

T4 ________________________________

T5 ________________________________

T6 ________________________________

JOINT PLAY MOVEMENTS

- Backward glide of humerus
- Forward glide of humerus
- Lateral distraction of humerus
- Caudul glide of humerus
- Backward glide of humerus in abduction
- Lateral distraction of humerus in abduction

Anteroposterior and cephalocausal movements of the clavical at the:

- Acromioclavicular joint
- Sternoclavicular joint
- General movement of the scapula

REMARKS:

MYOFASCIAL DYSFUNCTION SYNDROME

- Levator Scapula
- Supraspinatous
- Teres Minor
- Teres Major
- Rhomboid Minor
- Rhomboid Major
- Scalene Muscles
- Infraspinatous

- Lattissinus Dorsi
- Subscapularis
- Deltoid
- Biceps Brachii
- Pectoralis Major
- Pectoralis Minor
- Sternalis
- Serratus Anterior
- Coracobrachialalis
- Triceps Brachii
- Serratus Posterior Superior

REMARKS:

RADIGRAPHIC EXAMINATION:

DIAGNOSIS

APPENDIX F: PRESSURE ALGOMETER READINGS

Participants name:

File number:

Date:

SUBSCAPULARIS MUSCLE

	First Visit	Fourth Visit	Seventh visit
Reading 1 (kg/cm^2)			
Reading 2 (kg/cm^2)			
Reading 3 (kg/cm^2)			
Average			

APPENDIX G: PAIN RATING SCALE

Name: ______________________________

File number: _________________________

Date: _______________________________

Place a mark on the pain scale below that represents your pain at this point in time. On a scale of 0 to 10, 0 means “no pain” and 10 means “worst possible pain”. The middle of the scale describes “moderate pain”. A two or three rating would be “mild pain” and a rating of seven or higher would indicate “severe pain”.

Visit 1:

No pain Moderate pain Severe pain

0	1	2	3	4	5	6	7	8	9	10

Visit 4:

No pain Moderate pain Severe pain

0	1	2	3	4	5	6	7	8	9	10

Visit 7:

No pain Moderate pain Severe pain

0	1	2	3	4	5	6	7	8	9	10

APPENDIX H: CONTRA-INDICATIONS TO CHIROPRACTIC MANIPULATION (Gatterman, 2004)

1) Vascular complications
   - Vertebral artery syndrome
   - Aneurysms

2) Tumours
   - Primary to the bone
   - Secondary (metastasise to the bone)

3) Bone Infections
   - Tuberculosis of the spine
   - Osteomyelitis of the spine

4) Traumatic Injuries
   - Fracture
   - Instabilities
   - Dislocation
   - Unstable spondylolisthesis

5) Arthritis
   - Ankylosing Spondylitis
   - Rheumatoid Arthritis
   - Psoariatic Arthritis
   - Reactive Arthritis
   - Osteoarthritis

6) Psychological consideration
   - Malingering
   - Hysteria
   - Pain intolerance
   - Dependant personality
   - Disibility Syndromes

7) Neurological complications
   - Cervical disc lesions
   - Advancing neurological deficits
   - Space occupying lesions

APPENDIX I: CONTRA_INDICATIONS TO DRY NEEDLING (Dommerholt, 2013)

1) In a patient with a needle phobia

2) A patient who is unwilling

- Fear
- Beliefs of the patient

3) If the patient is unable to give consent

- Communication difficulties
- Age related factors

4) Medical emergencies or acute medical condition

5) Over an area with lymphedema

6) Abnormal bleeding tendencies

7) Compromised immune system

8) Vascular disease

9) Diabetes

10) Pregnancy

11) Children

12) Frail patients

13) Epilepsy

14) Psychological conditions

- Anxiety
- Emotional distress

15) Allergies

- Metals (particularly nickel and chromium)

16) Patient medication

- Immune suppressive medication
- Psychotropic medication
- Blood thinning medication

APPENDIX J: PARTICIPANT INFORMATION FORM

DEPARTMENT OF CHIROPRACTIC

FACULTY OF HEALTH SCIENCES

Telephone: (011) 559 6218

Date: ____________________

INFORMATION FORM

Dear Participant,

My name is **Nicole Oosthuizen**, and I am completing my Master's Degree at the University of Johannesburg. I would like to invite you to participate in my research study entitled:

"The effectiveness of dry needling versus cervical spine adjusting combined with dry needling of subscapularis myofascial trigger points in the treatment of shoulder pain."

Before agreeing to participate, it is important that you read and understand the following explanation of the purpose of the study, the study procedures, benefits, risks, discomforts, and precautions and your right to withdraw from the study at any time.

This information leaflet is to help you to decide if you would like to participate. You must understand what the research study is about before you agree to take part in this study. You may find that this form may contain words that you do not understand. If you have any questions, do not hesitate to ask me. You may also take home a copy of this form before signing the consent form to think about or discuss with family or friends before making your decision.

This intended study compares the effects of chiropractic adjustive therapy, namely chiropractic cervical spine manipulative therapy and a soft tissue protocol to aid in the treatment of shoulder pain.

The treatment procedure involves two treatment protocols: Chiropractic spinal manipulative therapy to the cervical spine. The Chiropractic manipulative therapy involves the restoration of normal joint motion. Abnormal joint motion will be detected by the researcher via motion palpation. The Chiropractic manipulative therapy is a safe, non-invasive treatment technique. The second treatment consists of a soft tissue programme in the form of dry needling, which is aimed at releasing hypertonic muscles and strengthening weakened muscles.

The inclusion criteria for this study are symptomatic male and female patients who have shoulder pain, participants must be between the ages of 18 and 40 years of age (these are the individuals who are most susceptible in developing shoulder pain due to activities involving the shoulder). The exclusion criteria for this study are participants with a body mass index higher than 25, if you are contra-indicated to cervical spine manipulative therapy, and if you have a history of cervical spine surgery.
From here measurements will be taken with the use of a pain rating scale and a pressure algometer.

The research study will take place at the University of Johannesburg Chiropractic Clinic
If you want any information regarding your rights as a research participant, or concerns regarding this research study, you may contact me or my supervisor or alternatively the Chairperson of the University of Johannesburg's Academic Ethics committee (Faculty of Health Sciences REC Chairperson: Prof. M. Poggenpoel 011 559 6686), which is an independent committee established to help protect the rights of research participants.

Your anonymity will be ensured as the recorded data being statistically analysed and data that may be recorded in scientific journals, will not include any information that could possibly identify you as a participant in this study. 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 study and its protocol have been submitted to the University of Johannesburg Academic Ethics Committee and written approval has been granted by the committee abovementioned.

Thank you for taking the time to read this form and consider participation in this study.
Should you have any concerns or queries regarding the current study, the following persons may be contacted.

Researcher: Nicole Oosthuizen Telephone number 061 226 3766
Supervisor: Dr C Yelverton Telephone number: (011) 559 6218

UJ Ethic's clearance number: REC-01-234-2015

APPENDIX K: CONSENT FORM

UNIVERSITY OF JOHANNESBURG

DEPARTMENT OF CHIROPRACTIC

FACULTY OF HEALTH SCIENCES

Telephone: (011) 559 6218

Date: ________________

CONSENT FORM

Dear Participant

Before signing this consent form please take time to read the information form.

Personal doctor/specialist notification option

Please indicate below, whether you want me to notify your personal doctor or your specialist of your participation in this study:

- YES, I want you to inform my personal doctor/ specialist of my participation in this study
- NO, I do not want you to inform my personal doctor/ specialist of my participation in this study
- I do not have a personal doctor / specialist

Do you have any questions related to this study?

INFORMED CONSENT

I hereby confirm that I have been informed by the researcher, Nicole Oosthuizen, about the nature, conduct, benefits and risks of this study with the title:

“The effectiveness of dry needling versus cervical spine adjusting combined with dry needling of subscapularis myofascial trigger points in the treatment of shoulder pain.”

I have also received, read and understood the information form (participant information leaflet) regarding this study.

- I am aware that the results of this study, including personal details regarding my gender, age, date of birth, and diagnosis will be anonymously processed into a study report.
- In view of the requirements of research, I agree that the data collected during this study can be processed
- I may, at any stage, without prejudice, withdraw my consent and participation in this study as it is on a voluntary basis.
- I have had sufficient opportunity to ask questions and (of my own free will) I declare myself prepared to participate in this study.
- The Data will be destroyed 2 years after completion of the trial and is kept in a locked room at the UJ Chiropractic Clinic.

Signed Participant

Printed name Signature Date and Time

Signed Researcher

Printed name Signature Date and Time

Signed Witnesses

Printed name Signature Date and Time

APPENDIX L: SOAP NOTE

RESEARCH

UNIVERSITY
OF
JOHANNESBURG

CHIROPRACTIC DAY CLINIC

SOAP NOTE

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

S: O:

A: P:

Comments:

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

S: O:

A: P:

Comments:

APPENDIX M: HIGHER DEGREES CLEARANCE LETTER

UNIVERSITY OF JOHANNESBURG

FACULTY OF HEALTH SCIENCES

HIGHER DEGREES COMMITTEE

HDC-01-159- 2015

08 October 2015

TO WHOM IT MAY CONCERN:

STUDENT: OOSTHUIZEN, N
STUDENT NUMBER: 200906708

TITLE OF RESEARCH PROJECT: "Dry Needling versus Cervical Spine Manipulation Combined with Dry Needling of Subscapularis Myofascial Trigger Points"

DEPARTMENT OR PROGRAMME: CHIROPRACTIC

SUPERVISOR: Dr CJ Yelverton **CO-SUPERVISOR:**

The Faculty Higher Degrees Committee has scrutinised your research proposal and concluded that it complies with the approved research standards of the Faculty of Health Sciences; University of Johannesburg.

The HDC would like to extend their best wishes to you with your postgraduate studies

Yours sincerely,

Prof Y Coopoo
Chair: Faculty of Health Sciences HDC
Tel: 011 559 6944
Email: yogac@uj.ac.za

APPENDIX N: ETHICS CLEARANCE LETTER

UNIVERSITY OF JOHANNESBURG

FACULTY OF HEALTH SCIENCES

RESEARCH ETHICS COMMITTEE
NHREC Registration no: REC-241112-035

REC-01-234-2015

08 OCTOBER 2015

TO WHOM IT MAY CONCERN:

STUDENT: OOSTHUIZEN, N
STUDENT NUMBER: 200906708

TITLE OF RESEARCH PROJECT: "Dry Needling versus Cervical Spine Manipulation Combined with Dry Needling in the Treatment of Subscapularis Myofascial Trigger Points"

DEPARTMENT OR PROGRAMME: CHIROPRACTIC

SUPERVISOR: Dr CJ Yelverton **CO-SUPERVISOR:**

The Faculty Research Ethics Committee has scrutinised your research proposal and confirm that it complies with the approved ethical standards of the Faculty of Health Sciences; University of Johannesburg.

The REC would like to extend their best wishes to you with your postgraduate studies.

Yours sincerely,

Prof M Poggenpoel
Chair : Faculty of Health Sciences REC
Tel: 011 559 6686
Email: mariep@uj.ac.za

APPENDIX O: TURN IT IN PLAGIARISM REPORT