CHAPTER ONE: INTRODUCTION

1.1 Problem statement

Myofascial pain syndrome (MFPS) is often seen in clinical practice as a cause for pain. It is characterized as a dull ache to a burning pain that can cause referral of pain to other areas of the body (Travell Simons and Simons, 1999). An epidemiological study conducted in South Africa, found that MFPS was the second most frequently diagnosed condition in a pain control clinic. This study shows MFPS to be a common condition in South Africa (Walker, Odendaal and Esterhuyse, 2006).

MFPS is a syndrome that is characterized by the presence of myofascial trigger points (TrP's). Myofascial TrP's are hyperirritable spots that when provoked refers pain, parathesia and autonomic symptoms to a location that is specific for the particular muscle (Travell and Simons, 1999). Myfascial TrP's are palpable as a harder consistency to the surrounding tissue. Finding a myofascial TrP's is based on the physicians skill assisted by the patient's expression of pain. Often when palpated a visual as well as palpable local twitch response can be seen and felt (David and Pamela, 2002). As said previously myofascial TrP's trigger points are very common and symptoms can range from painless and limited range of motion changes, to incapacitating and agonizing pain (Travell and Simons, 1999).

There are various methods of treating TrP's such as applying ice packs, heat packs, ischemic compression, using ultrasound and dry-needling the area (Fleckenstein et al 2010). One of the most commonly used and effective modalities of treatment is dry-needling of the myofascial TrP, (Kamanli et al 2005). Dry needling involves the insertion of an acupuncture needle directly into a TrP. These hyperirritable spots are theorized to be deactivated by dry-needling (Weiner, 2007).

One of the proposed mechanisms by which dry-needling is effective in the deactivation of TrP's is that it is able to mechanically disrupt the muscle or nerve fibers, thus stopping the pain-spasm cycle (Travell, Simons and Simons, 1999). Mechanical disruption of muscle fibers causes increased levels of extra cellular potassium, which in turn leads to the depolarization of nerve fibers (Dommerholt and Huijbregths, 2009). There is removal of nerve sensitizing substances by local hemorrhage and interruption of the central feedback mechanism (Travell, Simons and Simons, 1999).

A negative effect of dry-needling experienced by patients is post-needling soreness. Post-needling soreness is a completely separate entity and is not the same as myofascial pain (Lewit, 1979). It has been associated with a constant pressure or a dull aching sensation experienced by the patient after the dry-needling procedure (Hong, 1994). This discourages patients from seeking an effective modality of treatment and may prolong the patient's difficulty (Hong, 1994).

Post-needling soreness is associated with micro-hemorrhage caused by tissue damage at the needled site (Alvarez and Rockwell, 2002; Hong, 1994). It was found to be caused by both single insertions and fanning dry-needling techniques (Ferreira, 2006; Rowley, 2000). This can contribute to the delay of treatment and recovery as the development of post-needling soreness prevents any further needling of the same region for 3-4 days after treatment (Travell, Simons and Simons, 1999)

Ways to help alleviate this post-soreness have been mentioned such as: heat, stretching, ultrasound and application of pressure (Fleckenstein *et al*. 2010). All these modalities are done after the needle has been removed. This then adds an extra modality to the treatment as well as increased treatment time; therefore these modalities are often skipped by practitioners (Hong, 1994). Another factor

to look at is that many of these modalities have not been researched objectively for effectiveness on relieving the post-needling soreness (Kamanli *et al.* 2005).

Using a moxi cigar, placed on top of the acupuncture needle whilst inserted into the active trigger point is a way in which heat as a modality to treat post-needling soreness can be combined into the needling time. Doing this study would also objectively research if there are benefits to this added modality and its effectiveness on alleviating post-needling soreness.

1.2 Aim of study

The aim of the study is to investigate if heat conduction using a moxi cigar is an effective modality in alleviating post-needling soreness when compared to ultrasound and dry needling with no added modality in the treatment of MFPS.

1.3 Outcomes

A possible outcome of the study is that participants that receive needling with the moxi cigar may demonstrate less post needling soreness when compared to the other two groups in the study. If both groups with an added modality for treatment of post-needling soreness show an improvement in pain, it can be deduced that the moxi group achieved this during the needling time, unlike the ultrasound that requires additional treatment time. This then shows a new possible treatment method whereby heat can be incorporated into the dry needling technique without the additional time spent.

CHAPTER TWO: LITERATURE REVIEW

2.1. Introduction

Myofacial pain syndrome (MFPS) is a common condition found in patients. The cause of pain is from a hyperirritable spot located in a taut band of skeletal muscle. This spot produces pain locally as well as in a referred pattern. This hyperirritable spot is known as a trigger point (TrP) (Travell, Simons and Simons, 1999).

TrP's can occur in any muscle group, however the most common sites are in our postural muscles namely: Levator scapulae, upper trapezius, sternocleidomastoid, scalenes as well as quadratus lumborum (Richards, 2006).

TrP's develop as a result of either acute trauma or due to repetitive micro-trauma (Alvarez and Rockwell, 2002). Factors that perpetuate the trigger point include structural and mechanical stresses, psychological factors and metabolic and endocrine inadequacies (Mense and Gerwin, 2010).

There are various ways in which to treat MFPS most showing good prognosis. The most common of these treatments is dry needling the TrP's that contribute to the syndrome. A negative effect to the dry needling technique is post-needling soreness. This soreness is separate to MFPS and is a direct cause of the needling. The patient experiences a constant pressure, dull ache which is similar to that of a bruise. This pain often discourages patients from receiving further needling, which is required for resolution of MFPS (Hong, 1994).

This literature review will address MFPS caused by TrP's found in the upper trapezius muscle. Treatment of MFPS using dry needling will be explained with emphasis placed on post-needling soreness. Modalities such as ultrasound and moxibustion (as a means of heat transferal directly to the trigger point site) will be explained and their efficacy in the treatment of this post-needling soreness.

2.2 Skeletal muscle

Primary function of skeletal muscle is contraction. Contraction is the shortening of the muscle and occurs when an electrical signal is converted into a mechanical event (Plowman and Smith, 2003). Skeletal muscles are directly or indirectly attached to bones of the skeletal system. Through contraction skeletal muscles perform the following functions: produce skeletal movement, maintain posture and body position, support soft tissue, guard entrances and exits and lastly play a role in maintaining body temperature (Martini, 2004).

2.2.1 Organisation of skeletal muscle

Skeletal muscle is comprised of three layers of connective tissue that form the framework of the muscle and come together at each end of the muscle to form tendons. The layers are: epimysium, perimysium and endomysin.

- Epimysium- is a dense layer of collagen fibres that surrounds the muscle as a whole. The epimysium is found directly under the facia.
- Perimysium- divides the skeletal muscle into compartments known as fascicles, each fascicles contains a bundle of muscle fibers. The perimysium also houses blood vessels and nerves.
- Endomysium- surrounds and connects the individual muscle fibers that form the fascicle (Martini, 2004).

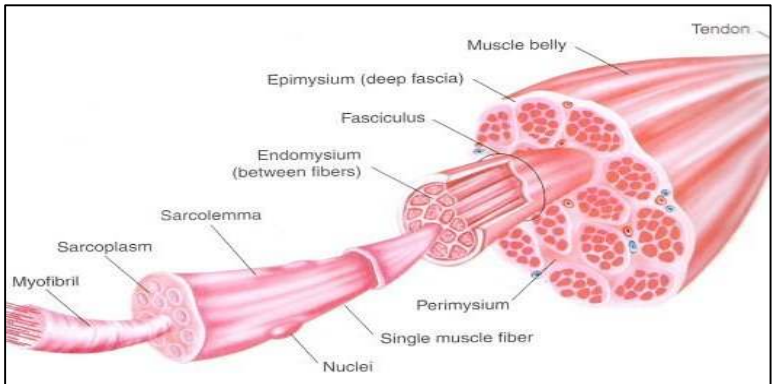


Figure 1: Muscle belly split into various component parts (from Essentials of Strength Training & Conditioning, National Strength & Conditioning Association)

Figure 2.1 Muscle belly split into various components (T.R.Baechle and R.W.Earle, 2008).

A muscle fibre is comprised of hundreds to thousands of myofibrils these in turn are comprised of smaller strands known as myofilaments. Myofilaments are the contractile proteins that are responsible for the muscle contraction. Sacromeres are the functional units of the muscle and are made up of two types of myofilaments: thick filaments, composed primarily of contractile protein myosin and thin filaments composed primarily of contractile protein, actin.

More closely, the scaromere is divided into dark bands (A bands) and light bands (I bands). The A band has three subsections:

1- The M line contains proteins that connect the central portion of the thick filament to its neighbors.
2- The H zone found either side of the M line contains thick filaments and no thin filaments.
3- The zone of overlap, where thin filaments are situated between the thick filaments.

The I band extends from the A band of one sarcomere to the A band of the next sarcomere. Z lines mark the boundaries between adjacent sarcomeres.

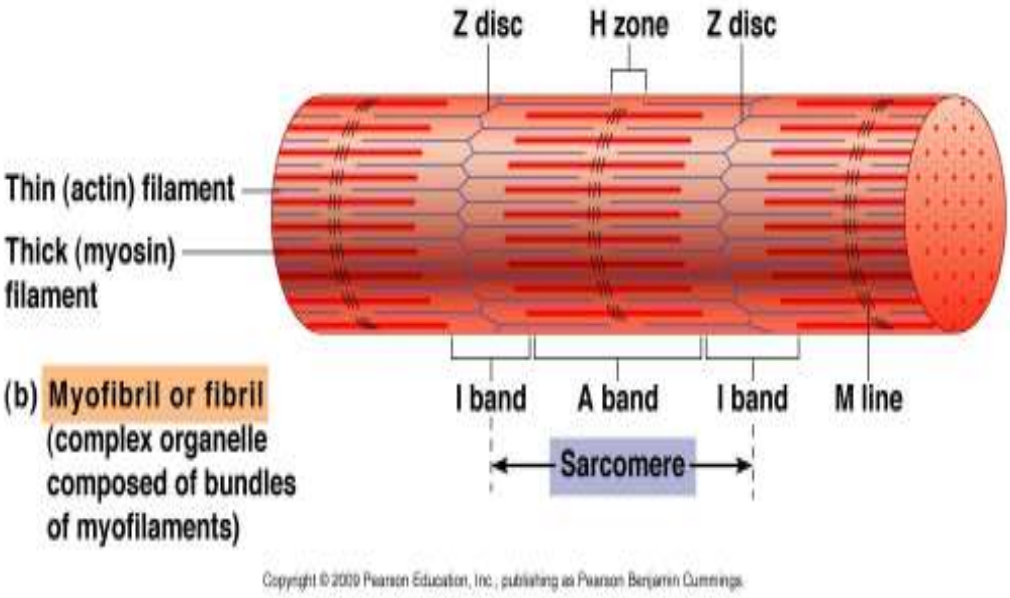


Figure 2.2 deep section through myofibril (Marieb and Hoehn, 2013)

2.2.3 Muscle contraction

A motor unit is the link between the central nervous system and the muscle fibres. A motor unit has a cell body that is found in the anterior horn of the spinal cord. The axon passes through a spinal nerve and then a motor nerve where it enters the muscle and branches to multiple muscle fibers. Motor end plates are structures that link the terminal dendrites of the motor-neuron to the muscle fiber. It is here that we have a neuromuscular junction and a synapse (Guyton and Hall, 1994).

When an action potential (electrical stimuli) arrives at the neuromuscular junction, it causes a chemical messenger to be released (acetylcholine). This acetylcholine (ACH) diffuses across the synaptic cleft to the muscles cell membrane and will bind to specific receptor molecules on the membranes surface. The ACH receptor complex opens the ion channels that allow the positive ions (sodium) into the muscle cell. The influx of positive charges

decreases the negative charge and allows for short lasting postsynaptic action potentials (Guyton and Hall, 1994).

A muscle fiber in a relaxed state has the ends of the two separate sarcomere's actin filaments barely overlapping whilst at the same time lying adjacent to myosin filaments. In the contracted state the actin filaments are pulled inwards to lie among the myosin filaments. This results in a large overlap between two consecutive sarcomere's actin filaments. Therefore we see how the filaments slide in towards each other in contraction and away in relaxation, this is known as the sliding mechanism of contraction and shows the muscle fibre shortening (Guyton and Hall, 1997).

2.3 Trapezius muscle

2.3.1 Anatomy of the trapezius muscle

The trapezius muscle so named as the left and right trapezius combines posteriorly to form a trapezium. The proximal attachment of the trapezius is the medial third of the superior nuchal line, the external occipital protuberance, the ligamentum nuchae and the spinous processes of C7-T12 vertebrae (Gatterman, 1990).

The Trapezius is divided into three according to the direction in which the fibers run. The upper third attaches medially to the medial third of the superior nuchal line and the ligamentum nuchae, the fibers then run anteriorly and laterally to their lateral attachment, posterior boarder of the lateral third of the clavicle. The middle third of the trapezius attaches medially to spinous processes and interspinous ligaments of C6 through to T3. The fibers run horizontally to their lateral attachment, medial margin of the acromion as well as the superior lip of the spine of scapular. The lower third attach medially to spinous processes and interspinous ligaments of T4-T12. The fibers are fan shaped and they laterally attach to medial end of the spine of scapular and are found to lie just lateral to the fibers of the levator scapulae (Moore and Dalley, 2006).

2.3.2 Innervation of the Trapezius

The trapezius receives innervation from two sources, one a motor component and the other a sensory component. The motor component is provided by the root of the spinal accessory nerve (cranial nerve XI). The spinal accessory nerve starts as a series of rootlets that emerge from the first 5-6 cervical segments of the spinal cord. The spinal accessory nerve then joins the vagus nerve as it passes through the jugular foramen it then separates from the vagus nerve as it exits. Thereafter it descends along the internal carotid artery, penetrating and giving innervation to the sternocleidomastoid (SCM). Once leaving the SCM it crosses the posterior cervical region and passes deep to the upper boarder of the trapezius muscle giving off multiple branches and innervating the trapezius muscle (Moore and Dalley, 1990). After innervating the trapezius the nerve then joins a plexus that is made up of C2, C3 and C4 spinal nerves (Travell and Simons, 1999). The sensory component which picks up pain and proprioception is made up of cervical nerves C3 and C4 (Moore and Dalley, 2006).

2.3.3 Blood supply to the Trapezius muscle

The main blood supply to the trapezius is from the dorsal scapular and transverse cervical arteries. Branches coming from the intercostal arteries also supply the middle and lower fibers of the trapezius. The upper fibres have added supply from the occipital and thyrocervical branches (Garbelotti, Rodrigues, Sgrott and Prates, 2001).

2.3.4 Function of the trapezius muscle

The trapezius muscle is divided into three different sections according to the direction in which the fibers run, therefore when looking at function we look at what each section does separately. The upper thirds main function is scapular elevation. Together the upper and the lower fibers of the trapezius rotate the glenoid cavity superiorly which allows for full rotation and movement of the upper limb (Moore and Dalley, 2006). Note that the upper fibers are synergistic with the sternocleidomastoid and antagonistic to the levator scapulae muscle, during

scapular rotation. When acting bilaterally the upper fibers help with extension if the head and neck. The upper fibers also play a vital role in aiding the accessory respiratory muscles when the body is placed under high levels of stress (Travell and Simons, 1999). The middle fibers of the trapezius main function is to retract the scapular (Moore and Dalley, 2006). The middle fibers act synergistically with the rhomboids in adduction of the scapular. The middle fibers along with the deltoid, supraspinatus and long head of the biceps brachii function to stabilize the scapular (Travell and Simons, 1999). The lower fibers help to stabilize the axis of rotation of the scapular. The lower fibers are synergistic with the serratus anterior and upper trapezius fibers, in upward rotation of the scapular (Travell and Simons, 1999). The lower fibers also play a role in scapular depression (Moore and Dalley, 2006).

2.3.5 Myofascial TrP's of the upper fibres of the trapezius muscle

The trapezius muscle has seven known trigger point locations. TrP's are found in various areas of all three thirds of the muscle. The upper fibers being known to be more prone then middle and lower thirds to the development of trigger points. The reason for this is that the upper fibers function in neck stabilization and are often overloaded therefore TrP1 and TrP2 are the most frequent TrP's found in the trapezius (Travell and Simons, 1999).

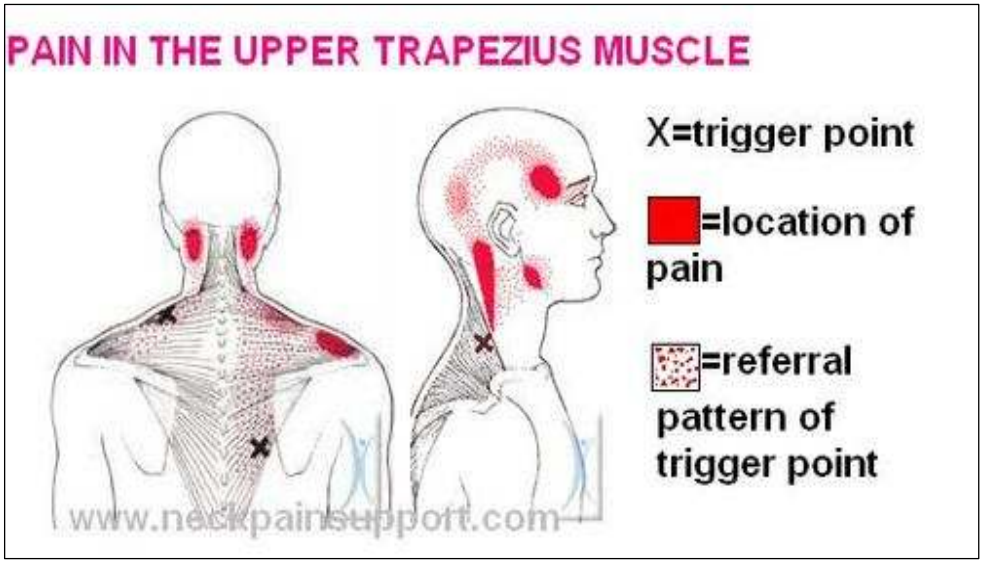


Figure 2.3 Trapezius trigger point 1 and referral pattern (Travell and Simons, 1999).

2.3.6 Referral pattern and the location of TrP 1 in the upper trapezius

TrP1 of the trapezius is located in the mid-potion of the upper fibers, it involves the most perpendicular fibers that attach to the anterior aspect of the clavicle. TrP1 refers pain unilaterally and upward into the posterior lateral aspect of the neck to the mastoid process. Often this TrP is associated with tension headaches. Referral from severe TrP1 involvement can go as far as to the side of the head centering in the temple and the posterior aspect of the orbit, showing patients presenting with pain behind the eye. In other cases it may involve the angle of the mandible, the occiput, the pinna and the lower molar teeth, patients present with tooth or ear ache (Travell and Simons, 1999).

2.3.7 Activation of TrP's in the upper trapezius fibres

In a recent study done by the company Steelcase, 2000 participants in wide range of postures around the work space using new aged modern technology devices were observed. The study was aimed at looking at the participant's posture and ways in which it alters using different devices. "We studied how the human body interacts with technologies and how it responds as workers shift from one device to another. Research revealed ergonomic implications that, if not adequately addressed, can cause pain and discomfort for workers" (Steelcase, 2013)

The study was performed by a company wanting to promote a work office chair that would find the user in a more supported posture so the information reported may be bias and one sided in the study. Validity can be taken from the way in which posture has been affected in everyday life due to added technologies. Our postural muscles now have to support our bodies in new positions.

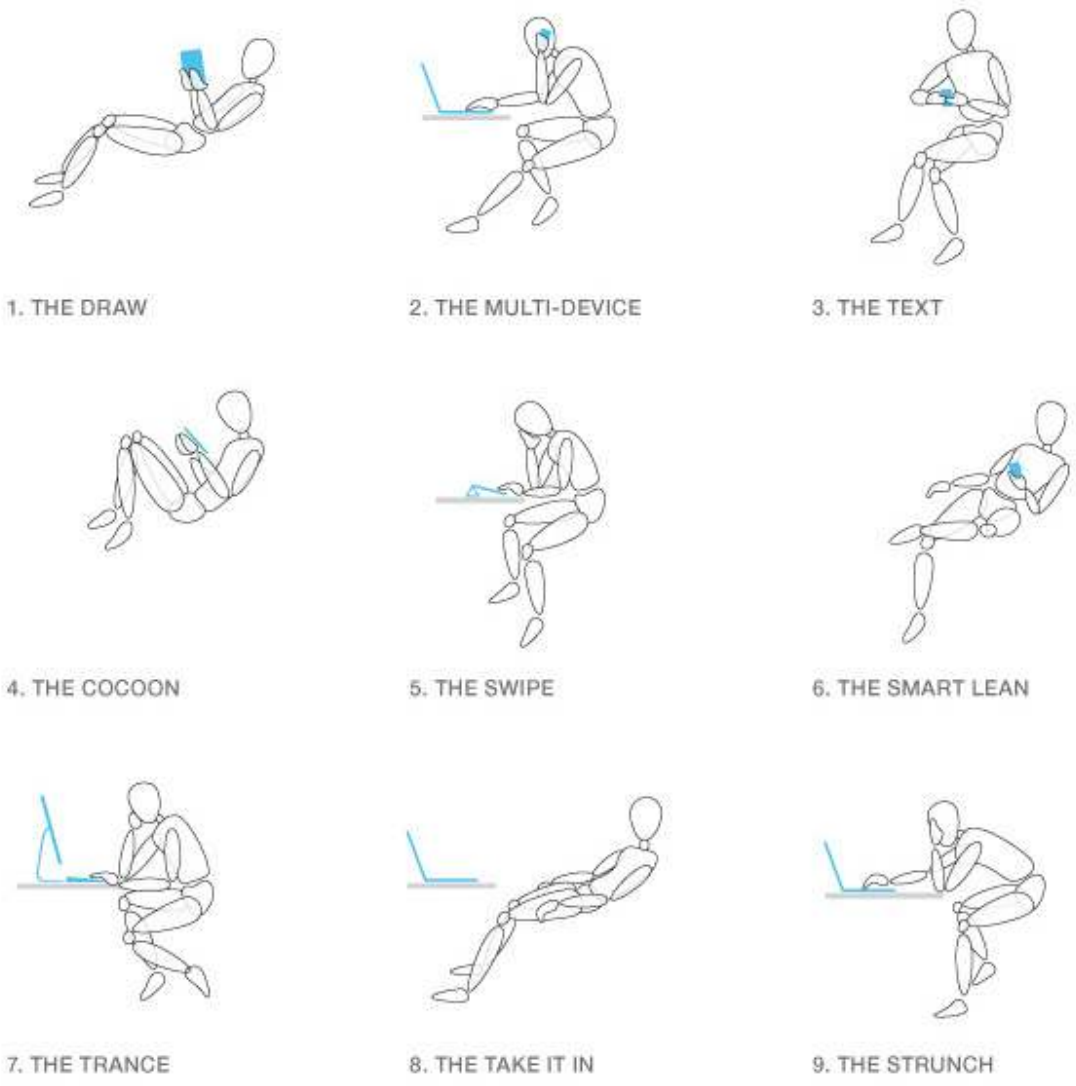


Figure 2.4: Postures adapted to technology negative to spinal health (Techvibes Perform, 2013)

The upper fibres of the trapezius help to keep the head and neck vertical and the eyes level. Upper trapezius plays a role in postural position therefore patients that have a rounded shoulder and increased anterior head carriage do tend to present with active TrP's in the trapezius. According to Gatterman (1990) the trapezius muscle is one of the most frequent muscles to be found to have TrP's. This may be due to its function as a stabilizer of the upper extremities.

Gatterman (1990) further stated that the trapezius muscle is frequently in static loading while the head is held forward and arms used out in front, this makes the trapezius particularly vulnerable to chronic muscle pain due to over use. These fibres can be overloaded in any position or activity that involves these fibers carrying the weight of the upper limb for prolonged periods of time. Examples of this being: typing on a computer keyboard, looking at a computer screen that is lower than eye level (Lap top), Holding a device up towards the eyes (cellular device, tablet) and while driving if steering wheel is too high or low versus the car seat (L.K. Huguenin, 2003).

Looking further down the spine trapezius TrP'smay occur any time that the shoulder-griddle axis is tilted, due to leg length inequality. Leg length inequality causes the pelvis to tilt laterally and in turn the lumbar spine tilts and bows into a functional scoliosis curve this transpires into the shoulders causing one side to drop and this then leads to active TrP's in the trapezius (Travell and Simons, 1999).

The upper trapezius fibers are more frequently strained by chronic overload and injury due to micro trauma over a time, then due to a gross trauma to the fibers (Travell and Simons, 1999). This chronic overload can be caused by clothing and accessories that put pressure over the upper trapezius fibers namely: tight bra straps, sling bags over the shoulders, heavy coats etc. When patients are under stress and anxiety they tend to elevate the shoulders up towards the neck, this elevation causes the upper trapezius fibers to be contracted and shortened to maintain this position and therefore they become over loaded and we start to see micro trauma and active TrP's as a result (Travell and Simons, 1999).

Another author Huguenin (2003) summarised that trapezius TrP's are due to prolonged muscle contraction in inappropriate postures as well added muscle imbalances and postural deficiencies.

2.3.8 Symptoms of active TrP1 in the trapezius

Patients with active TrP1 of the trapezius present to clinical rooms with their shoulders slightly elevated as well as a slight tilt of the neck to the effected side. Patients will often cross their arms and cradle their heads in their hands (Travell and Simons, 1999). When describing their symptoms patients will describe intense poster lateral neck pain that is a dull ache in nature progressing to a burning pain. Often patients report temporal headaches, tooth ache or even ear ache as associated symptoms (Travell and Simmons, 1999). In other cases patients have been known to present with dizziness and vertigo (Gustein-Good, 1940).

2.4 Myofascial Pain Syndrome

2.4.1 Introduction

The break down of the word “myofascial” leads to “myo” meaning muscle and “facia” which means connective tissue.

MFPS is a disorder in which the main source of pain is from myofascial structures, these structures may be located locally or distally to the perceived site of pain. MFPS occur anywhere in the body but more frequently are found in the neck, back, pelvis, hip rotators and postural stabilizers of the upper extremities (Gatterman, 1990).

The main characteristic of MFPS is the presence of TrP’s that relate to the patients pain and their dysfunction (Wolfe, Simons, Friction, Bennet, Goldenberg, Gerwin, Hathaway, Mc Cain, Russel, Sanders, and Skootsky, 1992).

Travell and Simons (1999) describe a general as well as specific definition for MFPS. The general being a regional muscle pain of any soft tissue origin that’s associated with the muscle tenderness. More specifically it is described as a myofascial pain that is caused by TrP’s.

TrP's are most frequently described in the setting MPFS, in which widespread or regional pain is associated with hyperalgesia, psychological disturbance, and significant restrictions of daily activities (Huguenin, 2004). Neural hyperactivity develops at the trigger point, it is this input that causes common musculoskeletal pain (Baldry, 1993).

TrP's can originate in any muscle group, but the most common muscle groups are those involved in posture namely: levator scapulae, upper trapezius, sternocleidomastoid, scalene and the quadratus lamborum. TrP's are not only found in the muscles but also in the tendons, ligaments, joint capsules, skin and periosteum (Manga, 2008)

2.4.2 Myofascial Trigger Points

TrP's are described as hyperirritable spots in a muscle that are associated with hypersensitive palpable nodules in a taut band of muscle. When compressed these points elicit pain but can also give rise to characteristic referred pain, referred tenderness, motor dysfunction and autonomic phenomena (Travell and Simons, 1999). Other symptoms that are apparent with TrP's include, painful restriction of range of motion, reproduction of the patient's pain on palpation, a "jump sign", muscle weakness without atrophy and any autonomic symptoms namely: sweating, localized vasoconstriction and pilomotor activity (Raj and Paradise, 2004).

TrP's can be classed into two groups on clinical presentation, either active or latent. An active trigger point is defined as a point that produces pain without digital compression, tender on palpation, produces characteristic referral pattern for that particular muscle group with or without digital compression, produces muscle weakness, decreases range of motion and reduces flexiability and may elicit a twitch response with digital compression or needle stimulation (Kostopoulous and Rizopoulos, 2001).

Latent TrP's only elicit pain when palpated (Travell and Simons, 1999). Latent TrP's can cause restricted range of motion, muscle weakness and prevent full lengthening of the muscle in which it is located therefore hindering its function (Starlanyl and Copeland, 2001). According to Huguenin (2004) latent TrP's can transform into active TrP's due to various muscle stimuli namely: muscular imbalance poor posture and overuse. Also the transformation is seen if the cause for the latent TrP is not removed or resolved.

Secondary and satellite TrP's develop as result of active and latent TrP's. Secondary, are TrP's that develop due to an overload placed on a muscle as it compensates for the muscle that contains the primary TrP. Satellite TrP's develop in a muscle because that muscle is located in the primary TrP's referral pattern (Starlanyl and Copeland, 2001).

2.4.3 Aetiology of myofascial trigger points.

MFTP are caused by primary as well as secondary factors (Dommerholt and Huijbregts, 2009).

Primary factors

Primary means to have a direct cause for the development of the MFTP. These primary causes can be: trauma, mechanical abuse, adverse environmental conditions, radiculopathy and prolonged contraction of the muscle. The most prominent primary cause being trauma. Trauma causes an inflammatory response, this response leads to the release of bradykinin, prostrogladins, serotonin, histamine and potassium ions. This release in turn results in the activation of A-delta (group III) and C (group IV) sensory nerve fibres. These are our pain nerve fibres and once stimulated patients feel the sensation of pain. Trauma includes excessive exercise of the muscle, repeated minor trauma as well as direct trauma or acute strain to the muscle. (Dommerholt and Huijbregts, 2009).

Within primary causes, TrP's can also be caused by adverse weather conditions such as excessive heat, cold or dampness (Dommerholt and Huijbregts, 2009). Radiculopathy caused by a ruptured intervertebral disc can lead to the development of TrP's in the muscle that is supplied by the compressed nerve, this falls under a primary factor causing TrP's (Travell and Simons, 1999).

Secondary factors

Secondary means to have an indirect cause for the development of TrP's. The main secondary cause being compensating synergistic and antagonistic muscles that lead to the development of TrP's secondary to the TrP's in the primary muscle. This occurs when the primary muscle containing a TrP doesn't function to its maximum strength and full function, the synergistic muscle then has to compensate for this malfunction, causing the synergistic muscle to become overloaded and finally developing multiple TrP's.

Antagonistic muscles will develop secondary TrP's when the antagonistic counteracts the tension in the primary muscle which contains the primary TrP (Dommerholt and Huijbregts, 2009)

As mentioned previously TrP's can develop in the pain referral zones of the primary TrP these known as satellite TrP's are also a form of secondary cause/development of TrP's (Dommerholt and Huijbregts, 2009).

2.4.4 Perpetuating factors of myofascial trigger points

Perpetuating factors are those that make the muscle more susceptible to the development of TrP's. It is vital for a clinician to take note of these factors as it will affect the treatment protocol as well as the prognosis (Auleciems, 1995).

Perpetuating factors include: mechanical stresses, as seen with skeletal asymmetry (short leg or hemi pelvis), skeletal disproportion (short upper arms)

and muscular stress (poor posture, constricting pressure on muscle, prolonged immobility and abuse of muscles) (Dommerholt and Huilbregts, 2009).

Psychological factors can also be seen as perpetuating such as with tension, depression and anxiety. These factors make the muscle more prone to development of TrP's but also prevents rapid recovery of the TrP's (Rickards, 2006).

Nutritional inadequacies are often overlooked but are factors that make a muscle more prone to TrP development. For the normal functioning of a muscle the following nutrients play a vital role namely: Vitamins B1, B6, B12, C and D, potassium, folic acid, calcium as well as iron. Low levels of any of these nutrients will disrupt the energy supply to muscles which in turn leads to TrP development (Mense and Gerwin, 2010).

Metabolic and endocrine inadequacies are perpetuating factors that include: hypothyroidism, hypocalcaemia, hypoxia, hyperuricemia and anemia. These insufficiencies will affect muscle metabolism and its recovery after exercise or stress, this all making the muscle prone to the development of TrP's (Mense and Gerwin, 2010).

Lastly factors such as chronic infections caused by viruses, bacteria, parasite invasion all affect muscle recovery and often muscle functioning leading to a greater risk of TrP development. Allergies and chronic visceral disease can also perpetuate the development of TrP's in the muscle (Rickards, 2006).

2.4.5 Pathophysiology of myofascial pain syndrome

Looking at the development of MFTP there is no definite scientific theory that can fully explain the pathophysiology behind the nature of myofascial TrP's (Bennett, 2007; Rickards, 2006). There are two theories that are most widely accepted namely: the energy crisis theory and the motor endplate hypothesis which in

conjunction provide the most credible explanation (Huguenin, 2004). The third theory was developed by Travell and Simons (1999), who took a combination of theory from the electrophysiological and the histopathological sources and concluded with an integrated hypothesis.

The Energy crisis theory

This theory being the first theory used as an explanation of trigger point development was founded in 1981. It postulated that the increase demand on the muscle resulted in macro or micro trauma to the muscle and in essence the sarcoplasmic retinaculum or the sarcolemma. This damage resulted in the muscle releasing calcium ions (Travell and Simons, 1999 and Huguenin, 2004). The increase of the calcium ion concentration leads to an activation of actin and myosin contractile activity. This sustained contraction increases the metabolic demands but at the same time compromises local circulation (Mense and Simons, 2001).

The mechanism for the sustained contraction of the muscle is continued irregular depolarization of the sarcolemma (postjunctional membrane). The depolarization is based on the excessive ach release from the dysfunctional nerve terminal (Travell and Simons, 1999). The depolarization results in action potentials being able to cross the neuromuscular junction and sarcolemma causing a sustained muscle contraction (Marieb, 2001).

The compromised blood supply leads to a drop of oxygen supply to the cells, cells need oxygen in order to produce adequate adenosine triphosphate. ATP is needed to initiate the active response of muscle relaxation (Dommerholt and Huijbregts, 2009). This shortage of ATP leads to taut bands found within the muscle. There is impaired function of the calcium pump causing levels of calcium to remain elevated and in turn causing activation of actin and myosin filaments as mentioned above (Dommerholt, 2004). The muscle remains in a contracted state therefore has a high metabolism and is producing metabolic by products. The

accumulation of the metabolic by products results in pain production at the TrP, by sensitization and direct stimulation of the sensory nerve fibers or noiceptors. We see a self-sustaining cycle whereby the mechanism “feeds” or drives itself (Huguenin, 2004).

The by-products of metabolism are: adenosine triphosphate, phosphocreatine and Adenosine diphosphate. These by products are phosphate containing compounds used to measure energy stores. The phosphate containing compounds donate their phosphate and this in turn causes a release of energy used in muscle function and thus compounds become low energy phosphates. From this a deduction can be made that TrP’s contain a smaller number of high energy phosphates and a high number of low energy phosphates (Partanen, Ojala and Arokoski, 2010). An early study that was conducted by Bengtsson, Henrikkson and Larsson (1986) found that high energy phosphates levels were reduced while low energy phosphate levels increases at the TrP sites. Therefore the findings of this study support the energy crisis theory.

The motor endplate hypothesis

The motor endplate hypothesis major foundation for the development of TrP’s is that the dysfunction occurs at the motor end plate. The terms end plate and neuromuscular junction are used interchangeably as the endplate represents the physical structure whereas the neuromuscular junction represents the function of the structure. Using an EMG, Hubbard and Berkoff (1993) showed that a TrP consists of small loci produce a characteristic electrical activity. They found both low-voltage continuous noises as well as intermittent spikes at the TrP location. Active loci producing electrical activity have been found grouped together within region of a clinically-identified TrP as well as loci being found among normal endplates. The localization of active loci in the endplate zone predominantly at the TrP has been confirmed experimentally (Simons’ and Hong, 1995).

The increased rate of release of Acetylcholine (ACh) from the nerve terminal was thought to be the cause for the endplate noise (Huguenin, 2004). This small amount of activity is not enough to cause a muscle contraction however is does result in action potentials being propagated a small distance along muscle cell membrane which in turn activate a few contractile elements of the muscle leading to a small degree of shortening.

The integrated hypothesis

The integrated hypothesis is a combination as said previously of electrodiagnostic and histopathological evidence (Dommerholt, Bron and Franssen, 2006). Combining these different arms of evidence indicates that a TrP is a region of numerous dysfunctional endplates and that each individual dysfunctional endplate is responsible for a section of the muscle fiber being maxiumally contracted. When combining these multiple dysfunctional endplates we see a larger area of contraction and a palpable “knot”. The integrated hypothesis links a contraction knot and dysfunctional endplate (Travell and Simons, 1999).

An initial insult to the muscle cause the mechanical rupture of the sarcoplasmic retinaculum or the muscle cell membrane itself. This damage leads to a release of stored calcium in the sarcoplasmic retinaculum. Calcium’s main function is to activate the myosin and actin filaments during contractile activity (Mense and Simons, 2001).

The sustained contractile activity of myosin and actin filaments leads to an increase in the muscle fibres metabolic demands. The muscles hypertonic state blocks the rich capillary blood supply to the muscle area, resulting in the fibre not being able to receive oxygen and nutrients. The combination of an increase demand and decreased supply can result in a severe energy crisis (Mense and Simons, 2001).

Simultaneously there is an excess release of acetylcholine (ACH) from the dysfunctional nerve terminal, this leads to abnormal depolarization of the postjunctional membrane. Therefore there is maximum contraction of the muscle fibres in the vicinity of the motor end plate. This contraction can be sustained without motor unit action potentials (Mense and Simons, 2001).

We see a drop in the ATP levels as the muscle becomes exhausted. This ATP is required for the calcium pump to pump calcium back into the sarcoplasmic retinaculum. When this calcium pump fails the contractile mechanism persists which then in turn continually leads to further failure of the calcium pump. Once ATP resources are exhausted a sustained contracture develops and this then completes the vicious cycle (Travell and Simons, 1999).

Severe tissue hypoxia and energy crisis as seen at the end of the cycle, stimulates the production of neuro-vasoreactive substances that will sensitize local noiceptors (Travell and Simons, 1999).

EMG studies have shown that there is spontaneous electrical activity at the TrP region this is believed to be due to the heightened levels of acetylcholine release by the dysfunctional terminal branch. Research showed that through these EMG studies that there are multiple sensitive loci that are concentrated in the region of a TrP. When these sensitive loci cause tenderness, referred pain and a local twitch response when stimulated mechanically, that are most likely noiceptors (Travell and Simons, 1999)

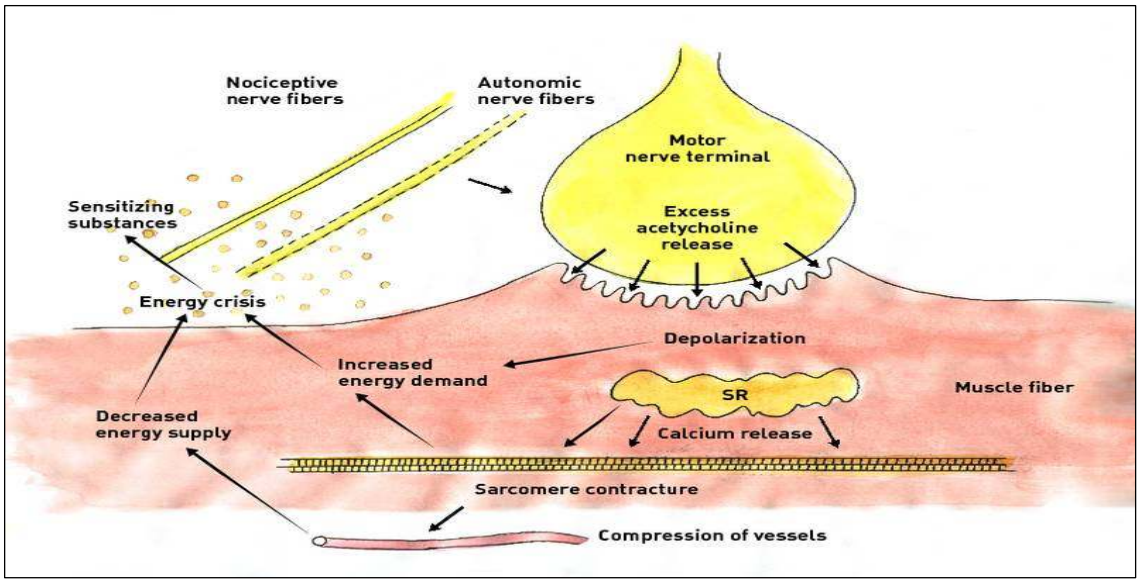


Figure 2.5 Integrated hypothesis illustration (Travell and Simons, 1999).

2.5 Management of myofascial pain

When treating MFPS the goal during treatment is to decrease the patient's pain and stiffness of the involved muscle and thereby increasing the patients ROM (Cummings and Baldry, 2007). MFPS is not completely curable but can be effectively managed and has an excellent prognosis when treated correctly (Auleciems, 1995). For treatment a multidisciplinary approach is needed where it is vital to diagnose and remove the perpetuating factors (Bruce, 1995). Han and Harrison wrote that treatment of MFPS needs to focus on both the physiological as well as the psychological stresses that are involved in the development and progression of the syndrome. As mentioned previously with correct treatment prognosis is excellent, however long-term treatment is required as well as lifestyle modification.

Treatment of MFPS needs to aim at disrupting and reverberating the neural circuits that are responsible for the self-perpetuation of the pain-spasm-pain cycle. This is achieved by inactivating the active TrP's found in a taut band of the involved muscle (Gatterman, 1990). There are numerous modalities that are aimed at inactivating TrP's namely: ice, heat, massage, ischemic compression, translucent electrical nerve stimulation, ultrasound, spray and stretch and dry needling.

2.5.1 Diagnosis of MFPS

To diagnose MFPS the practionaire needs to identify at least one clinically relevant TrP (Fernandez-de-las-Penas et.al, 2010). This identification is done by palpation and observation of the involved muscle. Palpation of the muscle elicits as well as can worsen the patient's referred pain for up to 48 hours, this makes it's vital to a practitioner to only examine for TrP's if myofacial therapy such as, cryotherapy, heat therapy or dry needling etc. will be used. The diagnostic criterion of a TrP on examination is tenderness at the nodule in a palpable taut band. This taut band feels like a palpable cord of tense muscle fibers along normally pliable fibers (Travell and Simons, 1999).

Palpation can be divided into: flat palpation, pincer palpation and deep palpation (Travell and Simons, 1999).

Flat palpation: the practitioner uses fingertip to slide the patient's skin across the muscle fibre (Figure 4), this movement will detect changes in the underlying structures (Travell and Simons, 1999). Flat palpation is used in an initial survey of the muscle to establish tone and any superficial tenderness (Yap, 2007). The practitioner will identify a ropy structure (taut band) as the finger rolls over the affected area. A snapping movement can also be made when using flat palpation, the sensation is compared to that of plucking a violin or guitar string (Travell and Simons, 1999). Often when snapping or when inserting a needle into the active locus of the TrP, a local twitch response can be visualized as well as felt, this helps identify the active TrP (Travell and Simons, 1999).

Pincer palpation: this palpation involves the practitioner grasping the belly of the muscle between the thumb and fingers, pressing the fibers between them and rolling the fingers back and forth. Once a taut band is identified, it is palpated along it length to find the area of maximum tenderness, which helps to identify the active TrP (Travell and Simons, 1999). When the practionaire is able to take a firm hold of the belly of the muscle, pincer palpation is preferred (Baldry, 1993).

The upper fibers of the trapezius muscle, as used in this trial, should be palpated for TrP's using pincer grip palpation (Dommeholt et al., 2006).

Deep palpation: this palpation is used when intervening tissue makes the muscle inaccessible to flat or pincer palpation. In deep palpation the practionaire places fingertip over the skin that lies over the motor point region or the attachment of a muscle suspected of harbouring TrP's (Travell and Simons, 1999).

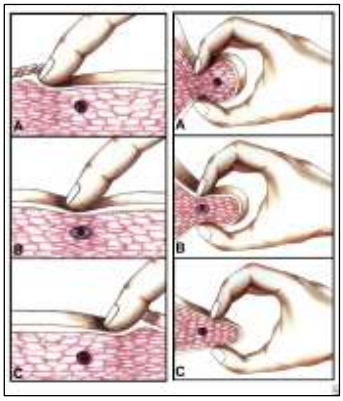


Figure 2.6: Cross sectional schematic drawing of pincer palpation, to localize taut band (Travell and Simons, 1999).

2.5.2 Treatment of MFPS

When treating MFPS and TrP's the following does need to be considered (Hong, 2006):

- Conservative versus invasive therapy: invasive therapy should only be considered once all conservative methods to treat TrP's have failed.
- Pain recognition: practitioner must consider which TrP's are the primary cause for patients discomfort and pain, treat those. Also the practitioner must distinguish between the active TrP's and the secondary or satellite latent TrP's.
- Superficial versus deep: the practitioner needs to distinguish the exact location of the TrP and whether it is superficial or deep, as there are different treatment methods required for different locations.

- Acute versus chronic: only if pain is unbearable should a TrP be inactivated in the acute stage.
- Eliminate the perpetuation factors: the factors that are responsible for the development or persistence of the TrP need to be identified and removed.
- Patient education: patients need to understand that the syndrome requires long-term treatment as well as lifestyle modifications it's important to educate them on this.

In chiropractic a manual approach is utilized when treating MFPS (Molina, 2000). There are numerous different modalities namely: stretch and spray technique, ischaemic compression, massage, application of heat or cryotherapy, ultrasound, diathermy, transcutaneous electrical nerve stimulation (TENS), exercise, acupuncture, trigger point injection or dry needling (Alvarez and Rockwell, 2002).

Spray and Stretch

A vapocoolant spray is applied to the area that the patient is experiencing pain. This spray blocks reflex spasm and pain allowing for the gradual and passive stretching of the muscle and in turn leading to inactivation of the TP (Auleciems, 1995). The muscle length will be restored and the muscle tension eliminated leaving the patient free of muscle spasm, sensitive points and referred pain (Raj and Paradise, 2004).

Tens

This modality is widely used and is a popular option for patients suffering from MFPS. At settings of low intensity the TENS machine selectively activates the large diameter nerve fibers, these fibers relay back to the spinal cord and close the pain gate in the dorsal horn of the spinal cord. The closing of the pain gate eliminates the patient's perception of pain (Melsack and Wall, 1985).

Ultrasound

This is another widely used modality in the treatment of MFPS, it uses high frequency acoustic energy generated using the reverse piezoelectric effect. Ultrasound is known to have both thermal as well as non-thermal effects on the tissues (Esenyel, 2000). These effects help to reduce joint stiffness, muscle pain and spasm, increase blood flow and even stimulate soft tissue repair and regeneration (Rickards, 2006).

Massage, Ischaemic compression, Acupressure

Massage and ischaemic compression are manual techniques that mechanically help to break down fibrous bands that form in the muscles involved in MFPS. This manual therapy also helps to aid circulation to the area, reduces muscle spasm and can when applied correctly elicit a “twitch response” this response helps in deactivating the Tp (Travell and Simmons, 1999).

Heat

Moist heat increases blood flow to the area that is affected in MFPS. This added blood flow does help in decreasing tension and relaxing the muscle. This effect will in turn decrease the patient’s referred pain and local tenderness (Auleceims, 1995).

Cold

Applying cold to the area depresses the nerve endings also it increases pain threshold. This will lead to the muscle decreasing its contractility and decrease the tension at the Tp site all aiding in pain relief and resolution of MFPS (Prentice, 1994).

Dry needling

Dry needling can deactivate active foci within the muscle fibres with rapid needle Insertion into multiple sites within the TrP’s this helps relieve pain, muscle spasm and referred pain (Travell and Simmons, 1999). Dry needling will be discussed further as this modality was chosen for this study in the treatment of MFPS.

2.6 Myofascial Dry Needling

Myofascial dry needling is an invasive technique that involves the insertion of an acupuncture needle into the active trigger point. The aim of myofascial dry needling is to reproduce the patient's symptoms, visualize and palpate the local twitch response, finally achieving relief from muscle pain and tension (Huguenin, 2004). Needling (including myofacial TrP injection, dry needling and acupuncture) has proven to be one of the most effective methods used to treat MFPS when preformed correctly (Hong, 2006).

A study done by Dommerholt, Bron and Franssen (2006) found that 75% of South African physical therapists use dry needling at least once a day in their practices. When needling techniques where compared to other less invasive modalities, it showed that needling techniques showed results a lot quicker than the non-invasive methods (Srbely, 2010). When looking at medicinal trigger point injections, unwanted side effects showed up such as allergic reactions, muscle necrosis (Baldry, 2002; Travell, Simons and Simons, 1999), tendon atrophy, skin depigmentation, apnoea, syncope and palpitations (Ruane, 2001). In eliminating the TrP by needling the focus is on mechanically disrupting a TrP rather than the solution that is injected into the TrP. Therefore it has been concluded that dry needling is the safest recommendation for a patients suffering from MFPS (Rickards, 2006).

The effectiveness of dry needling treatment is directly dependant in the intensity of the pain produced at the trigger zone and the precision of the practitioner to direct the acupuncture needle into the exact area of maximum tenderness.

The needle once inserted if penetrating normal muscle will have little to no resistance, when compared to a needle inserted into a contracture (as seen with TrP). When inserted into a contracture there will be dense resistance to needle insertion and the muscle will grasp onto the needle. This grasp of the muscle onto the needle will present as an atypical cramp-like grabbing sensation, as well

as a referred pain pattern specific to that muscle. It will be these signs that will aid the practitioner into locating the exact area of insertion that will result in the most effective dry needling for the patient (Gunn, 1989).

The aim of dry needling is to break up the TrP. The needle is directed to the point of maximum tenderness within the taut band, felt on palpation. When the inserted needle penetrates into the TrP it disrupts the taut band this may manifest as a local “twitch response” this response will be both visualized and felt (Yap, 2007). Dry needling as mentioned previously is known to be a very effective treatment of MFPS, it is thought that the needle causes a local twitch response which inhibits abnormal end plate noise and starts to restore the chemical imbalances found at the trigger point site. This treatment is usually rather painful for the patient but not unbearable. The mechanical disruption that the dry needle causes can also injure neighbouring structures such as: nerves, blood vessels etc. (Baldry, 2002). This minor injury and disruption causes a series of responses, namely inflammation. This pain is frequently perceived as post-needling soreness and may last up to two days. Post needling soreness however is distinguishable by the patient to that of the original pain complaint arising from MFP (Dommerholt, 2004).

2.6.1 Mechanism of myofascial dry needling

Dry needling treatments main role is to cause mechanical disruption of the TrP, release endorphins, inhibit nociception and provide pain relief by spinal cord modulation (Yap, 2007).

Various mechanisms have been proposed to play a role in the deactivation of MFTPs by the use of dry needling (Dommerholt and Huijbregts, 2009).

Rachlin (1994) summarized the mechanism of pain relief following TrP dry needling as follows:

The dry needle once inserted into the active TrP site, causes a mechanical disruption of the muscle fibers. This disruption leads to a release of extracellular

potassium, that in turn causes depolarization of the nerve fibers. Pain relief results due to an increase in endogenous opioids namely: neurohormonal beta-endorphins or somato-specific dorsal horn enkephalins which will alter the ventral feedback mechanism for pain perception.

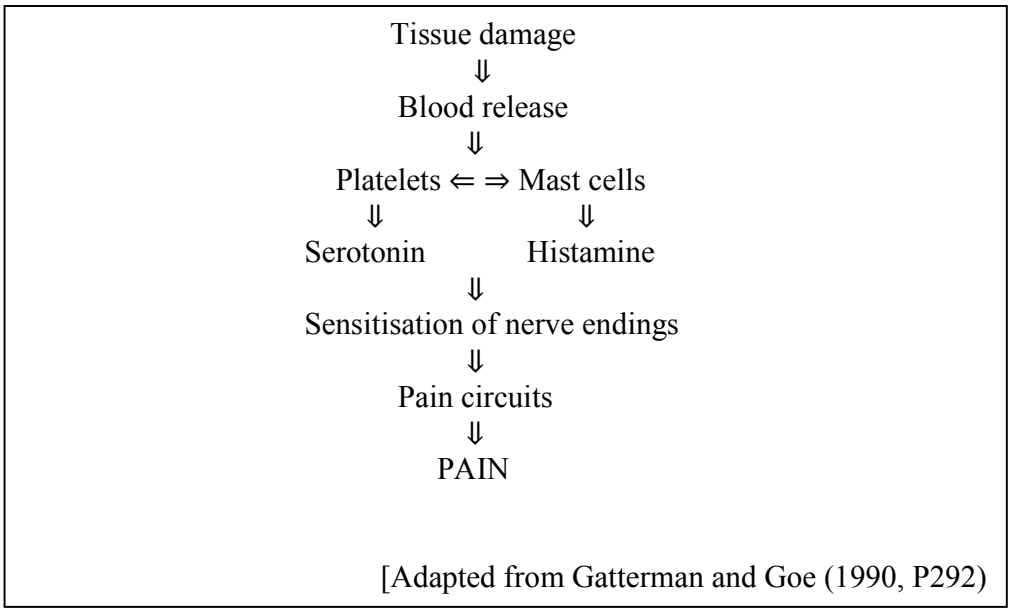
The process and method of dry needling can injure surrounding structures for example: nerves, blood vessels etc. (Baldry, 2002). This micro-damage results in an inflammatory response which is characterized by swelling, redness, heat and pain (Michlovits, 1996). This pain known as post needling soreness may last up to two days prior to dry needling treatment (Dommerholt, 2004).

2.7 Post needling soreness

Post needling soreness is defined as the pain that is felt by the patient due to the dry needling treatment. The patient is able to clearly distinguish this pain from the original complaint, post needling soreness is a completely separate entity from myofacial pain (Lewit, 1979). The pain is characterized as a constant pressure, dull ache pain, very similar to that of a bad bruise. This pain often discourages patients from receiving further needling, which is required to achieve resolution from MFPS. Some patients are discouraged from further treatment at all (Hong, 1994).

The post needling soreness described by patients following dry needling is more intense as well as longer lasting then patients who receive lidocaine injections, although post needling soreness is still reported by both groups of patients (Alvarez and Rockwell, 2002).

Post needling soreness is found to be worse if bleeding occurs whilst injecting or needling the trigger point (Travell, Simons and Simons, 1999). The following flow diagram taken from Gatterman and Goe (1990: P292) illustrates how tissue damage that is caused by dry needling and other needling techniques leads to the development of pain.



A previous study conducted by Ferreira (2006) investigated whether dry needling muscle tissue in asymptomatic subjects resulted in post-needling soreness. The study was a randomized, placebo-controlled experimental investigation that was made up of 60 subjects between the ages of 18 and 50 that were asymptomatic for lower back pain and were randomly allocated into three equal groups. Group one received dry needling using single insertion technique. Group two received the fanning dry needling technique, whereby a needle is inserted into the trigger point then removed into the subcutaneous tissue and then reinserted into the trigger point approximately ten times, the needling is never completely removed from the skin until after treatment (Travell, Simons and Simons, 1999). Group three made up a control group and placebo needling's were used to treat those subjects. The finding according to the NSR 101 and 24-hour pain diaries revealed that asymptomatic subjects in both group one and two experienced post needling soreness.

Another study conducted by Hong (1994), was a double blinded controlled study that investigated the effects of lidocaine injections versus dry needling of the upper trapezius myofascial TrP's in 58 subjects. The finding revealed that all

patients within the dry needling group developed post-needling soreness 2-8 hours after receiving needling. This post-needling soreness was of greater intensity and longer duration then those treated with lidocaine injections. Post-needling soreness is at its most severe 22-24 hours after the injection (Hugenin, 2004).

Many previous authors namely (Hong, 1994; Ferreiria, 2006; Travell, Simons and Simons, 1999), have all suggested that moist heat, application of pressure to prevent haemostasis and stretching should be used as a means to relieve some of the post-needling soreness experienced by a patient receiving dry needling. Patients still find dry needling painful, often being discouraged from this form of treatment, therefore an effective modality to reduce this post-needling soreness needs further investigation (Hugenin, 2004).

2.8 Modalities to alleviate post-needling soreness

2.8.1 Heat therapy

Heat therapy is one of the oldest modalities used to aid in pain relief. Heat therapy can date back as far as 3000BC as recorded in the Egyptian Edwin Smith's surgical papyrus (van der Zee, 2002). Heat therapy is any application of additional heat to the skin or body that will result in the increase of tissue temperature (Nadler, Weignand and Kruse, 2004) Heat therapy will cause an increase in blood flow, metabolism, connective tissue extensibility and finally provides pain relief (Nadler, Weignand and Kruse, 2004). All these qualities of heat when looked at in the MFPS model will decrease tension at the TrP site and decrease the patient's referred pain (Ga et al, 2007).

The effects brought on by heat can be divided as such: effects that are brought on by direct physical or chemical changes that occur at a tissue level due to the increase in temperature. And then effects that are brought about indirectly through neural and circulatory mechanisms that occur when temperature increase (Hooper, 1996).

When looking at heat one of the first changes we see in the tissue when heat is added is an increase in the blood flow, this increase occurs due to vasodilation of the skins superficial blood vessels. These superficial blood vessels are the body's most direct method of dissipating heat and controlling an optimal tissue temperature. Vasodilation occurs via a neural response, spinal reflex or an axonal reflex that originates from branches of receptor neurons in the skin, these neurons being the first to pick up the sensation of heat to the skin. Vasodilation is then further facilitated by chemical mediators such as Histamine and Prostaglandins. Lastly capillary permeability is increased as temperature rises, resulting in more oxygen delivery to the area. Also an increase in waste exchange is able to occur through more permeable capillary walls (Hooper, 1996).

There is an increase in cell metabolism which is the cells basic functioning that is increased when the temperature rises. This increase in function will aid in the healing of tissue as the influx of blood brings the correct healing chemical mediators and removes waste products (Hooper, 1996).

Heat is known for its ability to decrease pain, there are numerous hypothesis that explain this mechanism. These hypothesis can be divided into a neural response, muscular response and lastly a vascular response.

The neural hypothesis to heat is that the nerve fibres that detect this increase in temperature when heat is applied to the skin, are delta A fibres and C fibres. These nerve fibres also detect pain at this area. More of these fibres will be sensitized to the added heat than those that are activated by the pain, therefore fibres will be blocked to the pain and will rely a sensation of heat detection back to the spinal cord and in turn the brain, leading to less sensation of pain (Hooper, 1996).

A muscular response to added heat is also known as the pain-spasm-pain cycle. Pain that arises from a soft tissue injury or dysfunction occurring at this level often results in what is known as a muscle spasm, this is a sustained muscle contraction. By increasing the temperature of type II muscle spindle fibres, there will be a decrease in the discharge from these afferents that in turn causes a decrease in alpha motor neuron firing. Another aspect to a temperature increase is at the Golgi tendon organ of the muscle a rise in temperature here will result in an increase in the tendons firing. This has an inhibitory effect on the alpha motor neurons. If we combine the two above reactions to a temperature increase we see a decrease of firing of type II fibres and finally a release of tension. If the spasm decrease is great enough the pain-spasm-pain cycle will be broken and there will be a drastic decrease in perceive pain by the patient (Hooper, 1996).

Lastly the vascular mechanism results in a pain decrease indirectly through metabolic and circulatory means. As mentioned above the rise in temperature increases blood flow to the area and increases blood vessel permeability. Therefore removal of waste products and elimination of chemical irritants that cause pain, results (Hooper, 1996).

The therapeutic benefits summarised are:

- Increasing pain relief (Nadler, Weignand and Kruse, 2004).
- Increasing metabolism (Nadler, Weignand and Kruse, 2004).
- Decreasing muscle spasm (Nadler, Weignand and Kruse, 2004).
- Reducing disability (Nadler et al 2003).
- Increasing flexibility (Nadler et al, 2003).
- Reducing muscle stiffness (Nadler et al, 2003).

A 1 degree increase in the tissue temperature can increase the tissue metabolism by 10%-15% (Cameron, 1999). By increasing the tissues metabolism the healing process is also sped up as both metabolic and catabolic reactions needed to degrade and remove metabolic waste by-products are increased.

Increasing in blood supply also helps transport the correct cells that are needed in healing to the site of injury (Nadler et al, 2003).

Contraindications to heat therapy (Hooper, 1996)

- Malignancy
- Areas of diminished sensitization
- Patients receiving radiation therapy
- Bleeding tendencies
- Peripheral neuropathies
- Peripheral vascular diseases
- Over pregnant uterus
- Acute inflammatory disorders
- Skin rashes or over open wounds
- Over metal objects

2.8.2 Ultrasound

Ultrasound is a modality often used in clinical practice as a method to relieve the symptoms of post-needling soreness. Ultrasound energy is produced by converting electrical energy into mechanical energy in the form of sound waves. This is achieved through the piezoelectric effect. The piezoelectric effect involves transmitting a current through a crystal, this current causes the crystal to deform. The crystal is attached to a front plate, a change or deformation in the crystal causes this metal plate to move which in turn produces what we know as an ultrasonic wave (Forester and Palastanga, 1990). The operator is able to maintain control on the frequency current that is conveyed via coaxial cable to a transducer circuit and finally the crystal, thereby the operator can maintain a steady and regular rate of deformation at the crystal (Forester and Palastanga, 1990).

The unit that is used to measure ultrasound intensity is Watts, but this measurement is a gross measure of the power that is emitted by the treatment

head, therefore an average of this is usually used. The space averaged intensity is where the average intensity over a specified area is given e.g. Watts per centimetre squared (Forester and Palastanga, 1990). The operator need to decide on the intensity before treatment commences, this will be determined according to condition to be treated as well as the thickness of the body part to be treated. An example of settings can be: a chronic condition that requires deep penetration, settings will be 1.5w/cm on 2MHz for approximately 6minutes on continuous mode (Hooper, 1996).

When using ultrasound it is vital to use a coupling agent between the sound head and the skin in order to ensure that the ultrasound waves have a medium in which they can transmit through. The coupling agent needs to have the following properties: needs to be able to transmit ultrasound waves, needs to fill undulations with no air bubbles between the sound head and skin, absorb little sound, be stainless to clothing, and be hypo allergic and lastly inexspensible and easily available (Reid, 1992).

Ultrasound waves are thought to penetrate an average of 4-6cm into tissues. If the tissues have a high fluid content such as blood and muscles then sound waves will transmit much deeper than that of less hydrated tissue (Hopper, 1996).

Ultrasound waves has the following effects on tissues: It helps facilitate oxygen delivery, enhances micro-circulation reduces muscle pain and spasm, alters metabolic rates, enhances healing, increases tissue excitability and alters the extensibility of connective tissue. The thermal effects main property is the ability of the ultrasonic waves to increase the tissues temperature. This increase in temperature will result in a decrease in joint stiffness, reduction in muscle pain and spasm, production of a mild inflammatory reaction and causes an increase in blood flow. This increase in blood flow helps to resolve chronic inflammation and in turn helps resolve chronic pain (Rickards, 2006).

Non thermal effects of ultrasound include: stimulation of tissue regeneration, improvement of blood flow, stimulation of protein synthesis and finally aids in soft tissue repair (Hogan, Burke and Franklin, 1982).

Reid (1992) summarises the main effects of ultrasound on body tissues as follows:

- Reduction in inflammation
- Reduction in pain and spasm
- Promotion of healing
- Increase in extensibility of scar tissue
- Ability to perform phonophoresis

Contraindications to ultrasound (Forester and Palastanga, 1990)

- Vascular conditions- such as in thrombophlebitis, isonation can cause the emboli to breakoff
- Acute sepsis- there is danger of the infection spreading
- Radiotherapy- radiation causes tissues to be devitalized, therefore ultrasonic therapy is contra-indicated for six months prior to radiation
- Tumours- not isonated as risk of tumor growth of throw off of metastases
- Pregnancy- there is a risk of damage to the foetus or foetal development, therefore abdomen and lower back are contra-indicated in pregnancy
- Cardiac disease- these patients can be treated but at very low frequencies and intensities, to prevent sudden pain in these patients

2.8.3 Moxibustion

Moxibustion is known to be a heat treatment that will stimulate specific acupuncture points on the body. Indirect moxa is more popular than the direct moxa due to the much lower risk of burning and pain for the patient. Indirect

moxa induces a gradual warmth and vasodilatation response. (Hideaki- Tanaka, 2003)

Clinical studies have shown that moxibustion enhances immunity, improves circulation, accommodates neural response, elevates internal metabolism (Wu et al, 2001; Liu, 1999). However, moxibustion has not been accepted as a modern therapy due to the lack of research in standard practice as well as the risk of scalding patients (Huang et.al. 1997).

Existing moxibustion therapy techniques are divided into direct or indirect therapy. In this study indirect moxibustion was used, as this form poses the lowest risk of burning the patient. A moxa cone is placed on the inserted acupuncture needle, this moxa cone will then be ignited. Heat generated from the burning moxa will propagate through the needle and transfer a heat indirectly to the needles insertion point. Typically the distance between the skin and the burning moxa cone is about 2cm, the heat from the moxa cone will therefore not only cause heat to transfer into the underlying tissues but will bring warmth to the superficial skin directly under the cone (Huang et.al 1997). This design of heat conduction is known to enhance and follow the laws of the Seebeck effect, which is defined by heat being applied to one conductor will cause heated electrons to flow to a second cooler conductor, thus being the heated needle the first conductor and the second being the body and its tissues (Cohen, 1997).

It has been shown in a study run by Seung-Ho Yi (2009), whereby temperature measurements were taken using burning moxa technique and a garlic slice, that the maximum temperature that was recorded using indirect moxa was between 40-45 degrees of Celsius and that the total number of consecutive moxa on one slice was three.

Another study done by Huang *et.al.* (1997), that when using Moxibustion on a needle, the temperature along the centreline of the acupuncture needle

decreases very quickly from the centre of the burning moxa. The temperature heat of the needle showed to be only 1 degree higher than predicted temperatures elsewhere. This result will explain why we use the terms “warm needle treatment” as opposed to “hot needle treatment”. The heat felt at the trigger point and surrounding tissues is more of warmth then a hot heat.

Figure 2.7: Photo to illustrate burning of moxi cigar (C.J.Hogan, 2010)

Contraindications to the use of moxibustion (C.Dan-an and W.Ming, 1996).

- Febrile disease, especially where fever is present
- Back or the lower abdomen of a pregnant uterus
- Not used in vicinity of sensory organs e.g.: eyes, mouth or mucous membranes
- Avoid use over large blood vessels
- Avoid large creases namely: knee and elbow
- Not used over areas that are numb or have loss of sensation

2.9 Conclusion

MFPS is a musculoskeletal condition that is associated with the development and presence of myofacial TrP’s. This literature review has extensively covered the pathology behind this syndrome and treatment thereof with particular regard to the trapezius muscle. Special attention has been given to dry needling and post-needling soreness. Modalities to alleviate this post-needling soreness as well as too establish the most effective way to treat MFPS have been defined. Special attention is given to ultrasound and moxibustion.

The following chapter will describe the methods used to conduct this study.

CHAPTER THREE: METHODOLOGY

3.1 Introduction

This chapter serves to explain and describe in detail the way in which this study was constructed and carried out.

3.2 Study design

The study will be a comparative descriptive study. The three groups results were compared and contrasted to each other and final deductions were made.

3.2.1 Participant recruitment

Participants were required to receive treatment during the study. Treatment was at the Chiropractic day clinic of the University of Johannesburg, Droonfontein campus. Participants were recruited via advertisements (Appendix C) that were placed in the Day clinic as well as around the Droonfontein campus. Participants were also recruited via word of mouth. Only participants who met the inclusion and exclusion criteria were selected for the study.

3.2.2 Sample Selection and Size

Participants who presented with an active TrP1 of the trapezius muscle were considered and asked to take part in the study. The study required 90 participants. Those participants that showed an interest in taking part in the study had all procedures fully explained to them, and then were requested to sign an Information and Consent form (Appendix D).

3.2.3 Inclusion Criteria

- Participants needed to be over the age of 18 years
- Participants needed to have an active trapezius TrP1, either on the left or right

- Participants needed to have read and signed the informed consent form, undergone a complete case history, physical as well as cervical and shoulder regional

3.2.3 Exclusion criteria

- Any participant who exhibited contra-indications to Dry Needling (Appendix E)
- Any participant who exhibited contra-indications to Ultrasound therapy (Appendix F)
- Participants who had received dry- needling of the Trapezius two weeks prior to study
- Participants who had allergies or had negative reactions to light smoke were excluded from the study

3.3 Group allocation

Participants who met all criteria were divided into three groups of 30 participants each (total of 90 participants) by means of pulling numbers from a hat to maintain randomization. Participants in group one received DNT of TrP1 of the trapezius. Participants in group 2 received DNT of TrP1 of trapezius followed by six minutes ultrasound therapy over the area. Group 3 received DNT with the addition of moxi cigar as a means of heat transferal during treatment.

3.4 Treatment approach

3.4.1 Trigger point one of trapezius location

For this study, participants in all three of the groups received dry needling of trigger point one of the trapezius. During the cervical regional examination each participant underwent palpation of the upper fibres of the trapezius muscle. There are two trigger points located in these fibres namely TrP1 and TrP2, for this study TrP1 was dry needled using an acupuncture needle. During palpation the patient was lying prone with their head slightly tilted to the side that was examined, this creates muscle slack. The practitioner then used pincer grasp to lift the upper

fibres of the trapezius off the underlying supraspinatus muscle and the apex of the lung. The practitioner rolled the trigger point between the thumb and index finger to palpate the nodules and bands and identify the area of maximal point tenderness, TrP1 is found in the mid-portion of the anterior boarder of the trapezius. This trigger point involves the most vertical fibres that attach anteriorly to the clavicle (Travell and Simons, 1999).

3.4.2 First and follow up visits

Participants who had met all inclusion criteria for the study were asked to undergo treatment depending on the group they were selected for.

The following procedure took place for Group 1, Group 2 as well as Group 3:

- A full patient history and cervical and shoulder regional was taken for every participant
- Before treatment, participants were asked to fill out a numerical pain rating scale (NPRS) (Appendix A)
- A CROM device was used to record information regarding range of motion of the cervical spine before treatment
- Participants then lay prone on the chiropractic bed and an algometer reading of active trapezius TrP1 was recorded
- The predetermined active trapezius TrP1 was dry-needled following normal dry-needling protocol
- Group 3:
    - As above, except that once inserted, the dry needle had a moxi cigar placed on top of the needle, this cigar was lit to heat the penetrating needle
- The second CROM and algometer readings were taken for all three groups once the acupuncture needle had been removed after 10 min
- Group 1:
    - The participant was requested to wait 7 minutes before the second algometer and CROM readings were taken

- Although this is a commonly used, and standard treatment protocol, if the patient feels that the pain is unmanageable the participant was told to inform the researcher so that treatment for post needling pain can be done. The participant would have been withdrawn from the study

- Group 2:
  - The participant had ultrasound therapy over the needled area for 6 minutes.
  - Two minutes was allowed for the researcher to gather equipment and perform second algometer and CROM readings.
- Group 3:
  - The participant was requested to wait 7 minutes before the second algometer and CROM readings were taken
- The participant was then sent home and asked to start a pain diary (Appendix B) that would be filled out at 4 different intervals (4hrs, 8hrs, 12hrs and 24hrs) as a means of determining when post-needling soreness set in and when it subjectively was recorded as the worst
- To ensure that the pain diary was filled out at the correct time intervals, participants were asked whether they had a cellular phone on which they were requested if the researcher may set an alarm as a reminder as to when the pain diary needed to be filled out. For the participants who did not have a cellular phone, an alarm clock with the times set was given to them to use
- Participants returned their pain diary after 24 hours and were asked to fill out a final NPRS
- Final third algometer and CROM readings were taken for participants in all three groups

3.5 Protocol

3.5.1 Dry Needling protocol.

Dry needling involves an invasive procedure that involves inserting the acupuncture needle into the most painful site of the trigger point (Lewit, 1979). The needle penetrates the skin and subcutaneous tissue, aiming to reproduce the patient's symptoms, visualize local twitch response and achieve relief of muscle tension and pain (Yap, 2007). The needle is inserted and left for a duration of 10min. Once the needle is removed the practitioner places slight pressure over the area for haemostasis as per normal dry needling protocol (Travell and Simmons, 1999).

In this particular study for all three groups a 0.25 x 25mm acupuncture was used. The patients were placed in the prone position with their arms relaxed and on the arm rests of the chiropractic bed. The patients head was tilted slightly towards the side of dry needling as to create muscle slack so that a firm pincer grasp of the trigger point was achieved. The skin over TrP1 of the trapezius was sterilized using an alcohol swab. The practitioner ensured cleanliness of her hands by washing her hands thoroughly and then wearing medical gloves. The practitioner also ensured that the area was clean as to maintain a sterile environment.

The practitioner rolled her fingers so as to grip the trigger point in such a manner that the thumb is placed underneath the trigger point and the index finger above. The trigger point was then lifted off the underlying lung apex, the needle inserted from just above the thumb in an upwards direction towards the index finger. The needle then remained inserted for 10 min, at which point it was removed haemostasis was applied and area wiped again with an alcohol swab.

3.5.2 Ultrasound protocol

Participants in group 2 of this study received ultrasound after the dry needling as a post needling procedure. Ultrasound procedure involves using high frequency acoustic energy generated through a reverse piezoelectric effect (Esenyel et al, 2000).

The ultrasound unit used was a Dynatron® 850 plus with a 5cm² sound head. The setting were as follows: continuous wave mode, 2MHZ and intensity of 1.5c/cm² for 6 min. Ultrasound gel was used as the coupling agent between the ultrasound head and skin to ensure that the ultrasound waves a medium in which they can transmit through. The practitioner continuously moved the ultrasound head over the area that was needled, it is important for the practitioner to continue moving the ultrasound head for the six minutes to prevent burning (Esenyel et al, 2000).

3.5.3 Moxibustion protocol

Participants in group three of this study received dry needling with added moxibustion cigar used as a method of heating the needle whilst inserted. The acupuncture needle was inserted following normal dry needling protocol. A moxi cigar, made of compressed herb known as mugwart was lit and inserted on top of the inserted acupuncture needle, it remained ignited for the duration of needle insertion. Heat was transferred through the needle to the site of the trigger point, as well as heat could be felt over skin surface, overlying the trigger point.

It has been shown in a study run by Seung-Ho Yi (2009), whereby temperature measurements were taken using burning moxa technique and a garlic slice, that the maximum temperature that was recorded using indirect moxa was between 40-45 degrees of Celsius and that the total number of consecutive moxa on one slice was three.

3.6 Subjective data

3.6.1 Numerical Pain Rating Scale 101 (NRS 101) (Jensen *et. al*. 1986).

The NPRS 101 is a way in which individuals are able to rate their pain by scoring it a mark out of ten. Zero would indicate no pain perceived at all and ten would represent the most intense pain possible. The test is designed for individuals over the age of nine. Jensen et*. al.* (1986) conducted a study in which 75 participants, all suffering from chronic pain, graded their pain on a NPRS 101.

This scale proved to be precise, replicable, predictive and reliable when getting subjective data from a patient for their level of pain.

3.6.2 Pain Diary

Due to uncertainty regarding the time frame for the onset of post-needling soreness, to establish reliable subjective results from participants, a pain diary was included. The pain diary was divided into 4 sets of readings (4hrs, 8hrs, 12hrs and 24hrs) commencing straight after treatment. Participants were requested to tick “yes” or “no” as to whether they are experiencing any pain at that period. Participants were required to scale their pain on a zero to ten scale, zero being no pain at all and ten being the worst pain ever felt. Through this diary the researcher was able to see when the pain was at its worse and if pain changed in 24 hours. If any of the time sets fell into the time that the participant is asleep, they were not required to wake up in order to fill in the form. It was assumed that the post needling soreness did not disturb sleep and therefore seen as no soreness. If they however participants were woken due to post needling soreness they were requested to note it on the pain diary. The participants were requested to write the time they went to sleep and time they woke up on the pain diary.

3.7 Objective data

3.7.1 CROM

CROM device is short for, cervical range of motion device. It’s used primarily to determine the range of motion in the cervical spine and measures this in degrees. The CROM device in this study was used on the first visit before needling; these readings were taken again on the last visit after 24 hours from needling. The results were compared and data analysis took place. The CROM device has been found to be valid, reliable and recommended based on its clinometric properties and ratings (Koning, Van der Heuvel, Staal, Smits-Engelsman and Hendriks, 2008).

3.7.2 Algometer

Pressure algometry is seen in the medical society as a valid and reliable device used to measure localized pain to muscle, joints, tendons, ligaments and bones (Fischer, 1996). Studies done by Reeve *et.al*. (1986) show the reliability of the pressure threshold meter. The following was concluded from these studies: a high reliability between and within experimenters when measuring marked trigger point (TP) locations; significance between experimenter reliability in locating and measuring the same unmarked trigger point locations was shown, and lastly; that trigger points are discrete points of focal tenderness within the muscle. An algometer is a simple compressive-force gauge with a soft rubber tip implement. The compressive-force gauge measures the force in kilograms required to produce pain. The researcher applied the tip of the algometer to the area of discomfort and slowly applied force, the patient informed the researcher when they first felt pain and a measurement in kg/cm² was taken. The algometer measures pain threshold and not pain tolerance, pain threshold being when the patients first feels pain whereas tolerance is when the patient can no longer tolerate the pain (Bonci, 1994).

3.8 Data analysis

Objective data was obtained via a numerical pain scale questionnaire as well as a pain diary. Participants were asked to answer the numerical pain scale questionnaire before treatment begins and then again within 24 hours. The participants were asked to keep a pain diary that recorded the participant's pain at four points (4hrs, 8hrs, 12hrs and 24hrs). The reason for using a pain diary was due to the uncertainty around when post needling soreness set in and at which point the pain was recorded as at it worse. Time intervals allowed for the researcher to track this time. The interval between 12hrs and 24hrs was a stretched interval as to allow for sleep. The time started the minute treatment had ended.

Subjective data was obtained by means of CROM and algometer readings. The CROM readings were taken prior to treatment and then post treatment. The algometer readings were taken prior to treatment, immediately after needle had been removed, and then after a 7 minute interval. Group three differed, in that the needle was removed after the standard 10 minutes, participants then had an additional 5 minutes of ultrasound therapy over the area, followed by a 7 minute interval before an algometer reading was recorded.

Data collected by the researcher was analysed with the help of a statistician. Results were based on objective and subjective measurements that were collected from participants that took part in the clinical trial of the study. After consultation with STATKON at the University of Johannesburg's, Auckland park campus, it was concluded that results would be analysed using Shapiro-Wilk test for normality and Levene's test for equal variances. For all objective data collected, normality and equal variances were present. This added to the group size lead to conclude that parametric testing would be used on objective data. The parametric tests used were: One way Anova and Post Hoc test. For subjective data normality and equal variances were not present and thus non-parametric testing was used on subjective data namely: Kruskal Wallis, Wilcoxon-signed rank and Mann-Whitney U test.

3.9 Ethical considerations

All participants that partook in this particular study were requested to read and sign the information and consent form specific to this study. The information and consent form outlined the names of the researcher, purpose of the study and benefits of partaking in the study, participant assessment and treatment procedure. Any risks, benefits and discomforts pertaining to the treatments involved were also explained and that the participant's safety was ensured (prevention of harm). The information and consent form also explained that the participant's privacy was protected as only the doctor, patient and clinician would be in the treatment room and that anonymity was ensured as the patient

information was converted into data and therefore could not be traced back to the individual. The form also stated that standard doctor/patient confidentiality would be adhered to at all times when compiling the research dissertation. The participants were informed that their participation was on a voluntary basis and that they were free to withdraw from the study at any stage. Should the participant have had any further questions, these were explained by the researcher; whose contact details were made available. The participants were then required to sign the information and consent form, signifying that they understood all that is required of them for this particular study. Results of the study were made available on request.

With regards to this particular study the risks involved with the needling are very rare and every precaution was taken to ensure safety of the patient. The most serious of the risk with DNT was pneumothorax, symptoms being shortness of breath which may last several days or weeks. Pneumothorax was avoided by placing the patient prone with their arms resting on the arm rest. A pillow was placed under the patients head and shoulder so as to remove slack from the upper muscle fibres and lift the muscle off the underlying lung. The trigger point was held in a pincer grasp and fingers rolled so that the needle was directed towards the doctors index/middle finger avoiding the lung apex. Other risks included excessive bleeding which may have lead to bruising, therefore it was important to take note of bleeding history of the patient. The researcher also applied pressure for a few seconds after the needle was removed to prevent bruising and bleeding (haemostasis). A risk of infection is also a rare occurrence as every precaution was taken to ensure that the needles were taken straight out of their sterile packaging and that the area to be needled was properly cleaned. It was explained to the patient that some stiffness and tenderness may have been felt post needling and that this was normal and should have subsided in 24 hrs.

With Moxibustion there is a risk of skin burn, this was prevented by ensuring the burning moxa cigar never came into direct skin contact. Patient communication

was vital, if the patient felt that it got too hot at any stage the cigar was extinguished and the needle removed. Another risk is that the scent released when the moxi cigar was burning may have caused nausea and nasal congestion, a fan for ventilation was used to try prevent this. Patients that did react negatively to the scent were not suitable to continue with the trial.

Participants in group 2 had ultrasound therapy as an added modality. Ultrasound, as with all modalities does have risks associated with the treatment. These risks are mainly skin allergic reactions to either the gel used or that the sound therapy is not tolerated by the participant. Another risk is skin burn or osteo burns. This was prevented by the researcher ensuring the settings of the ultrasound were not too high and that the ultrasound head was kept moving while the machine was running. The participants should of felt a comfortable warmth and should of at all stages, vocalized what they were feeling to the researcher. A hot and cold test as well as sharp blunt test was preformed, to determine that the participant's sensations were working.

Treatment consisted of only one dry needling treatment. Patients often require multiple treatments to have resolution of the myofascial pain syndrome. Participants in the study were advised about this and treated after the study free of charge, if they so chose.Participants showing any other disorders were referred to the relevant health care professional. No participants that took part in this study required further referral.

Result of the study were made available to participants on request.

CHAPTER FOUR: RESULTS

4.1 Introduction

The following chapter represents the results that were obtained during the clinical trial of the study. The sample Group consisted of 90 participants overall. The 90 participants were divided into three equal Groups of 30 participants in each Group. All participants presented with MFPS involving TrP 1 of the trapezius. Participants in Group 1 received DNT of trigger point one with no post needling care. Participants in Group 2 received DNT of TrP1 of trapezius followed by ultrasound over the area, as a form of post needling care. Participants in Group 3 received DNT of Trp1 of the trapezius with added moxi cigar, as a means of heating the acupuncture needle whilst inserted into the TrP.

The statistical results only represent a small Group of participants and therefore no assumptions can be made with respect to the population as a whole. The p-value was set at 0.05 and this represents the level of significance in the results. If the p-value is greater than 0.05 then no statistical difference exists

The analyses include

1) Demographic data that consist of the participants age and gender distribution
2) Objective measurements consisting of pressure algometry and cervical spine range of motion (CROM) readings. These readings were done in flexion, extension, left and right lateral flexion and left and right rotation.
3) Subjective measurements that consist of Numerical pain scale rating and 24 hour pain scale readings.

4.2 Test for normality

The statistical test used for normality was the Shapiro-Wilk test. This assesses normality of distribution of scores. A non-significant result indicates normality, this is achieved when p-value is more than 0.05. A value lower than or equal to 0.05 suggests that there is a violation of the assumption of normality.

In this study, results from objective data had p-values that were greater than 0.05, therefore normality was assumed for objective data collected in the form of algometer readings and CROM readings

In this study, results from subjective data had p-values that were less than or equal to 0.05, therefore violation of normality was assumed for all subjective data in the form of a Numerical Pain scale rating and a Numerical pain scale diary.

4.3 Test for equality of variances

Levenes' test was the statistical test used to assess the equality of variances calculated for 2 or more Groups. If resulting p-value of Levenes' test is less than or equal to 0.05 then there is a difference between variances in the population. So if the p-value is greater than 0.05 the variability in the conditions is not significantly different. For Levenes' test on subjective and objective data the p-value was greater than 0.05 so therefore equality of variances can be assumed for all data collected.

4.4 Testing data

4.4.1 Objective data

When taking into account that for objective data normality as well as equal variances can be assumed, along with the Group sizes, the decision to use parametric testing was decided. Parametric testing included for intragroup analysis: repeated measures of Anova which was a multivariate test and pairwise comparison test. For intergroup testing: one way Anova and Post hoc test was used.

4.4.2 Subjective Data

For subjective data although equal variances could be assumed, normality could not. This lead to the decision to use non-parametric testing on subjective data collected. For intragroup analysis, the Friedman test and Wilcoxon signed rank

test was used. For intergroup analysis, the Mann-Whitney u test and Kruskal Wallis test was used.

4.5 Graphs

Throughout this chapter a bar graph has been used to illustrate the results produced for the three Groups in this study. Group 1 was the DNT only Group and is represented by the red column, Group 2 was DNT with added ultrasound and is represented by the blue column and Group 3 was DNT with added moxibustion and is represented by the green column. The time intervals are found on the x-axis of the bar graph, the variable measured values will be found on the y-axis of the bar graph.

4.6 Mean value percentages

A simple formula used throughout this chapter to calculate a mean value percentage was taking the first value x (pre-treatment) and subtracting the last value y (24 hours post-treatment), then dividing by the x value and multiplying by 100 to calculate a percentage. This was the clinical analysis of this study.
(X-Y/Y) X100= %

4.7 Demographic data

90 Participants took part in this study. The participants were equally divided into three Groups (30 participants in each Group). The participants were aged from 19-62 years old. The combined sample consisted of 45 males and 45 females.
Participants in Group 1 were aged from 23 to 60 with a mean age of 32.06 years. Group one consisted of 14 males and 16 females. Participants in Group 2 were aged from 19 to 62 with a mean age of 26.97. Group 2 consisted of 18 males and 12 females. Participants in Group 3 were aged from 23 to 50 with a mean age of 26.87. Group 3 had 12 males and 18 females. Therefore we are able to conclude that before treatment there were no statistically significant differences and thus the sample Group was homogeneous

Data	Group 1	Group 2	Group 3
Age distribution	23-60	19-62	23-50
Mean age	32.03	26.97	26.87
Gender	Males:14 Females:16	Males:18 Females:12	Males:12 Females:18

Table 4.1 Summarises demographic data of this study

4.8 Objective data analysis

4.8.1 Pressure Algometer

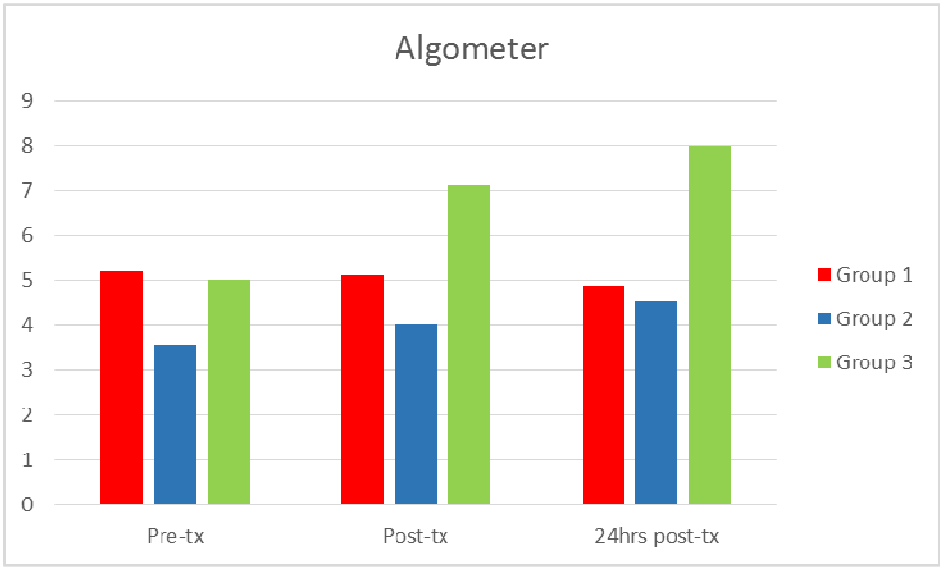


Figure 4.1 Bar graph comparing pressure algometer values taken in all three Groups at 3 different intervals in time.

Clinical Interpretation

Figure 4.1 compares pressure algometer readings that are taken in all three Groups involved in the study. The readings are taken at three points namely: pre-treatment, post-treatment and then 24 hours post-treatment. The X-axis represents the three time intervals at which readings were taken. The Y-axis represents the measurements for the algometer on a scale of 0.00Kg/cm²-100Kg/cm².

The mean value for the algometer reading for Group 1 (Dry needling) is represented by the red column in figure 4.1. Pre-treatment reading was 5.217kg/cm². Post-treatment reading was 5.130kg/cm². 24 Hours post-treatment reading was 4.870kg/cm². Analyse of the graph indicates that Group 1 had a decrease of 6.65% from pre-treatment to 24 hours post-treatment in recordings. Group 1 therefore had more pain sensitivity over the TrP over time.

The mean value for the algometer reading of Group 2 (Ultrasound) is represented by the blue column in figure 4.1. Pre-treatment reading was 3.577kg/cm². Post-treatment reading was 4.017kg/cm². 24 Hours post-treatment reading was 4.537kg/cm². Analyse of the graph indicates that Group 2 had a slight increase of 26.83% from pre-treatment to 24 hours post-treatment in recordings. Group 2 therefore had an increased pain tolerance of the needled TrP over time.

The mean value for the algometer readings of Group 3 (Moxibustion) represented by green in figure 4.1. Pre-treatment reading was 5.023kg/cm². Post treatment reading was 7.123kg/cm². 24 Hours post treatment reading was 7.980kg/cm². Analyse of the graph indicates that Group 3 had an increase of 58.87% from pre-treatment to 24 hours post-treatment recordings.

Group 3 as in Group 2 also had an increased pain tolerance over the needled TrP, over time. Note as well that Group 3 had the largest change in % over time.

Algometer before	Mean value	Standard deviation
Dry needling	5.217kg/cm²	1.542 kg/cm²
Ultrasound	3.577kg/cm²	1.737 kg/cm²
Moxibustion	5.023kg/cm²	1.492 kg/cm²
Algometer post treatment	Mean Value	Standard deviation
Dry needling	5.130kg/cm²	1.635 kg/cm²
Ultrasound	4.017kg/cm²	1.846 kg/cm²

Moxibustion	7.123kg/cm²	1.465 kg/cm²
Algometer 24 hours post	Mean Value	Standard deviation
Dry needling	4.870kg/cm²	1.604 kg/cm²
Ultrasound	4.537kg/cm²	1.793 kg/cm²
Moxibustion	7.980kg/cm²	1.570 kg/cm²

Table 4.2 represents the mean values and standard deviation of algometer readings taken for all three groups

Intragroup analysis

All multivariate tests yield the same result, the Wilks Lambda is of interested as it is the result most often reported on. If the p-value is less than or equal to 0.05 the three is statistical significance for time. To conclude, there is a change seen over time.

For the multivariate test over time all three Groups had (p=0.000), showing there was a change over time.

For multivariate test looking at each Group individually over time (p=0.000), showing there was a change over time for each Group.

Pairwise comparison is used to establish where the change was, time 1 represents pre-treatment reading, time 2 represents post-treatment reading and time 3 represents 24hrs post-treatment reading.

When comparing time 1-2 (p=0.000). When comparing time 1-3 (p=0.000). When comparing time 2-3 (p=0.000). This shows statistical significant change at all three points in time, for all three of the Groups

Intergroup Analysis

One way Anova test was then used to compare Groups for a change. Anova is used when there are 3 or more Groups of different subjects within the Group.

Anova gives the difference between Groups. If the p-value is less than or equal to 0.05 then there is a statistical significant difference. The Anova however doesn't tell you where the difference is. A Post Hoc test is a parametric test used when statistically significant results have been obtained in the one way Anova. A Post Hoc will determine where the difference is when comparing Groups. Take note that if the one way Anova showed no statistical difference, then there was no difference so therefore no need to do Post Hoc test on that series of results.

The one Anova parametric test produced a result of (p= 0.000) looking at pre-treatment readings. Anova produced (p= 0.000) at post-treatment readings. Anova produced (p= 0.000) at 24 hour post-treatment readings. Therefore there is a statistical significant difference found at all three points.

Post Hoc, comparing pre-treatment readings: Group 1 and Group 2 (p= 0,000), this is statistically significant. Group 1 and Group 3 (p=0.0896), which is not statistically significant. Group 2 and Group 3 (p= 0,003), which is statistically significant. In summary comparisons between Group 1 and 2 and then comparison between Group 2 and 3, showed statistically significant differences, showing that at the pre-treatment readings were non-comparable.

Post Hoc comparing post-treatment readings: Group 1 and Group 2 (p= 0.038), which is statistically significant. Group 1 and Group 3 (p= 0.000), which is statistically significant. Group 2 and Group 3 (p= 0.000) which is statistically significant. In summary the post-treatment reading was statistically significant for all three comparisons, showing they were all non-comparable. There was a change for Group 1 and 3 from comparable at pre-treatment to non-comparable at post-treatment, resembling a statistically significant difference, from pre and post readings.

Post Hoc comparing 24 hour post-treatment readings: Group 1 and Group 2 (p= 0.740), which is statistically not significant. Group 1 and Group 3 (p= 0.000),

which is statistically significant. Group 2 and Group 3 (p= 0.000), which is statistically significant. In summary for 24 hours post-treatment readings, when comparing Group 1 and 2, produced a non-statistical significant result. Remembering that the pre-treatment results were statistically significant. This change shows that there was a statistically significant difference for comparison of Group 1 and 2, when looking at pre-treatment readings versus 24 hour post-treatment reading.

4.8.2 CROM readings

4.8.2.1 Flexion

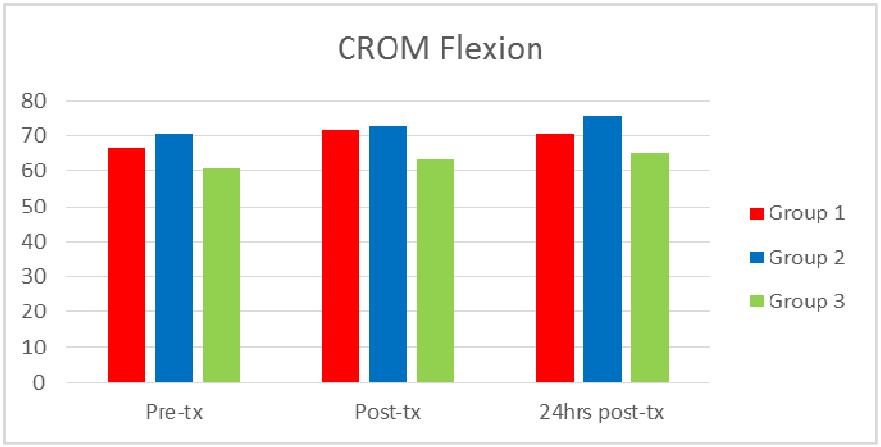


Figure 4.2 comparing cervical spine range of motion values in flexion for 3 Groups over at three points in time.

Clinical interpretation

Figure 4.2 compares cervical spine range of motion (CROM) values in flexion. The X-axis represents the three time intervals at which readings were recorded namely: pre-treatment, post-treatment and 24 hours post-treatment. The Y-Axis represents the percentages for the CROM device in a scale of 0.00˚- 100.00˚

The CROM flexion results showed Group 1 (Dry needling) is represented by the red column in figure 4.2. Pre-treatment mean value was 66.53˚, post-treatment

mean value was 71.73˚ and 24 hours post-treatment mean value was 70.53˚. In Group 1 an improvement of 6.01% was found in readings recorded.

Group 2 (Ultrasound) is represented by the blue column in figure 4.2. Pre-treatment mean value was 70.43˚, post-treatment values was 72.70˚ and 24 hours post-treatment value was 75.87˚. In Group 2 an improvement of 7.68% was found in readings recorded.

Group 3 (Moxibustion) is represented by the green column in figure 4.2. Pre-treatment mean value was 60.57˚, post-treatment value was 63.60˚ and a 24 hours post-treatment value was 65.40˚. In Group 3 an improvement of 7.97% was found in readings recorded.

CROM Flexion before	Mean Value	Standard deviation
Dry needling	66.53 ˚	11.227 ˚
Ultrasound	70.43 ˚	13.987 ˚
Moxibustion	60.57 ˚	8.732 ˚
CROM flexion post-treatment	Mean Value	Standard deviation
Dry needling	71.73 ˚	11.083 ˚
Ultrasound	72.70 ˚	12.975 ˚
Moxibustion	75.87 ˚	8.245 ˚
CROM flexion 24 hours post-treatment	Mean Value	Standard deviation
Dry needling	70.53 ˚	11.508 ˚
Ultrasound	75.87 ˚	13.688 ˚
Moxibustion	65.40 ˚	7.361 ˚

Table 4.3 Represents mean values and standard deviation for CROM flexion for all three Groups

Intragroup Analysis

For multivariate test looking at change over time for all three Groups, the test produced (p= 0.000). This is statistically significant for a change over time.
For multivariate test looking at change over time for each individual Group, the test produced (p= 0.069). This is not significantly significant for a change over time.

The pairwise comparison when comparing time 1-2 (p=0.000), this is statistically significant for change. When comparing 1-3 (p= 0.000), this is statistically significant for change. When comparing 2-3 (p=0.194), this is not statistically significant for change.

Intergroup Analysis

The Anova one way when looking at pre-treatment results produced (p= 0.005), post-treatment produced (p= 0.003) and 24 hours post- treatment produced (p= 0.002).

A Post hoc Test was used to compare between Groups. When looking at pre-treatment values: comparing Group 1 and Group 2 (p= 0.427), which is not statistically significant. When comparing Group 1 and Group 3 (p= 0.140), which has no statistical significance. When comparing Group 2 and Group 3 (p= 0.006) this is statistically significant. In summary at the pre-treatment readings comparison between Group 1 and 2 and comparison between Group 1 and 3, showed to be not statistically significant, showing that these readings were comparable. When looking at comparison of Group 2 and 3, note there was statistical significance, showing these readings to be non-comparable.

When looking at the values of post-treatment: comparing Group1 and Group 2 (p= 0.943) which is not statistically significant. When comparing Group 1 and Group 3 (p= 0.19) which is not statistically significant and when comparing Group 2 and Group 3 (p= 0.006) which is statistically significant. In summary, the Groups remained as above. Comparing, Group 1 and 2 and comparing Group 1

and 3, showed no statistically significant difference therefore remained comparable. Group 2 and 3 showed to have statistically significant difference therefore remained non-comparable.

When looking at values of 24 hours post-treatment: comparing Group 1 and Group 2 (p= 0.165), which is not statistically significant. When comparing Group 1 and Group 3 (p= 0.237), which is also not statistically significant. When comparing Group 2 and Group 3 (p= 0.002) this is statistically significant. In summary, the Groups remained as above. Comparing Group 1 and 2 and comparing Group 1 and 3 showed no statistically significant difference, remained comparable. Group 2 and 3 showed to have statistically significant difference, remained non-comparable. This shows that there was no statistically significant difference when comparing Groups from pre-treatment readings to 24 hours post-treatment readings. Therefore although we know all Groups improved in CROM in forward flexion we are unable to assume that one Group did better than another.

4.8.2.2 Extension

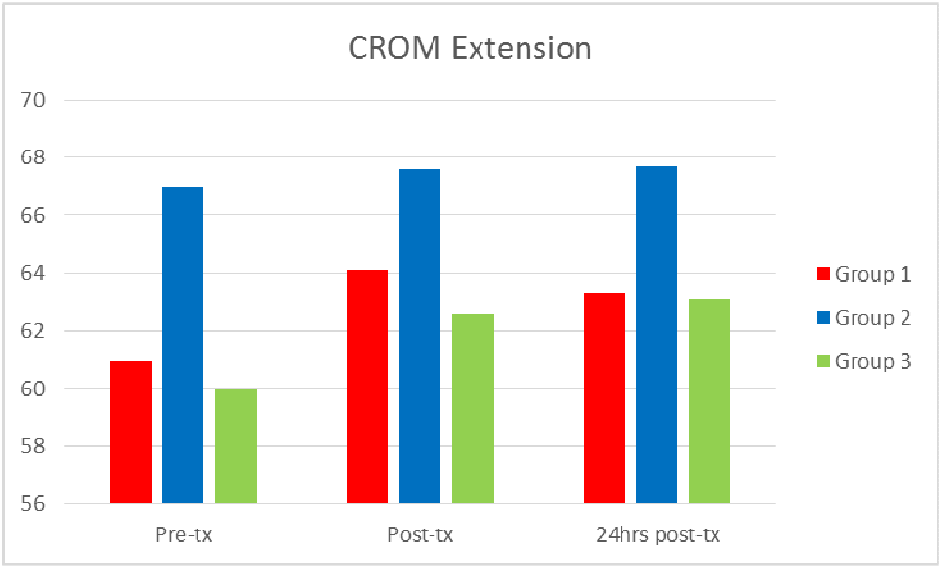


Figure 4.3 comparing cervical spine range of motion values in extension for 3 Groups over at three points in time.

Clinical interpretation

Figure 4.3 compares cervical spine range of motion (CROM) values in extension. The X-axis represents the three time intervals at which readings were recorded The Y-Axis represents the percentages for the CROM device in a scale of 0.00˚-100.00˚

The CROM extension results for Group 1 (Dry needling) is represented by the red column in figure 4.3 had a pre-treatment mean value of 60.95˚, post-treatment mean value of 64.10˚ and 24 hours post-treatment mean value of 63.33˚. In Group 1 an improvement of 3.94% was found in recorded readings.

Group 2 (Ultrasound) is represented by the blue column in figure 4.3, had pre-treatment mean value of 66.97˚, post-treatment values of 67.60˚ and 24 hours post-treatment value of 67.60˚. In Group 2 an improvement of 1.39% was found in recorded readings.

Group 3 (Moxibustion) is represented by the green column in figure 4.3, had a pre-treatment mean value of 58.97˚ a post-treatment value of 62.57˚ and a 24 hours post-treatment value of 63.07˚. In Group 3 an improvement of 6.95% was found in recorded readings

CROM Extension before	Mean Value	Standard deviation
Dry needling	60.95 ˚	12.182 ˚
Ultrasound	66.97 ˚	10.765 ˚
Moxibustion	58.97 ˚	9.449 ˚
CROM Extension post-treatment	Mean Value	Standard deviation
Dry needling	64.10˚	11.400 ˚
Ultrasound	67.60 ˚	11.921 ˚
Moxibustion	62.57 ˚	7.040 ˚

CROM Extension 24 hours post-treatment	Mean Value	Standard deviation
Dry needling	63.33 ˚	11.012 ˚
Ultrasound	67.60 ˚	11.125 ˚
Moxibustion	63.07˚	6.664 ˚

Table 4.4 representing mean value and standard deviation for CROM extension for all three groups

Intragroup Analysis

For multivariate test looking at change over time for all three Groups, the test produced (p= 0.002). This is statistically significant for a change over time.

For multivariate test looking at change over time for each individual Group, the test produced (p= 0.232). This is not significantly significant for a change over time.

The pairwise comparison when comparing time 1-2 (p= 0.002), this is statistically significant for change. When comparing 1-3 (p= 0.002), this is statistically significant for change. When comparing 2-3 (p= 1.000), this is not statistically significant for change.

Intergroup Analysis

A one-way Anova when used on CROM, extension values produced the following results: pre-treatment (p= 0.015), post-treatment (p= 0.161) and 24 hours post-treatment (p= 0.140). Therefore only pre-treatment results showed statistically significant difference and therefore only results for pre-treatment were reported on in the Post Hoc test.

Post Hoc test to compare CROM extension values pre-treatment. When comparing Group 1 and 2 (p= 0.105), this is not statistically significant. When comparing Group 1 and 3 (p= 0.782), this is not statistically significant. When comparing Group 2 and 3 (p= 0.020), there is a statistically significance here. In

summary when looking at pre-treatment readings and comparing Group 1 and 2 and comparing Group 1 and 3, the results show no statistical significant difference, showing the results to be comparable. When looking at Group 2 and 3, there is statistical significance here, showing results to be non-comparable.

4.8.2.3 Right lateral flexion

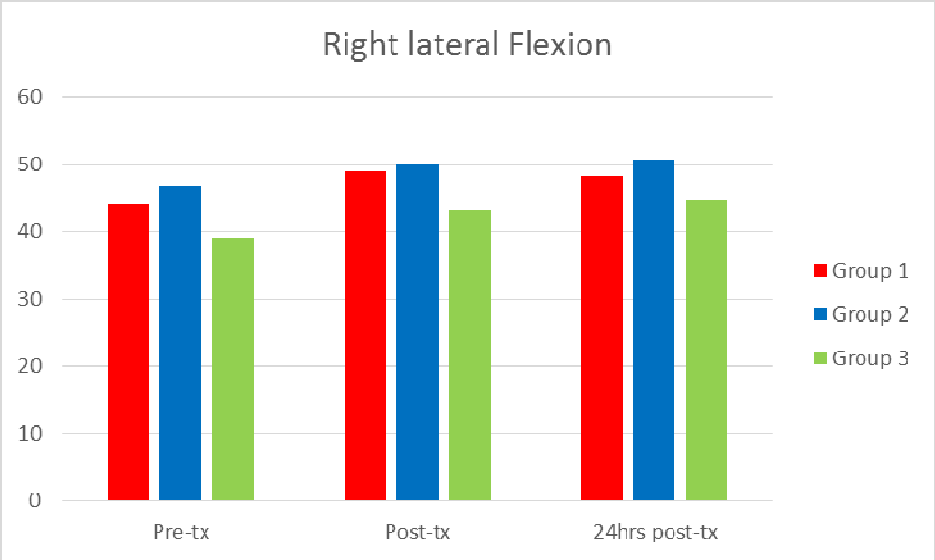


Figure 4.4 comparing cervical spine range of motion values in right lateral flexion for all 3 Groups at three points in time.

Clinical interpretation

Figure 4.3 compares cervical spine range of motion (CROM) values in right lateral flexion. The X-axis represents the three time intervals at which readings were recorded namely: pre-treatment, post-treatment and 24 hours post-treatment. The Y-Axis represents the percentages for the CROM device in a scale of 0.00˚- 100.00˚

The CROM right lateral flexion results showed Group 1 (Dry needling) is represented by the red column in figure 4.4, had a pre-treatment mean value of 44.23˚, post-treatment mean value of 47.87˚ and 24 hours post-treatment mean

value of 48.30˚. In Group 1 an improvement of 9.20% was found from reading recorded.

Group 2 (Ultrasound) is represented by the blue column in figure 4.4, had pre-treatment mean value of 46.77˚, post-treatment values of 50.00˚ and 24 hours post-treatment value of 50.60˚. In Group 2 an improvement of 8.19% was found from readings recorded.

Group 3 (Moxibustion) is represented by the green column in figure 4.4, had a pre-treatment mean value of 38.90˚ a post-treatment value of 43.30˚ and a 24 hours post-treatment value of 44.63˚. In Group 3 an improvement of 14.73% was found from readings recorded.

CROM Right lateral flexion before	Mean Value	Standard deviation
Dry needling	44.23 ˚	10.115 ˚
Ultrasound	46.77 ˚	7.877 ˚
Moxibustion	38.90 ˚	9.129 ˚
CROM Right lateral flexion post-treatment	Mean Value	Standard deviation
Dry needling	47.87˚	9.566 ˚
Ultrasound	50.00 ˚	8.847 ˚
Moxibustion	43.30 ˚	8.750 ˚
CROM Right lateral flexion 24 hours post-treatment	Mean Value	Standard deviation
Dry needling	48.30 ˚	10.093 ˚
Ultrasound	50.60 ˚	8.024 ˚
Moxibustion	44.63˚	9.331 ˚

Table 4.5 Represents mean values and standard deviation for CROM right lateral flexion for all three groups

Intragroup Analysis

For multivariate test looking at change over time for all three Groups, the test produced (p= 0.000). This is statistically significant for a change over time. A pairwise comparison was used to see where the change occurred.

For multivariate test looking at change over time for each individual Group, the test produced (p= 0.532). This is not significantly significant for a change over time. Due to no change detected, a pairwise comparison on these results was not needed.

The pairwise comparison when comparing time 1-2 (p= 0.000), this is statistically significant for change. When comparing 1-3 (p= 0.000), this is statistically significant for change. When comparing 2-3 (p= 0.136), this is not statistically significant for change.

Intergroup Analysis

A one-way Anova when used on CROM, right lateral flexion values produced the following results: pre-treatment (p= 0.004), post-treatment (p= 0.17) and 24 hours post-treatment (p= 0.045).

Post Hoc test to compare CROM right lateral flexion values pre-treatment. When comparing Group 1 and 2 the p-value was 0.560 this value is not statistically significant. When comparing Group 1 and 3 the p-value was 0.081 this is not statistically significant. When comparing Group 2 and 3 the p-value was 0.005 this is statistically significant. In summary at the pre-treatment readings comparison between Group 1 and 2 and comparison between Group 1 and 3, showed to have no statistically significant difference, showing that these readings were comparable. When looking at comparison of Group 2 and 3, note there was statistical significance, showing these readings to be non-comparable.

When looking at post-treatment values Post hoc produced the following. When comparing Group 1 and 2 (p= 0.661), this is not statistically significant. When comparing Group 1 and 3 (p= 0.155), this is not statistically significant. When comparing Group 2 and 3 (p= 0.020), this is statistically significant. In summary, the Groups remained as above. Comparing Group 1 and 2 and comparing Group 1 and 3, showed no statistically significant difference therefore remained comparable. Group 2 and 3 showed to have statistically significant difference therefore remained non-comparable.

When looking at 24 hours post-treatment values Post hoc produced the following. When comparing Group 1 and 2 (p= 0.627) this is not statistically significant. When comparing Group 1 and 3 (p= 0.308), this is not statistically significant. When comparing Group 2 and 3 (p= 0.047), this is statistically significant. In summary, the Groups remained as above. Comparing Group 1 and 2 and comparing Group 1 and 3 showed no statistically significant difference, remained comparable. Group 2 and 3 showed to have statistically significant difference, remained non-comparable. This shows that there was no statistically significant change when comparing Groups from pre-treatment readings to 24 hours post-treatment readings.

4.8.2.4 Left Lateral flexion

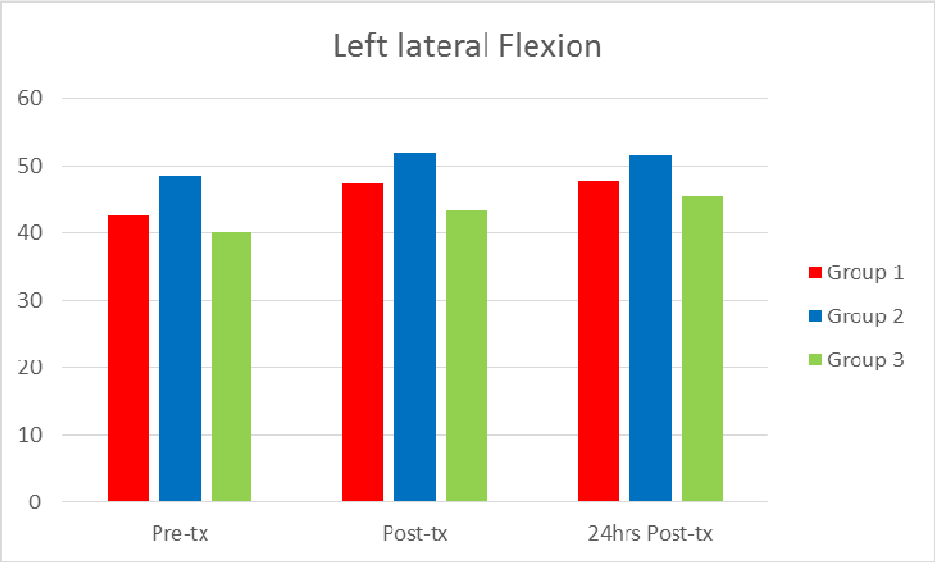


Figure 4.5 comparing cervical spine range of motion values in left lateral flexion 3 Groups at three points in time.

Clinical interpretation

Figure 4.4 compares cervical spine range of motion (CROM) values in left lateral flexion. The X-axis represents the three time intervals at which readings were recorded. The Y-Axis represents the percentages for the CROM device in a scale of 0.00˚- 100.00˚.

The CROM left lateral flexion results showed Group 1(Dry needling) is represented by the red column in figure 4.5, had a pre-treatment mean value of 42.67˚, post-treatment mean value of 47.33˚ and 24 hours post-treatment mean value of 47.57˚. In Group 1 an improvement of 11.48% was found from readings recorded.

Group 2 (Ultrasound) is represented by the red column in figure 4.5, had pre-treatment mean value of 48.40˚, post-treatment value of 51.90˚ and 24 hours post-treatment value of 51.53˚. In Group 2 an improvement of 6.47% was found from readings recorded.

Group 3 (Moxibustion) is represented by the green column in figure 4.5, had a pre-treatment mean value of 40.07˚, post-treatment value of 43.37˚ and a 24 hours post-treatment value of 45.50˚. In Group 3 an improvement of 13.55% from readings recorded.

CROM Left lateral flexion before	Mean Value	Standard deviation
Dry needling	42.67 ˚	10.097 ˚
Ultrasound	48.40 ˚	9.099 ˚
Moxibustion	40.07 ˚	9.063 ˚
CROM left lateral flexion post-treatment	Mean Value	Standard deviation
Dry needling	47.33˚	9.661 ˚
Ultrasound	51.90 ˚	10.018 ˚
Moxibustion	43.37 ˚	9.412 ˚
CROM Left lateral flexion 24 hours post-treatment	Mean Value	Standard deviation
Dry needling	47.57 ˚	10.657 ˚
Ultrasound	51.63 ˚	7.454 ˚
Moxibustion	45.50˚	9.339 ˚

Table 4.6 Represents mean value and standard deviation for CROM left lateral flexion readings from all three groups

Intragroup Analysis

For multivariate test looking at change over time for all three Groups, the test produced (p= 0.000). This is statistically significant for a change over time.

For multivariate test looking at change over time for each individual Group, the test produced (p= 0.158). This is not significantly significant for a change over time.

The pairwise comparison when comparing time 1-2 (p= 0.000), this is statistically significant for change. When comparing 1-3 (p= 0.000), this is statistically significant for change. When comparing 2-3 (p= 0.401), this is not statistically significant for change

Intergroup Analysis

A one-way Anova when used on CROM, left lateral flexion values produced the following results: pre-treatment (p= 0.003), post-treatment (p= 0.004) and 24 hours post-treatment (p= 0.042).

Post Hoc test to compare CROM left lateral flexion values pre-treatment. When comparing Group 1 and 2 (p= 0.068), this is not statistically significant. When comparing Group 1 and 3 (p= 0.568), this is not statistically significant. When comparing Group 2 and 3 (p= 0.004), this is statistically significant. In summary at the pre-treatment readings comparison between Group 1 and 2 and comparison between Group 1 and 3, showed to have no statistically significant difference, showing that these readings were comparable. When looking at comparison of Group 2 and 3, note there was statistical significance, showing these readings to be non-comparable.

When looking at post-treatment values Post hoc produced the following. When comparing Group 1 and 2 (p= 0.196), this is not statistically significant. When comparing Group 1 and 3 (p= 0.290), this is not statistically significant. When comparing Group 2 and 3 (p= 0.004), this is statistically significant. In summary, the Groups remained as above. Comparing Group 1 and 2 and comparing Group 1 and 3, showed no statistically significant difference therefore remained comparable. Group 2 and 3 showed to have statistically significant difference therefore remained non-comparable.

When looking at 24 hours post-treatment values Post hoc produced the following. When comparing Group 1 and 2 (p= 0.257), this is not statistically significant.

When comparing Group 1 and 3 (p= 0.688), this is not statistical significant. When comparing Group 2 and 3 (p= 0.046), this is statistically significant. In summary, the Groups remained as above. Comparing Group 1 and 2 and comparing Group 1 and 3 showed no statistically significant difference, remained comparable. Group 2 and 3 showed to have statistically significant difference, remained non-comparable. This shows that there was no statistically significant change when comparing Groups from pre-treatment readings to 24 hours post-treatment readings.

4.8.2.5 Right rotation

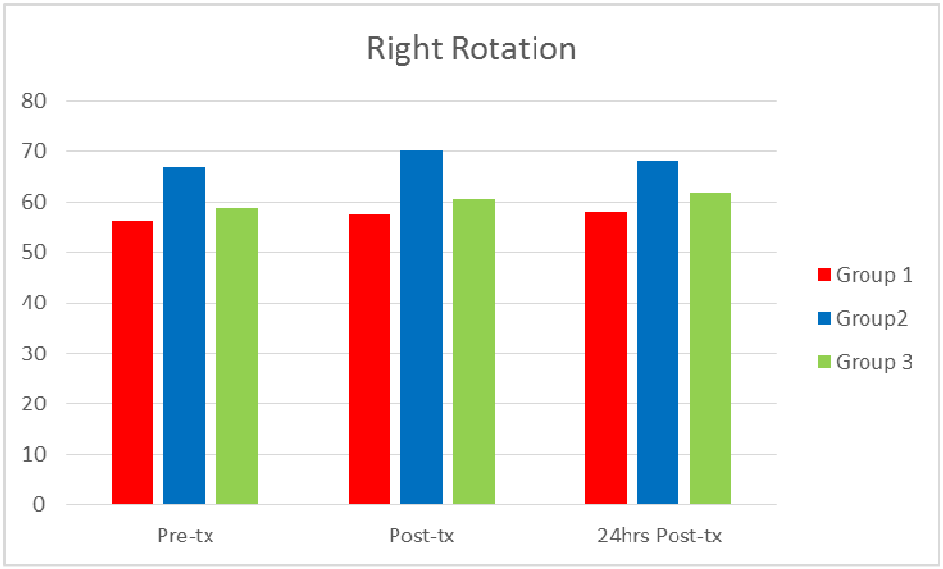


Figure 4.6 comparing cervical spine range of motion values in right rotation for all 3 Groups at three points in time.

Clinical interpretation

Figure 4.6 compares cervical spine range of motion (CROM) values in right rotation. The X-axis represents the three time intervals at which readings were recorded namely: pre-treatment, post-treatment and 24 hours post-treatment. The Y-Axis represents the percentages for the CROM device in a scale of 0.00˚-100.00˚

The CROM right rotation results showed Group 1(Dry needling) represented by the red column in figure 4.6, had a pre-treatment mean value of 56.03˚, post-treatment mean value of 57.43˚ and 24 hours post-treatment mean value of 57.90˚. In Group 1 an improvement of 3.34% was found from recorded readings.

Group 2 (Ultrasound) is represented by the blue column in figure 4.6, had pre-treatment mean value of 66.87˚, post-treatment values of 70.23˚ and 24 hours post-treatment value of 68.22˚. In Group 2 an improvement of 2.18% was found from recorded readings.

Group 3 (Moxibustion) is represented by the green column in figure 4.6, had a pre-treatment mean value of 58.77˚ a post-treatment value of 60.70˚ and a 24 hours post-treatment value of 61.73˚. In Group 3 an improvement of 5.04% from recorded values

CROM Right rotation before	Mean Value	Standard deviation
Dry needling	56.03 ˚	15.473˚
Ultrasound	66.87 ˚	19.319 ˚
Moxibustion	58.77 ˚	17.733˚
CROM Right rotation post-treatment	Mean Value	Standard deviation
Dry needling	57.43˚	14.345 ˚
Ultrasound	70.23˚	19.516 ˚
Moxibustion	60.70 ˚	16.696˚
CROM Right rotation 24 hours post-treatment	Mean Value	Standard deviation
Dry needling	57.90 ˚	14.354 ˚
Ultrasound	68.22 ˚	18.594 ˚
Moxibustion	61.73˚	17.021˚

Table 4.7 Represents mean values and standard deviation for CROM right rotation readings for all three groups

Intragroup Analysis

For multivariate test looking at change over time for all three Groups, the test produced (p= 0.000). This is statistically significant for a change over time. A pairwise test was used on these results to establish where the change occurred between the three time intervals at which readings were taken.

For multivariate test looking at change over time for each individual Group, the test produced (p= 0.158). This is not significantly significant for a change over time. Due to this no pairwise test was used on these results

The pairwise comparison when comparing time 1-2 (p= 0.000), this is statistically significant for change. When comparing 1-3 (p= 0.000), this is statistically significant for change. When comparing 2-3 (p= 0.401), this is not statistically significant for change

Intergroup Analysis

A one-way Anova when used on CROM, right rotation values produced the following results: pre-treatment (p= 0.051), post-treatment (p= 0.013) and 24 hours post-treatment (p= 0.056).

Post Hoc test to compare CROM right rotation values pre-treatment. When comparing Group 1 and Group 2 (p= 0.063) this is not statistically significant. When comparing Group 1 and Group 3 (p= 0.834) this is not statistically significant. When comparing Group 2 and Group 3 (p= 0.209) this is not statistically significant. In summary, all three comparison produced no statistically significant difference, showing all three to be comparable at pre-treatment readings.

When looking at post-treatment values Post hoc produced the following. When comparing Group 1 and Group 2 (p= 0.017) this is statistically significant. When

comparing Group 1 and Group 3 (p= 0.758) this is not statistically significant. When comparing Group 2 and Group 3 (p= 0.100) this is not statistically significant. In summary when looking at post-treatment readings and the comparisons of Group 1 and 2, the result show statistical significance, this was not so at the pre-treatment reading. Therefore comparison between Group 1 and 2 at post reading is non-comparable, showing a significant change here between pre-treatment and post treatment.

When looking at 24 hours post-treatment values Post hoc produced the following. When comparing Group 1 and Group 2 (p= 0.060) this is not statistically significant. When comparing Group 1 and Group 3 (p= 0.676) this is not statistically significant. When comparing Group 2 and Group 3 (p= 0.317) this is not statistically significant. In summary again it is noted that at 24 hours post-treatment comparison between Group 1 and 2, has gone from statistically significance found at post-treatment, to no statistical significance at 24 hours post-treatment. Therefore at post-treatment comparison result between Group 1 and 2 were non-comparable and at 24 hours ended being comparable.

4.8.2.6 Left rotation

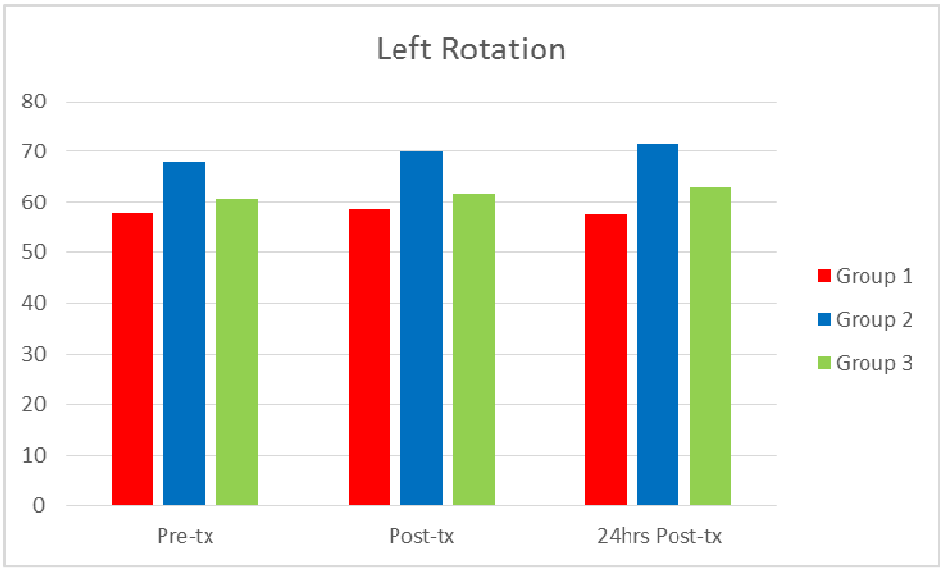


Figure 4.7 comparing cervical spine range of motion values in left rotation for 3 Groups at three points in time.

Clinical interpretation

Figure 4.7 compares cervical spine range of motion (CROM) values in left rotation. The X-axis represents the three time intervals at which readings were recorded. The Y-Axis represents the percentages for the CROM device in a scale of 0.00˚- 100.00˚

The CROM left lateral flexion results showed Group 1 (Dry needling) is represented by the red column in figure 4.7, had a pre-treatment mean value of 57.83˚, post-treatment mean value of 58.64˚ and 24 hours post-treatment mean value of 57.60˚. In Group 1 an improvement of 3.06% was found from readings recorded.

Group 2 (Ultrasound) is represented by the blue column in figure 4.7, had pre-treatment mean value of 67.97˚, post-treatment values of 70.00˚ and 24 hours post-treatment value of 71.63˚. In Group 2 an improvement of 5.38% was found from readings recorded.

Group 3 (Moxibustion) is represented by the green column in figure 4.7, had a pre-treatment mean value of 60.47˚ a post-treatment value of 61.73˚ and a 24 hours post-treatment value of 63.10˚. In Group 3 an improvement of 4.35% was found from readings recorded.

CROM Left rotation before	Mean Value	Standard deviation
Dry needling	57.83 ˚	17.009 ˚
Ultrasound	67.97˚	18.505 ˚
Moxibustion	60.47 ˚	17.512˚
CROM Left rotation post-	Mean Value	Standard deviation

treatment		
Dry needling	58.64˚	16.637 ˚
Ultrasound	70.00 ˚	19.712 ˚
Moxibustion	61.73 ˚	17.060 ˚
CROM Left rotation 24 hours post-treatment	Mean Value	Standard deviation
Dry needling	57.60 ˚	16.681 ˚
Ultrasound	71.63 ˚	18.517 ˚
Moxibustion	63.10˚	16.967˚

Table 4.8 Represents mean values and standard deviation for CROM left rotation for all groups.

Intragroup Analysis

For multivariate test looking at change over time for all three Groups, the test produced (p= 0.000). This is statistically significant for a change over time. A pairwise test was then used to establish where in time this change occurred.

For multivariate test looking at change over time for each individual Group, the test produced p= 0.158. This is not significantly significant for a change over time. Due to this no pairwise test was used on this set of results.

The pairwise comparison when comparing time 1-2 (p= 0.000), this is statistically significant for change. When comparing 1-3 (p= 0.000), this is statistically significant for change. When comparing 2-3 (p= 0.401), this is not statistically significant for change

Intergroup Analysis

A one-way Anova when used on CROM, left rotation values produced the following results: pre-treatment (p= 0.076), post-treatment (p= 0.044) and 24 hours post-treatment (p= 0.026).

Due to pre-treatments p value being higher than 0.05 we assume there is no difference in Groups, therefore no Post Hoc test will be reported on for pre-treatment values.

Post Hoc test to compare CROM left rotation values at post-treatment values. When comparing Group 1 and Group 2 (p= 0.053) this is statistically significant. When comparing Group 1 and Group 3 (p= 0.798) this is not statistically significant. When comparing Group 2 and Group 3 (p= 0.206) this is not statistically significant. In summary when looking at post-treatment readings, comparison between Group 1 and 2, showing statistical significance, showing therefore to be non-comparable. When looking at comparing Group 1 and 3 and comparing Group 2 and 3, these results showed no statistical significance, therefore were comparable.

When looking at 24 hours post-treatment values Post hoc produced the following. When comparing Group 1 and Group 2 (p= 0.032) this is statistically significant. When comparing Group 1 and Group 3 (p= 0.739) this is not statistically significant. When comparing Group 2 and Group 3 (p= 0.171) this is not statistically significant. In summary, the Groups remained as above. Comparing Group 1 and 2 and comparing Group 1 and 3 showed no statistically significant difference, remained comparable. Group 2 and 3 showed to have statistically significant difference, remained non-comparable. This shows that there was no statistically significant change when comparing Groups from pre-treatment readings to 24 hours post-treatment readings.

4.9 Subjective data analysis

4.9.1 Numerical pain scale rating

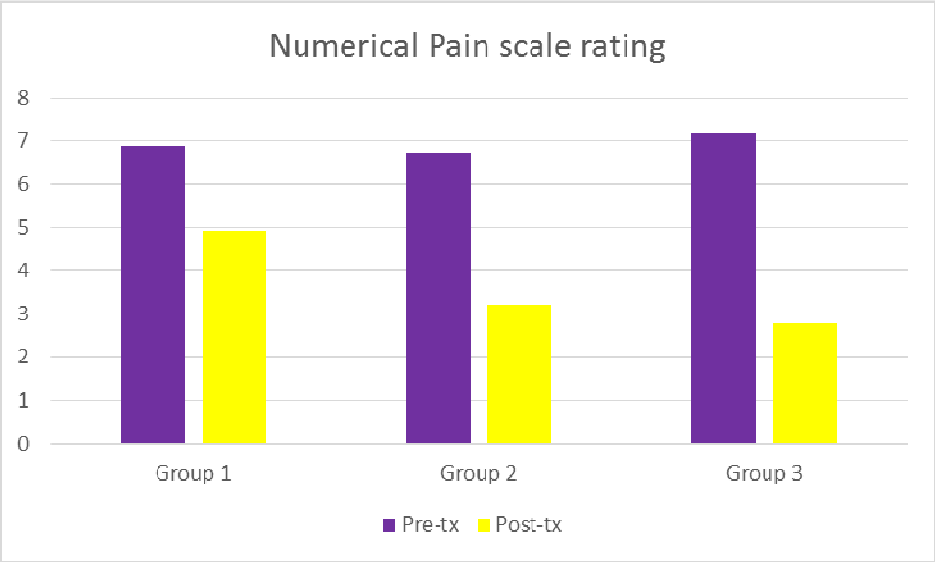


Figure 4.8 illustrates a bar graph comparing Numerical pain rating scale values recorded by participants in all three Groups at two points in time.

Clinical interpretation

Figure 4.8 illustrates a bar graph comparing Numerical Pain rating scale values for participants in all three Groups. Values were captured pre-treatment and post-treatment. Readings were not recorded at 24 hours post-treatment as that reading was included in the pain diary. The X-axis represents the 3 different Groups. The Y-axis represents the pain scale which have measurements on a scale 0.00-10.00. On the scale 0.00 represents no pain at all, and 10.00 represents worst pain ever perceived by the participant.

The Numerical pain scale value for Group 1 (Dry needling) was 6.867 pre-treatment and 4.917 post-treatment. Analysis of the graph indicates that Group 1 had a decrease of 28.40% between pre-treatment and post-treatment readings.
The scale for Group 2 (Ultrasound) was 6.750 pre-treatment and 3.217 post treatment. Analysis of the graph indicates that Group 2 had a 53.34% decrease in between pre-treatment and post-treatment readings.

The scale for Group 3 (Moxibustion) was 7.183 pre-treatment and 2.767 post-treatment. Analysis of the graph indicates that Group 3 had a decrease of 61.48% between pre-treatment and post-treatment readings.

Pain scale pre-treatment	Mean Value	Standard deviation
Dry needling	6.867	1.4794
Ultrasound	6.750	1.5907
Moxibustion	7.183	1.2211
Pain scale post-treatment	Mean Value	Standard deviation
Dry needling	4.917	1.8480
Ultrasound	3.217	1.9284
Moxibustion	2.767	1.1651

Table 4.9 Represents mean values and standard deviation of pain scale readings taken for all three groups

Intragroup Analysis

The Wilcoxon Signed rank test, a non-parametric statistical test produced (p= 0.000) when comparing pre and post treatment Numerical Pain rating scales of Group 1. In Group 2 the same comparison produced (p= 0.000) and in Group 3 the same comparison produced (p= 0.000).

Intergroup Analysis

The Kruskal Wallis non-parametric test to determine if Groups differ, it does not tell us where the Groups differ only if they do. The test produced (p=0.577) for measuring between Groups looking at pre-treatment Numerical Pain scale rating values. Due to the test producing a result of (p=0.577) which is higher than 0.05, we assume that there is no difference between Groups at the pre-treatment reading, it is due to this that no Mann-Whitney U test was performed on pre-treatment results. The Kruskal Wallis test produced (p= 0.000) for measuring between Groups looking the post-treatment Numerical Pain scale rating values. This value is lower than 0.05 showing that there is a difference between Groups

to establish where exactly the difference was, the Mann-Whitney U test was performed to compare Groups post-treatment readings

The Mann-Whitney U test used on post-treatment readings produced (p=0.000) when comparing Group 1 and Group 2, this value shows statistical significance. When comparing Group 2 and 3 the test produced (p= 0.276) this value shows no statistical significance. When comparing Group 1 and 3 the test produced (p= 0.000) this value shows that there is statistical significance. In summary when comparing Group 1 and Group 2 the statistical significance showed the Groups to be non-comparable. In the comparison of Group 2 and 3 and also the comparison of Group 2 and 3 no statistical significance showed that the Groups were comparable.

4.9.2 Pain diary

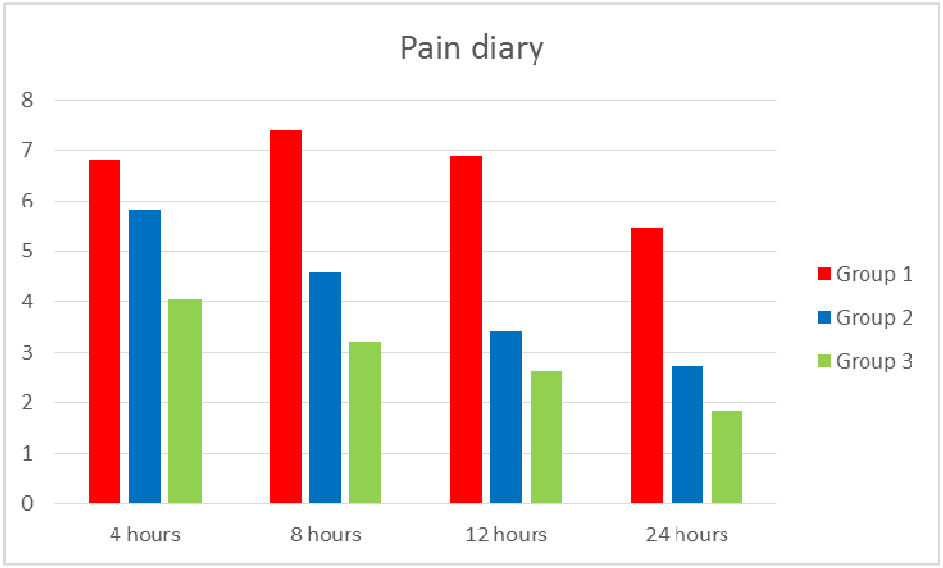


Figure 4.9 illustrates a bar graph comparing Pain diary readings, for all participants in all 3 Groups. Readings were recorded at 4 points in time after treatment.

Clinical interpretation

Figure 4.9 illustrates a bar graph that compares Pain diary readings that were recorded for all three groups. The readings were recorded at four different time

intervals from when treatment commenced namely: 4 hours, 8 hours, 12 hours and 24 hours. The X-axis represents the three time intervals. The Y-axis represents the pain scale measured from 0.00-10.00. On the scale 0.00 represents no pain at all, and 10.00 represents worst pain ever perceived by the participant.

The mean values for Group 1(Dry needling) is represented by the red column in figure 4.9 and were as follows: at 4 hours 6.83, at 8 hours 7.400, at 12 hours 6.90 and at 24 hours 5.467. Analysis shows that Group 1 had a decrease of 19.96% in recorded values over the four time intervals.

The mean values for Group 2 (Ultrasound) is represented by the blue column in figure 4.9 and were as follows: at 4 hours 5.80, at 8 hours 4.583, at 12 hours 3.43 and at 24 hours 2.717. Analysis shows that Group 2 had a decrease of 53.16% in recorded values over the four time intervals.
The mean values for Group 3 (Moxibustion) is represented by the red column in figure 4.9 and were as follows: at 4 hours 4.07, at 8 hours 3.233, at 12 hours 2.63 and at 24 hours 1.833. Analysis shows that Group 3 had a decrease of 54.96% in recorded readings over the four time intervals.

Pain Diary- 4 hours	Mean Value	Standard deviation
Dry-needling	6.83	1.289
Ultrasound	5.80	1.730
Moxibustion	4.07	0.828
Pain Diary- 8 hours	Mean Value	Standard deviation
Dry-needling	7.400	1.1626
Ultrasound	4.583	1.7718
Moxibustion	3.233	1.00063
Pain Diary- 12 hours	Mean Value	Standard deviation
Dry-needling	6.90	1.185
Ultrasound	3.43	2.329

Moxibustion	2.63	0.928
Pain Diary- 24 hours	Mean Value	Standard deviation
Dry-needling	5.467	1.4794
Ultrasound	2.717	2.2271
Moxibustion	1.833	1.0199

Table 4.10 Represents mean values and standard deviation of pain diary results taken in all three groups

Intragroup Analysis

The Friedman test used to compare results from the Pain diary over all four intervals. This test showed that in Group 1 (p= 0.000), in Group 2 (p= 0.000) and in Group 3 (p= 0.000). Therefore results showed to be statistically significant for all three groups.

The Wilcoxon Signed Rank test for the Numerical Pain diary scale compared the four values of each Group with one another. For Group 1 when comparing 4 hours with 8 hours (p= 0.009), 4 hours with 12 hours (p= 0.768), 4 hours with 24 hours (p= 0.000). When comparing 8 hours with 12 hours (p= 0.002), 8 hours with 24 hours (p= 0.000). When comparing 12 hours with 24 hours (p= 0.000).

For Group 2 when comparing 4hours and 8 hours (p= 0.000), 4 hours and 12 hours (p= 0.000), 4 hours and 24 hours (p= 0.000). When comparing 8 hours and 12 hours (p= 0.000), 8 hours and 24 hours (p= 0.000). When comparing 12 hours and 24 hours (p= 0.004).

For Group 3 when comparing 4 hours with 8 hours (p= 0.000), 4 hours with 12 hours (p= 0.000), 4 hours with 24 hours (p= 0.000). When comparing 8 hours with 12 hours (p= 0.000), 8 hours with 24 hours (p=0.000). When comparing 12 hours with 24 hours (p= 0.000).

All values for the Wilcoxon Signed rank test demonstrated statistically significant improvements, except for Group 1 (dry-needling) which at the 4-12 hour interval, results were not statistically significant. This shows that results for Group 1 at the 4 hour, 8 hour and 12 hour interval did not improve, and patients perceived more pain therefore recording higher results in the pain diary.

Intergroup Analysis

The Mann Whitney U test produced the following result when comparing Group 1 and 2: (p= 0.012) at 4 hours, (p= 0.000) at 8 hours, (p= 0.000) at 12 hours and (p= 0.000) at 24 hours. All of these results are statistically significant.

When comparing Group 1 and 3 the following was produced: (p= 0.000) at 4 hours, (p= 0.000) at 8 hours, (p= 0.000) at 12 hours and (p= 0.000) at 24 hours. All of these result are statistically significant.

When comparing Group 2 and 3 the following was produced: (p= 0.000) at 4 hours, (p= 0.001) at 8 hours, (p= 0.106) at 12 hours and (p= 0.138) at 24 hours. The results were statistically significant at 4 and 8 hours and were not statistically significant at 12 and 24 hours. This shows that for comparison between Group 2 and 3 results started off at the first two time intervals as non-comparable and then in the last two became comparable. This shows that there is a definite statistically significant change over time versus when looking at comparison of Group 1 and 2 and comparison of Group 1 and 3, where the results remained comparable over all four time intervals. Group 2 and 3 we know both improved to reach results that were more similar at 24 hours then when they started shows that both Groups had a similar improvement over time.

CHAPTER 5 DISCUSSION

5.1. Introduction

Chapter 4 presented the results that were obtained during the clinical trial. Chapter 5 will explain what was found and propose reasons for the results, whilst elaborating on explanations for the results. Reference will be made to pertinent text, literature and past studies.

The discussion in this chapter will be broken down as follows:

1. Demographic data
2. Objective data
    - Algometer
    - CROM
3. Subjective data
    - Numerical Pain rating scale
    - Numerical pain rating diary
4. Conclusion

5.2 Demographic data

A total number of 90 participants, randomly divided into three equal groups were included in the clinical trial. Group 1 received dry needling of TrP1 of the trapezius. Group 2 received dry needling of TrP1 of the trapezius followed by ultrasound therapy over the area. Group 3 received dry needling of TrP1 of the trapezius with a moxi cigar placed and ignited on top of the inserted acupuncture needle as a means of heat transferral.

The minimum age was 19 years old and the maximum age was 62 years old. The mean age percentage over all 90 participants was 28 years old. A study done by Veccheit, (2002) found that active MFTP's are most commonly found in patients under the age of 50 years. This may be accounted to the first 50 years being the most active years in a human beings average life span. This increased activity results in more susceptibility to micro trauma occurring in muscles often

due to overuse. When taking this into account this study falls well within this age demographic margin.

The study was evenly distributed regarding gender. The even distribution of gender was unable to be maintained in the treatment groups as these were chosen randomly. Hence, gender distribution did not reflect the prevalence of MFPD present within the general population. According to an epidemiological study, the prevalence of MFPD is slightly higher in the female population (Rollmant and Luutenbacher, 2001).

5.3 Objective data

5.3.1 Algometer

Clinical interpretation

Clinically the algometer readings that were taken for all three groups, showed that Group 2 and Group 3 improved over 24 hours. Group 1 showed that participants got worse over 24 hours and perceived lower algometer readings. The lower the reading the more pain perceived by the participant. The readings can be summarised by % changes. Group 1 had a decrease of 6.65%. Group 2 had an increase of 23.83% and Group 3 had an increase of 58.87%.

Intragroup Analysis

Results from all three groups in the intragroup analysis revealed a statistically significant change in pain tolerance with application of pressure by the algometer over 24 hours. With group 1 getting worse and group 2 and 3 improving.

Intergroup Analysis

In comparing Group 1 and Group 2, a statistically significant difference was found at the 24 hour post-treatment reading. Taking clinical and intragroup analysis into account, Group 2 showed a greater improvement over Group 1 at 24 hours post-treatment.

In comparing Group 1 and 3, a statistically significant difference is seen post-treatment. This difference is seen again at the 24 hours post-treatment readings. Taking clinical and intragroup analysis into account, Group 3 showed greater improvement over Group 1 from post-treatment, and maintained this greater improvement at the 24 hours post-treatment readings.

In comparing Group 2 and 3, results were not statistically significant throughout. From clinical and intragroup analysis it is known that both groups did show an improvement in algometer readings. Thus neither group had a significant improvement over the other.

However, it is important to note at which point in time the readings improved when compared with Group 1. For Group 2 we see this statistical difference over Group 1 at 24 hours post-treatment. For Group 3 we see the statistical difference over Group1 at the post-treatment reading. Thus we see that Group 3 did show improvement faster in time than the improvement of Group 2.

5.3.1.1 Algometer data explained

Algometer measurements quantitatively assess myofascial TrP's. It does this by using the participants pressure pain threshold (De las Panas, Campo, Carnero and Miangolarra-Page, 2005). Pressure pain threshold is defined by the minimum point of pressure applied where first sign of pain is felt by the participant (Ylinen, 2007).

Group 1, as mentioned above perceived more pain over time at a lower pressure, this may be due to participants in Group 1 experiencing post needling soreness.

Post needling soreness is pain felt by patients and is due to the dry needling treatment. Patients are able to clearly distinguish post needling soreness from the original complaint, post needling soreness is a completely separate entity from myofascial pain (Lewit, 1979).

In an investigation done by Ferriera (2006) to see the effect of dry needling of asymptomatic subjects with respect to post-needling soreness the following was found: both intervention groups did have a degree of post-needling soreness according to the findings from the NRS-101. Therefore the needle insertion was responsible for the post-needling soreness. The use of asymptomatic subjects in this study was to exclude the effect of pain from an active trigger point.

Many authors namely: (Hong, 1994; Ferreria, 2006; Travell, Simons and Simmons, 1999), have listed the addition of an added modality as a means to help alleviate some of the post-needling soreness that is experienced by patients that receive dry needling treatment. When looking at Group 2 and 3 both received an added modality to treatment, as a means of alleviating post-needling soreness. The intergroup analysis confirms that these two groups had greater improvements compared to Group 1 when looking at pressure algometer readings. As mentioned above Group 3 did see this improvement occurring faster in the 24 hour time frame when compared to Group 2. Moxibustion may therefore be more effective as an added modality to dry needling, when wanting to alleviate post-needling soreness.

Moxibustion is known to be a heat treatment that will stimulate specific acupuncture points on the body. The heat created is transferred directly to the TrP as well as superficially to the area, whilst the needle is inserted.

Ultrasound wave's thermal effects are its main property; it has the ability to increase the tissues temperature. It is this thermal property that will aid in alleviating post-needling soreness (Rickards, 2006).

A 1 degree increase in the tissue temperature can increase the tissue metabolism by 10%-15% (Cameron, 1999). By increasing the tissues metabolism, the healing process it also sped up as metabolic and catabolic reactions occur faster. These reactions are needed to break down and remove metabolic waste

by-products released by the MFTP. Increased blood supply also helps transport the correct cells that are needed in healing to the site of injury (Nadler et al, 2003).

Heat is known for its ability to decrease pain. Many hypothesis can explain this and are divided into three main responses namely: neural, vascular and muscular.

The neural hypothesis: nerve fibres that detect increase in temperature are delta A fibres and C fibres. These nerve fibres also detect pain at this area. More of these fibres will be sensitized to the added heat than those that are activated by the pain, therefore fibres will be blocked to the pain and will rely a sensation of heat detection back to the spinal cord and in turn the brain, leading to less sensation of pain (Hooper, 1996).

A muscular hypothesis: pain-spasm-pain cycle. Increasing the temperature of type II muscle spindle fibres leads to a decrease in the discharge from these afferents that in turn causes a decrease in alpha motor neuron firing. Another aspect to a temperature increase is at the Golgi tendon organ of the muscle. A rise in temperature here, will result in an increase in the tendons firing. This has an inhibitory effect on the alpha motor neurons. If combined, the two reactions above cause a decrease of firing of type II fibres as well as a release of tension. If the spasm decrease is great enough the pain-spasm-pain cycle will be broken and there will be a drastic decrease in perceived pain by the participant (Hooper, 1996).

Lastly the vascular hypothesis results in a pain decrease indirectly through metabolic and circulatory means. As mentioned above the rise in temperature increases blood flow to the area and increases blood vessel permeability. Therefore removal of waste products and elimination of chemical irritants that cause pain (Hooper, 1996).

Both forms of treatment provide heat that has proved effective in treating post-needling soreness. Moxibustion is able to achieve the addition of heat whilst the needle is inserted and doesn't require added time to the dry needling treatment. Therefore we assume that it utilizes practitioner time as well as patient treatment time more efficiently. Very importantly alleviates the post-needling soreness immediately, as seen clinically in this study.

5.3.2 Cervical Range of Motion (CROM)

a. Flexion

Clinical interpretation

Looking at clinical interpretation it reveals that Group 3 had the greatest CROM forward flexion improvement of 7.97%. Group 2 had the second greatest CROM forward flexion improvement of 7.68% which was followed by Group 1 that showed improvement of 6.01%. Refer to figure 4.2 for a graphical representation of this improvement.

Intragroup Analysis

For intragroup analysis all three groups did improve in CROM forward flexion. The improvement was seen at the post-treatment as well as at 24 hours post treatment readings. Dry needling of TrP1 of the trapezius thus improves CROM forward flexion immediately after treatment and this improvement was maintained 24 hours after treatment.

Intergroup

Intergroup analysis of CROM forward flexion revealed no statistical significance when comparing all three groups at the three time intervals. From clinical and intragroup analysis it is known that all three groups did show improvement. However none of the three groups when compared against one another showed to have greater improvement over the other.

b. Extension

Clinical interpretation

Looking at the clinical interpretation of CROM extension results, it reveals that Group 3 had the greatest improvement of 6.95% followed by Group 1 with an improvement of 3.94% and lastly Group 2 with an improvement of 1.39%. Refer to figure 4.3 for graphical representation of this change.

Intragroup Analysis

Intragroup analysis shows that all groups showed improved CROM extension readings. This improvement was seen at post-treatment as well as at the 24 hours post-treatment readings. Dry needling of TrP1 of the trapezius thus improves CROM extension immediately after treatment and the improvement was maintained 24 hours after treatment.

Intergroup analysis

According to the intergroup analysis, CROM extension showed no statistically significant differences when comparing Group 1 and 3 and when comparing Group 2 and 3, at the three time intervals at which readings were taken. Therefore there was no discrepancy in the average CROM extension readings over 24 hours. From clinical and intragroup analysis it is known the groups did show improvement. However neither of these groups showed to have had a significant improvement above the other.

A Statistically significant difference was seen when comparing Group 1 and 2. At the start of treatment, the two groups had non-comparable results, at 24 hours post-treatment results were comparable. When taking clinical analysis into account it can be assumed that Group 1 had a greater CROM extension improvement over Group 2 over the 24 hour time frame.

c. Right lateral flexion

Clinical interpretation

Looking at clinical interpretation it reveals that Group 3 had the greatest mean percentage improvement of 14.73%. Group 1 had the second greatest CROM right lateral flexion improvement of 9.20% which was followed by Group 2 that showed improvement of 8.19%. Refer to figure 4.4 for a graphical representation of this improvement.

Intragroup Analysis

Intragroup analysis shows that all three groups showed improvement in CROM right lateral flexion readings. The improvement was seen at post-treatment as well as at the 24 hours post-treatment readings. This shows that dry needling of TrP 1 of the trapezius improves CROM in right lateral flexion immediately after treatment and that the improvement was still seen 24 hours after treatment.

Intergroup

Intergroup analysis of CROM right lateral flexion results revealed no statistical significance when comparing all three groups at the three time intervals. From clinical and intragroup analysis it is known that all 3 groups did show improvement. However none of the three groups when compared against one another showed to have greater improvement over the other.

d. Left lateral flexion

Clinical interpretation

Looking at clinical interpretation it reveals that Group 3 had the greatest mean percentage improvement of 13.55%. Group 1 had the second greatest CROM left lateral flexion improvement of 11.48% which was followed by Group 2 that showed improvement of 6.47%. Refer to figure 4.5 for a graphical representation of this improvement.

Intragroup Analysis

Intragroup analysis shows that all groups showed an improvement CROM left lateral flexion readings. The improvement was seen in all three groups, at post-

treatment as well as at the 24 hours post-treatment readings. This shows that dry needling of TrP1 of the trapezius improves CROM in left lateral flexion immediately after treatment and that the improvement is still seen 24 hours after treatment.

Intergroup

Intergroup analysis of CROM left lateral flexion results revealed no statistical significance when comparing all three groups at the three time intervals. From clinical and intragroup analysis it is known that all three groups did show improvement. However none of the three groups when compared against one another showed to have greater improvement over the other.

e. Right rotation

Clinical interpretation

Looking at clinical interpretation it reveals that Group 3 had the greatest mean percentage improvement of 5.04%. Group 1 had the second greatest CROM right rotation improvement of 3.34% which was followed by Group 2 that showed improvement of 2.18%. Refer to figure 4.6 for a graphical representation of this improvement.

Intragroup Analysis

Intragroup analysis shows that all three groups had an improvement in CROM right rotation readings. The improvement was seen in all three groups, at post-treatment as well as at the 24 hours post-treatment readings. This shows that dry needling of TrP 1 of the trapezius improves CROM in right rotation immediately after treatment and that the improvement is still seen 24 hours after treatment.

Intergroup

According to the intergroup analysis, CROM right rotation showed no statistically significant differences when comparing Group 1 and 3 and when comparing Group 2 and 3, at the three time intervals at which readings were taken.

Therefore there was no discrepancy in the average CROM right rotation readings over 24 hours. From clinical and intragroup analysis it is known that the groups did show improvement. However neither of these groups showed a significant improvement above the other.

A Statistically significant difference was seen when comparing Group 1 and 2. At the start of treatment the two groups had comparable results. At post treatment as well as at 24 hours post-treatment results were non comparable. Taking clinical analysis into account it can be assumed that Group 1 had a greater CROM right rotation improvement over Group 2 at post-treatment and at 24 hours post-treatment readings.

f. Left rotation

Clinical interpretation

Looking at clinical interpretation it reveals that Group 2 had the greatest mean percentage improvement of 5.38%. Group 3 had the second greatest CROM left rotation improvement of 4.35% which was followed by Group 1 that showed improvement of 3.06%. Refer to figure 4.5 for a graphical representation of this improvement.

Intragroup Analysis

Intragroup analysis shows that all groups had an improvement in CROM left rotation readings. The improvement was seen, at post-treatment as well as at the 24 hours post-treatment readings. This shows that dry needling of TrP1 of the trapezius improves CROM in left rotation immediately and that the improvement is still seen 24 hours after treatment.

Intergroup

Intergroup analysis of CROM left rotation results revealed no statistical significance when comparing all 3 groups at the three time intervals. From clinical and intragroup analysis it is known that all 3 groups did show improvement.

However none of the 3 groups when showed to have greater improvement over the other.

5.3.2.1 CROM data explained

The CROM device measures cervical range of motion. In this study TrP1 of the trapezius was needled in isolation with Group 1 having just dry needling, Group 2 dry needling followed by ultrasound over the area and then Group 3 that had dry needling with moxibustion. The function of the trapezius muscle is bilaterally to aid in extension against resistance, shares a role in forward flexion, homolateral flexion and contralateral rotation (Travell and Simons, 1999).

A restricted range of motion can be due to muscle tension and functional shortening. Pain may also cause a decrease in the range of motion, as passive stretching of the muscle activates the noiceptors and this therefore limits the muscles stretch due to pain in turn limiting range of motion (Travell and Simons, 1999). A muscle that contains a TrP does not function optimally and effectively, due to the associated taut palpable band that will restrict is function. If the muscle is unable to stretch and contract correctly the range of motion of the moving segment it supports will be lessened and restricted (Gerwin, 2001). If a myofascial TrP is alleviated it will eliminate the taut palpable band, and return the muscle to full functionality and non-painful stretching and in turn restore correct range of motion (Travell and Simons, 1999).

By explaining this it can be seen why throughout the CROM readings taken in the study all three of the groups had an improvement in CROM. All three groups did have an active Tp1 of the trapezius needled. Looking at the clinical results closely we see that throughout the groups the greatest improvement was in lateral flexion followed then by flexion, rotation and lastly extension. This is explained by only needling TrP 1 of the trapezius on either the left or right, therefore bringing resolution to only one point that will affect one direction of movement of the trapezius, namely homolateral flexion.

Looking at all intra and inter group results for CROM readings we see very minimal if any statistically significant difference in results. The majority of results when compared against one another remained the same throughout, although showing improvement it cannot be concluded that one group had a better improvement in cervical range of motion over the other. It is also important to take note that this provides evidence that dry needling of an active TrP does increase range of motion to the segment the muscle supports. Also important to take note that although the CROM was used as an objective recording, it was for range of motion and did not test pain like other subjective and objective test did. The study was based on testing post-needling soreness and establishing which group presented with the least post-needling soreness.

To account for no statistical differences found in majority of the results the following has to be considered. The approximate values that are considered to be optimal range of motion for the cervical spine. According to Magee (2005) they are as follows:

- Flexion 45˚-50˚
- Extension 85˚
- Axial rotation 90˚
- Lateral flexion 40˚

Another aspect to consider is how cervical muscles are orientated. The upper cervical muscles are more individually arranged and fibres run in specific directions to ensure maximum functionality, this explains why upper cervical muscles are specific to their function. Lower cervical muscles are more united with other muscle and uniformly combined. This cause's one movement to not be specific to a muscle but to have a contribution from many muscles (Moore and Dalley, 2006). This explains why by needling one point in one muscle of the lower cervical spine in isolation may then cause a slight decrease in the range of motion of the segment it supports. The other muscles will then take over its

function giving inaccurate readings that are less precise to the involvement of the trapezius myofascial TrP when testing CROM.

In a journal by Eyadeh, Khamees, Kondeva and Hussein (2004) it is stated that although active TrP's cause pain, it is latent TrP's that play a role in restriction of motion and cause muscle weakness that can be found in the involved muscle (Eyadeh, Khamees, Kondeva and Hussein, 2004). Taking this into account, latent TrP's that may have been found in the rest of the cervical musculature could have been the reason for the restriction in the CROM and not the active TrP that was needled in this study.

To conclude on CROM findings, we can deduce that there is an improvement in the cervical range of motion when using dry needling to treat myofascial TrP's. We are unable to however conclude that one group performed this better than the other when comparing dry needling, ultrasound and moxibustion.

5.4 Subjective data

5.4.1 Numerical pain rating scale

Clinical interpretation

The clinical analysis for NPRS, showed all three groups had a decrease in readings from pre to post-treatment. This shows that participants perceived less pain post treatment. The decrease was highest in Group 3 with 61.48% followed by Group 2 with 53.34% and then Group 1 with 24.40%.

Intragroup Analysis

Results from the intragroup analysis for the NPRS show statistical significance for all three groups from pre-treatment readings to the post-treatment readings. Hence all three groups had statistically significant improvement in the participant's perceptions of pain from the myofascial TrP from pre-treatment to post-treatment.

Intergroup Analysis

According to intergroup analysis, the results for NPRS of all three groups started with no statistical differences and were comparable. At the post-treatment readings comparison with Group 1 and 2 and comparisons with Group 1 and 3 showed statistically significant differences. This is not seen when comparing Group 2 and 3 as the results remained comparable, showing little difference between the two groups reading from pre to post-treatment. Take note that Group 2 and 3 received post-treatment modality before the post-treatment reading whereas Group 1 did not.

5.4.1.1 NPRS explained

The statistical improvement in results revealed by statistical testing of NPRS can be explained by the following:

The acupuncture needle once inserted causes mechanical disruption, depolarization of the nerve fibres, release of endogenous opioids and creating local inflammatory reaction in the area of the active TrP (Rachlin, 1994).

Dry needling also works on the pain gate theory. The theory states that the dorsal horn of the spinal cord acts as a gate. When open stimulus flows to the brain and when closed it does not, therefore pain is not perceived when the gate is “closed”. The theory states that the gate closes when large diameter A-beta nerve fibres are stimulated (Baldry, 2002). This process occurs when an acupuncture needle is inserted directly into the most sensitive part of the TrP, a twitch response occurs. This local twitch response leads to a change in muscle fiber length. Change in length here stimulates the mechanoreceptors that send sensory afferent input via the A-delta fibres into the dorsal cord of the spinal cord. The influx of input from these fibres then blocks the gate to the stimulus from the noicreceptors that are originating at the TrP, therefore patient no longer perceives pain (Travell and Simons, 1999). Stimulation of the A-beta nerve fibres along with causing a pain gate blockage when stimulated, they also cause a

release of endogenous opioids. These play a major pain-inhibitory role (Baldry and Cummings, 2006)

Included in the above, insertion of a dry needle into an active TrP, results in a affect known as the “needle effect”. This is an immediate anaesthetic effect that is caused by deep needle insertion into the most tender site of the TrP. The “needle effect” is also seen with injections into the TrP with allopathic analgesic or local anaesthetic medication (Raj and Paradise, 2004).

In this study the pain scale readings were taken in all three Groups’ pre and then post-treatment. Taking the above into account explains why all three Groups improved.

As mentioned above Group 1 did show improvement in readings but this improvement is not as significant or as large as that of Group 2 and 3. The reason for this can be that Group 2 and 3 received a form of post-needling care to help alleviate post-needling soreness and Group 1 didn’t.

Group 2 and 3 both had a form of heat in addition to dry needing as a means to help alleviate post-needling soreness. The two groups showed greater improvements in pain perception than those participants in Group 1 that had no added heat. Heat and its benefits have been explained in above text under objective data explanation.

5.4.2 Pain Diary

Clinical interpretation

Looking at clinical analysis for the pain diary values showed a decrease in values. This showed that lower readings were recorded during the 24 hour period. Participants therefore recorded less pain over the time intervals. The greatest decrease was seen in Group 3 with a decrease of 54.96% followed by Group 2 with 53.16% and lastly Group 1 with 19.96%.

Intragroup analysis

Intragroup analysis produced statistically significant results for all readings except in Group 1 (dry-needling only) at the 4-12 hour interval. This indicates that all values have statistically significant improvements over the 24 hours, except for Group 1 at the 4-12 hour interval, this will be explained in text later on.

Intergroup Analysis

Intergroup analysis revealed that the pain diary results showed statistical significance at all four time intervals, when comparing Group 1 and 2, also when comparing Group 1 and 3. Thus at the first time interval (4 hours post-treatment) there was a discrepancy in the average pain perceived between these groups. At the last time interval (24 hours post-treatment) results still showed statistical significance and maintained discrepancy in the average pain perceived. Therefore no group can be assumed to have had a significant improvement over the other in these comparisons.

However, when looking at the results produced when comparing Group 2 and 3, they revealed that at the 4 hour and 8 hour interval results were statistically significant and non-comparable. The results then at the 12 hour and 24 hour interval showed no statistical significance, therefore were comparable. This change from being non-comparable at 4 hours and 8 hours to comparable at 12 hours and 24 hours shows that before treatment commenced there was a discrepancy in the average pain. However at the last time interval neither group showed a significant improvement above the other. The fact that both Group 2 and 3 showed to improve similarly, it can be assumed that both these groups had a significant improvement over Group 1.

5.4.2.1 Pain diary explanation

Clinical analysis shows that over the 24 hours all three groups had improved in their pain perceived over the area. The participants recorded lower pain scale readings.

A study conducted by Hong (1994) investigating the effect of lidocaine injections versus dry needling of the upper Trapezius's myofascial TrP found the following: all patients within the dry needling group developed post-needling soreness 2-8 hours after receiving needling. This post-needling soreness was of greater intensity and longer duration then those treated with lidocaine injections. Post-needling soreness is at its most severe 22-24 hours after the injection (Hugenin, 2004). This is a characteristic effect for patients that receive no post needling care. This theory is again confirmed if we look at intragroup results of Group 1. Group 2 and 3 did not have a time interval where results did not improve as with Group 1 this could be that post-needling care ensures a decrease in the characteristic post-needling soreness that is seen Group 1.

In intergroup analysis a pattern of improvement of results taken in the first interval to readings taken in the last time interval is seen. When comparing which group did better over time we see that Group 2 and 3 when compared show a similar pattern of improvement. Readings taken show to start non-comparable but end comparable, showing that participants at the 24 hour mark had similar readings when comparing Group 2 and 3. The change from non-comparable to comparable shows statistically significant difference found. Group 1 is that excluded from this improvement. This group when compared with the other two still remains non-comparable. So although we do see an improvement in results it is not as great as that which is seen in Group 2 and 3. Explanation for this is described above as Group 2 and 3 received post-needling care and this decreases pain perception for participants.

5.5 Conclusion

In concluding we note that all three groups showed improved clinical and statistically significant improvement over a 24 hour time frame for the objective and subjective data obtained.

Group 3 that involved dry needling with moxibustion, showed to have the greatest statistically significant improvements over the 24 hours in all objective and subjective tests. Clinically group 3 showed to have the greatest relief from pain, but also this relief being achieved the fastest after treatment. This can be seen when looking at the pain diary as well as algometer results that showed greater improvement immediately after treatment when compared with participants in Group 1 and Group 2. This is important to note as no added time was needed to be able to add a heat modality to the dry needling protocol. Clinically moxibustion can be assumed to be a better heat modality than ultrasound, having recorded better results.

Group 2 that involved dry needling and ultrasound, showed a very close and only slightly lower statistically significant improvement in objective and subjective results recorded. This does show that ultrasound is an effective therapy in alleviating post-needling soreness, but that it is not as quick at resolving post-needling pain as the moxibustion group was clinically. It also requires extra treatment time, as the ultrasound cannot be combined into the dry needling treatment time.

Group 1 showed the lowest pain improvement, but yet still showed improvement. This shows that post-needling soreness is something that is definitely present when dry needling and when looking at the pain diary results for group 1 a clear increase in pain was noted between 4-12 hours of needling when no modality has been added for post-needling pain relief.

CHAPTER SIX DISCUSSION AND RECCOMENDATIONS

6.1 Discussion

The aim of this study was to establish the most effective post-needling modality in treating post-needling soreness. It was to compare two heat modalities against one another namely: ultrasound and moxibustion. The study also aimed at showing the efficacy of using dry needling as a treatment in MFPS and the importance of a post-needling treatment to prevent post-needling soreness.

The study consisted of 90 participants that were equally divided into three groups. Group 1 received dry needling treatment only. Group 2 received dry needling treatment with ultrasound added as a post needling heat modality. Group 3 received dry needling treatment with a moxi cigar placed and ignited on top, as a means of heat transferral during the dry needling treatment. All participants had TrP 1 of the trapezius dry needled. Objective data was received in the form of algometer and CROM readings. Subjective data was in the form of a numerical pain scale rating questionnaire and numerical pain scale rating diary.

The end of the study showed that all three groups showed significant clinical as well as statistical improvement over the 24 hour time frame in both objective and subjective perception of pain in the upper trapezius muscle. All three groups also showed an improvement in cervical range of motion.

Although all treatments were effective, participants in group 1 statistically appeared to have more perceived pain from 4-12 hours post-treatment, as seen in the numerical pain scale rating diary. Group 2 and 3 had participants that received an added modality for treatment of post-needling soreness, the treatments both included heating the area as a means to alleviate the post-needling soreness. Both groups did appear to have greater statistically significant improvement over group 1 and less pain perception after treatment, but neither group 2 or 3 can be said to be statistically superior over the other.

Statistical evidence also found that dry needling with or without post-needling care resulted in increased CROM readings for all three groups, therefore showing that dry needling of upper trapezius does improve functionality of the cervical spine.

Based on these results presented in above text clinically the study showed that dry needling with the addition of ultrasound or moxibustion, as a treatment for post-needling soreness did appear to have better results. The use of these two added modalities did ease post-needling soreness which for many patients is the reason they don't wish to receive further dry-needling treatment. When using moxibustion the post-needling soreness is eased. This added treatment can be used during the dry needling and does not require additional treatment time for the practitioner or for the patient. To conclude, the efficacy of using a moxibustion to alleviate post-needling soreness has been seen clinically. This treatment can be used with minimal addition treatment time and should be used in clinical practice.

6.2 Recommendations

The following is a list of recommendations that can be used in future studies involving dry needling of upper trapezius in the treatment of MFPS as well as post-needling soreness.

a. A more extensive study, using a larger sample group, whereby the population is more accurately presented and statistically significant results can be obtained
b. A smaller age variable should be included so that the large age differences can be eliminated as a variable
c. A gender specific study should be done so that gender can be excluded as a variable

d. A study that is one arm specific (left or right) should be used to eliminate possible cross over effect and arm dominance that can affect the statistical analysis
e. Studies using follow-up treatments can be conducted at intervals that are greater than 24 hours in order to gather information on the long-term effect of dry-needling with respect to post-needling soreness. This allows for more accurate results and conclusions to be made with regards to the duration of post-needling soreness
f. A study using other forms of moxibustion, such as direct moxibustion can be used to test the efficacy of the moxibustion more accurately
g. An alternative to a heat modality can be added to this study as a means of another form of post-needling treatment, to test the efficacy of heat when treating post-needling soreness
h. Objective readings using a EMG can be used as a replacement to algometer or CROM or as an addition to test the muscle activity of the trapezius before and after treatment
i. To test the efficacy of dry needling in the treatment of MFPS in the upper trapezius a fourth group may be included that uses chiropractic adjustments on restricted segments in the c-spine. This will assess if the chiropractic adjustment has a positive influence on reducing MFPS when compared to dry needling.

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Appendix A

Numerical Pain Rating Scale – 101

Date:_____ File number:_____ Visit number:

Patient name:_____

Please indicate on the line below, the number between 0 and 10 that best describes the pain you experience **when it is at its worst**. A zero (0) would mean "no pain at all", and one hundred (10) would mean, "pain as bad as it could be".

Please write only one number.

0_____10

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

Please write only one number.

0_____100

Appendix B

PAIN DIARY

Dear patient.

Kindly complete this pain diary documenting any soreness you may experience, in the area that was needled, during the 24 hours following your treatment.

You will need to answer “yes” or “no” as to whether at that time period pain is experience, if yes then please scale it on a sale of 0-10, 0 being no pain and 10 being the worst pain you have ever experienced. Encircle your answers.

Please do not apply ice to the needled area, do not take any medication (anti-inflammatory drugs) and fill in the pain diary precisely according to the allocated times.

Date and time _____

4 Hours										Yes	No
1	2	3	4	5	6	7	8	9	10		

8 Hours										Yes	No
1	2	3	4	5	6	7	8	9	10		

12 Hours										Yes	No
1	2	3	4	5	6	7	8	9	10		

24 Hours										Yes	No
1	2	3	4	5	6	7	8	9	10		

My pain was the worst at _____hours. If there are any questions please feel free to contact me, Donielle Dampier, on 0829245459.

_____ _____

Researcher Signature

_____ _____

Appendix C

ADVERTISEMENT

IS THIS YOU?

If you older then 18 and have pain in your lower neck shoulder regions, come and see if you qualify to take part in a research trial at the chiropractic clinic Droonfontein!!!!

Your Trapezius, a muscle in your upper shoulder, may be the problem.

This trial involves dry needling of the Trapezius muscle.

Contact Donielle Dampier: 082 924 5459

Appendix D

Information and Consent form

DEPARTMENT OF CHIROPRACTIC (12)

INFORMATION AND CONSENT FORM (12)

I, Donielle Dampier, hereby invite you to participate in my research study. I am currently a Chiropractic student, completing my Masters Degree at the University of Johannesburg.

The aim of the study is to determine an effective way in which dry-needling can be used to treat myofacial pain syndrome with minimal post needling soreness, without added extra treatment time for both patients and practitioners.

You will be placed in one of three groups and ask to have one treatment involving dry needling of trigger point one of the trapezius muscle. Your pain threshold at the trigger point as well as range of motion of the neck will be measured, before we start treatment, after the needle has been removed and again 7 minutes later. This will then be measure for the final time 24 hours after the needling. On request a pain scale questionnaire will need to be answered before we start treatment and then again 24 hours later. You will be asked before leaving to keep a pain diary. This will require you to answer a very easy pain scale questionnaire at four time sets. It will be calculated such that your sleep cycle is not disturbed. The researcher will on request place a reminder on your phone for when to fill out the questionnaire that will take you no longer the 30 seconds. If you do not have a cell phone the researcher will give you an alarm clock that will go off when the diary needs to be filled out. The pain diary will be returned 24 hours later when final readings are taken.

Dry Needling is an invasive procedure but using the correct technique and safety measures the treatment usually is safe. If you are in group one, you will not be receiving treatment for post-needling soreness. The pain is described as tenderness over the needled spot, much the same as a bruise. This is a mild discomfort and should not prevent you from completing the normal day to day tasks. You will be reminded not to take any medication or any treatment for this pain. If at any stage this pain becomes too much for you, contact the researcher immediately and treatment will be performed to attempt to reduce your pain. For participants in group two, you will receive ultrasound therapy over the needled area after the needle has been removed, this is to allow blood flow into the area and increase the tissues metabolic rate, thereby increasing healing. There are minor risks with ultrasound namely: skin reactions and burns. This will be prevented by the ultrasound being set correctly and by the ultrasound head being moved constantly. You, as the participant must vocalized to the researcher if it feels to hot or the skin gets itchy or burns in any way. The sensation you should feel is mild, comfortable warmth. The researcher will perform what is known as a hot/cold test and sharp/blunt test to determine that you are able to distinguish the difference between these and that you have full sensation over the area to be ultra sounded.

For those participants in group three, a moxi cigar will be placed on top of the needle and lit. This cigar is designed to heat the acupuncture needle while it is inserted into the trigger point. With Moxibustion there is a risk of skin burn, this is prevented by ensuring the burning moxi cigar never comes in direct skin contact. You as the patient will be asked to communicate throughout the ten minutes and to inform the researcher if ever you feel it is to hot or burning you in any way, the needle in this case will be removed immediately and skin cooled. You will be withdrawn from the study. Another risk with the moxi cigar is that the scent released when the maxi cigar is burning may cause nausea and nasal congestion, a fan for ventilation will be used to try prevent this, but if at any stage you feel ill or the smoke is affecting you negatively the treatment will be stopped and you will be withdrawn from the study.

For all three groups dry needling will be used, Dry Needling is an invasive procedure but using the correct technique and safety measures the treatment will be safe. The most serious of the risks with dry needling is pneumothorax (collapse of the lung). The area being needled is in a risk area for hitting a lung with the needle, if this happens your symptoms will be shortness of breath which may last several days or weeks. Should this occur you will need to be sent to hospital to have the pneumothorax monitored and treated if necessary. Pneumothorax is avoided by placing you on your stomach on the bed with you arms resting on arm rest. A pillow will be placed under your head and shoulder so as to remove slack from the upper muscle fibers and lift the muscle off the underlying lung. The trigger point is held in a pincer grasp and fingers rolled so that the needle can be directed towards the researchers index/middle finger avoiding the lung apex. Other risks include excessive bleeding which may lead to bruising, therefore important to inform the researcher of any bleeding disorders in your history. The researcher will apply pressure for 15 seconds after the needle is removed to prevent bruising and bleeding (heamostasis). A risk of infection is also a rare occurrence as every precaution is taken to ensure that the needles are straight out of their sterile packaging and that the area to be needled is properly cleaned.

Treatment will consist of only one dry needling treatment in the study. Patients often require multiple treatments to have resolution of the myofascial pain syndrome. You will be advised about this and treated after the study free of charge if you so choose.

The research study will take place at the University of Johannesburg Chiropractic Day Clinic. Your privacy will be protected by ensuring your anonymity and confidentiality when compiling the research dissertation.

Your participation is entirely on a voluntary basis. If you are uncomfortable with continuing at any stage of the study, you will be allowed to withdraw. After the study is complete, I will provide you feedback regarding the outcomes if you so wish.

I have fully explained the procedures and their purpose. I have asked whether or not any questions have arisen regarding the procedures and have answered them to the best of my ability.

Date: _____ Researcher: _____

I have been fully informed as to the procedures to be followed and have been given a description of the discomfort risks and benefits expected from the treatment. In signing this consent form I agree to this form of treatment and understand my rights and that I am free to withdraw my consent and participation in this study at any time. I understand that if I have any questions at any time, they will be answered.

Date: _____ Participant: _____

Should you have any concerns or queries regarding the current study, the following persons may be contacted.

Researcher:	Donielle Dampier	082 924 5459
Supervisor:	Dr Charmaine Bester	011 559 6936

Appendix E

Contra-indications and precautions to myofascial dry needling (Mc Cutcheon, L. *et.al*. (2007).

Prohibited areas: nipples, umbilicus, external genitalia, and scalp area in infants.

Danger areas: Lung fields, varicose veins, infected tissue, limb affected by lymphademia, orbit of the eye.

Pregnancy should proceed with care

Diabetes

Confused patients

Children under the age of 16 need parental consent.

Bleeding disorders

Patients on Anti-coagulants

Extra caution with patients with cancer.

Patients with blood borne disease need to take note and added care

Patients with acute immune disorders need to take note and caution before proceeding.

Allergies to metals.

Frail patients.

Patients with neurological disorders.

Appendix F

Contra-indications to ultrasound therapy (Hooper, 1996).

Near a pacemaker

Over nerve plexuses

Over bony prominences

Blood thinning medication

Over metal implants

Malignancies

Peripheral neuropathies

Peripheral vascular disorders

Infection