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A Comparative Study between Low Level Laser Therapy and Myofascial Dry Needling on Active Gluteus Medius Trigger Points

A dissertation submitted to the Faculty of Health Sciences, University of Johannesburg, in partial fulfilment of the requirements for the degree of
Master of Technology: Chiropractic by:

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Dr. C. Hay
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ABSTRACT

Myofascial trigger points (MTrP’s) cause acute discomfort to intense pain and often lead to the use of pain medication as well as loss of man hours (Simons, Travell and Simons, 1999a; Tough, White, Cummings, Richards and Campbell, 2009).

Dry needling is very effective and is widely used for the treatment of MTrP’s (Vulfsons, Ratzmanky and Kalichman, 2012), but comes with various significant drawbacks, such as the experience of pain during or after treatment (post-needling soreness) or individuals with needle phobias (Unruh, Strong and Wright, 2002). More serious risks also exist, including damage to the viscera (Dommerholt and Fernandez-de-las-Penas, 2013).

Low level laser therapy (LLLT) is a non-invasive technique and very little discomfort or pain is experienced by the patient during and after treatment. LLLT is effective in the short- and long-term relief of trigger points and myofascial pain syndrome. Therefore it can easily serve as an alternative to myofacial dry needling (Chow and Barnsley, 2005).

This study aimed to determine whether LLLT or myofascial dry needling is more effective in the treatment of active MTrP’s, specifically those of the gluteus medius muscle. It also aimed to determine if LLLT could serve as an alternative treatment to dry needling in cases where dry needling is contraindicated or not desired.

Thirty participants who complied with the inclusion criteria were divided into one of two groups. Group 1 (n=15) received dosages of LLLT directly to the active MTrP’s in the gluteus medius muscle and Group 2 (n=15) received myofascial dry needling to active MTrP’s in the gluteus medius muscle. Each participant attended 6 treatment sessions over a course of 2 weeks as well as a 7th measurements-only session.

Subjective and objective measurements were taken during the 1st, 4th and 7th visits. Objective data was obtained using a pressure algometer and a
universal goniometer for active hip range of motion in abduction. Subjective data was obtained using the Numerical Pain Rating Scale (NPRS) and the revised chiropractic Oswestry Disability Index (ODI).

The results between the groups were insignificant and both dry needling and LLLT resulted in a subjective improvement. Clinically, however dry needling was slightly superior in terms of the subjective data. The greater clinical result is possibly due to the use of needles having a psychological effect on patients with treatment being more invasive and relatively time-consuming (Hong, 2002).

During the objective data analysis, dry needling only started to show a significant improvement between visits 4 and 7. LLLT showed a significant improvement between visits 1 and 4, and 4 and 7. This finding could imply that more dry needling sessions are required before a result can be seen. However, both groups improved significantly by the 7th visit.

Dry needling and LLLT were found to be equally effective in the treatment of MTrP’s. LLLT could provide an effective alternative to dry needling whenever dry needling is contraindicated, the patient simply prefers not to be treated with needles or when the patient has a fear of needles.
DEDICATION

I dedicate this work to my parents, Ben and Gerda van Heerden, for providing me with the opportunity to follow my dreams.
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CHAPTER 1: INTRODUCTION

1.1 General Information

A myofascial trigger point (MTrP) is a hyperirritable zone within a skeletal muscle that is associated with a hypersensitive palpable nodule in a tight muscular band (Simons, Travell and Simons, 1999a). These trigger points cause acute discomfort to intense pain and they often lead to the use of pain medication as well as a loss of man hours (Simons, Travell and Simons, 1999; Tough, White, Cummings, Richards and Campbell, 2009). Myofascial pain syndrome is the single most common reason for patients with musculoskeletal pain to visit their primary clinician (Kalichman and Vulfsons, 2010) and the main diagnosis made by pain management specialists (Harden, Bruehl, Gass, Niemic and Barbic, 2000). Therefore MTrP’s are very important to the chiropractor to diagnose and treat correctly.

Dry needling is very effective and is widely used for the treatment of MTrP’s (Vulfsons, Ratmansky and Kalichman, 2012), but comes with various significant drawbacks, such as the experience of pain during or after treatment (post-needling soreness) or individuals with needle phobias (Unruh, Strong and Wright, 2002). More serious risks also exist including damage to the viscera (Baldry, 2002).

Low level laser therapy (LLLT) is a non-invasive technique and very little discomfort or pain is experienced by the patient during and after treatment. A study done by Vernon and Shneider (2008) in the treatment of MTrP’s revealed LLLT to be the most effective amongst ischaemic compression, transcutaneous electrical nerve stimulation, spinal manipulation, osteopathic manipulative therapies, manual mobilisation, transverse friction massage, stretching, trigger point injection, myofascial dry needling, acupuncture, magnet therapy, electrical stimulation, high voltage
muscle stimulation, interferential current, frequency modulated neural stimulation, ultrasound, spray and stretch, soft tissue massage, strain/counterstrain and myofascial release. It was concluded that LLLT is effective in the short- and long-term relief of trigger points and myofascial pain syndrome. Therefore it can easily serve as an alternative to myofacial dry needling (Chow and Barnsley, 2005).

1.2 Aim of the Study

The aim of the study is to determine whether LLLT or myofascial dry needling will be more effective in the treatment of active MTrP’s, specifically those of the gluteus medius muscle. It will also provide further evidence as to the efficacy of LLLT and myofascial dry needling as a treatment for active MTrP’s, and will demonstrate any superiority between the two modalities.

1.3 Possible Outcomes and Contributions

The study may prove LLLT to be an alternative treatment modality for active MTrP’s. LLLT may also provide an effective means to treat MTrP’s when myofascial dry needling is contraindicated or when the patient prefers not to be treated with needles. The study can benefit the chiropractic profession by indicating which of the two modalities is more effective when treating myofascial pain. Therefore it may indicate to the chiropractor an alternative treatment option when dry needling cannot be used.

The next chapter will be dedicated to reviewing the relevant literature needed to fully understand this study. It includes all the relevant anatomy of the gluteus medius muscle, a discussion about what MTrP’s are,
including their causes, anatomy and physiology and discussions about myofascial dry needling and LLLT as treatment modalities.
CHAPTER 2: LITERATURE REVIEW

2.1 The Gluteus Medius Muscle

2.1.1 Introduction

The gluteus medius muscle is a thick, broad voluntary skeletal muscle that is situated on the outer surface of the pelvis. It is recruited during single-limb weight bearing and functions together with gluteus minimus to abduct the neutral thigh (Moore and Dalley, 2005).

2.1.2 Structure of voluntary skeletal muscle

Functional organisation
Skeletal muscle is composed of numerous muscle fibres. Each muscle fibre contains several hundred to several thousand myofibrils (Guyton and Hall, 2006) (Figure 2.1).

- A myofibril consists of approximately 10,000 sarcomeres. Sarcomeres are repeating functional units of bundles of thick and thin filaments
- Each myofibril is composed of about 3000 thin filaments and 1500 adjacent thick filaments. Thin filaments are composed mainly of actin. Thick filaments are composed mainly of myosin
- Thin filaments consist of four proteins: F-actin, nebulin, tropomyosin and troponin
- Thick filaments consist of a free head that projects outward towards the nearest thin filament and a long tail that is bound to the other myosin molecules
The sarcomere
Sarcomeres have A-bands and I-bands, which is seen as dark and light bands under a light microscope, respectively. An A-band is found in the centre of a sarcomere and consists of an M-line, H-zone and a zone of overlap and contains thick and thin filaments. An I-band contains only thin filaments and consists of a Z-line, which interconnects thick filaments of adjacent sarcomeres. From the Z-line thin filaments extend toward the M-
line and into the zone of overlap. The Z-line is surrounded by a meshwork of intermediate filaments, which interconnects adjacent myofibrils (Guyton and Hall, 2006). This can be seen in Figure 2.2.

![Figure 2.2: The sarcomere (Hall, 2011)](image)

**The sarcolemma, sarcoplasmic reticulum, T-tubules and terminal cisternae**
The sarcolemma acts as the cell membrane of the muscle fibre and surrounds the sarcoplasm, or cytoplasm of the muscle fibre. T-tubules are narrow tubes that are continuous with the sarcolemma and extend into the sarcoplasm at right angles to the cell surface. T-tubules form passages through the muscle fibres to allow electrical impulses conducted by the sarcoplasm to travel into the sarcolemma, allowing contraction of the muscle cell. The sarcoplasmic reticulum (SR) is a membrane complex forming a tubular network around each myofibril. On either side of a T-tubule, the tubules of the SR enlarge to form expanded chambers called terminal cisternae. A pair of terminal cisternae and a transverse tubule is known as a triad. Skeletal muscle fibres remove calcium ions from the sarcoplasm by actively transporting them into the terminal cisternae of the SR. The sarcoplasm of a resting skeletal muscle fibre contains very low
concentrations of calcium. The calcium concentration levels inside the terminal cisternae can be up to a 1000 times higher. A muscle contraction occurs when stored calcium ions are released into the sarcoplasm after which the ions diffuse into the sarcomeres (Guyton and Hall, 2006). This can be seen in Figure 2.3.

![Figure 2.3: The structural units of skeletal muscle (Martini, 2006)](image)

### 2.1.3 Muscle fibre contraction

During a muscle contraction the thin filaments slide alongside the thick filaments towards the centre of the sarcomere. This sliding occurs in every sarcomere along the myofibril. As a result the myofibril gets shorter. This is known as the sliding theory of muscle contraction. Because the myofibrils are interconnected via their attachment to the sarcolemma at each Z-line and at each end of the muscle fibre, the whole muscle fibre shortens (Guyton and Hall, 2006). Refer to Figure 2.4.

Muscle contraction can occur only when activated by neurons. Neurons activate muscle fibres via the stimulation of its sarcolemma. A neuron stimulating a muscle fibre starts with the arrival of an action potential. The
Figure 2.4: A relaxed(a) and contracted(b) sarcomere (Hall, 2011)

action potential reaches the synaptic terminal causing the permeability of the membrane to change, allowing Acetyl Choline (ACh) to be released into the synaptic cleft. ACh molecules diffuse across the SR to bind to ACh receptors on the sarcolemma at the motor end plate. This causes the motor end plate to become permeable to sodium ions. Extracellular fluid contains a high concentration of sodium and thus they rush into the sarcoplasm. An action potential is generated in the sarcolemma. An electronic impulse is generated at the edges of the motor end plate and sweeps across the entire membrane surface, inwards along the T-tubules to the sarcolemma. Before the action potential has spread, ACh gets broken down by Acetyl Choline Esterase (AChE). The breakdown products are absorbed by the synaptic terminal to re-synthesise ACh for subsequent release (Martini, 2006).

When the action potential reaches the triads, calcium is released from the terminal cisternae, which are located at the zones of overlap and the effect
on the sarcomere is almost instantaneous. Troponin is the lock that keeps the active sites inaccessible and calcium is the key to that lock. Calcium ions bind to the active sites on the F-actin molecules. This changes the shape of the troponin molecule, weakening the bond between troponin and actin. The troponin molecule changes position by rolling the tropomyosin strand away from the active site, allowing them to bind to the myosin heads forming cross-bridges. The myosin heads are already energised – at the start of a contraction cycle each myosin head has already split a molecule of adenosine triphosphate (ATP) and stored the energy that was released. The breakdown products, adenosine diphosphate (ADP) and phosphate remain bound to the myosin head. After cross-bridge formation the stored energy is released as the myosin head pivots toward the M-line. As this occurs, the ADP and phosphate molecules are released. Another ATP binds to the myosin head, breaking the bond between the actin and the myosin. Reactivation of myosin occurs with the splitting of ATP into ADP and phosphate. The energy released re-cocks the myosin head. The entire cycle is repeated several times per second for as long as calcium ion concentrations remain elevated and ATP reserves are sufficient (Martini, 2006).

2.1.4 Structure and function of the gluteus medius muscle

Anatomical attachments
Gluteus medius is a thick, fan-shaped muscle located between the gluteus maximus and gluteus minimus muscles (refer to Figure 2.5). The muscle attaches proximally to the external surface of the ilium between the anterior and posterior gluteal lines. Part of gluteus medius arises from the gluteal aponeurosis, which covers two thirds of the muscle. Distally it attaches to the lateral surface of the greater trochanter of the femur via a broad tendon (Simons, Travell and Simons, 1999b).
**Innervation**
Fibres originating from the fourth and fifth lumbar and first sacral nerves unite to form the superior gluteal nerve. The nerve passes between gluteus medius and minimus and sends branches to each muscle (Simons, Travell and Simons, 1999b). The main supply to gluteus medius is from the inferior branch of the superior gluteal nerve, but sometimes the superior branch also contributes to its innervations (Bos, Stoeckart, Klooswijk, van Linge and Bahadoer, 1994).

**Functions**
The primary function of the muscle is to support the pelvis during one-limb weight bearing by preventing the ipsilateral side of the pelvis from dropping. This function is especially important during the single-limb stance phase of the gait cycle.

Figure 2.5: The attachments of the gluteus medius muscle (Simons, Travell and Simons, 1999)
Gluteus medius is recognised as the most powerful abductor of the thigh. The anterior fibres of the muscle assist with medial thigh rotation. Thigh flexion and lateral rotation by gluteus medius is either minimal or dependant on the position of the thigh (Simons, Travell and Simons, 1999b).

2.1.5 The link between gluteus medius and low back pain

Low back pain has been described as an epidemic of the 20th century and the trend continues in the 21st century (Cusi, 2010). Sacroiliac joint (SIJ) dysfunction accounts for 50-70% of low back pain complaints (Chapman-Smith, 1993).

The term “SIJ dysfunction” refers to abnormal functioning of one or both of the SIJ’s. Over time, changes start to occur in the structures surrounding the joints, such as tightening of the ligaments and spasm of the muscles that cross the joint or attach to the pelvis (Simons, Travell and Simons, 1999b).

SIJ dysfunction leads to an abnormal distribution of loads in the body. This, in turn causes abnormal biomechanics of the lumbar spine, hip joints, ligaments and the surrounding muscles, including the gluteus medius muscle.

Some theories have suggested that SIJ dysfunction leads to ligament, fascia and muscular dysfunction. Others believe that MTrP’s of gluteus medius is the initial syndrome causing dysfunction of the SIJ’s. Inevitably the conditions are linked.

Gluteus medius serves to stabilise the pelvis during single-limb weight bearing and ambulation. When the SIJ’s become dysfunctional, gluteus medius is recruited to stabilise the pelvis. Due to the muscle’s constant activation it gradually develops trigger points (Sims and Mesnick, 2013).
In a porcine model, the SIJ was stimulated and subsequent responses occurred in the gluteus medius, gluteus maximus and quadratus lumborum muscles. This confirms that the SIJ could be directly involved in activating these muscles (Indahl, Kaigle, Reikeras and Holm, 1999).

2.1.6 Gluteus medius muscle trigger point locations and referral patterns

Gluteus medius has three trigger points which are found just beneath the iliac crest. Its locations and trigger points are described in Table 2.1 and can be visualised in Figure 2.6 (Simons, Travell and Simons, 1999b).

<table>
<thead>
<tr>
<th>Trigger Point</th>
<th>Location</th>
<th>Referral Pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>In the region close to the iliac crest near the SIJ, in the posterior portion of the muscle</td>
<td>Refers pain and tenderness along the posterior iliac crest to the region of the ipsilateral SIJ as well as over the sacrum on the same side. Pain may also extend over much of the buttock</td>
</tr>
<tr>
<td>2</td>
<td>Middle portion of the muscle, centred along the length of the iliac crest</td>
<td>Pain refers more laterally and to the mid-gluteal region, extending into the upper thigh posterior</td>
</tr>
</tbody>
</table>

Table 2.1: Gluteus medius MTrP’s: Their locations and referral patterns (Travell and Simons, 1999b)
Near the anterior superior iliac spine (ASIS) and lateral
Refers along the iliac crest, bilaterally over the sacrum and to the lowest lumbar region

Figure 2.6: A diagrammatic representation of the MTrP's of the Gluteus medius muscle, their locations and referral patterns (Simons, Travell and Simons, 1999b)

Events likely to activate or perpetuate these trigger points include (Simons, Travell and Simons, 1999b):

- Sudden falls
- Sports injuries
- Single-limb weight bearing for a prolonged time period
- Pelvic distortion
- SIJ dysfunction
- Prolonged hip flexion
2.2 Myofascial Trigger Points

A MTrP is a hyperirritable zone within a skeletal muscle which is associated with a hypersensitive palpable nodule in a tight muscular band. The zone is tender to palpation and becomes increasingly painful on compression. Active MTrP’s are spontaneously painful and latent MTrP’s are only painful when stimulated, for example, with digital pressure (Simons, Travell and Simons, 1999a).

The following diagnostic criteria are applicable in the identification of MTrP’s:

Essential Criteria:

- Taut Palpable Band
- Spot tenderness of a nodule in a taut band of skeletal muscle
- Reproduction of the patient’s current pain complaint by compression of the tender nodule
- Painful limited full stretch range of motion

Confirmatory Observations:

- A local twitch response (by visual or tactile identification)
- Imaging of a local twitch response induced by needle penetration of the tender nodule
- Pain or altered sensation in pattern that is specific to that muscle on compression of the tender nodule (Kostopoulos and Rizopoulos, 2001; Simons, Travell and Simons, 1999a).
2.2.1 Pathophysiology of MTrP’s

The exact aetiology of trigger point formation is unclear but numerous theories attempt to describe the development of MTrP’s. Theories include the energy crisis theory, the motor endplate hypothesis, the pain-spasm-pain cycle, the muscle spindle hypothesis, the fibrotic scar tissue hypothesis and the integrated hypothesis.

It has been suggested that the pain-spasm-pain cycle, the muscle spindle hypothesis and the fibrotic scar tissue hypothesis do not stand up to experimental verification (Simons, Travell and Simons, 1999a).

The energy crisis theory
This hypothesis was first introduced in 1983 (Simons, Travell and Simons, 1999a). Figure 2.7 shows the basic concept behind the energy crisis theory. It starts with an initial insult that causes mechanical disruption of the SR or the sarcolemma. Calcium leaks into the sarcoplasm and the contractile activity of the actin and myosin filaments become maximally activated. There is also abnormal depolarisation of the post-junctional membrane causing release of ACh from the dysfunctional neuromuscular junction (NMJ), which increases calcium release. A sustained contraction ensues that compresses the capillary beds in the muscle. The muscle is now in a state of high metabolic demand and low oxygen and nutrient supply, which leads to a local energy crisis. The calcium pump responsible for returning calcium to the SR is dependent on an adequate supply of ATP. When the pump fails, the contractile mechanism persists, assuring continued failure of the pump. When the ATP supply of the contractile mechanism is completely exhausted, a sustained contracture develops and the vicious cycle of the energy crisis theory is completed. In addition, severe local hypoxia along with the tissue energy crisis leads to the release of neurovasoreactive substances, sensitising local nociceptors (Simons, Travell and Simons, 1999a; Mense and Simons, 2001).
The motor endplate hypothesis

According to the motor endplate hypothesis, the formation of MTrP’s is a result of physiological dysfunction within the neuromuscular junction (NMJ) and surrounding connective tissue (Shah and Gilliam, 2008). Electromyographic (EMG) studies have shown that there is spontaneous electrical activity (SEA) at MTrP loci that is not present in the surrounding tissue. Active loci that produce electrical activity were clustered within the region of clinically identified MTrP’s (Hubbard and Berkoff, 1993). The localisation of active loci in the endplate zone predominantly at the MTrP has been confirmed experimentally (Simons, Hong and Simons, 1995). SEA was shown to be the result of an abnormal increase of ACh release by the nerve terminal (Simons, Travell and Simons, 1999a). Endplate noise observed on EMG represents the increased rate of ACh being released from the nerve terminal. Excessive ACh perpetuates the contraction of associated muscle fibres, increasing the metabolic demand of the muscle (Mense and Simons, 2001).

According to Huguenin (2004), the energy crisis theory and the motor endplate hypothesis may very well coexist.

Figure 2.7: The energy crisis theory (Simons, Travell and Simons, 1999a)
The integrated hypothesis

The integrated hypothesis brings together several findings of MTrP’s to describe as a possible sequence of MTrP development (Simons, Travell and Simons, 1999a). It combines electrodiagnostic and histopathologic evidence to provide a basis for a credible aetiology of MTrPs and accounts for all the major clinical characteristics of MTrPs. Figure 2.8 shows a positive-feedback cycle summarising the events occurring in the development of a MTrP after acute or chronic muscle overload. Each step is anchored by experimental data (Simons, 2004).

Figure 2.8: Positive-feedback cycle of the integrated hypothesis (Simons, 2004)

Step 1 – Abnormal ACh release: An initial event (acute or chronic muscle overload) activates a latent trigger point and increases the release of excessive ACh by the endplates into the neuromuscular junction (NMJ). This can be seen as endplate noise (EPN) on needle electromyographic studies (Couppe´, Midttun, Hilden, Jørgensen, Oxholm and Fuglsang-Frederiksen, 2001; Simons, Hong and Simons, 2002). EPN represents an abnormal increase in ACh at the NMJ (Heuser and Miledi, 1971; Ito, Miledi and Vincent, 1974).
Step 2 – Increased fibre tension: Palpable “knots” in muscles are regions of severely shortened sarcomeres involving all the sarcomeres in that part of the muscle fibre. Sarcomeres in the same muscle fibre, but beyond the knot are lengthened compared to the uninvolved sarcomeres. Contracted and stretched sarcomeres in one muscle fibre, increases the tension in the muscle fibre. If there is involvement of a sufficient amount of muscle fibres, a palpable taut band is produced. Motor endplates releasing excessive amounts of ACh produces knots in the muscles and subsequent palpable taut bands (Simons and Stolov, 1976).

Step 3 – Local hypoxia: A region of severe hypoxia has been found to exist in the center of a MTrP, which is surrounded by a region of normally oxygenated tissue (Brückle, Suckfü, Fleckenstein, Weiss, Müller and Gewebe, 1990). Severely shortened sarcomeres in the center of the previously mentioned knots have unusually high oxygen demands to maintain continuous maximum contractile activity. The increased tension of the shortened and compensatory stretched sarcomeres compresses the local circulation, producing local tissue ischaemia. Therefore it is evident that there is a high oxygen demand paired with a decreased blood supply, thus leading to severe local hypoxia (Simons, 2004).

Step 4 – Tissue distress: Tissue ischaemia and hypoxia leads to compromisation of glycolytic and aerobic energy supply to the muscle fibre. This leads to a reduction in ATP release as well as the release of sensitising substances. This results in tissue distress (Simons, 2004).

Step 5 – Sensitising Substances: Eight noxious histochemicals, protons, bradykinin, calcitonin-gene related peptide (CGRP), substance-P, tumor necrosis factor α (TNF-α), interleukin 1β (IL1-β), serotonin and norepinephrine, have been found in the chemical milieu of MTrP’s. The amounts of these substances were found to be very significant and consistently greater in active MTrP’s than in latent ones. In latent MTrP’s the chemical milieu of the above substances were found to be slightly
elevated, but consistently more than in MTrP-free muscles (Shah, Phillips, Danoff and Gerber, 2003; Shah and Gilliams, 2008).

Step 5’ - Sarcoplasmic reticulum (SR) dysfunction: The SR calcium pump requires ATP to function. Since the ATP concentration is low, MTrP’s compromise the uptake of calcium by the SR. The sustained increase in local calcium levels leads to a sustained contraction (Simons, 2004).

Step 6 – Autonomic modulation: MTrP’s influence and are influenced by the autonomic nervous system (ANS) (Simons, 2004). It has been shown that the amount of EPN is directly proportional to the rate of ACh release at the endplate (McNulty, Gevirtz, Hubbard and Berkoff, 1994; Lewis, Gevirtz, Hubbard and Berkoff, 1994). Autonomic influences can modulate, but are not completely responsible for increases in ACh release (Chen, Chen, Kuan, Chung and Hong, 1998). As ACh levels increase due to anxiety and nervous tension, the positive-feedback loop is reinforced and MTrP’s are aggravated. However, Simons (2004) stated that the links to and from step 6 are speculative with many reasonable possibilities that still require research and investigation.

2.2.2 Treatment

In order for a MTrP to be resolved, the positive-feedback cycle must be interrupted. Many different modalities are used by chiropractors to disrupt the cycle, including myofascial dry needling and LLLT.

2.3 Myofascial dry needling

The dry needling technique involves insertion of an acupuncture needle into a previously palpated trigger point. Mechanical, neurophysiologic and chemical effects are observed upon dry needling of a trigger point. This
ultimately leads to inactivation of the trigger point, pain relief and increased function (Shah, Phillips, Danoff and Gerber, 2005). Dry needling has been shown to reduce local and referred pain (Affaitati, Costantini, Fabrizio, Lapenna, Tafuri, and Giamberardino, 2011), improve joint range of motion (Lucas, Polus and Rich, 2004; Lucas, Rich and Polus, 2010) and decrease MTrP irritability both locally (Kuan, Hsieh, Chen, Chen, Yen and Hong, 2007) and more remotely (Hsieh, Chou, Joe and Hong, 2011).

2.3.1 The effects of myofascial dry needling

Mechanical effects
Dry needling mechanically disrupts the integrity of the dysfunctional motor endplates (Simons, Travell and Simons, 1999a).

The needle provides a localised stretch to the contracted cytoskeletal structures. The myosin filaments are disentangled from the titin gel at the Z-band. The sarcomere resumes its resting length by reducing the degree of overlap between actin and myosin filaments (Dommerholt, 2004).

Mechanical stimulation causes group II fibres to register a change in total fibre length. The pain-gate is activated and nociceptive input is blocked from the MTrP, reducing perceived pain (Dommerholt, 2004).

Fibroblasts are highly specialised contractile cells within the fascia that synthesise, organise and remodel collagen (Findley, 2011; Grinnel, 2003). Dry needling places fibroblasts in a high tension matrix, causing the fibroblast to change to a more lamellar shape, increasing collagen synthesis and cell proliferation (Hicks, Cao, Campbell and Standley, 2012; Langevin, Bouffard, Fox, Palmer, Wu, Iatridis, Barnes, Badger and Howe 2011).

Myofascial dry needling plays an important role in the process of mechanotransduction. Mechanotransduction is a process by which the
body converts mechanical loading into cellular responses (Hinz, Phan, Thannickal, Prunotto, Desmoulière, Varga, de Wever, Mareel and Gabbiani 2012; Hinz, 2010). When fibroblasts are activated by a solid filament, it has been shown to result in pain reduction (Langevin, Bouffard, Badger, Iatridis and Howe, 2005).

The mechanical pressure of a needle electrically polarises the connective tissue and muscle. A physical characteristic of collagen is that it contains intrinsic piezoelectricity, allowing the tissues to transform mechanical stress into electrical activity to allow tissue remodelling. This possibly contributes to the local twitch response (LTR) (Liboff, 1997).

**Neurophysiologic effects**

Dry needling stimulates A-nerve fibres (group III) for 72 hours after the needle was inserted. Prolonged stimulation of the sensory afferent A-nerve fibres activates enkephalinergic inhibitory dorsal horn interneurons causing opioid-mediated pain suppression (Baldry, 2001).

Dry needling activates serotonergic and noradrenergic descending inhibitory systems to block incoming noxious stimuli into the dorsal horn (Baldry, 2001).

Stimulation of the skin and muscle by needling has been shown to stimulate A- and C- afferent fibres in anesthetised rats producing an increase in cortical cerebral blood flow. This is possibly due to a reflex response of the afferent pathway including type II and IV afferent nerves and the efferent intrinsic nerve pathway and cholinergic vasodilation (Uchida, Kagitani, Suzuki and Aikawa, 2000). Dry needling of certain acupuncture points in chronic pain patients has shown similar cerebral blood flow changes (Alavi, LaRiccia, Patrick, Sadek, Newberg, Reich, Lee, Lattanand and Mozley, 1997).

**Chemical effects**

High levels of CGRP, substance P and bradykinin and a low pH are immediately restored to normal when a LTR is elicited in a MTrP (Shah
Dry needling diminishes endplate noise due to the elicitation of a LTR (Shah, Phillips, Danoff and Gerber, 2003). A LTR is a spinal cord reflex that is characterised by an involuntary contraction of the contractured taut band, which can be elicited by a snapping palpation or penetration with a needle (Rha, Shin, Kim, Jung, Kim and Lee, 2011).

The LTR is associated with mitigation of spontaneous motor endplate noise, a reduction of the concentration of numerous nociceptive, inflammatory, and immune system related chemicals and relaxation of the taut band (Ge, Fernandez de la Penas and Yue, 2011; Majlesi and Unalan, 2010).

Dry needling diminishes or even destroys motor endplates and causes denervation of distal axons when the needle hits the trigger point (Dommerholt, 2006). Changes in the endplate cholinesterase and ACh receptors are triggered as part of the normal muscle regeneration process (Gaspersic, Koritnik, Erzen and Sketelj, 2001). The relatively small diameter needles typically used (160-300 µm) causes very small focal lesions without significant risk of scar tissue formation. Muscle regeneration involves satellite cells which repair and replace damaged myofibrils (Schultz, Jaryszak and Valliere, 1985). Satellite cells migrate from other areas in the muscle and are activated following muscle damage (Sadeh, Stern and Czyzewski, 1985; Teravainen, 1970).
2.3.2 Conditions treated using dry needling

Myofascial dry needling specifically targets skeletal muscle and can be used in the treatment of fibromyalgia, back pain, headaches and acute/chronic trigger point pain (Williams and Din, 2013).

2.3.3 Advantages of dry needling

There are several advantages to the use of dry needling over other modalities in the treatment of MTrP’s, such as:

- Certain parts of a muscle and deeper muscles that are hard to reach can be treated, which most manual therapies cannot reach
- It doesn’t involve any drugs or chemical agents that are often associated with adverse effects and/or allergies
- Dry needling is quick to perform
- In the hands of a competent practitioner, it is a safe treatment modality
- Dry needling provides pain relief, increases range of motion and decreases muscle tightness

2.3.4 Complications

The complications associated with dry needling are extremely rare when safe dry needling techniques are used. This includes cleaning the needling site with alcohol swabs before and after treatment to help prevent infection, wearing of sterile gloves by the researcher and avoiding potential dangerous needling sites. Possible risks include minor bleeding, dizziness, fainting, bruising, infections, visceral damage and allergic reactions (Dommerholt, and Fernández-de-las-Peñas, 2013). The
discomforts that may be experienced include post-needling soreness and temporary aggravation of pain (Unruh, Strong and Wright, 2002).

2.3.5 Safety

When performed by trained therapists, dry needling is regarded as a safe treatment modality. Serious adverse effects are rare and are usually a result of negligence. The relevant anatomy of the area being needled should always be taken into account and the cervical and thoracic regions should not be treated without adequate training (Vulfsons, Ratmansky and Kalichman, 2012).

Possible complications and risks include vaso-vagal attacks, syncope, convulsions, damage to the viscera, excessive bleeding at the needling site, post-needling soreness and post-needling drowsiness. Vaso-vagal attacks and syncope occur because some people have a fear of needles and may even faint at the sight of a needle or when being injected. When treating such a person, it is best to position them in a prone or supine position to prevent injury should they faint or experience a vaso-vagal attack. Convulsions are rare, but it is possible for a person who has fainted to experience an epileptic seizure (Baldry, 2002).

Damage to the viscera is, although very serious, very rare when dry needling is performed by a competent practitioner (Vulfsons, Ratmansky and Kalichman, 2012). The organ most vulnerable to needle puncture is the lung, especially when treating the Trapezius, Rhomboid or Levator Scapulae muscles. When treating the Gluteus Medius muscle proper precautions have to be taken to prevent damage to the Sciatic nerve. Proper needling technique states to always insert the needle tangentially and aim towards a bony landmark, i.e. the iliac fossa (Baldry, 2002).
Excessive bleeding from the needling site is uncommon and can be controlled by applying pressure to the area after the needle has been removed. Person’s suffering from haemophilia or persons on anti-coagulants should not receive dry needling, as it could cause excessive, unstoppable bleeding from the needling site (Cummings and White, 2001). Refer to Appendix C for additional non-specific contraindications.

2.4 Low Level Laser Therapy

The term laser is an abbreviation for “Light Amplification by Stimulated Emission of Radiation”. LLLT is a form of intensive light therapy, which uses directed light at a defined wavelength and various frequencies to stimulate physiological processes in cells (photo-biostimulation) and support the healing process via photo-biomodulation (Füchtenbusch and Bringmann, 2004).

Surgical lasers ablate tissues by intense heat and are different from LLLT which uses light energy to modulate cell and tissue physiology to achieve therapeutic benefit without a macroscopic thermal effect (Chow, Johnson, Lopes-Martins and Bjordal, 2009).

2.4.1 The laser unit

According to the European Standard IEC 601 a laser unit is defined as “Any device which can be made to produce or amplify electromagnetic radiation (EMR) in the wavelength range of 180nm – 1mm primarily by the process of controlled stimulated emission”. The unit consists of an energy source (power supply), a lasing (amplifying) medium (can be solid, liquid or gas) and a resonating cavity (mirrors). The lasing medium must be able to store supplied energy by a process called population inversion. Stored
energy is emitted in an organised way (known as stimulated emission of radiation). Stimulated emission occurs when a photon is released into the electromagnetic field of an excited atom with stored energy. Some of the stored energy is emitted by creating an identical atom. The incident photon has exactly the same energy as the released photon. The first photon is not absorbed, but both photons stimulate other atoms in the lasing medium to emit their stored energy. The second photons always follow the oscillations of all of the first photons, so that all of the photons oscillate in phase. This phase-locked, wavelength-specific photon chain reaction results in an avalanche of monochromatic, coherent light. The lasing medium is elongated in shape with mirrors at its ends. When light is produced in the lasing medium, it is reflected a few times to stimulate new light production. One of the mirrors is somewhat transparent (1-20% transparency) so some of the light can be emitted and the rest continue reflecting inside the lasing medium (Tuner and Hode, 2010). Figure 2.9 provides a simplified sketch of a laser device.

Figure 2.9: The basic structure of a laser
2.4.2 Properties of laser light

The physical characteristics that sets laser light apart from ordinary white light are (Tuner and Hode, 2010):

**Monochromicity**
White light is a combination of many wavelengths ranging through the visible spectrum. During the production of laser light, only one specific wavelength is amplified.

**Coherence**
Coherence generally means order or synchronicity. White light consists of mixed wavelengths. Their oscillations are not in phase. Laser wavelengths are all in phase and oscillate uniformly in time (temporal coherence) and in space (spatial coherence).

**Directionality**
Ordinary white light scatters (diverges) from its source. Laser beams are mostly parallel and have minimal divergence. This property keeps the optical power of the device parallel and focused onto a relatively small area over considerable distances.

**Brilliance**
Brilliance is the measure of light and consists of the power of emission and the directionality of the source of radiation.

2.4.3 Laser parameters

**Wavelength**
Light is EMR and consists of small packets of energy called photons, travelling at the speed of light. A photon is in the form of a wave element, in which the wave has a defined wavelength and velocity. Wavelength is
measured in nanometers (nm). A laser device’s wavelength is determined by its lasing medium (Tuner and Hode, 2012). Wavelengths longer than 950nm are strongly absorbed by water and are used mainly for surgical purposes. Water molecules absorb the energy and raise the temperature, until, at 100°C, water in the tissue starts to vaporise and the tissue is ablated or carbonised. Wavelengths shorter than 600nm are strongly absorbed by haemoglobin and melanin, and are used in medicine, surgeries (coagulation of blood vessels) and for diagnostic purposes (doppler blood flow measurement) (Niemz, 1996). The therapeutic window lies between 600 and 950nm (Nussbaum, Baxter and Lilge, 2003). The majority of previous studies in the irradiation of MTrP’s have used wavelengths in the range of 780-904nm, because these wavelengths are capable of better tissue penetration (Al-Shenqiti and Oldman, 2003).

**Output power**

The strength or output power of a laser is measured in milliwatts (mW). A higher output power can achieve a higher power density and the desired dose can be reached in a shorter amount of time. The power specified for a laser is always its output power (Tuner and Hode, 2010). Lasers with output powers of 0.95-120mW have successfully been used to reduce the pain associated with MTrPs (Al-Shenqiti and Oldman, 2003).

**Power density**

Power density, irradiance or the intensity of light is measured in milliwatts per square centimetre (mW/cm²). If light is spread out over a large area, the intensity will be lower than if it is concentrated in a small area (Tuner and Hode, 2010). Previous studies have stressed the importance of the power density and authors often fail to report this parameter. Optimal power densities have not been established for use in laboratory-based research or in clinical applications (Al-Shenqiti and Oldman, 2003).

**Energy density**

The energy density is also known as the dose, fluence or radiant exposure. It is measured in joules per centimetre squared (J/cm²) and is
directly proportional to the treatment time (Tuner and Hode, 2010). The energy density is a critical factor in determining whether irradiation will be absorbed by the tissues (Nussbaum, Baxter and Lilge, 2003). The response of tissues to laser are thought to be governed by the Arndt-Schultz law, which states that weak stimuli excite physiological activity and strong stimuli retard it (Ohshiro and Calderhead, 1988). That is, a biological response will occur at a low energy density and increase linearly up to a maximum energy density. With added dosage it will steadily decline and ultimately biological responses will be inhibited. In previous clinical studies low energy densities in the range of 1.44-12.0 J/cm² have been favoured (Al-Shenqiti and Oldman, 2003) and energy densities in the range of 1-5 J/cm² have been recommended in the treatment of MTrP’s. However, the literature lacks studies of dosage effects in clinical conditions (Nussbaum, Baxter and Lilge, 2003).

2.4.4 Modes of application

The frequency of most laser devices can be changed to either a pulsed or continuous mode. Pulsed mode is recommended when treating acute conditions. The pulsed mode offers frequencies ranging from 1-1000Hz (Chow, Heller and Barnsley, 2006). A second type of pulsed mode exists, called a multifrequency mode. In this mode the laser doesn’t use a set frequency, but uses a frequency sweep so the tissue will absorb whichever frequency is required (Füchtenbusch and Bringmann, 2004). Continuous wave mode is effective in treating chronic conditions, as the absorption is better and is thus preferred in denser structures and deeper lying tissues (Chow, Heller and Barnsley, 2006).
2.4.5 Techniques of application

Different methods or techniques of application for LLLT exist depending on the condition and surface being treated. These techniques are the grid, scanning, stroking, open joint and point techniques (Hesvang, Christensen and Ulsted, 1997).

For the purposes of this study the point technique was used. During point application the laser probe is in contact with the skin directly over the area to be treated. This technique is used to treat acupuncture points, MTrP’s and scar tissue (Hesvang, Christensen and Ulsted, 1997). In the treatment of MTrP’s a firm skin contact is favoured, because it allows for deeper penetration of the laser beam (Tuner and Hode, 2010).

2.4.6 Penetration of the laser beam

As the laser light travels deeper into the tissue, it gets weaker. Due to tissue absorption, there is a limit at which light intensity is so low that no biological effects occur. This is known as the greatest active depth. The trigger points we are treating lies at a medium-deep depth from the skin’s surface. It is thus important that the laser penetrates deep enough into the tissue to reach the MTrP. The depth of penetration depends on the wavelength of the device used, the output power and on the application technique used (Tuner and Hode, 2010).

Tuner and Hode (2010) provided a rough guide to penetration depths of continuous wave and modulated continuous wave lasers (with all other parameters being equal) in Table 2.2.
Visible red (630-700 nm) & 0.5 – 1 cm \\
Near-infrared (700 – 800 nm) & 2 – 3 cm \\
Near infrared (800 – 960 nm) & 3 – 5 cm \\
Near infrared (970 – 990 nm) & 1 – 2 cm \\
Near infrared (990 – 1200 nm) & 4 – 5 cm \\

The point technique is recommended for treatment of structures lying at a medium depth. This is especially useful when a firm skin contact is used. When a light probe is pressed against the skin, blood flows to the sides and the tissue right in front of the probe empties of blood. Because haemoglobin is responsible for the most absorption of laser light, this will allow the light to travel deeper (Tuner and Hode, 2010).

Different tissue types absorb light at different degrees. The following factors are known to reduce penetration:

- Dirty skin
- Dark pigmentation

Adipose tissue is more transparent than muscle tissue. Thus the laser will travel through the adipose tissue without being absorbed, to the muscle tissue, where it will be absorbed.
2.4.7 Principles of photochemistry

There are three laws of photochemistry that also govern photobiology and light-tissue interactions (Helbling and Zagarese, 2003).

The Grotthus-Draper law
Light energy must be absorbed for photochemical effects to occur. Laser irradiation is absorbed by photo-sensitive molecules, called chromophores. The wavelengths that a particular molecule can absorb comprise its absorption spectrum. The absorption spectrum of individual molecules is limited, but at the level of a tissue or a cell the absorption spectrum is broad, because cells are composed of many and diverse molecules. In addition, a variety of minerals and trace elements that absorb light are found both in the cell and in its environment.

The Stark-Einstein law
Only one photon of sufficient energy is required to affect a photochemical change in each molecule; however, a photochemical event need not necessarily follow even if the light is absorbed. When a photochemical event occurs, energy can secondarily be transferred from one molecule to another via chemical interactions that are no longer dependant on light. This chain of events makes it possible for a small dosage of laser to produce clinically significant effects.

The Bunsen-Roscoe law
For any given radiant exposure, chemical or biological effects are independent of irradiance and exposure time. According to this law treatment outcomes should be the same whether energy is delivered at a low rate for a long time or at a higher rate for less time, provided that the total energy remains the same in both cases.
2.4.8 Physiological effects of LLLT

The effects of LLLT are due to photochemical activation of enzymes that catalyse the processing of molecular substrates (Michlovitz, Bellew and Nolan, 2012).

According to early research; ATP was synthesised after irradiation with a 5 J/cm² HeNe laser. This indicated a possible effect on the phosphorylative component of the mitochondrial membrane (Passarella and Molinari, 1984). Even though this is still generally accepted, in 1994 Helium-Neon irradiation of HeLa cells (stable human malignant cells first cultured from patient Henrietta Lacks) demonstrated protein degradation (Loevschall and Arenholt-Bindslev, 1994).

As previously mentioned, it is thought that haemoglobin is the molecule responsible for most low level laser absorption. The photoreceptors responsible for the conversion of the laser light remain undetermined. Either, elements in the mitochondrial cytochrome system or endogenous porphyrins (an intermediate substance in haemoglobin synthesis) have been suggested as the chromophores responsible (Michlovitz, Bellew and Nolan, 2012).

There are many primary and secondary effects of LLLT. The primary effects relate to the interactions between the photons and molecules and the secondary effects relate to the chemical changes induced by the primary effects (Tuner and Hode, 2010).

Primary effects

Polarisation effects: Polarised light is a property of light that causes it to oscillate with more than one orientation. When tissue is irradiated with coherent light, light is polarised due to the formation of laser speckles. Laser speckles is a form of optical noise which manifests in tissues during irradiation, due to interference between different beams with random direction, amplitude and phase. Porphyrins possess absorption dipoles
and absorb and emit linearly polarised light of a determined polarity (Tuner and Hode, 2010).

Heat: It is possible that the effects of laser are due to the heating effect of the laser on the tissues. There are two types of heat: macroscopic and microscopic heating. Macroscopic heating is achieved with a blanket, a hot shower, heat lamps or heat packs. Temperature is distributed in an even and smooth manner. A heat lamp has a power output of 50-100W, while a laser has a power output of 5-100mW. Therefore low level lasers produce no perceptible heating and the effect of laser cannot be due to macroscopic heating (Tuner and Hode, 2010).

During microscopic heating, uneven, speckled light distribution causes local temperature changes (Tuner and Hode, 2010). This leads to local gradients in the concentration of certain substances, causing a transport of materials in the tissue. A temperature difference across a cell membrane of 0.01 °C leads to pressure difference of 1.32 atm (Spanner, 1954). This causes the distribution pattern of potassium and sodium to change. These pressure gradients can significantly influence the paths and speeds of biological processes (Rubinov, 2003).

Excitation effects: Photochemical and photobiological effects are thought to be due to excitation of photon-absorbing molecules. A photon gets absorbed and energy is transferred to an electron, which changes the energy state of the electron. There are numerous hypotheses regarding the exact mechanisms which occur, but they all lead to a similar result. That is: the modulation of the redox state of mitochondria, which leads to a cellular signalling cascade (Tuner and Hode, 2010).

Secondary effects
Effect on pain: Serotonin is a neurotransmitter in the central nervous system which is involved in the analgesia system of the brain. Serotonin is secreted in the dorsal horns of the spinal cord which leads to the pre- and post-synaptic inhibition of type C and type Aδ pain fibres (Guyton and Hall,
Plasma serotonin levels were shown to increase after laser irradiation (Mizokami, Aoki, Iwabuchi, Kasai, Yamazaki, Sakurai, Samejima, and Yoshii 1993).

Damaged cells release mediators of inflammation. Amongst these are superoxide radicals which are highly reactive and combine with arachadonic acid to form prostaglandin-E. Prostaglandin-E breaks down ATP and sensitises nociceptors leading to the formation of pain. After low level laser irradiation, superoxide dismutase (SOD), an enzyme, increases its activity and reduces the formation of prostaglandin-E, leading to pain reduction (Rosetti, 1995).

Endorphins can also help to relieve pain by inactivating pain pathways in the brain’s opiate system (Guyton and Hall, 2006). It has been shown that LLLT increases the production of endorphins (Montesinos, 1988).

Furthermore, polarisation of C-afferent pain fibres are also blocked by LLLT, therefore the pain signals cannot reach the brain (Wakabayashi, Hamba, Matsumoto, and Tachibana, 1993).

The pain-gate is also activated due to the contact technique that was used. The pain-gate theory states that in each dorsal horn a gate-like mechanism exists. It can facilitate or inhibit the flow of afferent impulses in the spinal cord by opening or closing the gate. Opening or closing of the gate depends on the relative activity in the large diameter A-β and small diameter A-δ and C-fibres. Activity in the large fibres closes the gate and activity in the small fibres opens it. The large diameter A-β fibres are responsible for transmitting sensations of pressure, while the small diameter A-δ and C-fibres are responsible for transmitting sensations of pain. Thus, whenever pressure is applied to a painful structure, the gate closes to small diameter nerve fibres and perceived pain levels are reduced (Dickerson, 2002).
Effect on local circulation: Thermographic studies have shown that laser treatment indirectly increases the local temperature in tissues, primarily due to increased blood flow (Sendi and Gomi, 1985; Taguchi, 1991). The average temperature rise is 0.9 ºC (Wakabayashi, Hamba, Matsumoto, and Tachibana, 1993). The increase in local circulation lasts for 20 minutes after cessation of the treatment (Tuner and Hode, 2010).

In addition to all of the above, Hakguder, Birtane, Gurcan, Kokino and Turan (2003) suggested a mechanism for the effectiveness of laser treatment resulting in functional recovery and decreased pain from a treated MTrP. They suggested that oxygen supply is increased to hypoxic cells in MTrP’s, which decreases the constriction of muscle arterioles, normalising the local metabolic rate and activating the pain gate.

2.4.9 Conditions treated using LLLT

LLLT has been proven to be successful in the treatment of a number of conditions, including arthritis, bone and cartilage regeneration, carpal tunnel syndrome, migraine, inner ear conditions, muscle regeneration, oedema and plantar fasciitis to name a few (Tuner and Hode, 2010).

2.4.10 Advantages of LLLT

Advantages of using LLLT are:

- It can be used immediately after injury
- It can be used over pins, plates and bony prominences
- There are no known serious side-effects (Kitchen and Partridge, 1991)
- It is a relatively safe treatment therapy
• It can be applied to a vast amount of conditions (Chow and Barnsley, 2005).

2.4.11 Complications
The complications associated with LLLT could include a slight initial pain increase, tiredness, nausea, dizziness, hyperpigmentation, short-term parasthesia and damage to the retina (Füchtenbusch and Bringmann, 2004).

The discomforts that may be experienced during treatment include local erythema and a slight sensation of warmth over the treatment area (Füchtenbusch and Bringmann, 2004).

2.4.12 Safety
Therapeutic lasers are of insufficient strength to damage cells and are therefore considered very safe to use.

Laser technology has always been associated with an increased risk for retinal damage. This is due to narrow and parallel beams allowing the entire volume of light to pass through the pupil. In order to reduce this risk, lasers are divided into five categories (Class 1, 2, 3A, 3B and 4) according to their potential to damage the eye. Classes 1-3A are considered safe, class 3B involves a certain risk and Class 4 a definite risk. According to Tuner and Hode (2010) a very small amount of accidents have been reported and reports on eye injuries are very rare. However, when they do occur, they usually involve the use of very strong industrial lasers where protective measures have been ignored or where people have become careless over time. They state that irradiating a naked eye with a visible, non-collimated beam below 100mW is
completely harmless. However, the use of recommend protective goggles is advised during treatment (Tuner and Hode, 2010). Refer to Appendix B for additional non-specific contraindications.
CHAPTER 3: METHODOLOGY

3.1 Introduction

This clinical trial compared LLLT with myofascial dry needling to establish the more suitable technique for the relief of active MTrP’s of the gluteus medius muscle.

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

3.2 Study Design

The purpose of this research study was to determine whether LLLT or myofascial dry needling of active MTrP’s of the gluteus medius muscle is more effective in reducing the patient’s perceived pain and increase their hip range of motion the most.

3.2.1 Sample size and selection

A sample group of 30 participants with active MTrP’s in the gluteus medius muscle were required to participate in the study. Participants for this study were recruited by advertisements (Appendix A) which were placed in and around the University of Johannesburg Doornfontein Campus and the University of Johannesburg Health Clinic and via word of mouth from candidates already involved in the study. The study was conducted at the University of Johannesburg Chiropractic Day Clinic in Doornfontein.
3.2.2 Inclusion criteria

Participants for this study needed to comply with the inclusion criteria, which were as follows:

- Aged between 18 and 40 years
- The participant must have presented with at least one active MTrP in the gluteus medius muscle

3.2.3 Exclusion criteria

Potential participants were excluded from the trial if they had any of the following:

- Contraindication(s) to LLLT (Füchtenbusch and Bringmann, 2004) (Appendix B).
- Contraindication(s) to myofascial dry needling (Dommerholt and Huijbregts, 2011) (Appendix C).
- Previous treatment of any nature to the Gluteus Medius MTrP’s in the past 6 weeks
- Recent major trauma/surgery to the gluteal or surrounding areas
- Skin conditions, such as acne, psoriasis or eczema
- Fibromyalgia

After a participant met all the criteria they were required to read the information form (Appendix D) and sign the consent form (Appendix E).
3.2.4 Randomisation

Thirty participants were placed into either Group 1 or 2 through random allocation. The study consisted of 30 participants. They were assigned to either Group 1 (n=15) or 2 (n=15) by means of drawing a number from a hat until group saturation. Group 1 received myofascial dry needling and Group 2 received LLLT.

3.3 Treatment Approach

3.3.1 Initial and follow-up visits

During the initial visit all participants had to read the information form (Appendix D) and sign the consent form (Appendix E), undergo a case history (Appendix F), full physical examination (Appendix G) and a lumbar spine and pelvis regional (Appendix H) and these were summarised on a SOAP note (Appendix I). After all of the inclusion and exclusion criteria were met, the participant filled in a numerical pain rating scale (NPRS) (Appendix J) and Oswestry Disability Index (ODI) (Appendix K). Universal Goniometer readings of the participants’ hip range of motion and Pressure Algometer readings of the participants’ MTrP’s (Appendix L) were taken.

During visits 4 and 7 the participants were re-evaluated with the use of the NPRS and the ODI and readings taken by using a Universal Goniometer and a Pressure Algometer.

Participants received respective treatments during all visits, except for visit 7, which served as an evaluation-only visit.
3.3.2 Evaluation of skin sensation

Skin sensation of each participant was evaluated before the first treatment was administered. In order to do this a hot-cold and a sharp-blunt test was performed over the skin of the gluteus medius area. Before the tests were administered, the participant was shown an example of each test and the tests were explained.

For the hot-cold test the participants’ eyes were to remain closed and a heat pack or an ice pack was placed on the skin and the participant had to identify which was which.

The sharp-blunt test was repeated in the same manner, but with the sharp and blunt ends of a paperclip.

Both pain and temperature stimuli are transmitted by the spinothalamic spinal tracts to the thalamus (Guyton and Hall, 2006).

If the participant passed both the tests, they were included in the study and treatment commenced. If they didn’t pass either of the tests, they were excluded from the study, as they couldn’t reliably inform the researcher of abnormal skin sensations during treatment, which could have lead to tissue damage if the participant was unable to experience pain.

3.3.3 Trigger point examination

All participants underwent a MTrP examination of the gluteus medius muscle. There are 3 MTrP’s of the gluteus medius muscle (refer to Figure 3.1), namely trigger point 1 (TrP1), trigger point 2 (TrP2) and trigger point 3 (TrP3). The trigger points were palpated with the patient side-lying on the side opposite to the affected side (lesioned-side up). A pillow was
placed between the patient’s knees to prevent stretching of the muscle and to increase patient comfort. The gluteal area was exposed, while the areas not being treated was covered by towels.

A flat palpation technique was used to locate the trigger points. TrP1 has the most posterior location of the trigger points. TrP2 and TrP3 are located more anteriorly and are covered only by skin and subcutaneous tissue. To find these trigger points the muscle fibres were rolled against the underlying bone by rubbing across the fibres (perpendicular to the fibre direction).

3.3.4 Myofascial dry needling technique

After the trigger points were palpated the area was cleaned with an alcohol swab (saturated with 70% isopropyl alcohol) to avoid infection. The researcher wore disposable nitrile gloves on both hands during the treatment to maintain a sterile environment (Dommerholt, and Fernández-de-las-Peñas, 2013). The index and middle fingers or thumb of the researcher was used to palpate the trigger points with flat palpation. The researcher used either hand, depending on the side of the trigger point, to insert the needles. The needle was inserted between the index and the
middle fingers of the palpating hand. The needle was directed perpendicular to the pelvic bone. The needle was held in place whilst the palpating hand released the trigger point. Only once the palpating hand had let go of the needle, the needle was let go by the other hand. This soft tissue control technique was used to prevent deviation of the needle. The needle was left in for 10 minutes in order for physiological effects to occur. After the needle was removed it was placed directly in a sharps disposal bin and pressure was applied to the needling site with an alcohol swab for haemostasis to occur.

Hwato sterilised, individually packaged, single-use needles were used. They were 0.30mm in diameter and 75mm long.

3.3.5 Low level laser therapy

After an active MTrP was identified, participants in Group 2 received LLLT with the Medilaser de Luxe laser. The following laser parameters were used (Appendix M):

- Manufacturer: Medilaser de Luxe by Chris Engineering Industries CC, Randburg, Johannesburg
- Wavelength: 675 nm
- Wave emission: Continuous
- Power Output: 20mW
- Power Density: 0.08 W/cm²
- Spot Size: 1 cm²
- Dosage: 1.2 J
- Duration of Irradiation: 60 seconds

The participant was placed in a side-lying posture (lesioned-side up) and relevant areas were exposed. The participant was instructed to close his/her eyes and safety goggles were worn by the researcher. The laser
probe was held at a 90° angle to the skin with a firm skin contact and the point technique was used. The treatment continued for 60 seconds, after which the laser device automatically switched off.

3.4 Subjective Data

Each participant completed a NPRS (Appendix J) and the chiropractic revised ODI (Appendix K) at the initial treatment consultation, during visit number 4 and during visit number 7. During the initial and 4th visit the subjective data was collected before treatment was administered to the patient. The objective of these questionnaires was to verify any subjective changes in the participants with regard to their pain during the 3 week research study.

3.4.1 Numerical pain rating scale

The NPRS (Appendix J) has demonstrated validity, reliability and has been shown to be appropriate for use in clinical practise (Williamson and Hoggart, 2004). The NPRS is a scale from 0-10, with 0 representing no pain at all and 10 representing the worst pain of the participant’s life. The participants filled in the questionnaire before treatment was administered. The participants weren’t shown their answers from the previous visits to avoid biased answers.

3.4.2 The chiropractic revised Oswestry disability index

The chiropractic revised ODI (Appendix K) has increased sensitivity for less disabled patients (Fairbank and Pynsent, 2000). The ODI is a valid,
reliable and responsive condition-specific assessment tool (Vianin, 2008). It assesses how the participants' pain affects their quality of life during everyday activities.

The chiropractic revised ODI consists of 10 sections, each with 6 statements to choose from. For each section the total score is 5. If the 1st statement is marked, the score = 0. If the last statement is marked, the score = 5. Intervening statements are scored according to rank. If more than one box is marked in a section, the highest score is accepted. The score is calculated as follows:

\[
\text{(Total score}/(5 \times \text{number of questions answered})) \times 100\%
\]

Example 1: If the total score = 16

\[
(16/(5 \times 10)) \times 100\% = 32\%
\]

Example 2: If the total score = 16 and only nine out of the ten sections were answered

\[
(16/(5 \times 9)) \times 100\% = 35.6\%
\]

It was explained to the participant how to fill in the questionnaire and they were asked to fill it in as honest and accurately as possible. The questionnaire was answered before any treatment was administered during the initial and 4th visits. None of the participants were told his/her scores, nor were they shown the scores from previously completed questionnaires.

3.5 Objective Data

The objective measurements (Appendix L) were taken during the initial, 4th and 7th consultations. During the initial and 4th consultations the data was recorded before any treatment was administered.
3.5.1 The pressure algometer

The pressure algometer, also known as a pressure threshold meter, is a force gauge fitted with a disc-shape rubber tip bearing a surface of exactly 1 cm². The range of the gauge is 0–5 kg/cm², divided into one-tenth of a kilogram. All readings are expressed as kilograms per square centimetre (kg/cm²) (Figure 3.1)

![Pressure Algometer Image](image)

Figure 3.2: A pressure algometer (Vermeulen and Wisse, 2008)

The pressure algometer is designed to determine the pressure threshold, pressure compliance and tissue compliance (Fisher, 1987). Pressure threshold is defined as the minimal amount of pressure that produces pain (Vaughan, McLaughlin and Gosling, 2007). The algometer has been shown to have high reliability and validity (Pontinen, 1998) and is successful in evaluating different treatments for myofascial and musculoskeletal pain (Rachlin, 1994).

Pressure algometry of the active MTrP’s of the gluteus medius muscle was measured. Initially, digital pressure was applied to the active MTrP’s in order to elicit pain from an active MTrP of the gluteus Medius muscle. The
pressure algometer was then placed over the same active trigger point at a 90° angle to the skin. Pressure was then applied slowly downwards until the participant indicated that the pressure was causing pain. The algometer was removed and a reading in kg/cm² was taken and recorded on the Objective data form (Appendix L).

3.5.2 The universal goniometer

A universal goniometer is a device used to measure joint angles and joint range of motion (ROM) in degrees for either active or passive ROM. A traditional goniometer is a protractor with extending arms.

To measure the hip abduction ROM the participant was positioned supine. The fulcrum of the device was placed on the anterior superior iliac spine (ASIS) of the involved side. The moving arm of the goniometer was aligned with the midline of the patella. The stationary arm was aligned with the ASIS of the opposite side, so that the reading on the goniometer showed 90°. The patient was asked to abduct the hip as far as possible and the goniometer reading was taken. This procedure was repeated 3 times and 90° were subtracted from the recorded readings. The average of the readings were calculated and recorded in degrees.

3.6 Body Mass Index

Body Mass Index (BMI) is a rough measure of body fat based on height and weight (Stedman’s Medical Dictionary for the Health Professions and Nursing, 2008). The use of BMI is valid and reliable, except for in individuals with a high percentage of muscle mass (Hendrickson, 2014). BMI is classified as follows:
Table 3.1: BMI Classification (Bickley, 2007)

<table>
<thead>
<tr>
<th>Classification</th>
<th>BMI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight</td>
<td>&lt;18.5</td>
</tr>
<tr>
<td>Normal</td>
<td>18.5-24.9</td>
</tr>
<tr>
<td>Overweight</td>
<td>25.0-29.9</td>
</tr>
<tr>
<td>Obesity Class I</td>
<td>30.0-34.9</td>
</tr>
<tr>
<td>Obesity Class II</td>
<td>35.0-39.9</td>
</tr>
<tr>
<td>Obesity Class III</td>
<td>≥40</td>
</tr>
</tbody>
</table>

The height and weight of each participant was recorded in order to calculate their BMI’s. It can be assumed that individuals with a higher BMI will have a thicker layer of subcutaneous fat which needed to be penetrated in order to reach the muscle. In these individuals there was a risk that either the needle or the laser beam might not have reached the trigger point successfully.

3.7 Statistical Analysis

Demographic, subjective and objective data was collected during the research trials and sent to STATKON for statistical analysis.

STATKON provided graphical and analytical results using the following tests:

- Frequencies and descriptions: A frequency-distribution table indicating the mean, standard deviation, median, mode, range and minimum and maximum values was used to describe the data obtained from the research trials.
- Cross-tabulation: Cross-tabulation was used to compare data between Groups 1 and 2 regarding the gender distribution of the research trials.
• The Shapiro-Wilk test: The Shapiro-Wilk test was used to test for normal distribution of the data.

• Intra-group analysis: Intra-group analysis was performed to compare each group, individually, over time. The Friedman test was used to determine if a statistically significant change occurred over time between visits 1 and 7. If statistically significant changes were found using the Friedman test, further testing was done using the Wilcoxon Signed Ranks test. The Wilcoxon Signed Ranks test was used to determine exactly where (between visits 1 and 4, 4 and 7 of 1 and 7) changes occurred over time.

• Inter-group analysis: Inter-group analysis was performed to determine if any statistically significant changes where present between the groups during their respective visits. Levene’s test was used to determine if the groups demonstrated equal variances at each visit. The Independent Samples T-test or the Mann-Whitney-U test was used to determine if any statistically significant changes occurred between the groups during their respective visits. The Independent Samples T-test was used only if Levene’s test demonstrated equal variances. If not, then the Mann Whitney-U test was used.

3.8 Ethical Considerations

All participants that wished to partake in this particular study were requested to read the information form (Appendix D) and sign the consent form (Appendix E) specific to this study. The information and consent forms 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 participants safety were ensured (prevention of harm). The information and consent forms also explained
that the participants’ privacy were protected by ensuring their anonymity and confidentiality when compiling the research dissertation. The participants were informed that their participation is on a voluntary basis and that they were free to withdraw from the study at any stage. If the participant had any further questions, these were explained by the researcher; contact details were made available. The participants were required to sign the information and consent forms, signifying that they understood all that were required of them for this particular study. Results of the study will be made available on request.

The risks associated with dry needling are extremely rare when safe dry needling techniques are used. The possible risks are minor bleeding, dizziness, fainting, bruising, infections and allergic reactions. The discomforts that may be experienced include post-needling soreness and temporary aggravation of pain (Unruh, Strong and Wright, 2002). These risks were reduced by applying pressure to the needling site after the needle was removed as well as including allergy, bleeding tendencies and needle phobia questions in the history examination.

The risks associated with LLLT are slight initial pain increase, tiredness, nausea, dizziness, hyperpigmentation, short-term paraesthesia and damage to the retina. The discomforts that may be experienced include local erythema and a slight sensation of warmth (Füchtenbusch and Bringmann, 2004). These risks were reduced by wearing safety goggles, not staring directly into the laser beam and by not exceeding the recommended time and dosage.
CHAPTER 4: RESULTS

4.1 Introduction

This chapter presents the results obtained from the clinical trial of the study. The study consisted of 2 groups of 15 participants each. Group 1 received dry needling and Group 2 received LLLT. Subjective and objective data was taken on the 1st, 4th and 7th visits.

All of the data collected was statistically analysed in order to determine if there were any statistically significant improvements in either of the groups and if there were any statistically significant differences between the two groups. If any significant differences were found, further tests were performed in order to determine where the differences occurred.

The significance level (p-value) for all tests was set at 0.05 (except where otherwise stated) and represents the level of significance of the results.

The analyses consisted of:

- Demographic data analysis
  - Age of participants
  - Gender of participants
  - Body mass index of participants

- Subjective measurements
  - Numerical pain rating scale
  - Oswestry Disability Index

- Objective measurements
  - Algometer measurements
  - Goniometer measurements
4.2 Demographic Data Analysis

4.2.1 Age distribution

Table 4.1: Age distribution of the participants

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean Age (Years)</th>
<th>Standard Deviation</th>
<th>Median Age (Years)</th>
<th>Minimum Age (Years)</th>
<th>Maximum Age (Years)</th>
</tr>
</thead>
</table>
| Group 1 
Dry Needling    | 24.47            | 2.774              | 24.00              | 18                  | 29                  |
| Group 2 
LLLT             | 24.47            | 1.457              | 24.00              | 23                  | 27                  |

As can be seen from Table 4.1, the mean age of participants in Group 1 was 24.47 years (with a standard deviation of 2.774). The median age of participants in Group 1 was 24.00 years, meaning half of the participants were older than 24 years of age and the other half of the participants were younger than 24 years old. The youngest participant in Group 1 was 18 years old and the eldest was 29 years old. The mean age of the participants in Group 2 was also 24.47 years (standard deviation=1.457). The median age of participants in Group 2 was also 24.00 years of age. The youngest participant in Group 2 was 23 years old and the eldest participant was 27 years old.
4.2.2 Gender distribution

Table 4.2 shows that Group 1 consisted of 15 participants, of which 4 were male (26.7%) and 11 were female (73.3%). Group 2 also consisted of 15 participants, of which 6 were male (40.0%) and 9 were female (60.0%).

<table>
<thead>
<tr>
<th>Group</th>
<th>Participants</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1 (Dry Needling)</td>
<td>Number of participants</td>
<td>4</td>
<td>11</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Percentage within group</td>
<td>26.7%</td>
<td>73.3%</td>
<td>100%</td>
</tr>
<tr>
<td>Group 2 (LLLT)</td>
<td>Number of participants</td>
<td>6</td>
<td>9</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Percentage within group</td>
<td>40.0%</td>
<td>60.0%</td>
<td>100%</td>
</tr>
<tr>
<td>Total</td>
<td>Number of participants</td>
<td>10</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Percentage within group</td>
<td>33.3%</td>
<td>66.7%</td>
<td>100%</td>
</tr>
</tbody>
</table>

4.2.3 Body mass index

Table 4.3: BMI distribution of the participants

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean BMI</th>
<th>Standard Deviation</th>
<th>Median BMI</th>
<th>Minimum BMI</th>
<th>Maximum BMI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1 Dry Needling</td>
<td>22.7</td>
<td>2.30</td>
<td>23.4</td>
<td>17.9</td>
<td>26.0</td>
</tr>
<tr>
<td>Group 2 LLLT</td>
<td>23.6</td>
<td>4.55</td>
<td>21.8</td>
<td>18.6</td>
<td>37.6</td>
</tr>
</tbody>
</table>
From Table 4.3 it can be seen that the participants in Group 1 had a mean BMI of 22.7 (standard deviation = 2.30). The median BMI was 23.4; half of the participants in Group 1 had a BMI higher than 23.4 and the other half of the participants had a BMI lower than 23.4. The lowest BMI recorded in Group 1 was 17.9 and the highest was 26.0. The participants in Group 2 had a mean BMI of 23.6 (standard deviation = 4.55). The median BMI was 21.8; half of the participants in Group 2 had a BMI higher than 21.8 and the other half of the participants had a BMI lower than 21.8. The lowest BMI recorded in Group 2 was 18.6 and the highest was 37.6.

4.3 Subjective Data Analysis

4.3.2 The numerical pain rating scale

The NPRS was used to determine the participants’ subjective perception of their pain. The NPRS is a scale from 0-10, with 0 representing no pain at all and 10 representing the worst pain of the participant’s life.

The Shapiro-Wilk test was used to determine if the data in both groups were normally distributed. All of the p-values were greater than 0.05, and thus showed normally distributed data.

<table>
<thead>
<tr>
<th>Group</th>
<th>Visit 1</th>
<th>Visit 4</th>
<th>Visit 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>Mean</td>
<td>6.27</td>
<td>3.67</td>
</tr>
<tr>
<td>(Dry)</td>
<td>Standard</td>
<td>1.22</td>
<td>1.88</td>
</tr>
<tr>
<td>Needling)</td>
<td>Deviation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------</td>
<td>-----------</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>6.00</td>
<td>4.00</td>
</tr>
<tr>
<td></td>
<td>Minimum</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>Group 2</td>
<td>Mean</td>
<td>5.73</td>
<td>3.60</td>
</tr>
<tr>
<td>(LLLT)</td>
<td>Standard</td>
<td>2.69</td>
<td>2.20</td>
</tr>
<tr>
<td></td>
<td>Deviation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>6.00</td>
<td>4.00</td>
</tr>
<tr>
<td></td>
<td>Minimum</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>9</td>
<td>7</td>
</tr>
</tbody>
</table>

From table 4.4 it can be seen that at visit 1, in Group 1, the mean of the NPRS scores obtained was 6.27 and in Group 2 it was 5.73. At visit 4 the mean of the NPRS scores obtained was 3.67 for Group 1 and 3.60 for Group 2. At visit 7 the mean of the NPRS scores for Group 1 was 1.53 and 1.60 for Group 2.

Figure 4.1: Box-and-whisker plot of the data obtained from the NPRS
Figure 4.1 gives an overview of the comparisons of the 2 groups at their respective visits.

Visit 1 (blue): It can be seen that the medians of the 2 groups lie relatively close to each other. It can also be seen that Group 2 has a much larger range than Group 1 and Group 2 also has larger 2\textsuperscript{nd} and 3\textsuperscript{rd} quartiles. The maximum NPRS scores of both groups are very similar. Group 2 seems to have more participants who were in less pain than in Group 1.

Visit 4 (green): The medians of the 2 groups can be seen to be equal. The minimum scores and the 2\textsuperscript{nd} and 3\textsuperscript{rd} quartiles are also equal. Group 2 has a slightly larger range and a slightly higher maximum score than Group 1. Overall an improvement in the NPRS scores can be seen in both groups compared to visit 1.

Visit 7 (beige): Even though the medians are no longer equal, they can be seen to still lie close to each other. The ranges of the groups are now seen to be equal. Overall an improvement can be seen in both groups compared to visits 1 and 4 and the improvements seem to be equal.

Three outliers were identified in these sets of data. An outlier is an observation that lies an abnormal distance from other values in a random sample from a population.

**Intra-group analysis**

Each group was compared individually, over time, using the Friedman test. The p-values obtained for both groups were less than 0.05, indicating that both groups changed significantly over time.

The Wilcoxon signed ranks test was used for further testing. This test is used to detect specifically where the changes occurred over time in each group. It compares the changes occurring between visits 1 and 4, visits 4 and 7 and visits 1 and 7.

Table 4.5 shows that the p-values between the different visits for both groups were less than 0.0167 (applying the bonferroni adjustment for
multiple tests on a single data set). Thus, according to the Wilcoxon signed ranks test significant improvements occurred between visits 1 and 4, visits 4 and 7 and between visits 1 and 7.

Table 4.5: The p-values obtained from the Wilcoxon signed ranks test, comparing visits 1 and 4, visits 4 and 7 and visits 1 and 7

<table>
<thead>
<tr>
<th>Group</th>
<th>Visits 1 and 4</th>
<th>Visits 4 and 7</th>
<th>Visits 1 and 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td>Dry Needling</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 2</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td>LLLT</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Inter-group analysis
Levene’s test for equal variances resulted in a p-value < 0.05 for visit 1 (p=0.001) thus equal variances cannot be assumed for visit 1. For visits 4 and 7 the p-value was > 0.05, demonstrating equal variances across both groups for visits 4 and 7.

Further testing was done using the Independent samples T-test. The p-values for visit 1, 4 and 7 were greater than 0.05, indicating that the groups did not differ significantly at visits 1, 4 and 7.

Figure 4.2 represents the results of the NPRS during visits 1, 4 and 7. From this figure it can be seen that, even though there was no statistical difference between the groups, Group 1 had a slightly higher mean NPRS score at visit one than Group 2. At visits 4 and 7 the mean scores obtained were very similar between the groups.

Between visits 1 and 7, Group 1 underwent a mean improvement of 76% (4.47) in their NPRS scores and Group 2 underwent a mean improvement of 72% (4.13) in their NPRS scores.
4.3.1 The revised chiropractic Oswestry disability index

The revised chiropractic ODI consists of a questionnaire to determine each participant’s degree of disability. The results of the questionnaire were converted to percentages. A low percentage indicated that the participant was less disabled by their pain and a high percentage indicated the participant was more disabled by their pain.

The Shapiro-Wilk test was used to determine if the data was normally distributed across both groups. All of the p-values were greater than 0.05, indicating that the data is normally distributed.
From Table 4.6 it can be seen that at visit 1, in Group 1, the mean of the ODI scores obtained was 29.1 and in Group 2 it was 22.8. At visit 4 the mean of the ODI scores obtained was 15.9 for Group 1 and 14.3 for Group 2. At visit 7 the mean of the NPRS scores for Group 1 was 8.80 and 8.40 for Group 2.

Figure 4.3 gives an overview of the comparisons of the 2 groups at their respective visits.

Visit 1 (blue): It can be seen that the medians of the 2 groups lie relatively close to each other. The range of group 1 is larger than the range of Group 2. The 2nd and 3rd quartiles of Group 1 also span a larger range than in Group 2. Group 1 is also seen to lie slightly higher than Group 2,
Figure 4.3: Box-and-whisker plot of the data obtained from the ODI indicating that Group 1 had overall higher ODI scores compared to those of Group 2.

Visit 4 (green): The medians of the groups still lie close to each other and the range of Group 1 is still larger than Group 2. The 2\textsuperscript{nd} and 3\textsuperscript{rd} quartiles are also still larger than in Group 1. Overall an improvement in the ODI scores can be seen in both groups compared to visit 1 and the improvements seem to be of equal magnitude.

Visit 7 (beige): The medians of both groups are still lying close to each other. The ranges of the groups are now of similar size. An overall improvement in the ODI scores can be seen in both groups compared to visits 1 and 4.

One outlier was identified in Group 2 during visits 1 and 4. An outlier is an observation that lies an abnormal distance from other values in a random sample from a population.
**Intra-group analysis**

The Friedman test was used to compare each group individually, over time. The p-values for both groups were less than 0.05. This indicates that both groups experienced significant changes over time.

Further testing was done with the Wilcoxon signed ranks test. This test detects where the differences occurred over time in each group. It compares visits 1 and 4, visits 4 and 7 and visits 1 and 7.

<table>
<thead>
<tr>
<th>Group</th>
<th>Visits 1 and 4</th>
<th>Visits 4 and 7</th>
<th>Visits 1 and 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td>Dry Needling</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 2</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td>LLLT</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As can be seen from table 4.7, the p-values between different visits for both groups were less than 0.0167 (applying the bonferroni adjustment). This indicates that there was a significant improvement in the ODI scores between visit 1 to visit 4, from visit 4 to visit 7 and from visit 1 to visit 7.

**Inter-group analysis**

Levene’s test for equality of variances resulted in a p-value > 0.05 for visits 1, 4 and 7, demonstrating equal variances across both groups at visits 1, 4 and 7.

Further testing was done using the Independent samples T-test. The p-values for visits 1, 4 and 7 were all greater than 0.05. Thus, the groups did not differ significantly at visits 1, 4 or 7.
Figure 4.4 is a linear graph representing the results obtained from the ODI during visits 1, 4 and 7 of both groups. From this figure it can be seen that, even though there was no statistical difference between the groups, Group 1 obtained slightly higher mean ODI scores during visit 1 than Group 2. By visit 4, the mean ODI scores of Group 1 was much more similar to Group 2 than during visit 1. By visit 7 the mean ODI scores were very similar.

Between visit 1 and 7, Group 1 underwent a mean improvement of 70% (20.27) in their ODI scores and Group 2 underwent a mean improvement of 62% (13.87) in their ODI scores.

4.4 Objective Data Analysis

4.4.1 Pressure algometer
Pressure algometry of the active MTrP’s of the Gluteus Medius muscle were measured.

The Shapiro-Wilk test was done to determine if the data was normally distributed across both groups. The p-values for visits 1 and 4 were greater than 0.05 for both groups, indicating normality of the data during those visits. During visit 7, however the p-values were less than 0.05 for both groups. The p-value was 0.008 for Group 1 and 0.005 for Group 2 during visit 7. This indicates that the data was not normally distributed across the groups for visit 7.

Table 4.8: Mean, standard deviation, median, minimum and maximum readings of the pressure algometer

<table>
<thead>
<tr>
<th>Group</th>
<th>Visit 1</th>
<th>Visit 4</th>
<th>Visit 7</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group 1</strong> (Dry Needling)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>3.53</td>
<td>3.86</td>
<td>4.35</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.83</td>
<td>0.88</td>
<td>0.75</td>
</tr>
<tr>
<td>Median</td>
<td>3.70</td>
<td>4.00</td>
<td>4.50</td>
</tr>
<tr>
<td>Minimum</td>
<td>1.25</td>
<td>1.90</td>
<td>2.40</td>
</tr>
<tr>
<td>Maximum</td>
<td>4.60</td>
<td>5.00</td>
<td>5.00</td>
</tr>
<tr>
<td><strong>Group 2</strong> (LLLT)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>2.85</td>
<td>3.64</td>
<td>4.25</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.84</td>
<td>0.83</td>
<td>0.81</td>
</tr>
<tr>
<td>Median</td>
<td>2.90</td>
<td>3.50</td>
<td>4.55</td>
</tr>
<tr>
<td>Minimum</td>
<td>1.75</td>
<td>1.95</td>
<td>2.00</td>
</tr>
<tr>
<td>Maximum</td>
<td>4.40</td>
<td>4.80</td>
<td>5.00</td>
</tr>
</tbody>
</table>

From Table 4.8 it can be seen that at visit 1, in Group 1, the mean of the pressure algometer readings obtained was 3.53 and in Group 2 it was 2.85. At visit 4 the mean of the pressure algometer readings obtained was
3.86 for Group 1 and 3.64 for Group 2. At visit 7 the mean of the NPRS scores for Group 1 was 4.35 and 4.25 for Group 2.

Figure 4.5: Box-and-whisker plot of the data obtained from the pressure algometer

Figure 4.5 gives an overview of the comparisons of the 2 groups at their respective visits.

Visit 1 (blue): It can be seen that the medians of the 2 groups both lie between 3 and 4 kg/cm². The middle quartiles of the groups are different from each other in respect of where they lie as well as their sizes. Group 1 has higher overall readings than group 2 with respect to the median and minimum values as well as the 2\textsuperscript{nd} and 3\textsuperscript{rd} quartiles. However the maximum values of the groups are similar.

Visit 4 (green): The medians of the groups lie close to each other and the middle quartiles of both groups are similar. The ranges of both the groups
are similar with similar minimum and maximum readings. Overall the pressure algometer readings of both groups improved compared to visit 1.

Visit 7 (beige): The medians of both groups are still lying close to each other. The ranges of the groups are still of similar size as well as their middle quartiles. An overall improvement in the pressure algometer readings can be seen in both groups compared to visits 1 and 4.

Four outliers were identified in these sets of data. An outlier is an observation that lies an abnormal distance from other values in a random sample from a population.

**Intra-group analysis**

The Friedman test was used to compare each group individually, over time. The p-values for both groups were less than 0.0001. This indicates that both groups experienced significant changes over time.

Further testing was done using the Wilcoxon signed ranks test. This test is used to detect where in time changes took place. The test compares the changes between visits 1 and 4, visits 4 and 7 and between visits 1 and 7.

<table>
<thead>
<tr>
<th>Group</th>
<th>Visits 1 and 4</th>
<th>Visits 4 and 7</th>
<th>Visits 1 and 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry Needling</td>
<td>0.038</td>
<td>0.001</td>
<td>0.003</td>
</tr>
<tr>
<td>Group 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LLLT</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
</tr>
</tbody>
</table>

The p-values that can be seen in table 4.9 shows the results of the Wilcoxon signed ranks test. Applying the bonferroni adjustment (significance level=0.0167); Group 1 didn’t show a significant improvement.
between visits 1 and 4 (p>0.0167). Only between visits 4 and 7 and 1 and 7, a significant improvement can be seen in Group 1. Group 2 showed a significant improvement between visits 1 and 4, visits 4 and 7 and between visits 1 and 7.

**Inter-group analysis**

Because of the abnormal distribution of the data, the Mann-Whitney U-test was used to compare the groups over time. The p-value obtained for visit 1 was less than 0.05 (p-value=0.015), indicating that there was a significant difference between the values obtained in Group 1 and Group 2 during visit 1. This can be seen in Figure 4.6 below. The p-values obtained for visits 4 and 7 were greater than 0.05, indicating insignificant differences between the groups at those visits.

The statistical difference in the mean pressure algometer readings between the groups at visit 1 can clearly be seen in Figure 4.6 above. At visits 4 and 7, Group 1 still has higher mean readings than Group 2, albeit statistically insignificant.

Group 1 underwent a mean improvement of their algometer readings by 23% (0.82 kg/cm²). Group 2 underwent a mean improvement of their algometer readings by 49% (1.4 kg/cm²).

**4.4.2 Goniometer**

A universal goniometer is a device was used to measure joint angles and joint ROM degrees. Active hip joint abduction was measured for the purposes of this study.
The Shapiro-Wilk test was applied to determine if the data was normally distributed across the groups. All the p-values were greater than 0.05, indicating the data to be of normal variance.

Table 4.10: Mean, standard deviation, median, minimum and maximum goniometer readings for Group 1 and 2

<table>
<thead>
<tr>
<th>Group</th>
<th>Visit 1</th>
<th>Visit 4</th>
<th>Visit 7</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group 1</strong> (Dry Needling)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>49.4</td>
<td>49.3</td>
<td>55.0</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>11.4</td>
<td>12.4</td>
<td>10.5</td>
</tr>
<tr>
<td>Median</td>
<td>45.0</td>
<td>45.0</td>
<td>40.0</td>
</tr>
<tr>
<td>Minimum</td>
<td>28.0</td>
<td>33.0</td>
<td>30.0</td>
</tr>
<tr>
<td>Maximum</td>
<td>65.0</td>
<td>70.0</td>
<td>56.0</td>
</tr>
<tr>
<td>Group 2 (LLLT)</td>
<td>Mean</td>
<td>38.2</td>
<td>40.8</td>
</tr>
<tr>
<td>--------------</td>
<td>------------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td></td>
<td>Standard Deviation</td>
<td>10.8</td>
<td>9.03</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>40.0</td>
<td>40.0</td>
</tr>
<tr>
<td></td>
<td>Minimum</td>
<td>24.00</td>
<td>30.0</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>55.00</td>
<td>56.0</td>
</tr>
</tbody>
</table>

From Table 4.10 it can be seen that at visit 1, in Group 1, the mean of the goniometer readings obtained was 49.4 and in Group 2 it was 38.2. At visit 4 the mean of the pressure algometer readings obtained was 49.3 for Group 1 and 40.8 for Group 2. At visit 7 the mean of the goniometer readings for Group 1 was 55.0 and 43.6 for Group 2.

Figure 4.7 gives an overview of the comparisons of the 2 groups at their respective visits.

![Box-and-whisker plot of data obtained from the goniometer readings](image)

**Figure 4.7:** Box-and-whisker plot of data obtained from the goniometer readings
Visit 1 (blue): It can be seen that the medians of the 2 groups both lie close to each other. Group 1 spans a larger range and also has a higher maximum goniometer reading compared to Group 2. Although the groups have similar minimum values, Group 1 obtained overall higher readings at visit 1 than Group 2.

Visit 4 (green): It can be seen that the medians of the groups lie close to each other. Group 1 has higher overall readings compared to Group 2 and also spans a larger range. An overall improvement can be seen in both groups compared to visit 1 and the improvements in both groups seem to be similar.

Visit 7 (beige): The medians of the groups lie a little further apart compared to visit 4. Group 1 spans a larger range and also has a higher maximum goniometer reading compared to Group 2. Although the groups have similar minimum values, Group 1 obtained overall higher readings at visit 7 than Group 2. An overall improvement can be seen in both groups compared to visits 1 and 4, and the improvements in both groups seem to be similar.

**Intra-group analysis**

The Friedman test was used to compare each group individually, over time. In both groups significant changes occurred over time (P<0.0001).

Further testing was done using the Wilcoxon signed ranks test. This test is used to find where in a time-period specific changes occurred. The test compared visits 1 and 4, 4 and 7 and 1 and 7.
Table 4.11: The p-values obtained from the Wilcoxon signed ranks test, comparing visits 1 and 4, visits 4 and 7 and visits 1 and 7

<table>
<thead>
<tr>
<th>Group</th>
<th>Visits 1 and 4</th>
<th>Visits 4 and 7</th>
<th>Visits 1 and 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1 Dry Needling</td>
<td>0.637</td>
<td>0.007</td>
<td>0.010</td>
</tr>
<tr>
<td>Group 2 LLLT</td>
<td>0.014</td>
<td>0.028</td>
<td>0.008</td>
</tr>
</tbody>
</table>

As can be seen in table 4.11, between visits 1 and 4, the p-value for Group 1 was less than 0.0167 (applying the bonferroni adjustment; significance level=0.0167). This indicates that there was no significant improvement for Group 1 between visits 1 and 4. Between visits 4 and 7 and visits 1 and 7 a significant improvement occurred (p>0.0167). Group 2 improved significantly between visit 1 and 7, visit 4 and 7 and visit 1 and 7 (p>0.0167).

**Inter-group analysis**

Levene’s test for equal variances resulted in a p-value > 0.05 throughout all of the visits. This indicates that the data across both groups are of similar variances.

The results of the independant samples T-test showed the p-value to be less than 0.05. This indicates that the groups differed significantly at the first visit and continued to differ significantly throughout visits 4 and 7.

The differences between Groups 1 and 2 can be seen in Figure 4.8. Their initial mean values differ significantly at visit 1. At visit 4 the mean goniometer readings between the groups still differ significantly and by visit 4 the difference increases even more. It can also be seen in Figure 4.8 that Group 1 only started to increase their mean goniometer readings after visit 4, while Group 2 linearly increased their mean readings from the 1st visit.
The goniometer readings of Group 1 underwent a mean improvement of 11% (5.6°) and Group 2 underwent a mean improvement of 14% (5.4°).

![Line graph representing the Estimated marginal means of the goniometer readings](image)

**Figure 4.8:** Line graph representing the Estimated marginal means of the goniometer readings

**Comparison of goniometer based on gender**

The statistically significant differences found between the groups could possibly be accounted for by the fact that Group 1 had more male participants than Group 2 and that males are generally less flexible than females.

The Shapiro-Wilk test was used to determine if the data in both groups were normally distributed. All of the p-values were greater than 0.05 and thus the data is of similar variances.
Table 4.12: Comparison of goniometer based on gender

<table>
<thead>
<tr>
<th>Group</th>
<th>Gender</th>
<th>Visit 1</th>
<th>Visit 4</th>
<th>Visit 7</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Dry Needling)</td>
<td>Male</td>
<td>52.0</td>
<td>54.0</td>
<td>56.5</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>11.2</td>
<td>12.0</td>
<td>11.1</td>
</tr>
<tr>
<td></td>
<td>Standard Deviation</td>
<td>52.5</td>
<td>53.5</td>
<td>55.0</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>40.0</td>
<td>42.0</td>
<td>46.0</td>
</tr>
<tr>
<td></td>
<td>Minimum</td>
<td>63.0</td>
<td>67.0</td>
<td>70.0</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>48.5</td>
<td>47.5</td>
<td>54.5</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>11.9</td>
<td>12.7</td>
<td>10.8</td>
</tr>
<tr>
<td></td>
<td>Standard Deviation</td>
<td>45.0</td>
<td>45.0</td>
<td>53.0</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>28.0</td>
<td>33.0</td>
<td>41.0</td>
</tr>
<tr>
<td></td>
<td>Minimum</td>
<td>65.0</td>
<td>70.0</td>
<td>76.0</td>
</tr>
<tr>
<td><strong>Group 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(LLLT)</td>
<td>Male</td>
<td>31.7</td>
<td>36.7</td>
<td>41.5</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>9.97</td>
<td>7.94</td>
<td>7.34</td>
</tr>
<tr>
<td></td>
<td>Standard Deviation</td>
<td>26.5</td>
<td>33.5</td>
<td>39.5</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>24.0</td>
<td>30.0</td>
<td>35.0</td>
</tr>
<tr>
<td></td>
<td>Minimum</td>
<td>48.0</td>
<td>50.0</td>
<td>55.0</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>42.6</td>
<td>43.6</td>
<td>45.0</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>9.45</td>
<td>9.06</td>
<td>7.38</td>
</tr>
<tr>
<td></td>
<td>Standard Deviation</td>
<td>44.0</td>
<td>44.0</td>
<td>45.0</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>29.0</td>
<td>30.0</td>
<td>35.0</td>
</tr>
<tr>
<td></td>
<td>Minimum</td>
<td>55.0</td>
<td>56.0</td>
<td>56.0</td>
</tr>
</tbody>
</table>

Table 4.12 shows that the mean goniometer readings obtained at visit 1 for the male participants in Group 1 was 52.0 and 48.5 for the female participants. At visit 1 the male participants of Group 2 had a mean
goniometer reading of 31.7 and the females had a mean goniometer reading of 42.6. At visit 4 the male participants in Group 1 had a mean goniometer reading of 54.0 and the female participants had a mean goniometer reading of 47.5. The Group 2 male participants had a mean reading of 36.7 and the females had a mean reading of 43.6, at visit 4. At visit 7 the Group 1 male participants had a mean goniometer reading of 56.5 and the females had a mean goniometer reading of 54.5. The male participants in Group 2 had a mean goniometer reading of 41.5 at visit 7 and the females had a mean goniometer reading of 45.0 at the same visit.

Figure 4.9: Box-and-whisker plot of a comparison of goniometer based on gender for Group 1

Figure 4.9 shows a comparison of the different goniometer readings based on gender for Group 1. Comparing the respective visits, it can be seen that the medians are lying close to each other, the middle quartiles are comparable and Group 1 has a larger range.
Figure 4.10 compares the different goniometer readings of Group 2 based on gender. Comparing the respective visits, it can be seen that the medians are lying far apart from each other, the middle quartiles are not comparable and Group 1 and Group 2 have very different ranges.

Thus, at visit 1, the hip flexibility of the male participants in Group 1 seem comparable to the females. In Group 2, however, the males show less flexibility at visit 1 than the females.

Testing was done using the Mann-Whitney test to compare goniometer readings of the male participants with those of the female participants. The results showed that the p-value was greater than 0.05 at all of the visits for both groups, indicating that there is no statistical difference between the male and female participants in both groups and during all visits.
CHAPTER 5: DISCUSSION

5.1 Introduction

Chapter 5 serves to discuss the results obtained in Chapter 4, in reference to the demographic, objective and subjective results. Explanations of the results will be provided, along with clinical reasoning, with an aim to substantiate the clinical outcome and implications of the study.

5.2 Demographic Data

A total of 30 participants took part in the study. Group 1 was treated using dry needling and consisted of 15 participants. Group 2 was treated using LLLT and also consisted of 15 participants.

5.2.1 Age distribution

Statistical analysis
The ages of the participants in Group 1 ranged from 18 to 29 years of age and in Group 2 they ranged from 23 to 27 years. The mean age of both groups was 24.47 years (Table 4.1). Thus the sample group consisted of only young adults, most in their 20’s.

Discussion
The presence of MTrP’s is a highly prevalent occurrence (Edwards, 2005). Myofascial pain syndrome is the single most common reason for patients with musculoskeletal pain to visit their primary clinician (Kalichman and Vulfsons, 2010) and the main diagnosis made by pain management specialists (Harden, Bruehl, Gass, Niemic and Barbic, 2000).

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Gluteus medius MTrP’s are activated and perpetuated by sports injuries, running, one-limb weight bearing for an extended time period and injection of medications into the muscle (Simons, Travell and Simons, 1999b). It can be assumed that younger adults have higher activity levels, which could explain the age ranges of the participants.

Based on the location of the research trials (the University of Johannesburg Chiropractic Day Clinic on the Doornfontein campus), it was noted that the majority of the participants were young adult students who lead active lifestyles.

5.2.2 Gender distribution

**Statistical analysis**
Both groups consisted of more female than male participants. Group 1 consisted of 73.3% female participants and 26.7% male participants. Group 2 had more male participants than Group 1, with 60.0% females and 40.0% males (Table 4.2).

**Discussion**
Musculoskeletal pain has been reported to be more common in females than in males (Treaster and Burr, 2004). Females have increased days of absence from work and also have greater expenditures for health-care than males (Rollman and Lautenbacher, 2001). This provides an explanation for the greater ratio of females to males in both Group 1 and 2.

Females also seem to have lower pressure-pain thresholds compared to males (Ge, Madeleine, Cairns and Arednt-Nielsen, 2002). One explanation is that females have increased central sensitisation. Another explanation is that descending inhibition is weaker in females than in males. The role of oestrogen in the development of hypersensitisation can also be
considered as an explanation (Dommerholt, J. and Huibregts, P., 2011). This finding could further substantiate the greater percentage of females taking part in the study.

5.2.3 Body mass index distribution

Statistical analysis
The mean BMI in Group 1 was 22.7. The minimum BMI was 17.9 and the maximum BMI was 26.0. In Group 2 the mean BMI was 23.6. The minimum BMI was 18.6 and the maximum BMI was 37.6. In Group 1, 1 participant was classified as underweight with a BMI of 17.9. Two participants in Group 1 were overweight (BMI=26.0 and 25.3). There were no obese participants in Group 1. In Group 2, 2 participants were overweight (BMI=25.1 and 26.4). One participant in Group 2 was classified as obese class II (BMI=37.6) (Table 4.3).

Discussion
The inclusion of BMI data in the study was to provide a general prediction of trigger point depth of the gluteus medius muscle. In a study done by Sakamaki, Yasuhara, Motoki, Takase, Tanioka and Locsin (2013) the relationship between BMI and subcutaneous fat over the gluteus medius muscle was compared. The results showed that a higher BMI is related to an increased depth of the gluteus medius muscle.

The needles that were used in Group 1 for dry needling, were 75mm long. According to Zayback, Günes, Tamsel, Khorshid and Eşer (2007) for individuals with a BMI of less than 25, a needle of at least 25-38mm needs to be used in order to successfully reach and penetrate the muscle. For individuals with a BMI>25, a needle longer than 38mm should be used. Thus, 75mm needles were adequate to successfully reach the trigger points.
The low level laser device used in Group 2 had a wavelength of 675nm. Wavelength plays a critical role in the penetration depth of the laser beam. Lower wavelengths (<700 nm) is absorbed more readily by muscle tissue than higher wavelengths. The depth of penetration of a low level laser of wavelength 630-1100nm should penetrate human tissue up to 50mm (Enwemeka, 2001). If 25-38mm needles can successfully reach and penetrate the muscle in individuals with a BMI<25 (Zayback, Günes, Tamsel, Khorshid and Eşer, 2007), then it can be assumed that laser light capable of penetrating up to 50 mm (Enwemeka, 2001) in human tissue, will be successfully absorbed by the muscle.

5.3 Subjective Data Analysis

5.3.2 The numerical pain rating scale

Statistical analysis – Intra-group analysis
Both Group 1 and Group 2 demonstrated clinical improvements that were statistically significant regarding the NPRS. The statistically significant changes were consistent throughout visits 1, 4 and 7 (Figure 4.1).

Statistical analysis – Inter-group analysis
No statistically significant changes occurred between the groups at the respective visits regarding the NPRS (Figures 4.1 and 4.2).

Discussion
In a study done by Hugenin, Brukner, McCrory, Smith, Wajwelner and Bennel (2005) the effectiveness of dry needling gluteus medius MTrP’s on straight leg raise, hip internal rotation and perceived pain levels were evaluated. The results indicated that, although straight leg raise and hip internal rotation remained unaffected, perceived pain levels decreased significantly. These results substantiated that the scores of the NPRS
decreased significantly in the dry needling group. Dry needling can reduce perceived pain levels by activation of fibroblasts (Langevin, Bouffard, Badger, Iatridis and Howe, 2005) and also by opioid-mediated pain suppression (Baldry, 2001).

A study done by Gur, Sarac, Cevik, Altindag and Sarac (2004) showed that LLLT is effective in the relief of myofascial pain. They compared LLLT with placebo laser and found that the LLLT group had improved functional ability and quality of life as well as decreased pain following 2 weeks of daily treatment. LLLT can reduce perceived pain levels via activation of the pain gate, formation of prostaglandin-E (Rosetti, 1995) and increased endorphin production (Montesinos, 1988).

Group 1 experienced an increased clinical reduction in their NPRS scores. The use of needles might have a psychological effect on patients. The invasive manner of the dry needling procedure compared to the non-invasive procedure of LLLT could have influenced the participants’ subjective pain measurements (Hong, 2002).

5.3.1 The revised chiropractic Oswestry disability index

Statistical analysis – intra-group analysis
Group 1 and Group 2 both demonstrated clinical improvements that were statistically significant regarding the revised chiropractic ODI. The statistically significant changes were consistent throughout visits 1, 4 and 7 for both groups (Figure 4.3).

Statistical analysis – inter-group analysis
No statistically significant changes occurred between the groups at the respective visits regarding the revised chiropractic ODI (Figures 4.3 and 4.4).
Discussion

An improvement was seen in both groups for the revised chiropractic ODI. The ODI is one of the most commonly used outcome measures for measuring the degree of functional limitation in patients with low back pain (LBP) (Khorsan and Coulter, 2008).

The ODI is used when assessing patients with LBP. It was chosen for this study due to the close relationship of gluteus medius trigger points and LBP. SIJ dysfunction accounts for 50-70% of LBP complaints (Chapman-Smith, 1993). SIJ dysfunction leads to an abnormal distribution of loads in the body. This, in turn causes abnormal biomechanics of the surrounding joints and muscles, including the gluteus medius muscle. Due to the muscle’s constant activation it gradually develops trigger points (Sims and Mesnick, 2013). A previous study has shown that the SIJ might also be directly involved in activating the gluteus medius muscle (Indahl, Kaigle, Reikeras and Holm, 1999).

The chiropractic revised ODI consists of the following sections: pain intensity, personal care, lifting, walking, sitting, standing, sleeping, social life, travelling and changing degree of pain (Appendix K).

Myofascial pain syndrome can cause prolonged morbidity and significantly reduce health-related quality of life (HRQOL). The HRQOL encompasses the factors of physical, functional, mental and emotional well-being. Patients with myofascial pain syndrome report to have worse HRQOL in terms of pain, energy, physical mobility, sleep and emotional reactions (Celiker, Atalay and Guven, 2010). Pain, physical mobility and sleep are evaluated by the revised chiropractic ODI under the sections of pain intensity, personal care, lifting, walking, sitting, standing and sleeping.

A population study conducted by Pedisic, Pranic and Jurakic (2013) showed that patients with back and neck pain are limited in attending social activities and events. Back and neck pain was also shown to reduce physical activity and working capacity, causing disability and occupational
absenteeism. Limited social activities, reduced physical activity and reduced working capacity are evaluated by the revised chiropractic ODI under the sections of lifting, walking, sitting, standing, social life and travelling.

Dry needling and LLLT are both therapies that aim to restore the full optimal length of the involved muscle, which ceases the chain of events causing impairments and functional restrictions, by releasing the MTrP. Restoring the full length of a sarcomere decreases the interaction of actin and myosin (Simons, Travell and Simons, 1999a).

Therefore, it can be concluded that the overall improvement of the ODI scores in both groups can be attributed to the successful relief of the MTrP’s in the gluteus medius muscles.

Group 1 had a greater clinical improvement on the ODI. Dry needling specifically causes the sarcomere to return to its resting length and reduces the degree of overlap between actin and myosin filaments by providing a localised stretch to the contracted cytoskeletal structures, disentangling the myosin filaments from the titin gel at the Z-band (Dommerholt, 2004). Based on the theory that restoring the full optimal length of the sarcomere will limit functional impairments and restrictions, this can account for the greater clinical improvement in Group 1.

5.4 Objective Data Analysis

5.4.1 Pressure algometer

Statistical analysis – intra-group analysis
Both Groups 1 and 2 demonstrated statistically significant improvements regarding the pressure algometer. The changes were not consistent throughout visits 1, 4 and 7. Group 1 only showed statistically significant
improvements between visits 4 and 7. Group 2 improved significantly between visits 1 and 4, and 4 and 7 (Figure 4.5).

**Statistical analysis – inter-group analysis**

At visit 1 there was a significant difference between the pressure algometer readings of Group 1 and 2. Group 1 had a higher mean reading (3.53 kg/cm²) than Group 2 (2.85 kg/cm²) at visit 1. During visits 4 and 7 there was no statistically significant difference between Groups 1 and 2 (Figures 4.5 and 4.6).

**Discussion**

The pain gate was activated in the treatment of both Group 1 and Group 2. Thus, accounting for the significantly improved pressure algometer readings in both Groups 1 and 2. Mechanical stimulation of the needle activated group II fibres, which, in turn activates the pain-gate control system in Group 1. In Group 2 the pain-gate was activated by mechanical stimulation of the contact method used to administer the LLLT.

It is possible that the faster improvement seen in Group 2 compared to Group 1 is due to the pain-gate mechanism being activated by the firm skin contact technique used. Dry needling uses a sharp needle, which could, initially have activated nociceptors and small diameter Aδ- and C-fibres, and later only started to activate the large diameter Aβ-fibres via direct pressure. LLLT is non-invasive, insufficient to damage cells and does not cause significant heating of the superficial tissues, thus LLLT doesn’t activate any nociceptors or small-diameter Aδ- or C-fibres (Kitchen and Partridge, 1991; Hakguder, Birtane, Gurcan, Kokino, and Turan, 2003). The same mechanism could be responsible for the greater clinical effect observed in Group 2 compared to Group 1.
5.4.2 Goniometer

**Statistical analysis – intra-group analysis**

Both Groups 1 and 2 demonstrated statistically significant improvements regarding the goniometer readings. Although, the changes were not consistent throughout visits 1, 4 and 7. Group 1 only showed statistically significant improvements between visits 4 and 7. Group 2 showed significant improvements between visits 1 and 4, and 4 and 7 (Figure 4.7).

**Statistical analysis – inter-group analysis**

At visits 1, 4 and 7 there were a significant difference between the goniometer readings of Group 1 and 2. Group 1 had higher mean readings than Group 2 at visits 1, 4 and 7 (Figures 4.7 and 4.8).

**Discussion**

A restricted active ROM is a result of muscle tension and functional shortening within the muscle. That is, the shortened sarcomere has decreased ability to optimally contract. Restriction of movement can also be attributed to pain from sensitised nociceptors within the MTrP. Increasing tension within a functionally shortened muscle, will cause pain and decreased ROM will be apparent due to pain inhibition (Simons, Travell and Simons, 1999a).

Both Group 1 and Group 2 experienced statistically significant improvements of their goniometer readings. Dry needling provides the necessary energy in the form of ATP to unlock actin-myosin cross bridge formations and to reuptake calcium (Simons, Travell and Simons, 1999a). This, along with pain reduction, will restore the muscle’s normal ROM. LLLT increases ATP and protein synthesis in the cell, which causes a growth factor response in cells and tissues. This improves cell proliferation as well as cell membrane permeability, increasing calcium re-uptake (Kitchen and Partidge, 1991).
The goniometer readings of Group 1 were consistently higher than the readings of Group 2 from visit 1 through to visit 7 (Figure 4.8). This is possibly due to the fact that the participants in Group 1 started off with a higher baseline reading than Group 2 and continued to improve from that reading onwards.

It was found that Group 1 had a greater ratio of female participants compared to Group 2. In general, females are more flexible than males. This is possibly due to anatomical and physiological differences between the 2 sexes. Other factors that may play a role include smaller muscle mass, joint geometry and gender-specific collagenous muscle structure (Alter, 2004). Statistically significant differences between the groups can possibly be due to Group 2 consisting of more male participants than Group 1, which caused the group’s mean goniometer readings at visit 1 to be significantly lower than Group 1’s, which may be responsible for the differences seen at visits 4 and 7 as well.

5.5 Conclusion

In conclusion, both Group 1 and Group 2 showed clinical and statistically significant improvements over time for the subjective and objective data results obtained.

Group 1 improved statistically as much as Group 2 during the subjective data analysis. Regarding clinical improvements; Group 1 improved slightly more than Group 2 in the ODI and NPRS readings. The use of needles might have a psychological effect on patients. The invasive manner of the dry needling procedure compared to the non-invasive procedure of LLLT could have influenced the participants’ subjective measurements due to dry needling being a more invasive and relatively time consuming procedure (Hong, 2002).
During the objective data analysis, Group 1 only started to show an improvement between visits 4 and 7. Thus, if dry needling is used as a treatment protocol of choice, more treatment sessions may be needed before a significant result is seen. However, by visit 7 both treatments had improved in participants’ objective readings.

During the subjective data analysis Group 2 showed slightly greater improvements. This finding can be explained by the initial nociceptor activation and the pain-gate only being activated at a later stage when using dry needling (Hong, 2002). Whereas LLLT is non-invasive and insufficient to damage cells while still penetrating deep into the tissue and without any significant heating of the superficial tissues (Kitchen and Partridge, 1991; Hakguder, Birtane, Gurcan, Kokino, and Turan, 2003).
CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The aim of the research was to determine whether LLLT or myofascial dry needling is more effective in the treatment of active MTrP’s, specifically those of the gluteus medius muscle. It could also have provided further evidence as to the efficacy of LLLT and myofascial dry needling as treatment choices for active MTrP’s, aiming to demonstrate any superiority between the two modalities. Treatment was applied to gluteus medius MTrP’s, on which subjective (revised chiropractic ODI and NPRS) and objective (pressure algometer and goniometer) results were based. The study consisted of 30 participants, 15 participants per group. Each participant was treated 6 times over a period of 2 consecutive weeks. Subjective and objective data was collected during visits 1, 4 and 7.

Dry needling showed superior clinical results regarding the subjective measurements. Statistically the results between the groups were insignificant and both dry needling and LLLT caused a subjective improvement. The greater clinical results is possibly due to the use of needles having a psychological effect on patients, due to the treatment being more invasive and relatively time-consuming (Hong, 2002).

During the objective data analysis, dry needling only started to show a statistically significant effect between visits 4 and 7. The LLLT showed a statistically significant improvement between visits 1 and 4, and 4 and 7. This finding could imply that more dry needling sessions are required before a result can be seen. However, both groups improved significantly by the 7th visit.

In conclusion, dry needling and LLLT are both equally effective in the treatment of MTrP’s. Although they work via different methods and to different objective extends. The LLLT could provide an effective alternative
to dry needling whenever dry needling is contraindicated, the patient simply prefers not to be treated with needles or when the patient has a fear of needles. LLLT could also release the trigger point faster in certain result-driven patients.

6.2 Recommendations

- The use of a laser with a higher wavelength may penetrate deeper towards the trigger point for improved results
- A possible study could compare the results of treating myofascial pain at different wavelengths
- The exact number of treatments required for either dry needling or LLLT is still unknown. A future study could compare groups with different treatment frequencies for either dry needling or LLLT
- A more extensive study could be performed, including a larger sample group, to allow a more accurate presentation of the population. A larger sample size will also allow for trends within the results to become more apparent
- The study could possibly repeated, but with treating only one specific trigger point on either the dominant or non-dominant side only to rule out the effect of different usage patterns in different parts of the muscle and dominancy
- The study could possibly be repeated, but on a different muscle to allow for discrepancies between different muscles
- The study could be repeated, focusing on a specific population group (athletes, students, geriatrics, pregnant females, post-partum females, paediatrics)
- Dry needling and LLLT could be compared with a spinal manipulation group to determine the combined effect of treating
the active MTrP together with adjusting the spinal levels which directly innervate the gluteus medius muscle

- The long-term effects of the study could be measured by repeating the study and taking a 4th set of measurements 1 week or 1 month after the trial
REFERENCES


• Ge, H., Madeleine, P., Cairns, B. and Arendt-Nielsen, L. (2002) Hypoalgesia in the Referred Pain Areas after Bilateral Injections of Hypertonic Saline into the Trapezius Muscles of Men and Women:


• Teravainen, H. (1970) Satellite Cells of Striated Muscle after Compression Injury so Slight as not to cause Degeneration of


APPENDIX A: ADVERTISEMENT

Do you suffer from pain in your buttock area?

Does the pain radiate to your low back?

Does the pain radiate to your upper thigh area?

If you answered YES to any of the above questions, you might be eligible to participate in a research study.

If you are interested please do not hesitate to contact Marili van Heerden on 076 902 0701.
APPENDIX B: CONTRAINDICATIONS TO LLLT

Contraindications to low level laser therapy:

- **Absolute contraindications:**
  - Strongly heightened photosensitivity, light dermatoses
  - Chronic skin illnesses in their acute stage
  - Skin damage through UV light
  - After and during therapy with cytostatics, immunosuppressants, high doses of corticosteroids (except creams/ointments) and arsenic-containing medications (heightened photoallergic readiness to react)
  - Pre-cancerous and malignancy
  - Open fontanelles and epiphyseal cartilage of the long hollow bones in childhood and early youth
  - Untreated epilepsy
  - Decompensated heart insufficiency
  - Acute feverish infection
  - Pregnancy
  - Thrombosis and thrombophlebitis when there is a possibility of embolism
  - Irradiation of the eye directly and in the area of the orbital rim (Füchtenbusch and Bringmann, 2004)

- **Relative contraindications:** (refers to conditions where certain areas of the body should be exempted from treatment)
  - Pacemaker patients (thorax)
  - Therapeutically adjusted epilepsy (head)
  - Heart rhythm disturbances and coronary insufficiency with organic origins (thorax)
- Hyperthyroidism (throat and neck area)
- Dysmenorrhoea (lower abdomen, lumbar area)
- Inflammations of the subcutaneous tissues (erysipelas, phlegmones) over large areas
- Fresh posttraumatic haematomas in the acute phase over larger areas (laser therapy only after acute treatment with compression bandage and cryotreatment, approx. 6-8 hours later)
- Endocrine organs (Füchtenbusch and Bringmann, 2004)
APPENDIX C: CONTRAINDICATIONS TO DRY NEEDLING

Contraindications to dry needling:

- Malignancy or tumours
- A history of vascular disease or bleeding disorders
- Anticoagulant therapy
- Subdural haematoma
- Acute trauma with haematoma
- Local or generalised skin lesions or infections
- Fear of needles (trypanophobia)
- Diabetes Mellitus
- Unstable epilepsy (Dommerholt and Huibreghts, 2011)
APPENDIX D: INFORMATION FORM

DEPARTMENT OF CHIROPRACTIC

INFORMATION FORM

My name is Marili van Heerden and I am currently a Chiropractic student completing my Masters Degree at the University of Johannesburg. I would like to thank you for volunteering to participate in this study entitled “A Comparative Study between Low Level Laser Therapy and Myofascial Dry Needling on Active Gluteus Medius Trigger Points”.

The aim of this study is to determine whether low level laser therapy or dry needling is the best technique to use in the treatment of myofascial trigger points of the gluteus medius muscle.

Your gluteus medius muscle is located around the top part of your buttocks. You will be required to expose this area during the treatments. All measures will be taken to protect your dignity with the placement of towels. Only the area treated will be exposed.
Dry needling involves the insertion of an acupuncture needle into a myofascial trigger point. A trigger point is felt as a hard ball inside a muscle and is painful to pressure. Before the needling takes place, I will clean the needling site with an alcohol swab to help prevent infection. Once the needle is inserted, it will remain inside the muscle for ten minutes. Pillows will be placed to ensure that you are comfortable during this time, because you will be required to remain motionless. I will then proceed to remove the needle from the muscle, after which I will put pressure on the needling site with an alcohol swab for one minute to prevent local bleeding and further prevent any infections. You may experience slight pain during needling as well as some post-needling soreness and redness.

Low level laser therapy involves the movement of a red laser beam over the trigger points. The laser beam is in the form of a handheld device, which I will be moving over your trigger points for a maximum of two minutes thirteen seconds. Before the treatment starts I will test that your temperature and pain receptors are fully functional by presenting you with a warm and a cool object which you need to identify as well as a sharp and a blunt object which you will need to identify. During the treatment you may experience a slight sensation of warmth. You can indicate to me at any point during the treatment if it starts to feel too hot. During the treatment you will be required to wear protective eyeglasses to prevent any reflection from the laser device damaging your retina. After the treatment you may experience a slight initial pain increase, tiredness, nausea, dizziness, hyperpigmentation or short-term paresthesia.

Before you will be treated I will take a Case History from you and perform a Full Physical Examination and Lumber and Pelvis Regional. If you comply with the inclusion criteria and have none of the exclusion criteria then you will be included in the study. I will proceed by recording your initial subjective and objective readings. You will draw a number from a hat
which will allocate you to either Group 1 of Group 2. If you are in Group 1 you will receive dosages of Low Level Laser Therapy and if you are in Group 2 you will receive dry needling. Low level laser therapy involves the use of a low level laser on skin over the trigger points. This is pain free and the less invasive of the two techniques. The dry needling technique involves inserting an acupuncture needle into a muscular trigger point in order to restore the muscle to an optimum level of functioning. Dry needling is associated with some post-needling soreness and slight bleeding at the needling site.

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

All procedures will be explained to you and all participation is entirely on a voluntary basis; withdrawal at any stage will not cause you any harm. I have fully explained to you the dangers of dry needling and low level laser therapy and that all precautions will be taken to ensure your safety. After this study is complete, I will provide you feedback regarding the outcomes if you so wish.

University of Johannesburg's ethics clearance number: AEC34-01-2013
Should you have any concerns or queries regarding the current study, the following persons may be contacted.

Researcher: Marili van Heerden 076 902 0701
Supervisor: Dr. C. Hay 011 559 6500
APPENDIX E

DEPARTMENT OF CHIROPRACTIC

CONSENT FORM

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: _______________


APPENDIX F

UNIVERSITY OF JOHANNESBURG
CHIROPRACTIC DAY CLINIC

CASE HISTORY

Date: ____________

Patient: ___________________________ File No: ___________

Age: _____ Sex: _________ Occupation: ________________

Student: __________________________ Signature: ________________

=================================================================

Complies with Inclusion criteria of the research:

Clinician: __________________________
Signature: __________________________

=================================================================

Examination:
Previous: UJ Current: UJ
Other Other

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

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

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

Recommendations:
Students case history

1. Source of history:

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

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

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

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

8. **Psychosocial history:**
   - Home situation
   - Daily life
   - Important experiences
   - Religious beliefs

9. **Review of systems:**
   - General
   - Skin
   - Head
Eyes
Ears
Nose/sinuses
Mouth/throat
Neck
Breasts
Respiratory
Cardiac
Gastro-intestinal
Urinary
Genital
Vascular
Musculoskeletal
Neurologic
Haematologic
Endocrine
Psychiatric
APPENDIX G

PHYSICAL EXAMINATION

Underline abnormal findings in RED. Date: ________________

Patient: __________________ File No: ____________
Clinician: __________________ Signature: ____________
Student: __________________ Signature: ____________

Height: _______ Weight: _______ Temp: _______
Rates: Heart: _______ Pulse: _______ Respiration: _______

Blood pressure: | Arms: | L | R |
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<td>Legs:</td>
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General Appearance:
_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________
STANDING EXAMINATION

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

L. Rot
Flex.
R. Rot

L. Lat Flex

R. Lat Flex

Ext.

/ = pain-free limitation  // = painful limitation

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

15. Visual acuity

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

**SEATED EXAMINATION**

1. Spinal posture
2. Head
   - hair
   - scalp
   - skull
   - face
   - skin
3. Eyes:
   Observation
   - conjunctiva
   - sclera
   - eyebrows
   - eyelids
   - lacrimal glands
   - nasolacrimal duct
   - position and alignment
   - corneas and lenses
   - corneal reflex
   - ocular movement

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

4. Ears:
   - auricle
   - ear canal
   - drum
   - auditory acuity
   - Weber test
   - Rinne test

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

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

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

9. Neck
   - posture
   - size
   - swelling
   - scars
   - discoloration
   - hair line
Ranges of motion (cervical spine)

The following are normal ranges of motion:

- **Forward flexion** = 45° chin to larynx or sternum
- **Extension** = 55° forehead parallel to ground
- **L/R Rotation** = 70°
- **L/R Lat Flexion** = 40°

- lymph nodes
- trachea
- thyroid
- carotid arteries (thrills, bruit)
- Cranial Nerves
  - CN V
  - CN VII
  - CN VIII (nystagmus)
  - CN IX
  - CN XI
  - CN X11
9. **NEUROLOGICAL EXAMINATION (CERVICAL SPINE)**

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9. **Peripheral vasculature:**
   - Inspection
     - skin
     - nail beds
     - pigmentation
     - hair loss
   - Palpation
     - pulses:    - femoral    - dorsalis pedis
                  - popliteal    - radial
                  - post. Tibial  - brachial
     - lymph nodes    - epitrochlear
                      - femoral (horizontal & vertical)
     - temperature (feet and legs)
   - Manual compression test
• Retrograde filling (Tredelenburg) test
• Arterial insufficiency test

10. Musculoskeletal:
   (i) ROM
   • hip

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<tr>
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</table>

• knee
• ankle

(ii) leg length
• Co-ordination - point to point
  - dysdiachokinesia

10. TMJ
• Inspection - ROM
  - deviation
• Palpation - crepitus
  - tenderness

11. Thorax
• Inspection - skin
  - shape
  - respiratory distress
  - rhythm (respiratory)
  - depth (respiratory)
  - effort (respiratory)
  - intercostals supraclavicular retraction
• Palpation
  - tenderness
  - masses
  - respiratory expansion
  - tactile fremitus

• Percussion
  - lungs (posterior)
  - diaphragmatic excursion
  - kidney punch

• Auscultation
  (i) breath sounds
    - vesicular
    - bronchial
  (ii) adventitious sounds
    - crackles (rales)
    - wheezes (rhonchi)
    - rubs
  (iii) voice sounds
    - broncophony
    - whispered pectoriloquy
    - egophony

• Cardiovascular
  - auscultation (aortic murmurs)
  - Allen’s test

SUPINE EXAMINATION

1. JVP
2. PMI
3. Auscultation heart
   (L. lat. Recumbent)
4. respiratory excursion
5. percussion chest
   (anterior)
6. breast palpation
7. Abdominal Examination

• Inspection
  - skin
  - umbilicus
  - contour
  - peristalsis
  - pulsations
  - hernias (umbilical/incisional)

• Auscultation
  - bowel sound
  - bruit

• Percussion
  - general
  - liver
  - spleen

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

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

**MENTAL STATUS**

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

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

(ii) Mood

(v) Memory and attention  
- orientation (time, place, person)
- remote memory
- recent memory
- new learning ability

(vi) Higher cognitive functions  
- information and vocabulary
- (general and specialised knowledge)
- abstract thinking
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</table>
APPENDIX H

UNIVERSITY OF JOHANNESBURG
CHIROPRACTIC DAY CLINIC

REGIONAL EXAMINATION
LUMBAR SPINE AND PELVIS

Date: __________________________

Patient: __________________________  File No: ________________

Clinician: __________________________  Signature: ______________

Student: __________________________  Signature: ______________

A. STANDING

1. BODY TYPE
2. POSTURE
3. OBSERVATION: -

   • Muscle Tone
   • Bony + Soft Tissue Contours
   • Skin
   • Scars
   • Discolouration
   • Step deformity

4. SPECIAL TESTS

   • Schober’s Test
   • Spinous Percussion
   • Treadmill
   • Minor’s Sign
   • Quick Test
   • Trendelenburg Test
5. RANGE OF MOTION

Forward flexion = 40 - 60° (15cm from floor)
Extension = 20 - 35°
L/R Rotation = 3 - 18°
L/R Lat Flexion = 15 - 20°

Left Rotation

Flexion

Right Rotation

Left Lateral Flexion

Right Lateral Flexion

Extension

\[ / = \text{Pain free limitation} \quad \text{and} \quad // = \text{Painful limitation} \]

6. GAIT

- Rhythm, pendulousness
- On Toes (S1)
- On Heels (L4, 5)
- Halt Squat on one leg (L2, 3, 4)
- Tandem Walking

7. MOTION PALPATION – sacroiliac joints

B. SITTING

01. SPECIAL TESTS

- Tripod Test
- Kemp’s Test
- Valsalva Manoeuvre
2. MOTION PALPATION

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C. SUPINE

01. OBSERVATION
   - Hair, Skin, Nails
   - Fasciculations

2. PULSES
   - Femoral
   - Popliteal
   - Dorsalis Pedis
   - Posterior Tibial

3. MUSCLE CIRCUMFERENCE

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<tr>
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5. ABDOMINAL EXAMINATION

- Observation
- Abdominal Reflexes
- Auscultation Abdomen and Groin
- Palpation Abdomen and Groin

Comments: _______________________________________________________________

________________________________________________________________________

NEUROLOGICAL EXAMINATION

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<td>Knee Flexion (L5/S1)</td>
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<td>Hip Int. Rot (L4/L5)</td>
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7. SPECIAL TESTS

- SLR
- WLR
- Braggard’s
- Bowstring
- Sciatic Notch Pressure
- Sign of the Buttock
- Bilateral SLR
- Patrick Faber
- Gaenslen’s Test
- Gapping Test
- “Squish” Test
- Gluteus Maximus Stretch
- Thomas’ Test
- Rectus Femoris Contracture Test
- Hip Medial Rotation
- Psoas Test

LATERAL RECUMBENT

- Sacroiliac Compression
- Ober’s Test
- Femoral Nerve Stretch Test
- Myotomes: - Quadratus Lumborum Strength
                  - Gluteus Medius Strength
PRONE

- Facet joint challenge
- Myofascial Trigger points:
  - * Quadratus Lumborum
  - * Gluteus Medius
  - * Gluteus Maximus
  - * Piriformis
  - * Tensor Fascia Lata
  - * Hamstrings
- Skin Rolling
- Erichsen’s Test
- Sacroiliac Tenderness
- Pheasant’s Test
- Gluteal Skyline
- Myotomes:
  - * Gluteus Maximus strength

NON-ORGANIC SIGNS

- Pin-point pain
- Axial Compression
- Trunk Rotation
- Burn’s Bench Test
- Flip Test
- Hoover’s Test
- Ankle Dorsiflexion Test
- Pin-point pain
### APPENDIX I

#### CHIROPRACTIC DAY CLINIC

**SOAP NOTE:**

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<td>Date:</td>
<td>Clinician:</td>
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**Subject (S):**

**Object (O):**

**Action (A):**

**Plan (P):**

**Comments:**

---

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<td>Clinician:</td>
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**Subject (S):**

**Object (O):**

**Action (A):**

**Plan (P):**

**Comments:**
APPENDIX J

Numerical Pain Rating Scale

Name:__________________________

On a scale from 0 to 10, 0 being no pain at all and 10 being the worst imaginable pain, how would you rate your pain RIGHT NOW?

Visit : _______                                                                                            Date:_______

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<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
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APPENDIX K

Chiropractic Revised Oswestry Pain Questionnaire (Hudson-Cook, Tomes-Nicolson and Breen, 1989)

Participant Number: ____________________

Date: _____________________

Instructions: Please circle the one number in each section which most closely describes your problem.

Section 1 – Pain Intensity

0. The pain comes and goes and is very mild
1. The pain is mild and does not vary much
2. The pain comes and goes and is moderate
3. The pain is moderate and does not vary much
4. The pain comes and goes and is severe
5. The pain is the severe and does not vary much

Section 2 – Personal Care (Washing, Dressing etc.)

0. I would not have to change my way of washing and dressing in order to avoid pain
1. I do not normally change my way of washing or dressing even though it causes some pain
2. Washing and dressing increases the pain, but I manage not to change my way of doing it
3. Washing and dressing increase the pain and I find is necessary to change my way of doing it
4. Because of the pain I am unable to do some washing and dressing without help
5. Because of the pain I am unable to do any washing and dressing without help

**Section 3 – Lifting**

0. I can lift heavy weights without extra pain
1. I can lift heavy weights, but it gives extra pain
2. Pain prevents me from lifting heavy weights off the floor
3. Pain prevents me lifting heavy weights, but I can manage if they are conveniently positioned, e.g. on a table
4. Pain prevents me from lifting heavy weights, but I can manage light to medium weights if they are conveniently positioned
5. I can only lift very light weights at the most

**Section 4 – Walking**

0. I have no pain on walking
1. I have some pain with walking, but it does not increase with distance
2. I cannot walk more than one mile without increasing pain
3. I cannot walk more than ½ mile without increasing pain
4. I cannot walk more than ¼ mile without increasing pain
5. I cannot walk at all without increasing pain

**Section 5 – Sitting**

0. I can sit in any chair as long as I like
1. I can only sit in my favourite chair as long as I like
2. Pain prevents me from sitting more than 1 hour
3. Pain prevents me from sitting more than ½ hour
4. Pain prevents me from sitting more than 10 minutes
5. I avoid sitting, because it increases pain immediately
Section 6 – Standing

0. I can stand as long as I want without pain
1. I have some pain on standing, but it does not increase with time
2. I cannot stand for longer than 1 hour without increasing pain
3. I cannot stand longer than ½ hour without increasing pain
4. I cannot stand longer than 10 minutes without increasing pain
5. I avoid standing, because it increases the pain immediately

Section 7 – Sleeping

0. I get no pain in bed
1. I get pain in bed, but it does not prevent me from sleeping well
2. Because of my pain my normal nights’ sleep is reduced by less than ¼
3. Because of my pain my normal nights’ sleep is reduced by less than ½
4. Because of my pain my normal nights’ sleep is reduced by less than ¾
5. Pain prevents me from sleeping at all

Section 8 – Social Life

0. My social life is normal and gives me no pain
1. My social life is normal, but it increases the degree of pain
2. Pain has no significant effect on my social life apart from limiting my more energetic interests e.g. dancing, etc.
3. Pain has restricted my social life and I do not go out very often
4. Pain has restricted my social life to my home
5. I have hardly any social life because of the pain

Section 9 – Travelling

0. I get no pain when travelling
1. I get some pain when travelling, but none of my usual forms of travel make it any worse
2. I get extra pain while travelling, but it does not compel me to seek alternate forms of travel
3. I get extra pain while travelling which compels me to seek alternate forms of travel
4. Pain restricts all forms of travel
5. Pain prevents all forms of travel except that done lying down

**Section 10 - Changing Degree of Pain**

0. My pain is rapidly getting better
1. My pain fluctuates but overall is definitely getting better
2. My pain seems to be getting better but improvement is slow at present
3. My pain is neither getting better or worse
4. My pain is gradually worsening
5. My pain is rapidly worsening
APPENDIX L

Participant Number: _____________        Visit Number: ______

Date: __________

Universal Goniometer
Readings:

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<tr>
<td>3</td>
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Pressure Algometer Reading: __________
APPENDIX M

TABLE OF SUGGESTED TREATMENT DOSAGES (MEDILASER DE LUXE INSTRUCTION MANUAL)

4.4.3 TABLE OF SUGGESTED TREATMENT DOSAGE

The treatment times listed below are a guideline only. When commencing a course of treatments, start with a low dose and work upwards. The best possible results are normally obtained with a low dosage.

The photon reaction from laser treatment can often occur well after treatment i.e. 1-2 days later, under normal circumstances this reaction will occur within 4 hours.

The table below is based on using a 670mm laser diode delivering 20mW.

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<td>LOW</td>
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<td>Deep Trigger Point</td>
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<td>90</td>
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<tr>
<td>Aricular Point</td>
<td>15</td>
<td>30</td>
<td>0,3</td>
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