The immediate effect of myofascial trigger point dry needling of four shoulder girdle muscles on the 100m lap- times of asymptomatic competitive swimmers in Bloemfontein

By

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I, Sarah Schmidt-Kinsman, do declare that this dissertation is representative of my own work in both conception and execution (except where acknowledgements indicate to the contrary)

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DEDICATION

To my Mom and Dad, Hans and Beth Schmidt, thank you for giving me the opportunity to study Chiropractic, thank you for your continual love, support and encouragement over the years.

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ABSTRACT

Background

Competitive swimming, as with most other sports that are participated in at more than a recreational level, involves a substantial amount of training. Training excessively results in the overuse of muscles. The overuse of muscles commonly causes the production of myofascial trigger points (MFTPs) within the overworked muscles. The presence of MFTPs is a condition known as myofascial pain syndrome (MPS).

Myofascial trigger points may be active or latent. Either way, they produce a wide range of effects. This study focuses on the effect of reduced muscle strength. Muscle strength is essential to athletes as it determines performance. Swimmers with MFTPs will not perform at their full ability.

Dry needling is an effective form of treatment for MFTPs as it produces immediate relief from the effects of MFTPs. There is not enough information on the immediate effects of dry needling on athlete performance. Since dry needling brings about the immediate relief of MFTPs, this study aims to restore a swimmer's muscle power and hence improvement of their swimming performance post-intervention.

Aim

The aim of this study was to determine the immediate effect of dry needling common myofascial trigger points (MFTP) found in four muscles of the shoulder girdle on competitive swimmers' 100m freestyle lap-times.

Methods

The design was a pre-test post-test quasi-experimental study. Thirty five competitive swimmers between the ages of 16 and 30 years old participated in this study. Each participant underwent one assessment. Participants' lap-times were taken using a Sportline Econosport Stopwatch. The pre- and post-intervention lap-times were compared to each other using statistical analysis. The intervention for the purpose of the study was trigger point dry needling. Myofascial trigger points were assessed using manual palpation and the Myofascial Diagnostic Scale (MDS).

Results

The median lap time was slightly longer post intervention (0:01:16.10) than pre-intervention (0:01:16.03), and was highly statistically significant (p=0.001). The results of the study were inconclusive, however, as there were too many confounding variables (for example, fatigue due to repeatedly swimming laps, swimmers of a lower caliber and hence quicker fatigue rate being included in the study)which negated the effect of dry needling and so the poorer performance of the participants post-intervention could not be attributed entirely to the intervention. A small number of participant's lap-times decreased post-intervention i.e. they performed better post-intervention. These individualswere predominantly sprint-swimmers.

Conclusion

Dry needling negatively affects immediate lap-time performance. Future studies should reduce the number of variables affecting the study, for example, having a sprinter versus long-distance swimmer group, testing the outcome of dry needling after the swimmer has had sufficient time (for example, a day) to rest post-intervention.

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DEFINITIONS

Abduction:

Movement of a limb/s away from the midline of the body (the midline of the body referring to a line separating the body into right and left halves (Tortora and Derrickson, 2009).

Active myofascial trigger point (AMFTP):

A myofascial trigger point that has the clinical characteristics of a myofascial trigger point and that produces spontaneous pain (Travell*et al.,*1999).

Adduction:

The opposite of abduction i.e. movement of a limb/s towards the midline of the body (Tortora and Derrickson, 2009).

Agonist:

A muscle that produces a desired motion (Tortora and Derrickson, 2009).

Analgesic:

A substance or activity that when applied to the body results in pain relief (Dreyer, 2007).

Anatomical position:

The position of the body standing upright with the head, eyes and toes oriented anteriorly, the arms are alongside the left and right sides of the trunk with the palms oriented anteriorly, the legs are together and the feet and toes are parallel oriented anteriorly (Moore *et al.,*2006).

Antagonist:

A muscle having the opposite action of its agonist (Tortora and Derrickson, 2009).

Anterior/ventral:

A position that is in the vicinity of the front half of the body (Tortora and Derrickson, 2009) if the body were divided into a front and a back half.

Asymptomatic:

The state of any participant meeting the criteria in the myofascial diagnostic scale other than spontaneous shoulder pain i.e. the participant may only complain of pain upon mechanical stimulation of a MFTP, they should not have unprovoked pain.

Competitive swimmer:

Any person having competed in any of the following events over the course of the year preceding the study (Moreira *et al.,* 2011; Riemann *et al.,* 2011):

- A minimum of 3 minor qualifying events (these include age group galas) and/or
- Provincial galas (or any other equivalent event) and/or
- 1 national event or 1 international event, and/or a combination of the above
- A competitive swimmer will also be required to swim 4 hours or more per week all year round or average over 4 hours per week if seasonal swimmers (Moreira *et al.,* 2011; Riemann *et al.,* 2011).

Correlate:

A relationship in which either one of two or more facts are closely related and have a mutual relationship in which one is dependent or affects the other (Learner's Dictionary, 2016).

COX-2 inhibitors:

Also known as cyclo-oxygenase-2 inhibitors. These are a type of analgesic that selectively inhibit only cyclo-oxygenase 2, an enzyme (other analgesics inhibit cyclo-oxygenase 1 and 2). By selectively inhibiting cyclo-oxygenase-2, they do not cause as many side-effects of the gastro-intestinal tract (Cox-2 inhibitors, 2016).

Disequilibrium:

The diminishment or disturbance of balance (Disequilibrium, 2015).

Extension:

The process by which the angle between two bones is increased e.g. straightening the arm (Tortora and Derrickson, 2009).

External/lateral rotation:

The movement of a joint around its rotational axis away from the midline of the body e.g. if the right arm is externally/laterally rotated from the anatomical position, it will be rotated in a clockwise direction (External rotation,2015).

Flexion:

The opposite of extension in which the angle between two bones is decreased e.g. bending the arm (Tortora and Derrickson, 2009).

Inferior:

A position nearer to the feet e.g. the knee is inferior to the hip (Standring, 2008; Tortora and Derrickson, 2009).

Internal/medial rotation:

The opposite of external rotation and is the movement of a joint around its rotational axis toward the midline of the body e.g. if the right arm is internally/medially rotated from the anatomical position, it will be rotated in an anti-clockwise direction (Internal rotation, 2015).

Lacrimation:

When the eyes produce tears (Lacrimation, 2015).

Latent myofascial trigger point (LMFTP):

A myofascial trigger point that may have the same clinical effects as an active myofascial trigger point but that is painful on palpation and is not spontaneously painful (Travell*et al.,*1999).

Muscle activation patterns (MAPs):

Measurements of muscular activity during the performance of motor tasks in order to determine normal and pathological motor recruitment using electromyographic studies (van Bolhuis and Gielen, 1999).

Myofascial pain syndrome (MPS):

Defined as“the sensory, motor, and autonomic symptoms caused by myofascial trigger points” (Moran, 1992; Travell*et al.,*1999; Chaitow and Delany, 2003).

Myofascial trigger points (MFTPs):

Defined as “the presence of an exquisite tenderness at a nodule in a palpable taut band (of muscle)” (Travell *et al*., 1992; Huguenin, 2004).

Needle effect:

Defined as “the immediate analgesia / pain relief produced by needle insertion into the MFTP” (Lewit, 1979; Tough and White2011).

Nociceptors:

These are peripherally located nerve cells that respond to stimuli that are potentially threatening or that are already threatening the integrity of the tissues (Dubin and Patapoutian, 2010).

Non-steroidal anti-inflammatories (NSAIDs):

Drugs that reduce fever and inflammation, and bring about pain relief (Dreyer, 2007).

Palpate:

The use of touch to examine something, in the case of this study, muscle bulk (Tortora and Derrickson, 2009).

Piloerection:

The erection of hair – this term is more commonly referred to as ‘goosebumps’(Piloerection, 2015).

Posterior/dorsal:

A position close to or at the back of the body e.g. in the anatomical position, the heel of the foot is posterior to the toes(Tortora and Derrickson, 2009).

Prevalence:

in statistical terms, refers to the number of cases of a disease or other finding present in a certain population at any given time (Prevalence, 2016).

Proprioception:

A sensation that is transmitted by joints. It allows the brain to be aware of movement as well as the position of parts of the body (Moore and Dalley, 2006).

Rami communicantes:

Branches from spinal nerves (Tortora and Derrickson, 2009).

Range of motion:

The amount of movement (measured in degrees) that can be achieved by a muscle or joint.

Reciprocal inhibition:

The process in which a muscle relaxes during contraction of its antagonist (Reciprocal inhibition, 2015).

Reliability:

The extent to which a measurement/assessment tool produces consistent and steady results (Phelan and Wren, 2016).

Snapping palpation:

Defined as suddenly pressing down with a fingertip perpendicular to the taut band representing a MFTP and rolling the underlying muscle fibres back along with the skin (Travell *et al.,* 1999).

SOAPE note:

A summary of a patient or participant's condition.'S' represents Subjective information; 'O' represents Objective information; 'A' represents the Assessment findings; 'P' represents the treatment Plan and 'E' represents Education.

Superior:

The opposite of inferior and is a position nearer to the head e.g. in the anatomical position, the hip is superior to the knee (Standring, 2008; Tortora and Derrickson, 2009).

Topical analgesics:

Analgesics (see definition of analgesic on page xiv) that are applied to the skin (Dreyer, 2007).

Trigger point dry needling:

Defined as, "the insertion of an acupuncture needle directly into an MFTP to achieve the needle effect" (Travell *et al*., 1999).

Validity:

The competence of a measurement tool/test measures what it claims to measure (Phelan and Wren, 2016).

Vasoconstriction:

When a blood vessel narrows due to the smooth muscle of the blood vessel contracting (Tortora and Derrickson, 2009).

Vasodilation:

The opposite of vasoconstriction and a widening of a blood vessel caused by relaxation of the smooth muscle of the blood vessel (Tortora and Derrickson, 2009)

ABBREVIATIONS

%	Percentage
>	Greater/more than the figure preceding it
<	Smaller/less than the figure preceding it
ADP	Adenosine triphosphate
ACh	Acetylcholine
5/4AMTP	Active myofascial trigger point
ATP	Adenosine triphosphate
CNS	Central nervous system
COX-2	Cyclo-oxygenase-2
DOMS	Delayed onset muscle soreness
IH	Integrated hypothesis
KZN	KwaZulu-Natal
LMTP	Latent myofascial trigger point
MAPS	Muscle activation patterns
MDS	Myofascial Diagnostic Rating Scale
MFTP	Myofascial trigger point
MPS	Myofascial pain syndrome
n	Sample size
NMJ	Neuromuscular junction
NRS	Numerical pain rating scale
NSAIDS	Non-steroidal anti-inflammatory drugs
p	The p-value indicates the statistical significance of the presented data (Swinscow, 1996; Wright, 1998; Hinton, 2001; Campbell and Swinscow, 2009).
PNS	Peripheral nervous system
SD	Standard Deviation of the presented data
SDI	Shoulder disability index
SOAPE note	Subjective information; Objective information; Assessment findings; treatment Plan and ‘E’ represents Education.

Chapter 1 : Introduction

1.1 Introduction

Swimming has gained in popularity over the years (Pollard and Fernandez, 2004; Cooper *et al.,* 2007). This is evident from reports, for instance, of 100-120 million Americans partaking in recreational swimming (Johnson e*t al.,* 2003). Many people enjoy swimming for recreation, or swim as a form of exercise (Tate *et al.,* 2012). Children usually start competing at five or sixyears old (O'Donnell *et al.,* 2005). A contributing factor to the rise in popularity of this sport is the fact that it poses a relatively low risk of long-term musculoskeletal problems because water is a low gravity environment (Pollard and Fernandez, 2004; Cooper *et al.,* 2007). Swimming is a sport that can be continued well into old age for this reason. No studies on the demographics of swimming in South Africa could be found, though the South African swimming team represents South Africa at the Olympic Games as well as other international events (Puckree and Thomas, 2006). Swimming at a competitive level, however, predisposes swimmers to certain musculoskeletal problems due to the repetitive nature of the movements in swimming. This is because competitive swimming involves many hours of training, so much so that the swimmer can over-train and this, then, starts to take its toll on their musculoskeletal system (Leão Almeida e*t al.,* 2011; Huguenin, 2004; Ramsi *et al.,* 2004; O'Donnell *et al.,* 2005; Lynch *et al.,* 2010; Riemann *et al.,* 2011; Leão Almeida e*t al.,* 2011).

Swimmers who take part in competitive swimming events train most often in the freestyle stroke because it is "used in training 80% of the time regardless of the competitive swimmer's event" (Richardson *et al.,* 1980; Pollard and Croker, 1999; Puckree and Thomas, 2006). Competitive swimmers average 8km to 12km a day, training twice a day, five to seven days of the week (Beach *et al.,* 1992; Pollard and Croker,1999).Puckree and Thomas (2006) estimated that a swimmer's shoulder would undergo 1 200 000 rotations per year if they averaged 10km per day, 5 days of the week, for 10 months of a year at an average of 15 strokes per length in a 25m pool. More recently, a study based in KwaZulu-Natal (KZN), South Africa, indicated that training sessions of competitive swimmers averaged 90 minutes per session with sessions occurring twice daily, five days a week (Puckree and Thomas, 2006).

Swimming involves repetitive movements that introduce stress, fatigue, microtrauma, laxity of ligaments, and muscular imbalances which then transform the normal biomechanics of the glenohumeral joint, ultimately predisposing it to injury (Allegrucci *et al.*, 1994; Pollard and Croker, 1999). Repetitive overuse of muscles during competitive swimming predisposes swimmers to shoulder girdle fatigue, and this is a causative factor of myofascial trigger points (MFTPs) (Alvarez and Rockwell, 2002: Huguenin, 2004; Gerwin, 2005). Myofascial trigger points are defined in the literature as "the presence of an exquisite tenderness at a nodule in a palpable taut band (of muscle)" (Travell *et al.,*1992; Huguenin, 2004).

Thus, a swimmer's shoulder is very prone to injury due to repetitive microtrauma and overuse (McMaster and Troup, 1993; Bak and Fauno, 1997; Pollard and Croker, 1999; Pollard and Fernandez, 2004; Lynch *et al.,* 2010; Leão Almeida, 2011). This results in shoulder pain which is a very common complaint (Richardson *et al.,* 1980; Pollard and Croker, 1999; Johnson*et al*., 2003; Puckree and Thomas, 2006). According to Bak (1996) and Riemann *et al.*(2011), competitive swimmers' main musculoskeletal complaint is shoulder pain. Overuse injuries (particularly of the shoulder) result in pain and are the commonest cause of lost training time for swimmers (McMaster and Troup, 1993).

Another important contributing factor that may cause shoulder injury in swimmers is muscular imbalance which is evident in a competitive swimmer's shoulder girdle musculature (Pollard and Croker, 1999). Swimmers tend to have increased strength of the pectoralis major and latissimus dorsi muscles, and weakness of the rhomboids, middle trapezius, and upper latissimus dorsi muscles, as well as weakened external rotators of the shoulder girdle (Pollard and Croker, 1999). The biomechanics that are necessitated in swimming promote muscular imbalances that stress the capsuloligamentous structures in the shoulder which then contributes to shoulder instability (O'Donnell *et al.*, 2005). Swimmers also stretch before training and before competitions and this has been viewed negatively by some (O'Donnell *et al.,* 2005) since stretching increases the flexibility of the joint capsule of the glenohumeral joint. As this joint is already lax from the high biomechanical demands of swimming, stretching compounds the problem of instability (O'Donnell *et al.,* 2005). Evidence indicates that extended periods of swimming produce instability of the static stabilizers of the glenohumeral joint – a result of the increased anterior and internal rotator musculature with the compounded problem of repetitive microtrauma to the joint (O'Donnell *et al.*, 2005). The instability of the static stabilisers means that the glenohumeral joint has an increased range of motion in competitive swimmers (O'Donnell *et al.*, 2005). Stretches are therefore included or excluded by the swimmer's coach for each swimmer depending on their individual needs and biomechanical status (McMaster and Troup, 1993; O'Donnell *et al.,* 2005).

Notwithstanding the above, in order for swimmers to excel in competitive swimming, they need to improve on their mechanical efficiency (O'Donnell, 2005 *et al.*; Beach *et al.,* 1992). Poor body mechanics are known to result in increased drag and therefore decreased swimming efficiency and increased time (McMaster and Troup, 1993; O'Donnell*et al.*, 2005). This is especially so, as according to Ramsi *et al*. (2004), most upper extremity overuse injuries have been associated with the ability of the muscles to produce internal rotation and external rotation of the glenohumeral joint.

Myofascial trigger points are either active or latent; differing only when spontaneous pain is produced (that is, the person will only feel pain on direct palpation of the latent MFTP) (Kaur *et al*., 2014). Latent MFTPs cause all the same dysfunction (though to a lesser degree) as active MFTPs do (Alvarez and Rockwell, 2002; Lucas, 2008; Ge *et al.,* 2011; Bron and Dommerholt, 2012). Most people have latent MFTPs and these are precursors to active MFTPs (Travell *et al.,* 1999).

One of the accepted hypotheses used to explain MFTPs is the "Integrated Hypothesis (IH)" (Srbely, 2010). This hypothesis proposes that MFTPs are initiated by local acute or chronic overload injury of the affected muscle/s (Gerwin, 2005; Srbely, 2010). This overload injury leads to a continuous release of acetylcholine which thus propagates muscle action potentials continuously (Simons, 2008; Srbely, 2010). The muscle therefore becomes hypertonic (taut band of muscle fibres in the affected muscle) (Simons, 2008). If this state remains for a long period of time, hypoxia and eventually ischaemia develops in that area (Simons, 2008). Vasoactive and inflammatory substances are released and these increase tissue sensitivity in terms of the pain felt from the site of the MFTP (Mense *et al.,* 2001; Gerwin, 2005; Simons, 2008; Srbely, 2010).

The IH explains most of the concomitant signs and symptoms associated with MFTPs (Gerwin, 2005) namely, a taut band within the affected muscle, resistance to stretch and pain. It also explains how latent MFTPs are precursors to active MFTPs (that is, the longer the cycle is allowed to remain without intervention, the more irritable the latent MFTPs become).

The effects of MFTPs on the muscles in which they are found are numerous (Travell *et al.,* 1999; Alvarez and Rockwell, 2002). Myofascial triggerpoints may be associated with a taut band of muscle fibres in the affected muscle, which produces a transient contraction of the muscle fibres when directly palpated or dry needled/injected (known as a local twitch

response) (Travell *et al., 1999*; Alvarez and Rockwell, 2002).The muscle also remains in a shortened state and resists stretching, hence, there is also an associated decrease in the range of motion of associated joint/s (Audette *et al.,* 2004; Gerwin, 2005).Myofascial triggerpoints cause a reduction in muscle power without any muscle atrophy of the affected muscle (Travell *et al.,* 1999; Audette *et al.,* 2004; Alvarez and Rockwell, 2002; Gerwin, 2005; Cummings and Baldry, 2007; *et al.,* 2011). Collectively, muscle weakness is thought to be due to central inhibition which occurs to prevent the muscle from contracting painfully (Lawrence *et al.,* 1996; Audie, 2005).

In addition to MFTPs, pain and muscle imbalance alter normal biomechanics (Pollard and Croker, 1999; Travell *et al.,* 1999; Dommerholt *et al.*, 2006a), which together with muscle weakness (Gerwin, 2005) compound the adverse effects on a competitive swimmer's performance (Kinsman, 2014). Since latent MFTPs do not produce spontaneous pain (Lucas, 2008), some swimmers may not necessarily have shoulder pain, but they will still have latent MFTPs due to muscle overuse (Fernandez-de-las-Penas *et al.,* 2005). This, according to Bron *et al.* (2011), may lead to decreased muscle strength.

According to Lucas (2008), active or latent MFTPs result from altered muscle activation patterns (MAPs) and lack of muscle contraction synchronicity during scapular rotation.Lucas (2008) conducted a study in which latent MFTPs were deactivated using dry needling followed by passive muscle stretching. This outcome implies that dry needling of latent MFTPs normalized MAPs and increased the range of motion of associated joint/s. Dry needling of MFTPs has been shown to be an effective treatment (Cummings, 2001; Dommerholt *et al.,* 2006b; Vernon and Schneider, 2009) in clinical practice as it minimises or completely alleviates the effects of MFTPs. Dry needling of active MFTPs improves the range of motion and decreases tenderness at the primary MFTP location (Gerwin, 2010).Subrayan (2008) found that bowling speed was increased as a result of dry needling. Cricket and swimming are similar in that they are both known as 'overhead' sports, where the athlete is required to have full range of shoulder motion to perform at their optimum. Subrayan's (2008) study showed favourable outcomes and as such it is expected that a similar study on swimmers could reflect similarly favourable outcomes.

Studies on swimmers byHawley and Williams, (1991) and Hawley *et al.* (1992) concluded that freestyle swimming performance was determined by 'muscle power.' Thus, this study will investigate whether deactivating latent MFTPs restores muscle power.

1.2 Problem statement

This study serves as a follow-up to a study by Kinsman (2014). The study conducted in 2014 investigated the appearance of sport-specific combinations of MFTPs. The study design was a cross-sectional, observational study. Swimmers were compared to non-swimmers (the non-swimmer group was made up predominantly of soccer players). Each group consisted of 40 participants, that is, 40 participants in the swimmer group and 40 participants in the non-swimmer group. Twelve muscles of the shoulder girdle (namely, the trapezius, latissimus dorsi, pectoralis major, pectoralis minor, supraspinatus, infraspinatus, teres major, teres minor, latissimus dorsi, subscapularis, biceps brachii and triceps brachii muscles) were assessed bilaterally in each participant. The shoulder disability index (SDI) score, numerical pain rating score (NRS), algometer measurement, MDS score, as well as the location of any MFTPs that were found were recorded. This data was then statistically analysed to determine differences in MFTP location between the two participant groups. The infraspinatus muscle presented with a *p* value of 0.027 – nine swimmers presented with MFTPs in this muscle compared to three non-swimmers, hence, the infraspinatus muscle appeared to be more problematic in swimmers when compared to non-swimmers. The remainder of the muscles that were assessed did not have statistically significant *p* values when comparing the swimmers to the non-swimmers, yet there were three other muscles that proved to have a high incidence of MFTPs. These muscles were the suprapinatus, trapezius and latissimus dorsi muscles. The supraspinatus muscle presented with MFTPs in 3 swimmers and 8 non-swimmers. The trapezius muscles presented with MFTPs in 27 swimmers and 30 non-swimmers. The latissimus dorsi muscle presented with MFTPs in 1 swimmer and 1 non-swimmer. Due to the findings of this study, this follow-up study assessed and provided an intervention to all MFTPs that were identified in the infraspinatus, supraspinatus, trapezius and latissimus dorsi muscles as these muscles appeared to have a higher incidence of MFTPs.

There is a paucity of literature regarding the effects of MFTP deactivation on performance insports. However, it is possible that MFTP (active or latent) deactivation would restore theMAPs of affected muscles, negate the central inhibition of muscles, increase the range of motion of affected joint/s, and ultimately restore the strength of the muscle to where it was before the MFTP developed (Hawley et al., 1992; Lucas, 2008; Subrayan, 2008). In individuals with shoulder pain, who are needled, it is expected that, along with pain reduction, there is a restoration of normal swimming biomechanics (Gerwin, 2005). Deactivation of MFTPs, therefore, may result in an improved performance time for the swimmer. It is, however, anticipated that the effects of the deactivation will only last for a

short period subsequent to treatment since the perpetuating factor of muscle overuse will remain, so eventually MFTPs will return (Gerwin, 2005). Due to Kinsman's (2014) study, this follow-up study assessed and provided an intervention to all MFTPs that were identified in the infraspinatus, supraspinatus, trapezius and latissimus dorsi muscles as these muscles appeared to have a higher incidence of MFTPs. The study design for this study was a pre-test post-test quasi-experimental study consisting of one participant group of 35 competitive swimmers between the ages of 16 and 30 years old. One assessment was performed on each participant. Each participant was required to swim three consecutive 100m freestyle laps, with an average rest of one minute between laps. Each lap time was taken using a Sportline Econosport Stopwatch and recorded. The four muscles mentioned in the preceding paragraph were assessed bilaterally and any MFTPs that were identified were treated by means of trigger point dry needling. Following treatment, the participant had to repeat three separate 100m freestyle lapswith an average rest of one minute between laps and their times were taken and recorded once again. This data was then analysed by the researcher with the assistance of a biostatistician, where pre-intervention lap times were compared to the post-intervention lap times.

1.3 Aims and objectives

The aim of this study was to determine the immediate effect of dry needling common myofascial trigger points (MFTP) found in four muscles of the shoulder girdle on competitive swimmers' 100m freestyle lap-times.

The First Objective was to identify myofascial trigger points (active or latent) in each participant's shoulder girdle musculature and to quantify trigger points objectively according to the myofascial dysfunction scale (Vaghmaria, 2005).

The Second Objective was to measure the effect of the intervention on performance by comparing the 100m freestyle lap time prior to the intervention to the 100m freestyle lap time following the intervention.

1.4 Study hypothesis and null hypothesis

The hypothesis of this study is that the intervention would ease the negative effects of the MFTPs and thus help the affected muscle/s perform effectively which would result in a better lap time performance i.e. a shorter lap time average post-intervention. The null hypothesis is that the intervention will not result in a better lap time performance i.e. a longer lap time average post-intervention.

1.5 Benefits / Rationale of this study

Based on the results of this study, health practitioners working in conjunction with athletes, particularly chiropractors and physiotherapists, could possibly incorporate a short- and long-term treatment regime which could help increase athletes' performance as well as decrease the risk of shoulder girdle pathology (Kammer *et al.,* 1999; Blanch, 2004; O'Donnell *et al.,* 2005; Tovin, 2006; Cooper *et al.*, 2007).

Based on the hypothesis of this research, the lap-time of competitive swimmers would be expected to increase because muscle strength would be restored (Lucas, 2008), providingadded benefit for the swimmer.

The improvement of joint range of motion (Esenyel *et al.*, 2000; Grieve, 2006; Hsieh *et al.,* 2007) will have an effect on the restoration of normal swimming biomechanics and thus allow the swimmer to be more efficient at stroke technique.

1.6 Outline of chapters

Chapter 1 was an outline on the literature associated with this study topic, the aims and objectives of this study, the benefits and rationale of this study, and the limitations of this study. Chapter 2 is a review of the literature with regards to shoulder anatomy, myofascial pain syndrome and its treatment, as well as the freestyle stroke. Chapter 3 serves as an explanation of the materials and methods that were used to complete this study. Chapter 4 reveals the results of this study and will include a discussion of the study results. Chapter 5 is the concluding chapter in which final thoughts and recommendations are discussed and conclusions drawn.

Chapter 2 : Literature Review

2.1 Introduction

Chapter 2covers the anatomy and physiology of the shoulder girdle, the pathophysiology of myofascial pain syndrome, dry needling as a form of treatment for MFTPs and swimming biomechanics.

2.2 Swimming

2.2.1 The freestyle stroke

Swimming is unlike most other sports as most of the muscle power used to move the arms through the water is derived from the shoulder joints (Puckree and Thomas, 2006; McLeod, 2010).

When discussing the biomechanics of the freestyle stroke, names identifying the phase of the stroke are assignedin relation to the arm position.There are different variations of the description of the stroke phases according to different authors, but the components of the stroke are essentially the same. According to Magee(2011),thestroke consists of four phases occurring in each arm, namely the early mid and late pull-through phases, and lastly the recovery phase.

2.2.1.1 Early pull-through phase

During this phase, the arm enters the water and reaches forward, extending forward at the anterior aspect of the shoulder.The backward movement of the arm is initiated once the arm is submerged in the water.The arm and the forearm face the backward direction while the fingers are pointing down.

2.2.1.2 Mid pull-through phase

The humerus is perpendicular to the body.

2.2.1.3 Late pull-through phase

The hand of the swimmer continues moving in the backwards direction where it passes alongside the ipsilateral hip and exits the water guided by the flexed elbow.

2.2.1.4 Recovery phase

The arm exits the water completely and is swung above the water to be in a position to enter the water and undergo this cycle once again.This phase can be divided into two – an early, and a late recovery phase.At the late recovery phase the elbow is extended to reach forward.This phase is led by the elbow.Some swimmers use the hand to lead, but this puts the shoulder in a vulnerable position and is hence not favourable.

This arm movement is accompanied by axial rotation of the body – the body rolls over slightly toward the side of arm entry into the water.As the arm extends at the elbow and enters the water the shoulder, as well as the ipsilateral side of the body, rotate below the surface of the water.During the recovery phase, counter-rotation of the ipsilateral side occurs.When breathing, the axial rotation of the body increases and in some elite swimmers, this angle is found to be up to 90°.Excessive rotation, however, has a negative effect on the ability of the swimmer to have a good lap-time and so swimmers need to try to minimize the amount of axial body rotation occurring.

2.2.2 Muscle activation during freestyle

2.2.2.1 Glide phase

This is when the hand enters the water. The elbow is positioned slightly above the hand.During this time, the arm is held anterolaterally to the head. To enable the head of the humerus to move in the glenoid cavity of the scapula, the upper fibres of the trapezius muscle, the rhomboid major and minor muscles, as well as the serratus anterior muscle are utilized (Heinlein and Cosgarea, 2010).

Other muscles that are utilized, but that do not contribute as much, are the pectoralis major, teres minor flexor carpi radialis, palmaris longus, flexor carpi ulnaris, flexor digitorum superficialis, flexor dittorum profundus, and flexor pollicis longus muscles(McLeod, 2010).

2.2.2.2 Pull-through phase

The early pull-through phase starts at the end of glide phase. The hand has reached as far forward as possible and the arm is hencemaximally extended until the humerus is almost perpendicular to the body’s long axis. The arm begins to pull downwards in the water. The pectoralis major and teres minor muscles are very active during this phase, working together to enable the humerus to extend, adduct and internally rotate. The serratus anterior,

perctoralis major and latissimus dorsi muscles are constantly active during this phase in order for the body to move over the hand that is in the water.(Heinlein and Cosgarea, 2010).

Other muscles that are utilized, but that do not contribute as much, are the flexor carpi radialis, palmaris longus, flexor carpi ulnaris, flexor digitorum superficialis, flexor digitorum profundus, flexor pollicis longus, biceps brachii short head, brachialis, brachioradialis, and pronator teres muscles (McLeod, 2010).

Mid pull-through: This is a transitional phase between early and late pull-through where the arm is pointing to the bottom of the pool (Heinlein and Cosgarea, 2010).

Late pull-through: This phase starts from the perpendicular position of the humerus until the hand exits the water.The latissimus dorsi is very active during this phase, extending the humerus. The subscapularis internally rotates the humerus and is assisted by the latissimus dorsi. The serratus anterior, perctoralis major and latissimus dorsi muscles are constantly active during this phase in order for the body to move over the hand that is in the water (Heinlein and Cosgarea, 2010).

Other muscles that are utilized, but that do not contribute as much are thebiceps brachii short head, brachialis, brachioradialis, and pronator teres(Heinlein and Cosgarea, 2010; McLeod, 2010).

2.2.2.3 Recovery phase

This phase starts from when the hand exits the water posteriorly until it enters the water again anteriorly. When the hand exits the water, the elbow is slightly flexed; this position is produced when the posterior and middle aspects of the deltoid, and suprapinatus muscles contract, causing extension and abduction of the humerus. The rhomboid major and minor muscles retract or pull back the scapula, causing the body to roll over in the water towards the opposite side so that the opposite arm can initiate the pull-through phase. The scapula is rotated to an upward position due to the upper fibres of the trapezius and the serratus anterior muscles being activated. The deltoid muscle is active thereafter with all three groups of the muscle fibres playing a part: the posterior aspect of the deltoid causes extension of the humerus; the middle aspect cause abduction of the humerus; and finally, the anterior aspect stabilizes the shoulder, as the hand is preparing to re-enter the water (Heinlein and Cosgarea, 2010).

Other muscles that are utilized, but that do not contribute as much, are the biceps brachii short head, brachialis, brachioradialis, pronator teres, triceps brachii long head, triceps brachii lateral head, triceps brachii medial head, and the aconeus(McLeod, 2010).

Figure 2.1 is a depiction of the muscles utilized at each phase of the freestyle stroke.

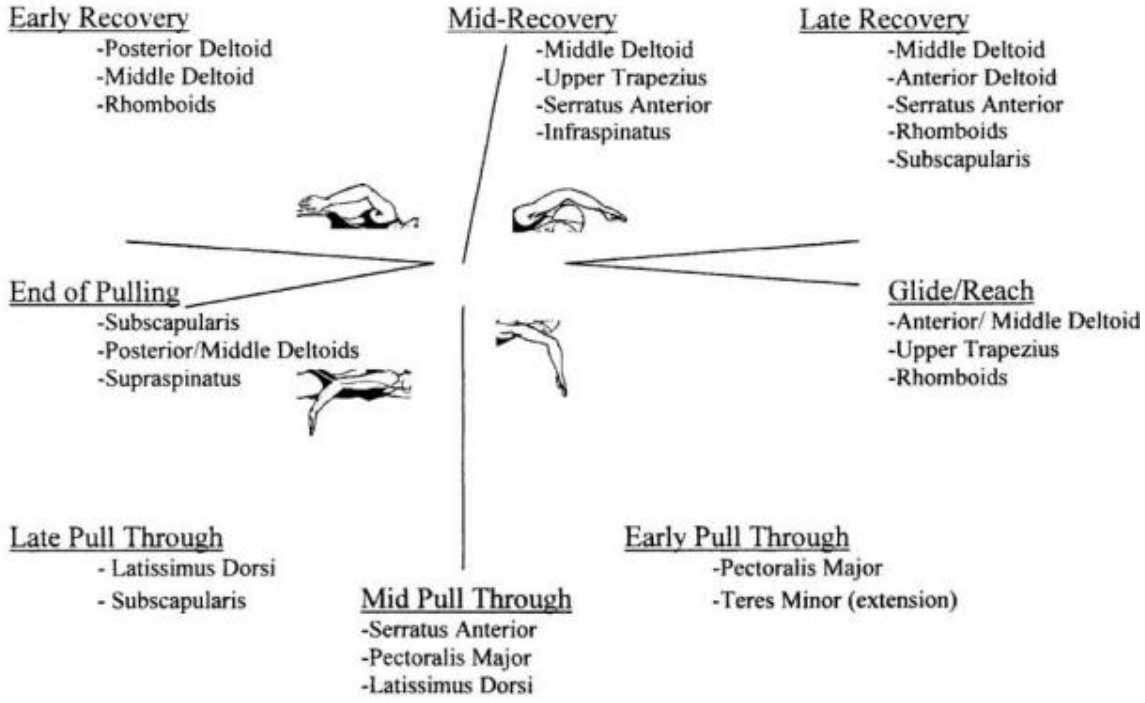

Figure 2.1: Depiction of the freestyle stroke and muscles utilized at each phase
Source: Heinlein and Cosgarea (2010)

2.3 The shoulder girdle

The shoulders are used in all swimming strokes, so much so that the shoulders are often problematic in swimmers.As a result of this, shoulder injury due to overuse has received its own diagnostic term, ‘swimmer’s shoulder.’ This is because overuse injuries of the shoulder in swimmers are so common (Tate, *et al.,* 2012).

The shoulder girdle comprises the bones and joints formed by the bony articulations (the glenohumeral joint, the sternoclavicular joint, the acromioclavicular joint and the scapulothoracic joint), the ligaments supporting the joints, the muscles attaching to and originating from the bones in that area, as well as the associated nerves and blood vessels (Standring, 2008). The shoulder girdle will now be discussed in greater detail as the shoulder plays a large part in this study. Each section (for example, joints, muscles and so on) will

begin with a discussion of the micro-anatomy of the shoulder girdle componentsfollowed by the macro-anatomy of the shoulder girdle components.

2.3.1 Micro-anatomy of the joint cartilage

Joints, as the name implies, join separate bones together to allow movement (Moore and Dalley, 2006; Tortora and Derrickson, 2009). They also stabilize and distribute any forces applied to the body (Setton, *et al.,* 1999). Joint surfaces are covered in cartilage and the joint spaces are covered in a joint capsule which is usually filled with synovial fluid (Moore and Dalley, 2006). Cartilage is a semi-rigid structure that is very resilient to the loading, tensile forces and friction that impact onthe body during motion (Moore and Dalley, 2006). It is present in areas of the body that require increasedflexibility and it covers joint surfaces so that these surfaces, with the help of synovial fluid (a lubricating agent), can move against each other smoothly and freely(Moore and Dalley, 2006).

Hyaline cartilage is the most common type of cartilage in the body (Young *et al.,* 2000; Krause and Krause, 2005). Elastic cartilage has a similar structure to hyaline cartilage, the difference being the presence of branching elastic fibres (Young *et al.,* 2000; Krause and Krause, 2005). There is also a large amount of collagen with interspersed elastic fibres (Young *et al.,* 2000). Elastic cartilage does not occur in the shoulder (Young *et al.,* 2000). Fibrocartilage is arranged in a pattern of interchanging layers of hyaline cartilage matrix and thick layers of collagen fibres (Young *et al.,* 2000).

Joint capsules have nerve endings (Moore and Dalley, 2006). Hilton's Law states that the nerves that supply a joint also supply the muscles that move the joint or the skin covering their distal attachments (Moore and Dalley, 2006). The nerves that leave joints transmit proprioception along with other sensations such as pain and vibration (Moore and Dalley, 2006).

2.3.2 Macro-anatomy of the joints of the shoulder girdle

2.3.2.1 Sternoclavicular joint

This articulation is formed by the sternal (or medial) end of the clavicle articulating with the lateral aspect of the manubrium and the first costal cartilage. Classified as a saddle type of synovial joint, the sternoclavicular joint functions isa ball-and-socket joint since the articular disc separating it into two joint surfaces increases the mobility of the joint (Moore and Dalley, 2006; van de Graaff, 2002).

2.3.2.2 Acromioclavicular joint

The acromioclavicular joint is formed by the articulation of the acromial (or lateral) end of the clavicle with the acromion of the scapula (Di Giacomo *et al.,* 2008). It is classified as a plane type of synovial joint. This joint contains a wedge-shaped incomplete articular disc (Standring, 2008).

2.3.2.3 Glenohumeral joint

This jointis classified as a ball-and-socket joint, which is a type of synovial joint, and is held in place by the rotator cuff muscle tone. This joint is made by the articulation of the humeral head with the glenoid cavity of the scapula. This joint is inherently instable since it permits a widerange of movement (ROM) and since the large humeral head articulates with the small glenoid cavity of the scapula. In fact, it is the most mobile joint of the body. The glenoid cavity is deepened slightly by means of the glenoid labrum (Moore and Dalley, 2006).

2.3.2.4 Scapulothoracic joint

The scapula is suspended on the thoracic wall by muscle forming a ‘physiological joint’ – the scapulothoracic joint. These muscles act to stabilize and/or to actively move the scapula. Active movements of the scapula help increase the range of motion of the shoulder joint (Di Giacomo *et al.,* 2008, Moore and Dalley, 2006).

2.3.3 The ligaments of the shoulder girdle

2.3.3.1 The four ligaments of the sternoclavicular joint

2.3.3.1.1 Anterior sternoclavicular ligament

This ligament is presumed to be the strongest ligament of this joint (Brossmann *et al.,* 1996).It is attached to the anterosuperior aspect of the medial epiphysis of the clavicle and inserts to the anterior aspect of the upper part of the manubrium (Brossmann *et al.,* 1996). It is medioinferior in relation to the clavicle (Brossmann *et al.,* 1996).

2.3.3.1.2 Posterior sternoclavicular ligament

The posterior sternoclavicular ligament attaches to the posterior aspect of the medial surface of the clavicle and inserts on the postero-superior aspect of the manubrium (Brossmann *et al.,* 1996).It is also inferomedial in relation to the clavicle (Brossmann *et al.,* 1996).

2.3.3.1.3 Interclavicular ligament

This ligament connects the superior and medial parts of the clavicle to the manubrium, strengthening the joint superiorly (Brossmann *et al.,* 1996).

2.3.3.1.4 Costoclavicular (or rhomboid) ligament

This is an extra-articular ligament.It attaches to the inferior surface of the medial clavicle and inserts onto the superior aspect of the first rib and costal cartilage (Brossmann *et al.,* 1996).

2.3.3.2 The four ligaments of the acromioclavicular joint

2.3.3.2.1 Acromioclavicular capsular ligaments

The joint is protected from excessive anterior and posterior movement by these ligaments (Owens, 2015).

2.3.3.2.2 Coracoclavicular ligmanents (conoid and trapezoid ligaments)

These two ligaments arise from the coracoid process of the scapula and attach to the inferior surface of the distal part of the clavicle, medial to the acromioclavicular joint. These ligaments support the joint inferiorly and superiorly – that is, they prevent excessive movement in the superior and inferior directions. If these ligaments are compromised in any way, the deltoid and trapezius muscles offer dynamic stabilization of the joint (Owens, 2015).

2.3.3.2.3 Coracoacromial ligament

Originating from the superior surface of the coracoid process, this ligament inserts into the inferior surface of the acromial process, it offers minimal stability to the joint (Owens, 2015).

2.3.3.3 The four ligaments of the glenohumeral joint

2.3.3.3.1 Superior glenohumeral ligament

The origin of this ligament varies from body to body and it inserts close to the lesser tubercle of the humerus (Kishner, 2015).This ligament provides stability in that it prevents inferior dislocation of the humeral head when the arm is in the anatomical position,that is, 0° of abduction (Hughes, 2015).

2.3.3.3.2 Middle glenohumeral ligament

The origin of this ligament is the glenoid labrum and its insertion is to the humerus, medial to the lesser tubercle (Kishner, 2015).It affords the joint stability by preventing anterior and posterior movement of the joint surfaces whilst the arm is at 45° of abduction and is externally rotated (Hughes, 2015).

2.3.3.3.3 Inferior glenohumeral ligament

The inferior glenohumeral ligament is composed of three different bands: anterior, posterior and superior.The bands of this ligament originate as the other ligaments do – from the glenoid labrum.They attach at the anatomical neck of the humerus(Moore and Dalley, 2006)The positioning of the bands in relation to each other determines which is anterior, which is posterior and which is inferior, and hence the function of each band.

- Anterior band

  This band assists in the restraint of anterior/inferior translation of the humerus when it is abducted to 90°and maximally externally rotated (Hughes, 2015).
- Posterior band

  The posterior band prevents posterior translation of the humeral head when the humerus is at 90° flexion and internally rotated (Hughes, 2015).
- Superior band

  This band assists in preventing inferior dislocation of the humeral head.It is an important static stabilizer of the glenohumeral joint (Hughes, 2015).

2.3.3.3.4 Coracohumeral ligament

This ligament originates on the base and lateral border of the coracoid process of the scapula, it inserts at the greater tubercle of the humerus (Kishner, 2015).It helps to prevent posterior translation of the humeral head with the shoulder in a flexed, adducted and

internally rotated position (Hughes, 2015).It also prevents inferior translation and external rotation of the humeral head in the adducted position (Hughes, 2015).

2.3.4 Micro-anatomy of voluntary/skeletal muscles

Voluntary/skeletal muscles are the muscles that we have conscious control over (Tortora and Derrickson, 2009), for example, the quadriceps muscle is consciously activated to straighten the leg when we stand up from a seated position. Skeletal muscle is made up of muscle fibres called myofibrils (Young *et al.,* 2000) (Figure 2.2). The contractile proteins are arranged in such a way in skeletal muscle fibres that this type of muscle is designated "striated muscle" (Young *et al.,* 2000). The myofibrils are elongated, multinucleated contractile cells in structure and are grouped and supplied by individual nerve fibre branches (Young *et al.,* 2000; Krause and Krause, 2005). A myofibril with its associated nerve supply is called a motor unit, a number of motor units together exist within individual muscles and these are responsible for bringing about muscle tone, muscle contraction and muscle relaxation (Young *et al.,* 2000; Tortora and Derrickson, 2009).

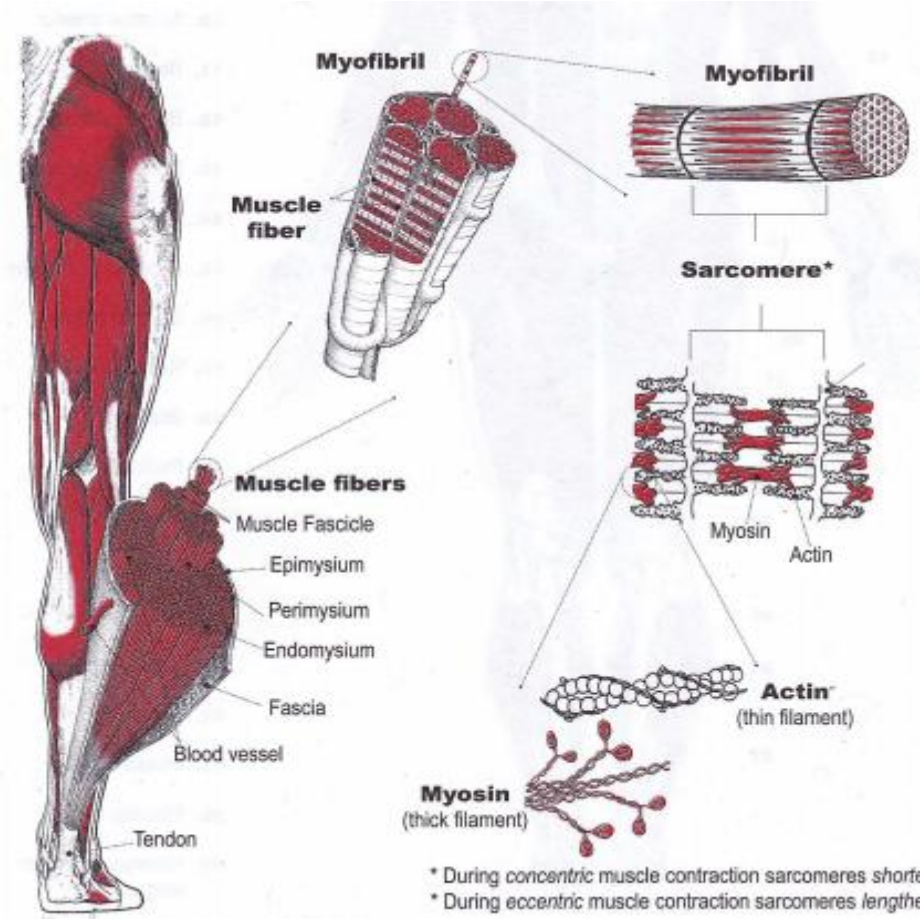

Figure 2.2: Organization of muscle
Source: Vizniak (2011)

A group of parallel myofibrils is called a fascicle (Young *et al.,* 2000; Krause and Krause, 2005). The myofibrils have gaps between them and they contain connective tissue called endomysium. The endomysium is a layer of connective tissue ensheathing each myofibril and contains capillaries and nerves which overliethe myofibril's sarcolemma (cell membrane) (Tortora and Derrickson, 2009). Each fascicle is covered by a collagenous tissue called perimysium (Young *et al.,* 2000; Krause and Krause, 2005). A muscle is composed of many fasciculi and these fasciculi groups are in turn covered by epimysium which is a connective tissue sheath (Young *et al.,* 2000; Krause and Krause, 2005). The nuclei of the myofibrils are found below the sarcolemma which is the plasma membrane of a myofibril (Young *et al.,* 2000; Krause and Krause, 2005). The sarcolemma has tiny openings called transverse tubules (T-tubules), which form a tunnel from the outside towards the centre of each individual myofibril (Young *et al.,* 2000; Krause and Krause, 2005).The T-tubules contain interstitial fluid (Young *et al.,* 2000). Muscle action potentials multiply and travel along the sarcolemma, through the T-tubules, then spread through all the myofibrils (Young *et al.,* 2000; Krause and Krause, 2005). The action potential thus stimulates all the myofibril parts simultaneously (Young *et al.,* 2000).

2.3.5 Macro-anatomy of the muscles that attach to and move the shoulder joint

Although there are more than four muscles that move the shoulder girdle, only the following four muscles will be discussed as these muscles pertain to this study specifically.

2.3.5.1 Trapezius

The trapezius is a triangular shaped muscle.It passes over the posterior aspect of the neck and the upper thorax (Standring, 2008). When viewing the left and right muscles together as they appear anatomically, a diamond shape is formed, hence the name of the muscle (Standring, 2008). The superior fibres descend, superior fibres ascend and the intermediate fibres run horizontally; all the fibres ultimately pass laterally to converge on the shoulder (Standring, 2008) (Figure 2.3).

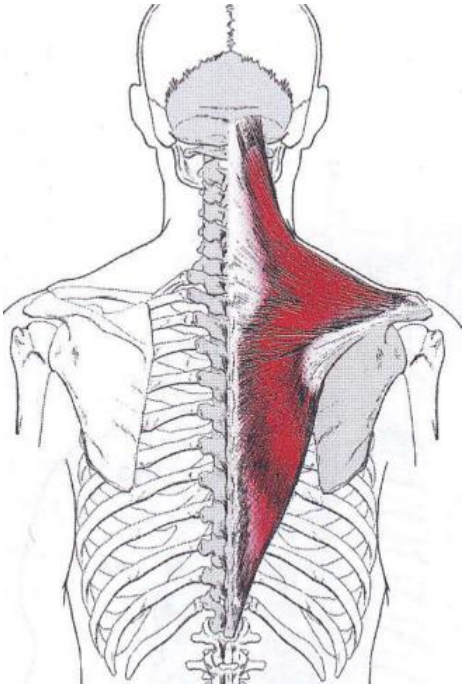

Figure 2.3: Trapezius muscle
Source: Vizniak (2011)

2.3.5.2 Supraspinatus

This muscle is narrow and triangular shaped. The suprasinatus muscle fibres run in a horizontal direction from the point of origin to the point of insertion. Being part of the rotator cuff muscles it acts with them (Figure 2.4).

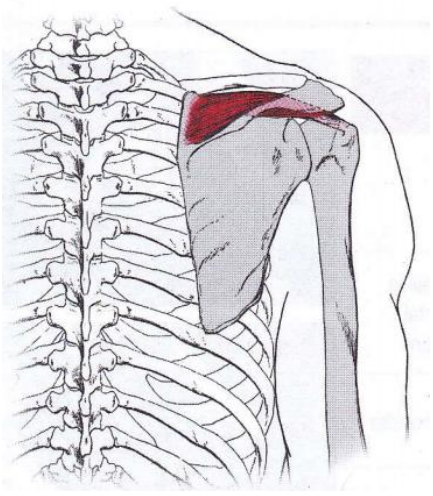

Figure 2.4: Supraspinatus muscle
Source: Vizniak (2011)

2.3.5.3 Infraspinatus

The infraspinatus muscle is also part of the rotator cuff muscles. It is thick and triangular in shape. The muscle fibres run in a superolateral direction from their origin to their insertion (Figure 2.5).

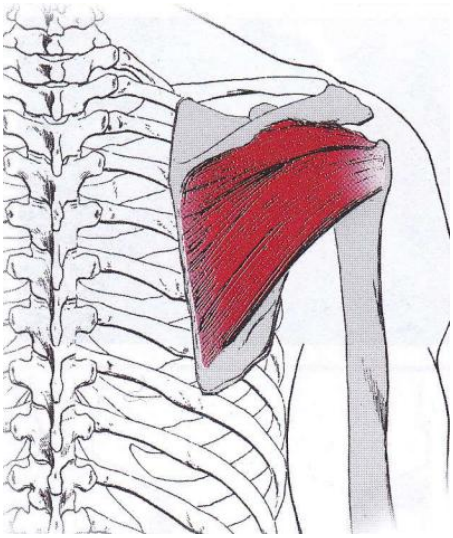

Figure 2.5: Infraspinatus muscle
Source: Vizniak (2011)

2.3.5.4 Latissimus dorsi

This is a large, thin triangular muscle covering the lower half of the back.The muscle fibres run in a horizontal direction laterally, eventually running in a more superolateral direction to reach their point of attachment (Figure 2.6).

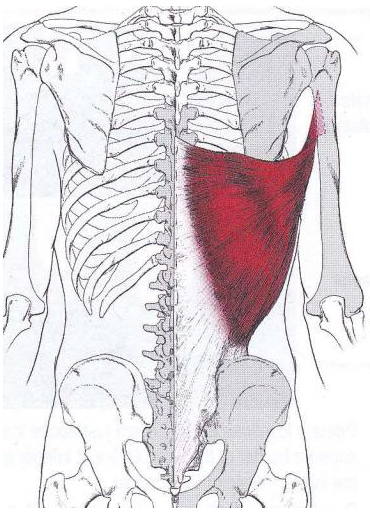

Figure 2.6: Latissimus dorsi muscle
Source: Vizniak (2011)

2.4 Physiology of muscle action

2.4.1 A basic description of the organization and functions of the brain with regards to motor activity and sensation

The central nervous system (CNS) comprises the brain and spinal cord. It coordinates and influences the activity of all parts of the body. The peripheral nervous system (PNS) comprises the nerves that leave and join the spinal cord to supply or transmit information from and to the spinal cord from the areas of the body that they supply. It connects the CNS to the organs and limbs of the body allowing information to travel back and forth between the brain and these structures (Guyton and Hall, 1997; Crossman and Neary, 2010; Moore and Dalley, 2006; Tortora and Derrickson, 2009).

The cerebral cortex is divided into motor (the precentral gyrus is the primary motor area of the cerebral cortex) and sensory (the postcentral gyrus is the primary somatosensory area of the cerebral cortex) areas. The motor areas control voluntary movements. The sensory areas receive and make sense of sensory information.

When information is transmitted along nerves from the muscles to the brain, ittravels through three-neuron sets known as first-order, second-order and third- order neurons. Signals are transferred to the cerebral cortex, the cerebellum, and the reticular formation of the brain stem (Guyton and Hall, 1997; Crossman and Neary, 2010; Moore and Dalley, 2006; Tortora and Derrickson, 2009).

2.4.2 Spinal tracts from brain to muscles

Motor pathways from the brain to the muscles are either direct or indirect. There are two direct (pyramidal) pathways, the corticospinal and corticobulbar pathways. The corticospinal pathway is responsible for skeletal muscles in the limbs and trunk whilst the corticobulbar pathway is responsible for skeletal muscles of the head. There are five indirect (extrapyramidal) pathways, the rubrospinal, tectospinal, vestibulospinal, and the medial and lateral reticulospinal tracts. These indirect tracts transfer information from motor centers in the brain stem to the muscles (Guyton and Hall, 1997; Crossman and Neary, 2010; Tortora and Derrickson, 2009).

2.4.3 Spinal tracts from muscle to brain

Nerve impulses carrying touch, pressure, vibration and conscious proprioception from the limbs, trunk, neck and posterior head ascend to the cerebral cortex along the posterior column, also called the medial lemniscus pathway. Nerve impulses for pain, temperature, itch and tickle from the aforementioned areas ascend along the anterolateral (spinothalamic) pathway. The anterior and posterior spinocerebellar tracts are responsible for transmitting impulses for conscious proprioception from the trunk and lower limbs to the cerebellum (Guyton and Hall, 1997; Crossman and Neary, 2010; Tortora and Derrickson, 2009).

2.4.4 The neuromuscular junction (NMJ)

The NMJ in basic terms is where a nerve meets the muscle to supply or send away information from the muscle (Figure 2.7). Nerves can be afferent or efferent. Afferent nerves are nerves that transmit signals from the brain to the muscle. Efferent nerves are nerves that transmit signals from the muscle to the brain.

This paragraph discusses efferent NMJs. Somatic motor neurons stimulate skeletal myofibrils.Muscle action potentials begin at the NMJ which is a synapse between a somatic motor neuron and a skeletal myofibril.A nerve impulse travels down the nerve to the synaptic end bulbs.This causes synaptic vesicles to undergo exocytosis – the synaptic vesicles fuse with the motor neurons plasma membrane and release acetylcholine (ACh – a neurotransmitter) into the synaptic cleft.Acetylcholine diffuses across the synaptic cleft.When two molecules of ACh bind to the receptor on the motor end plate an ion channel is opened in the ACh receptor, allowing small cations, especially sodium, to flow across the membrane.The influx of sodium makes the inside of the myofibril more positively charged.The change in membrane potential triggers a muscle action potential which travels along the sarcolemma into the T-tubule system.The sarcoplasmic reticulum then releases its stored calcium ions into the sarcoplasm, causing the myofibril to contract (Guyton and Hall, 1997; Tortora and Derrickson, 2009).

This paragraph discusses an afferent NMJs. Afferent neurons called sensory receptor neurons or afferent axons transmit neurological signals from sensory organs to the central nervous system. These are pseudounipolar neurons with a single long axon and no dendrites, they also have a rounded cell body. They aggregate outside the spinal cord and this aggregation is called a dorsal root ganglion. From here, the impulse travels along the spinal cord to the medulla oblongata of the brain stem known as the medial lemniscus

terminating in the primary somatosensory cortex of the parietal lobe (Guyton and Hall, 1997; Tortora and Derrickson, 2009).

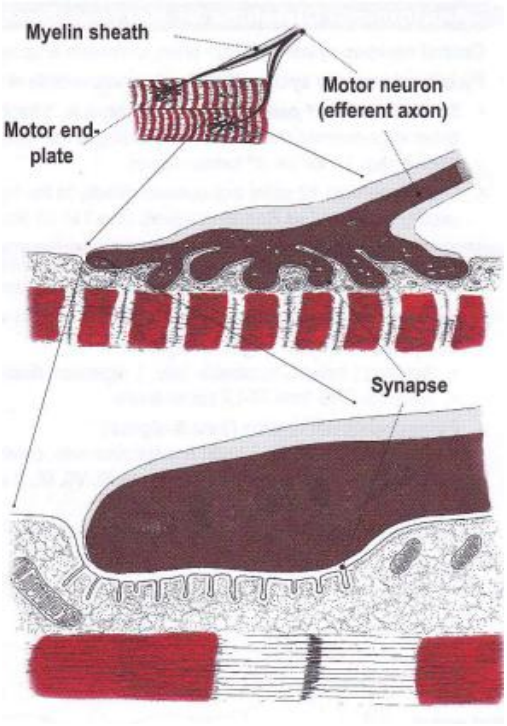

Figure 2.7: The neuromuscular junction
Source: Vizniak (2011)

2.4.5 Muscle proteins

Three types of proteins make up myofibrils: contractile, regulatory and structural proteins.The two contractile proteins are actin and myosin, a diagrammatic representation of these hormones can be seen in Figure 2.2 (Guyton and Hall, 1997; Tortora and Derrickson, 2009).

Regulatory hormones control whether a muscle is contracting or not.Two regulatory hormones are present – tropomyosin and troponin.The myosin-binding sites on actin filaments are covered by tropomyosin when the myofibril is in a relaxed state. This prevents myosin from binding to actin.When troponin binds with calcium ions and changes shape, the myosin-binding sites on actin are exposed as the tropomyosin moves away from the myosin-binding sites and this allows muscle contraction to take place as myosin can bind to actin (Guyton and Hall, 1997; Crossman and Neary, 2010; Moore and Dalley, 2006; Tortora and Derrickson, 2009).

2.4.6 The sliding filament mechanism

Accoding to Tortora and Derrickson (2009):

> When a contraction begins, the sarcoplasmic reticulum releases calcium ions into the cytosol.They bind to troponin which moves the tropomyosin away from the myosin-binding sites on actin.ATP (adenosine triphosphate) hydrolysis occurs: the myosin head has an ATP-binding site to which an ATPase (an enzyme that hydrolyzes ATP into ADP – adenosine diphosphate and a phosphate group) attaches.The hydrolysis reaction reorients and energizes the myosin head.The products of the hysdrolysis remain attached to the myosin head.Cross-bridges are formed when the myosin head attaches to the myosin-binding site on actin and releases the phosphate group.The power stroke occurs after this whereby the site on the cross-bridge where ADP is still bound opens.The cross-bridge rotates and releases the ADP – this generates force as it rotates toward the centre of the sarcomere, sliding the actin filament past the myosin filament toward the M-line.The cross-bridge remains attached to actin until it binds another molecule of ATP.As ATP binds to the ATP-binding site on the myosin head, the myosin head detaches from actin.

Microscopically, the sliding filament mechanism appears when the thinner and thicker filaments slide over each other using energy in the form of ATP. This leads to the sarcomere becoming shortened and occurs due to the myosin heads attaching and moving along the thin filaments towards the M-line. This leads to the thin filaments sliding inwards and the Z-lines approximating and therefore the myofibril shortens as a whole and in turn the entire muscle shortens (Guyton and Hall, 1997; Tortora and Derrickson, 2009).

This cycle repeats itself as long as ATP is available and the calcium ion level near the actin filament is high enough (Tortora and Derrickson, 2009).

2.4.7 Muscle metabolism

Since this study involves the contraction of voluntary muscles, the muscles in question alternate between a low level of activity (hence using a small amount of ATP) and a high level of activity (using a large amount of ATP).As a result, a substantial amount of ATP is required so that calcium can enter the sarcoplasmic reticulum.There is a storage depot of ATP within the muscle fibres at any given moment that can be used but it is not much and so the muscle fibres need to create more ATP so that strenuous exercise can be undertaken. The muscle fibres create ATP in three ways: 1)via creatine phosphate; 2) anerobic cellular

respiration and 3) aerobic cellular respiration. (Guyton and Hall, 1997; Tortora and Derrickson, 2009).

During initial muscle contraction, the ATP within the storage depots of the muscle fibres is used, this continues until after around 4-6 seconds when ATP is created via creatine phosphate (Bron and Dommerholt, 2012).

According to Guyton and Hall (1997), a 100m swimming event would mainly utilize the anaerobic cellular respiration system. If all three processes have been exhausted, the muscle will run out of ATP and sustained sarcomere contractions may start to occur and this can bring about the development of MFTPs (Bron and Dommerholt, 2012).

Due to the fact that muscles will eventually run out of ATP, they can be easily overloaded leading to fatigue. When fatigued there is a high risk of muscle rupture, sprain, tears and tendinopathies occurring. When these occur, they affect the performance of the athlete, and in serious cases may prevent that athlete from continuing to compete in his or her sport until sufficient rehabilitation and treatment or surgery has been performed. (Mueller-Wohlfahrt *et al.,* 2012).

2.4.8 Types of muscle contraction

There are two types of muscle contraction, isotonic and isometric.Isotonic contraction is further separated into concentric and eccentric contraction.

2.4.8.1 Isotonic contraction

During isotonic contraction, the muscle length changes whilst the tension that is produced in the muscle remains almost constant.In concentric isotonic contraction the muscle is able to shorten and pull on a structure as the tension created within the muscle is greater than the resistance of the structure in question. In eccentric isotonic contraction the muscle lengthens as the tension that develops in the muscle resists the load (Moore and Dalley, 2006; Tortora and Derrickson,2009).

2.4.8.2 Isometric contraction

Isometric contraction occurs when the resistance of an object is too great to be moved by the tension created in the muscle/s (Moore and Dalley, 2006; Tortora and Derrickson, 2009).

2.5 Myofascial pain syndrome (MPS)

Myofascial pain syndrome (MPS) is defined “as sensory, motor, and autonomic symptoms that are caused by myofascial trigger points (MFTPs)” (Lavelle *et al.,* 2007). Although the work of Travell, Simons and Simons is very well known, the importance of identifying pain as a result of myofascial dysfunction was really first pioneered by Travell and Rinzler in 1952 (Vernon and Schneider, 2009).‘Myofascial trigger point’ is a term coined by Travell and Simons (1983) after specific areas in muscles of affected participants were identified to have characteristic effects and locations.A MFTP, according to Travell *et al.,* (1999), is “a hyperirritable spot, usually within a taut band of skeletal muscle or in the muscle fascia which is painful on compression and can give rise to characteristic referred pain, motor dysfunction and autonomic phenomena” (1983 cited in Lavelle *et al.,* 2007; Tough and White, 2011).

There are four different types of MFTPs: primary, associated, secondary, and satellite MFTPs. A primary MFTP is a MFTP that has developed independently of the presence of MFTPs in the surrounding muscle in which it is found due to either active or chronic trauma of the affected muscle or overload of the affected muscle. An associated MFTP is a MFTP that has arisen as a result of the muscle compensating by increasing its mechanical output due to MFTPs that are present in another muscle. A secondary MFTP is a type of associated MFTP in that it also arises as a result of compensation by the muscle when MFTPs are present in a synergist or agonist muscle of the muscle in question. A satellite MFTP is also a type of secondary MFTP which is a MFTP that was latent but then became active because it was in the presence of the referral zone of MFTPs situated in other muscles (Travell*et al*., 1992).

The compression of MFTPs produces subjective pain in a zone of reference (Sola and Bonica, 1996; Lavelle *et al.,* 2007); in many instances this zone of reference is remote to the actual source of the pain (that is, the MFTP).This zone of reference rarely occurs in neuronal distributions; however, it always follows a consistent pattern for each MFTP in question (Hong and Simons, 1998; Long and Kephart, 1998; Travell *et al.*, 1999; Hong, 2006; Lavelle *et al.,* 2007).The minimum acceptable criteria recommended by Gerwin *et al.* (1997) and Simons *et al.* (1999) for the presence of an active trigger point diagnosis is a palpable taut band, an exquisite tender spot in the taut band, the patient’s ‘familiarity’ with the pain that is produced, and pain on stretching the tissue containing the MFTP (Fernandez-de-las-Penas *et al*., 2003). In their discussion on regional myofascial pain, Cummings and Baldry (2007) added the presence of a local twitch response in the muscle band when the muscle is stimulated using snapping palpation to the list of essential clinical features of MFTPs.

According to Alverez and Rockwell (2002), it is important to differentiate between MFTPs and tender points.MFTPs exhibit local tenderness, a taut band, a twitch response, a jump sign whilst tender points are only locally tender. Alvarez and Rockwell (2002) describe that a person may get a single or multiple MFTPs whilst there are multiple tender spots.MFTPs occur in any skeletal muscle, whereas tender points occur in very specific locations on both sides of the body, that is, right arm and left arm.MFTPs can cause a specific referred pain pattern, whereas tender points do not do this but can result in a total body increase in pain sensitivity (Alvarez and Rockwell, 2002).

2.5.1 Epidemiology of MPS

Simons (2002) states that MFTPs are common yet commonly undiagnosed or underdiagnosed and as a result inadequately treated and managed. This is particularly attributed to inadequate training of medical practitioners in terms of the identification and subsequent treatment and management of MTrPs.

Information regarding myofascial pain is gathered mostly from statistics reporting on musculoskeletal pain since MPS is categorized as a musculoskeletal condition (Srbely, 2010).In 2007 it was reported that musculoskeletal pain affects 85% of the population at some point; myofascial pain is considered to be a common cause of this musculoskeletal pain (Staud, 2007).Vernon and Schneider (2009) stated that MPS was considered to be the primary diagnosis among specialists in pain management, as well as the primary diagnosis of patients reporting pain to general practitioners.According to Tough and White (2011), MFTPs are widely accepted by clinicians as well as researchers as a primary source of regional musculoskeletal pain.

In elderly patients, the prevalence of MPS is closer to 85% (Podichetty *et al.*, 2003).A study conducted at a pain centre on 283 consecutive patients found that two physicians independently reported MPS as the primary diagnosis in 85% of cases in which patients had been admitted into a comprehensive pain centre (Cummings and Baldry, 2007; Yap, 2007).

2.5.2 Natural history of MPS

Although MFTPs can be treated successfully using a variety of treatment methods, Travell *et al*.(1999) indicate that MFTPs have a high incidence of recurrence if perpetuating factors are present in a patient or the patient's environment.These perpetuating factors have beengrouped into common factors such as mechanical stress (such as postural stresses,

structural inadequacies, constriction of muscles, etc.); nutritional inadequacies (thiamine, pyroxidine, cobalamin and folic acid, ascorbic acid, trace elements and mineral deficiencies); metabolic and endocrine inadequacies (gouty diathesis, hypometabolism, hypoglycaemia); psychological factors (depression, anxiety, tension); chronic infection and infestations (viral disease, bacterial infection, infestations); other factors (allergic rhinitis, impaired sleep, nerve impingement).In order to negate recurrence, it is important that the patient rest and avoid perpetuating factors.The findings of Hains *et al.* (2010) match the findings of Travell *et al*. (1999) Hains *et al.* (2010) investigatedchronic shoulder pain of myofascial origin.The reseasrchers found that avoidance of perpetuating factors and rest allowed MFTPs to revert to a latent state; however, when the muscle stress exceededthe muscle's tolerance state, reactivation of the MFTPs occurred, which could account for the history of recurrent pain episodes in the same areas over a period of time (Hains *et al.*, 2010).

Yap (2007) discussed additional precipitating and perpetuating factors such as trauma (macro- and micro-trauma) and degeneration. This researcher also indicated that chronic muscle imbalance could lead to myofascial pain.

Cummings and Baldry (2007) added muscle wasting, muscle ischaemia, pain referral from body organs, and climatic conditions to a list of factors resulting in the development of MFTP activity.

2.5.3 Etiology of MPS

There are a number of proposed histopathologic mechanisms that are said to cause MFTPs, yet scientific evidence supporting these mechanisms is lacking (Alvarez and Rockwell, 2002; Wong and Wong, 2012).No longitudinal studies have been undertaken to track MFTPs developing in response to their proposed causes (Tough and White, 2011). The fundamental pathophysiological abnormalities that are encountered with MFTPs appear to be at a location in the centre of a muscle in the area of the motor endplate zone (where the nerve branches meet the myofibrils) (Cummings and Baldry, 2007).

As noted in Chapter 1, the most accepted hypothesis is the integrated hypothesis which was first proposed by Travell *et al*.(1999).The reason for the general acceptance of this hypothesis is due to study results agreeing with it.Hubbard and Berkoff (1993) demonstrated spontaneous electrical activity (SEA) at areas of MFTPs; adjacent asymptomatic areas showed no similar activity. Ge *et al.* (2011) also studied the presence and effects of SEA in areas where MFTPs are present. Shah *et al.* (2008) performed biochemical tests on

participants' trapezius muscles,comparing the biochemical compositions of participants with active MFTPs to participants with latent MFTPs as well as participants with no MFTPs.The results of these tests showed that there wasan increased number of inflammatory mediators, neuropeptides, catecholamines, and cytokines in areas where active MFTPs were present.

This hypothesis suggests that there are a number of muscle fibres within a MFTP whose motor endplates release excessive amounts of the neurotransmitter, acetylcholine (Gerwin *et al.*, 2004; Dommerholt, 2010).As acetylcholine causes contraction of muscle fibres, there is associated histopathological evidence of regional sarcomere shortening (Dommerholt, 2010).As discussed in the physiology of muscle action above, muscle fibres need oxygen to maintain contraction.When muscle fibres are contracted, the capillaries cannot provide much blood to the contracting fibres as the blood vessels are compressed around the area of the contracting muscle fibres.This results in ischaemia of the muscle fibres.This ischaemia combined with the increased metabolic demand of the contracting muscle fibres could account for the severe local hypoxia in the area of a MFTP.Ischaemia and hypoxia of a muscle result in damage to the muscle.The damaged muscle results in a release of various substances such as ATP, bradykinin, 5-hydroxytryptamin, prostaglandins and potassium (Gerwin *et al.*, 2004).These substances account for the localized sensitivity and referred pain of MFTPs as they activate the nociceptors in the area of the MFTP.

It is generally agreed upon by researchers and practitioners that anything resulting in muscle overuse or direct trauma to a muscle could lead to MFTP development (Alvarez and Rockwell, 2002; Gerwin *et al.,* 2004; Dommerholt, 2010).Such factors can be classified as direct (including direct involvement of the affected muscles) and indirect (including factors that secondarily affect muscle such as nutritional factors, metabolic factors, etc.).Muscles that are put under repetitive stress due to occupational or recreational activities are in a position where they are chronically stressed which can lead to the development of MFTPs (Alvarez and Rockwell, 2002).

This study involved athletes, thus it is more pertinent to consider the factor of direct muscle overload causing MFTPs. Sustained or repetitive low-level muscle contractions, eccentric muscle contractions, and maximal or submaximal concentric muscle contractions are thought to be the cause of muscle overload (Dommerholt, 2010).Bron and Dommerholt (2012) expanded on this concept in a later study in which they found that due to these types of contractions requiring large amounts of ATP, the muscles initially utilize readily available ATP within the muscle but then move on to direct phosphorylation of ADP by creatine phosphate after 4-6 seconds of activity.These two mechanisms combined provide enough

energy for 14-16 seconds of contraction.In cases where the muscle is not allowed to rest, these two mechanisms of available ATP usage and aerobic production are exhausted.When the muscles are no able to continue these mechanisms, anaerobic cellular respiration increasingly takes over the production of ATP. The muscle will begin to run out of ATP, resulting in sustained sarcomere contractions – this begins the production of MFTPs.As discussed in Chapter 1, competitive swimmers train between 8km to 12km a day, training twice a day, five to seven days of the week, and as a result, their muscles are overloaded, and they are thus very prone to the development of MFTPs.

2.5.4 Findings as related to MFTPs in the various muscles

2.5.4.1 Sensory effects

MFTPs vary in their sensory effects, they can be spontaneously painful, however they can also be asymptomatic but painful only upon mechanical or metabolic stimulus (Gerwin *et al.*, 2004).Pain may also be localized to the site of the MFTP, or it may be referred elsewhere (Gerwin *et al.*, 2004).When the pain is referred elsewhere the term used for the area of tenderness is the 'reference zone.'There are different reference zones for different MFTPs.These zones are recorded in Myofascial Pain and Dysfunction: The Trigger Point Manual(Travell *et al.,*1999).In this manual, all the common MFTPs in muscles are discussed in terms of number and location.It was found that patients with the same MFTPs had consistent references zones. The reference zone rarely corresponds to dermatologic and neuronal distributions (Lavelle *et al.*, 2007). Pain is usually related to muscle activity (Alvarez and Rockwell, 2002), especially when a muscle containing an active MFTP is strongly contracted against resistance. Pain may, however, also be persistent regardless of activity (Alvarez and Rockwell, 2002). Pain increases when the affected muscle is passively or actively stretched. A phenomenon known as a jump sign occurs occasionally in response to mechanical stimulus of a MFTP, the patient winces or jumps away from the mechanical stimulus in response to pain (Baldry*et al*., 2001).

Pressure algometry has been studied and it has been found to be a reliable tool to assess MFTP sensitivity (Cummings and Baldry, 2007). In 2005, Vaghmaria demonstrated that pressure algometry showed a high inter-examiner reliability.

2.5.4.2 Palpatory effects

Myofascial trigger points are identified as a constant, discrete hardness within the affected muscle, and is usually a taut band or a nodularity that can be felt with the fingertips (Gerwin

et al., 2004). This band is constantly hard, thus it is assumed to be a number of muscle fibres within the muscle bulk that are contracted (Gerwin, 2005).

2.5.4.3 Motor effects

The taut band within the affected muscle has been found to contract sharply (termed a local twitch response) if it is stimulated physically by inserting a needle or by the use of snapping palpation with the fingers. There is also a decreased range of motion of affected muscles (Bron and Dommerholt, 2012). As shown above, the band of muscle identifying a MFTP is believed to be contracted muscle, as muscles containing MFTPs have increased tension and muscle stiffness (Dommerholt *et al.*, 2006a) which is thought to be a result of reciprocal inhibition. Reduced coordination may be reported by a patient (Cummings and Baldry, 2007). There is also reduced muscle strength of muscles containing MFTPs which is thought to be as a result of reflex inhibition of the affected muscle caused by the MFTP (Borg-Stein and Stein, 1996). This is of particular interest with regards to this study as reduced muscle strength would result in reduced performance of any activity involving the affected muscle/s.For example, MFTPs within a swimmer's shoulder musculature could decrease the swimmer's performance and an increased lap-time would result.

To summarize the motor effects: LMTPs and AMTPs both result in muscle stiffness, muscle dysfunction and restricted ROM of affected muscles, although LMTPs have these effects to a lesser degree than AMTPs (Shah *et al.,* 2015).

2.5.4.4 Autonomic effects

Autonomic effects include excessive coldness of an extremity, proprioceptive abnormalities, disequilibrium (Cummings and Baldry, 2007), vasoconstriction, vasodilation, lacrimation, as well as piloerection (Dommerholt *et al.*, 2006a).

2.5.5 MPS in athletes and the effect of MPS on muscle function as seen in literature

One of the primary reasons for the development of MFTPs is muscle overuse (Shah *et al.,* 2015). Competitive athletes are overusing their muscles on a daily basis because of the high intensity of training that they do and as a result it can be deduced that there will be a high incidence of MPS in competitive athletes.

Due to the effects discussed in the sections above, MPS will have a negative impact on competitive athletes, as they may train less or be afraid to do certain exercises and/or movements due to the sensory effects of MPS. They may experience a decrease in performance due to the motor effects of MPS as well.

According to Ma (2011), delayed onset muscle soreness (DOMS) (muscle soreness that occurs within 6-8 hours of strenuous exercise, lasting an average of 48 hours) due to overtraining and insufficient recovery between training and competing occur commonly in athletes. It also occurs in recreational athletes or non-athletes who have exposed their muscles to unaccustomed eccentric loading (Zondi*et al*., 2015). The aetiology and exact mechanisms of DOMS are not fully understood, but most studies comparing eccentric, concentric and static muscle loading note that DOMS is initiated by eccentric muscle loading (Zondi *et al.,* 2015). These factors (overtraining and not enough recovery time) make athletes more prone to injury, decreases (or impairs) sports performance and can ultimately result in a shorter athletic career. In the opinion of the author, dry needling when applied correctly is the most effective treatment discovered that helps athletes to recover from these effects, this being especially true for athletes who do not show any physical signs of pathology, but who are instead undergoing intense physiological stresses that can lead to future injuries and/or premature tissue degradation.

Though the effects of MPS are known in a broader sense, that is, the sensory, palpatory, motor and autonomic effects are applicable to people presenting with MPS, there is minimal information on the effects of MPS on specific individuals. For example, the effects of MPS on sport performance and career performance. A lot of what is discussed about MPS in these scenarios is purely from poor sources such ascase reports and anecdotal accounts, as not enough formal research has been done into these subjects.

Ma (2011) alluded to the fact that the full potential of dry needling in sports medicine has not yet been recognized.Three reasons for this problem were given: 1) practitioners do not understand the physiological mechanisms of dry needling, hence basing their practice on empirical evidence; 2) empirical evidence has a place in practice, but often the results that the practitioner observes are not as good as they could be; 3) only applying dry needling to MFTPs when dry needling can be applied to at least three other types of myofascial conditions that affect athletes (muscle tension, muscle spasm, and muscle deficiency).

Ma (2011) noted that by incorporating dry needling in practice, especially when treating athletes or patients who lead highly active lives, future potential for injury is reduced,

extending the career of athletes or the active individual. Ma (2011) also noted that many athletic careers have ended prematurely when this could have been prevented with regular treatment using dry needling.

One case report (Jayaseelan *et al.,* 2014) described the treatment of two patients who were runners. These patients presented with proximal hamstring tendinopathy. A combination of trigger point dry needling and prescribed patient-specific exercise consisting of eccentric loading of the hamstring muscles, as well as lumbopelvic stabilization exercises was given to each patient. The treatment protocol was applied over a period of 8 to 10 weeks in 8 to 9 consultations. The treatment protocol resulted in clinically significant improvements in pain, tenderness and function. Both patients returned to running following the treatment protocol.

A study by Grieve e*t al.* (2013) investigated the treatment of triceps surae dysfunction with the use of MFTP. The study sample was made up of 10 participants who presented with triceps surae dysfunction and who had a high prevalence of AMTPs and LMTPs. The effects of the dysfunction were recorded before and after the treatment regime by using a Lower Extremity Functional Scale (LEFS), NRS, recording MFTP prevalence, ankle dorsiflexion ROM, and pressure pain threshold (PPT). The interventions applied were trigger point pressure release, self MFTP release and a home stretching programme. Upon discharge, all AMTPs had decreased to 0%, LMTPs were still present, and there were positive outcomes for the remainder of the measurements. When assessing the short term to medium term (6 weeks after discharge) treatment outcomes, it was found that there was an overall mean LEFS increase of 11 points – upon presentation the mean LEFS score was 61/80, and upon discharge it had risen to 72/80.

2.5.6 Identification and diagnosis of a MFTP

Patient history is always important in aiding diagnosis. The patient is likely to complain about pain, particularly if an active MFTP is present.*Pain* is typically described as a deep aching which is poorly localized; in some cases, pain can be pin-pointed if the muscle with the MFTP is easily accessible to the patient (Cummings and Baldry, 2007). Pain is usually exacerbated by muscle activity (Alvarez and Rockwell, 2002) but may be relieved if light exercise combined with stretching is performed (Cummings and Baldry, 2007). A patient may also complain of *dysfunction* in the form of the autonomic and/or motor effects described in the previous section. The patient may struggle to *sleep* due to pain and sleeping position may aggravate the MFTP (Cummings and Baldry, 2007) as affected muscles are either stretched or shortened for prolonged periods of time. Taking into account

the *age* and *sex* of the patient may also aid the diagnosis (Cummings and Baldry, 2007);although MFTPs can affect a person at any age, they are common in middle-age and MFTPs are a more common complaint amongst women.According to Cummings and Baldry (2007) active MFTPs are encountered more commonly in middle-aged people and latent MFTPs are encountered more commonly in the elderly.

Palpation is the most widely accepted method used to diagnose MFTPs. There are different techniques of palpation, namely flat palpation (the thumb and fingers are extended and pressed over the muscle); pincer palpation (the thumb and fingers are flexed forming a pincer shape and the muscle bulk is squeezed between the thumb and fingers); fingertip palpation (fingertips apply transverse pressure to muscle fibres); and overlying hand palpation (this is used for deep muscles as one hand applies pressure whilst the underlying hand palpates the deep muscles) (Yap, 2007).

There have been a number of studies conducted evaluating the efficacy of palpation as a diagnostic tool.It has been found that the presence of the taut band, spot tenderness, and pain recognition was noted as highly reliable between sessions and examiners, whereas with regards to the findings of referred pain and local twitch responses in subjects, reliability varied depending on the muscle being studied, but was unique to each muscle in its presentation (Al-Shenqiti and Oldham, 2005 and Bron *et al.,* 2007).The presence of a taut band and a tender point within the taut band are minimum criteria that are used to differentiate between a MFTP and another tender area (Dommerholt *et al.*, 2006a). Criteria used to diagnose a MFTP for the purpose of this study is discussed at length in Chapter 3.

2.5.7 Presentation of MTPFs in the muscles related to this study

As stated previously, Travell *et al.* (1999) published the book Myofascial Pain and Dysfunction: The Trigger Point Manual where they discussed findings with regards to MFTP location, causes, symptoms, referred pain patterns and treatment methods. These two books are very thorough in the description of MFTPs. Below is a summary of the MFTP locations and referred pain patterns of the muscles in question for the purpose of this study found in Volume 1 of The Trigger Point Manual.

2.5.7.1 Presentation of MFTPs in the supraspinatus muscle

There are two areas where MFTPs have commonly been found in the supraspinatus muscle.

MFTP1 of the supraspinatus is situated in the area of the muscle between the origin and the acromioclavicular joint. It refers pain over the area of the supraspinatus muscle and down the later aspect of the arm and forearm with areas of intensity around the lateral aspect of shoulder and the elbow.

MFTP2 is located laterally near the attachment of the tendon to the greater tubercle of the humerus. It refers pain to the lateral aspect of the shoulder.

2.5.7.2 Presentation of MFTPs in the infraspinatus muscle

There are four areas where MFTPs are commonly found in the infraspinatus muscle.

MFTP1, 2 and 3 are situated in the superior part of the muscle beneath the spine of the scapula and also in the muscle in line with the centre of the infraspinous fossa of the scapula. They refer pain to the anterolateral and posterolateral parts of the shoulder, arm, forearm and hand. The referred pain is concentrated around the lateral and anterior aspects of the shoulder into the anterior arm. Pain is also referred to the posterior aspect of the upper neck on the same side as the affected muscle.

MFTP4 is located in the mid-line along the medial/vertebral border of the scapula. It refers pain in the interscapular region medial to the medial/vertebral border of the scapula.

2.5.7.3 Presentation of MFTPs in the trapezius muscle

The trapezius has seven common trigger point locations.

MFTP1 of the trapezius is located in the superoanterior aspect of the trapezius above the clavicle.This MFTP refers pain up the side of the neck and head with zones of intensity posterior to the orbit and at the temple. It may also refer pain to the angle of the jaw.

MFTP2 is located inferolateral to MFTP1 in the centre of the fibres as they become more horizontally oriented. It refers pain down the neck posterior to the referred pain pattern of MFTP1.

MFTP3 is located near the inferior border of the muscle in the mid-section of the muscle; it refers severe pain to the upper cervical region of the paraspinal muscles, to the adjacent mastoid and also to the acromion of the scapula. It is also responsible for occasionally causing a deep aching pain and tenderness in the suprascapular region.

MFTP4 is located medially below the spine of the scapula. It causes a steady burning sensation downward along the vertebral border of the scapula.

MFTP5 is situated anywhere in the mid-fibre region of the muscle fibres making up the middle section of the trapezius. The referred pain is mostly described as a superficial burning sensation between the MFTP and the C7 and T3 spinous processes.

MFTP6 is situated laterally near the acromion of the scapula, it refers an aching pain to the apex of the shoulder or the acromion of the scapula.

MFTP7 is described as more of a skin trigger point than a MFTP, it causes more of an autonomic response than a motor response. It can be situated in the area between MFTP6 and the spine.It causes a shivery sensation and pilomotor erection along the lateral part of the arm and thigh on the same side as the affected muscle.

2.5.7.4 Presentation of MFTPs in the latissimus dorsi muscle

The latissimus dorsi muscle has two areas where MFTPs are found.

MFTP1 is situated in the area of the posterior axillary fold. Pain is referred from this MFTP to the inferior angle of the scapula on the same side as the affected muscle and the midthoracic region on the same side. It spreads over the scapula and down the medial aspect of the arm, forearm and hand.

MFTP2 is situated along the lateral aspect of the lower ribs. It is not as common as MFTP1. It refers pain below the ribcage over the lateral aspect of the trunk on the same side as the affected muscle. It also refers pain to the anterolateral aspect of the shoulder on the same side.

2.5.8 Trigger point dry needling

MFTPs are treated in various ways.These methods include MFTP injection which involves the injection of an analgesic substance into the MFTP (Travell *et al.,* 1999); spray and stretch which incorporates stretching the affected muscle and spraying a cooling substance onto the skin covering the affected muscle (Travell *et al.,* 1999); ultrasound which uses ultrasound waves that penetrate the skin and stimulate the MFTP causing increased blood flow to the affected area (Travell *et al.,* 1999); massage which involves massaging the

muscle and particularly the MFTP to stretch muscle fibres and increase blood flow (Travell *et al.,* 1999); ischaemic compression in which the clinician uses either their thumb or some other firm object to compress the MFTP causing reduced blood flow which results in a reciprocal increase in blood flow to the area in question upon removal of the object compressing the MFTP (Travell *et al.,* 1999); medication such as NSAIDs, COX-2 inhibitors, muscle relaxants and topical analgesics (Travell *et al.,* 1999). Another treatment method that is used is trigger point dry needling. (Travell *et al.,* 1999; Srbely, 2010; Bron *et al.,* 2011). This will be discussed in depth now as this was the treatment method incorporated for this particular study.

Dry needling involves the insertion of needles into MFTPs. It is termed dryneedling as it does not involve the injection of substances into the soft tissue. The needle is inserted parallel to the direction of the muscle fibres of the muscle containing the MFTP. Although Travell first promoted lidocaine injection into MFTPs, it has been found in various needling therapy studies that merely inserting a needle into a MFTP site produced the same effect as injecting substances such as local anaesthetic, botulinum toxin or corticosteroids (Tough and White, 2011).Thus it can be concluded that it is the mechanical stimulus of the MFTP by the needle that relieves the MFTP rather than the injected medication (Tough and White, 2011).

Dry needling is commonly used by physiotherapists and chiropractors.It was found that of the approximate 9000 physiotherapists in South Africa, an estimated 75% of these physical therapists use dry needling at least once daily (Dommerholt *et al.*, 2006b). Though there are a lot of different treatment methods, dry needling is one of the most cost effective and simple ways to effectively treat MFTPs, hence its popularity in private practice. In South Africa currently, it is also not within the chiropractic scope of practiceto inject substances and so chiropractors do not inject MFTPs(Allied Health Professions Council of South Africa [Act 63 of 1982 as amended]). It is also not within their scope of practice to prescribe schedule 3+ medications(Allied Health Professions Council of South Africa [Act 63 of 1982 as amended]).

Though dry needling involves the use of acupuncture needles, it must not be confused with acupuncture as MFTPs can occur in any muscle, whereas acupuncture points correspond to fixed locations (meridian pathways) on the surface of the skin (Han and Harrison, 1997). Dry needling also involves deeper needle insertion as the needles are inserted into muscle, whereas acupuncture involves the insertion of needles into the skin and subcutaneous tissue.

Dry needling is highly effective a treating acute and chronic soft tissue damage, it is also effective in the prevention of chronic injuries resulting from repetitive overuse of the muscles commonly experienced in athletes (Ma, 2011).

Dry needling often results in a phenomenon called 'needle effect' which is the immediate analgesia of an area containing a MFTP upon insertion of an acupuncture needle (Han and Harrison, 1997). Elimination of pain relies on the therapist's ability to accurately identify and insert the needle into the most tender area within a taut band (Han and Harrison, 1997). The mechanismfor the effect of dry needling is poorly understood though direct correlation between dry needling and relief of symptoms has been found (Gerwin, 2005; Hong, 2006). Stimulating a local twitch response when dry needling has been linked to the efficacy of the dry needling of a patient (Cummings and Baldry, 2007), that is, when a local twitch response is elicited by the insertion of the needle, the immediate elimination of pain is more likely.

2.6 Summary and Conclusions

Competitive athletes are required to train in their specific sport every day. With regards tocompetitive swimmers in Kwa-Zulu Natal, it was found in a study conducted by Puckree and Thomas in 2006 that 96% of competitive swimmers trained 11-12 months of each year. The majority of swimmers had an average of 11 training sessions of 90 minutes per session per week.

It is well known that the glenohumeral joint sacrifices stability to gain mobility (Cailliet, 1991; Cailliet, 1996). This requires a great amount of strength of the dynamic stabilizers in order to prevent injury (Cailliet, 1991; Cailliet, 1996). Since swimming requires repetitive motion of this joint, it has a high incidence of overuse injuries (Pollard and Croker, 1999). Overuse and the resulting fatigue of muscles predisposes them to the development of myofascial trigger points (Alvarez and Rockwell, 2002; Huguenin, 2004; Gerwin, 2005).

These myofascial trigger points cause symptomatic pain when active; but even when they are asymptomatic (hence latent), they have still been shown to decrease the amount of contractile power in the muscle/s in which they are located, though to a lesser degree than active myofascial trigger points (Alvarez and Rockwell, 2002; Lucas, 2008; Ge *et al.,* 2011).
There is a paucity of literature regarding the effects of MFTP deactivation on performance in sports.It stands to reason that MFTP (active or latent) deactivation would negate the central inhibition of muscles and ultimately restore the strength the muscle had before the MFTP

develop (Lucas, 2008). Deactivation of MFTPs may therefore result in an improvement of performance time of the swimmer as well (Gerwin, 2005).

Chapter 3 : Materials and methods

3.1 Research design

The design of this study was a pre-test post-test quasi-experimental study conducted on competitive swimmers in which pre-intervention 100m lap times were compared to post-intervention times. The intervention used in this study was trigger point dry needling on selected muscles of the shoulder girdle.

A control group was not used in this study because the participants were viewed as their own individual control. This was because each participant's post-intervention lap time was compared to his/her pre-intervention lap time. Upon completing the study, however, the implications of having a separate control group came to light and as such, this was added as a limitation and a future recommendation.

Participants of the study were recruited through the researcher approaching swimming coaches at various clubs in the Bloemfontein area. The study was explained to coaches who then suggested individuals who they thought met the age and competitive criteria of the study. To ensure whether potential participants met the inclusion criteria of the study (and ultimately be included in the study), they were asked a set of standardized questions (Appendix N) either face-to-face or telephonically. In so doing, homogeneity of the group of participants was ensured.

Once accepted into the study, each participant was assessed at the chosen off-site venue (University of the Free State swimming pool as well as the Saint Andrews School swimming pool). The researcher then performed all tests and documentation required to open a file for each participant at the Durban University of Technology (DUT) Chiropractic Day Clinic.Thereafter, specific assessments and measurements for the purpose of the study were taken and recorded. This data collection occurred on-site.

The data collection only involved objective measurements since participants were required to be asymptomatic.These two measurements were a Myofascial Diagnostic Scale reading (Appendix J) and a stopwatch measurement of each participant's time taken to complete each lap.

3.2 Permission for off-site venue use

Permission was sought from the relevant parties in order to make use of the off-site venues (Appendix I). The Saint Andrews School swimming pool and the University of the Free State swimming pool were used with the permission of the respective swimming coaches (Appendix I1 and Appendix I2).

3.3 Off-site supervisor

The off-site supervisor, Dr M. Roodt (MTech: Chiropractic), signed an agreement form by which she agreed to supervise the data collection process (Appendix M). The role of the off-site supervisor was supervision in terms of the legal aspects of the research process (Dr Roodt did not assess the participants herself) as well as monitoring the research process and giving feedback in terms ofresearch progress, the conduct of the researcher and so on to the research supervisors; hence bias was not introduced. This is a requirement of the Allied Health Professions Council of South Africa (Act 63 of 1982 as amended).

The roles of the off-site supervisor were:

- To be present at each consultation with the participants at all times
- To watch the researcher using the stopwatch to ensure that timing is being done accurately
- To watch the researcher writing down the stopwatch times
- To watch over the dry needling of the participants

3.4 Participant recruitment

Purposive sampling was used as potential participants were identified by the researcher after approaching swimming coaches and explaining the study to them. The coaches then singled out individuals that swam with them that met the age and competitive criteria of the study.

3.5 Telephonic/face-to-face interview

Potential participants who were interested in being part of the study were each asked the set of questions listed in Appendix N upon approaching or contacting the researcher. If the required answers to each question were given (as per the right-hand column), the potential participant was accepted into the study. If any of the answers did not match the required answer, the potential participant was thanked and excluded from the study.

3.6 Sample

3.6.1 Sample size

The sample size as per an *a prioiri* analysis, which allowed a high likelihood of statistically significant outcomes to this study was given as 35. In order to calculate this, a mean change of 0.4 seconds was used to determine whether there had been a statistically significant change in time. In other words, participants achieving a change of 0.4 seconds or more (whether it be an increase or decrease of 0.4 seconds) would have demonstrated a statistically significant change in time.

3.6.2 Sample allocation/method

Two selective sampling methods were used: purposive and snowball methods, whereby swimming coaches were approached and participants were also asked to tell other participants they knew about the study.

An advertisement was approved (Appendix H). However, this was not used as the coaches recruited the necessary number of participants.

3.6.3 Sampling characteristics

3.6.3.1 Inclusion criteria

I. Participants aged between 16 and 30 years old. This age range was selected as a number of studies have investigated the effects of age and peak performance in sports. Swimmers tend to perform best when they are 20 years of age (Ericsson, 1990). A study by Letzelter *et al.* in 1986 showed a linear decrease in performance (lap times were slower) with increasing age of swimmers (Ericsson, 1990). The study compared the best times in swimming events for different age groups starting at 25 years of age and increasing age with increments of 5 years (Ericsson, 1990).Another study (Allen*et al.,*2014) investigated the relationship between competitive swimmers' best performances of their careers and their age at the time. This study was performed so that projections could be made in order to enable Olympic swimmers to reach these benchmark figure projections (Allen*et al.,*2014). This was accomplished by assessing the annual best times of swimmers in the top 16 in pool events at the 2008 and 2012 Olympic Games, the times recorded at the Olympic Games were compared to each swimmer's earliest

recorded swimming event time until 2012 (Allen*et al.,*2014). In total, there were 6959 times that were assessed from 683 swimmers (Allen*et al.,*2014). The study found that women reached peak performance at 22.5 ± 2.4 years (mean ± SD) and men reached peak performance at 24.2 ± 2.1 years (mean ± SD) (Allen*et al.,*2014).Professional sporting careers are also relatively short compared to most other careers as the majority of athletes will retire in their mid to late 20's (Hatamleh, 2013).

II. Potential participants provided the required answers during the telephonic interview (Appendix N) and the physical examination criteria as per Table 3.1.

III. Potential participants were required to reside in the Bloemfontein area as defined by the telephone code 051.

IV. Participants were required to compete in swimming events, defined as participants having competed in any of the following events during the course of the year prior to participation in the study (Moreira *et al.,* 2011; Riemann *et al.,* 2011):

   i. A minimum of three minor qualifying events (these include age group galas) and/or
   ii. Provincial galas (or any other equivalent event) and/or
   iii. One national event or one international event, and/or a combination of the above
   iv. Participants were required to swim four hours or more per week all year round or average over four hours per week if seasonal swimmers (Moreira *et al.,* 2011; Riemann *et al.,* 2011).

V. Participants were required to be asymptomatic but have latent myofascial trigger points (that is, they had no spontaneous pain) which the researcher identified and scored with the aid of the myofascial diagnostic scale (MDS). With regards to the MDS, participants who scored under 9 for a MFTP were classified as a LMFTP and those who scoredover 9 and over were classified as AMFTP and this would result in symptoms. Criteria to identify the presence of myofascial trigger points are discussed inTable 3.1.These criteriaare used to define what an "asymptomatic participant" is for the purpose of this study – that is, the participant needs to be asymptomatic in terms of unsolicited shoulder pain.Participants required to meet all of the criteria specified by Travell *et al.* (1999) and/or the criteria in the Myofascial Diagnostic Scale developed by Chettiar (2001) (Appendix J).Points eliciting a score of >9/17 on the Myofascial Diagnostic Scale was classified as AMFTPs, and points eliciting a score of 5 or > but <9/17 was classified as LMFTPs.

Table 3.1: Findings indicating the presence of MPS

Essential criteria (minimum required)
Palpation of a taut band within the muscle being tested (if muscle accessible).
A nodule within a taut band that exhibits an exquisite spot tenderness upon palpation.
Weakness of the muscle being tested when compared bilaterally (if there is unilateral involvement).
Limitation of full stretch range of motion accompanied by pain.
Confirmatory observations (confirmatory findings)
A local twitch response within the muscle identified visually or through tactile palpation.
Participant experiences pain or altered sensation (in the distribution expected from a trigger point in that muscle) upon manual compression of a tender nodule.

Source: Adapted from Travell *et al*. (1999).

3.6.3.2 Exclusion criteria

I. Anyone who had surgery to the upper extremities and/or neck (Chaitow and DeLany, 2000;Chaitow and DeLany, 2003; Kendall and Kendall, 2005).
II. Anyone who had macro-trauma to the upper extremities and/or neck (Chaitow and DeLany, 2000; Chaitow and DeLany, 2003).
III. Any potential participant who had a needle phobia or those prone to convulsions e.g. epilepsy participants (Travell *et al.,* 1999; Alvarez and Rockwell, 2002; Chaitow and DeLany, 2003).
IV. If pain was produced during the researcher's examination of the participant which was not related to MFTPs (Travell *et al.,* 1999; Chaitow and DeLany, 2003).
V. Participants with any concomitant shoulder pathologies such as shoulder impingement syndrome, adhesive capsulitis, bicipital tendonitis, glenohumeral instability, ligamentous laxity; rotator cuff injuries.
VI. Anyone who did not willingly sign the Letter of Information and Informed Consent (Appendix A if aged 18 years old and above; Appendices B and C if aged less than 18 years old).
VII. Anyone with contra-indications to dry needling (for example bleeding disorders) (Travell *et al*., 1999).

3.7 Procedure

Upon answering the interview questions (Appendix N) with the required answers, the participants were asked to read and sign consent forms (Appendix A, if 18 years old and above; Appendices B and C, if less than 18 years old).

The research was explained to all participants. If the participant agreed with the time-frame and outline of the research being conducted, they were required to read and sign a Letter of Information and Consent (Appendix A).

In the case of participants aged less than 18 years old, their guardian or parent/s had to agree to the study requirements and were required to read and sign a Parental Consent clause which was included in the Letter of Information and Consent (Appendix B). The underage participant was also required to sign a Letter of Assent (Appendix C). The Letter of Information and Consent (Appendix B) for underage participants was written in age-appropriate language to ensure that the underage participants understood the study to the same degree as their guardian/s. If the participant or guardian or parent/s disagreed, the participant was excluded from the study. If they agreed and signed the Letter of Information and Consent, they were included into the study. Each participant was required to fill in and sign a Patient Information Sheet (Appendix O).

The researcher then screened the participant by recording their case history (Appendix D), and undertaking general physical (Appendix E) and orthopaedic (shoulder [Appendix F]) examinations to ensure that they met all the required inclusion criteria.

These examinations were undertaken in the change rooms at the off-site venues to offer the participants privacy during their assessment and intervention. A physical examination was conductedin order to ensure the participants did not meet any exclusion criteria (for example,systemic disease that may cause trigger points).

Participants were screened during the initial examination for any contra-indications to treatment with dry needling (for example, fever, anticoagulation or bleeding disorders) (Han and Harrison, 1997; Travell *et al.,* 1999; Alvarez and Rockwell, 2002; Boon, 2006).

A SOAPE (Subjective, Objective, Assessment, Plan, Education) note was completed for each participant (Appendix G).

3.8 Measurements

3.8.1 Myofascial Diagnostic Rating Scale (MDS) (Chettiar 2001)

This scale (Appendix) is used to assess the degree to which patients suffer from myofascial pain syndrome (MPS). The scale is used along with criteria according to Travell *et al.*'s(1999) diagnostic criteria listed in Table 3.1 above. The scale divides any palpated trigger points into active or latent.Its rating is based on the clinician/researcher's findings from palpation of the patient/participant's muscles. This tool was developed by Chettiar (2001) and underwent testing by a focus group to determine its face validity – it was found that the scale was a valid measurement device. The MDS has been found to be a reliable and valid method used for the diagnosis of MPS (Vaghmaria, 2005).The scale is made up of four numerical grades/indicators. It has been found to be an effective assessment tool as it was positively correlated to the Numerical Pain Rating Scale (Vaghmaria, 2005) in other words, the objective finding of the clinician (using the MDS) correlated very highly with the subjective experience of pain (measured with the Numerical Pain Rating Scale). A score of greater than or equal to nine on the MDS is needed to make a diagnosis of MPS (Vaghmaria, 2005).

The scale has only been tested in two studies thus far (Chettiar, 2001 and Vaghmaria, 2005). It was used in this study only to serve as a way to quantify the MFTPs objectively since participants were asymptomatic. Though participants had scores over 9 out of 17, their MFTPs were classified as latent because none of the participants had any pain complaints. When assessed, however, a rating over 9 was given as an average of all the MFTPs assessed in each individual. This scale needs to undergo further testing in future studies as the differentiation between active and latent MFTPs does not seem reliable. What also needs to be taken in to account is that these athletes undergo intense training, followed up with an insufficient rest period (Ma, 2011), the combination of these factors is probably the cause of the higher MDS rating for LMFTPs because these factors lower the pain threshold.

3.8.2 Lap time to within hundredths of a second [Appendix K]

Stopwatch equipment was used to record participant lap times before and after the intervention. The stopwatch used was a Sportline Econosport Stopwatch, which is water- and shock-resistant, timing with 1/100th second accuracy.This stopwatch times single events, time-out competitions, cumulative splits and 1-2 fast finishes. It features a water-resistant design and has time of day and alarm functionality. Although human error is a concern with stopwatches, touchpads were unavailable for this study.

Hetzler *et al.* (2008) compared handheld stopwatches to electronic timing devices (single-split timers and multiple split-timers) to determine the accuracy and reliability of these methods of timing sprint performance. They found that no significant differences occurred between the three methods of timing (p>0.99) and intraclass correlation values that were calculated were high. The researchers made the conclusion that on the basis of the small mean error and the high intraclass correlations, the use of handheld stopwatches may be a viable alternative to electronic timing equipment.

3.9 Treatments / Interventions

Once the participant passed all the inclusion criteria, he or she was permitted to take part in the study. The following steps were followed:

i. The participant warmed-up according to his/her normal warm-up procedure.
ii. Since this study was a follow on to Kinsman's (2014) study the researcher assessed the bilateral muscles that proved to be problematic (infraspinatus, supraspinatus, trapezius and latissimus dorsi muscles [Kinsman, 2014]).
iii. Any trigger points found in these muscles were described using the Myofascial Diagnostic Rating scale (Appendix J) and recorded on the data sheet.
iv. The participant was required to swim three separate 100m laps in the freestyle stroke, in a 50m length swimming pool. It was requested that each participant sprint each lap.Each participant rested between each 100m sprint. The rest period averaged 1 minute between each sprint.
v. While the participant was swimming, his/her times for each 100m lap were recorded using a stopwatch (Appendix K).
vi. An average time of the three pre-intervention laps were calculated (Appendix K).
vii. If more than one MFTP existed in a muscle, the one that produced the most pain on palpation for the participant (that is the primary MFTP) was treated using dry needling. This method of treatment was applied bilaterally (that is, in the case of the same MFTP existing bilaterally in the same muscle/s, these were both treated).
viii. The researcher performed dry needling by inserting acupuncture needles into the MFTP/s. The needles were left in the muscle/s until reactive hyperaemia (reddening of the surface of the skin around the needle) was observed. The average time taken between the pre- and post-intervention readings was 30 minutes. This time varied depending on how many MFTPs were found and needled. The needles used were 0.25mm x 40mm in measurement.Aseptic techniques were used, that is, alcohol swabs were used to clean the area that was treated and once treatment was

completed, the region was cleaned again with a new alcohol swab. The single application needles were disposed of in a sharps bin and incinerated at a later stage.

ix. The participant's trigger points were reassessed to determine whether the intervention was successful, that is, whether the taut, palpable band/s of muscle/swere removed (Hong, 2006; Lavelle *et al.,* 2007). In the event that the intervention was unsuccessful (i.e. the dry needling did not achieve its intended outcome), the participant was excluded from the study.

x. The participant was required to swim another three 100m laps in the freestyle stroke and the times for lap completion was recorded once again (Appendix K).

xi. An average of the three post-intervention laps was calculated (Appendix K) and recorded.

3.10 Statistical analysis

IBM SPSS version 23 was used to analyse the data. A *p* value <0.05 was considered as statistically significant. The data was significantly skewed and thus non-parametric statistics were used to describe and compare the times. Times were described using median and interquartile range, and compared using a paired Wilcoxon signed rank test (Esterhuizen, 2015).

The data format for the lap times was: 0.0.00.00, the first zero represents hours, the second zero represents minutes, the third zeroes represent seconds and the fourth zeroes represent hundredths of a second. This data is presented in Appendices P1 and P2 on pages 112 and 113.

3.11 Ethical considerations

3.11.1 Non-maleficence

All participants were free to withdraw from the study without implications for future care at the Chiropractic Day Clinic.

Needling may result in post needle soreness and/or transient pain one or two days after treatment (Travell *et al.,*1999). The effects of dry needling were explained to the participants, as well as ways in which these effects may be minimised.

3.11.2 Beneficence

Participants received no compensation for their participation in the study. As the participants were dry needled, they would feel relief if they felt muscle stiffness.

3.11.3 Justice

Since the study was being conducted off-site, an off-site supervisor was appointed to supervise the researcher (Appendix M). This is a requirement of the Allied Health Professions Council of South Africa (Act 63 of 1982 as amended).

There was no discrimination towards potential participants and participants of the study.

All participant information gathered during the course of this study was kept confidential. All participants had a research file opened for them at the off-site facility. This information was then transferred into the Chiropractic Day Clinic (CDC) participant system via email so that the supervisors were able to track the progress of the researcher. The original files were stored at a private practice in a facility that had 24-hour security. Upon completing data collection, the original files were couriered to the CDC.

All data was kept in the respective participant's file and will be stored in the CDC until medical law requires (after five years of storage) the file to be destroyed. This ensured participant confidentiality.

Participants did not receive any feedback regarding their lap times during the data collection period, and their results were not shared with other participants and/or coaches.

3.11.4 Autonomy

The participants were asked to complete Letters of Information and Consent prior to the start of the study.

For participants under 18 years of age, a parent or legal guardian signed a consent letter (Appendix B). The minor participant also had to sign a Letter of Assent (Appendix C) before the study could continue.

3.11.5 Veracity

The requirements of the participants, as well as the data collection process were explained to each participant prior to them agreeingto take part in the study.

All the data that was collected was truthfully and accurately recorded under the supervision of the appointed clinical supervisor.

Chapter 4 : Results and Discussion

4.1 Data sources

The primary data that was used for this study was obtained from:

- Telephonic/face-to-face interview questions (Appendix N)
- Case history and physical examination (in order to confirm that each participant was asymptomatic) (Appendices D and E)
- Shoulder regional examination (Appendix F)
- Myofascial diagnostic scale (Appendix J)
- The pre- and post-intervention lap times of the participants (Appendix K)

The secondary data that was used was obtained from journals, books, websites, dissertations, theses, letters to editors, communication with researchers, statisticians, and other sources that are involved in the context of this study.

4.2 CONSORT diagram (Moher *et al.,* 2001)

A CONSORT diagram is used to assess and reveal any biases that may have occurred with regards to the inclusion of study participants (Mouton 2002; Mouton, 2006). This is accomplished by reviewing the number of participants that were included, excluded, omitted from the results and that withdrew from participating in the study (Moher *et al.*, 2001). This information is presented in a CONSORT diagram. The CONSORT diagram for this study is seen below in Figure 4.1.

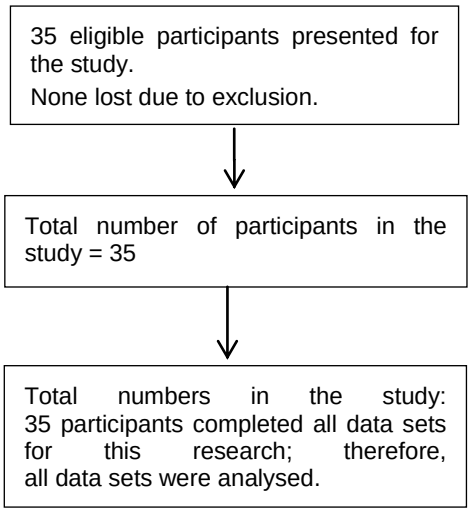

Figure 4.1: CONSORT diagram
Source: Aadapted from Moher *et al.* (2001).

All of the potential participants that were approached were included in the study. This is because each coach was approached beforehand and the study was discussed with them. The coach then provided a list of potential participants who met the study criteria and so none of the potential participants were excluded from the study as the lists provided made it highly likely that each potential participant could be included into the study. Due to their high intensity of training, all potential participants also presented with at least one LMFTP. None of the participants presented with AMFTPs in terms of a spontaneous pain complaint. This is possibly due to the coaches excluding participants who had injuries or who were undergoing treatment for a current complaint and who were hence taking a break from swimming.

As this study was a one appointment visit, assessment study with concurrent clinical intervention, there were no drop outs in the study. Also to be noted, no participants withdrew from the study during the duration of the assessment and none were foundto require exclusion on review of their data when data capture occurred.

4.3 Results and discussion

This study only assessed the pre- and post-intervention lap times, so statistical analysis was not performed on other details such as the number and type of MFTPs that were found, as well as the ratio of MFTPs found in the gender types. The caliber of the participants was also not taken into account when assessing the data.

Although analysis was not done on the above information, upon looking at participant files, information can be supplied regarding the gender and ages of the participants so that the reader can have an idea of the demographical data of the study sample.

Table 4.1: Demographic data of study participants

Participant number	Gender	Age in years
1.	Male	16
2.	Male	16
3.	Male	16
4.	Male	16
5.	Male	20
6.	Male	19
7.	Male	19
8.	Male	18
9.	Male	16
10.	Male	17
11.	Male	22
12.	Male	26
13.	Male	17
14.	Male	16
15.	Male	19
16.	Female	23
17.	Female	17
18.	Female	21
19.	Female	23
20.	Female	19
21.	Female	18
22.	Female	17
23.	Female	22
24.	Female	16
25.	Female	16
26.	Female	18
27.	Female	16
28.	Female	24
29.	Female	18
30.	Female	18
31.	Female	17
32.	Female	21
33.	Female	16
34.	Female	17
35.	Female	24

Table 4.1 above shows that more female participants were seen than male participants. Fifteen of the 35 participants were male (43% of the sample). Twenty of the 35 participants were female (57% of the sample). The mean age of the participants was 18.5 years old with the mean age of the female participants being 19 years old, and the mean age of the male participants being 18 years old.

Table 4.2 and Table 4.3 show the MFTPs and MDS scores of the right and left shoulder respectively. Of all the locations assessed, TP2 of the trapezius muscle was the most common area to present with LMFTPs in the right and left shoulders; 19 participants presented with LMFTPs of TP2 in the trapezius muscle on the right, and 18 participants presented with LMFTPs of TP2 in the trapezius muscle on the left. TP2 of the infraspinatus muscle was the second most common area to be affected and 13 participants presented with a LMFTP of TP2 of the infraspinatus muscle on the right, and 10 presented with a LMFTP of TP2 of the infraspinatus muscle on the left. The third most common areas to be affected were TP2 of the supraspinatus muscle on the right (5 participants presented with this LMFTP), TP7 of the trapezius muscle on the right (5 participants presented with this LMFTP) and TP3 of the infraspinatus muscle on the right (5 participants presented with this LMFTP).

Table 4.2: Right shoulder MFTPs and MDS score

Right Shoulder Participant	MFTPs in muscles below															MDS Rating
	Trapezius							Supraspinatus		Infraspinatus				Latissimus dorsi		
	1	2	3	4	5	6	7	1	2	1	2	3	4	1	2	
1		×														10/17
2											×					11/17
3		×														11/17
4												×				10/17
5		×														11/17
6		×									×					10/17
7		×														11/17
8		×										×				11/17
9		×									×					10/17
10									×							11/17
11*																11/17
12												×				11/17
13											×				×	11/17
14		×										×				11/17
15												×				11/17
16							×									10/17
17		×					×				×					11/17
18											×					11/17
19		×														11/17
20									×							11/17
21		×									×					11/17
22									×							11/17
23											×					10/17
24		×									×					11/17
25						×			×							11/17
26		×				×					×					12/17
27							×				×					11/17
28		×														12/17
29		×									×					11/17
30		×									×					10/17
31									×		×					10/17
32		×														11/17
33		×					×									10/17
34		×					×									11/17
35*																11/17

Key: participant number* indicates that there will be no data in the table for this participant as there were no MFTPs found in the right shoulder girdle.
'x' indicates the presence of a MFTP

Table 4.3: Left shoulder MFTPs and MDS score

Left Shoulder Participant	MFTP in muscles below															MDS Rating
	Trapezius							Supraspinatus		Infraspinatus				Latissimus dorsi		
	1	2	3	4	5	6	7	1	2	1	2	3	4	1	2	
1		×														10/17
2		×													×	11/17
3															×	11/17
4		×														10/17
5											×					11/17
6*																10/17
7									×							11/17
8									×							11/17
9*																10/17
10		×														11/17
11		×													×	11/17
12												×				11/17
13											×				×	11/17
14*																11/17
15												×				11/17
16		×					×									10/17
17*																11/17
18											×					11/17
19									×							11/17
20		×														11/17
21		×														11/17
22		×									×					11/17
23		×				×					×					10/17
24											×					11/17
25*																11/17
26						×										12/17
27											×					11/17
28		×														12/17
29		×									×					11/17
30		×														10/17
31		×									×					10/17
32*																11/17
33*																10/17
34		×									×					11/17
35		×														11/17

Key: participant number* indicates that there will be no data in the table for this participant as there were no MFTPs found in the right shoulder girdle.
'x' indicates the presence of a MFTP

The data gathered regarding type and rating of MFTPs was not statistically analysed as the focus of this study was the pre- and post-intervention lap-times.The 'x' in the tables above represent the MFTPs that were present in each participant. In some cases there is more

than one ‘x’ present because there may be more than one MFTP in a given muscle and MFTPs could be present in more than one muscle,for example, the left half of the trapezius muscle of participant 16 presented with a TP2 and TP7 MFTP; the left trapezius and infraspinatus muscles had MFTPs in the case of participant 29. Some participants had no data, for example, participant 25 presented with no MFTPs in the left side (Table 4.3) (the left shoulder) but had MFTPs as indicated in Table 4.2.

The MDS ratings that are given in Tables 4.2 and 4.3 are average ratings per participant. If participants had more than one MFTP, each MFTP was not given a rating, rather an average was given. As stated previously, the use of this measurement tool was only a way to add to the objective quantification of the MFTPs, this measurement tool was not used to analyse the results of the study as the prequel study (Kinsman, 2014) to this study addressed the quantification of MFTPs that were found in swimmer vs non-swimmer athletes, whilst this study only serves to assess the effect of the intervention on swimmer performance.

The pre-intervention lap times were recorded and an average of these three 100m freestyle lap times was calculated. This data was then sent to the biostatistician to be analysed. The post-intervention lap times were also recorded and an average of these three 100m freestyle lap times was calculated and sent to the biostatistician to be analysed.

These recorded times are presented in Appendices P1 and P2. The mean pre-intervention lap time was 1.19.37 seconds and the mean post-intervention lap time was 1.21.05.

The times that were recorded show that in most cases, participant’s successive lap times were inconsistent as their lap time increased with each 100m lap, showing that they swam slower. Fatigue thus played a great role in decreasing participant performance and as noted later, a limitation of this study would be the fact that so many laps were swum and so future researchers should limit the amount of swimming to minimize the effects of fatigue.

Table 4.4:Statistical analysis results

p = 0.001	Median	Percentile 25	Percentile 75
Average pre-intervention 1,2 3	0:01:16.03*	0:01:10.58	0:01:23.21
Average post-intervention 1,2,3	0:01:16.10*	0:01:09.60	0:01:26.41

The median pre-intervention lap times were faster than the median post-intervention lap times, and were statistically significant (p=0.001) indicating that the difference in the median times was highly statistically significant. Expanding upon this, the role of fatigue is a

significant factor due to the fact that the participants did three 100m sprints, and although they had a small rest period during the timing of the laps, as well as during and after the intervention, lap-times would be reduced especially if they have a higher level of fitness as they would require a much longer rest period. This finding is what we would expect to occur in this scenario because the participant will start to fatigue more and more with each consecutive lap.

The data was significantly skewed and as a result, non-parametric statistics were used to describe and compare the lap times. The times were compared using a paired Wilcoxon signed ranks test. The median time was slightly longer post-intervention than pre-intervention (with a difference of 0:00:00:07 seconds), and it was highly statistically significant (p=0.001).

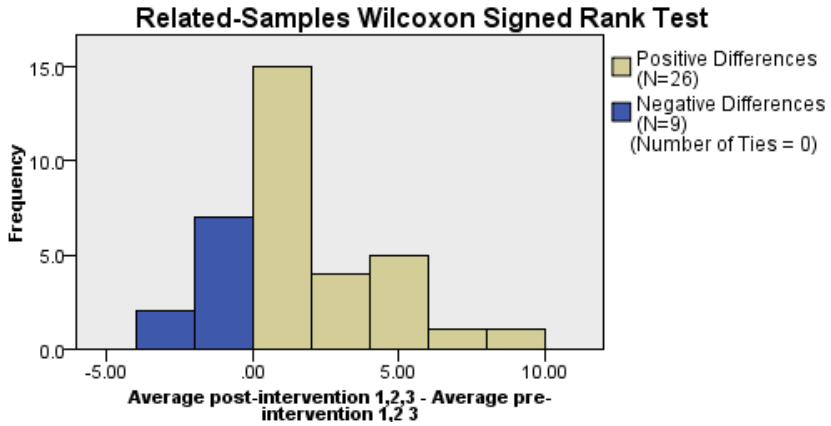

Figure 4.2: Representation of Wilcoxon Signed rank test results depicting the skewed data

Figure 4.2 shows the skewed study data. The beige bars represent positive differences (i.e. post-intervention lap times that were longer than pre-intervention lap times) and the blue bars represent negative differences (i.e. post-intervention lap times that were shorter than pre-intervention lap times). Twenty six of the 35 participants had a slower post-intervention lap time average and so their ability to perform well decreased post-intervention. Nine of the 35 participants had a faster post-intervention lap time average and therefore their ability to perform well increased post-intervention. It can be seen that there was a higher frequency of positive differences i.e. there was a higher frequency of a longer post-intervention lap time. It can be deduced then, that the majority of the participants had a longer post-intervention lap time average than the pre-intervention lap time average, and so the majority of the participants' post-intervention performance was worse than their pre-intervention performance.

A future study needs to look at possibly assessing participants on two separate occasions after the same warm up ritual has been performed, as fatigue is a factor that potentially negatively affects the results. Another possible suggestion for a future study would be the need to include a control group that received a sham intervention so that the effects of fatigue and timing irregularities could be better controlled. The effects of fatigue and calibre level of soccer players was studied by Rampinini *et al.* (2009) – two groups of soccer players were assessed, with one group being of a higher athletic calibre than the other group. Performance before and after the second half of the soccer match was assessed. It was determined that regardless of the calibre or fitness level of the teams, the study showed a significant decline ($p < 0.01$) in physical performance and some technical scores between the first and second halves of the match.A later study by Mendez-Villanueva (2008) investigated the effect of fatigue in repeated-sprint exercise. Participants were required to perform various forms of cycling sprints such as sprinting until failure and 10 x 6 second cycling sprints with 30 seconds rest between a set. The peak power output and the mean power output decreased by a quarter from the maximal value (i.e. the value taken at the initiation of exercise) This tells us that fatigue will have an effect on athletic performance if not enough rest is allowed for recovery before the athlete continues partaking in his or her sport.

Table 4.5: Related-Samples Wilcoxon Signed Rank Test final test statistics results

Total N	35
Test Statistic	512.000
Standard Error	61.053
Standardized Test Statistic	3.227
Asymptotic Sig. (2-sided test)	.001

Table 4.5 shows that the Asymptotic Sig. (2-sided test) value is .001, which refers to the *p*-value of the test.The Total N is the sample size of the study. The Test Statistic, the Standard Error and the Standardized Test Statistic are values that were used by the biostatistician to calculate the *p*-value.

Notwithstanding this, these results do go some way to support the presence of muscle dysfunction occurring before patients become symptomatic because the participants of the study had no complaints in terms of pain, a feeling of decreased power, and / or a decreased

ability to stretch, or other effects of MFTPs as discussed in Chapter 2. However, dysfunction was still found in the form of MFTPs. This indicates that muscle fatigue, tone and strength, should be assessed in swimmers as the presence of MFTPs all contribute to changes in these factors.

The results of this study may give some insight with regards to the use of dry needling in connection with the timing of participation in sports events. Though there were many confounding factors that could have caused the decrease in swimming performance, it cannot be said with certainty that the intervention did not cause this decrease. This leads us to consider carefully the time interval between treatment and subsequent performance.

The decline in performance immediately post-needling may be due to microtrauma caused during the intervention as well as the reactive erythema occurring in the area causing a temporary inflammatory state(Patrick *et al.,* 2016). The effects of microtrauma to the muscle tissue are minor, but they could possibly result in poorer muscle recruitment strategies, altered biomechanics, and poorer performance. Unfortunately, no international articles were found to support this statement because there has not been any research into the immediate effects of dry needling on sport performance.There was a study conducted by another researcher at DUT previously in which the immediate effect of dry needling of the rotator cuff muscles on bowling speed of action cricket players was assessed (Subrayan, 2008). A significant treatment effect was observed in the intervention group (the study also included a control group that received a sham intervention) whereby there was an increase in bowling speed, an increase in algometer readings, as well as a decrease in pain reported on the Numerical Pain Rating Scale. However, it must be noted that the nature of cricket is more explosive than the more sustained nature of swimming, which might account for the difference in results between the two studies.

Due to microtrauma caused by dry needling(Patrick *et al.,* 2016) perhaps alternative treatment methods can be considered by physicians when an athlete needs treatment close to competing in an event i.e. a physician may decide that dry needling may not be the best form of treatment on a patient who’s about to compete in an event, so they may choose a less invasive treatment method such as applying a coolant spray and stretching an affected muscle or applying ischaemic compression to an affected muscle.

The implications of studies such as this can also result in evidence-based treatment protocols being used in the realm of sports medicine in order for athletes to perform at their optimum capability. Healthy athletes who have minimal altered biomechanical patterns and

who have fewer muscle imbalances will also be less prone to injury. This can result in extended career times of athletes (as stated previously, in most sports, aprofessional athlete's career period is 10-20 years). Ma (2011) alluded to this in the book Biomedical Acupuncture for Sports and Trauma Rehabilitation: Dry Needling Techniques, whereby it was noted that by incorporating dry needling in practice, especially when treating athletes or patients who lead highly active lives, future potential for injury is reduced, and this thus results in extending the career of athletes or the active individual. Ma (2011) also noted that many athletic careers have ended prematurely when this could have been prevented with regular treatment using dry needling. Taking into account that the results of this study demonstrate that the immediate effects of dry needling are negative, possible future studies can examine the medium- and long-term effects of dry needling, or the use of a dry needling treatment protocol used over a period of time.

Athletes are always looking at alternate methods to improve their performance. The list of substances and supplements that are banned in the competitive world grows ever longer, and so methods that are not harmful, that allow athletes to compete at their optimum level without allowing athletes to have an unfair advantage over other athletes need to be researched (Ma, 2011). Doping has become so widely spread that as soon as an athlete is deemed to have had an exceptional performance at a sporting event, they are requested to undergo testing to ensure that they have not been doping. Future studies would be of great benefit to the realm of sports medicine, filling a much needed gap in the literature.

Chiropractic is being increasingly accepted into the sports medicine realm as an effective treatment form. Many studies address sedentary individuals, and this is especially true in terms of chiropractic research. Although dry needling is also used by physical therapists, more chiropractic studies should be conducted on the effect of chiropractic-specific treatment on sports performance enhancement. In that way, chiropractic will gain credibility and be more readily accepted in the sports medicine realm. There has been some headway with chiropractic being accepted into sports medicine, yet there are still some issues that crop up as stated by Pollard *et al.* (2007) because of some practitioners still resorting to outlandish treatment methods. In order to be better accepted chiropractors as a whole need to make a concerted effort to use evidence-based practice when they treat patients as this has a firm foundation and scientific backing (Pollard *et al.,* 2007).

4.4 Limitations of this study

1. A limitation to this study was that unforeseen circumstances can affect levels of fitness, for example, prior illness could have led to certain participants skipping training sessions.
2. Since all participants could not be recruited from one swimming team this would also have impacted fitness levels due to different methods of training. The impact of this limitation on the study results was reduced due to each participant being their own "control" and so the participant's performances were not be compared to other participant's performances, but rather to their own performance during the pre-intervention laps that were swum.
3. As the study involved dry needling, another foreseeable limitation to the study was potential participants declining to take part in the study as they were afraid to be dry needled.
4. The use of stopwatches as timing equipment brought human error into question. There was unfortunately no access to other equipment such as timing pads at the venues where the data was collected.Hetzler *et al.,* (2008) compared handheld stopwatches to electronic timing devices (single-split timers and multiple split-timers) to determine the accuracy and reliability of these methods of timing sprint performance. They found that no significant differences occurred between the three methods of timing (p>0.99) and intraclass correlation values that were calculated were high. The researchers made the conclusion that on the basis if the small mean error and the high intraclass correlations, the use of handheld stopwatches may be a viable alternative to electronic timing equipment. Ebben *et al.* (2009) compared manual timing to electronic timing 20 yards and 40 yards sprints and concluded that manual timing equipment had a higher variability rate than electronic timing equipment and that electronic timing produced slower, yet more accurate testing results and less variability when compared to manual timing equipment.
5. Fatigue greatly affected participants because three laps were swum pre- and post-intervention. The results of the study could thus not be linked back to the intervention.Participants that are elite athletes, however, would be able to recover at a quicker rate. The study does not mimic swimming events accurately though, as swimming events would not require participants to swim consecutive laps with very little rest between laps.
6. The participant sample was too varied. The criteria for participants to be included into the study was not strict enough, which allowed participants with lower levels of fitness to participate and this resulted in too great a variation of results to accurately relate back to the intervention.
7. This study lacked a control group. The use of a control group would have helped to link any findings that differed between the two groups back to the intervention that was used and

it would have been more easily identified whether or not the intervention actually had any effect on the participants (Subrayan, 2008). It would have also helped greatly in realizing the effects of fatigue on the performance of the participants if a control group had been used in which times were taken, but no intervention was given, this would have once again made the results more relatable to the intervention instead of fatigue.

8.Since there is a high incidence of DOMS in this population group, participants can easilyconfuse DOMS with MFTPs or vice versa, and as such, they may not have reported a pain complaint as they thought their pain was as a result of DOMS. The criteria used for the study to identify MFTPs helped to differentiate between MFTPs and DOMS as DOMS typically involves a whole muscle being painful, whereas MFTPs result in spot areas of exquisite tenderness within a given muscle. Due to human error, however, some of the MFTPs that were identified may have really been DOMS. DOMS and MFTPs have entirely different treatment protocols and as such, dry needling would not have helped with the participant's DOMS.

9. Seeing each participant on one day was a limitation as they were required to swim many lengths without enough rest and this also impacted on fatigue.

Chapter 5 : Conclusion and Recommendations

5.1 Conclusion

The study results show that the majority of participants in this study performed more poorly post-intervention but the study design and methodology had many limitations. As a result of these limitations, it cannot be said with certainty that dry needling resulted in poorer performance. Other confounding factors would have influenced the effects of dry needling. Since the study design required a number of consecutive laps to be swum, participants could have become very fatigued and this slowed their performance. The inclusion criteria of the study was also too broad,allowing participants who could arguably not be classified as competitive swimmers to participate in the study.These participants could have fatigued much faster and so the results of fatigue would most likely attribute to their poor post-intervention performance. This studywas not representative of real-life swimming galas as the participants had to swim pre-intervention lap-times on the same day and this would lead to fatigue. This would not be the case at galas as swimmers would have rested for a significantly longer period between participating in different events at the gala. It cannot be guaranteed then that the dry needling was the cause of a slower lap-time as the 25th percentile of participants actually showed an improvement in performance. It can thus be concluded that overall the participants performed more poorly post-intervention, however, but it can be deduced that the 25th percentile participants had a higher level of fitness than the rest of the sample as their post-intervention lap-times suggested that fatigue did not affect their performance.Future researchers would benefit greatly by applying the recommendations that follow in order to achieve better study results.

5.2 Recommendations

- Future studies should attempt to reduce the number of variables affecting the study, for example:
  - Have a study/studies differentiating between sprinters and long-distance participants and separating them in to their own groups.
  - Future studies investigating competitive athletes should have stricter inclusion and exclusion criteria, thus ensuring that the participants of studies are of an elite level. In that way, more accurate results would be obtained which could be better applied to competitive athletes. An example of stricter criteria would be that a participant would be required to have met a qualifying time for his/her provincial

team the year of, or year prior to the study being conducted and who had provincial colours (Puckree and Thomas, 2006).

- Have a study/studies differentiating between participants who have a higher level of fitness and participants who have a lower level of fitness.
- Future studies investigating the effects of dry needling on competitive athletes should attempt to mimic competitive sporting events as closely as possible. For example, a future study may require participants to swim one 50m pre- and post-intervention lap instead of three as one lap would be more realistic a scenario. This would also serve to negate the effects of fatigue.
- Allow a longer rest period, for example, assess pre-intervention time the day before and post-intervention time the following day to negate the effects of fatigue on the lap-times.
- Have a set rest period, as well as a set intervention period. By having set time periods, the effects of fatigue can have less of an impact on participants in future studies and the effects of dry needling can be related back to the study results more accurately.
- Have one pre- and post-intervention lap as this would be more realistic as a competitive setting, thereby also reducing the effects of fatigue, allowing about ten minutes before taking post-intervention lap-times.
- Different timing equipment could be used to negate human error from occurring and to ensure accurate timing, for example, touch plates at the end of the pool.
- Specify that participant's main competitive swimming style be that of the swimming style the study is assessing e.g. a participant must compete mainly in the freestyle stroke if they are participating in a study involving the timing of freestyle stroke laps.
- The number of participants in this study was small and although information was gathered with as much precision as possible, larger trials of a similar nature may indeed result in different outcomes. It is suggested then, that the results of this study be further validated.
- As discussed in Chapter 2, there are many other methods used to treat MFTPs, and so future studies can test the effects of other treatment methods such as ischaemic compression followed by ice, stretching, and so forth. This recommendation was listed because dry needling causes micro-trauma to the muscle fibres and this may then hinder the muscles directly thereafter, so alternative treatment methods may be more beneficial to athletes.
- Future studies should incorporate a control group for the reason discussed in the limitations section in Chapter 4.

- Future studies would benefit from analyzing the demographic data of the participants and linking this information to the results of the study. By interpreting the study results along with data that was gathered on the demographics of the participants, a lot more information can be discussed, and patterns may emerge that were not previously thought of. The athletic ability (caliber) of the participants could also be taken in to account in future studies as this can allow the researcher to determine to what extent the study results were affected by athlete fatigue.
- Future studies would also benefit if data was analyzed and presented on the number and type of MFTPs found, as well as the findings compared between the right and left sides of the body. Once again, by analyzing more information, a lot more can be noted in the study results and greater knowledge and thus understanding can be gained on myofascial pain syndrome.
- Future studies using the Randomized Clinical Trial (RCT) design would produce more reliable results as RCT's are seen as the gold standard for clinical trials (Victoria e*t al.,* 2004). RCT's remove any bias from studies since random allocation methods are used when dividing participants into placebo and intervention groups. By using this study design in this type of study the effects of the intervention can be compared to other variables impacting both groups – any changes in the intervention group that are different to the placebo group can be linked with more surety to the intervention.

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Van Bolhuis, B. and Gielen, C. 1999. A comparison of models explaining muscle activationpatterns for isometric contractions. *Biological Cybernetics*, 81(3): 249-261.

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APPENDICES

Appendix A: Letter of Information

Dear Participant, welcome to my research project.

Title of Research: The immediate effect of myofascial trigger point dry needling of four shoulder girdle muscles on the 100m lap- times of asymptomatic competitive swimmers in Bloemfontein.

NAME OF RESEARCH SUPERVISORS

Dr. Graeme Harpham Contact Number (031) 205 6534

[MTech-Chiropractic] - SUPERVISOR

Dr. Charmaine Korporaal Contact Number (031) 373 2094

[MTech-Chiropractic; CCFC; CCSP; ICSSD] – CO-SUPERVISOR

NAME OF RESEARCH STUDENT

Sarah Schmidt Contact Number 074 599 3363

Background:

Due to the high level of repetitive movements undertaken by the shoulder during swimming training, the muscles of the shoulder girdle are exposed to overuse, and are ultimately fatigued.Myofascial trigger points (MFTPs) have been shown to develop in muscles which are overused.These MFTPs may cause shoulder pain and prove to have a negative effect on shoulder range of motion and amount of muscle power in affected muscles.This research aims to locate and treat these MFTPs (if present) in certain muscles of the shoulder girdle, and assess whether the absence of MFTPs has an effect on the 100m freestyle lap time of the participant by timing pre- and post-intervention lap times.The method of treatment will be trigger point dry needling, by which an acupuncture needle is inserted into the MFTP.

Research process:

The consultation will take place at a venue that has access to a swimming pool and a private area to ensure confidentiality.The purpose of this consultation is to screen you for suitability as a participant in this study.Hence, a case history, physical examination, and shoulder regional examination will be completed.

If you are eligible to participate in the study, the next step is identification and marking of MFTPs in the appropriate muscles.Thereafter, you will be required to swim three 100m laps of freestyle and your lap times will be recorded.Your MFTPs will then be treated with trigger point dry needling and you will be required to swim another three 100m laps of freestyle.

All measurements and the intervention (i.e. trigger point dry needling) will be performed by the research student, under the supervision of a qualified chiropractor.

Inclusion and Exclusion:

Participants in this study must be between 16 and 30 years of age and partake in competitive swimming events (a set number and type of event/s is required); the presence of MFTPs in selected shoulder girdle muscles will also be required.

Participants who have needle phobia or any contraindications to trigger point dry needling will be excluded from this study.

Risks and discomfort:

The assessment and intervention for MFTPs may cause temporary discomfort (which will most likely subside within 24 hours), but will not cause any adverse side effects.

Benefits of the study:

Your participation in this study will assist the expansion of the knowledge base within the chiropractic profession, and may ultimately lead to the incorporation of new treatment protocols for the management of swimmers during training and swimming events.The final dissertation will be published and will be kept at the Durban University of Technology library.

Withdrawal from the study:

If you wish to withdraw from this study at any time during the data collection process, you will be allowed to without any discrimination or impact on any further chiropractic treatment.If you fail to comply with informed consent form, you will be excluded from the study.

Remuneration and costs:

As a participant, you will be offered one free treatment voucher which can be redeemed at the Chiropractic Day Clinic at Durban University of Technology.You will also not be required to cover any costs in order to participate in this study.You will not receive any form of remuneration for your study participation.

Confidentiality:

All data collected during the course of this study is confidential.Measures will be taken by the research student to ensure this.These measures will include the storage of all participant files at the Chiropractic Day Clinic for fifteen years, after which they will be destroyed.Patient information will only be discussed between the research student and the supervisor present.

Should you have any questions regarding the study, feel free to ask.If you would like to contact my supervisor, or co-supervisor, their contact numbers are on the first page.Alternatively, you could contact the Faculty of Health Sciences Research and Ethics Committee as per Mr. Vikesh Singh (031) 373 2701.

Statement of agreement to participate in the study:

I_____, ID number_____,
have read this document in its entirety and understand its contents. Where I have had any questions or queries, these have been explained to me by the researcher to my satisfaction. Furthermore, I fully understand that I may withdraw from this study at any stage without any adverse consequences and my future health care will not be compromised. I therefore, voluntarily agree to participate in this study.

Participant's name:_____Signature:_____Date:_____

Researcher's name:_____Signature:_____Date:_____

Coach's name:_____Signature:_____Date:_____

Supervisor's name:_____Signature:_____Date:_____

Appendix B: Parental Consent Form

Dear Parent,

Welcome to my research project and thank you for taking the time to consider the participation of your child.

Title of Research: The immediate effect of myofascial trigger point dry needling of four shoulder girdle muscles on the 100m lap- times of asymptomatic competitive swimmers in Bloemfontein.

NAME OF RESEARCH SUPERVISORS

Dr. Graeme Harpham Contact Number (031) 205 6534

[MTech-Chiropractic] - SUPERVISOR

Dr. Charmaine Korporaal Contact Number (031) 373 2094

[MTech-Chiropractic; CCFC; CCSP; ICSSD] – CO-SUPERVISOR

NAME OF RESEARCH STUDENT

Sarah Schmidt Contact Number 074 599 3363

Background:

Due to the high level of repetitive movements undertaken by the shoulder during swimming training, the muscles of the shoulder girdle are exposed to overuse, and are ultimately fatigued.Myofascial trigger points (MFTPs) have been shown to develop in muscles which are overused.These MFTPs may cause shoulder pain and are known decrease shoulder range of motion, as well as amount of muscle power in affected muscles.This research aims to locate and treat these MFTPs (if present) in four of the muscles making up the shoulder girdle, and assess whether the absence of MFTPs has an effect on the 100m freestyle lap time of the participant by timing pre- and post-intervention lap times. Your child will therefore be assisting in determining whether the removal of MFTPs has any effect on his/her lap time. The method of treatment will be trigger point dry needling, by which an acupuncture needle is inserted into the MFTP.

Research process:

At the consultation your child will be screened for suitability as a participant and a case history, physical examination, and shoulder regional examination will be completed.This consultation will take place at a venue with access to a swimming pool and a private area to ensure confidentiality.

If your child is eligible to participate in the study, they will then be screened to identify and mark MFTPs in the appropriate muscles.Thereafter, he/she will be required to swim three 100m laps of freestyle and his/her lap times will be recorded.Any MFTPs that were found will then be treated with trigger point dry needling and he/she will be required to swim another three 100m laps of freestyle.

All measurements and the intervention (i.e. trigger point dry needling) will be performed by the research student, under the supervision of a qualified chiropractor.
Inclusion and Exclusion:

Participants in this study must be between 16 and 30 years of age and partake in competitive swimming events (a set number and type of event/s is required); the presence of MFTPs in selected shoulder girdle muscles will also be required.

If your child has needle phobia or any contraindications to trigger point dry needling, he/she will be excluded from this study.

Risks and discomfort:

The assessment and intervention for MFTPs may cause temporary discomfort (which will most likely subside within 24 hours), but will not cause any adverse side effects.

Benefits of the study:

Your child's participation in this study will assist the expansion of the knowledge base within the chiropractic profession, and may ultimately lead to the incorporation of new treatment protocols for the management of swimmers during training and swimming events.The final dissertation will be published and will be kept at the Durban University of Technology library.

Withdrawal from the study:

Your child is free to withdraw from the research at any stage and should you wish your child to discontinue participating in the research you may with draw them without any prejudice to you or your child. If informed consent is not obtained your child will be excluded from the study.

Remuneration and costs:

As a participant, your child will be offered one free treatment voucher which can be redeemed at the Chiropractic Day Clinic at Durban University of Technology.You will also not be required to cover any costs in order to participate in this study.Your child will not receive any form of remuneration for his/her study participation.

Confidentiality:

All data collected during the course of this study is confidential.Measures will be taken by the research student to ensure this.These measures will include the storage of all participant files at the Chiropractic Day Clinic for fifteen years, after which they will be destroyed.Patient information will only be discussed between the research student and the supervisor present.

Should you have any questions regarding the study, feel free to ask.If you would like to contact my supervisor, or co-supervisor, their contact numbers are on the first page.Alternatively, you could contact the Faculty of Health Sciences Research and Ethics Committee as per Mr. Vikesh Singh (031) 373 2701.

Statement of agreement to participate in the study:

I _____, ID number _____,

have read this document in its entirety and understand its contents. Where I have had any questions or queries, these have been explained to me by the researcher to my satisfaction. Furthermore, I fully understand that I may withdraw from this study at any stage without any adverse consequences and my future health care will not be compromised. I therefore, voluntarily agree to participate in this study.

Parent/legal guardian's name:_____Signature:_____Date:_____

Researcher's name:_____Signature:_____Date:_____

Coach's name:_____Signature:_____Date:_____

Supervisor's name:_____Signature:_____Date:_____

Appendix C: Letter of Assent

Dear Participant, welcome to my research project.

Title of Research: The immediate effect of myofascial trigger point dry needling of four shoulder girdle muscles on the 100m lap- times of asymptomatic competitive swimmers in Bloemfontein.

NAME OF RESEARCH SUPERVISORS

Dr G. Harpham [MTech Chiropractic]Contact Number (031) 2056534

Dr C. Korporaal [MTech Chiropractic]Contact Number (031) 373 2094

NAME OF RESEARCH STUDENT

Sarah Schmidt Contact Number (031) 3732511.

Background:

Due to the high level of repetitive movements undertaken by the shoulder during swimming training, the muscles of the shoulder girdle are exposed to overuse, and are ultimately fatigued.Muscles “knots” have been shown to develop in muscles which are overused.These “knots” may cause shoulder pain and have been shown to decrease shoulder range of motion and the amount of muscle power in affected muscles.This research aims to locate and treat these “knots” (if present) in certain muscles of the shoulder girdle, and assess whether their absence has an effect on the 100m freestyle lap time of the participant by timing pre- and post-intervention lap times.The method of treatment will be trigger point dry needling, by which an acupuncture needle is inserted into the MFTP.

Research process:

In order to participate in the research you must be between 16 – 30 years of age, and swim competitively (i.e. compete in swimming events such as galas, etc.).Upon agreeing to participate and getting parental consent, you will undergo a case history (asking you some questions about your health), physical examination (looking at your body to make sure you are healthy), and a shoulder examination to ensure that you meet the inclusion criteria of the study. This will take place at a venue that has access to a swimming pool and a private area to ensure confidentiality.

If you are eligible to participate in the study, the next step is identification and marking of “knot” location in the appropriate muscles.Thereafter, you will be required to swim three 100m laps of freestyle and your lap times will be recorded.Any “knots” will then be treated

with trigger point dry needling and you will be required to swim another three 100m laps of freestyle.

All measurements and the intervention (i.e. trigger point dry needling) will be performed by the research student, under the supervision of a qualified chiropractor.

Inclusion and Exclusion:

Participants in this study must be between 16 and 30 years of age and partake in competitive swimming events (a set number and type of event/s is required); the presence of MFTPs in selected shoulder girdle muscles will also be required.

Participants who have needle phobia or any contraindications to trigger point dry needling will be excluded from this study.

Risks and discomfort:

The assessment and intervention may cause temporary discomfort (which will most likely subside within 24 hours), but will not cause any adverse side effects.

Benefits of the study:

Your participation in this study will assist the expansion of the knowledge base within the chiropractic profession, and may ultimately lead to the incorporation of new treatment protocols for the management of swimmers during training and swimming events.The final dissertation will be published and will be kept at the Durban University of Technology library.

Withdrawal from the study:

If you wish to withdraw from this study at any time during the data collection process, you will be allowed to without any discrimination.If you fail to comply with informed consent form or don’t meet the inclusion criteria for the study, you will be excluded from the study.

Remuneration and costs:

As a participant, you will be offered one free treatment voucher which can be redeemed at the Chiropractic Day Clinic at Durban University of Technology.There is no cost to you or your family in order to participate in this study.

Confidentiality:

All data collected during the course of this study is confidential.Measures will be taken by the research student to ensure this.These measures will include the storage of all participant files at the Chiropractic Day Clinic for fifteen years, after which they will be destroyed.Patient information will only be discussed between the research student and the supervisor present.

Should you have any questions regarding the study, feel free to ask.If you would like to contact my supervisor, or co-supervisor, their contact numbers are on the first page.Alternatively, you could contact the Faculty of Health Sciences Research and Ethics Committee as per Mr. Vikesh Singh (031) 373 2701.

Statement of agreement to participate in the study:

I_____, ID number_____,

have read this document in its entirety and understand its contents. Where I have had any questions or queries, these have been explained to me by the researcher to my satisfaction. Furthermore, I fully understand that I may withdraw from this study at any stage without any adverse consequences and my future health care will not be compromised. I therefore, voluntarily agree to participate in this study.

Parent/legal guardian's name:_____Signature:_____Date:_____

Participant's name:_____Signature:_____Date:_____

Researcher's name:_____Signature:_____Date:_____

Coach's name:_____Signature:_____Date:_____

Supervisor's name:_____Signature:_____Date:_____

Appendix D: Chiropractic Day Clinic Case History

DUT DURBAN UNIVERSITY OF TECHNOLOGY | DEPARTMENT OF CHIROPRACTIC AND SOMATOLOGY

CHIROPRACTIC PROGRAMME

CHIROPRACTIC DAY CLINIC CASE HISTORY

Patient: _____ Date: _____

File #: _____ Age: _____

Sex: _____ Occupation: _____

Student: _____ Signature _____

FOR CLINICIANS USE ONLY:

Initial visit

Clinician: Signature:

Case History:

Examination:
Previous: Current:

X-Ray Studies:
Previous: Current:

Clinical Path. lab:
Previous: Current:

CASE STATUS:

PTT: Signature: Date:

CONDITIONAL:
Reason for Conditional:

Signature: Date:

Conditions met in Visit No: Signed into PTT: Date:

Case Summary signed off: Date:

Student's Case History:

1. **Source of History:**

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

3. **Present Illness:**

	Complaint 1(principle complaint)	Complaint 2 (additional or secondary complaint)
Location		
Onset : Initial:		
Recent:		
Cause:		
Duration		
Frequency		
Pain (Character)		
Progression		
Aggravating Factors		
Relieving Factors		
Associated S & S		
Previous Occurrences		
Past Treatment		
Outcome:		

4. **Other Complaints:**

5. **Past Medical History:**

General Health Status

Childhood Illnesses

Adult Illnesses

Psychiatric Illnesses

Accidents/Injuries

Surgery

Hospitalizations

6. Current health status and life-style:

Allergies

Immunizations

Screening Tests incl. x-rays

Environmental Hazards (Home, School, Work)

Exercise and Leisure

Sleep Patterns

Diet

Current Medication
Analgesics/week:
Other (please list):

Tobacco
Alcohol
Social Drugs

7. Immediate Family Medical History:

Age of all family members
Health of all family members
Cause of Death of any family members

	Noted	Family member		Noted	Family member
Alcoholism			Headaches		
Anaemia			Heart Disease		
Arthritis			Kidney Disease		
CA			Mental Illness		
DM			Stroke		
Drug Addiction			Thyroid Disease		
Epilepsy			TB		
Other (list)					

8. Psychosocial history:

Home Situation and daily life
Important experiences
Religious Beliefs

9. Review of Systems (please highlight with an asterisk those areas that are a problem for the patient and require further investigation)

General

Skin

Head

Eyes

Ears

Nose/Sinuses

Mouth/Throat

Neck

Breasts

Respiratory

Cardiac

Gastro-intestinal

Urinary

Genital

Vascular

Musculoskeletal

Neurologic

Haematological

Endocrine

Psychiatric

Appendix E: Physical Examinination – Senior

CHIROPRACTIC PROGRAMME

PHYSICAL EXAMINATION: SENIOR

Patient Name: _____				**File no:** _____	**Date:** _____
Student:			**Signature:**		
VITALS:					
Pulse rate:				Respiratory rate:	
Blood pressure:	R	L		Medication if hypertensive:	
Temperature:				Height:	
Weight:	Any recent change?	Y / N	If Yes: How much gain/loss		Over what period
GENERAL EXAMINATION:					
General Impression					
Skin					
Jaundice					
Pallor					
Clubbing					
Cyanosis (Central/Peripheral)					
Oedema					
Lymph nodes	Head and neck				
	Axillary				
	Epitrochlear				
	Inguinal				
Pulses					
Urinalysis					
SYSTEM SPECIFIC EXAMINATION:					
CARDIOVASCULAR EXAMINATION					
RESPIRATORY EXAMINATION					
ABDOMINAL EXAMINATION					
NEUROLOGICAL EXAMINATION					
COMMENTS					
Clinician:			**Signature:**		

Appendix F: Shoulder Regional Examination

DUT DURBAN UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF CHIROPRACTIC AND SOMATOLOGY

CHIROPRACTIC PROGRAMME

SHOULDER REGIONAL EXAMINATION

Patient: _____ File No: _____ Date: _____

Student: _____ Signature: _____

Clinician: _____ Signature: _____

Observation

Posture		S-C Joints	
Skin		Clavicles	
Swelling		A-C Joints	
Shoulder levels		Scapulae	
Comments			

Palpation

S-C Joint:		SCM:		Scalenes:	
Sternum:		Ribs and costal cartridge:			
Clavicle:		Coracoid process:			
A-C Joint:		Acromion:			
Greater Tuberosity:					
Lesser Tuberosity:					
Intertubercular (bicipital groove):					
Trapezius:		Deltoid:			
Biceps:		Triceps:			
Supraspinatus insertion:					
Musculotendinous portion of supraspinatus:					
Axilla:	Lymph nodes:				
	Brachial artery:				
	Serratus anterior (medial wall):				
	Pectoralis major (anterior wall):				
	Lattisimus dorsi (posterior wall):				
Scapula	Borders:		Spine:		
	Supraspinous fossa:				
	Infraspinous fossa:				
Cervico-thoracic spine:					

Active Movements (note ROM and pain)

Elevation through abduction (170-180°):			
Painful arc with abduction:			
Elevation through forward flexion (160-180°):			
Elevation through scapula plane (170-180°):			
Lateral rotation (80-90°):		Medial rotation (60-100°):	
Extension (50-60°):		Adduction (50-75°):	
Horizontal adduction/abduction (130°):			
Circumduction (200°):			
Apley's Scratch:			

Passive movements (note end-feel, ROM and pain)

Elevation through abduction (bone to bone or tissue stretch) _____

Elevation through forward flexion (tissue stretch) _____

Lateral rotation (tissue stretch) _____

Medial rotation (tissue stretch) _____

Extension (tissue stretch) _____

Adduction (tissue approximation) _____

Horizontal adduction (tissue stretch or approximation) _____

Horizontal abduction (tissue stretch) _____

Quadrant Test_____

Resisted Isometric Movements (note strength and pain)

Flexion		Medial rotation	
Extension		Lateral Rotation	
Adduction		Elbow flexion	
Abduction		Elbow extension	

Joint Play Movements (and motion palpation)

SC Joint	Supero-inferior (shrug shoulder with arm at side):	
	Horizontal add/abduction (arm abducted 90°):	
AC Joint	A-P Shear:	
	Supero-inferior shear:	
Scapula	Normal scapulo-humeral rhythm?:	
	General mobility of scapula:	

Glenohumeral Joint

Lateral movement of humeral head		
Inferior movement of humeral head (Caudal glide)(50°)		
Anterior movement of humeral head (P-A glide) (25°)		
Posterior shear of humeral head (A-P glide) **>50%**	At 10° flexion	
	At 90° flexion	
Backward glide of humeral head in abduction		
Long-axis distraction of humeral head in abduction		
Downward and backward (S-I and A-P)		
Outward and backward (med-lat and A-P		
External rotation of humeral head		
Internal rotation of humeral head		

Instability Tests

1. Anterior Instability Tests	R			L		
	Pos	Neg	n/a	Pos	Neg	n/a
Anterior drawer Test						
Rowe Test						
Fulcrum Test						
Apprehension (crank) Test						
Clunk Test (tear of labrum)						
Rockwood Test						
2. Posterior Instability Tests						
	Pos	Neg	n/a	Pos	Neg	n/a
Posterior Apprehension Test						
Norwood Stress Test						
Push-pull Test						
Jerk Test						
3. Inferior and Multi-directional instability tests						
	Pos	Neg	n/a	Pos	Neg	n/a
Inferior Shoulder Instability Test						
Feagin Test (antero-inferior instability)						

A-C Joint Stress Test: _____

S-C Joint Stress Test: _____

Tests for Muscle or Tendon Pathology

1.	Gilchrest Sign (bicipital tendonitis)	
2.	Speed's Test (bicipital tendonitis)	
3.	Hawkins-Kennedy Impingement Test (supraspinatus tendonitis)	
4.	Supraspinatus Test (supraspinatus tendonitis)	
5.	Drop –arm Test (rotator cuff tear)	
6.	Impingement Test	
7.	Ludington's Test (rupture of long head of biceps)	
8.	Pectoralis Major Contracture Test	

Tests for neurological function

Brachial Plexus Tension Test			Radial Nerve										
			Median Nerve										
Tinel's Sign (Scalene triangle)													
Dermatones	C4		C5		C6		C7		C8		T1		T2
Reflexes	Biceps(C5/6)						Triceps (C7/8)						

Thoracic Outlet Syndrome Tests

Adson's Test		Halstead's Test	
Costoclavicular Test		Eden's Test (cervical rib)	
Hyperabduction Test		Roos Test	
Allen's Test			

Appendix G: SOAP Note

DUT DURBAN UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF CHIROPRACTIC AND SOMATOLOGY

CHIROPRACTIC PROGRAMME

Patient Name:		**File number:**	**Page:**
Date: **Visit:**	**Student:**		
Attending Clinician:		**Signature:**	
S: Numerical Pain Rating Scale (Patient) Least 0 1 2 3 4 5 6 7 8 9 10 Worst	Student Rating ☐	**A:**	
O:		**P:**	
		E:	
Special attention to:		**Next appointment:**	
Date: **Visit:**	**Student:**		
Attending Clinician:		**Signature:**	
S: Numerical Pain Rating Scale (Patient) Least 0 1 2 3 4 5 6 7 8 9 10 Worst	Student Rating ☐	**A:**	
O:		**P:**	
		E:	
Special attention to:		**Next appointment:**	
Date: **Visit:**	**Student:**		
Attending Clinician:		**Signature**	
S: Numerical Pain Rating Scale (Patient) Least 0 1 2 3 4 5 6 7 8 9 10 Worst	Student Rating ☐	**A:**	
O:		**P:**	
		E:	
Special attention to:		**Next appointment:**	

Appendix H: Advertisement

Are you a competitive swimmer?

You are invited to participate inresearch being conducted at DurbanUniversity of Technology Chiropractic Day Clinic.

Participants will receive a free treatment voucher redeemable at the Chiropractic Day Clinic at Durban University of Technology.

For more information contact:

Sarah Schmidt

074 599 3363

Appendix I1: Letter of Permission to use off-site venue 1

LETTER OF PERMISSION
To Whom It May Concern:

My name is Sarah Schmidt and I am currently doing my Masters Degree in Chiropractic at the Durban University of Technology,

The title of my research project is: The immediate effect of myofascial trigger point dry needling of four shoulder girdle muscles on the 100m lap- times of asymptomatic competitive swimmers in Bloemfontein

Name of supervisor:	Dr G Harpham (031) 205 6534 M.Tech: Chiropractic
Name of co-supervisor:	Dr C Korporaal (031) 204 2094 M.Tech: Chiropractic, CCSP, CCFC, ICSSD, FICS
Name of Research Student:	Sarah Schmidt (074 599 3363) (Email – sarahirmgard@gmail.com)
Name of Institution:	Durban University of Technology

The purpose of the study:
This study will involve research on competitive swimmers in Bloemfontein in order to determine the influence that an intervention of myofascial trigger points will have on their post-intervention 100m freestyle stroke lap-times.

Procedures:
The swimmers will be required to undergo an invasive intervention (trigger point dry needling of affected shoulder girdle muscles); which will have no adverse side effects and will be required to swim three 100m freestyle laps before and after the intervention. The average time for each swimmer to complete this process will approximately take an hour.

Benefits:
Should they be suffering from any injuries during the course of their participation in this research, they are offered 1 optional free treatment voucher which can be redeemed at the Chiropractic Day Clinic at the Durban University of Technology. If you would like them, the results of this study will be made available to you.

Cost:
There is no cost involved from your participation in the study.

Based on the nature of this study, I am required to seek your permission to utilize the swimming pool on your premises.

Yours in anticipation,

Sarah Schmidt
(Chiropractic Intern) [redacted]

Dr G Harpham
(Supervisor) [redacted]

Dr C Korporaal
(Co-supervisor) [redacted]

I [redacted] (name) hereby give Sarah Schmidt consent to conduct the above-mentioned research at [redacted].

Signature: [redacted] Date: 26/01/205

Appendix I2: Letter of Permission to use off-site venue 2

LETTER OF PERMISSION
To Whom It May Concern:

My name is Sarah Schmidt and I am currently doing my Masters Degree in Chiropractic at the Durban University of Technology.

The title of my research project is: The immediate effect of myofascial trigger point dry needling of four shoulder girdle muscles on the 100m lap- times of asymptomatic competitive swimmers in Bloemfontein

Name of supervisor:	Dr G Harpham (031) 205 6534 M.Tech: Chiropractic
Name of co-supervisor:	Dr C Korporaal (031) 204 2094 M.Tech: Chiropractic, CCSP, CCFC, ICSSD, FICS
Name of Research Student:	Sarah Schmidt (074 599 3363) (Email – sarahirmgard@gmail.com)
Name of Institution:	Durban University of Technology

The purpose of the study:
This study will involve research on competitive swimmers in Bloemfontein in order to determine the influence that an intervention of myofascial trigger points will have on their post-intervention 100m freestyle stroke lap-times.

Procedures:
The swimmers will be required to undergo an invasive intervention (trigger point dry needling of affected shoulder girdle muscles); which will have no adverse side effects and will be required to swim three 100m freestyle laps before and after the intervention. The average time for each swimmer to complete this process will approximately take an hour.

Benefits:
Should they be suffering from any injuries during the course of their participation in this research, they are offered 1 optional free treatment voucher which can be redeemed at the Chiropractic Day Clinic at the Durban University of Technology. If you would like them, the results of this study will be made available to you.

Cost:
There is no cost involved from your participation in the study.

Based on the nature of this study, I am required to seek your permission to utilize the swimming pool on your premises.

Yours in anticipation,

Sarah Schmidt
(Chiropractic Intern)
[redacted]

Dr G Harpham
(Supervisor)
[redacted]

Dr C Korporaal
(Co-supervisor)
[redacted]

I [redacted] (name) hereby give Sarah Schmidt consent to conduct the above-mentioned research at [redacted].

Signature: [redacted] Date: 26/01/205

Appendix J: Myofascial Diagnostic Scale

Figure 2.1 The Myofascial Diagnostic Scale

Trigger Point Signs:

1. Soft Tissue Tenderness Grade:	0	No Tenderness	0
	I	Tenderness to palpation WITHOUT grimace or flinch	1
	II	Tenderness to palpation WITH grimace or flinch	2
	III	Tenderness with WITHDRAWAL (+ Jump sign)	3
	IV	Withdrawal (+ Jump sign) to non-noxious stimuli (i.e. Superficial palpation, gentle percussion)	4
2. Snapping palpation of the trigger point evokes a local twitch response			4
3. The trigger point is found in a palpable taut band.			4
4. Moderate, sustained pressure on the trigger point causes or intensifies pain in the reference zone.			5
Total out of 17			

Appendix K: Data sheets

Participant no.	Trapezius MFTPs							Supraspina-tus MFTPs		Infraspinatus MFTPs				Latissimus dorsi MFTPs	
RIGHT SHOULDER	1	2	3	4	5	6	7	1	2	1	2	3	4	1	2
1															
2															
3															
4															
5															
6															
7															
8															
9															
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32															

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35															

Participant no.	Trapezius MFTPs							Supraspina-tus MFTPs		Infraspinatus MFTPs				Latissimus dorsi MFTPs	
LEFT SHOULDER	1	2	3	4	5	6	7	1	2	1	2	3	4	1	2
1															
2															
3															
4															
5															
6															
7															
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32															
33															
34															
35															

Participant no.	Pre-intervention lap time 1	Pre-intervention lap time 2	Pre-intervention lap time 3	Average
1				
2				
3				
4				
5				
6				
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35				

Participant no.	Post-intervention lap time 1	Post-intervention lap time 2	Post-intervention lap time 3	Average
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2				
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Appendix L: IREC approval

DUT
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TECHNOLOGY

Institutional Research Ethics Committee
Faculty of Health Sciences
Room MS 49, Mansfield School Site
Gate 8, Ritson Campus
Durban University of Technology

P O Box 1334, Durban, South Africa, 4001

Tel: 031 373 2900
Fax: 031 373 2407
Email: lawishad@dut.ac.za
http://www.dut.ac.za/research/institutional_research_ethics

www.dut.ac.za

15 July 2014

IREC Reference Number: **REC 29/14**

Ms S I Schmidt
Marble Arch 55
87 Ridge Road
Musgrave
Durban
4001

Dear Ms Schmidt

The immediate effect of myofascial trigger point dry needling of four shoulder girdle muscles on the 100m lap-times of competitive swimmers in the greater Durban area

I am pleased to inform you that Full Approval has been granted to your proposal REC 29/14.

The Proposal has been allocated the following Ethical Clearance number **IREC 044/14**. Please use this number in all communication with this office.

Approval has been granted for a period of one year, before the expiry of which you are required to apply for safety monitoring and annual recertification. Please use the Safety Monitoring and Annual Recertification Report form which can be found in the Standard Operating Procedures [SOP's] of the IREC. This form must be submitted to the IREC at least 3 months before the ethics approval for the study expires.

Any adverse events [serious or minor] which occur in connection with this study and/or which may alter its ethical consideration must be reported to the IREC according to the IREC SOP's. In addition, you will be responsible to ensure gatekeeper permission.

Please note that any deviations from the approved proposal require the approval of the IREC as outlined in the IREC SOP's.

Yours Sincerely

[redacted]

Prof J K Adam
Chairperson: IREC

DUT
DURBAN
UNIVERSITY OF
TECHNOLOGY

Institutional Research Ethics Committee
Faculty of Health Sciences
Room MS 49, Marshfield School Site
Gate 8, Ritson Campus
Durban University of Technology

P O Box 1334, Durban, South Africa, 4001

Tel: 031 373 2900
Fax: 031 373 2407
Email: bwishad@dut.ac.za
http://www.dut.ac.za/research/institutional_research_ethics

www.dut.ac.za

16 September 2015

Ms S I Schmidt
9 van der Stel Street
Dan Pienaar
9310

Dear Ms Schmidt

Application for Amendment of Approved Research Proposal

The immediate effect of myofascial trigger point dry needling of four shoulder girdle muscles on the 100m lap- times of asymptomatic competitive swimmers in Bloemfontein

I am pleased to inform you that your application for amendment to the sample size of your research proposal has been Approved.

Yours Sincerely

[redacted]

Professor M N Sibiya
Deputy Chairperson: IRBC

DUT DURBAN UNIVERSITY OF TECHNOLOGY
2015 -09- 16
INSITUTUTIONAL RESEARCH ETHICS COMMITTEE
P O BOX 1334 DURBAN 4000 SOUTH AFRICA

DUT
DURBAN UNIVERSITY OF TECHNOLOGY

Institutional Research Ethics Committee
Faculty of Health Sciences
Room MS 49, Marshfield School Site
Gate 8, Ritson Campus
Durban University of Technology

P O Box 1334, Durban, South Africa, 4001

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http://www.dut.ac.za/research/institutional_research_ethics

www.dut.ac.za

16 September 2015

Ms S I Schmidt
Marble Arch 55
87 Ridge Road
Musgrave
Durban
4001

Dear Ms Schmidt

The immediate effect of myofascial trigger point dry needling of four shoulder girdle muscles on the 100m lap- times of asymptomatic competitive swimmers in Bloemfontein
Ethics Clearance Number: IREC 044/14

The Institutional Research Ethics Committee acknowledges receipt of your Safety Monitoring and Annual Recertification report.

I am pleased to inform you that the study has been approved to continue.

Please note that ethical approval has been extended till 15 July 2016, if the research is not complete within this time, you will be required to apply for recertification three months before the expiry date.

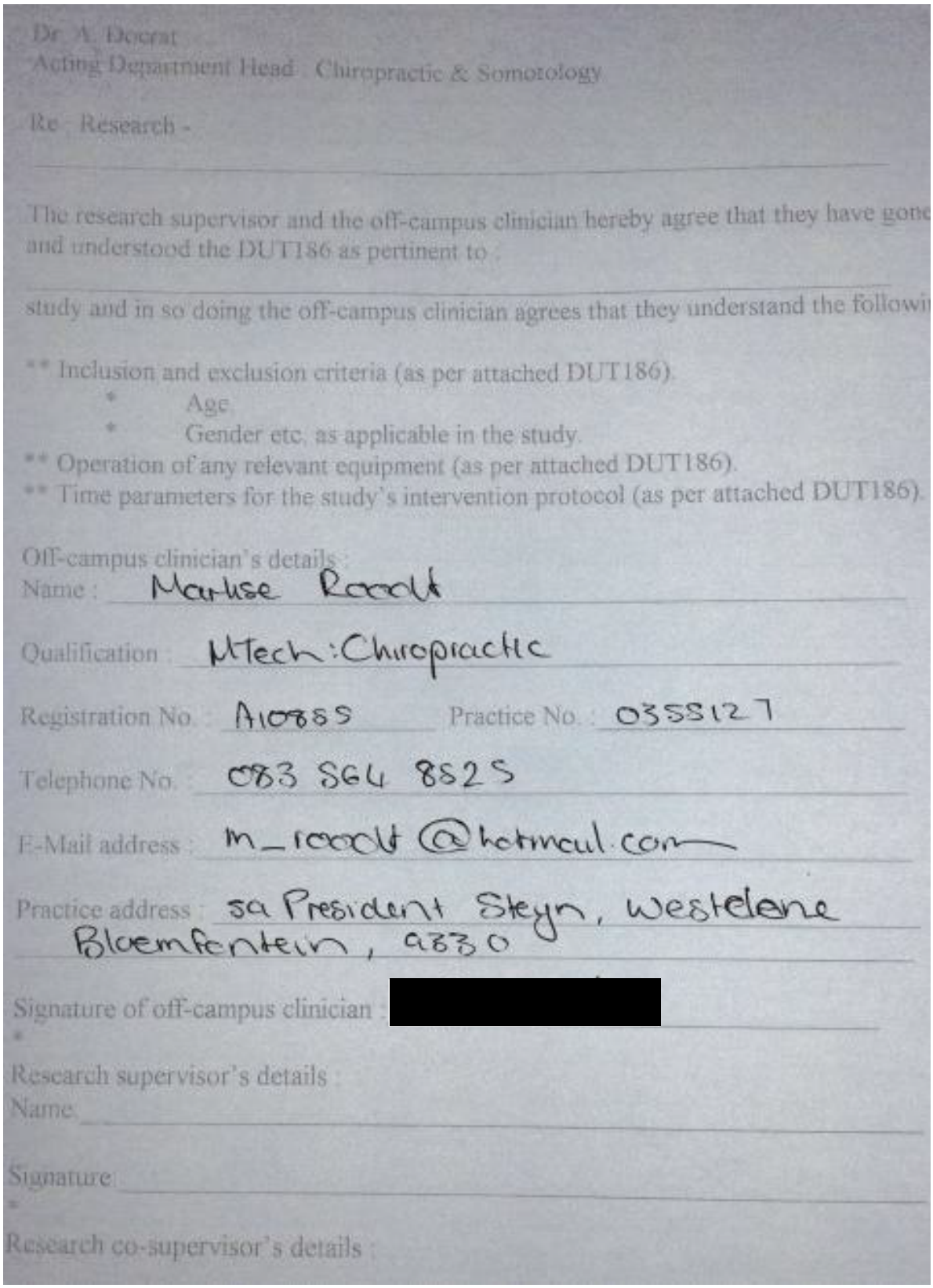
Yours Sincerely

[redacted]

Professor M N Sibiya
Deputy Chairperson: IREC

DUT DURBAN UNIVERSITY OF TECHNOLOGY
2015 -09- 16
INSITUTUTIONAL RESEARCH ETHICS COMMITTEE
P O BOX 1334 DURBAN 4000 SOUTH AFRICA

Appendix M: Off-site supervisor agreement



Dr. A. Docrat
Acting Department Head : Chiropractic & Somatology

Re : Research -

The research supervisor and the off-campus clinician hereby agree that they have gone
and understood the DUT186 as pertinent to :

study and in so doing the off-campus clinician agrees that they understand the followi

** Inclusion and exclusion criteria (as per attached DUT186).
* Age.
* Gender etc. as applicable in the study.
** Operation of any relevant equipment (as per attached DUT186).
** Time parameters for the study's intervention protocol (as per attached DUT186).

Off-campus clinician's details :
Name : Marlise Roodt

Qualification : MTech: Chiropractic

Registration No. : A10885 Practice No. : 0355127

Telephone No. : 083 564 8525

E-Mail address : m_roodt@hotmail.com

Practice address : 5a President Steyn, Westdene
Bloemfontein, 9330

Signature of off-campus clinician : [redacted]

Research supervisor's details :
Name :

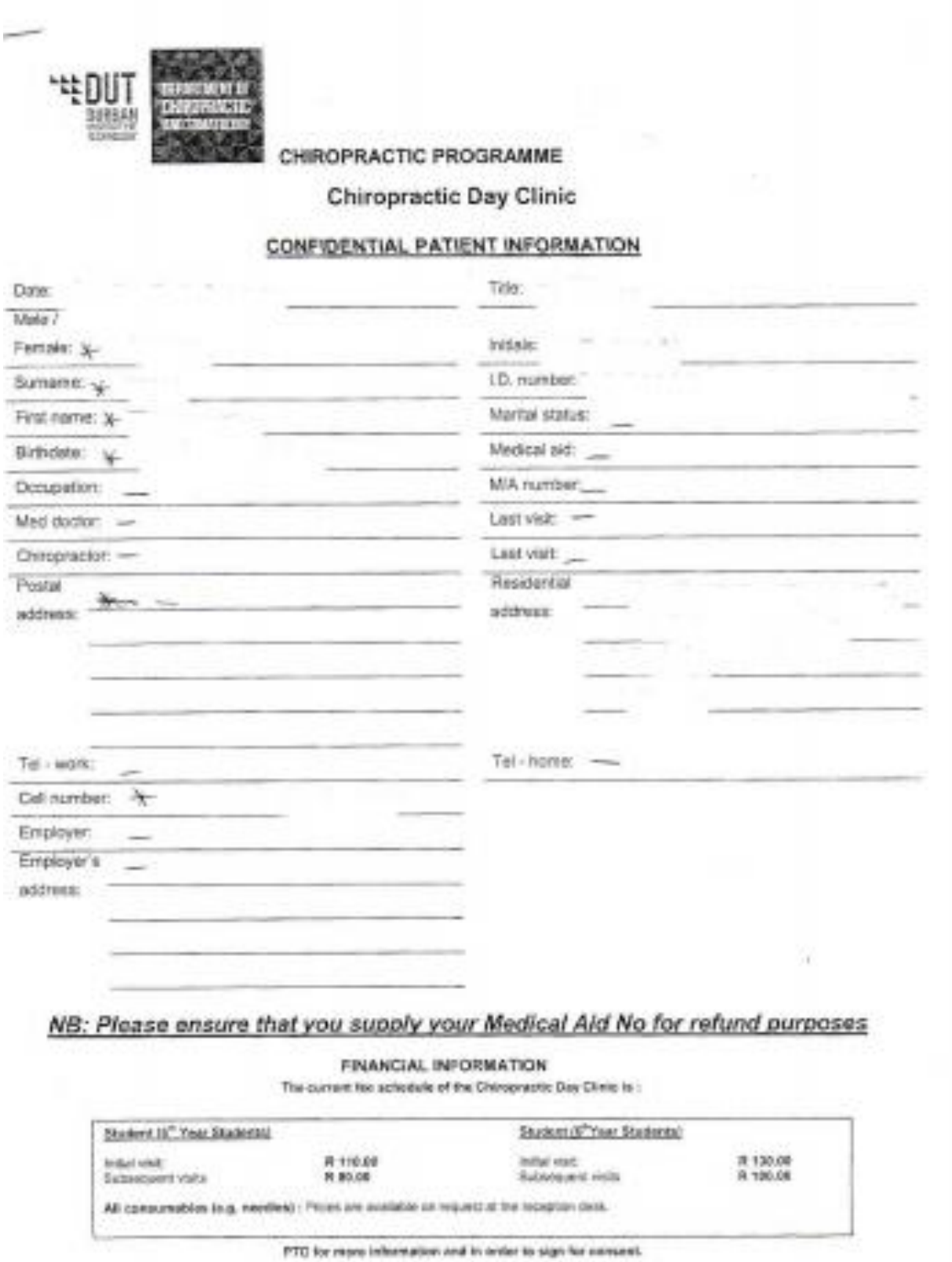
Signature :

Research co-supervisor's details :

Appendix N: Interview questions

Interview questions	Required answers to the questions
1. "How old are you?"	16 – 30 years old
2. "How many galas have you participated in during the last year?"	1 (can be 1 - 3) or 3(can be > 3)
2.1 If the answer to question 2 was 1 (or >1 but <3) in question 2: "What type of event/s did you compete in?"	A provincial, national or international event
2.2 If the answer to question 2 was 3 (or more than 3): "What type of event/s did you compete in?"	3 minor qualifying events (i.e. school galas)
3. "If you had to average the number of hours you swim weekly, what would that average be?"	4 hours or more
4. "Have you had surgery to your neck and/or shoulder?"	No
5. "Have you ever injured your neck and/or shoulder and had to be taken to the hospital for emergency treatment?"	No
6. "Will you be willing to have dry needling (which is similar to acupuncture) as part of this study?	Yes
7. "Do you have any bleeding disorders?"	No
8. "Do you have any shoulder pathologies such as shoulder impingement syndrome, adhesive capsulitis, bicipital tendonitis, glenohumeral instability, ligamentous laxity, rotator cuff injuries?"	No
9. "Have you ever been referred to an orthopaedic surgeon for a second opinion due to shoulder and/or neck pain?"	No

Appendix O: Patient information sheet



CHIROPRACTIC PROGRAMME

Chiropractic Day Clinic

CONFIDENTIAL PATIENT INFORMATION

Date:

Title:

Male /

Female: X

Initials:

Surname: X

I.D. number:

First name: X

Marital status:

Birthdate: X

Medical aid:

Occupation:

M/A number:

Med doctor:

Last visit:

Chiropractor:

Last visit:

Postal address: X

Residential address:

Tel - work:

Tel - home:

Cell number: X

Employer:

Employer's address:

NB: Please ensure that you supply your Medical Aid No for refund purposes

FINANCIAL INFORMATION

The current fee schedule of the Chiropractic Day Clinic is :

Student (1st Year Students)		Student (2nd Year Students)	
Initial visit:	R 110.00	Initial visit:	R 130.00
Subsequent visits	R 80.00	Subsequent visits	R 100.00

All consumables (e.g. needles) : Prices are available on request at the reception desk.

PTO for more information and in order to sign for consent.

Medical Aid schemes play in varying degrees for coverage of Chiropractic Services. This coverage is therefore medical aid dependant and we request that you check with your medical aid in this respect. The DUT Chiropractic Day Clinic is contracted out of medical aid, which means that we run on a strictly cash only basis, whereby you are requested to pay cash in advance of services rendered. You will be sent a monthly statement which you must submit to your medical aid for them to refund you directly. This statement will be sent out at the end of each month.

Charges are not applicable to research patients

Medico-Legal Reports:
As the Chiropractic Day Clinic is a teaching facility we are not in a position to generate any reports required for medico-legal purposes, claims that relate to injury on duty (IOD) or workman's compensation

Report of findings:
It is imperative that the student treating you explains fully your diagnosed condition, both as an educational requirement for the student but also, and most importantly, such that you are able to make an informed decision about the type of treatment that you wish to receive.

Treatment options:
It is imperative that the student explores all treatment options that are available for you based on the diagnosed condition(s) that was/were given to you in respect of the above.

Risks/Benefits:
The student must explain to your satisfaction/understanding all risks and benefits in relation to treatment of your reported diagnosis/condition(s).

As a Patient at this, the Chiropractic Day Clinic, I understand that I am attending an educational facility and I give my permission to allow observation, and if necessary the video recording of supervised examination and treatment by Doctors of Chiropractic and Students. In addition I, as the patient note, that information generated through my attendance of the clinic, may be used for research purposes (either through my direct participation in the research or alternatively through data collected in my patient file).

By signing this form I agree that:

a) I understand and take full financial responsibility for consultations.
b) I understand that I cannot request records for medico-legal reasons.
c) I understand that should I be on medical aid, that my diagnosis and treatment information will be shared for the purposes of medical aid reimbursing me according to that which I am contractually bound in terms of my medical cover (and that only a written request or instruction from myself will be accepted in terms of discontinuing this practice by my health care provider – the Chiropractic Day Clinic).
d) Should I need to be referred that my medical information (pertinent to my condition) will be shared with the doctor / specialist to whom I have been referred.
e) I understand that with my attendance at the Chiropractic Day Clinic, that my medical information will be discussed between the student responsible for my care and the supervising clinician who is responsible for overall oversight of my care.

Date:		Patient Signature:	
Parent/legal guardian signature: (In the case of patient's who are under the age of 12 years and those requiring assistance between the ages of 12-18 years)			
Relationship of guardian to the minor:			
Date:		Student Signature:	
Date:		Clinician Signature:	

By signing this section of the form I agree that (to be completed after you have been assessed and prior to your treatment / referral):

a) The student has discussed with me to my satisfaction, and I fully understand, my / my minor child's diagnosed condition(s) that I have.
b) The student has discussed with me to my satisfaction, and I fully understand all treatment and/or non treatment options and their relative successes and/or failures as applicable to the diagnosed condition(s).
c) I am making an informed decision with regard to, and will submit to / consent to my minor child being submitted to, the treatment protocol as explained.

Based on the above I therefore give consent for the treatment of my name/ complaint by signing the form hereunder:

Date:		Patient Signature:	
Parent/legal guardian signature: (In the case of patient's who are under the age of 12 years and those requiring assistance between the ages of 12-18 years)			
Relationship of guardian to the minor:			
Date:		Student Signature:	
Date:		Clinician Signature:	

Appendix P1: Pre-intervention 100m lap times

Participant number	Pre-intervention lap time 1	Pre-intervention lap time 2	Pre-intervention lap time 3	Average pre-intervention 1,2 3
1	0.1.18.91	0.1.22.94	0.1.26.57	0.1.23.21
2	0.1.13.56	0.1.14.65	0.1.14.53	0.1.14.38
3	0.1.15.47	0.1.16.34	0.1.18.25	0.1.16.55
4	0.1.25.66	0.1.26.16	0.1.26.69	0.1.26.30
5	0.1.18.32	0.1.19.50	0.1.23.63	0.1.20.48
6	0.1.34.78	0.1.49.69	0.1.55.53	0.1.47.07
7	0.1.23.16	0.1.26.56	0.1.26.59	0.1.25.44
8	0.1.26.84	0.1.40.41	0.1.41.94	0.1.36.53
9	0.1.34.07	0.1.39.91	0.1.42.34	0.1.39.04
10	0.1.39.08	0.1.52.59	0.1.56.63	0.1.49.43
11	0.1.51.72	0.2.07.81	0.2.17.85	0.2.06.19
12	0.1.02.47	0.1.02.38	0.1.03.09	0.1.02.51
13	0.1.05.66	0.1.05.44	0.1.06.06	0.1.05.59
14	0.1.17.53	0.1.18.38	0.1.18.42	0.1.18.24
15	0.1.11.03	0.1.10.78	0.1.10.44	0.1.11.02
16	0.0.59.85	0.1.03.78	0.1.06.90	0.1.04.04
17	0.1.08.22	0.1.10.68	0.1.11.94	0.1.10.41
18	0.1.14.59	0.1.18.32	0.1.19.03	0.1.17.31
19	0.1.10.22	0.1.10.25	0.1.08.52	0.1.09.53
20	0.1.07.18	0.1.11.19	0.1.11.66	0.1.10.14
21	0.1.14.68	0.1.18.65	0.1.17.91	0.1.17.35
22	0.1.18.08	0.1.19.09	0.1.19.18	0.1.18.52
23	0.1.09.18	0.1.12.47	0.1.14.97	0.1.12.34
24	0.1.09.69	0.1.12.85	0.1.12.73	0.1.12.16
25	0.1.13.72	0.1.15.97	0.1.16.50	0.1.15.53
26	0.1.10.81	0.1.10.50	0.1.09.88	0.1.13.00
27	0.1.21.63	0.1.30.68	0.1.32.16	0.1.28.29
28	0.1.20.19	0.1.23.38	0.1.24.32	0.1.22.50
29	0.1.12.12	0.1.10.25	0.1.12.41	0.1.11.46
30	0.1.10.34	0.1.10.89	0.1.10.50	0.1.10.58
31	0.1.06.41	0.1.06.16	0.1.07.43	0.1.06.53
32	0.1.14.29	0.1.15.94	0.1.17.07	0.1.16.03
33	0.1.09.07	0.1.10.57	0.1.11.23	0.1.10.29
34	0.1.12.14	0.1.11.51	0.1.08.58	0.1.11.01
35	0.1.19.48	0.1.20.91	0.1.20.26	0.1.20.25

Appendix P2: Post-intervention 100m lap times

Participant number	Post-intervention lap time 1	Post-intervention lap time 2	Post-intervention lap time 3	Average post-intervention 1,2,3
1	0.1.23.84	0.1.34.60	0.1.35.44	0.1.31.43
2	0.1.15.35	0.1.14.78	0.1.13.28	0.1.14.47
3	0.1.15.40	0.1.17.63	0.1.18.65	0.1.17.36
4	0.1.27.33	0.1.26.13	0.1.26.16	0.1.26.41
5	0.1.24.56	0.1.24.44	0.1.28.69	0.1.26.16
6	0.1.41.79	0.1.51.91	0.1.53.31	0.1.49.27
7	0.1.28.32	0.1.26.04	0.1.26.58	0.1.27.11
8	0.1.33.66	0.1.43.31	0.1.44.72	0.1.40.56
9	0.1.38.07	0.1.43.53	0.1.48.38	0.1.43.33
2110	0.1.54.93	0.1.57.40	0.1.54.28	0.1.55.54
11	0.1.59.53	0.2.06.69	0.2.09.44	0.2.05.35
12	0.1.02.36	0.1.03.16	0.1.04.28	0.1.03.27
13	0.1.07.10	0.1.06.47	0.1.06.97	0.1.07.11
14	0.1.16.81	0.1.18.50	0.1.18.34	0.1.18.15
15	0.1.10.68	0.1.09.94	0.1.11.06	0.1.10.56
16	0.1.01.19	0.1.06.50	0.1.05.48	0.1.04.39
17	0.1.07.91	0.1.08.10	0.1.10.53	0.1.09.11
18	0.1.13.29	0.1.16.20	0.1.18.23	0.1.16.04
19	0.1.09.90	0.1.09.15	0.1.09.40	0.1.09.48
20	0.1.08.14	0.1.10.44	0.1.10.50	0.1.09.56
21	0.1.16.38	0.1.19.00	0.1.19.65	0.1.18.34
22	0.1.19.23	0.1.21.07	0.1.21.50	0.1.20.47
23	0.1.12.34	0.1.12.23	0.1.15.28	0.1.13.28
24	0.1.13.87	0.1.15.13	0.1.15.97	0.1.15.26
25	0.1.14.32	0.1.16.06	0.1.16.66	0.1.15.55
26	0.1.10.90	0.1.08.56	0.1.08.93	0.1.09.60
27	0.1.28.25	0.1.34.50	0.1.34.55	0.1.32.43
28	0.1.28.25	0.1.22.63	0.1.27.72	0.1.24.12
29	0.1.12.84	0.1.16.19	0.1.18.47	0.1.16.10
30	0.1.10.92	0.1.11.46	0.1.11.63	0.1.11.47
31	0.1.07.62	0.1.08.59	0.1.09.42	0.1.08.54
32	0.1.16.84	0.1.19.32	0.1.20.40	0.1.19.00
33	0.1.09.58	0.1.11.49	0.1.11.49	0.1.11.12
34	0.1.07.79	0.1.06.96	0.1.08.46	0.1.08.14
35	0.1.21.00	0.1.23.08	0.1.21.97	0.1.22.15