AN INVESTIGATION INTO THE EFFECTIVENESS OF DRY NEEDLING OF MYOFASCIAL TRIGGER POINTS ON TOTAL WORK AND OTHER RECORDED MEASUREMENTS OF THE VASTUS LATERALIS AND VASTUS MEDIALIS MUSCLES IN PATELLOFEMORAL PAIN SYNDROME IN LONG DISTANCE RUNNERS.

By

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Dissertation submitted in partial compliance with the requirements for the Master's Degree in Technology: Chiropractic at Durban Institute of Technology.

I, Donna Weyer-Henderson, do declare that this dissertation is representative of my own work in both conception and execution.

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DEDICATION

To my parents, Blair and Linda Henderson, for their unconditional love, support and encouragement in all that I do.

Thank you

I'm proud to be your daughter.

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ABSTRACT

Patellofemoral Pain Syndrome according to current literature suggests an extensor mechanism dysfunction as the most probable etiology, however this syndrome has posed many unsolved mysteries and challenges to the medical fraternity and remains a difficult condition to treat.

Myofascial pain syndrome in contrast to this is a regional muscular disorder that results from myofascial trigger points within the muscle. The presence of these trigger points could result in anterior knee pain, imbalance of the extensor mechanism and instablility of the patellofemoral joint, which could present as a Patellofemoral Pain Syndrome.

Further to this, in a study performed by Boucher et al. (1992) it was shown that an important neuromuscular imbalance between VMO and VL is associated with PFPS and that it can be investigated through VMO:VL ratios of activity.

The aim of this investigation was to evaluate the role of active myofascial trigger points in the vastus lateralis (VL) muscle as perpetuating, causative or concomitant factors in the alteration of VL/VM Total Work (TW) in PFPS in distance runners.

The design was that of a randomised placebo controlled clinical trial of forty participants from the greater Durban area with patellofemoral pain, and running an average of 20km/wk. Each participant underwent a case history, relevant physical and knee regional examination. Group A (n=20) formed the treatment group, and received dry-needling therapy, and Group B (n=20) formed the placebo group, and were treated with detuned Ultrasound therapy. Three treatments were advocated for each group. Isokinetic tests were performed before the first treatment, and after the last treatment.

Subjective measurements included the Numerical Pain Rating Scale, and Patient Specific Functional Scale. Objective measurements included the Myofascial Diagnostic Scale, algometer readings, and Cybex isokinetic readings.

Descriptive analysis was achieved by frequency tabulations of categorical variables and calculation of means, medians and standard deviations in the case of quantitative variables.
Pearson's correlation coefficients were calculated to assess correlation between two quantitative variables.
Repeated measures ANOVA was used to compare the two treatment groups over the three visits with regards to quantitative outcomes.
A p value of <0.05 was considered statistically significant.

There was no difference between the groups for the subjective tests of NRS and PSFS.
A change over time was shown in both groups to the same extent for NRS, PSFS, Algometer readings (VL and VM), VM MDS readings and cybex readings in all directions tested, however, there was no significant treatment effect differentiating the two groups.

The number of active VL trigger points decreased significantly faster in the Group A than group B and there was a suggestion of a trend towards the same effect in VM trigger points. Thus the treatment had an effect over and above the placebo for MDS and number of active trigger points.

This study suggests that pain and inhibition evident in the VMO, is actually initiated by active Myofascial trigger points in the Vastus lateralis muscle causing a reflex inhibition in VM.

There seems to be a high degree of overlap between the presence of myofascial trigger points and Patellofemoral Pain Syndrome (PFPS).

It would therefore seem to suggest that the focus of PFPS rehabilitation should begin with an important perpetuator, the Vastus Lateralis. Treating the MTrps in this muscle would then reflexly affect the pain and muscle inhibition experienced in the medial aspect of the knee due to the presence of active MTrps, and allow for greater improvement in muscular performance once initial inhibitory factors have been removed.

Key Words: Patellofemoral Pain Syndrome, Myofascial Pain Syndrome, Dry-Needling, Distance runners.

GLOSSARY

Patellofemoral Pain Syndrome

Patellofemoral Pain Syndrome (PFPS) refers to a syndrome associated with the following signs and symptoms: anterior knee pain, inflammation, imbalance, instability or any combination thereof (Wood, 1998).

A Myofascial Trigger Point (Mtrp's)

Is defined as "a hyperirritable spot in skeletal muscle that is associated with a hypersensitive palpable nodule in a taut band. Snapping or palpation of the band may produce a local twitch response. The spot is painful on compression and can give rise to characteristic referred pain, referred tenderness, motor dysfunction and autonomic phenomena" (Travell, Simons and Simons, 1999:5; Chaitow and Delany, 2002:18).

Myofascial Pain Syndrome

Myofascial Pain Syndrome (MPS) is a regional muscular disorder that results from MTrp's (Lee et al., 1997; Chaitow and Delany, 2002:124). Both active and latent MTrp's can result in MPS (Hou et al., 2002: 1411-1412).

An Active Myofascial Trigger Point:

A MTrp that causes a clinical pain complaint. "It is a focus of hyperirritability in a muscle or it's fascia that is symptomatic with respect to pain; it refers to a pattern of pain at rest and/or in motion that is specific for the muscle. An active trigger point is always tender, prevents full lengthening of a muscle, weakens the

muscle, usually refers pain on direct compression, mediates a local twitch response of the muscle fibers when adequately stimulated and often produces specific autonomic phenomena, generally in its referral zone" (Travell, Simons and Simons, 1999:1).

A Latent Myofascial Trigger Point:

"It is defined as a focus of hyperirritability in a muscle or its fascia that is clinically quiescent with respect to spontaneous pain: it is only painful when palpated. A latent myofascial trigger point may have all the other clinical characteristics of an active trigger point, from which it is to be distinguished" (Travell, Simons and Simons, 1999:4).

Chaitow and Delany (2002:124) and Travell, Simons and Simons (1999 1:12), agree that the main difference between active and latent MTrp's is that only active MTrp's spontaneously refer pain.

Latent myofascial trigger points	Active myofascial trigger points
Commonalities	
Decreased stretch range of motion.	Decreased stretch range of motion
Muscular stiffness.	Muscular stiffness.
Local twitch response.	Local twitch response
Painful and weak muscle on contraction.	Painful and weak muscle on contraction.
Differences	
Localized pain on manual compression.	Localized and referred pain on manual compression.

No spontaneous pain referral.	Spontaneous pain referral.
Recognition of an unfamiliar or previous pain.	Recognition of current pain.

As compiled by Wilks (2003:21).

Total Work:

The total area underneath the curve is the total work of the torque curve with each repetition regardless of speed, range of motion (ROM) or time. This is dependant on the subject's muscular power capability at the test velocity (Davies 1992, pg 59).

Peak Torque:

This is the single highest point on the torque curve (graph) regardless of where in the ROM it occurs.

Total Work Compared to Body Weight

Comment [1]: saved from url=(0056)http://www.isokinetics.net/interpretation/forms/twbw.htm

To compare results between individuals work is calculated compared to body weight (either kilos or pounds). Lower limb work is dependent on body weight and can be expressed in this way. W(ork) = torque x angular displacement . Total work (TW) = Area under torque curve x angular displacement (according to Hislop and Perrine 1967).

Set Total Work

Comment [2]: saved from url=(0056)http://www.isokinetics.net//interpretation/forms/stw.htm

The amount of work set at the beginning of a contraction, compared to the amount of work done (www.isokinetics.net)

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and NRS, PSFS, Algometer and MDS scores at baseline – Internally Rotated Position

CHAPTER ONE

INTRODUCTION

1.1 The Problem:

Patellofemoral pain syndrome (PFPS) is a term used to encompass a large number of conditions. These include runner's knee, chondromalacia patellae, extensor mechanism dysfunction and subluxing or dislocating patella (Herrington and Payton. 1997).

According to Wood (1998), patellofemoral pain syndrome (PFPS) refers to a syndrome that comprises of the following signs and symptoms: anterior knee pain, inflammation, imbalance, instability, or any combination thereof.

The aetiology of PFPS is poorly understood (Kannus et al. 1999). The many names used, as well as the variety of proposed aetiological factors and different treatments, is an illustration of the complexity of this syndrome (Thomee et al. 1995). The current trend in literature suggests an extensor mechanism dysfunction as the most probable aetiology (Galantly et al., 1994; Juhn, 1999).

The diagnosis is currently based on the presence of localized peri- or retropatellar pain originating from the peripatellar tissue or the patellofemoral joint (Rowlands and Brantingham, 1999). Prolonged sitting, climbing stairs, kneeling and squatting aggravates the pain (Powers, Landel, and Perry. 1996).

According to prevailing literature, the presence of myofascial trigger points (MFTP's) in quadriceps femoris (QF) muscle could result in a combination of the following signs and symptoms:

- Retro- or peripatella pain,
- Weakness of the quadriceps muscle (Chaitow and DeLany, 2002)

- Loss of full lengthening (Travell and Simons, 1983:248-250)

Therefore there appears to be a clinical overlap between the two syndromes, in terms of an extensor mechanism dysfunction and of signs and symptoms (See Appendix A).

Any of the above would result in inhibition of QF muscle activity and a resultant extensor mechanism dysfunction (Travell and Simons, 1983:248-250), therefore insufficiency of the VMO has been labeled as a cause of patellofemoral knee pain (Hunter, 1985). Further to this, in a study performed by Boucher et al. (1992) it was shown that an important neuromuscular imbalance between VMO and VL is associated with PFPS and that it can be investigated through VMO:VL ratios of activity.

In a pilot non-intervention clinical assessment study, Dippenaar (2003) showed that 95% of subjects suffering from PFPS presented with active and /or latent myofascial trigger points of the quadriceps femoris muscle. Dippenaar (2003) also noted that latent myofascial trigger points in the VMO only occurred in the presence of active myofascial trigger points in the VL. The implication that arises is that the presentation of VM signs and symptoms (referred pain deep in the knee joint which often interrupts sleep; knee buckling; and, weakness of knee extension) may actually be secondary to the development of the myofascial component of the VL.

The common denominator in all treatment modalities used for Myofascial Pain Syndrome (MPS) is the release of contractures in the taut bands of skeletal muscle (Schneider, 1995). Lewit (1978) found dry needling to be highly effective in the treatment of chronic myofascial pain.

Numerous studies have been conducted attempting to determine the presence and the role of Quadriceps Femoris (QF) weakness in PFPS (Callaghan and

Oldham. 1996). These studies have been unable to draw adequate consensus around the issue due to methodological issues related to measurement and hence outcomes (Callaghan and Oldham, 1996; Souza and Gross. 1991).

According to Davies (1992:p62), one of four factors that appear to be most specific in demonstrating "weakness" existing in a muscle is the Total Work (TW) of the quadriceps. Thus, isokinetic measurement is considered the most appropriate tool as a direct indicator of functional status (Wright. 2004).

Rowlands and Brantingham (1999), state that the prevalence of PFPS in the general population may be as high as 40% and may account for up to 25% of all running injuries for which medical attention is sought.

The aim of this investigation is therefore to evaluate the role of active myofascial trigger points in the vastus lateralis (VL) muscle as perpetuating, causative or concomitant factors in the alteration of VL/VM Total Work (TW) in PFPS in distance runners.

1.2 Aims and Objectives of the Study:

This study aims to investigate the effectiveness of dry needling of Myofascial Trigger Points in the Vastus Lateralis muscle on Quadriceps muscle functional ability in Patellofemoral Pain Syndrome in long distance runners.

Sub problem 1:

To evaluate changes in subjective and objective clinical findings pre- and post-dry needling of active trigger points in the VL.

Hypothesis: Dry needling the VL would reduce symptoms of PFPS.

Sub problem 2:

To assess correlations between the objective and subjective clinical findings pre- and post- dry needling of active trigger points in the VL.

Hypothesis: The patient should improve in terms of both parameters.

Sub problem 3:

To compare the outcomes of Total work in VL, VMO and Quadriceps to objective and subjective clinical outcomes.

Hypothesis: Trigger points in VL affect the functioning of the other muscles, which make up the rectus femoris muscle. Treating the trigger points in VL should reduce symptoms in VMO and Quadriceps muscles.

Sub problem 4:

To compare the outcomes of vastus medialis to vastus lateralis in order to determine the relationship between the 2 muscular components of the quadriceps femoris muscle in PFPS in long distance runners.

Hypothesis: Active myofascial trigger points in the vastus lateralis (VL) muscle may be perpetuating, causative or concomitant factors in the alteration of VL/VM Total Work (TW) in PFPS in distance runners

1.3 Benefits of this Study:

This research aims to provide information regarding the role of myofascial trigger points in the VL, VMO and Quadriceps muscles as a possible aetiology or perpetuating factor in the clinical presentation of Patellofemoral pain syndrome.

Previous electromyographic investigation has proven inconclusive as to the presence and extent of quadriceps femoris weakness in PFPS (Callaghan and

Oldham. 1996). By more rigorous evaluation of the quadriceps femoris weakness theory using isokinetic dynamometry it is hoped that the significance of any weakness can be identified and quantified in order to determine the role the presence of any such weakness may play in this poorly understood syndrome.

With knowledge of specific conservative therapies, myofascial trigger points (MTrp's) could then be employed for the treatment of PFPS and their benefits may alter some of the current treatment methods as well as alleviate the trauma, costs and complications of surgical intervention.

CHAPTER 2

REVIEW OF RELATED LITERATURE:

2. Introduction:

This chapter provides a review of the available literature on Patellofemoral Pain Syndrome and Myofascial Pain Syndrome and attempts to highlight the areas of overlap between the two syndromes. The information reviewed will provide a clearer understanding of the current concepts in the aetiology, diagnosis and treatment of both conditions highlighting on the similarities and differences between the two.

Anatomy of the Patellofemoral joint:

The patella is a triangular sesamoid bone with its apex pointing inferiorly and is embedded in the quadriceps femoris tendon with the patella ligament (ligamentum patella) attaching it to the tibial tuberosity (Moore and Dalley, 1999:619). The patella acts as a guide for the quadriceps mechanism, sliding in the sulcus between the femoral condyles, which hold it in place (Davidson, 1993).

The patellofemoral articulation consists of the facets of the patella in contact with the sulcus of the anterior femur (Moore and Dalley, 1999:617). The patella surface can include up to seven facets, with three on the medial and lateral surfaces and an extra (odd) facet on the medial side (Tria et al., 1992).

The surface anatomy of each side of the patellofemoral articulation, the overall rotational anatomy of the entire lower limb and the relationship of the surrounding muscles affect the contact between the two surfaces (Tria et al., 1992).

According to Moore and Dalley (1999: 534), the quadriceps muscle is divided into four components, which are responsible for extension of the knee:

- The vastus lateralis (VL),
- The vastus medialis (VM),
- The vastus intermedialis (VIM) and
- The rectus femoris (RF)

The femoral nerve, made up of the posterior divisions of L2, 3 and 4, innervates this muscle (Moore and Dalley, 1999: 530).

The anatomical origins are described as follows: (Moore and Dalley, 1999: 534)

- Rectus Femoris:
  Anterior inferior iliac spine and groove superior to the acetabulum
- Vastus Lateralis:
  Greater trochanter and the lateral lip of the linea aspera of the femur
- Vastus medialis:
  Intertrochanteric line and medial lip of the linea aspera of the femur
- Vastus intermedialis:
  Anterior and lateral surfaces of the body of the femur.

These muscles insert into the patella proximally in a layered fashion. According to Lieb and Perry (1969), the common direction of pull of the muscle fibers is as follows:

- RF: 7-10 degrees medially in the frontal plane
- VL: 12-15 degrees laterally in the frontal plane
- VM longus (VML): 15-18 degrees medially in the frontal plane and
- VM obliquus (VMO): 50-55 degrees medially in the frontal plane.

Laterally, the patella is stabilized by the lateral retinaculum, iliotibial tract and the vastus lateralis (VL). Medially, stability is provided by the vastus medialis obliquus (VMO) and the medial retinaculum (Bose et al. 1980). The knee has a valgus alignment; therefore tension in the quadriceps muscles tends to produce a lateral movement of the patella.

This lateral movement is resisted by the VMO, the medial retinacular structures and the prominence of the lateral facet of the trochlea of the femur (Sakai et al. 2000). However during the last 30 degrees of knee extension, the patella sits above the trochlear groove with little support offered by osseous structures (Bose et al. 1980).

Biomechanics of the Patellofemoral joint:

The main biomechanical function of the patella is to increase the effective lever arm of the quadriceps muscles in effecting knee extension or resisting knee flexion and to centralize the efforts of divergent muscle groups of the quadriceps (Hungerford and Barry. 1979).

Two forces act on the patella during knee movement (Outerbridge and Dunlop, 1975):

1. The first is a compressive force, also known as the patellofemoral Joint reaction force (PFJRF) and is a measure of the compression of the patella against the femoral condyles and depends on the angle of flexion of the knee and the muscle tension (Hungerford and Lennox, 1983).

2. The second is a quadriceps muscle tension force (Outerbridge and Dunlop, 1975).

Proper tracking of the patella during flexion and extension of the knee is influenced by a number of factors:

- The height of the femoral condyles and hence the depth of the sulcus which keeps the patella “seated” and tracking properly.

- The shape of the facets on the undersurface of the patella which helps determine the “fit” between the patella and the femoral groove.
- The medial and lateral retinacula keep the patella centered between the femoral condyles during movement.
- The composite angle of the pull of the quadriceps group referred to as the Q angle.
- Relative strength of individual muscles composing the quadriceps group.

Any abnormality of anatomic structures influencing patella movement can cause excessive pressure between the patella and the femoral condyles (Davidson. 1993)

Variations in patella shape and size (eg. Wiberg type 1-3, Baugmaurti, patella parva, pebble, half-moon and patella magna) are believed to result in abnormal contact between the patella and the trochlea which result in Patellofemoral pain (Tria et al., 1992). Patella alta predisposes to malalignment because the patella is late in engaging the femoral trochlea during knee flexion (Singerman, Davy and Goldberg. 1994).

Prolonged or excessive foot pronation results in excessive internal rotation of the tibia, which concentrates stress on the peri-articular soft tissues around the knee and produces anterior knee pain. Patients should be observed for all lower limb alignment (eg. Femoral anteversion, knee alignment, tibial rotation and foot pronation (Popagelopolous and Sim, 1997).

Patellofemoral Pain Syndrome

Definition of PFPS:

Patellofemoral Pain Syndrome (PFPS) refers to a syndrome associated with the following signs and symptoms: anterior knee pain, inflammation, imbalance, instability or any combination thereof (Wood, 1998).

The term PFPS was chosen for this study as it is "descriptive, identifies the condition as a syndrome and is non assumptive" (Meyer et al., 1990).

Incidence of PFPS:

PFPS is frequent, periodic and affects both sexes (Blond and Hansen. 1998). Once the problem has begun it frequently becomes chronic and may force subjects to limit physical activity (Kannus et al. 1999). McConnel (1986) states that PFPS affects 25% of the general population, with the problem frequently seen in young adults (Kannus et al. 1999) mostly between the ages of 10 and 20 with a predominance of teenage females (Tria et al. 1992)

In a study of 196 consecutive injuries at a runner's clinic, Pinshaw et al. (1984) reported a 22% incidence of runner's knee. LaBrier and O'Neil (1993), state that PFPS is amongst the most common complaints of athletes, while Paluska and McKeag (1999), state that disorders occur in both recreational and competitive athletes. However Salem and Powers (2001), found that athletes who participate in sports that involve jumping or running activities are at greater risk of developing patellofemoral joint related injuries.

Natural History of PFPS:

In a 5.7year follow up study of PFPS by Blond and Hansen (1998), it was found that PFPS in not a self-limiting condition.
Sandow and Goodfellow (1985) found that PFPS is a benign condition, which affects individuals for many years after the initial onset causing residual pain in most cases. Further to this, only a small percentage experienced an increase in pain, which may have severely restricted sporting activities in some cases.

Kannus et al. (1999), in a 7 year follow up study, used bone densitometry, radiography and Magnetic Resonance Imaging (MRI) and found that PFPS did not lead to patellofemoral osteoarthritis or osteopenia. Mild abnormalities such as a slight decrease in patella cartilage thickness, slight increase in the signal density of the patella cartilage, indicating cartilaginous degeneration, or slight roughness of the patella surface were noted. Kannus et al. (1999) state that only a 10-20 year follow up study will provide a clear picture of the natural history of the disorder.

Aetiology of PFPS:

The etiology of PFPS is poorly understood (Kannus et al. 1999) and an unsolved problem, but several biomechanical factors appear very likely. Predisposing factors include: tightness of the lateral retinaculum, Quadriceps insufficiency, increased Q angle, increased femoral anteversion, external rotation of the tibia, hyperpronation of the foot, patella dysplasia and patella rotation (Kannus et al. 1999) However, according to Kannus et al. (1999), the most important predisposing factor appears to be peripatella tenderness.
According to Devereaux and Lachman (1984), in a five-year study on 137 athletes with PFPS, actual patella trauma only occurred in 29% of subjects. It would therefore appear unlikely that patella trauma plays a significant role in the etiology of PFPS.

In prospective studies, authors are lacking in agreement whether malalignment (Shellock et al. 1989) or overloading of the patellofemoral joint (Fairbank et al. 1994, Galantly. 1994) is the most common characteristic cause of PFPS. However Davidson (1993) states that the etiology of PFPS develops under one of two circumstances, either anatomic abnormality or repetitive microtrauma.

1. Anatomical abnormalities:

Variations in patella shape or size, for example Weiberg type 1-3, patella magna, patella parva; are believed to result in abnormal contact between the patella and the trochlea which resulted in patellofemoral pain (Tria et al., 1992).

Patella alta predisposes one to malalignment, as the patella is late in engaging the femoral trochlea during flexion (Singerman, Davy and Goldman, 1994) According to Sakai et al. (2000), dysplasia in the femoral condyle groove or malposition of the tibial tuberosity may contribute to patella maltracking and Walsh (1994) believes that almost all patellofemoral disorders can be related to an anatomical predisposition.

2. Repetitive trauma:

According to Salem and Powers (2001), athletes who participate in sports that involve jumping or running activities are at greater risk of developing patellofemoral joint related injuries. Fairbank et al. (1984) and Galantly et al. (1994), agree that overload of the patellofemoral joint is the most likely cause of PFPS.

A commonly cited cause of PFPS is that of selective dysfunction or insufficiency of certain components of the quadriceps (LaBrier and O'Neil. 1993).

Thus the popularly held beliefs include:

1) **Decrease in QF muscle strength**

(Gilleard, McConnell and Parson, 1998; William, 1998; Juhn, 1999; Gotlin, 2000). Powers, Landel and Perry (1996), found subjects with PFPS demonstrated less activity of all the vastus muscles when compared to healthy subjects.

The effect of long term weakening of the VMO on the integrity of the static stabilizers, such as the patellofemoral ligaments, is unclear (Sakai et al. 2000). The role of the VMO and VL may be secondary to that of passive structures in the pathology of PFPS (Herrington and Payton. 1997).

2) **Delayed activation of the VMO**

(Voight and Wieder, 1991; Gilleard, McConnell and Parson, 1998). According to Gotlin (2000), the VMO plays a crucial role in cushioning the forces directed to the anterior knee. The stronger the VMO the less stress is transferred to the patellofemoral joint.

3) **Flexibility deficits of the QF muscle**

(Delee and Drez, 1994; William, 1998; Juhn, 1999).

4) **Significant muscle inhibition in the QF muscle**.

In a study of subjects with PFPS, Suter et al. (1998), demonstrated the QF muscle inhibition was closely associated with anterior knee pain.

Despite the various research results and opinions as to the role of the QF muscle in the etiology of PFPS, there can be little doubt of the importance of normal quadriceps activity to the functional integrity of the knee joint (Powers et al., 1996). Bennett and Strauber (1986) suggest that a loss of eccentric quadriceps torque may be specific to subjects with PFPS.

Continued research is thus necessary to establish whether timing differences actually exist in this population (Powers, Landel and Perry. 1996), as studies do not form any consensus as to the supposed role of the VMO:VL ratio and its supposed role in the etiology of PFPS (Callaghan and Oldham. 1996).

Davies (1992:p362) states that isolation of knee extensor muscle groups is possible using an Isokinetic Dynamometer. Performance of isokinetic exercise through a 60-85 degree arc or motion is more effective at selectively activating the VMO than VL (Callaghan and Oldham. 1996).

Wright (2004) and Jackson (2003) both agree that Isokinetic testing is more effective than EMG when evaluating the presence and extent of muscle weakness. Since when using surface EMG to measure muscle activity, it is only possible to measure the potential of the most superficial fibers of superficial muscles. Therefore Isokinetic measurement is currently considered the most appropriate tool as a direct indicator of functional status.

2.3.5 Presentation of PFPS

2.3.5.1 Clinical History And Symptoms:

Most often the patient with PFPS presents with peripatella or retropatella pain (Juhn, 1999). The pain is usually dull and aching becoming sharp with patella compressive activities including climbing or descending stairs, squatting or deep knee bends or

sitting for prolonged periods of time with the knee flexed (movie goer's sign) (Davidson, 1993). Powers et al. (1996) and Delee & Drez (1994), add kneeling, physical exercise and isometric quadriceps femoris contractions to the above mentioned points as factors that aggravate the pain associated with PFPS.

Complaints of crepitus, effusions, intermittent catching during knee extension, a sense of insecurity or giving way (Blond and Hansen, 1998), knee stiffness and patella pseudolocking may also occur (Kannus et al., 1999).

According to Herrington and Payton (1997), greater degrees of pain occur at angles of knee flexion lower than 30 degrees. Therefore patients will complain of pain during activities in this range. Scaringe (1994) found that rest relieves the pain, especially when seated with the knee in the extended position. This enables the patella to disengage the femoral trochlea.

Tria et al. (1992) identifies five main groups of patients in which PFPS may occur:

1. Non-specific anterior knee discomfort in teenage girls
2. Patella instability with patella subluxation or dislocation
3. Direct trauma to the anterior knee
4. Athletic over activity
5. Arthritis of the patellofemoral joint

2.3.5.2 **Physical Findings:**

On physical examination Davidson (1993), found three findings fairly specific for PFPS when the pain is originating from the patellofemoral joint:

1. Tenderness of the medial and lateral facets of palpation.
2. Compression of the patella on the femoral condyles may cause discomfort.

3. When both sides of the patella are grasped while the patient contracts the QF muscle the pressure of the patella against the femoral condyles may cause discomfort.

When the pain is extra-articular a consistently painful area involving retinaculum may be palpated (Davidson, 1993). Walsh (1994) stated that patella mobility might be increased or decreased. Although most literature suggests a tightened lateral retinaculum will restrict the medial glide of the patella (Mc Connel, 1986).

Blond and Hansen (1998), found a tight lateral retinaculum more likely to be associated with movie goer's sign. Mc Connel (1996) believes the majority of patients have some degree of restricted glide of the patella that needs correction.

Post (1998), suggested that the iliotibial band (ITB), which is frequently tight in subjects with PFPS, may result in a patella restriction due to the ITB's strong attachment to the patella through the lateral retinaculum.

Clifton (2003), in a study using an Isokinetic Dynamometer, confirmed the presence of both concentric and eccentric quadriceps femoris weakness in participants with PFPS.

There may thus be a decrease in muscular flexibility of the following muscles:

- Quadriceps Femoris
- Hamstring
- Gastrocnemius and soleus
- Tensor fasciae latae

(Walsh, 1994; William, 1998; Wood, 1998; Clifton, 2003).

2.3.6 Diagnosis of PFPS:

Blond and Hansen (1998), state the diagnosis relies predominantly on history and characteristic symptoms / signs. The clinical diagnosis of PFPS was based on the

criteria as used by Powers et al. (1996) and by Rowlands and Brantingham (1999), for the purpose of this study:

- Participants must present with retro- or peripatella pain (Rowlands and Brantingham, 1999).
- Participants must present with at least three of the following:
    - Retro- or peripatella pain
    - Pain on prolonged sitting (movie-goers sign)
    - Pain on climbing and descending stairs
    - Pain on deep knee bends or squats
    - Pain on kneeling

    (Powers, Landel, Perry. 1996)

2.3.7 **Differential Diagnosis:**

Knee pain may be referred to the knee from other origins e.g. from the hip such as Legg-Calve-Perthes Disease or Slipped Capital Femoral Epiphysis which are conditions occurring in children or adolescence (Post, 1998). Other conditions, which must be excluded, are lumbar radiculopathy and peripheral nerve entrapment (Post, 1998).

Patella subluxation and chondromalacial patella have a very similar presentation to PFPS (Davidson, 1993), and it is important to differentiate between these. In chondromalacia patella there is morphological change or damage to the cartilage on the posterior aspect of the patella. Many subjects with this degeneration are asymptomatic while many symptomatic patients have normal patella articular surfaces. There is no correlation between the morphological changes and the symptomatology. It is therefore incorrect to use the term chondromalacia patella in young people with patellofemoral complaints (Insal, 1979).

2.3.8 Management of PFPS:

Conservative Treatment:

Davidson (1993) states that only after 3-6 months of unsuccessful conservative management, should surgery be considered. Meyer et al. (1990) shares this opinion.

Listed below, are techniques, commonly used in the treatment of PFPS:

1) Exercise:

Exercise is the most commonly used conservative approach and focuses on rehabilitation of the quadriceps muscle (Callaghan and Oldham, 1996).

According to Davidson (1993), a rehabilitation program consisting of Quadratus Femoris setting, straight leg raises and terminal arc extension necessary to improve tracking and help prevent excessive pressure on the lateral facet. Although in contrast a review by Callaghan and Oldham (1996) quotes many authors stating that the straight leg raise exercise is not effective for rehabilitation of PFPS.

Powers, Landel and Perry (1996) question the use of biofeedback and muscle re-education techniques used in rehabilitation of PFPS.

When comparing isolated versus multiple muscle group strengthening, both types of strengthening improve strength. However they provide differences with regard to functional performance, indicating the need to accurately determine the role and extent of quadriceps femoris weakness in PFPS (Gotlin. 2000).

2) Rest and activity modification: Davidson (1993), Shelton (1992)

3) Taping and Bracing: Tria et al., (1992), Kowall et al. (1996)

4) Orthotics: (Post. 1998).

Non-Conservative Treatment:

1) Medication: Davidson (1993) Tria et al., (1992), Suter et al. (1998)

2) Surgery: Juhn (1999), Scaringe (1994), Davidson (1993), Delee and Drez (1994) and Biedert et al. (1992).

2.4 Introduction to Myofascial Pain Syndrome:

Myofascial Pain Syndrome is an extremely common type of muscular condition that frequently presents to primary health care practitioners and is (similar to PFPS) of a multi-factoral origin (Gatterman, 1990:287; Hubbard, 1998:16; Chaitow and Delany, 2002:18-20).

In a review article written by Han and Harrison (1997:90) the incidence of Myofascial Pain Syndrome is reported as high as 85% at certain American pain clinics, yet it remains to be one of the least understood conditions, often being misdiagnosed, mistreated or simply unrecognized (Auleciems, 1995:18). This seems to stem from the lack of obvious organic findings and a lack of unified theory to explain it (Fricton, 1990).

2.4.1 Incidence of MPS:

Although the literature available on MPS concentrates on the postural muscles of the lower back and neck, with little information available on the quadriceps muscle, it is worthy to note than in American studies based at pain clinics, the incidence of MPS was found to be as high as 85% (Han and Harrison, 1997:90).

Travell and Simons (1983:248-250), describe the presence of MTrp's in the QF muscle as extremely common and frequently overlooked, but their findings are based on clinical experience and not clinical trials. Goldberg (1987), Travell, Simons and Simons (1990 1:12) and Gatterman (1990:287) all state that latent MTrp's are more common than active MTrp's.

MPS occurs in both sexes but appears to be more prevalent in females (2:1) (Han and Harrison, 1997:89). Travell, Simons and Simons (1999 1:13) and Han and Harrison (1997:90), suggested that individuals in their later years (30-49) are more likely to suffer from MPS.

2.4.2 Natural History of MPS:

According to Travell, Simons and Simons (1999 1:20), with adequate rest and in the absence of perpetuating factors an active trigger point may revert spontaneously to a latent state. Pain symptoms disappear but reactivation of the MTrp by exceeding the muscles stress tolerance can account for the history of recurrent episodes of the same pain over a period of years.

2.4.3 Etiology of MPS:

Travell, Simons and Simons (1999 1:19) and Chaitow and Delany (2002:20), agree that several primary factors may result in the development or activation of MTrp's:

Primary Factors:

- Mechanical abuse (repetitive muscle overload)
- Trauma
- Leaving the muscle in a shortened position
- Nerve compression
- Adverse environmental conditions
- Systemic biochemical imbalances

Secondary Factors: (Baldry, 1993)

- Compensating synergistic or antagonistic muscles
- Satelite MTrp's
- Low oxygenation of tissues

2.4.4 Presentation of MPS of the QF Muscle Group:

Patients with MPS most often complain of a mild ache to excruciating pain either dull or sharp. The patient may complain of decreased range of motion and muscle strength (Han and Harrison, 1997:92).

Motor disturbances as described by Travell, Simons and Simons (1999 1:21) include:

- Muscle weakness,
- Spasm of synergistic and/or antagonistic muscles and
- Decreased muscle power or work tolerance.

Presentation of MTrp's in the Rectus Femoris (RF) muscle:

(Figure 1)

According to Travell and Simons (1983:248-288) and Chaitow and Delany (2002:483-486), the trigger points are located in the following areas:

TP 1 - At hip level, just below the anterior inferior iliac spine (ASIS). The referred pain pattern is felt at the knee in and around the patella and occasionally deep within the knee joint.

TP 2 - At the lower end of the muscle just above the patella. Pain is referred deep into the knee joint. This Trp is frequently overlooked as a source of knee pain since it lies a significant distance from its referral zone and is less common than Tp 1.

Patients may present with knee pain and a sense of weakness when descending stairs (Chaitow and Delany, 2002:483-486). The pain is often worse at night, especially if the patients sleep with the hip flexed and the knee extended in a side lying position, placing the muscle in a fully shortened position. This muscle seldom undergoes a full stretch in daily activity and frequently has restrictions in its range of motion. (Chaitow and Delany, 2002:483-486).

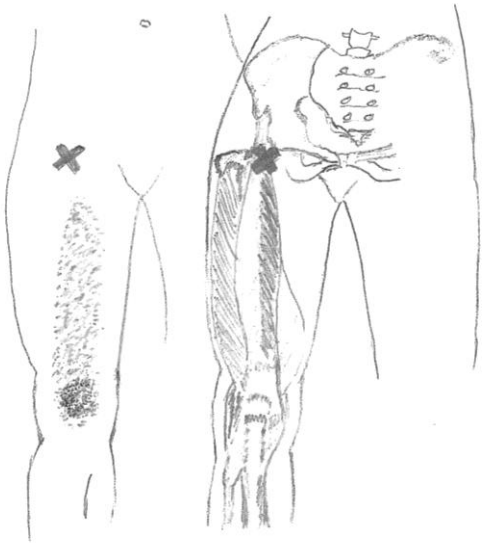

Figure 1: Rectus Femoris Trigger Point Referral Pattern

Presentation of MTrp's in the Vastus Intermedius (VIM) muscle:
(Figure 2)

The MTrp's found here cannot be directly and easily palpated as they are hidden beneath the RF muscle (Travell and Simons, 1983:250). MTrp's in this muscle are usually multiple and rarely solitary.

They refer pain over the anterior thigh just superior to the knee (Travell and Simons, 1983:250; Chaitow and Delany, 2002:484).

Patients with active MTrp's have difficulty climbing stairs or standing up after prolonged sitting. The pain occurs during active movements and rarely during rest (Travell and Simons, 1983:248-288; Chaitow and Delany, 2002:483-486).

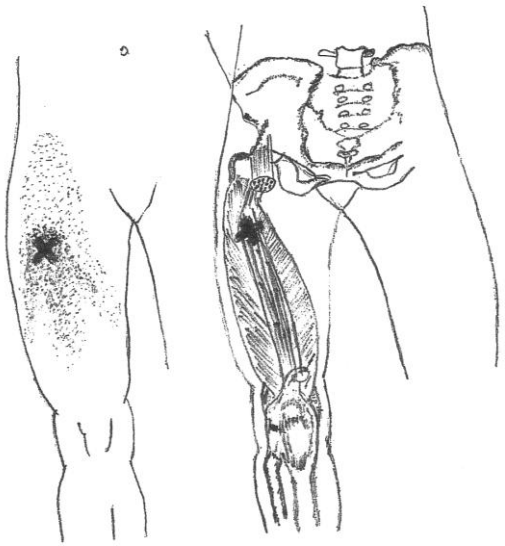

Figure 2: Vastus Intermedius Trigger Point Referral Pattern

<u>Presentation of MTrp's in the Vastus lateralis (VL) muscle:</u>
(Figure 3)

This large muscle develops multiple MTrp's along the lateral aspect of the thigh (Travell and Simons, 1983:251). The five areas in which the MTrp's can occur are spread out along the length of the muscle. They refer pain through out the full length of the muscle and to the lateral aspect of the patella (Chaitow and Delany, 2002:483).

Activation of MTrp's in the distal muscle can result in immobilization of the patella and loss of normal patella movement (Chaitow and Delany, 2002:484), since its distinctive feature is a "**stuck patella**" in combination with pain around the lateral boarder of the patella (Travell and Simons, 1983:251-252).

The “**hornets nest**” of MTrp’s is found at mid thigh level slightly anteriorly. These trigger points are common and can refer pain over the entire length of the thigh and distally it swings anteriorly around the anterior boarder of the patella and occasionally the pain may refer posteriorly to the popliteus space. (Travell and Simons, 1983:248-288; Chaitow and Delany, 2002: 483-486)

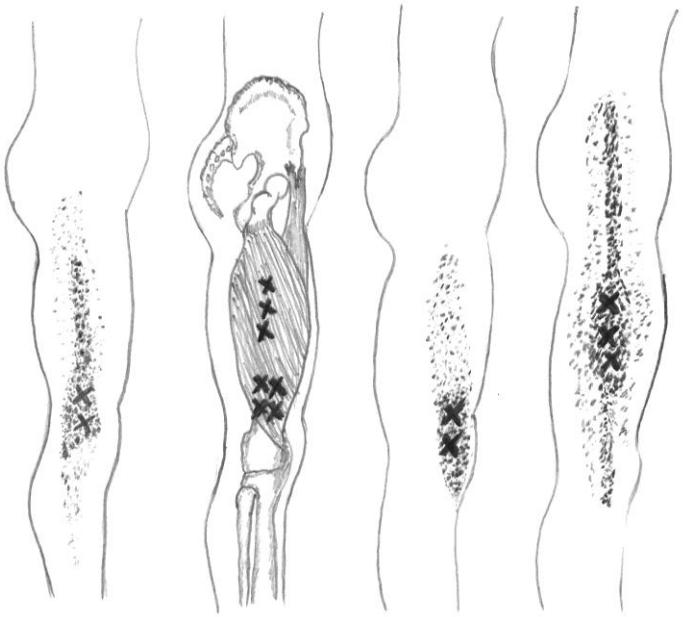

Figure 3: Vastus Lateralis Trigger Point Referral Patterns

<u>Presentation of MTrp’s in the Vastus Medialis (VM) muscle:</u>
(Figure 4)

TP 1 - Found in the distal muscle superomedial to the patella. This is the most common VM MTrp, and refers pain to the anterior knee with some referral to the anteromedial aspect of the knee and some to deep within the knee joint.

TP 2 - Found proximal to TP 1 at mid thigh level.
This point refers pain in a linear fashion over the anteromedial knee and lower thigh. These MTrp's are frequently overlooked as they often produce dysfunction and not pain. Often after a period of a few weeks the pain phase changes to inhibition phase resulting in unexpected episodes of quadriceps weakness. This may result in buckling of the knee (Travell and Simons, 1983:248-288; Baker, 1989:129-131; Chaitow and Delany, 2002: 483-486).

This muscle is likely to develop MTrp's as a result of strenuous athletic activity such as running, basketball, football or skiing (Travell and Simons, 1983:266). Deep knee bends may perpetuate MTrp's in the QF muscle, especially those in the VM (Travell and Simons, 1983:265). MTrp's in the vastus medialis muscle may restrict normal lateral mobility of the patella (Travell and Simons, 1983:267).

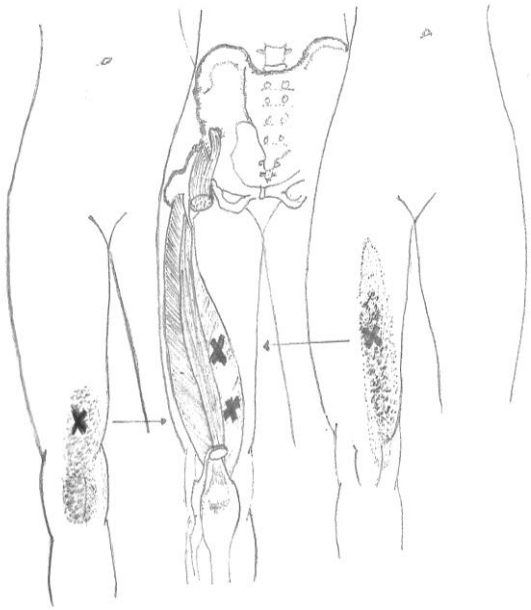

Figure 4: Vastus Medialis Trigger Point Referral Patterns

2.4.5 Physical Findings in MPS:

Travell, Simons and Simons (1999 1:21-22), state that MTrp's can be identified clinically by the following common characteristics:

a) **A palpable taut band.**
The taut band can be snapped or rolled under the fingers in accessible muscles. Gerwin and Shannon (2000:1257), state that the presence of a taut band is the most important factor in the physical examination as it distinguishes MTrp's from other muscle pains such as fibromyalgia.

b) **Tender nodule.**
Palpation along the taut band reveals a nodule exhibiting a highly localized exquisitely tender spot that is characteristic of an MTrp.

c) **Weakness of the muscle.**
This may reflect reflex inhibition of the muscle by the MTrp's (Borg-Stein and Stein, 1996:309).

d) **Restricted stretch range of motion** (Simons, 2000:706).

e) **Increased pain**
On active and /or passive stretch: Passive stretching results in greater restrictions. This may be due to reciprocal inhibition.

f) **Referred pain on manual compression**
Digital pressure on either a active or latent MTrp can elicit a referred pain pattern characteristic for that muscle.

g) **Local twitch response:**
Snapping palpation of the MTrp frequently evokes a transient response of the taut band fibers (Kuan et al., 2002:513).

h) **Painful contraction:**
When a muscle with an active MTrp is strongly contracted against resistance the patient feels pain. This effect is most marked when an attempt is made to contract the muscle in a shortened position. (Travell, Simons and Simons, 1999 1:21-22).

2.4.6 Diagnosis of MPS:

The diagnosis is currently based on the presence of localized peri- or retropatellar pain originating from the peripatellar tissue or the patellofemoral joint (Rowlands and Brantingham, 1999). Prolonged sitting, climbing stairs, kneeling and squatting aggravates the pain (Powers, Landel, and Perry. 1996).

According to prevailing literature, the presence of myofascial trigger points (MFTP's) in quadriceps femoris (QF) muscle could result in a combination of the following signs and symptoms:

- Retro- or peripatella pain,
- Weakness of the quadriceps muscle (Chaitow and DeLany, 2002)
- Loss of full lengthening (Travell and Simons, 1983:248-250)

Lee et al.(1997) and Gerwin et al (1997) both reported using these criteria to identify trigger points. The recommended criteria for identifying a latent or active trigger point according to Travell, Simons and Simons (1999:35) are as follows:

Essential Criteria:

1. Taut band palpable (if muscle accessible)
2. Exquisite spot tenderness of a nodule in a taut band.
3. Patients recognition of current pain complaint by pressure on the tender nodule (identifies active TP's).
4. Painful limit to full stretch range of motion.

Confirmatory Observations:

1. Visual or tactile identification of local twitch response.
2. Pain or altered sensation on compression of the tender nodule.

For the diagnosis of MFTP's all 4 essential criteria must be present (Travell, Simons and Simons, 1999; Murphy, 1989). The presence of the confirmatory signs serves to reinforce the diagnosis.

The minimum criteria for identifying a MFTP according to Chaitow and DeLany (2002) are as follows:

Minimal criteria:

- Taut palpable band
- Exquisite spot tenderness of a nodule in a taut band
- Subject's recognition of pain

Compression of the MFTP may result in:

- The person's recognition of a current pain complaint, which indicates an active MFTP.
- The person's recognition of an unfamiliar or previous pain, which indicates a latent MFTP.

2.4.7 Differential Diagnosis:

Pain in the region of the knee may arise from articular degeneration or dysfunction, meniscal tears, ligamentous injury, tendonitis or trochanteric bursitis. L4 Peripheral neuropathy and lateral femoral nerve entrapment are common differentials.

2.4.8 Management of MPS:

Patient management is dependant on recognizing the underlying problems that influence the patient's pain by increasing the tension and irritability of the involved muscle (Fomby and Mellion, 1997). The treatment protocol must therefore take into consideration the contributing and perpetuating factors, so that long-term relief can be

obtained (Esenyl et al., 2000). Esenyl et al. (2000), feels the main goal of treatment is to relieve the muscle pain and spasm of the involved muscle.

The common denominator in all treatment modalities used for Myofascial Pain Syndrome (MPS) is the release of contractures in the taut bands of skeletal muscle (Schneider, 1995). Thus previous treatment for MPS has included: myofascial trigger point injection, dry needling, exercise, massage, transcutaneous electrical nerve stimulation (TENS), medication and stretch and spray (Han and Harrison, 1997; Hubbard, 1998). The choice of treatment seems to be based more on personal preference than on clinical evidence (Anderson, 1997).

MFTP Injection And Dry Needling:

Trigger point injections have been widely used to inactivate MTrp's (Esenyl, 2000:49) and are commonly used in the management of MPS with wide spread clinical acceptance (Alvarez, 2002:657).

According to Han and Harrison (1997:96), MTrp injection is preferred to dry needling because of the analgesic effect that the local anesthetic agent offers to the surrounding muscle tissue.

However Garvey et al. (1989), conducted a randomised double-blind study comparing four different treatment methods in 63 patients with active MTrp's. The results of the study show that dry needling and acupressure are more effective than transcutaneous injection of either local anesthetic or local anesthetic and steroids. This led the researchers to believe that the relief is likely due to the mechanical stimulation of the MTrp by the needle as appose to the substance injected.

Lewit (1978) found dry needling to be highly effective in the treatment of chronic myofascial pain. Of the 312 patients treated by Lewit, immediate analgesia was produced by dry needling in 86.6%. The needle effect (immediate analgesia without

hypesthesia) may be produced by precisely needling the most sensitive spot of the trigger point.

Rowley (2001) compared the effectiveness of a single dry needle insertion to multiple fanning needle insertions in the treatment of MPS in the cervical and thoracic spines. Results showed that there was no statistical difference between the two techniques in terms of objective and subjective findings.

Han and Harrison (1997:96), propose the following mechanism by which both needling and MTrp injection relieves the MTrp pain:

1. Mechanical disruption of muscle fibers, causing a release of potassium, which results in depolarisation of nerve fibers
2. Mechanical disruption of nerve fibers
3. Interruption of central feedback mechanism that perpetuates pain
4. Local dilution of nociceptive substances by the local anesthetic or saline that is infiltrated.
5. Vasodilatory effect of local anaesthetics, which increase the removal of metabolites.

Recommendations by Dippenaar (2003), suggest that further studies should focus more on specific populations, such as long distance runners. This is supported by Rowlands and Brantingham (1999), who state that the prevalence of PFPS in the general population may be as high as 40% and may account for up to 25% of all running injuries for which medical attention is sought.

Thomee (1999) also states that further studies are necessary in order to establish the significance of various strength deficits and muscular imbalances, and to clarify whether a specific disturbance in muscular activation is a cause or an effect (or both) of PFPS.

Therefore the focus of this study was directed at the correction of vastus lateralis dysfunction with outcomes measuring the response from vastus medialis and vastus lateralis muscle total work, in long-distance runners, running on average 20kms/week.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Introduction

The aim of this research is to provide greater insight into the role of Myofascial Trigger Point alleviation in the Vastus Lateralis Muscle on Quadriceps muscle functional ability in Patellofemoral Pain Syndrome in long distance runners.

Therefore this chapter gives a description of:

- The primary and secondary data,
- The subjects,
- The design and
- The interventions used.

Each measurement parameter is discussed and an overview of each scale is given. Statistical analysis is also discussed.

3.2 The Data

The data consisted of primary and secondary data.

3.2.1 The Primary Data:

The primary data consisted of:

- Case history (Appendix ٥)
- Physical examination (Appendix ٦)
- Knee Regional examination (Appendix ٧)

- Location of Quadriceps Femoris MTrp's (Appendix ٨)
- Numerical Pain Rating Scale (Appendix 9)
- Patient Specific Functional Scale (Appendix ١٠)
- Myofascial Diagnostic Scale (Appendix ١١)
- Algometer readings for Pressure-pain Threshold (Appendix 12)
- Cybex ٧٠٠ Isokinetic Dynamometer readings

3.2.2 The Secondary Data:

The secondary data was obtained from various sources including journal articles, textbooks and medical search engines on the Internet (Mantis, Pubmed, Medscape and Google).

3.3 Study Design:

The design was that of a randomised placebo controlled clinical trial of forty participants.

3.4 The Subjects:

The subjects consisted of volunteers suffering from patellofemoral pain syndrome residing in the Kwazulu-Natal province.

3.4.1 Advertisements For Subject Recruitment:

The public was informed of the study by advertisements placed at local gyms, sports shops, in local newspapers and on the DIT Campus advertising for free participation in a research program being conducted on knee pain.
Flyers were also handed to runners after various races run in the Durban Metropolitan area.

The advert called on patients between the ages of 18 and 60 years of age, running an average of 20km a week or more, suffering from knee pain that was around or behind the kneecap (Appendix 1).

Upon reply all participants were required to undergo a cursory telephonic discussion with the examiner to exclude subjects that did not fit the criteria for the study (Appendix 2).

3.4.2 Sampling And Group Allocation Of Subjects:

A non-probability convenience sampling technique was used. The study was limited to distance runners (running an average of 20km/wk) suffering from patellofemoral pain syndrome residing in the Kwa-Zulu Natal province.

The first 40 participants were consecutively selected from those successfully complying with the telephonic interview and randomly allocated to one of two groups. Group A formed the treatment group, and Group B formed the placebo group. The participants were then asked to attend the Chiropractic Day Clinic for an initial assessment in terms of the inclusion and exclusion criteria.
All patients received a letter of information (Appendix 3) and were required to sign an informed consent form (Appendix 4) before treatment commenced.

3.4.3 Clinic Assessment Procedure:

An initial consultation was scheduled during which a case history (Appendix 5), relevant physical examination (Appendix 6) and knee regional examination (Appendix 7) were conducted. The participants were also screened for vastus medialis and vastus lateralis myofascial trigger points which were then plotted on a diagram. Following this, an initial two Isokinetic test sessions were performed. The first of which was for subject familiarization and the second being the actual

first test where baseline data was captured, assessing Total Work of the Quadriceps muscle in the presence of active myofascial trigger points (Chan and Maffulli. 1996:p80-100).

Acceptance of the candidate was dependant on whether or not they met the specific inclusion criteria indicated below:

3.4.3.1 Inclusion Criteria:

* Participants were required to be between the ages of 18years and 60years (Rowlands and Brantingham. 1999).
* Participants had to be distance runners (running on average 20km/wk).
* Participants were required to present with patellofemoral pain syndrome.
* In diagnosing PFPS emphasis was placed on case history and physical findings, as opposed to specific orthopaedic tests, as these had not yet been proven to be reliable;

    Participants were required to present with at least three of the following:
    - Retro- or peripatella pain
    - Pain on prolonged sitting (movie-goers sign)
    - Pain on climbing and descending stairs
    - Pain on deep knee bends or squats
    - Pain on kneeling

    (Powers, Landel, Perry. 1996)

* Participants had to present with a minimum Numerical Rating Scale reading of 6.

3.4.3.2 Exclusion Criteria:

Subjects were excluded for the following reasons:

- Any neurological deficit that influenced their gait (Rowlands and Brantingham, 1999).
- Participants who had undergone knee surgery within the past two years or have any history of traumatic patella dislocation (Rowlands and Brantingham, 1999)
- Participants who presented with any of the following: bursitis, patella tendonitis or any systemic arthritides that affects the knee (Powers et al., 1996).
- Participants who presented with evidence of a meniscal tear, ligamentous instability, abnormalities indicative of osteoarthritis, osteochondritis dessicans or loose bodies (Kannus et al., 1999).
- Participants who were pregnant or breastfeeding (Kannus et al., 1999). The hormones relaxin and estrogen secreted during pregnancy act to relax the ligaments of the body (Guyton and Hall, 1997). This may result in increased ligament laxity and instability of the knee.
- Patients were excluded if they were receiving any form of therapy, manual or medicinal (Poul et al. 1993) for their patellafemoral pain syndrome during the course of the research period. Therapy excluded the use of the Cybex isokinetic machine, used to gain measurements during the course of this study.
- Patients who had not signed the informed consent form were automatically excluded from this study.
- Patients presenting with acute, severe PFPS experiencing pain that may have prevented them from completing the isokinetic test were excluded from the study (Cybex 1996: p1-13).

To avoid the aggravation of symptoms, patients were not permitted to run a marathon during the course of the treatment; however, they could continue their regular training regimen.

3.4.4 **Clinical Treatment Plan:**

Following the initial isokinetic tests, subjects were divided into two groups. Two standard treatment modalities were used, one of which was dry-needling therapy, and the other was a placebo treatment using detuned ultrasound therapy.

Group"1" received dry needling of the active trigger points in the VL muscle. Lewit (1979) found dry needling to be highly effective in the treatment of myofascial trigger points. A single needle insertion technique was used whereby the needle was inserted directly into the TP and then left for five minutes. The needle was then manually stimulated using the thumb and forefinger, left in position for another five minutes before it was again manually stimulated (Rowley, 2001). Three treatments (Travell and Simons 1998:166) every second day (Mance et al. 1986), and an assessment consultation was advocated.

Group "2" was a control group and received detuned ultrasound therapy, which consisted of a 5 min application of detuned ultrasound over them Vastus Lateralis muscle. Three treatments were scheduled in accordance with the treatment regime for the Group 1, followed by an assessment consultation.

Subjective and objective measurements were taken at the beginning of every treatment, while Algometer readings were taken at the beginning and end of each treatment.

The assessment consultation took place at the King's Park Sports Medical centre under the supervision of Mr J. Wright HonsB (Biokinetics). Here the patient

underwent concentric-concentric isokinetic muscle testing of the knee to evaluate whether alleviation of trigger points in the VL had any effect on the total work of the VL and VMO muscles. This was performed on a Cybex Isokinetic Dynamometer.
The participants were offered two free treatments after the completion of the study.

3.5 Study Assessments:

3.5.1 Diagnosis and assessment readings related to the myofascial trigger Points:

Once the participant was included in the study they were screened for myofascial trigger points.

It is the opinion of Travell, Simons and Simons (1999:34-35) that no one diagnostic examination alone is a satisfactory criterion for the identification of a trigger point. According to Travell and Simons (1983:12-16) the signs of a trigger point are as follows:

- Referred pain in the zone of reference
- Local twitch response
- Palpable taut band and
- Focal tenderness

Banks et al. (1998) and Gerwin et al (1997) both reported to using these criteria to identify trigger points.

The recommended criteria for identifying a latent or active trigger point according to Travell, Simons and Simons (1999:35) are as follows:

Essential Criteria:

1. Taut band palpable (if muscle accessible)
2. Exquisite spot tenderness of a nodule in a taut band.
3. Patients recognition of current pain complaint by pressure on the tender nodule (identifies active TP's).
4. Painful limit to full stretch range of motion.

The Myofascial Trigger Points Were Recorded As Follows:

3.5.1.1. Objective Measurements:

3.5.1.1.a. Location of the trigger points: (Appendix 8)

The specific location of the trigger point within the four muscles, which constitute the QF, was noted as indicated by Chaitow and DeLany (2002:483-485) and Travell and Simons (1983:249-272).

- Trigger points in the vastus medialis muscle are usually found close to the medial border of the muscle in the mid belly and at the distal attachment of the muscle.

- Trigger points in the vastus lateralis muscle lie deep in the muscle and are extensively distributed throughout the length of the muscle.

- The vastus intermedius muscle can develop multiple trigger points along its length, deep to the rectus femoris muscle and therefore can not be directly palpated.

- The rectus femoris muscle trigger points are commonly located

proximally in the muscle close to the anterior inferior iliac spine.

3.5.1.1.b. **The Myofascial Diagnostic Scale (MDS):** (Chettiar 2001) (Appendix 11)

The purpose of this scale is to determine the extent to which a patient suffers from myofascial pain syndrome. The scale is rated out of 17points. A score of 9 is considered indicative of latent trigger points. Even though the MDS is not fully validated, it appears from various studies to be the most appropriate tool that can be applied to achieve a consistent result. (Dippenaar 2003, Cumming 2003, Walker 2002). This scale was applied to all the trigger points located in the QF muscle at each consultation.

3.5.1.1.c. **Algometer:** (Appendix 12)

Reeves et al. (1986), and Fischer (1986) demonstrated the reliability and validity of the pressure algometer in measuring myofascial trigger point sensitivity. The algometer chosen for this study is the force dial manufactured by Wagner Instruments: P.O. Box 1217 Greenwich CT 06836 as its pressure range measures kilograms as opposed to Newton meters which is preferable for this study.

The MTrp was located through palpation of the quadriceps femoris muscle. The footplate was placed over the MTrp with the shaft exerting pressure in the direction of the pain produced on palpation. The gauge was then turned away from the patient and pressure was applied at a rate of approximately 1kg / cm squared / second. The patient was informed to indicate when pain was first perceived by saying “yes”. At this response, the instrument was removed and the reading recorded in kg per square centimetre.

The total number of MTrp's was noted and the mean weight in kg was calculated by dividing the average algometer reading by the number of MTrp's present.

3.5.1.1.d. **Cybex 700 Isokinetic Dynanometer at King's Park Sports Medical Centre**

(under the supervision of Mr J. Wright, HonsB(Biokinetics)).

The isokinetic dynamometer was used to measure concentric quadriceps total work .

(i) Patient Positioning

- Subjects were seated in a comfortable position to allow a Maximum of 90 degrees hip flexion.
- Straps were placed over the shoulders, waist and the leg Being tested to stablilise the torso and the limb.
- The axis of the power hand as aligned with the axis of the Knee joint.
- The tibial pad was placed proximal to the medial malleolus.
- Patients were instructed to grip the handles of the machine At all times.
- Strict standard verbal instruction was provided.
- Patients were allowed to see the computer screen during Testing.
- Patients were given standard, scripted verbal encouragement while performing the test.
- All data with regard to patient position and machine set up was recorded and repeated on subsequent test sessions.

(ii) Patient Procedure

Methodology with the use of the Cybex 700 Isokinetic Dynanometer, as recommended by Wright, included:

- 5 minute warm-up on an exercise bicycle
- Quadriceps and Hamstring stretches for 15 seconds repeated 3 times.
- 4 – 6 sub-maximal warm-up repetitions on the Cybex 700 Isokinetic Dynanometer in order to customize the participant to the machine.
- Actual test will consist of 6 maximum efforts where an average of the 6 repetitions will be taken for the entire quadriceps muscle, the VL and the VMO individually.

Gravity correction was used in order to eliminate confounding errors due to the weight of the limb being tested (Perrin 1993: 39; Chan and Maffulli 1996: 16).

The cybex machine used was calibrated weekly for the duration of the study (Clifton 2003).

(iii) Reliability and Validity of an Isokinetic Dynamometer

Davies (1992:35) states that several studies have been conducted confirming reliability and validity of the Cybex, and that it is possible to isolate knee extensor muscle groups using an Isokinetic Dynamometer. Callaghan et al. (2000) demonstrated that individuals suffering from PFPS were weaker than their healthy counterparts when examining peak torque values on a Biodex system 2 Dynanometer, using a multiple joint attachment.

According to Marridd (1996:11), Isokinetics can be used in the diagnosis of injuries, as with anterior knee pain which tend to result in a torque curve which is dramatically flattened with a wavy plateau occurring through the mid-range of motion (ROM) as opposed to being peaked as seen in an uninjured knee (Marridd, N 1996). In conclusion, Callaghan et al. (2000), stated that researches should have confidence in using a multi-joint device, ie: Cybex 700, when testing patients with PFPS.

According to Davies (1992:p62), one of four factors that appear to be most specific in demonstrating "weakness" existing in a muscle is the Total Work (TW) of the quadriceps. This is dependant on the subject's muscular power capability at the test velocity, as well as available anaerobic energy stores and pH tolerance in the working muscles (Davies, 1992). The total area underneath the curve is the TW of the torque curve with each repetition regardless of speed, range of motion or time (Davies, 1992:p59).

Isokinetic measurement is considered the most appropriate tool as a direct indicator of functional status.

3.5.1.2 Subjective Measurements:

3.5.1.2.a. The Numerical Rating Scale (NRS): (Appendix 9)

The NRS assesses the patient's perception of their pain intensity. The questionnaire consists of a numerical scale of eleven points with 10 representing pain at it's worst and 0 representing no pain. Liggins (1989) states that the NRS is the most appropriate method of rating pain intensity without comparison.

3.5.1.2.b. **The Patient Specific Functional Scale (PSFS):** (Appendix 10)

Chatman et al. (1997) found the PSFS to be an appropriate tool for assessing changes in disability.

3.6. Statistical Analysis:

Data were captured in MS Excel and exported into SPSS version 12 (SPSS inc. Chicago, Ill) for analysis.

Descriptive analysis was achieved by frequency tabulations of categorical variables and calculation of means, medians and standard deviations in the case of quantitative variables.

Comparison of categorical variables between independent groups: chi - square or Fisher's exact tests where appropriate.
Quantitative variables were checked for normality using the skewness statistic and its standard error. Comparison of quantitative variables between two independent groups: t-test or Mann-Whitney test where appropriate
Pearson's correlation coefficients were calculated to assess correlation between two quantitative variables.
Repeated measures ANOVA was used to compare the two treatment groups over the three visits with regards to quantitative outcomes.

Hypothesis testing decision rule: a two tailed p value of <0.05 was considered statistically significant.

3.7 Ethics:

The ethical procedures were adhered to in accordance with the Durban Institute of Technology guidelines.

Each patient was required to complete and sign an informed consent form (Appendix 4). The research involved no more than minimal risk and all information was treated as confidential.

CHAPTER FOUR

RESULTS AND DISCUSSION:

4.0 Introduction:

This chapter involves the discussion of the demographic data and the results after the statistical analysis of the data obtained from the subjective (NRS and the Patellofemoral Pain Severity Scale) and objective (algometer readings, Myofascial Diagnostic Scale readings and Cybex 700 Isokinetic Dynamometer readings) correlation tests. Problems encountered through the course of this study are also discussed in this chapter.

The results will be discussed in four parts:

- Demographic Data
- Baseline comparisons of outcomes
- Correlation comparisons
- Change in outcome measurements over time and between groups

4.1 Criteria Governing the Admissibility of Data:

Data was collected only from those patients who met the research criteria and who participated for the full duration of the research program. Only subjective pain perception data that was completed under the supervision of the researcher were utilized. Only objective algometer readings, Myofascial Diagnostic Scale readings, location of MTrp's readings and Cybex 700 Isokinetic Dynamometer readings, taken by the researcher were utilized.

4.2 Demographics Data:

Forty participants between the ages of 21 and 58 were selected for the trial and randomized into two groups. Demographic characteristics which differed between the two groups were height and weight, where group A consisted of taller and heavier subjects than group B. This may be explained by the fact that there were significantly more males in group A than in group B (p=0.029). The majority of participants were white (82.5%). The demographics between the groups are shown in Table 1.

Table 1: Comparison of demographic characteristics between the two groups (n=40)

Variable	Group A	Group B	P value
Age: mean (SD)	34.4 (10.08)	33.0 (10.58)	0.671
Height (m) : mean (SD)	1.76 (0.97)	1.67 (0.11)	**0.006**
Weight (Kg): mean (SD)	75.45 (15.44)	62.85 (11.41)	**0.006**
Distance per week (Km)	33.0 (15.08)	40.75 (18.08)	0.149
Gender :n (%) male	14 (70)	7(35)	**0.027**
Race: n (%) white	17 (85)	16 (80)	0.387

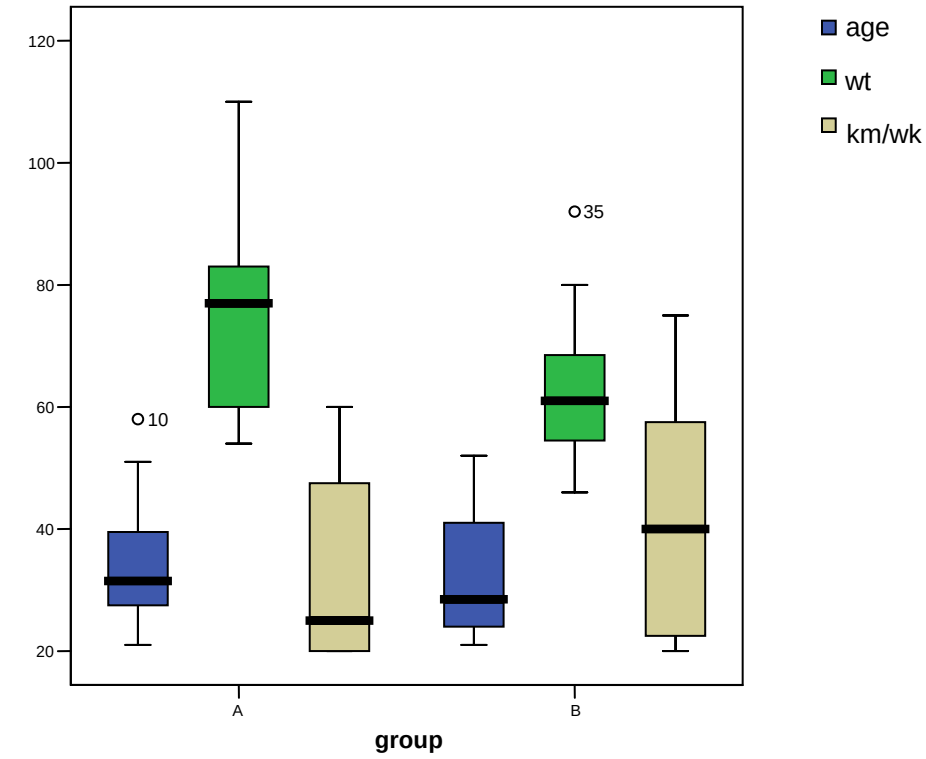

Figure 5: Boxplot of age, weight and distance run per week by group

4.2.1 Age Distribution:

Figure 5 above, shows that the mean age for participants in group A and B was 34 years and 33 years respectively. It does not appear to correlate well with the general picture of PFPS, which is frequently seen in young athletes, with subjects mostly between the ages of 10-20 years (Kannus et al., 1999), however, this is also a function of the age restrictions that were used as part of this study.

In terms of the MPS, there seems to be a greater correlation. Han and Harrison (1997) state that people between the ages of 30 – 49 are more commonly plagued by the condition, which then decreases with age, since, with advancing age, comes reduced activity and stiffness and restricted range of motion of latent

MFTrP's becomes more prominent that the pain of active MFTrP's (Travell, Simons and Simons, 1999 1:13).

4.2.2 Weight and Height Distribution:

In table 1, above, it is shown that there is a statistical difference in height and weight between the two groups. Group A has a mean height of 1,76m and a mean weight of 75,45kg, where as group B has a mean height of 1,67m and a mean weight of 63,85kg. This is largely due to the fact that there were more males in group A, and more females in group B.

4.2.3 Distance Distribution:

Although not statistically significant, figure one does exhibit a slight increase in the average number of kilometers run per week by the subjects in group B.
The effect may be twofold:

1) It may contribute to PFPS since the slight increase in mileage may lead to a larger degree of weight-bearing impact, which could exacerbate PFPS symptoms to a greater degree in group B; or
2) An increase in weekly mileage could lead to greater muscle conditioning, which is less likely to develop into MFPS.

The fact that MFPS is less common in laborers than in sedentary workers implies a protective effect of daily vigorous activity (Han and Harrison, 1997: 90).

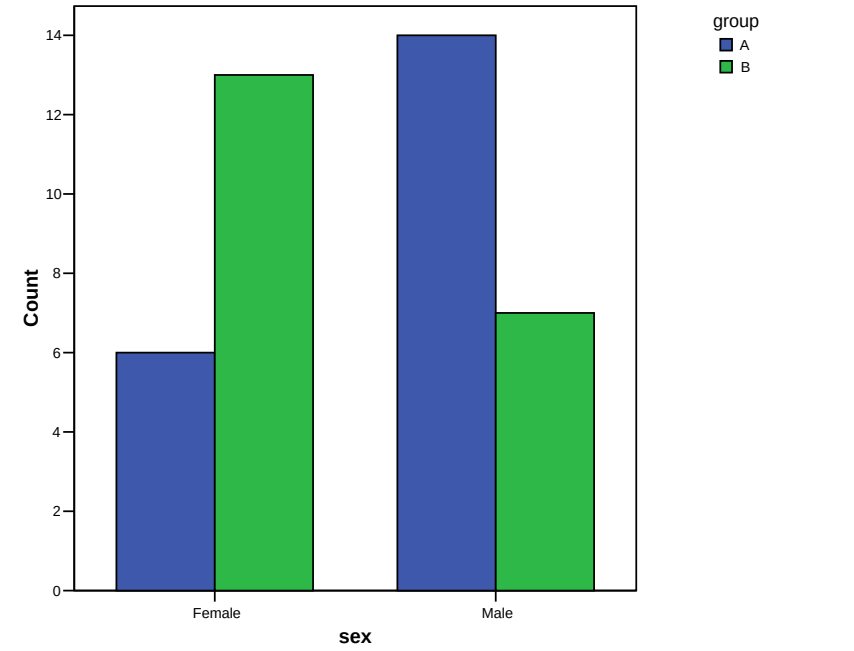

Figure 6: Frequency of males and females by group

4.2.4 Gender Distribution:

In fig.6 above, the results show that in group A, 70% of the participants were male, and 30% were female, and in group B, 35% of the participants were male, and 65% were female.

Hou et al., (2002:1411-1412) report that Myofascial Pain Syndrome occurs in both sexes, however it appears to be more common in females.

This predominance of female presentations seems to be prevalent in PFPS as well, where it is significantly common in female athletes (Salem and Powers, 2001). Davidson (1993) also commented on the higher incidence amongst women. In contrast to this Powers et al. (1996) state that the incidence of PFPS is greater in males than in females when athletes are considered and to

complicate matters Blond and Hansen (1998) state that the prognosis for males was more than twice as good compared to females with regard to PFPS.

4.3 Baseline Comparison Of Outcomes

The outcomes measured were NRS, PSFS, Algometer, Cybex and MDS. It is important to assess if there were any baseline differences in the measurements, since further changes over time could only be attributed to the intervention or placebo if the groups were equivalent at baseline. Due to the randomization process, no baseline differences were expected. T-tests were done since the scores were relatively normally distributed.

4.3.1 NRS Scores:

There was no significant difference in mean NRS score at baseline between the two groups (p=0.337). This is shown in Table 2.

Table 2: Independent samples t-test for the difference in mean NRS at baseline

	Mean (SD) NRS baseline	t	df	p. (2-tailed)
Group A	43.35 (10.12)	-.972	38	.337
Group B	47.50 (16.18)			

4.3.2 PSFS Scores:

There was no difference between the mean PSFS scores at baseline between the groups. See Table 3.

Table 3: Independent Samples t-Test of mean PSFS scores between groups at baseline

	GROUP	Mean (SD)	t	df	p. (2-tailed)
PSFS RUNNING	A	5.13 (2.316)	.375	38	.710
	B	4.85 (2.323)			
PSFS STAIR CLIMBING	A	5.25 (2.381)	.417	38	.679
	B	4.95 (2.164)			
PSFS SITTING	A	5.50 (2.705)	.456	38	.651
	B	5.15 (2.110)			

4.3.3 Algometer Readings:

The mean VL algometer reading at baseline was significantly different between the two groups (p = 0.030). Group A had a higher mean than group B. For VM there was no difference at baseline. This is shown in Table 4. There were significantly more females in group B (n=13). Travell and Simons (1999: 27) state that the absolute value obtained at any one site can be strongly influenced by variations in the thickness and compliance of subcutaneous tissues from subject to subject. According to this, factors such as body weight may play a role in pain sensitivity.

Campbell (2004) confirmed that women are more sensitive to pain than men.

Table 4: Independent Samples t-Test of mean algometer readings between groups at baseline

	GROUP	Mean (SD)	t	df	p. (2-tailed)
Algometer mean VL pre visit 1	A	7.01 (1.71)	2.261	38	**.030**
	B	5.90 (1.38)			
Algometer mean VM pre visit 1	A	6.16 (2.16)	.846	37	.403
	B	5.63 (1.74)			

4.3.4 MDS Scores:

There was no significant difference in mean MDS scores for VL or VM trigger points at baseline. See Table 5

Table 5: Independent Samples t-Test of mean MDS score difference between the groups at baseline

	GROUP	Mean (SD)	t	df	Sig. (2-tailed)
mds vl mean visit1	A	10.98 (1.92)	1.211	38	.233
	B	9.92 (2.06)			
mds vm mean visit1	A	7.20 (2.01)	-.322	38	.749
	B	7.28 (3.25)			

4.3.5 Cybex 700 Isokinetic Dynamometer Readings

Neutral position: There was a significant difference between the groups with regard to work in joules and set work (p = 0.019 and p = 0.022 respectively). This is shown in Table 6. In both cases group A had higher values.
External position: There was a significant difference in baseline external Cybex readings for joules, percent and set work. This is shown in Table 7. Once again group A had higher values.
Internal position: Similarly all baseline internal readings were significantly higher in group A than in group B, as shown in Table 8.

Since there were significantly more males in group A, total work in joules and set work were expected to be higher. This is influenced by the increase in average height and weight of this group. This suggests incomplete randomization into groups A and B. However, it is not as significant in a repeated measures study design as all subjects acted as their own controls.

Table 6: Independent Samples t-Test for mean differences between baseline neutral position Cybex readings

	GROUP	Mean (SD)	T	df	p. (2-tailed)
neutral pre joules	A	150.5 (54.2)	2.451	38	**.019**
	B	111.25 (46.8)			
neutral pre percent	A	199.14 (54.03)	1.770	38	.085
	B	169.00 (53.67)			
neutral pre set	A	820.70 (304.35)	2.384	38	**.022**
	B	602.95 (272.53)			

Table 7: Independent Samples t-Test for mean differences between baseline external position Cybex readings

	GROUP	Mean (SD)	t	Df	p. (2-tailed)
ext pre joules	A	127.60 (45.9)	2.814	38	**.008**
	B	88.7 (41.5)			
ext pre percent	A	169.32 (45.46)	2.081	38	**.044**
	B	139.97 (43.73)			
ext pre set	A	697.3 (255.68)	2.851	38	**.007**
	B	478.30 (229.44)			

Table 8: Independent Samples t-Test for mean differences between baseline internal position Cybex readings

	GROUP	Mean (SD)	t	df	Sig. (2-tailed)
int pre joules	A	140.10 (40.41)	3.635	38	**.001**
	B	95.20 (37.66)			
int pre percent	A	187.23 (35.25)	3.149	38	**.003**
	B	148.85 (41.57)			
int pre set	A	775.65 (227.50)	3.709	38	**.001**
	B	516.60 (214.05)			

4.4 Correlation between Outcome Measurements:

Baseline outcome measures were correlated against each other in order to assess the relationships between the various outcome measurements. This is shown in Appendix 14-16)

4.4.1 Correlation between NRS and MDS readings for VM Trigger points: (Appendix 13)

The NRS was positively correlated with MDS for VM trigger points (correlation coefficient 0.336, p =0.034) but not with MDS for VL trigger points at baseline. This meant that an increase in pain (NRS) was only associated with an increase in VM MTrp severity (MDS).

Patellofemoral Pain Syndrome is defined as a syndrome that may develop due to repetitive trauma (Davidson, 1993), which indicates that prior to the musculature developing overt clinical signs and symptoms; there is inherent musculature overload (or repetitive overuse). This would, in theory, support the development of latent MTrp's in the initial sub-clinical overload phase of the condition and the presence of active MTrp's at that point where the PFPS becomes an overt clinical syndrome.

This supports a finding by Dippenaar (2003) who noted that latent myofascial trigger points in the VMO only occurred in the presence of active myofascial trigger points in the VL. The implication is that the presentation of VM signs and symptoms (referred pain deep in the knee joint which often interrupts sleep; knee buckling; and, weakness of knee extension) may actually be secondary to the development of the myofascial component of the VL.

MTrp tension in the distal portion of the vastus lateralis muscle may result in loss of normal patella movement especially in a medial direction (Travell and Simons, 1983:267; Chaitow and Delany, 2002:484). Dippenaar (2003) states that a similar motion restriction pattern can be seen on the medial aspect, where it was found that the distal portion of the vastus medialis also contained a significant number of active MTrp's and was associated with aberrant motion.

Therefore, the correlation between an increase in knee pain and VM MDS may be an indication of the chronicity of MFPS. This would also explain the negative correlation between the NRS and some of the cybex measurements such as percent work in the neutral position, and set work and work in joules in the externally rotated position. Although these are not strong correlations, it does imply that as the VM MDS score increased, total work decreased in the VM (externally rotated position) and in the rest of the quadratus femoris muscle (neutral position) due to painful inhibition and apprehension whilst performing the test.

The negative correlation between NRS and VL MDS readings may again support the development of latent MTrp's in the initial sub-clinical overload phase of the condition and the presence of active MTrp's at that point where the PFPS becomes an overt clinical syndrome. It may also indicate that the clinical pain perceived by the patient does not originate from the VL trigger points but from another source.

4.4.1 Correlation between PSFS scores: (Appendix 14)

PSFS scores were not correlated with NRS scores.
The lack of correlation between NRS and PSFS readings may indicate latency of MTrp's in the VL / VMO, since these trigger points are clinically quiescent with respect to spontaneous pain. A latent trigger point may have all the other clinical characteristics of an active trigger point and always has a taut band that increases muscle tension and restricts range of motion (Travell and Simons, 1999: 4).

PSFS scores were all positively correlated with each other, except between running and sitting. This means that subjects experienced equal difficulty with stair – climbing, as with prolonged sitting, and stair – climbing and running, but that running was not hindered to the same extent as sitting.

There was a negative correlation between MDS VM measurement and PSFS scores for running (correlation coefficient -0.392, p = **0.012**), implying that as VM MDS scores increased, PSFS for running decreased. This indicates that as the severity of MFPS increased, so running comfort and performance decreased.

Pain during activities such as stair-climbing, sitting and running, has been linked with Patellofemoral Pain Syndrome, and has also been shown to increase the likelihood / aggravate myofascial trigger points. This is especially true of the MTrp's of the quadriceps femoris muscle that result from strenuous athletic activity such as running (Travell and Simons, 1999: 265).

Running results in a repeated weight-bearing impact, which contributes to PFPS, whilst the pain experienced during deep knee bends and prolonged sitting is due to an increase in pressure between the patella and its various points of contact with the femur. This, according to Juhn (1999), is an indication of PFPS and confirmed by studies in respect of the patellofemoral joint reaction force (PFJRF), which is a measure of the compression of the patella against the femoral condyles and depends on the angle of flexion of the knee and the muscle tension (Hungerford and Lennox, 1983).

Therefore, the correlations between PSFS scores for:

a) stair - climbing and sitting and
b) stair – climbing and running are similar.

These activities all require a reasonable degree of knee flexion, and may indicate the presence of latent VL / VMO MTrp's, causing a shortening of the muscles, resulting in an uneven pull on the patella, generating an increase in pressure between the patella and its various points of contact with the femur.

Various factors may contribute to the negative correlation between VM MDS scores and PSFS for running. One of which is, Melzack and Walls' Gate Control theory, whereby the runner is engaged in a variety of stimuli whilst on a run, thereby detracting from the original source of pain stimulus. To date, the studies have pointed to endorphins (endogenous opioids) as the chemical mediators of the effects of exercise on a variety of physiological parameters including increased pain thresholds, improved psychological states, and increased immunity (Jonsdottir et al. 1997).

A biomechanical explanation may be that during a run, the quadriceps femoris muscles are warmed up, there is an increase in tissue oxygenation, and muscle fibers are lengthened, thereby decreasing the lateral pull on the patella, and reducing patella shear forces. The myofascial pain syndrome argument, is further supported by Thomee et al. (1999), who state that the most common symptom of PFPS is pain during and after physical activity, during body weight loading of lower extremities.

This may then suggest that with respect to functional ability, the PSFS seems to measure MTrp's activity rather than PFPS presentation. It is therefore queried whether the PSFS is a scale that has been developed through clinical experience with an entity known as PFPS, without being specific enough to isolate the PFPS from other known clinical entities. Thus further research is needed to clarify this PSF scale.

4.4.2 Correlation between Algometer readings in VL and VM And Cybex readings: (Appendix 15)

Algometer readings for VL were positively correlated with the cybex readings in Table 10. This indicates that as Algometer readings decreased, due to an increase in pain, muscle inhibition increased (Suter et al., 1998) thereby decreasing Total Work.

The converse also applies in that as Algometer readings increased due to a decrease in pain sensitivity, cybex readings increased. So, as the muscles became less tender, they were able to exert more power in terms of Total Work.

This is explained by the fact that the algometer functions by exerting pressure to the muscle, thereby exacerbating the already sensitive tissues (Dippenaar, 2003) Therefore on active (acutely painful) MTrp's, the algometer gave a decreased algometer (pressure) reading.

The correlation between NRS readings and VM MDS scores (as discussed in 4.4.1), and VL algometer reading correlations with cybex measures, once again may be an indication of chronicity (4.4.1), since at this stage, active MTrp's are acutely painful in the VL and VM portions of the quadriceps femoris muscle.

In a study of subjects with PFPS, Suter et al. (1998) demonstrated that quadriceps femoris muscle inhibition was closely associated with anterior knee pain. Bennett and Strauber (1986) suggest that a loss of eccentric quadriceps torque may be specific to subjects with PFPS. However, it must also be noted that patients with MFPS may complain of decreased range of motion and as a result, a decrease in muscle strength (Han and Harrison, 1997:92), this is supported by Travell, Simons and Simons (1999 1:21), who state that patients with MFPS have motor disturbances, which include:

- Muscle weakness,
- Spasm of synergistic and/or antagonistic muscles and
- Decreased muscle power or work tolerance.

The correlation between myofascial pain and a decrease in Total work seems to suggest the presence of active or latent MTrp's.
MDS scores for VL were not correlated with any other outcome measure at baseline.

4.4.3 **Correlations between Cybex readings:** (Appendix 16, 17 & 18)

The cybex measurements were mostly all highly correlated with the other cybex measurements. It is unclear as to why this phenomenon is present. It may be due to the chronicity of the knee pain, however, it is surprising to note such a high correlation between the various positions, considering that NRS, PSFS and VL algometer readings are only correlated with TW measured in the neutral and externally rotated position.

This finding may support the suggestion by Dippenaar (2003), that VM signs and symptoms are secondary to VL signs and symptoms, implying that weakness (decreased TW), due to latent MTrps in the sub-clinical phase of MFPS, may already exist in the VL, when pain and weakness is initiated in VM.

Continued research is thus necessary to establish whether timing differences actually exist in this population (Powers, Landel and Perry. 1996), as studies do not form any consensus as to the supposed role of the VMO: VL ratio and its supposed role in the etiology of PFPS (Callaghan and Oldham. 1996). Such studies may need to consider that VMO dominance may be a personal trait with large inter-individual variance (Callaghan and Oldham. 1996).

The following observations of Sczepanski et al, (1991), may need further investigation in this context:

- Performance of isokinetic exercise through a 60º to 85º arc of motion is more effective at selectively activating VMO than VL.
- Eccentric rather than concentric exercise may be better at selectively activating VMO dependent on angular velocity.

A larger sample size is also necessary for a more accurate analysis.

4.5 Change in Outcome Measurements over Time and Between Groups:

4.5.1 NRS Scores:

Repeated measures ANOVA was used to assess if:

a) there was an overall change in time in the groups (time effect)
b) there was an overall difference between the groups (group effect)
c) the rate of change over time was different between the groups (group*time interaction).

Table 9: Results of hypothesis tests for repeated measures ANOVA for NRS

Effect	statistic	p value
Time	Wilk's lambda 0.591	<0.001
Group	F=2.472	0.124
Time*group	Wilk's lambda 0.938	0.732

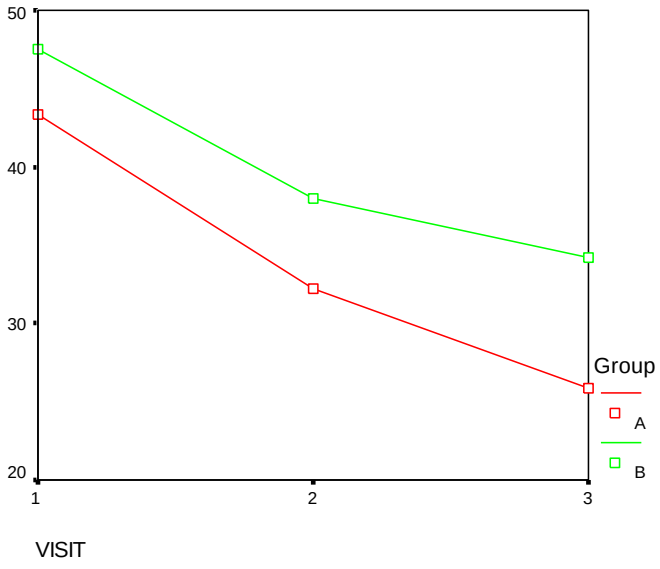

Figure 7: Mean NRS over time by group

From Table 9 it can be seen that there was a significant effect of time in both groups overall (p<0.001), but no difference between the groups, nor time group

interaction. This means that both groups experienced a significant decrease in NRS score over the 3 visits, however, the graph for group B seems to flatten between treatment 2 and 3, compared to a slightly steeper descent in group A. This difference may not be significant, but it does indicate that the treatment group showed a slightly greater improvement in pain intensity.

The outcome evident in group B may be an indication of the natural course of PFPS. Juhn (1999) states that spontaneous resolution of PFPS pain may occur, although many patients have already tried a "wait and see" approach by the time they seek medical attention. It is also possible that patients may have wanted to please the researcher by reporting an improvement of pain intensity after "treatment".
As discussed in point 4.5.3.2, the researcher suggests that the algometer may have had a significant treatment effect on the active MTrps in both groups, which may also explain why NRS readings improved in both groups over time.

4.5.2 PSFS Scores:

Table 10: Results of hypothesis tests for repeated measures ANOVA for PSFS: Running

Effect	statistic	p value
Time	Wilk's lambda 0.630	<0.001
Group	F=0.00	0.898
Time*group	Wilk's lambda 0.990	0.829

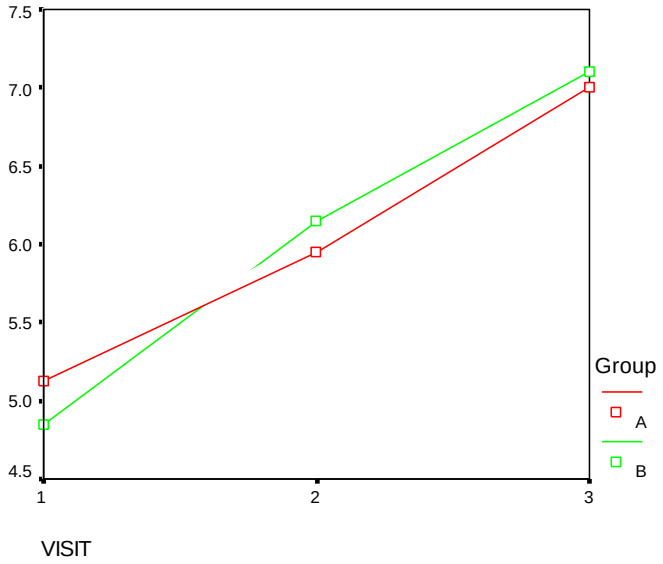

Figure 8: Mean PSFS: Running over time by group

Table 10 shows that both groups changed significantly over time but there were no differences, between the groups, nor in the rate of change between the groups (p = 0.829). This is mirrored in Figure 8.

Table 11: Results of hypothesis tests for repeated measures ANOVA for PSFS: Stair climbing

Effect	statistic	p value
Time	Wilk's lambda 0.756	0.006
Group	F=0.075	0.786
Time*group	Wilk's lambda 0.957	0.441

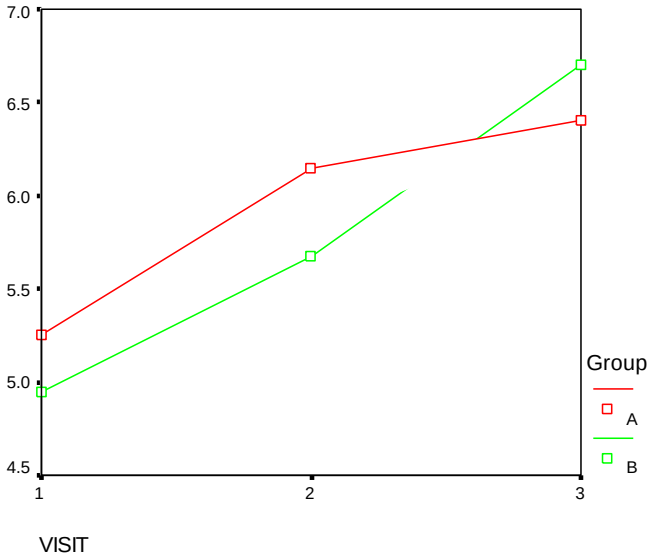

Figure 9: Mean PSFS: Stair climbing over time by group

There was a significant time effect in both groups but no differences between the groups or in the rate of change with time (p = 0.441). In Figure 9 and 10, it shows that both groups increased at the same rate between visit 1 and 2, but group A started to level off to visit 3. Although this is not significant, it could possibly indicate stiffness in the VL following dry - needling, a normal phenomenon referred to as post-needle stiffness.

This, as seen in figure 8, is not as marked whilst running, and as previously discussed, may have a biomechanical explanation, in that jogging would warm and lengthen the muscle and help to relieve the stiffness.

Sitting and stair - climbing also require greater degrees of knee flexion than jogging, so the degree of stiffness would most likely be more pronounced. (Hungerford and Lennox, 1983).

Table 12: Results of hypothesis tests for repeated measures ANOVA for PSFS: Sitting

Effect	statistic	p value
Time	Wilk's lambda 0.846	0.045
Group	F=1.233	0.274
Time*group	Wilk's lambda 0.977	0.655

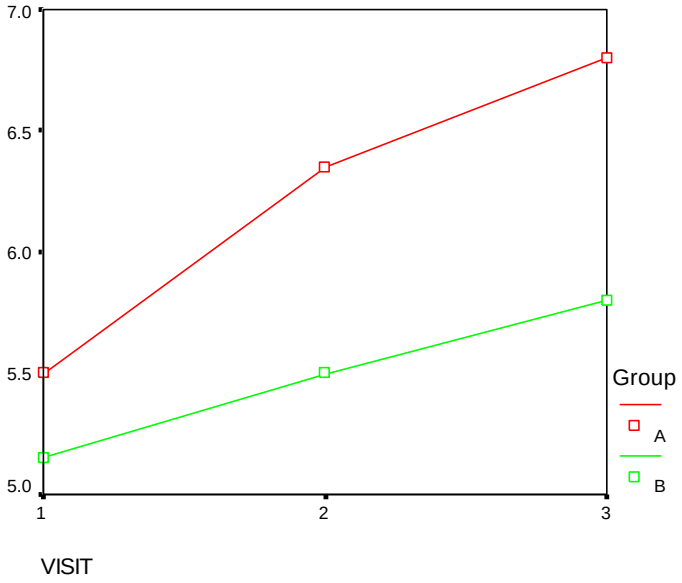

Figure 10: Mean PSFS: Sitting by group over time

For sitting, there was a significant change over time in both groups and once again no significant difference between the groups or in the rate of change over time. Figure 10 shows that group A appears to increase at a faster rate than B but this is not significant (p = 0.274).

Although there was no significant change evident in figure 10 between the two groups, group A did however change at a faster rate. This may be an effect of treatment on the active MTrps of VL, lengthening this muscle, easing the uneven pull on the patella, thereby decreasing the pain, and increasing the patient's ability to sit.

This may then suggest that with respect to functional ability, the PSFS seems to measure MTrp's activity rather than PFPS presentation. It is therefore queried whether the PSFS is a scale that has been developed through clinical experience with an entity known as PFPS, without being specific enough to isolate the PFPS from other known clinical entities. Thus further research is needed to clarify this PFP scale.

4.5.3 Algometer Readings:

For algometer readings, an additional within-subjects measurement was added to the repeated measures model: the pre and post reading to assess if there was a change pre and post treatment within a visit.

Table 13: Results of hypothesis tests for repeated measures ANOVA for Algometer readings for VL trigger points

Effect	statistic	p value
Time	Wilk's lambda 0.867	0.072
Group	F=60.96	0.035
Time*group	Wilk's lambda 0.969	0.562
Pre and post	Wilk's lambda 0.800	0.004
Pre and post * group	Wilk's lambda 0.958	0.203
Pre and post * visit	Wilk's lambda 0.998	0.964

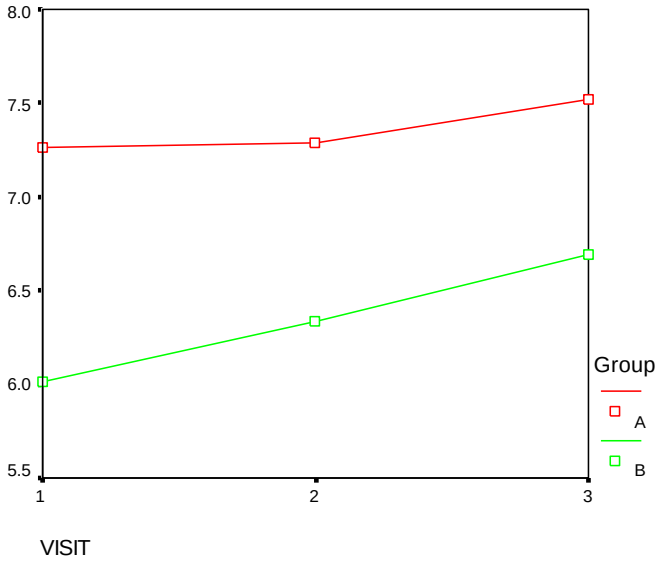

Figure 11: Mean VL algometer readings over 3 visits by group

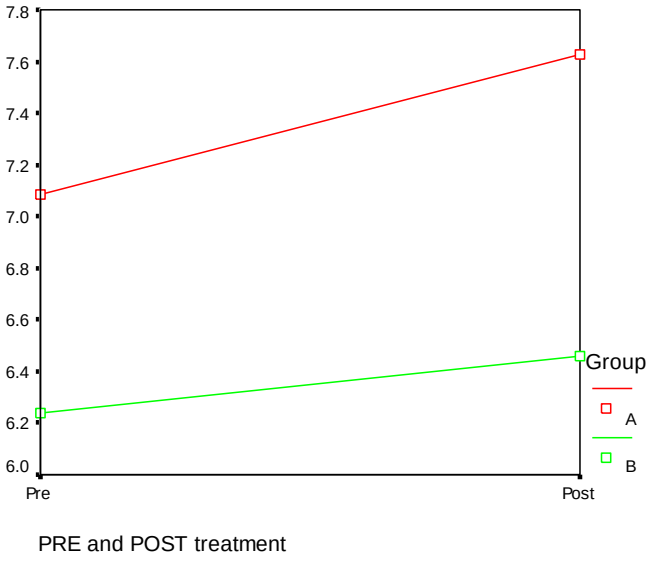

Figure 12: Mean algometer reading for VL pre and post treatment by group

4.5.3.1 VL:

There was a significant change from pre to post treatment in both groups (p = 0.004). Figure 12 shows that both group's scores increased from pre to post treatment. There was no significant interaction between group and pre and post

(p=0.203), indicating that both groups increased at the same rate from pre to post treatment.

There was also a significant difference between the two groups at all time points (group effect p = 0.035). This can be seen in Figure 11 since the readings of group A are at all times higher than those of group B. This is not an indication of treatment effect but rather an artifact of the higher baseline readings in group A.

The initial lack of change seen in Group A (fig. 11) between the first two treatments, may be due to microtrauma and slight bruising following dry-needling, which would increase pain sensitivity.

Table 14: Results of hypothesis tests for repeated measures ANOVA for Algometer readings for VM trigger points

Effect	statistic	p value
Time	Wilk's lambda 0.787	0.044
Group	F=64.34	0.022
Time*group	Wilk's lambda 0.983	0.789
Pre and post	Wilk's lambda 0.636	0.001
Pre and post * group	Wilk's lambda 0.933	0.175
Pre and post * visit	Wilk's lambda 0.906	0.278

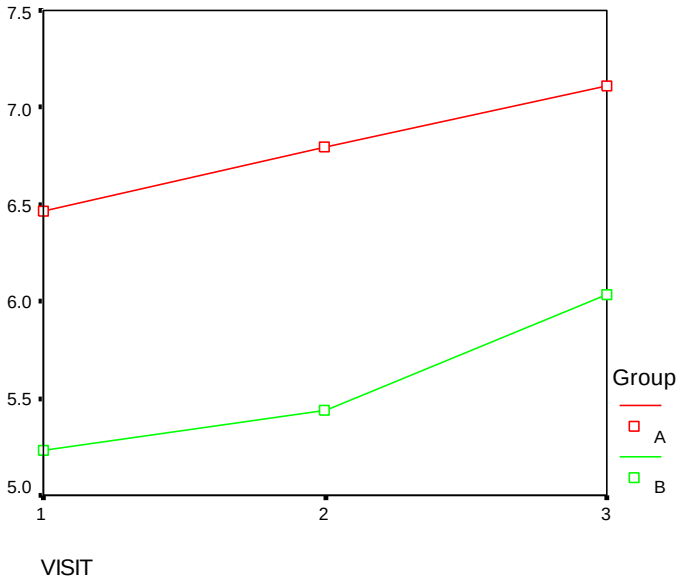

Figure 13: Mean VM algometer readings over 3 visits by group

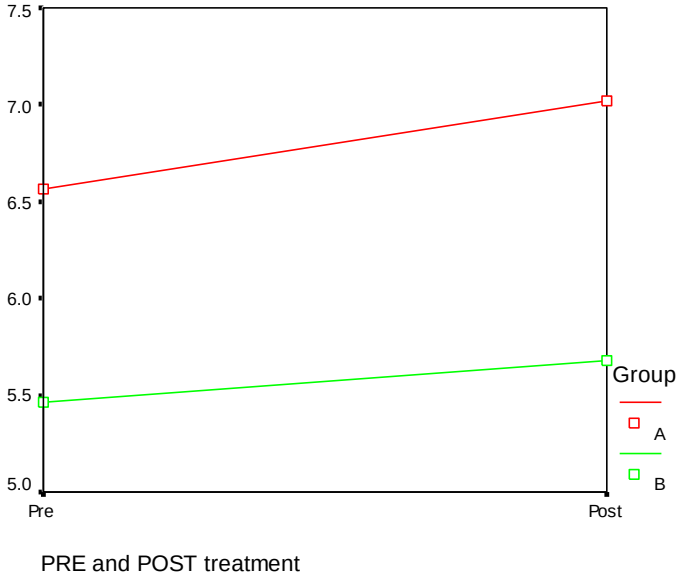

Figure 14: Mean algometer reading for VM pre and post treatment by group

4.5.3.2 VM

There was a significant time effect overall (p = 0.044) and a significant group effect over all (p = 0.022). Thus both groups changed with time and at all time

points one group (Group A) was always higher than the other group. There was also a significant increase in mean algometer readings from pre to post treatment ($p = 0.001$) but this was not dependent on the group or the visit. This is reflected in the figures above.

The algometer was not the most appropriate measuring tool for this study, as it may have acted as a significant treatment modality. Readings were taken 6 times over the course of the study (before and after each treatment). The researcher observed large twitch responses in the VL muscle of both groups during the first 2 treatments. This may explain the significant improvement of both groups over time, as well as the improvements in PSFS scores and NRS readings, as the probing action of the algometer head may have had a significant treatment effect on active TrP's in both groups.

Reeves et al. (1985) indicate that the repeated application of pressure greater than "just noticeable" or "threshold", may alter trigger point sensitivity, thus confounding the measurement process.

This finding supports Boucher's (1992) suggestion, that an important neuromuscular imbalance between the VMO and VL is associated with PFPS, as it seems to show that VM is reflexly inhibited by VL, as VM signs and symptoms improved when VL was treated.

It is recommended that future studies look at developing another tool for the measurement of objective pain rating.

4.5.4 Cybex measurements:

Cybex measurements were taken once prior to treatment (at baseline) and once after all three visits. Thus there were only 2 time points for Cybex readings. The objective was to assess if there was any change over time in each of the

positions (neutral, internal and external) by group and to assess if the changes in each of the positions were different depending on group. Thus a new within-subjects effect of position was added to the repeated measures ANOVA.

Table 15: Results of hypothesis tests for repeated measures ANOVA for Cybex measurements for Work in Joules

Effect	statistic	p value
Time	Wilk's lambda 0.746	**0.001**
Group	F=9.361	**0.004**
Time*group	Wilk's lambda 0.985	0.746
Position	Wilk's lambda 0.373	**<0.001**
Position * group	Wilk's lambda 0.977	0.651
Position *visit	Wilk's lambda 0.935	0.289

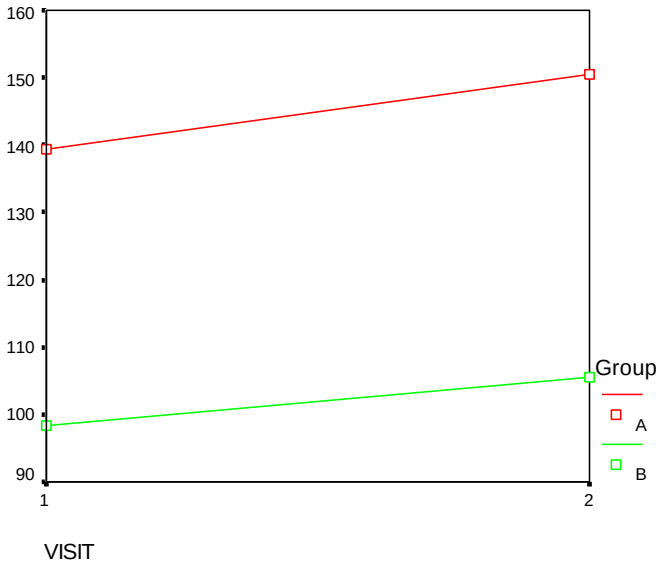

Figure 15: Mean work in Joules at two visits by group

4.5.4.1 Work in Joules:

There was a significant change over time in all groups (**p =0.001**) for work in joules. There was also a significant group effect (**p = 0.004**) which was not dependant on time (p = 0.746), thus at all time points one group (Group A) was higher than the other, which is not indicative of a treatment effect, but as

previously mentioned, group A had more male participants, with a greater average height and weight, which would result in a greater work output. There was also a significant position effect, which was not dependant on time or group. Thus the neutral position had higher readings at all time points, followed by the internal position and lastly external position. Key: position 1 = neutral, 2 = external, 3 = internal.

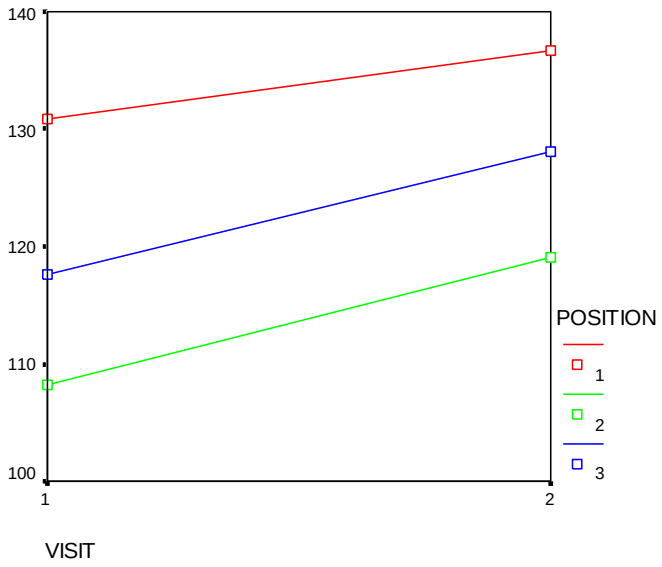

Figure 16: Mean work in Joules over two visits by position

Table 16: Results of hypothesis tests for repeated measures ANOVA for Cybex measurements for Work in Percent

Effect	Statistic	p value
Time	Wilk's lambda 0.745	**0.001**
Group	F=6.023	**0.019**
Time*group	Wilk's lambda 0.998	0.768
Position	Wilk's lambda 0.474	**<0.001**
Position * group	Wilk's lambda 0.980	0.691
Position *visit	Wilk's lambda 0.980	0.694

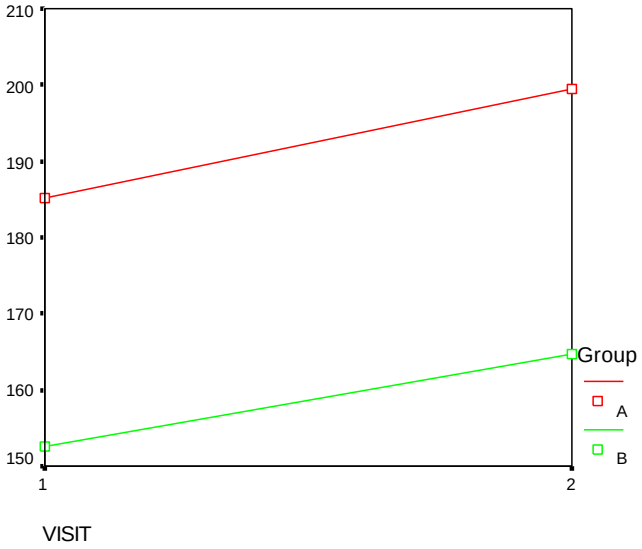

Figure 17: Mean work in percent over two visits by group

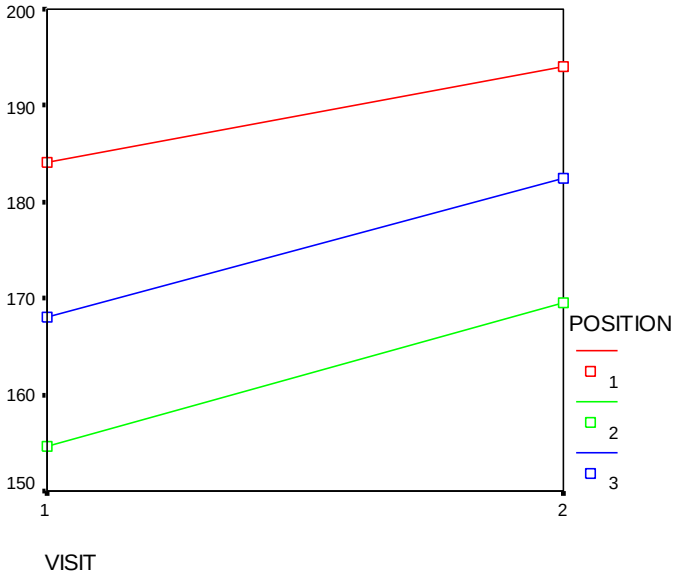

Figure 18: Mean work in percent over two visits by position

4.5.4.2 Work in Percent:

As with work in joules, there was a significant time and group effect, as well as a significant position effect (**p<0.001**) for work in percent. Thus there was no

treatment effect but both groups changed over time and the positions were significantly different to each other at all time points, independently of time or group.

Table 17: Results of hypothesis tests for repeated measures ANOVA for Cybex measurements for Work Set

Effect	statistic	p value
Time	Wilk's lambda 0.760	**0.002**
Group	F=7.99	**0.008**
Time*group	Wilk's lambda 0.992	0.595
Position	Wilk's lambda 0.414	**<0.001**
Position * group	Wilk's lambda 0.972	0.597
Position *visit	Wilk's lambda 0.970	0.580

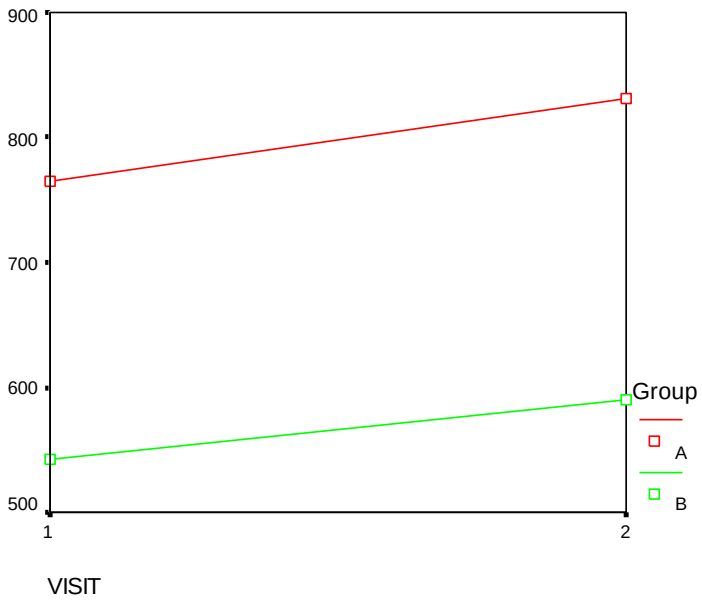

Figure 19: Mean set work over two visits by group

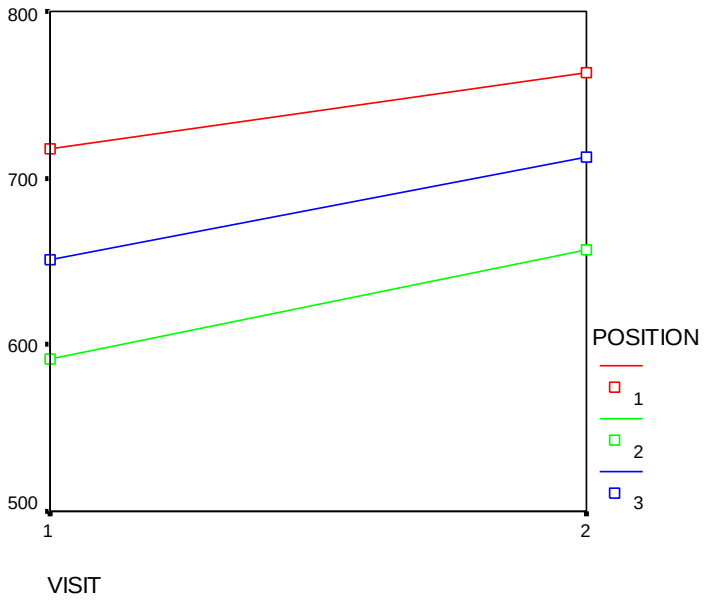

Figure 20: Mean set work over two visits by position

4.5.4.3 Set Work:

As with joules and percent, set total work changed significantly over time (p = **0.002**), and there was a significant difference between the groups (**p = 0.008**) and positions (**p <0.001**) at all time points. There were no significant interactions, thus there was no evidence of a treatment effect for any of the Cybex measurements.

4.5.5 MDS Scores:

For MDS measurements, 3 readings were taken, one at baseline, and one before each treatment. Thus the design here was a simple factorial design with one within-subjects effect (time) and one between –subjects effect (group). The interaction of time and group would be the treatment effect.

Table 18: Results of hypothesis tests for repeated measures ANOVA for VL MDS

Effect	statistic	p value
Time	Wilk's lambda 0.854	0.054
Group	F=0.113	0.739
Time*group	Wilk's lambda 0.814	0.022

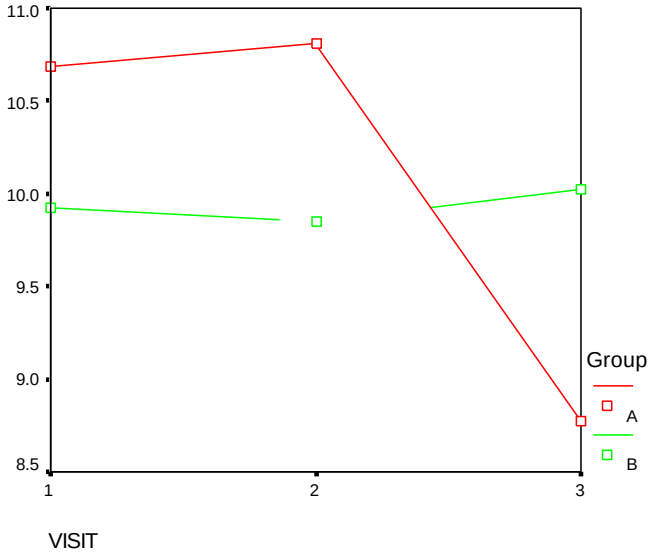

Figure 21: Mean MDS scores for VL trigger points by group over time

4.5.5.1 VL Trigger Points:

Table 18 shows that there was a significant time*group interaction (**p = 0.022**). Thus we cannot interpret the main effects of time and group. This means that the effect of time was different according to which group the subjects were in, i.e. the rate of change over time was group and therefore treatment dependent. If one examines Figure 21 above, one can see that from visit 2 onwards group A decreased over time while group B remained the same. Thus the treated group showed a significant improvement in MDS scores for VL trigger points relative to the placebo group.

This finding does not fully support the second hypothesis, in that dry-needling the VL has significantly improved objective findings in terms of MDS readings and the reduction of active MFTP's in the treatment group. This would indicate that dry - needling has had a significant effect on MFPS, but its effect on PFPS, remains questionable, as cybex readings, and subjective findings have improved steadily in both groups over time.

Table 19: Results of hypothesis tests for repeated measures ANOVA for VM MDS

Effect	statistic	p value
Time	Wilk's lambda 0.709	**0.006**
Group	F=0.320	0.576
Time*group	Wilk's lambda 0.940	0.396

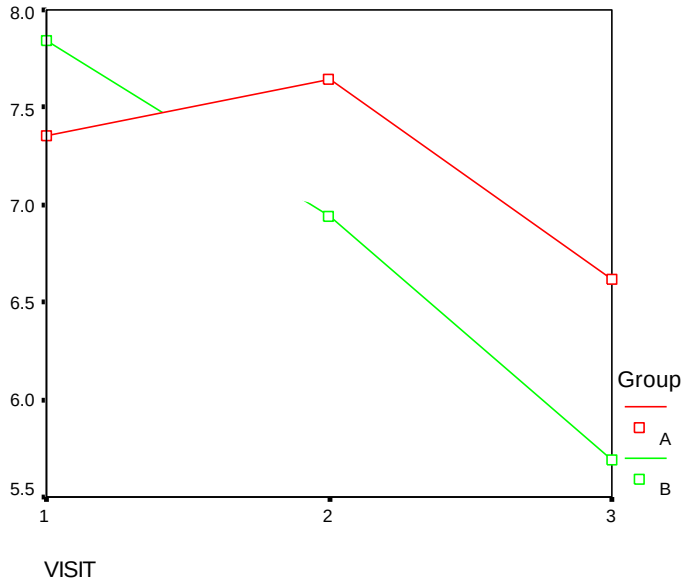

Figure 22: Mean MDS for VM trigger points by group and time

4.5.5.2 VM Trigger Points:

There was a significant time effect in both groups, but no time*group interaction. Thus for VM trigger points both groups experienced a decrease in MDS score at the same rate over time. This can be seen in Figure 22.

This finding once again supports Boucher's (1992) suggestion, that an important neuromuscular imbalance between the VMO and VL is associated with PFPS, as it seems to show that VM is reflexly inhibited by VL, thereby allowing for the improvement of VM signs and symptoms as VL is treated.

A follow –up consultation may have produced a more significant treatment effect, allowing greater VL: VMO response time.

Dry-needling the VL has shown no significant improvement in the treatment group, as compared to the control. However, noting the trend above, with a possible greater VL: VMO response time, there may well be an effect on VM by treating active VL myofascial trigger points.

4.5.6 Number Of Active Trigger Points Over Time:

Number of active trigger points was compared between groups and within-subjects (over time) using repeated measures ANOVA separately for VL and VM trigger points.

Table 20: Results of hypothesis tests for repeated measures ANOVA for number of active VL trigger points

Effect	statistic	p value
Time	Wilk's lambda 0.636	<0.001
Group	F=2.397	0.130
Time*group	Wilk's lambda 0.819	0.025

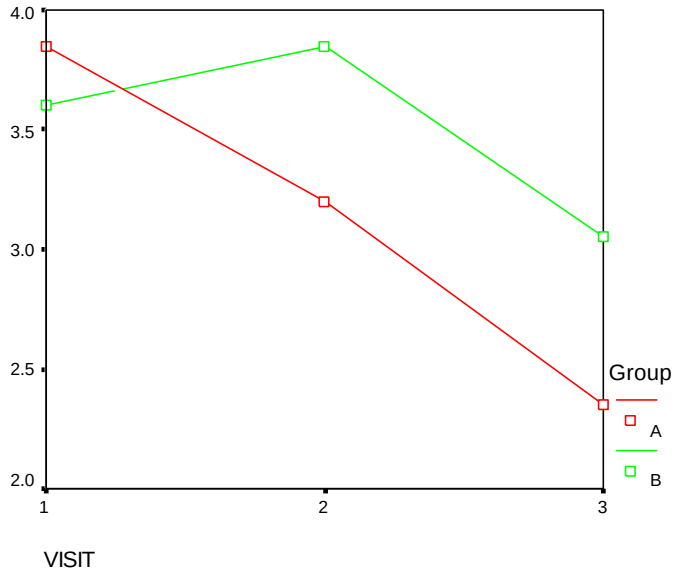

Figure 23: Mean number of active VL trigger points by group and time

4.5.6.1 VL:

Table 20 shows that there was a significant interaction between time and group (p = 0.025). Thus the change over time in mean number of active trigger points was dependant on group. Examination of figure 23 shows that Group A decreased in the number of active VL trigger points at a faster rate than Group B.

This result indicates that dry - needling was effective in significantly reducing the number of active trigger points in group A.

Table 21: Results of hypothesis tests for repeated measures ANOVA for number of active VM trigger points

Effect	statistic	p value
Time	Wilk's lambda 0.776	0.009
Group	F=0.315	0.578
Time*group	Wilk's lambda 0.898	0.137

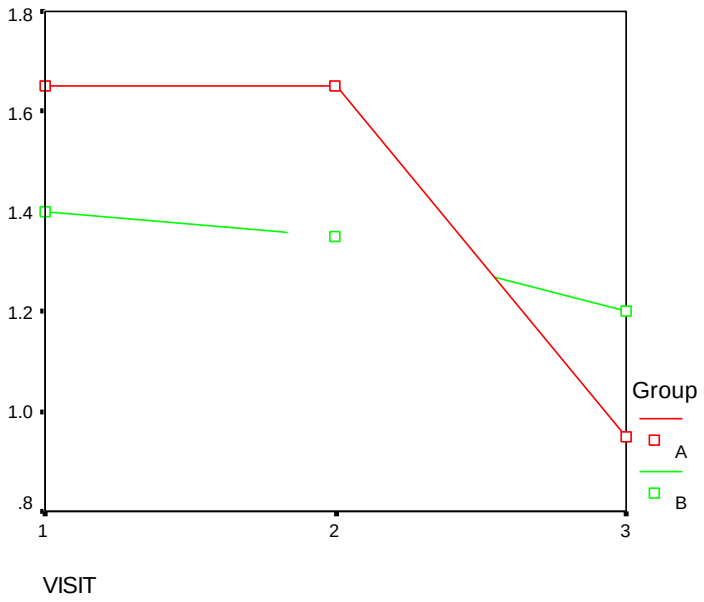

Figure 24: Mean number of active VM trigger points by group and time

4.5.6.2 VM:

Table 21 shows that there was a significant decrease over time in mean number of active VM trigger points in both groups which was independent of group. There was no time*group interaction (p = 0.578). Figure 24 shows that while the interaction (treatment effect) may not be statistically significant there is a trend which is suggestive that the effect in Group A is stronger than in Group B, since after visit 2 the number of active trigger points decreases steeply in group A and maintains its level in Group B. A follow –up consultation may have produced a more significant treatment effect, allowing greater VL: VMO response time.

It appears evident that dry-needling the VL has had a reflex effect on reducing the number of active MFTrP's in VM in group A. This supports the study by Boucher et al. (1992), where it was shown that an important neuromuscular imbalance between VMO and VL is associated with PFPS and that it can be investigated through VMO: VL ratios of activity.

This finding questions the therapeutic exercise regimes traditionally used by various authors (McConnel, 1986. Ingersoll and Knight, 1991. Hanten WP, Schulthies SS, 1990.) to strengthen the quadriceps muscle, with emphasis placed on the Vastus medialis obliquus muscle to overcome the lateral pull of the much larger Vastus lateralis muscle. Emphasis should perhaps be directed towards the removal of VL myofascial trigger points, since this study seems to suggest that the VL has a reflex inhibitory effect on VM. This would speed up the recovery process, as once the reflex inhibitory effect of the VL on VMO has been addressed, the patient may well respond to VM strengthening and muscle reeducation techniques to a greater extent.

Further research is required to assess the long – term effects of dry-needling on VL: VMO ratios of activity.

4.6 Summary Of Results

There were certain baseline differences between the two groups, which may have confounded the results of certain of the outcome measurements. These differences were present in mean algometer readings where group A had significantly higher mean baseline readings than B, and as discussed in 4.4.3, may be attributed to the gender distribution in these groups.

Mean cybex readings were also significantly higher (in all positions tested) in group A than group B, due to a greater mean average height and weight in group A, but, as discussed in 4.3.5, this is not as significant in a repeated measures study design as all subjects acted as their own controls.

There was no difference between the groups for the subjective tests of NRS and PSFS.

A change over time was shown in both groups to the same extent for NRS, PSFS, Algometer readings (VL and VM), VM MDS readings and cybex readings in all directions tested, however, there was no significant treatment effect differentiating the two groups.

Algometer readings showed significant pre and post treatment effects in both groups over time and significant time effects in both groups. However, due to the large baseline differences between the groups, there was no significant treatment effect detected in this outcomes measurement. This, as previously discussed, may have been influenced by the treatment effect of the algometer head. Group A would then have had a treatment effect of the dry – needling, as well as the effect of the algometer, whereas group B would just have had the treatment effect from the algometer. This may explain why both groups improved steadily over time, but why, although insignificant, group A improved at a slightly faster rate. This would then apply for all measurements taken (Figures: 7,9,10,12,14).

Cybex readings also showed significant changes over time in both groups alike, but no treatment effects. The position effect was significant in that the three positions (neutral, external and internal) all showed significantly different mean values at all time points, which was not dependant on group or time.

The MDS scores showed a significant treatment effect for VL trigger points, this was expected because the VL was being treated. Group A decreased scores over time while Group B remained stable. This did not happen for VM MDS scores which both decreased at the same rate over time. Dry-needling and ischaemic compression (algometer head) in group A appears to have had a greater effect than the algometer effect alone, in the treatment of active MTrp's.

The same applies as above, where the number of active VL trigger points decreased significantly faster in the Group A than group B and there was a suggestion of a trend towards the same effect in VM trigger points. Thus the

treatment had an effect over and above the placebo for MDS and number of active trigger points.

This finding seems to contradict the norm, as the VMO has traditionally been the focus of PFPS rehabilitation. This study suggests that pain and inhibition evident in the VMO, is actually initiated by active Myofascial trigger points in the Vastus lateralis muscle causing a reflex inhibition in VM, this is supported by Kowall et al (1996) who state that the inhibition is as a result of pain and effusion.

It would therefore seem to suggest that the focus of PFPS rehabilitation should begin with an important perpetuator, the Vastus Lateralis. Treating the MTrps in this muscle would then reflexly affect the pain and muscle inhibition experienced in the medial aspect of the knee due to the presence of active MTrps, and allow for greater improvement in muscular performance once initial inhibitory factors have been removed.

In summary and based on the foregoing discussion, dry-needling has been shown to be effective in reducing the signs and symptoms in group A in terms of objective readings, but, improvements in subjective readings in group A were not significantly greater than the improvements shown in group B therefore ***hypothesis one*** is rejected.

The ***second hypothesis*** is rejected in that dry-needling the VL has significantly improved objective findings in terms of MDS readings and the reduction of active MFTP's in the treatment group. This would indicate that dry - needling has had a significant effect on MFPS, but its effect on PFPS, remains questionable, as cybex readings, and subjective findings have improved steadily in both groups over time.

The ***third hypothesis*** is also rejected as dry – needling resulted in a significant improvement in the number of active MTrps and VL MDS scores (objective

parameters), in group A as compared to the control group, but failed to show a significantly greater improvement in subjective readings in the experimental group, over and above the improvement noted in both groups over time.

In response to hypothesis 3, the researcher is of the opinion that VL MTrps are a causative factor in the alteration of VL / VM Total Work, since removal of active VL trigger points has been shown to have a reflex effect on reducing the number of active MTrps in the VM, and the correlation between cybex readings in all positions, as discussed in 4.4.4 also suggest that VM signs and symptoms are secondary to VL signs and symptoms in PFPS in distance runners.

Regarding the ***fourth hypothesis***, treating the trigger points in VL in group A, did have a significant effect on reducing the number of active MTrps in VL and reducing MDS scores as compared to the control, and the same pattern is suggested for VM (4.5.6.2), however, there is no significant change between groups for cybex readings before and after treatment, therefore, this hypothesis is rejected, but only on the basis of there being no change in cybex readings between the two groups. This may be a type 2- error, as this result does not necessarily mean that there is no difference between the two groups after treatment.

The results may have been skewed by the treatment effects of the algometer, incomplete randomisation of groups and the relatively small sample size used. Blond and Hansen (1998) also mention that there is a considerable risk of coincidental improvement, if the period of observation is too short. With this in mind, further research is necessary to assess the long-term effects of dry-needling in PFPS, with these suggestions of improvement considered.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS:

5.1 Conclusions:

The diagnosis of PFPS is currently based on the presence of localized peri- or retropatellar pain originating from the peripatellar tissue or the patellofemoral joint (Rowlands and Brantingham, 1999). Prolonged sitting, climbing stairs, kneeling and squatting aggravates the pain (Powers, Landel, and Perry. 1996).

According to prevailing literature, the presence of myofascial trigger points (MFTP's) in quadriceps femoris (QF) muscle could result in a combination of the following signs and symptoms:

- Retro- or peripatella pain,
- Weakness of the quadriceps muscle (Chaitow and DeLany, 2002)
- Loss of full lengthening (Travell and Simons, 1983:248-250)

Any of the above would result in inhibition of QF muscle activity and a resultant extensor mechanism dysfunction (Travell and Simons, 1983:248-250), therefore insufficiency of the VMO has been labeled as a cause of patellofemoral knee pain (Hunter, 1985).

The results show that the number of active VL trigger points decreased significantly faster in the Group A than group B and there was a suggestion of a trend towards the same effect in VM trigger points. Thus the treatment had an effect over and above the placebo for MDS and number of active trigger points.

This finding seems to contradict the norm, as the VMO has traditionally been the focus of PFPS rehabilitation. This study suggests that pain and inhibition evident

in the VMO, is actually initiated by active Myofascial trigger points in the Vastus lateralis muscle causing a reflex inhibition in VM, this is supported by Kowall et al (1996) who state that the inhibition is as a result of pain and effusion.

It would therefore seem to suggest that the focus of PFPS rehabilitation should begin with an important perpetuator, the Vastus Lateralis. Treating the MTrps in this muscle would then reflexly affect the pain and muscle inhibition experienced in the medial aspect of the knee due to the presence of active MTrps, and allow for greater improvement in muscular performance once initial inhibitory factors have been removed. It should also be stressed that despite these findings, a thorough analysis of the problem must be made to identify the contributory factors. Each factor must be specifically addressed to affect a change in this syndrome.

This therefore indicates that there is a high degree of overlap between the presence of myofascial trigger points and Patellofemoral Pain Syndrome, and that patients with patellofemoral pain have an imbalance between the activity of the VMO and VL components of the Quadriceps.

Thus it can be concluded that Myofascial Pain Syndrome is a positive predictive and concomitant factor in Patellofemoral Pain Syndrome.

5.2 Recommendations:

a. During the course of this research it was noted that a large majority of the MTrp's were located in the vastus lateralis muscle. This muscle is closely Associated with the iliotibial band (Moore and Dalley. 1999: 564). As a result, the researcher questions whether the diagnosis of Iliotibial band friction syndrome is precipitated by, concomitant with or a cause of the MTrp's that were found in the generic PFPS population.

b. The palpation of the MTrp's was performed by the researcher, a sixth year Chiropractic student. An experienced chiropractor would have been able to provide more reliable palpation findings especially in the tendinous portions of the VM and VL muscles.

c. Mention must be made of the vague criteria required to diagnose PFPS. Many low grade or chronic knee conditions are likely to be diagnosed as PFPS due to the non-specific nature of the diagnostic criteria. More sensitive and accurate measures such as diagnostic ultrasound or radiographic examination should be considered for use in further studies.

d. The researcher questions the use of detuned Ultrasound as a reliable, Non-intervention control. This devise was not turned on during the treatment period, and caution was taken, to ensure minimal pressure of the handle upon application of this device over the length of the VL, however, participants in group B reported a sense of ease within the muscle after treatment. It may be that there was a slight massage effect experienced. A suggestion would be to include this detuned ultrasound into both groups' treatment regimes.

e. The Myofascial Diagnostic Scale was thought to lack sensitivity in

Measuring the degree of trigger point activity, in that, a trigger point may exhibit a twitch response or a palpable band in treatment 1,2 and 3, but of a much less intensity, and still have the same numerical grading, so a point may score 15 on all 3 treatments, but exhibit a completely different clinical picture. It is therefore recommended that this scale be more specific, and include a grading system for each criterion.

f. It is also suggested that when assessing sensitivity of MTrps in a study Where the outcomes are dependant on the effectiveness of treatment of MTrps, a tool other than the Algometer is used to measure pain threshold. Reeves et al (1985) mentions that the repeated application of pressure greater than "just noticeable" or "threshold" may alter trigger point sensitivity, thus confounding the measurement process.

g. Further studies should include a larger sample size, with an equal number of males and females in each group. This would improve this would increase the reliablility of their findings.

h. Further studies should include a follow – up consultation to assess the long – term benefits of needling the VL muscle.

i. By increasing the minimum mileage to 40km / week, a larger sample of classic marathon runners would be selected, this would minimize the chance of athletes competing in other sports, which may affect or contribute to the diagnosis, of entering a study, that is designed to target a specific population. For example, a rugby player would run an average of 20km / week, but be likely to sustain injury from a different origin.

CHAPTER SEVEN

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Wright, J[B. Hons (HMS) PU for CHE. Dipl. Sports Science NU] 2004.
Interviewed by D. Weyer-Henderson. Kings Park Sports Medicine Center, Durban, 2 June 2004.

APPENDIX 1:

ARE YOU SUFFERING FROM

KNEE PAIN?

RESEARCH IS CURRENTLY BEING CONDUCTED ON

PATELLOFEMORAL PAIN SYNDROME

AT THE DURBAN INSTITUTE OF TECHNOLOGY CHIROPRACTIC DAY CLINIC.

FREE TREATMENT

IS AVAILABLE TO THOSE WHO QUALIFY TO TAKE PART IN THIS STUDY.
FOR MORE INFORMATION CONTACT:

DONNA WEYER-HENDERSON
031- 204 2205

APPENDIX 2:

Questions to be asked during the telephonic interview:

Inclusion Criteria:

Are you between the ages of 18 and 60 years?
Is the pain you are experiencing underneath or around your kneecap?
Do any of the following aggravate your pain?

(1) Squatting
(2) Stair climbing
(3) Kneeling
(4) Prolonged sitting
(5) Physical activity

Exclusion Criteria:

Have you had a history of any of the following?

(6) Traumatic kneecap dislocation
(7) Any neurological problem affecting the way you walk
(8) Have you undergone any knee surgery over the past two years
(9) A cartilage tear
(10) Injury causing instability
(11) Does your knee give way underneath you
(12) Arthritis in your knees

Are you pregnant or breastfeeding at present?

APPENDIX 3

LETTER OF INFORMATION

Dear patient.

Welcome to my study. Thank you for your interest.

The title of my study is: An investigation into the effectiveness of dry needling of Myofascial Trigger Points on Total work and other recorded measurements of the Vastus Lateralis and Vastus Medialis muscles in Patellofemoral Pain Syndrome in long distance runners.

Name of supervisors: Dr N. De Busser (031 - 2042205)
Dr C. Korporaal (031-2042611)

Name of research student: Donna Henderson (031- 2042205)

This study involves research on 40 patients, to determine the effect of the alleviation of myofascial trigger points (knots) in the Vastus Lateralis (thigh) muscle, on quadriceps (thigh) muscle total work and knee pain in people with a condition commonly known as Runners' Knee.

Procedures:

You will be required to undergo an initial consultation which will consist of a full patient history, physical examination and a knee regional examination, conducted at the Chiropractic Day Clinic at D.I.T. At this consultation you will be asked various questions regarding your knee pain, and specific tests will be conducted to ensure an accurate diagnosis of Runner's Knee. You will also be assessed for the presence of myofascial trigger points (knots) in the thigh region. You will then be required to undergo an initial isokinetic testing session at the King's Park Medical Centre, under the supervision of Mr J. Wright, a registered Biokinetist, where baseline quadriceps total work will be assessed.

The second to fifth consultations:
You will be required to undergo three treatments scheduled on alternate days and will take approximately 30 minutes each. Following the completion of the treatment program, a final isokinetic testing session will be squeduled, and total work (TW) will be retested at the King's Park Medical Centre. The date of this appointment shall be made subject to availability of Mr Wright. You will also be required to fill out a pain questionnaire and answer some questions regarding your knee pain. You may experience slight transient discomfort during or after the examinations and trigger point treatment, however the utilisation of an algometer (a tool used to measure your pain levels) may also be beneficial as it mimics a therapeutic intervention.

Directions to get to the King's Park Medical Centre from the Durban Institute of Technology Chiropractic Clinic will be provided.

Risks / Discomfort:

Isokinetic testing is painless and non-invasive. This type of strength testing involves a maximum effort contraction of your thigh muscle. This may lead to some stiffness being felt in that muscle after testing.

Benefits:
There will be no charge for any of these consultations. The treatment provided is in line with normal clinical procedure for the treatment of Patellofemoral Pain Syndrome. Your participation is voluntary and you are free to withdraw at any point in time.

New findings:
You have the right to be informed of any new findings that are made.

Reasons why you may be withdrawn from the study without you consent:
You may be removed from the study without your consent for the following reasons:
- Changing any lifestyle habits, any medication or supplementation that you are on for the period of your participation in this study, as this may affect the results of the research.
- If you experience any discomfort during the isokinetic testing session.

All patient information is confidential and the results will be used for research purposes only, although supervisors and senior clinic staff may be required to inspect records.

Persons to contact for problems or questions:
You may ask questions of an independent source if you wish to my supervisors who are available on the above numbers. If you are not entirely satisfied with any are of the study, please feel free to forward any concerns to the Durban Institute of Technology Research and Ethics Committee.

Thank you for your participation in this study.

Donna Henderson
(Chiropractic intern)

APPENDIX 4

INFORMED CONSENT FORM

Date :

Title of research project: : An investigation into the effectiveness of dry needling of Myofascial Trigger Points on Total work and other recorded measurements of the Vastus Lateralis and Vastus Medialis muscles in Patellofemoral Pain Syndrome in long distance runners.

Name of supervisor: Dr. N. De Busser (031 – 2042205)
Dr. C. Korporaal (031 – 2042205)

Name of research student: Donna Weyer – Henderson (031 – 2042205)

This study involves research on 40 patients, to determine the effect of the alleviation of myofascial trigger points (knots) in the Vastus Lateralis (thigh) muscle, on quadriceps (thigh) muscle strength and knee pain in people with a condition commonly known as Runners' Knee.

Please circle the appropriate answer	**YES /NO**	
1. Have you read the research information sheet?	Yes	No
2. Have you had an opportunity to ask questions regarding this study?	Yes	No
3. Have you received satisfactory answers to your questions?	Yes	No
4. Have you had an opportunity to discuss this study?	Yes	No
5. Have you received enough information about this study?	Yes	No
6. Do you understand the implications of your involvement in this study?	Yes	No
7. Do you understand that you are free to withdraw from this study? at any time without having to give any a reason for withdrawing, and without affecting your future health care.	Yes	No
8. Do you agree to voluntarily participate in this study	Yes	No
9. Who have you spoken to?		

Patient /Subject Name:_____ Signature: _____

Witness Name:_____ Signature:_____

Research Student Name:_____ Signature:_____

If you have answered NO to any of the above questions, please do not hesitate to contact my supervisor who will be able to assist you.

APPENDIX 5:

DURBAN INSTITUTE OF TECHNOLOGY
CHIROPRACTIC DAY CLINIC
CASE HISTORY

Patient: _____

Date: _____

File: _____

Sex: _____

Age: _____

Occupation: _____

Intern : _____ _____

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:

Intern's Case History:

1. **Source of History:**

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

3. **Present Illness:**

	Complaint 1	**Complaint 2**
Location ▸ Onset : Initial: Recent: 1. ▸ 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. xrays
- Environmental Hazards (Home, School, Work)
- Exercise and Leisure
- Sleep Patterns
- Diet
- Current Medication
  Analgesics/week:
- Tobacco
- Alcohol
- Social Drugs

7. Immediate Family Medical History:

- Age
- Health
- Cause of Death
- DM
- Heart Disease
- TB
- Stroke
- Kidney Disease
- CA
- Arthritis
- Anaemia
- Headaches
- Thyroid Disease
- Epilepsy
- Mental Illness
- Alcoholism
- Drug Addiction
- Other

8. Psychosocial history:

- Home Situation and daily life
- Important experiences
- Religious Beliefs

9. Review of Systems:

- General
- Skin
- Head
- Eyes
- Ears
- Nose/Sinuses
- Mouth/Throat
- Neck
- Breasts
- Respiratory
- Cardiac
- Gastro-intestinal
- Urinary
- Genital
- Vascular
- Musculoskeletal
- Neurologic
- Haematologic
- Endocrine
- Psychiatric

APPENDIX 6:

Durban Institute of Technology

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
NEUROLOGICAL EXAMINATION: See Regionals
Clinician: **Signature :**

APPENDIX 8

Duration of Condition in Months:

1	2	3	4	5	6	7	8	9	10	11	>11

Location of MTrp's:

	Vastus medialis	Vastus lateralis	Vastus intermedialis	Rectus femoris
Tendinous portion				
Distal muscular portion				
Mid belly of muscle				
Proximal muscular portion				
Other				

APPENDIX 9

Numerical Rating Scale - 101 Questionnaire

Date:_____ File no:_____ Visit no:_____

Patient name:

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

Please write only **one** number.

0 100

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

Please write only **one** number.

0 100

APPENDIX 10

CLINICIAN TO READ AND FILL IN BELOW: Complete at the end of the history and prior to physical examination.

Initial assessment:

I am going to ask you to identify up to three important activities that you are unable to do or are having difficulty with as a result of your_____ problem. Today, are there any activities that you are unable to do or are having difficulty with because of your_____ problem/ (Clinician: Show scale to patient and have the patient rate each activity.)

Follow-up assessments:

When I assessed you on (state previous assessment date), you told me that you had difficulty with (read all activities from list at the time). Today do you still have difficulty with: (read and have patient score each item on the list)?

PATIENT – SPECIFIC ACTIVITY SCORING SCHEME (Point to one number):

0	1	2	3	4	5	6	7	8	9	10
Unable to Perform activity										Able to perform activity at same level as before injury or problem

(Date and score)

Activity	Initial	8th	9th			
1						
2						
3						
4						
5						
Additional						
Additional						

APPENDIX 11

Myofascial Diagnostic Scale:

TRIGGER POINT SIGNS.

1. Soft tissue tenderness		
Grade: 0	No tenderness	0
I	Tenderness to palpation without grimace	1
II	Tenderness to palpation with grimace or flinch	2
III	Tenderness with withdrawal (+ve jump sign)	3
IV	Withdrawal (+ve jump sign) to non noxious stimuli (ie. 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		

Numerical Rating Scale:

0	1	2	3	4	5	6	7	8	9	10

APPENDIX 12

Algometer Readings:

	Tendinous Portion				Distal muscle				Mid-belly				Proximal muscle				Other				Total
Vastus Medialis																					
Vastus Lateralis																					
Vastus Inter-medialis																					
Rectus Femoris																					

Total number of MTrp's _____

Mean weight (kg) _____

APPENDIX 13

Pearson's Correlations between NRS and all other scores at baseline

		NRS baseline
PSFS RUNNING	Pearson Correlation	-.194
	Sig. (2-tailed)	.231
	N	40
PSFS STAIRS	Pearson Correlation	**-.039**
	Sig. (2-tailed)	.813
	N	40
PSFS SITTING	Pearson Correlation	.205
	Sig. (2-tailed)	.203
	N	40
Algometer mean VL pre visit 1	Pearson Correlation	-.276
	Sig. (2-tailed)	.085
	N	40
Algometer mean VM pre visit 1	Pearson Correlation	-.220
	Sig. (2-tailed)	.178
	N	39
neutral pre joules	Pearson Correlation	-.302
	Sig. (2-tailed)	.059
	N	40
neutral pre percent	Pearson Correlation	-.319(*)
	Sig. (2-tailed)	**.045**
	N	40
neutral pre set	Pearson Correlation	-.290
	Sig. (2-tailed)	.070
	N	40
ext pre joules	Pearson Correlation	-.355(*)
	Sig. (2-tailed)	**.025**
	N	40
ext pre percent	Pearson Correlation	-.273
	Sig. (2-tailed)	.088
	N	40
ext pre set	Pearson Correlation	-.335(*)
	Sig. (2-tailed)	**.035**

	N	40
int pre joules	Pearson Correlation	-.265
	Sig. (2-tailed)	.098
	N	40
int pre percent	Pearson Correlation	-.231
	Sig. (2-tailed)	.152
	N	40
int pre set	Pearson Correlation	-.266
	Sig. (2-tailed)	.097
	N	40
mds vl mean visit1	Pearson Correlation	**.005**
	Sig. (2-tailed)	.975
	N	40
mds vm mean visit 1	Pearson Correlation	.336(*)
	Sig. (2-tailed)	**.034**
	N	40

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

APPENDIX 14

Pearson's Correlation between PSFS scores and other readings at baseline

		PSFS RUNNING	PSFS STAIRS	PSFS SITTING
NRS1	Pearson Correlation	-.194	-.039	.205
	Sig. (2-tailed)	.231	.813	.203
	N	40	40	40
PSFS RUNNING	Pearson Correlation	1	.415(**)	.180
	Sig. (2-tailed)	.	**.008**	.266
	N	40	40	40
PSFS STAIRS	Pearson Correlation	.415(**)	1	.411(**)
	Sig. (2-tailed)	**.008**	.	**.008**
	N	40	40	40
PSFS SITTING	Pearson Correlation	.180	.411(**)	1
	Sig. (2-tailed)	.266	**.008**	.
	N	40	40	40
Algometer mean VL pre visit 1	Pearson Correlation	.118	-.164	-.007
	Sig. (2-tailed)	.469	.312	.964
	N	40	40	40
Algometer mean VM pre visit 1	Pearson Correlation	.254	-.035	-.024
	Sig. (2-tailed)	.118	.833	.884
	N	39	39	39
neutral pre joules	Pearson Correlation	.234	.172	-.017
	Sig. (2-tailed)	.145	.289	.915
	N	40	40	40
neutral pre percent	Pearson Correlation	.193	.333(*)	-.020
	Sig. (2-tailed)	.233	**.036**	.903
	N	40	40	40
neutral pre set	Pearson Correlation	.230	.161	-.042
	Sig. (2-tailed)	.154	.322	.797
	N	40	40	40
ext pre joules	Pearson Correlation	.234	.178	-.003

	Sig. (2-tailed)	.146	.272	.986
	N	40	40	40
ext pre percent	Pearson Correlation	.235	.312	.037
	Sig. (2-tailed)	.144	.050	.822
	N	40	40	40
ext pre set	Pearson Correlation	.274	.201	-.023
	Sig. (2-tailed)	.087	.214	.887
	N	40	40	40
int pre joules	Pearson Correlation	.204	.066	.031
	Sig. (2-tailed)	.206	.686	.849
	N	40	40	40
int pre percent	Pearson Correlation	.161	.184	.047
	Sig. (2-tailed)	.320	.257	.775
	N	40	40	40
int pre set	Pearson Correlation	.195	.077	.005
	Sig. (2-tailed)	.228	.635	.975
	N	40	40	40
mds vl mean visit1	Pearson Correlation	.015	.211	.156
	Sig. (2-tailed)	.928	.192	.337
	N	40	40	40
mds vm mean visit 1	Pearson Correlation	-.392(*)	-.070	.111
	Sig. (2-tailed)	**.012**	.669	.497
	N	40	40	40

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

APPENDIX 15

Pearson's Correlation between Algometer readings and other scores at baseline

		Algometer mean VL pre visit 1	Algometer mean VM pre visit 1
NRS1	Pearson Correlation	-.276	-.220
	Sig. (2-tailed)	.085	.178
	N	40	39
PSFS RUNNING	Pearson Correlation	.118	.254
	Sig. (2-tailed)	.469	.118
	N	40	39
PSFS STAIRS	Pearson Correlation	-.164	-.035
	Sig. (2-tailed)	.312	.833
	N	40	39
PSFS SITTING	Pearson Correlation	-.007	-.024
	Sig. (2-tailed)	.964	.884
	N	40	39
Algometer mean VL pre visit 1	Pearson Correlation	1	.669(**)
	Sig. (2-tailed)	.	**.000**
	N	40	39
Algometer mean VM pre visit 1	Pearson Correlation	.669(**)	1
	Sig. (2-tailed)	**.000**	.
	N	39	39
neutral pre joules	Pearson Correlation	.531(**)	.301
	Sig. (2-tailed)	**.000**	.063
	N	40	39
neutral pre percent	Pearson Correlation	.313(*)	.154
	Sig. (2-tailed)	**.049**	.348
	N	40	39
neutral pre set	Pearson Correlation	.514(**)	.265
	Sig. (2-tailed)	**.001**	.103
	N	40	39

ext pre joules	Pearson Correlation	.512(**)	.230
	Sig. (2-tailed)	**.001**	.159
	N	40	39
ext pre percent	Pearson Correlation	.330(*)	.085
	Sig. (2-tailed)	**.037**	.605
	N	40	39
ext pre set	Pearson Correlation	.478(**)	.208
	Sig. (2-tailed)	**.002**	.205
	N	40	39
int pre joules	Pearson Correlation	.530(**)	.320(*)
	Sig. (2-tailed)	**.000**	**.047**
	N	40	39
int pre percent	Pearson Correlation	.284	.157
	Sig. (2-tailed)	.076	.339
	N	40	39
int pre set	Pearson Correlation	.530(**)	.279
	Sig. (2-tailed)	**.000**	.085
	N	40	39
mds vl mean visit1	Pearson Correlation	-.176	-.013
	Sig. (2-tailed)	.279	.938
	N	40	39
mds vm mean visit 1	Pearson Correlation	-.267	-.162
	Sig. (2-tailed)	.096	.325
	N	40	39

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

APPENDIX 16

Pearson's Correlations between Cybex readings and NRS, PSFS, Algometer and MDS scores at baseline – Neutral Position

		neutral pre joules	neutral pre percent	neutral pre set
NRS1	Pearson Correlation	-.302	-.319(*)	-.290
	Sig. (2-tailed)	.059	**.045**	.070
	N	40	40	40
PSFS RUNNING	Pearson Correlation	.234	.193	.230
	Sig. (2-tailed)	.145	.233	.154
	N	40	40	40
PSFS STAIRS	Pearson Correlation	.172	.333(*)	.161
	Sig. (2-tailed)	.289	**.036**	.322
	N	40	40	40
PSFS SITTING	Pearson Correlation	-.017	-.020	-.042
	Sig. (2-tailed)	.915	.903	.797
	N	40	40	40
Algometer mean VL pre visit 1	Pearson Correlation	.531(**)	.313(*)	.514(**)
	Sig. (2-tailed)	**.000**	**.049**	**.001**
	N	40	40	40
Algometer mean VM pre visit 1	Pearson Correlation	.301	.154	.265
	Sig. (2-tailed)	.063	.348	.103
	N	39	39	39
neutral pre joules	Pearson Correlation	1	.838(**)	.991(**)
	Sig. (2-tailed)	.	**.000**	**.000**
	N	40	40	40
neutral pre percent	Pearson Correlation	.838(**)	1	.828(**)
	Sig. (2-tailed)	**.000**	**.**	**.000**
	N	40	40	40
neutral pre set	Pearson Correlation	.991(**)	.828(**)	1
	Sig. (2-tailed)	**.000**	**.000**	.
	N	40	40	40
ext pre joules	Pearson Correlation	.943(**)	.767(**)	.942(**)
	Sig. (2-tailed)	**.000**	**.000**	**.000**

	N	40	40	40
ext pre percent	Pearson Correlation	.801(**)	.828(**)	.793(**)
	Sig. (2-tailed)	**.000**	**.000**	**.000**
	N	40	40	40
ext pre set	Pearson Correlation	.937(**)	.760(**)	.945(**)
	Sig. (2-tailed)	**.000**	**.000**	**.000**
	N	40	40	40
int pre joules	Pearson Correlation	.903(**)	.716(**)	.903(**)
	Sig. (2-tailed)	**.000**	**.000**	**.000**
	N	40	40	40
int pre percent	Pearson Correlation	.701(**)	.783(**)	.699(**)
	Sig. (2-tailed)	**.000**	**.000**	**.000**
	N	40	40	40
int pre set	Pearson Correlation	.899(**)	.735(**)	.910(**)
	Sig. (2-tailed)	**.000**	**.000**	**.000**
	N	40	40	40
mds vl mean visit1	Pearson Correlation	-.016	.058	-.028
	Sig. (2-tailed)	.924	.724	.865
	N	40	40	40
mds vm mean visit 1	Pearson Correlation	-.187	-.124	-.206
	Sig. (2-tailed)	.247	.446	.202
	N	40	40	40

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

APPENDIX 17

Pearson's Correlations between Cybex readings and NRS, PSFS, Algometer and MDS scores at baseline - Externally Rotated Position

		ext pre joules	ext pre percent	ext pre set
NRS1	Pearson Correlation	-.355(*)	-.273	-.335(*)
	Sig. (2-tailed)	**.025**	.088	**.035**
	N	40	40	40
PSFS RUNNING	Pearson Correlation	.234	.235	.274
	Sig. (2-tailed)	.146	.144	.087
	N	40	40	40
PSFS STAIRS	Pearson Correlation	.178	.312	.201
	Sig. (2-tailed)	.272	**.050**	.214
	N	40	40	40
PSFS SITTING	Pearson Correlation	-.003	.037	-.023
	Sig. (2-tailed)	.986	.822	.887
	N	40	40	40
Algometer mean VL pre visit 1	Pearson Correlation	.512(**)	.330(*)	.478(**)
	Sig. (2-tailed)	**.001**	**.037**	**.002**
	N	40	40	40
Algometer mean VM pre visit 1	Pearson Correlation	.230	.085	.208
	Sig. (2-tailed)	.159	.605	.205
	N	39	39	39
neutral pre joules	Pearson Correlation	.943(**)	.801(**)	.937(**)
	Sig. (2-tailed)	**.000**	**.000**	**.000**
	N	40	40	40
neutral pre percent	Pearson Correlation	.767(**)	.828(**)	.760(**)
	Sig. (2-tailed)	**.000**	**.000**	**.000**
	N	40	40	40
neutral pre set	Pearson Correlation	.942(**)	.793(**)	.945(**)

	Sig. (2-tailed)	**.000**	**.000**	**.000**
	N	40	40	40
ext pre joules	Pearson Correlation	1	.887(**)	.990(**)
	Sig. (2-tailed)	**.**	**.000**	**.000**
	N	40	40	40
ext pre percent	Pearson Correlation	.887(**)	1	.875(**)
	Sig. (2-tailed)	**.000**	**.**	**.000**
	N	40	40	40
ext pre set	Pearson Correlation	.990(**)	.875(**)	1
	Sig. (2-tailed)	**.000**	**.000**	.
	N	40	40	40
int pre joules	Pearson Correlation	.887(**)	.726(**)	.883(**)
	Sig. (2-tailed)	**.000**	**.000**	**.000**
	N	40	40	40
int pre percent	Pearson Correlation	.689(**)	.758(**)	.685(**)
	Sig. (2-tailed)	**.000**	**.000**	**.000**
	N	40	40	40
int pre set	Pearson Correlation	.898(**)	.745(**)	.900(**)
	Sig. (2-tailed)	**.000**	**.000**	**.000**
	N	40	40	40
mds vl mean visit1	Pearson Correlation	-.031	-.007	-.025
	Sig. (2-tailed)	.847	.966	.878
	N	40	40	40
mds vm mean visit 1	Pearson Correlation	-.274	-.211	-.270
	Sig. (2-tailed)	.087	.191	.092
	N	40	40	40

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

APPENDIX 18

Pearson's Correlations between Cybex readings and NRS, PSFS, Algometer and MDS scores at baseline – Internally Rotated Position

		int pre joules	int pre percent	int pre set
NRS1	Pearson Correlation	-.265	-.231	-.266
	Sig. (2-tailed)	.098	.152	.097
	N	40	40	40
PSFS RUNNING	Pearson Correlation	.204	.161	.195
	Sig. (2-tailed)	.206	.320	.228
	N	40	40	40
PSFS STAIRS	Pearson Correlation	.066	.184	.077
	Sig. (2-tailed)	.686	.257	.635
	N	40	40	40
PSFS SITTING	Pearson Correlation	.031	.047	.005
	Sig. (2-tailed)	.849	.775	.975
	N	40	40	40
Algometer mean VL pre visit 1	Pearson Correlation	.530(**)	.284	.530(**)
	Sig. (2-tailed)	**.000**	.076	**.000**
	N	40	40	40
Algometer mean VM pre visit 1	Pearson Correlation	.320(*)	.157	.279
	Sig. (2-tailed)	**.047**	.339	.085
	N	39	39	39
neutral pre joules	Pearson Correlation	.903(**)	.701(**)	.899(**)
	Sig. (2-tailed)	**.000**	**.000**	**.000**
	N	40	40	40
neutral pre percent	Pearson Correlation	.716(**)	.783(**)	.735(**)
	Sig. (2-tailed)	**.000**	**.000**	**.000**
	N	40	40	40
neutral pre set	Pearson Correlation	.903(**)	.699(**)	.910(**)
	Sig. (2-tailed)	**.000**	**.000**	**.000**
	N	40	40	40
ext pre joules	Pearson Correlation	.887(**)	.689(**)	.898(**)
	Sig. (2-tailed)	**.000**	**.000**	**.000**
	N	40	40	40

ext pre percent	Pearson Correlation	.726(**)	.758(**)	.745(**)
	Sig. (2-tailed)	**.000**	**.000**	**.000**
	N	40	40	40
ext pre set	Pearson Correlation	.883(**)	.685(**)	.900(**)
	Sig. (2-tailed)	**.000**	**.000**	**.000**
	N	40	40	40
int pre joules	Pearson Correlation	1	.844(**)	.984(**)
	Sig. (2-tailed)	.	**.000**	**.000**
	N	40	40	40
int pre percent	Pearson Correlation	.844(**)	1	.830(**)
	Sig. (2-tailed)	**.000**	**.**	**.000**
	N	40	40	40
int pre set	Pearson Correlation	.984(**)	.830(**)	1
	Sig. (2-tailed)	**.000**	**.000**	.
	N	40	40	40
mds vl mean visit1	Pearson Correlation	.046	.155	.044
	Sig. (2-tailed)	.776	.340	.787
	N	40	40	40
mds vm mean visit 1	Pearson Correlation	-.094	.033	-.137
	Sig. (2-tailed)	.562	.839	.398
	N	40	40	40

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).