

The role of and relationship between Hamstring and Quadriceps muscle myofascial trigger points in patients with patellofemoral pain syndrome.

By

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A mini-dissertation submitted in partial compliance with the requirements for the Master's Degree in Technology:

Chiropractic

at the Durban University of Technology

I, Karen Louise Frandsen Smith, declare that this dissertation is representative of my own work in both conception and execution (except where acknowledgements indicate to the contrary).

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Date

Dedication

I dedicate this work to everyone who loves me and have supported me throughout these years of studying and all the difficult times. It is thanks to you that I have reached my dream.

Dad, you would be so proud.

Acknowledgements

Thank you to the DUT staff, patients, and supervisor, Dr Brian Kruger for making this happen. Thanks to my class mates for making the years fly by, and creating lifelong memories.

This dissertation would not have been completed without supportive, generous and helpful people. Special thanks to you, Dr Danella Lubbe for motivating me and thank you so much Dr Charmaine Korporaal for “picking me up” and helping me finish.

Endless gratitude goes to you Damon, Cherine, Mom and Viggo. You are / were all my anchors in the storm, and without your belief in me, I would be nowhere.

Abstract

Purpose: Patellofemoral Pain Syndrome is a common condition in all age groups, with a multifactorial etiology. This study aimed to investigate the association between the Quadriceps femoris muscle group, Hamstring muscle group and Adductor muscle group, and to establish the relationship between myofascial trigger points (MFTP's) in these muscle groups and patellofemoral pain syndrome (PFPS).

Methods: A cross-sectional, observational, quantitative non-intervention clinical assessment study was conducted at the Chiropractic Day Clinic at Durban University of Technology (DUT), to determine the extent of the PFPS, the MFTPs and thus the relationship between the two. The study included eighty patients with PFPS, who were recruited by convenience sampling. The results were captured using Microsoft excel and SPSS version 15.0 was used to analyze the data.

Results: Quadriceps femoris muscle group MFTPs were noted in 92.5% of the patients (most prevalent being Vastus medialis TP1 (63.8%), Vastus lateralis TP1 (33.8%) and Vastus intermedius at 27,5%). Least common was Vastus lateralis TP2 only presenting in 2,5% of the patients. Hamstring muscle group MFTPs were found overall in 86.3% of patients (most prevalent being in Biceps femoris muscle (66%), and least prevalent being in Semitendinosus muscle (11,3%)). MFTPs were present in 64% overall of the Adductor muscle group (Adductor magnus muscle being the most common). Significant associations were made between the presence of MFTPs in the Vastus lateralis TP2 ($p=0.00$), Vastus medialis TP1 ($p=0.046$; 0.005 ; 0.004), the NRS and the PPSS. Also significant was the relationship between the NRS, PPSS and the Semimembranosus and Adductor magnus muscles indicated that these muscles were the most likely causes of pain even though they had fewer MFTPs than other comparable muscles.

Conclusion: The outcomes of this study supports previous research indicating that an extensor dysfunction of the Quadriceps femoris muscle group may be of MFTP origin and indicates that other muscles in the thigh require further research indicating their role in the development of PFPS.

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List of Definitions

Extensor mechanism

Consists of four distinct muscle bellies, namely the four components of the Quadriceps femoris muscle group. They all share a common tendon of insertion (http://www.medscape.com/viewarticle/433605_2, 2011).

Flexion contracture

A resistance to motion due to structural changes secondary to a common underlying biochemical process (Daniel, Akeson and O'Connor, 1990).

Lateral pressure syndrome

A syndrome where the lateral facet of the normal patella is subject to repeated high loads, which has given rise to a cartilage change (Reid, 1992).

Motor dysfunction

This includes muscular restricted range of motion, weakness, reduced co-ordination and spasm in other muscles (Cummings and Baldry, 2007)

MFTPs – Myofascial trigger points – this is a highly irritable spot in voluntary muscle that is associated with a hypersensitive, palpable nodule within a taut band (Travell, Simons and Simons, 1999; Chaitow and DeLany, 2002). The band is known to cause a local twitch response on compression and may also be painful. Compression usually gives rise to characteristic referred pain, referred tenderness, motor dysfunction and / or autonomic phenomena (Travell, Simons and Simons, 1999; Chaitow and Delany, 2002).

An active MFTP:

A MFTP that causes a clinical pain complaint is usually an active MFTP. It is a focus of hyperirritability in a muscle and / or its fascia, is symptomatic with respect to pain and refers a pattern of pain at rest and/or in motion (that is specific for the muscle). An active MFTP is always tender,

prevents full lengthening of a muscle, weakens the muscle, refers pain on compression, mediates a local twitch response when stimulated and often produces specific autonomic phenomena (Travell, Simons and Simons, 1999).

A latent MFTP:

This is defined as a focus of hyperirritability in a muscle and / or its fascia, which is clinically quiescent with respect to spontaneous pain and is painful when palpated (Travell, Simons and Simons, 1999).

Chaitow and Delany (2002) and Travell, Simons and Simons (1999), agree that the main difference between active and latent MFTP is that only active MFTP spontaneously refer pain.

MPS – Myofascial pain syndrome - The sensory, motor, and autonomic symptoms caused by MFTP (Moran, 1992; Lee *et al.*, 1997; Travell, Simons and Simons, 1999; Chaitow and Delany, 2002). Both active and latent MFTPs can result in MPS (Hou *et al.*, 2002).

Pain recognition on compression

Pain recognition identified when application of digital pressure on a trigger point elicited a referred pain pattern characteristic of that muscle and the patient 'recognized' the elicited sensation as a familiar experience (Al-Shenqiti, Al-Munawarah and Oldham, 2005).

Proprioceptive deficits

A dysfunction of the information that provides awareness of movement and position of the different parts of the body (Moore and Dalley, 1999).

Synergists

Refers to synergistic muscles, which are by definition muscles that reinforce or complement each other when they contract (Travell and Simons, 1993).

Taut band

Can be palpated within a muscle, and is a group of muscle fibers extending from a MFTP to the muscle attachments. The tension of the fibers is caused by contraction knots that are located in the region of the MFTP (Travell and Simons, 1993).

Twitch response:

This is an involuntary spinal cord reflex contraction of the muscle fibers in a taut band following palpation or needling of the band or MFTP (Travell and Simons 1993; Chaitow and Delany, 2002). A local twitch response is an involuntary spinal cord reflex contraction of the muscle fibres in a taut band following palpation or needling of the band or MFTP (Hong, 1994; Hong and Torigoe, 1994).

Chapter One

The problem and its setting

1.1 Introduction

Patellofemoral pain syndrome (PFPS), also known as Runner's knee, anterior knee pain, Patellalgia or Miserable Mal-alignment Syndrome (Servi, 2008), is a common overuse condition and is one of the most common musculoskeletal complaints in all age groups (Thomeé *et al.*, 1999; Yildiz *et al.*, 2003; Servi, 2008). Generally, the term PFPS is used for non-specific sub-patellar and peri-patellar pain that is unable to be otherwise definitively diagnosed, and, therefore often becomes a diagnosis of exclusion (Reid, 1993; Crossley *et al.*, 2004; Naslund *et al.*, 2006; White, Dolphin, Dixon, 2008).

As a result, patients commonly present with one or more of the following signs and / or symptoms (McConnell, 1986; McConnell, 1996; Wood, 1998; Magee, 2002; Naslund *et al.*, 2006):

1. Anterior or peri-patellar knee pain,
2. Pain on ascending and descending stairs,
3. Pain on squatting and kneeling,
4. Pain on prolonged sitting,
5. Pain on walking or running,
6. Crepitus associated with movement,
7. Occasional swelling following exercise and / or
8. Pseudo locking or giving way.

To be diagnosed with PFPS, patients require the presence of four of the above eight signs and symptoms for a confirmatory diagnosis of PFPS (Avraham *et al.*, 2007; Brantingham *et al.*, 2009). Given the non-specific and wide range of

associated clinical signs and symptoms, PFPS is still not very well understood, and the etiology is often seen as complex and multi-factorial, resulting from a combination of intrinsic and extrinsic factors (Reid, 1992; Austermuehle, 2001). This is in contrast to the high incidence which indicates that PFPS is commonly reported and found to occur in 15-33% of the active adult population (Lindberg *et al.*, 1986; Akbas *et al.*, 2011) and therefore often present for treatment (Long-Rossi and Salsich, 2010; Harvie *et al.*, 2011; Willson *et al.*, 2011).

Thus, as a result of the multiple etiologies there are multiple and varied treatment approaches and combination of treatment approaches, mentioned in literature, such as (McConnell, 1986; Gerrard, 1989; McConnell, 1996; Juhn, 1999; Thomeé *et al.*, 1999; Crossley, Bennell, Green, Cowan, and McConnell, 2002; Dixit, Difiori, Burton, and Mines, 2007; Servi, 2008):

- Individually adapted exercise programs (including stretching, strengthening, proprioceptive training and / or endurance training),
- Corrected ergonomics, training styles, training intensities and training environments,
- Orthotics and shoe wear correction,
- Strapping, bracing, taping and padding and / or
- Adjustment / manipulation / mobilization techniques in order to facilitate improvement in the kinematic chain biomechanics.

To further complicate the clinical picture, the clinical presentation of myofascial pain syndrome (MPS) (characterised by myofascial trigger points (MFTPs)) in the thigh seems to mimic the signs and symptoms outlined for patients with PFPS (Travell, Simons and Simons, 1999), which then compounds the problems of varied treatment and management processes in PFPS.

The possibility that MPS / MFTPs may be associated with PFPS, seems to be consistent with the fact that PFPS correlates with the presence of an extensor mechanism misalignment (Scruideri, 1995), which is identified by weakness of

one or more of the Quadriceps femoris muscle group, Quadriceps femoris muscle dysfunction and peri-patella pain (Engle, 1991; Callahan and Oldham, 2004; Piva, Goodnite, Childs, 2005; Naslund *et al.*, 2006; Pribut, 2008). One possible cause for the symptoms and findings of the above, involving decreased knee extension and subsequent muscular dysfunction, is the presence of MPS / MFTPs (Grabiner, Koh, and Draganich, 1994; Witvrouw, Sneyers, Lysens, Victor, and Bellemans, 1996; Neptune, Wright, and Van Den Bogert, 1999). This is supported by Dippenaar's exploratory study in 2003 (Dippenaar *et al.*, 2008), which indicated that there was a relationship between the severity and presence of MFTPs in the Quadriceps femoris muscle group and the increase in severity of PFPS. To this end found that 95% of PFPS patients presented with MFTPs in the Quadriceps femoris muscle group. This finding was later supported by Daly (2005), who confirmed the association between PFPS and MFTPs in the Quadriceps femoris muscle group.

This implies that there may also be a relationship between PFPS and MPS / MFTPs in other thigh muscles (viz. Hamstring muscle group and Adductor muscle group) (Neptune *et al.*, 1999; Thomeé *et al.*, 1999; Clifton, 2003; Dippenaar, 2003; and Piva *et al.*, 2005), particularly in light of the fact that shorter Hamstring muscles (White *et al.*, 2008) and eccentric under-activity of the Hamstring muscles (Liebensteiner, Szubski, Raschner, Krismer, Burtscher, Platzer, Deibl, and Dirnberger, 2008) have been documented in patients with PFPS. This supports previous research which indicated that patients with PFPS had been found to have flexion contractures and tightness of the Hamstring muscles (Engle, 1991; Piva *et al.*, 2005; Naslund *et al.*, 2006; Pribut, 2008; White *et al.*, 2008). These latter clinical signs are also possible sequelae of MFTPs (Lee *et al.*, 1997; Gerwin *et al.*, 1997; Banks *et al.*, 1998; Travell, Simons and Simons, 1999; Chaitow and DeLany, 2002; Al-Shenqiti, Al-Munawarah and Oldham, 2005; Bron *et al.*, 2007; Cummings and Baldry, 2007). Similarly, the Adductor muscle group has also been implicated, as they are synergists to the Hamstring muscles and have been known to present with proprioceptive deficits

(Travell and Simons, 1993; Baker, Bennell, Stillman, Cowan, and Crossley, 2002) in PFPS patients.

In this context, MPS is described in the literature as a regional muscular disorder that results from MFTPs (Lee *et al.*, 1997). This syndrome is known to be caused by MFTPs, which are hyperirritable spots in skeletal muscle associated with a hypersensitive palpable nodule in a taut band (Chaitow and DeLany, 2002). MFTPs are extremely common, with patients usually complaining of “poorly localized, regional, aching pain in subcutaneous tissues, including muscles and joints” (Travell, Simons and Simons, 1999) and motor dysfunctions such as spasm, weakness, loss of co-ordination and decreased work tolerance; which are not much different from the complaints noted in PFPS (Brantingham *et al.*, 2009; Collins *et al.*, 2010; Myer *et al.*, 2010; Earl and Hoch, 2011; Harvie *et al.*, 2011; Paoloni *et al.*, 2011; Willson *et al.*, 2011).

Clinically, MFTPs are characterized by a taut band, a tender nodule, pain recognition on compression, referred sensory sign, local twitch response, limited range of motion, painful contraction, and weakness (Travell, Simons and Simons, 1999). In addition, a primary or key MFTP can induce a satellite MFTP in another muscle, which may be a synergist, an antagonist or in a muscle linked neurologically (Travell, Simons and Simons, 1999).

Thus, it is reasonable to note that this overlap in the clinical presentation between MFTPs and PFPS has in part been responsible for the lack of consensus on etiology of PFPS, which in turn complicates the management of PFPS (Crossley *et al.*, 2002; Dippenaar, 2003). In accordance with this it is, therefore, important to clinically delineate the clinical presentations of MFTPs and PFPS individually and then also determine the extent of overlap between the two clinical entities in order to be able to determine the best possible clinical management protocols for patients presenting with one or both of these conditions simultaneously.

As a result, this particular study investigated the relationship between MFTPs in the Quadriceps femoris muscle group, the Hamstring muscle group, and the Adductor muscle group as well as their relationship to the clinical presentation of PFPS.

1.2 The aims and objectives of the study

1.2.1 The aim

The aim of this study was to investigate the role and relationship of the presence of MFTPs in the Quadriceps femoris muscle group, Hamstrings muscle group, and Adductor muscle group in patients with PFPS.

1.2.2 The Objectives

1.2.2.1 Objective 1

To record the location and severity of MFTPs in the Hamstring muscle group, Quadriceps femoris muscle group, and Adductor muscle group of patients with PFPS.

1.2.2.2 Objective 2

Subjectively measure the clinical presentation of PFPS in terms of Patellofemoral pain severity scale (PPSS) and Numerical pain scale (NRS).

1.2.2.3 Objective 3

Objectively measure the flexibility of the Hamstring muscle group, to determine the relevance of this flexibility and association to PFPS and noted MFTPs.

1.2.2.4 Objective 4

To assess the association between location and severity of MFTPs and the clinical presentation of PFPS.

1.3 Rationale and benefits

1. PFPS is a very common condition amongst active population of adults as well as adolescents (Servi, 2008). Research was conducted on 2002 runners with injuries at a sports medicine centre in America, and PFPS was recorded as the most common injury (Taunton *et al.*, 2002). Due to the fact that PFPS is very common, it is essential to document more about the etiology and co-morbid conditions of PFPS, in order to assist patients and medical practitioners with the aim of preventing future injuries; as well as to manage and treat current injuries (Garcia *et al.*, 2010; Heiderscheit, 2010; Akbas *et al.*, 2011; Bolga and Boling, 2011; Harvie *et al.*, 2011; Paoloni *et al.*, 2011).
2. PFPS is multi-factorial and complex in nature and the condition presents as a challenge for healthcare providers (Austermuehle, 2001). It is therefore important to find causative factors for the condition, in order to prevent the condition evolving into a chronic state, preventing patients doing exercise and decreasing their quality of life (Kettunen, Harilainen, Sandelin Schlenzka, Hietaniemi, Seitsalo, Malmivaara and Kujala, 2007).
3. Research has previously been conducted to investigate the presence of MFTPs in the Quadriceps femoris muscle group only in patients with PFPS (Dippenaar, 2003; Dippenaar *et al.*, 2008), and a significant relationship was found. Therefore, this study was conducted to investigate the relationship between MFTPs in the Quadriceps femoris muscle group,

the Hamstring muscle group, and the Adductor muscle group. This was to determine if the relationship of the Hamstrings muscle group and Adductors muscle group MFTPs, were also associated with PFPS. This would allow for a more comprehensive clinical picture and therefore treatment / management strategies to be developed (Kettunen *et al.*, 2007; Heiderscheit, 2010; Akbas *et al.*, 2011; Bolga and Boling, 2011; Harvie *et al.*, 2011; Paoloni *et al.*, 2011).

1.4 Delimitations

Results of the subjective and objective findings are based on the honesty of the patient and researcher at the time of performing the tests (Mouton, 1996). These can easily be influenced by pain, irritation, awkwardness, and wanting to please the researcher (the Hawthorne effect) (Mouton, 1996; Dyer, 1997).

1.5 Conclusion

As can be seen from the introduction, PFPS is a commonly encountered condition in all age groups, with a multi-factorial etiology which lends itself to extensive treatment variations. With respect to the PFPS and its etiology, one factor that prevails is the dysfunction of the Quadriceps, which seems to be particularly related to MPS / MFTPs in the Quadriceps femoris muscle group. There is, however, a lack of literature with regards to relationships between the PFPS, the Quadriceps femoris muscle group and other thigh muscle groups. This study aimed to investigate the association between the Quadriceps femoris muscle group, Hamstring muscle group and Adductor muscle group, to try and establish the relationship between MFTPs in these muscle groups and PFPS.

In order to achieve this, the literature review that follows in Chapter Two will expand on the information regarding PFPS from anatomy through to diagnosis, Chapter Three will address study methodology in a step by step format. Chapter

Four will address all statistical analysis of the data, and Chapter Five includes the interpretation of the data obtained in Chapter Four, and Chapter Six explores aspects such as future recommendations and final conclusions about the study.

Chapter Two

Literature review

2.1 Introduction

This chapter will present available literature on PFPS and MFTPs and attempt to draw attention to the correlation between the two. The chapter will emphasize current concepts in the etiology, clinical presentation, and treatment.

Muscles of the medial Thigh

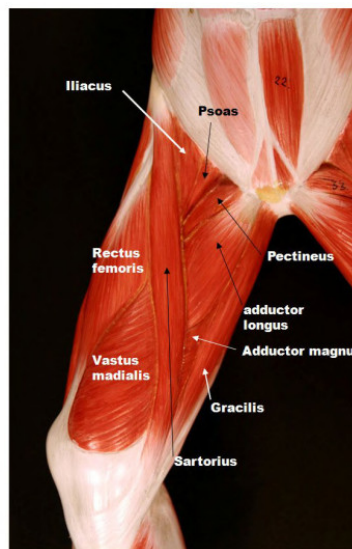


Figure 2.1 : Muscles of the medial thigh (available from <http://digital.library.depauw.edu/cdm4/>, 2011)

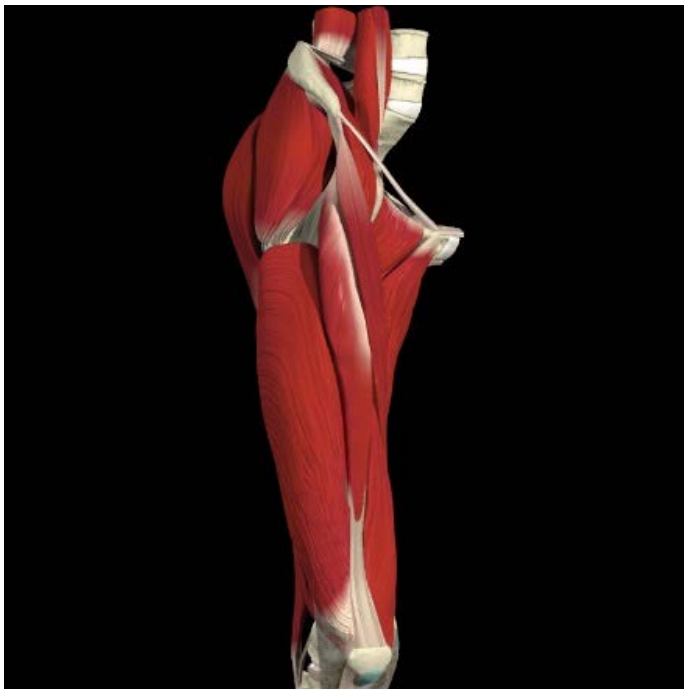
2.2 Anatomy of the thigh and related structures

Three groups of muscles will be discussed in this section, namely the Quadriceps femoris muscle group, the Hamstring muscle group, and aspects of the Adductor muscle group.

2.2.1 The Quadriceps femoris muscle group

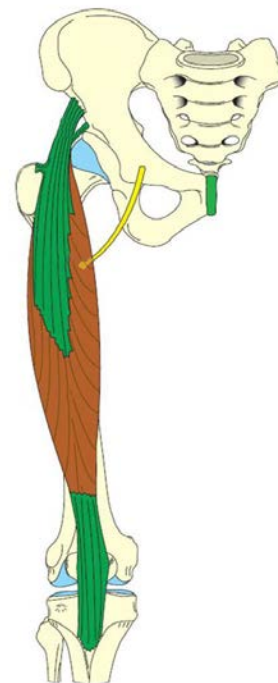
The Quadriceps femoris muscle group consists of four muscles; the Rectus femoris, Vastus lateralis, Vastus intermedius, and Vastus medialis, which are all supplied by the femoral nerve (Moore and Dalley, 1999; Standring, 2008; Martini *et al.*, 2012).

Individually, the Rectus femoris is the only muscle within this group that crosses two joints, as it attaches proximally to the anterior inferior iliac spine of the ilium (therefore, it crosses the femoro-acetabular joint) and distally it merges with the other Quadriceps femoris muscle group to form part of the patella tendon, which inserts into the tibial tuberosity via the patella ligament (therefore, it crosses the tibiofemoral joint). Thus, the Rectus femoris muscle is able to extend the portion of the lower limb between the knee and the ankle, and it also assists in flexion of the hip joint (Moore and Dalley, 1999; Standring, 2008; Martini *et al.*, 2012).



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(Pelissier, n.d.)

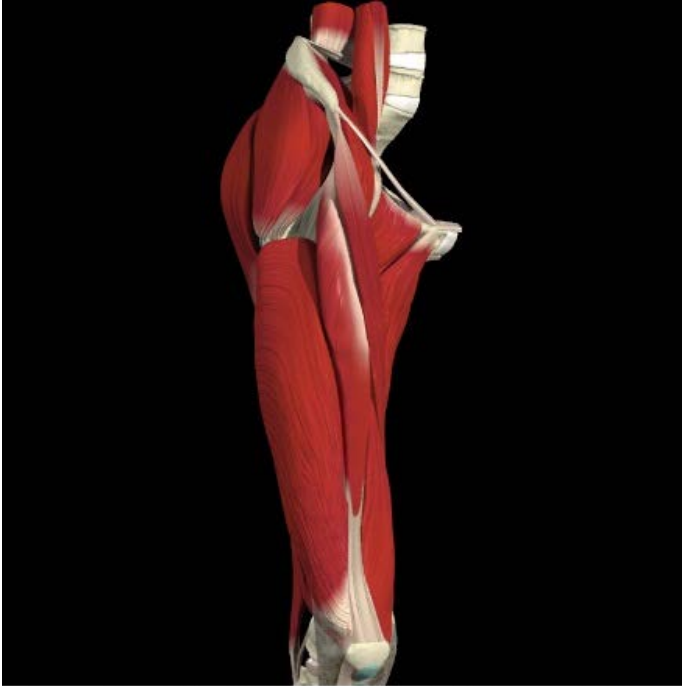
Figure 2.2: Rectus femoris muscle (Quadriceps femoris muscle group)

In contrast to the Rectus femoris muscle, the Vastus muscles are more difficult to distinguish, this is because: (Moore and Dalley, 1999; Standring, 2008; Martini *et al.*, 2012).

- The Vastus muscles, the Vastus lateralis is the largest and most lateral, attaching proximally to the Greater trochanter and Linea aspera.
- The Vastus intermedius lies deep to the Rectus femoris between the Vastus lateralis and the Vastus medialis. It attaches proximally to the intertrochanteric line and Linea aspera.
- The Vastus medialis faces the medial aspect of the thigh, with it attaching proximally to the body of the femur, including the intertrochanteric line, the Linea aspera, the supracondylar line, and the insertional tendons of Adductor longus muscle and Adductor magnus muscle.

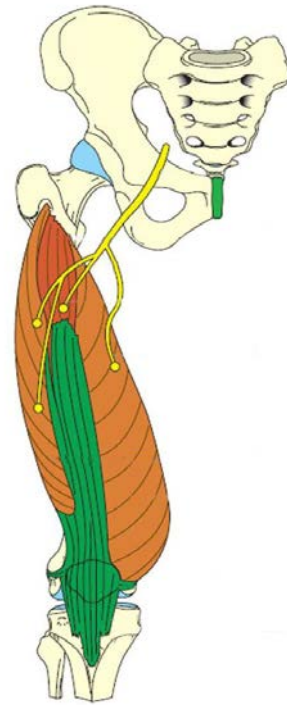
In terms of the distal attachment of the Vastus muscles, they merge to form the Quadriceps (patella) tendon along with the Rectus femoris muscle, which attaches these muscles to the patella, and subsequently to the tibial tuberosity via the patellar ligament (Moore and Dalley, 1999; Standring, 2008; Martini *et al.*, 2012).

Thus, when combined, these four muscles are responsible for extending the leg at the tibiofemoral joint and flexing the hip at the femoro-acetabular joint (Moore and Dalley, 1999; Standring, 2008). The stability created between Vastus lateralis and Vastus medialis maintains the normal position and tracking of the patella, allowing for the normal lever arc and thus smooth movement (Martini *et al.*, 2012). Thus, when in action, the Quadriceps femoris muscle group manages movement particularly while an individual is squatting, sitting down, and ascending / descending stairs (Travell and Simons, 1993; Standring, 2008).



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(Pelissier, n.d.)

Figure 2.3: Vastus muscles (Quadriceps femoris muscle group)

2.2.2 The Hamstring muscle group

According to Travell and Simons (1993), the Hamstring muscle group is the primary antagonist to the Quadriceps femoris muscle group (Martini *et al.*, 2012). The Hamstring muscle group is assisted in this by the Gastrocnemius muscle (Martini *et al.*, 2012).

The Hamstring muscle group consists of 3 muscles, namely the Biceps femoris muscle, the Semimembranosus muscle and the Semitendinosus muscle, which are all supplied by divisions of the Sciatic nerve (Moore and Dalley, 1999; Standring, 2008; Martini *et al.*, 2012).

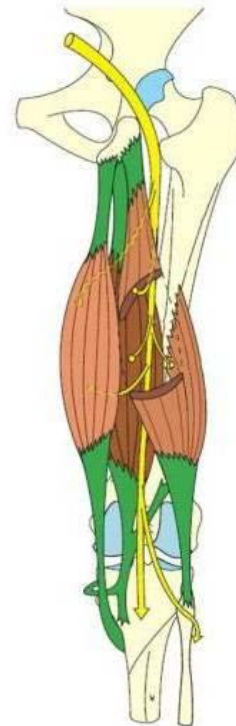
The Biceps femoris muscle contains a short and long head (Standring, 2008; Martini *et al.*, 2012). Proximally the short head attaches to the Linea aspera and

the long head to the Ischial tuberosity. Distally they attach together at the lateral aspect of the head of fibula (Moore and Dalley, 1999; Standring, 2008; Martini *et al.*, 2012). In contrast, the Semimembranosus and Semitendinosus muscles attach proximally to the Ischial tuberosity and distally, the Semimembranosus muscle attaches to the posterior part of the medial condyles of the Tibia, while the Semitendinosus muscle attaches to the medial surface of the superior part of the Tibia (Moore and Dalley, 1999; Standring, 2008; Martini *et al.*, 2012).

As a result of their collective attachments, these muscles cross both the hip joint and the knee joints and are, therefore, responsible for extending the thigh (at the femoro-acetabular joint) and flexing the leg (at the tibiofemoral joint). In addition, the Biceps femoris muscle extends the thigh and flexes the leg whilst rotating the femur laterally. By comparison, the Semimembranosus and Semitendinosus muscles work together to extend the thigh and flex the leg whilst rotating the femur medially. When contracting all three Hamstring muscle components simultaneously and bilaterally, they assist with extension of the trunk (Moore and Dalley, 1999; Standring, 2008; Martini *et al.*, 2012). The Hamstring muscle group are also known to assist with decelerating the body during walking and running, and also has an important role to play whilst cycling and climbing stairs (Travell and Simons, 1993).



(Pelissier, n.d.)



(Pelissier, n.d.)

Figure 2.4: Hamstring muscle group

2.2.3 The Adductors

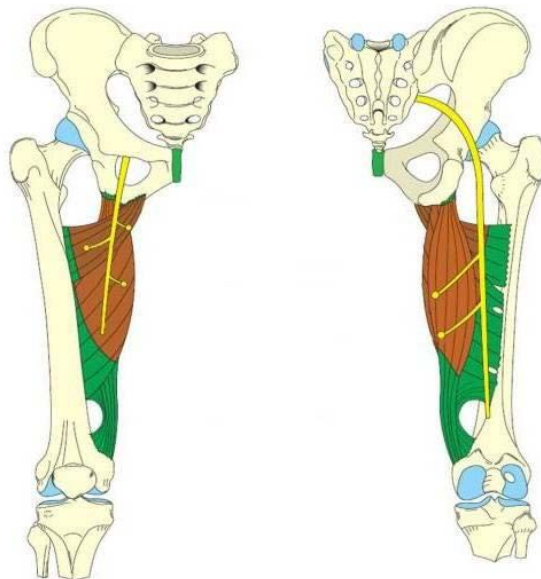
The muscles of the Adductor group relevant to this study are: the Adductor longus muscle, Adductor brevis muscle, and Adductor magnus muscle. These are all supplied by divisions of the Obturator nerve (Moore and Dalley, 1999; Standring, 2008; Martini *et al.*, 2012).

The Adductor longus muscle is the most superficially placed of the three. It arises proximally at the body of Pubis (inferior pubic ramus), and attaches distally to the middle third of the Linea aspera. The Adductor brevis muscle lies deep to Adductor longus muscle and arises proximally from the body and inferior ramus of the Pubis and attaches distally to the Pectineal line and proximal part of Linea aspera. Collectively, the Adductor longus muscle and the Adductor brevis

muscles are responsible for adducting the thigh (Moore and Dalley, 1999; Standring, 2008; Martini *et al.*, 2012).

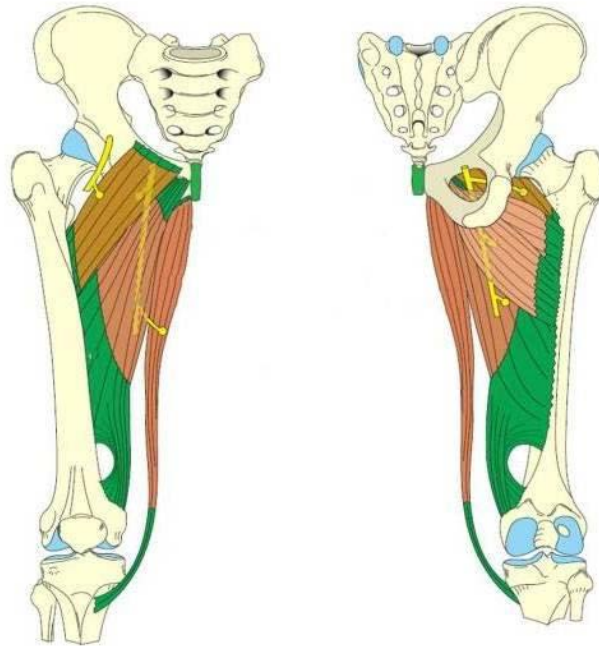
The Adductor magnus muscle, in contrast to the other two muscles in this group, has two parts to it (viz. an Adductor component and a Hamstring component). The Adductor component arises proximally from the inferior ramus of the Pubis and the Gluteal tuberosity and inserts distally to Linea aspera and medial Supracondylar line. The Hamstring component arises at the Ischial tuberosity proximally and attaches to the Adductor tubercle of the Femur distally. Individually, the Adductor component flexes the thigh, whereas the Hamstring component extends the thigh. Collectively, the components assist with adduction of the thigh (Moore and Dalley, 1999; Standring, 2008; Martini *et al.*, 2012).

As a group, these Adductor muscles become active and play a role in walking, and running. Furthermore, Adductor magnus muscle is active during stair climbing and also helps to assist the Hamstring muscle group (Travell and Simons, 1993).



(Pelissier, n.d.)

Figure 2.5: Adductor magnus muscle (Adductor muscle group)



(Pelissier, n.d.)

Figure 2.6: Adductor longus muscle / Adductor brevis muscle (Adductor muscle group) / Gracilis muscle

2.3 Patellofemoral anatomy and biomechanics

The anatomy of the patellofemoral articulation; the overall biomechanics of the lower limb and the relationship with the surrounding muscles affect the contact between the surfaces of the patella and the femur (Tria *et al.*, 1992). This includes the muscles, their tendons and ligaments surrounding the patella, which provides stability and generates movement of the joint (Moore and Dalley, 1999; Standing, 2008; Martini *et al.*, 2012).

2.3.1 Joints of the knee:

The knee joint consists of the:

- Tibiofemoral joint, which articulates laterally and medially via the lateral and medial femoral condyles on the tibial plateau (around the x-axis);
- Patellofemoral joint, which articulates intermediately via the patella in the femoral groove (around the x-axis) and
- Tibiofibular joint via the head of the fibula and the lateral tibia (around the x-axis, but also along the Y-Z plane) (Standring, 2008; Martini *et al.*, 2012).

The tibiofemoral joint is a hinge joint allowing for flexion and extension, and the patellofemoral joint is a modified plane joint that allows for gliding, which is similar to the tibiofibular joint, but in another plane (Magee, 2002). As an entity, the knee joint (collectively the patellofemoral, tibiofemoral and tibiofibular joints) allows for flexion, extension, gliding, rolling and slight rotation, thus providing stability while offering mobility (Moore and Dalley, 1999; Standring, 2008; Martini *et al.*, 2012).

The patella is a triangular sesamoid bone over-passing the femur and the tibia. It is found deeply embedded in the Quadriceps femoris muscle group (patella tendon) and attaches via the patellar ligament to the tibia (Magee, 2002; Standring, 2008; Martini *et al.*, 2012). Hungerford and Barry (1979), Heng and Haw (1996) and Earl and Hoch (2011), state that the main biomechanical function of the patella is to increase the effective lever arm of the Quadriceps femoris muscle group in effecting knee extension or resisting knee flexion, as well as to centralize the efforts of divergent actions of the muscles of the Quadriceps femoris muscle group. In addition, Magee (2002) adds that the

functions of the patella are to assist in knee joint extension, control of capsular tension, and act as a bony shield for the cartilage of the femoral condyles.

Normally, the patella is positioned over the femur in a straight / vertical line by the pull of the various muscles within the Quadriceps femoris muscle group. However, mal-alignment of the lower limb (e.g. rotation of the leg) may lead to an increased Quadriceps angle (Q-angle) and result in lateral patella tracking. This mal-alignment permits the inferior part of the patella to irritate the articulating surfaces of the femur leading to chronic inflammation and pain (Lin, Wang, Koh, Hendrix and Zhang, 2004).

According to Lin *et al.*, (2004), habitual lateral tracking may produce adaptive changes, and could in time cause the Quadriceps tendon to position itself more laterally in relation to the tibiofemoral joint. This, in turn, affects the musculature and could result in the Vastus medialis muscle becoming elongated and the Vastus lateralis muscle becoming shortened with contracture forming. A similar response occurs with the patellar retinaculum, where the lateral side contracts (or becomes fibrosed in a condensed position) and the medial side stretches (by a process of hysteresis and creep (Ciarletta, Dario and Micera, 2008), leading to an excessive lateral pressure syndrome (hyperpressure syndrome) and a decrease in pressure medially, which is referred to as a hypopressure syndrome (Reid, 1993).

In a study by Lin *et al.*, (2004) 18 knees were examined *in vivo* for three-dimensional patella tracking. The purpose of this study was to investigate *in vivo* and non-invasively patellar tracking induced by individual Quadriceps femoris muscle group components. They found that the medial and lateral Quadriceps femoris muscle group components moved the patella in rather different directions, with the Vastus medialis muscle pulling the patella medially and proximally, whilst the Vastus lateralis pulled the patella proximally and laterally. Additionally, the Vastus medialis muscle was found to rotate the patella to a

greater extent round the mediolateral rotation axis than the Vastus lateralis muscle (with the effects more noticeable in full extension). This is confirmed by Dutton (2012), who stated that the cause of imbalance is usually due to tension in the Vastus lateralis muscle, the Tensor fasciae latae and / or the Iliotibial band.

Therefore, Lin *et al.*, (2004) confirmed that appropriate patella tracking is dependent on balanced actions of the different Quadriceps femoris muscle group components, and stated that a reduced action of the medial stabilizers, especially the Vastus medialis, is thought to be an important factor in patellofemoral malalignment and abnormal patella tracking. This has been previously been noted by Boucher and Hodgdon (1993), Powers (1998), Sakai, Luo, Rand and An (2000), Austermuehle (2001) and Yildiz, Aydin, Sekir, Cetin, Ors and Kalyon (2003) and subsequently confirmed by Pribut (2008). In particular Yildiz *et al.*, (2003) state that some researchers have found a significant difference in Vastus medialis – Vastus lateralis activity ratios in patients with Patellofemoral Pain Syndrome (Souza and Gross, 1991; Dippenaar, 2003; Daly, 2005) and other researchers have not found a significant difference (Mirzabeigi, Jordan, Gronley, Rockowitz and Perry, 1999). Some research also suggests that the activity ratios may be linked to muscle inhibition, which means that the Vastus medialis is inhibited by the contracture and pain on the lateral aspect of the knee, as found in PFPS and ITBFS (Dippenaar, 2003; Dippenaar *et al.*, 2008). This, then, negatively reinforces the aberrant mechanics at the patellofemoral joint.

2.3.2 Ligaments of the patellofemoral joint:

The lateral aspect the patella is supported by the Iliotibial band, Vastus lateralis, and the lateral retinaculum, while on the medial aspect, support is provided by the medial retinaculum and the Vastus medialis (Moore and Dalley, 1999; Standring, 2008; Martini *et al.*, 2012). Additionally, the joint capsule of the tibiofemoral joint, the lateral collateral and medial collateral ligaments provide support independently of the muscular structures that support the patellofemoral joint (Moore and Dalley, 1999; Standring, 2008; Martini *et al.*, 2012).

2.3.3 Factor affecting the biomechanics of the patellofemoral joint

Therefore, according to Davidson (1993), Reid (1993), Paoloni *et al.*, (2011), and Pattyn *et al.*, (2011) correct tracking is influenced by:

- The height of the femoral condyles and hence the depth of the femoral groove, keeping the patella “seated” and tracking correctly.
- The shape of the facets on the under surface of the patella determines the “fit” between the patella and the femoral groove.
- The size and shape of the patella and whether or not the patella is apartitie, bipartite or multipartite.
- The anatomical position of the patella (patella baja / patella alta).
- The medial and lateral retinaculæ which keep the patella “centered” in the femoral groove (retinacular restraint abnormalities).
- The composite angle of the pull of the Quadriceps femoris muscle group referred to as the Q-angle.
- The relative strength of the individual muscles comprising of the Quadriceps femoris muscle group.
- Biomechanical factors of the lower limb that impact on the tibiofemoral joint resulting in changes between the amount of rotation that is evident

between the femur and the tibia, as this places additional strain on the patella ligament.

- Any abnormality in the above factors can cause disproportionate amounts of pressure between the patella and the femoral condyles.

As a result of the above factors, it is possible that the patient may develop PFPS due to a singular or combined number of factors. Nevertheless, the most prominent of the factors that result in overt complaints from patients are those related to muscles (Paoloni *et al.*, 2011; Pattyn *et al.*, 2011), as these structures are more prone to develop overuse pathologies when incorrect patella tracking occurs. This concurs with previous literature indicating that the following muscle groups must be studied more intensively in terms of their contribution to and association with PFPS (Moore and Dalley, 1999; Travell and Simons, 1993; Dippenaar, 2003; Daly, 2005):

- The Quadriceps femoris muscle group.
- The Hamstring muscle group and / or
- The Adductor muscle group.

2.4 Myofascial pain syndrome (MPS)

2.4.1 Definition

According to Travell and Simons (1993), MPS is a syndrome of the sensory, motor, and autonomic symptoms caused by myofascial trigger points (MFTPs). Others define it as a pain disorder with referred pain from local or distant MFTPs within myofascial structures (Gerwin, 2005), and additionally some define it as a regional pain syndrome of any soft tissue origin (Simons, 1990).

This condition is noted to be extremely common in voluntary muscle (skeletal muscle); is of multi-factorial origin and is a frequent cause for patients to present to healthcare providers (Gatterman, 1990; Hubbard, 1998; Blyth *et al.*, 2001; Elliott *et al.*, 2002; Eriksen *et al.*, 2003; Cote *et al.*, 2004; Porterfield and de Rosa, 2004; Dommerholt *et al.*, 2006a). Notwithstanding this, Yap (2007) states that MFTPs / MPS are / is often under-diagnosed, and if left untreated could lead to chronic pain syndromes (Auleciems, 1995; Testa *et al.*, 2003; Simons and Dommerholt, 2006a; Cummings and Baldry, 2007).

2.4.2 Pathophysiology

Normally spontaneous electrical activity (SEA) is registered by intramuscular needle electromyography (EMG) when the muscle is at rest (Ge *et al.*, 2011). The electromyographic activity that is associated with the MFTP and its associated taut band is represented by the presence of a negative-positive potential or SEA (Hubbard and Berkoff, 1993; Gerwin, 2001; Simons *et al.*, 2002). New evidence has emerged suggesting that SEA plays an important role in MFTP formation and the cause of muscle pain (Ge *et al.*, 2011). It may also contribute to the formation of the taut muscular band in MFTPs. In this context, SEA is characterised by dysfunctional extrafusal motor endplate potentials (Simons *et al.*, 2002) within the muscle fibres which exhibit muscle tissue

disruption in the form of a muscle cramp potential (Xu *et al.*, 2010; Ge *et al.*, 2011). Therefore, SEA is clinically represented by this focal muscle fibre contraction (Ge *et al.*, 2011). Associated with these localised muscle cramps, are induced intramuscular hypoxia, increased accumulation of algescic substances, direct mechanical stimulation of nociceptors and pain as a result of an inflammatory response (due to tissue degeneration). All of these contribute significantly to the formation of muscle tension and MFTPs (Mense and Simons, 2001; Laferriere *et al.*, 2008; Ge *et al.*, 2011).

2.4.3 Incidence

According to three systematic reviews and one commentary on MPS and MFTPs, there are limited numbers of epidemiological studies indicating the incidence and prevalence of MPS or MFTPs (Baldry, 2001; Alvarez and Rockwell, 2002; Schneider *et al.*, 2005; Vernon and Schneider, 2009), therefore it is only possible to note these figures indirectly through the work of others who have looked at specific population groups (outlined in Table 2.1).

Table 2.1: Incidence and Prevalence of MPS		
Author	Percentage of patients with MPS	In text Comments
Gerwin (2010)	- None recorded	MFTPs are an extremely common cause of acute and chronic muscle pain.
Lucas <i>et al.</i> (2009)	85% of patients presenting to a tertiary pain clinic	Pain believed to be of musculoskeletal / MFTP origin is a common complaint in primary care and is a major public health concern.
Ge and Yue (2008)	36% in the general adult population	Common medical problem.
Cummings and Baldry (2007)	74% of 96 patients with musculoskeletal pain seen by a neurologist in a community pain medical Centre had MFTPs; 85% of 283 consecutive admissions to a comprehensive pain centre were reported to have MFTPs; and the primary diagnosis in 36% of 431 subjects with pain during the previous 7 days was attributed to MFTPs	MFTPs are a common cause of pain and dysfunction in the musculoskeletal system.

Author	Percentage of patients with MPS	Comment
Lucas (2007)	Common	Patients with a variety of pain complaints.
Al-Shenqiti <i>et al.</i> , (2004)	None recorded	MFTPs associated with the development of many common conditions.
Alvarez and Rockwell (2002)	10% of the entire population	None recorded
Small (2002)	Musculoskeletal complaints account for 20% of the visits to primary care physicians and 80% of the visits to sports medicine clinics	MFTPs fairly common in this context.
Rashiq and Galer (1999)	70% of patients	Patients with complex regional pain syndrome patients.
Chaiamnuay <i>et al.</i> , (1998)	MPS was the primary diagnosis in 36% of 431 patients	None recorded
Han and Harrison (1997)	85% of patients	American studies based at pain clinics.
Schneider (1995)	Most predominant soft tissue syndromes injuries.	Patients presenting to a clinical setting.
Friction <i>et al.</i> , (1990)	54% of patients	Patients complaining of head and neck pain.
Schiffman <i>et al.</i> , (1990)	50% of patients	Patients with temporomandibular joint disorders.
Skootsky, Jaeger and Oye (1989)	30% of patients	Patients presenting at a university medical centre.
Sola, Rodenberger and Getty (1955)	Most common frequent problems	General patient complaint seen by physicians.

To support this, it has been noted that MPS is the most common work-related injury (Roffey *et al.*, 2010a; Roffey *et al.*, 2010b; Roffey *et al.*, 2010c; Roffey *et al.*, 2010d; Roffey *et al.*, 2010e; Wai *et al.*, 2010a; Wai *et al.*, 2010b) and has been noted as the second most common reason for visits to physicians (Hubbard, 1998; Cote *et al.*, 2004; Dommerholt *et al.*, 2006a). This concurs and supports review articles by Han and Harrison (1997) and Simons and Dommerholt, (2006a), which indicated that the incidence of MPS was as high as 85% at certain pain clinics in the United States of America (Fishbain *et al.*, 1986).

2.4.4 Etiology of MPS / MFTPs

The etiology of MPS and / or MFTPs is still uncertain and as a result, there are many factors that are thought to predispose to it (Cummings and Baldry, 2007; Delgado *et al.*, 2009). Delgado *et al.*, (2009) further indicates that there are no positive predictive values that have been determined for any one or combination of the currently identified etiological factors. Therefore, Table 2.2 outlines those factors that have been identified as possible etiologies in MPS / MFTPs development.

It is further noted by Travell, Simons and Simons (1999); Testa *et al.*, (2003); Huguenin (2004); Rickards (2006); Yap (2007) and Srbely (2010) that the etiological factors have also been noted as perpetuating factors in those instances where MPS / MFTPs have already been diagnosed in patients.

Table 2.2 : Etiological factors and perpetuating factors implicated in MPS / MFTPs	
Primary Factors	Secondary factors (Baldry, 2001):
<p>These include one or more of the following (Wedderkopp <i>et al.</i>, 2005; Rechartd <i>et al.</i>, 2010):</p> <ul style="list-style-type: none"> • Mechanical abuse: where there is acute sustained or repetitive muscle overload (Travell, Simons and Simons, 1999; Chaitow and Delany, 2002; Lavelle <i>et al.</i>, 2007). • Trauma: this includes the development of MFTPs as a result of a local inflammatory response (Travell, Simons and Simons, 1999; Chaitow and Delany, 2002). • Muscles in shortened position for a prolonged period of time (Travell, Simons and Simons, 1999; Chaitow and Delany, 2002). • Identifiable neuropathic electromyographic changes, which result in disturbed motor endplate dysfunction (Travell, Simons and Simons, 1999; Chaitow and Delany, 2002; McPartland and Simons, 2006). <p>Musculoskeletal factors (Feldman <i>et al.</i>, 2001; Rechartd <i>et al.</i>, 2010) and psychological factors (Sherry <i>et al.</i>, 1991; Vikat <i>et al.</i>, 2000) :</p> <ul style="list-style-type: none"> • Systemic biochemical imbalances (Travell, Simons and Simons, 1999; Chaitow and Delany, 2002). • Structural disharmony (Fricton <i>et al.</i>, 1985) or skeletal imbalance (Rosen, 1994) and related muscle fatigue (Rosen, 1994). • Hypermobility or ligamentous laxity which requires muscular stabilization (Ferrell <i>et al.</i> 1999; Malleson <i>et al.</i>, 2001; Adib <i>et al.</i> 2005; Nijs, 2005; Ofluoglu <i>et al.</i> 2006). <p>And life style factors (EI-Metwally <i>et al.</i>, 2007; Rechartd <i>et al.</i>, 2010)</p> <ul style="list-style-type: none"> • Adverse environmental conditions (Travell, Simons and Simons, 1999; Chaitow and Delany, 2002). • Sedentary lifestyles (Fricton <i>et al.</i>, 1985; Alvarez and Rockwell, 2002; Delgado <i>et al.</i>, 2009) • Nutritional deficiencies or sleep disturbances (Fricton <i>et al.</i>, 1985). • Social deprivation (Malleson <i>et al.</i>, 2001). • Abuse and abusive environments (Malleson <i>et al.</i>, 2001). 	<ul style="list-style-type: none"> • Compensating synergistic or antagonistic muscles to those housing MFTPs may as a result develop MFTPs. • Satellite MFTPs can evolve in referral zone of primary MFTPs. • Low oxygenation of tissues. • The development of active and latent MFTPs occur as a result of the same factors mentioned above (primary and secondary) but to varying degrees (Travell, Simons and Simons, 1999).

2.4.5 Clinical presentation of MPS and assessment of active MFTPs

Clinically, MFTPs present as musculoskeletal pain, limited range of motion, weakness, and referred pain (Travell and Simons, 1993). According to Gerwin (2005), there may even be signs of clumsiness and in-coordination. In particular, active MFTPs can cause pain at rest, and when pressure is applied to an active MFTP it causes an aggravation of pain similar to the patient's complaint (Alvarez and Rockwell, 2002). Therefore, the pain induced by the active MFTP is either felt locally or referred distally.

An active MFTP reveals signs and symptoms such as (Lee *et al.*, 1997; Gerwin *et al.*, 1997; Banks *et al.*, 1998; Travell, Simons and Simons, 1999; Chaitow and DeLany, 2002; Al-Shenqiti, Al-Munawarah and Oldham, 2005; Bron *et al.*, 2007; Cummings and Baldry, 2007):

- A palpable taut band,
- A tender nodule with pain and spot tenderness,
- Local twitch response, noted by a painful contraction and muscle twitching,
- Jump sign (where a patient attempts to move away from the painful stimulus),
- Decreased range of motion,
- Increased pain on active or passive stretch
- Referred pain,
- Pain on contraction of the muscle,
- Weakness and / or limited range of motion of the muscle and / or
- A disturbance of autonomic and motor functions.

In addition to the above signs and symptoms, the patient may complain of pain that is usually dull, aching, regional, poorly localized, and often aggravated by activity (Skootsky, Jaeger, Oye, 1989; Travell and Simons, 1993). Compression of the MFTP causes referred pain that is often identified by the patient as familiar

to the pain that they have been experiencing. All of the above signs and symptoms, according to Travell and Simons (1993), lead to decreased strength, endurance and work tolerance (Rickards, 2006; Yap, 2007; Srbely, 2010).

The signs and symptom combinations differ depending on which muscle is involved, but commonly, on physical examination, the MFTP can be felt as a tender, abnormally hard nodule, sometimes within a tender taut band within the muscle (Travell and Simons, 1993; Gerwin, 2005).

In order to standardise assessment and diagnosis, a study conducted by Chettiar (2001) developed the myofascial diagnostic scale (MDS). This scale was developed for assessment purposes and the differentiation of latent and active MFTPs. The scale was designed with signs of MFTPs used as an indicator (Chettiar, 2001). According to Travell and Simons (1993), signs of MFTPs are: focal tenderness, palpable band, a twitch response, and referred pain. For a MFTP to be diagnosed as active on the MDS, a score above nine is necessary (Chettiar, 2001).

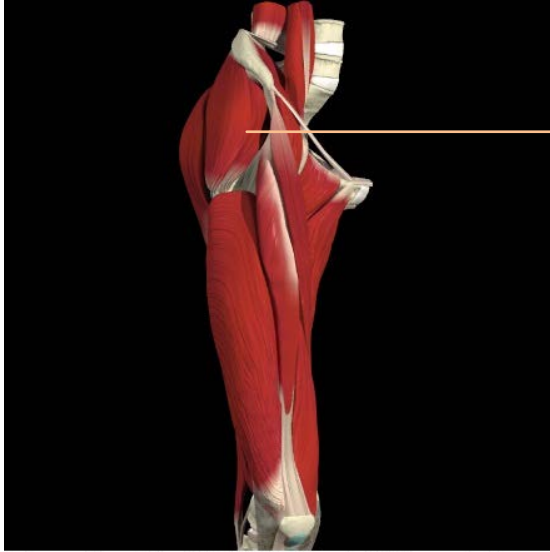
In conjunction with the MDS, pressure algometry is used as an indicator of severity of the MFTP, measuring the level of pain sensitivity (or pain pressure threshold), objectively, in the sense that the patient does not see the value on the algometer display (Fischer, 1986; Smidt *et al.*, 2002).

2.4.5.1 Quadriceps femoris MFTP presentation and assessment

Collectively, the Quadriceps femoris muscle group refers pain to the thigh and knee area, more specifically Rectus femoris muscle and Vastus medialis muscle MFTPs generate anterior knee pain, whereas Vastus lateralis muscle produces posterolateral knee pain. Table 2.3 summarises the pain referral, pain patterns and associated signs and symptoms.

Table 2.3 Pain referral of the Quadriceps femoris muscle group		
Muscle	Pain referral	Associated signs and symptoms
Rectus femoris muscle	Sub- and peri-patellar pain.	Frequent deep aching pain at night.
Vastus intermedialis muscle	Anterior knee and thigh pain, more commonly located in the mid thigh region and superior knee area.	-
Vastus lateralis muscle	Sharp lateral knee and thigh pain. However, palpation reveals tenderness that is diffuse and difficult to localize. The lower Vastus MFTPs also refer to the lateral and infra-patella region.	Often disturbs sleep, prevents the patient from sleeping on the involved side.
Vastus medialis muscle	Pain referral is to the patella over its anterior surface, around the patella (mostly on the medial aspect) and up the inner thigh (more diffusely).	Signs of weakness and sudden buckling of the knee.
Composed from Travel and Simons, (1993); Chaitow and DeLany (2002); Dippenaar (2003).		

When assessing the Quadriceps femoris muscle group, the MFTPs are found in particular regions (Travel and Simons, 1993; Chaitow and DeLany, 2002) and this has been described by means of the following Figures (Figure 2.7 to 2.10).

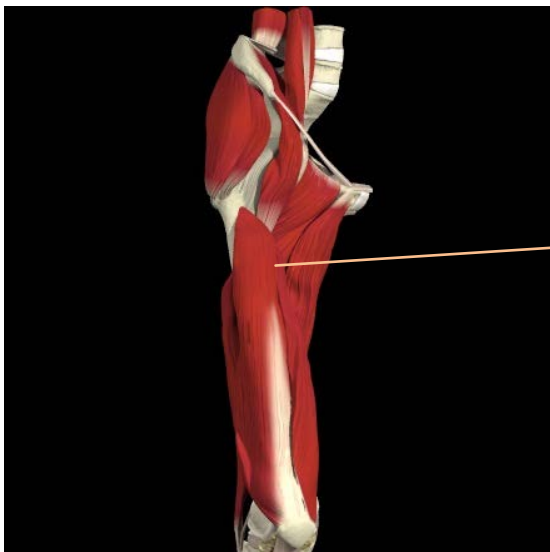


TP1

As illustrated alongside, the MFTPs in the Rectus femoris are commonly, located high in the muscle proximal to the anterior inferior iliac spine (Travell and Simons, 1993). The muscle is differentiated from the Sartorius muscle by asking the patient to isometrically extend the knee. Examination of this MFTP is done by flat palpation.

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Figure 2.7 Rectus femoris muscle MFTPs

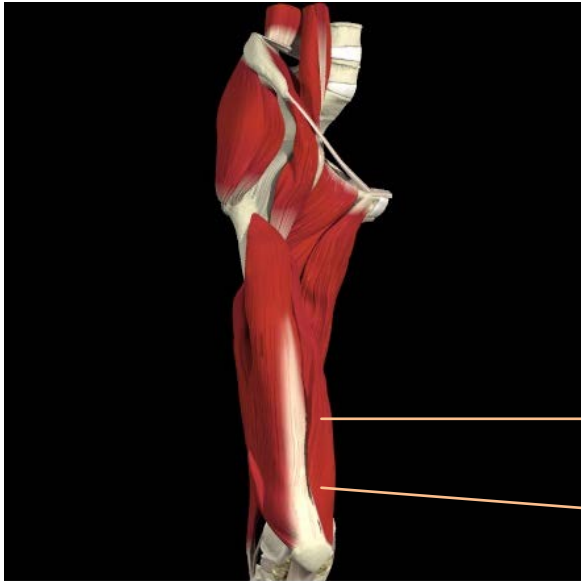


TP 1

Deep to the Rectus femoris is Vastus intermedius muscle. The MFTPs of this muscle are commonly found along the lateral border of Rectus femoris. The entire muscle can be palpated with digital pressure and general tension of the muscle is commonly found. (Travell and Simons, 1993).

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Figure 2.8 Vastus intermedius muscle MFTPs



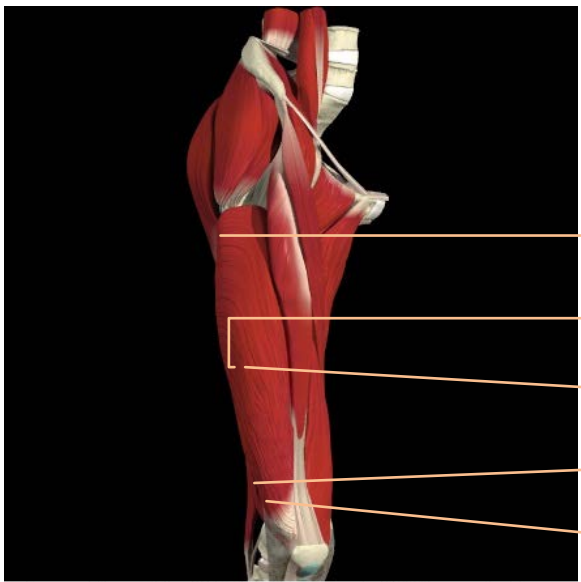
Interactive Hip © 2000 Primal Pictures Ltd.

Figure 2.9: Vastus medialis muscle MFTPs

Vastus medialis muscle MFTPs are normally found in the medial border of the muscle, proximally and distally. TP1 is distal, TP2 proximal. Examination of these MFTPs are done with flat palpation. (Travell and Simons, 1993).

TP 2

TP 1



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Figure 2.10: Vastus lateralis muscle MFTPs

A cluster of MFTPs are found in the Vastus lateralis muscle on the lateral and mid thigh, where the muscle is thickest and its fibers blend with Vastus intermedius muscle. (Travell and Simons, 1993).

TP 5

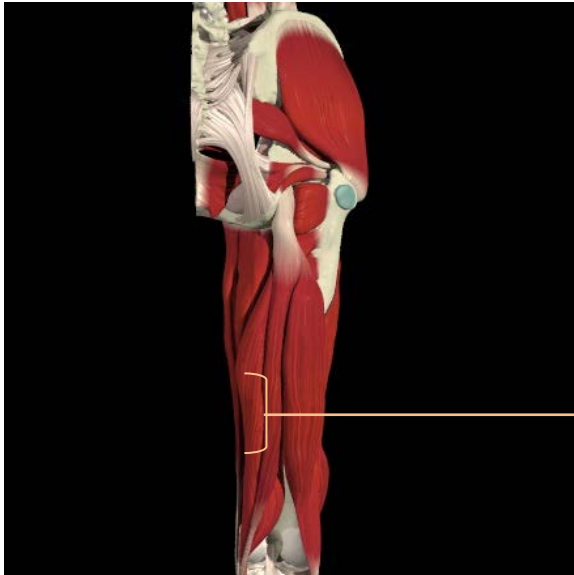
TP 4

TP 3

TP 2

TP 1

2.4.5.2 Hamstring MFTP presentation and assessment



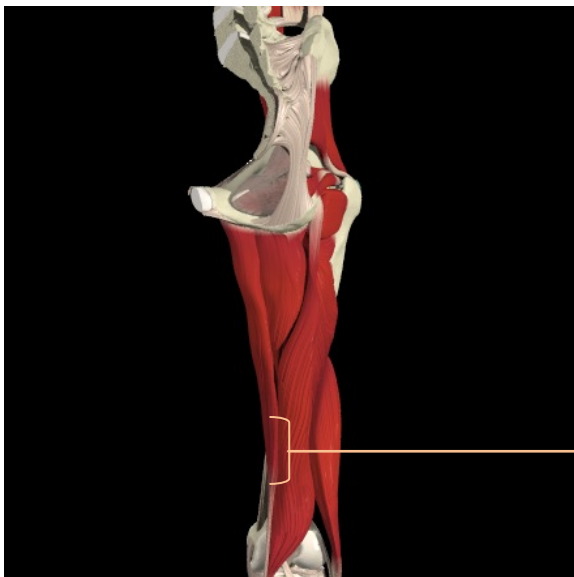
Interactive Hip © 2000 Primal Pictures Ltd.

Figure 2.11: Semitendinosus MFTP's

TP
group

MFTP's in the Hamstring muscle group produce pain in the posterior thigh and knee on walking and sitting, and difficulty rising from a seated position (Travel and Simons, 1993; Chaitow and DeLany, 2002).

On examination of the Hamstring muscle group, MFTP's can be palpated in the Semimembranosus muscle and Semitendinosus muscle distally on the medial aspect, with pincer palpation. It is noted that the Semimembranosus MFTP's are deeper in location than the Semitendinosus.



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Figure 2.12: Semimembranosus MFTP's

TP
group



Interactive Hip © 2000 Primal Pictures Ltd.

Figure 2.13: Biceps femoris MFTPs

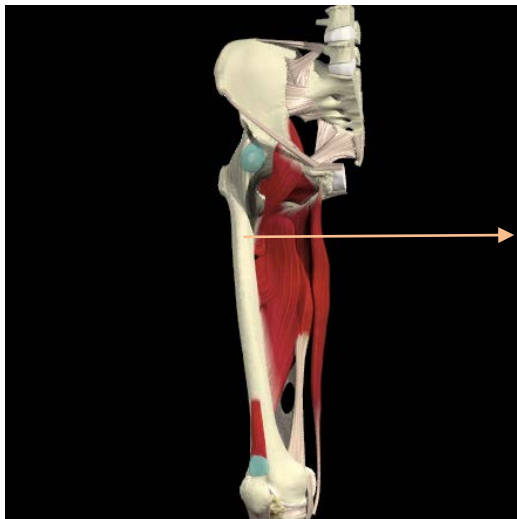
TP
group

On the lateral aspect, the Biceps femoris can be palpated with flat palpation. In isolation, the Biceps femoris generate disturbed and restless sleep. The presentation of MFTPs in Biceps femoris, are commonly associated with shortening of the muscle.

Collectively, MFTPs in the Hamstring muscle group can lead to limited range of motion as a result of muscle shortening and pain (Travell and Simons, 1993). Therefore, in this study, a straight-leg raising test was performed to assess the flexibility of the Hamstring muscle group in relation to PFPS (Travel and Simons, 1993; Chaitow and DeLany, 2002). According to Travell and Simons (1993), the normal measurement of the straight-leg raising test is 80 degrees (Magee, 2002); in cases of decreased flexibility the test has been shown to greatly improve following the application of cold and stretch on the Hamstrings (Travell and Simons, 1993), indicating that MFTPs are a likely cause for decreased Hamstring flexibility.

2.4.5.3 Adductor muscle MFTP presentation and assessment

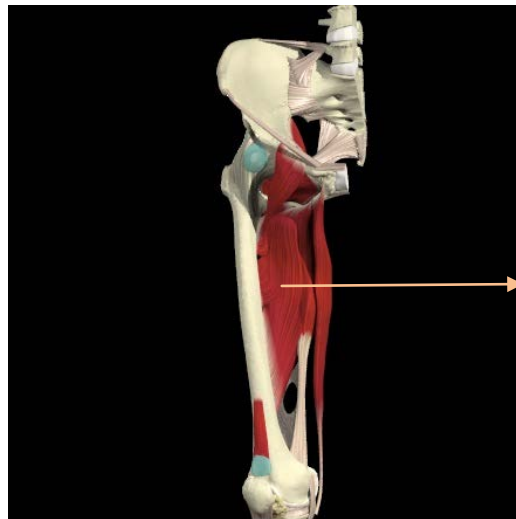
Collectively the three Adductor muscles: Adductor brevis muscle, Adductor longus muscle, and Adductor magnus muscle produce pain on the medial aspect of the thigh, from the groin region (deep in the pelvis to the superficial groin) through to the knee area. The pain is deep and diffuse, and most commonly felt on weight bearing activity, associated with restriction of adduction of the thigh.



TP
group

Interactive Hip © 2000 Primal Pictures Ltd.

Figure 2.14: Adductor brevis muscle

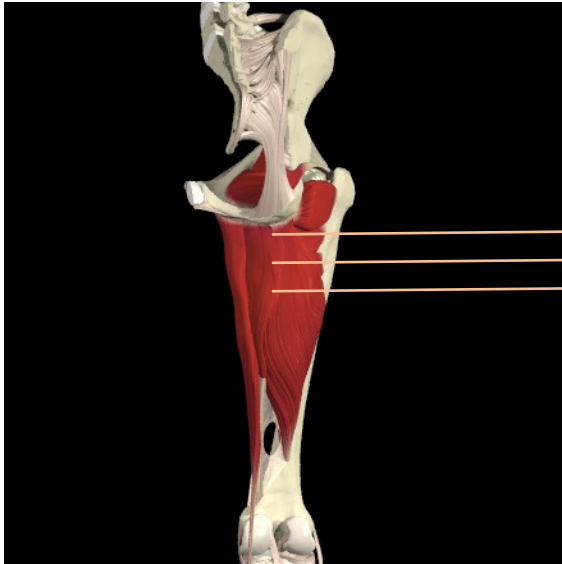


TP
group

Interactive Hip © 2000 Primal Pictures Ltd.

Figure 2.15: Adductor longus muscle

On examination, the proximal portions are felt with pincer palpation and the distal portions with flat palpation. Adductor brevis muscle lies deep to Adductor longus muscle and is diagnosed mainly by patient's pain response to deep palpation (Travell and Simons, 1993). The Adductor magnus muscle is only examinable in its proximal portion, due to the overlying muscles of Gluteus maximus muscle, Biceps femoris muscle, Semimembranosus muscle and Semitendinosus muscle (Moore and Dalley, 1999; Standring, 2008; Martini *et al.*, 2012). Travell and Simons (1993) refer to this proximal portion as the "window of palpation". It is examined against the Ischium with flat palpation.



Region of the most common MFTPs in the Adductor magnus muscle

Interactive Hip © 2000 Primal Pictures Ltd.

Figure 2.16: Adductor magnus muscle

(Travell and Simons, 1993)

2.4.6 Management

The aim of managing MFTPs is to inactivate them, restore flexibility of the involved muscle, and to eliminate the perpetuating factors through rehabilitation and education (Gerwin, 2005). Specific treatment methods include; cold and stretch, post-isometric relaxation, moist heat, procaine / lidocaine injections, corrective posture and activities, structural stress corrections, and exercise therapy (Travell and Simons, 1993; Alvarez and Rockwell, 2002; Ge *et al.*, 2011; Dagenais and Haldeman, 2012). Furthermore, ischemic compression, stripping massage, dry needling, electro therapy, and ultrasound can be used on persistent MFTPs (Travell and Simons, 1993; Alvarez and Rockwell, 2002; Gerwin, 2005; Yap, 2007; Dagenais and Haldeman, 2012).

2.4.6.1 Management of Quadriceps femoris muscle group

In addition to the above, managing the Quadriceps femoris group includes increasing the mobility of the associated joints, such as tibiofemoral, patellofemoral and tibiofibular joints. Further, corrective actions and prevention of MFTPs involves fall-proofing (decreasing the numbers of instances the patient falls) techniques, avoidance of overload and prolonged mobilisation, and attempt not to leave the muscle in a prolonged shortened position. Any structural variances, such as pronated feet and leg length discrepancy, should be corrected, and appropriate exercises, such as home stretching and strengthening, and patella mobilisations, should be given (Travell and Simons, 1993; Cibulka and Watkins, 2005; Rickards, 2006; Yap, 2007 and Srbely, 2010).

2.4.6.2 Management of Hamstring muscle group

In contrast to the Quadriceps femoris muscle group, the Hamstring muscle group require increased mobility and relaxation of the lower spine / musculature and lengthening of the Adductor magnus muscle for purposes of treatment. And the corrective actions include improved ergonomics and individually adjusted exercise gear, such as bicycle corrections (Salter, 1999). Furthermore, home stretching, strengthening and breathing control should be taught (Travell and Simons, 1993; Lee *et al.*, 1997; Gerwin *et al.*, 1997; Banks *et al.*, 1997; Travell, Simons and Simons, 1999; Chaitow and DeLany, 2002; Al-Shenqiti, Al-Munawarah and Oldham, 2005; Bron *et al.*, 2007; Cummings and Baldry, 2007).

2.4.6.3 Management of the Adductor muscle group

As this muscle group share features with both the Hamstring and Quadriceps femoris muscle groups, the management and treatment of the Adductor muscles, include options applicable to both the other muscle groups. A challenge suggested by Travell and Simons (1993), is that the deactivation of MFTPs in the Adductor muscles can activate MFTPs in the Gluteal muscles. In keeping with this, these muscles will need to be incorporated in the management protocol. Corrective actions of these muscles, includes avoiding crossing legs when sitting and avoiding immobilisation. Stretching and strengthening exercises can be given as a home program to prevent recurrence (Travell and Simons, 1993; Lee *et al.*, 1997; Gerwin *et al.*, 1997; Travell, Simons and Simons, 1999; Chaitow and DeLany, 2002; Al-Shenqiti, Al-Munawarah and Oldham, 2005; Cummings and Baldry, 2007).

In summary therefore, the MFTPs of the muscles of the thigh are known to cause a constellation of symptoms and signs which patients may complain of and / or present with. The following table (Table 2.4) outlines those signs and symptoms that most closely resemble PFPS signs and symptoms as noted in patients that have reported with PFPS (Naslund *et al.*, 2006; White, Dolphin, Dixon, 2008). The clinical syndrome will, therefore, be discussed in the next section.

Latent MFTPs	Active MFTPs
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.
Localised pain on manual compression.	Localised and referred pain on manual compression.
No spontaneous pain referral.	Spontaneous pain referral.
Recognition of an unfamiliar or previous pain.	Recognition of current pain.
Compiled and adapted from Travell and Simons, (1993); Wilks (2003); Dippenaar (2003); Rickards (2006); Yap (2007) and Srbely (2010).	

2.5 Patellofemoral pain syndrome

2.5.1 Introduction

PFPS is a common overuse condition, with a multi-factorial etiology and several proposed treatment methods; as a result it has no clear consensus on terminology, etiology or treatment (Cutbill, Ladly, Bray, Thorne, Verhoef, 1997; Juhn, 1999; Thomeé, 1999; Austhermuehle, 2001). The term PFPS is used for non-specific sub-patellar and peri-patellar pain that is unable to be otherwise definitively diagnosed and, therefore, often becomes a diagnosis of exclusion (Reid 1993; Crossley *et al.*, 2004). According to Crossley, Cowan, Bennell, and McConnell (2004) it is likely that the cause of pain is not the same for all patients, and it becomes difficult to define the syndrome due to the fact that patients may experience different levels of pain and physical impairment (Thomeé *et al.*, 1999).

The condition is diagnosed clinically and can be defined as retro-patellar, sub-patellar or peri-patellar pain resulting from physical and biochemical changes in the patellofemoral joint (Juhn, 1999).

2.5.2 Incidence and prevalence of PFPS

PFPS is one of the most common musculoskeletal complaints in all age groups (Thomeé *et al.*, 1999; Yildiz *et al.*, 2003; Servi, 2008) and the most common cause of knee pain (Dixit *et al.*, 2007). The incidence of PFPS is reported as high as 23-33% for an active adult population and 21-45% of an active adolescent population (Lindberg *et al.*, 1986; McConnell, 1986; Thomeé *et al.*, 1999; Servi, 2008). Further studies supporting this can be seen in Table 2.5.

Table 2.5 Incidence and Prevalence of PFPS		
Author	Date	Incidence and prevalence of PFPS
Akbas <i>et al.</i> ,	2011	In the general population it is found in up to 25% of adolescents and adults.
Earl and Hoch	2011	Earl and Hoch, noted that 25% of all knee injuries seen in athletes in a sports medicine clinic were of PFPS origin. Further it was noted that of 20% to 40% of all visits to physical therapy clinics were as a result of knee pain of which 10% were PFPS.
Harvie <i>et al.</i> ,	2011	Noted PFPS as one of the most common knee conditions seen by physiotherapists, affecting one in four people of the total population.
Nejati <i>et al.</i> ,	2011	According to these authors, the reported incidence rate of PFPS among athletes in United States is greater than 25%, which compares favourably with results of a study in a British sports injury clinic have indicated that PFPS accounts for 5% of all injuries seen and 25% of knee injuries. Whereas other comparative results show that the prevalence of PFPS in Iranian female athletes is 16.74%.
Willson <i>et al.</i> ,	2011	It was noted by these authors that up to 80% of runners may experience an overuse injury sometime during their running career, with PFPS being the most commonly cited lower extremity overuse injury, which was estimated to account for over 20% of all visits to an outpatient sports medicine center.
Long-Rossi and Salsich	2010	PFPS was recorded as one of the most common musculoskeletal pain conditions.
Myer <i>et al.</i> ,	2010	These authors noted that PFPS is a common pain disorder experienced by young adults and adolescent athletes who participate in jumping, cutting and pivoting sports. Up to 40% of clinical visits for knee problems are attributed to PFPS, with adolescent females and young adult women more often (2 to 10 times) affected than their male counterparts. Further it was noted that PFPS symptoms can affect up to 30% of young students (13–19 years) and the symptoms may cause 74% to limit their sport activities or lead to sports cessation.
Brantingham <i>et al.</i> ,	2009	It was noted that PFPS prevalence rates range between 2% and 30%, including 10% of all runners. Further it was stated that PFPS has a general incidence rate of at least 7% in athletic young adults, 15% of soldiers and within a lifetime may affect 10% to 40% of the general population ages 18 to 45 as well as older active adults.
Tiggelen <i>et al.</i> ,	2009	Of all knee injuries, an estimated 25% are attributed to PFPS, which makes it one of the most common knee impairments in athletes.
Bily <i>et al.</i> ,	2008	PFPS was noted to be frequently seen in sports medicine clinics, up to 10% of all visits and in armed forces recruits in up to 15% of the population.
Nakagawa <i>et al.</i> ,	2008	PFPS was noted as ranging from 21 to 40% in the general population and occurring twice as often in females as in males.
Avraham <i>et al.</i> ,	2007	It was noted that PFPS was found in 25% of all knee injuries treated in sports medicine clinics.
Cosca and Navazio	2007	These authors noted PFPS as a common overuse injury in runners and other endurance athletes.
Dixit <i>et al.</i> ,	2007	PFPS was noted as the most common cause of knee pain in the outpatient setting, with 11% of musculoskeletal complaints in the office setting being caused by anterior knee pain (noted as PFPS) and PFPS constituting 16 to 25 % of all injuries in runners.
Ivkovic <i>et al.</i> ,	2007	Anterior knee pain was indicated as the most common symptom presenting in sports medicine, with an incidence of the PFPS in women at 20% compared with 7.4% in men.
Tyler <i>et al.</i> ,	2006	PFPS is one of the most common disabilities of the knee joint in sports medicine

From Table 2.5, it can be seen that PFPS is most frequently encountered in athletes, and many authors cite PFPS as the most common diagnosis in the sports medicine field (Crossley *et al.*, 2002; Akbas *et al.*, 2011; Harvie *et al.*, 2011; Willson *et al.*, 2011). These recent references in the literature support the previous assertions with regards to the high incidence and prevalence of PFPS:

- Taunton, Ryan, Clement, McKenzie, Lloyd-Smith, and Zumbo (2002) studied 2002 runners for injuries. Out of these, 331 runners suffered from PFPS, and in total, 42% had some type of knee injury. Taunton *et al.*, (2002) maintains that PFPS is the most common injury in a study population, and the incidence is highest in recreational runners and women.
- Scruideri, (1995) and Salem and Powers, (2001), previously stated that young women and athletes participating in impact sports (i.e. running and jumping) are at greatest risk for developing patellofemoral related injuries.
- Davidson (1993) and Dutton (2012) ascribe this higher incidence in women to be due to the wider pelvic structure, which in turn increases the Q-angle and results in an excessive lateral pressure on the patella.

2.5.3 Etiology and pathophysiology of PFPS

A significant amount of research has been conducted on PFPS along with its contributing factors, and the etiology. The condition is poorly understood (Kannus *et al.*, 1999) and it reveals a lack of consensus regarding etiology and management (Juhn, 1999). According to Thomeé *et al.*, (1999), Austermuehle (2001), and Crossley *et al.*, (2002) the condition is multi-factorial and not consistent for all patients. Researchers (Thomeé *et al.*, 1999; Naslund *et al.*, 2006) suggest further investigation into the patho-etiology of PFPS.

In 2006, Naslund *et al.*, (2006) conducted an observational study on the pathophysiology of PFPS, to explore possible pain mechanisms. He states that no conclusion can be made on what causes patellofemoral pain. Furthermore, it

is maintained that unexplained anterior knee pain, with the elimination of serious pathology can be diagnosed as PFPS (Naslund *et al.*, 2006).

Reid (1992) and Austermuehle (2001) adhere to the fact that the condition can be caused by either extrinsic or intrinsic factors:

- Extrinsic being poor exercise training techniques or improper foot wear.

To this end, Thomeé *et al.*, (1999) state that a sudden increase in activity could lead to peri-patellar soft tissue irritation and subsequent pain and dysfunction. This supports Ficat (1977) and Grayson (1990) who suggest that a temporary overuse leads to muscle imbalance with decreased strength, or even Quadriceps muscle group atrophy (Callaghan and Oldham, 2004) as the main cause of PFPS. However, Thomeé *et al.*, (1999) questions whether this decrease in strength is a cause or an effect of PFPS.

- In contrast, intrinsic factors like poor flexibility, mal-alignments, or structural abnormalities.

Was recently reviewed and studied by Waryasz and McDermott (2008), in which the controversy on the etiology of PFPS was again highlighted. The majority of researchers concur on the presence of Quadriceps femoris weakness [extensor mechanism failure] (Bennett and Strauber, 1986; Thomeé, Renstroem, Karlsson, Grimpy, 1995; Callaghan and Oldham, 2004) and Hamstring muscle group tightness (Smith, Straud, McQueen, 1991; Piva, Goodnite, Childs, 2005), but differ regarding the significance of the Q-angle, with only three studies supporting it (Aglietti, Insall, Cerulli, 1983; Messier, Davis, Curl, Lowery, Pack, 1991; Hains and Hains, 2010); opposed to four studies negating it (Caylor, Fites, Worrel, 1993; Thomeé *et al.*, 1995; Witvrouw, Lysens, Bellemans, Cambier, Vanderstraeten 1996; Duffey, Martin, Cannon, Craven, Messier, 2000). Similarly, controversy was noted regarding the role of the Adductor muscles and

Gastrocnemius muscles and their involvement in PFPS (Waryasz and McDermott, 2008).

In contrast to the failed extensor mechanism debate, Scruideri (1995), Naslund *et al.*, (2006) and Dixit *et al.*, (2007) suggest that the most widely accepted theory, regarding the etiology behind PFPS is an excessive patellofemoral joint stress due to abnormal patellar tracking (Naslund, 2006). Engle (1991), Scruideri (1995), Thomeé *et al.*, (1999), Piva *et al.*, (2005), and Pribut (2008) propose that the abnormal patellar tracking and thereby PFPS is caused by an extensor mechanism misalignment (not failure) that is caused by three main factors, namely (Thomeé *et al.*, 1999):

- Abnormal patellofemoral configuration.
- Deficiency of supporting muscular or guiding mechanics and / or
- Mal-alignment of the extremities relating to the knee mechanism.

Concurrently, Boucher and Hodgdon (1993), Thomeé *et al.*, (1999), Dye (2005), Servi (2008) and Dutton (2012) state that simple overload is the principle reason for and best accounts for the etiology of PFPS. Furthermore, Thomeé *et al.*, (1999) expands on the overload theory, and states that most patients present with some form of temporary overload. During activity, the patella is able to move up and down, and also tilt and rotate. The femur does, at various points during motion, come into contact with the under surface of the patella. In cases of repetitive trauma this can lead to mechanical breakdown of the cartilage and subsequent pain (Austermuehle, 2001; Pribut, 2008).

2.5.4 Presentation of PFPS

PFPS most commonly presents as anterior knee pain, which increases with activity (Juhn, 1999). Patients commonly report that the development of their pain is insidious and that the pain is either sharp and acute or diffuse and chronic (Austermuehle, 2001; Naslund, 2006). Duri, Aichroth, Wilkins, Jones (1999) state that the most consistent symptom is a deep pain and discomfort on prolonged sitting.

Therefore, PFPS is generally indicated by the following symptoms (McConnell, 1986; McConnell, 1996; Naslund *et al.*, 2006):

- Anterior or peri-patellar knee pain.
- Pain on ascending and descending stairs.
- Pain on squatting and kneeling.
- Pain on prolonged sitting and
- Pain on walking or running.

PFPS typically presents with the following signs (McConnell, 1986; McConnell, 1996; Magee, 2002):

- Crepitus associated with movement.
- Occasional swelling following exercise.
- Pseudo locking or giving way.
- Positive Waldron's test, Clarke's test and patella tilt or tenderness.

2.5.5 Diagnosis and clinical evaluation of PFPS

Based on the varied presentation (aetiology, incidence and prevalence), PFPS is considered a diagnosis by exclusion (Naslund *et al.*, 2006; White, Dolphin, Dixon, 2008). As a result of the multiple etiologies, PFPS is diagnosed clinically by the absence of any recognisable pathology and characterised by a stereotypical group of signs and symptoms as mentioned above (See Section 2.5.4) (Crossley

et al., 2002). Crossley *et al.*, (2004) state that PFPS can be identified as: “the presence of pain around the patella in association with activities that load the patellofemoral joint”.

In a study by Naslund *et al.*, (2006), symptoms and clinical findings were compared in subgroups of individuals with PFPS. It was concluded that no commonly used clinical test had both good sensitivity and specificity. In the absence of radiological findings and the presence of unexplained anterior knee pain, Naslund *et al.*, (2006) therefore, stated that: “the report of typical pain is sufficient for a diagnosis of PFPS”.

In agreement with the previous literature, Table 2.6 outlines the following signs and symptoms:

Author	Date	Diagnostic criteria
Harvie <i>et al.</i> ,	2011	The latest literature shows that diffuse retro/peripatellar pain aggravated with activities which load the patellofemoral joint, such as climbing stairs, squatting, running, and prolonged sitting, are the most classic indicators of PFPS.
Nejati <i>et al.</i> ,	2011	PFPS is associated with functional activities such as ascending and descending stairs, squatting, and prolonged sitting and crepitus, clicking, catching, and the sensation of giving way. Symptoms are typically bilateral and persistent, lasting over several years with little change.
Paoloni <i>et al.</i> ,	2011	Retropatellar or peripatellar pain.
Willson <i>et al.</i> ,	2011	PFPS is associated with decreased hip strength
Collins <i>et al.</i> ,	2010	Insidious onset of anterior knee or retropatellar pain greater than six weeks duration and provoked by at least two of: prolonged sitting or kneeling, squatting, running, hopping, or stair walking; Tenderness on patellar palpation, or pain with step down or double leg squat; Pain over the previous week of at least 30 millimetres on a 100 millimetre visual analogue scale.
Earl and Hoch	2010	Aching pain in the peripatellar region that is increased by physical activities such as climbing stairs, squatting, jumping, and running and/or by sitting with the knees flexed for prolonged periods of time. It was further noted that patients have deficits in hip abduction, extension, and external rotation strength and moderate evidence for a decrease in adduction and internal rotation strength compared to healthy controls.
Myer <i>et al.</i> ,	2010	Retropatellar and peripatellar pain, clinically referred to as PFPS.

Author	Date	Diagnostic criteria
Brantingham <i>et al.</i> ,	2009	Anterior, peripatellar, or retropatellar knee pain of more than 3 months from at least 2 of the following: 1. Prolonged sitting, stair climbing, squatting, running, kneeling, and hopping/jumping or overuse activities with the pain of any of these activities relieved by rest. 2. Insidious or gradual onset of symptoms unrelated to a traumatic incident. 3. Presence of pain upon palpation of the patellar facets, on step down from a 25-cm step, or during a double-legged squat. 4. X-ray or MRI findings were not required as there is no clear correlation between severity of complaints and arthroscopic or radiologic findings. 5. A visual analogue scale (worst pain) of ≥ 5.0 and an anterior knee pain scale of ≥ 50 . 6. The "PARTS" system was used to facilitate determination of concurrent segmental joint dysfunction or "subluxation complex" requiring chiropractic manipulative therapy (CMT).
Tiggelen <i>et al.</i> ,	2009	This condition presents clinically as diffuse anterior or retropatellar knee pain exacerbated by activities such as stair climbing and descending as well as prolonged sitting, squatting, or kneeling.
Bily <i>et al.</i> ,	2008	Inclusion criteria were anterior knee pain for 6 to 12 months and at least 3 of the 4 following clinical criteria: pain associated with prolonged sitting with bended knees, descending stairs, kneeling and squatting, or sports activities.
Avraham <i>et al.</i> ,	2007	Diagnosed with PFPS according to the following inclusion criteria's based on clinical findings: 1. Positive sign (i.e., local pain) in patellofemoral gliding test. 2. Negative McMurry test. 3. Full knee range of motion. 4. Anterior knee pain, related to prolonged sitting, climbing stairs, and descending stairs. 5. No relevant patellofemoral degenerative changes on imaging. 6. No history of knee trauma.
Cosca and Navazio	2007	Anterior knee pain exacerbated by running, jumping, or cycling. Pain on climbing or descending stairs or hills. Pain with prolonged sitting with knees flexed (i.e., "theater sign" / "movie goers" sign).
Dixit <i>et al.</i> ,	2007	Pain "behind," "underneath," or "around" the patella. The symptoms included those of gradual onset, and may be bilateral. Common symptoms included stiffness or pain, or both, on prolonged sitting with the knees flexed (sometimes called the "theater sign"), and pain with activities that load the patellofemoral joint ("circle sign"). The pain was described as "achy," but it can be sharp at times. Patients may complain of the knee giving way.
Cibulka and Watkins	2005	Impaired joint mobility, muscle performance, and range of motion associated with ligament or other connective tissue disorders.

2.5.6 Management of PFPS

A substantial amount of research has been conducted on the treatment of PFPS. Due to the lack of consensus on etiology and, therefore, management there are many treatment methods described in the literature (McConnell, 1986; McConnell, 1996; Crossley *et al.*, 2002; Saxena and Haddad, 2003; Yildiz *et al.*, 2003; Michaeli (2004), Dixit *et al.*, 2007; Pribut, 2008; Patellofemoral pain

syndrome [online], 2008; Servi, 2008). Most of whom adhere to some kind of exercise program with strengthening and stretching (Wood, 1998; Juhn, 1999; Kannus, 1999; Neptune *et al.*, 1999; Crossley *et al.*, 2002; Yildiz *et al.*, 2003; Michaeli, 2004; Dixit *et al.*, 2007; Patellofemoral pain syndrome [online], 2008; Pribut, 2008; Servi, 2008). Some of these authors, however, concur that no individual can benefit from the same program and, therefore, they should be treated individually and further research should be conducted (Neptune *et al.*, 1999; Thomeé *et al.*, 1999; Crossley *et al.*, 2002; Dixit *et al.*, 2007).

In 1986, an anterior knee pain management programme was pioneered by McConnell (1986). This program, with muscle control management, was demonstrated to be effective in patients with PFPS in a 12 month follow up study by Gerrard (1989). Along with exercises, improving mobility of tight structures, and timing of elongated muscles, the McConnell program also uses tape to relieve pain and continue rehabilitation (Gerrard, 1989). Furthermore, the program focused on maintenance following cessation of treatment, for the problem not to recur. This program has, over the years been modified, approved and tested by many (Wood, 1998; Crossley *et al.*, 2002; Patellofemoral pain syndrome [online], 2008).

According to Waryasz and McDermott (2008), two thirds of the patients that visit sport injury clinics are successfully treated with a rehabilitation protocol. In a study by Kannus *et al.*, (1999), a 67% success rate is reported in treating chronic PFPS through a rehabilitation protocol over a seven year time frame. According to Witvrouw *et al.*, (1996), rehabilitation exercises “can restore patellofemoral joint homeostasis although the anatomical mal-alignment of PFPS cannot be corrected”.

McClelland (1998) conducted research comparing patients with PFPS receiving physical therapy for 6 weeks and patients with PFPS attending a home exercise

program for 6 weeks. There was no statistically significant difference between the groups, however both improved.

Another difficulty reported by several authors is the fact that tight Gastrocnemius and Hamstring muscle group can lead to functional equinovarus and foot pronation, this is also associated with internal tibial rotation, increase in Q angle, lateral patella movement, and subsequent pain (Wood, 1998; Neptune *et al.*, 1999; Pribut, 2008). It is, therefore, stipulated by many to stretch the involved tight muscles, apply foot orthotics, and tape (Wood, 1998; Juhn, 1999; Neptune, 1999; Saxena and Haddad, 2003; Michaeli, 2004; Christau, 2004; Pribut, 2008; Servi, 2008). In a study conducted by Saxena and Haddad (2003), 102 patients were treated with semi-flexible orthotics, and 76.5% improved with a significant reduction of symptoms. Additionally, authors recommend avoiding certain exercises that overload the patellofemoral joint, decrease running, adapt proper exercise training techniques and ergonomics, and apply ice (Wood, 1998; Michaeli, 2004; Dixit *et al.*, 2007; Pribut, 2008; Servi, 2008). Finally, according to Wood (1998), adjustments of adjacent joints have been shown to benefit in the management of PFPS. This is supported by Meyer, Zachman, Keating, and Traina (1990) and Gelfound and DeVore (1995). However, a study by Mead (2003) shows no beneficial effects of sacroiliac adjustment on the improvement of PFPS.

Author	Date	Treatment options
Akbas <i>et al.</i> ,	2011	VMO strengthening to promote active medial stabilisation of the patella within the femoral trochlea and patellar realignment procedures, such as stretching, taping, and bracing, taping, kinesiotaping, kinesiotaping,
Bolgia and Boling	2011	Improvement of patella tracking to reduce abnormal stress to patellofemoral joint structures (Quadriceps exercises represent the most commonly used intervention, along with taping, patellar bracing, and knee bracing and exercises that target the hip for patients with PFPS.
Harvie <i>et al.</i> ,	2011	Exercise therapy targeting neuromuscular deficits, including Quadriceps, vastus medialis, proximal strength deficits, tightness of soft tissues, or dynamic alignment/control abnormalities. The range of exercises employed to target these deficits include various combinations and variations of open and closed kinetic chain exercises, exercises aimed at selectively or non-selectively recruiting muscles and stretching.

Table 2.7 Treatment options for PFPS continued ...		
Author	Date	Treatment options
Paoloni <i>et al.</i> ,	2011	Despite the positive effect of patellar taping combined with exercises on pain in PFPS has previously been demonstrated over a short follow-up period with a recent meta-analysis concluding that taping promptly reduces pain, longer term results are less promising
Garcia <i>et al.</i> ,	2010	The electrical stimulation of the VMO muscle and the Quadriceps femoris to normalise muscle function.
Heiderscheit	2010	Footwear, orthoses, bracing, patellar taping, and Quadriceps strengthening have been traditionally promoted.
Brantingham <i>et al.</i> ,	2009	Exercise alone, applied locally, has been demonstrated useful in the short-term treatment of PFPS at 6 weeks. Exercise with or without manipulative and soft tissue therapy or, combined with other modalities such as orthotics, knee braces, and tape, demonstrates comparable short-term usefulness.
Syme <i>et al.</i> ,	2009	The first approach places emphasis on generally strengthening the Quadriceps musculature. The second approach places emphasis on the 'selective activation' and re-education of the VM component of the Quadriceps femoris muscles.
Bily <i>et al.</i> ,	2008	Exercise therapy. Quadriceps femoris muscle strengthening, patellar taping, and weight-bearing exercises to influence the timing of contraction and strength of hip and thigh musculature.
Nakagawa <i>et al.</i> ,	2008	Strengthening, patellar taping, stretching and biofeedback.
Avraham <i>et al.</i> ,	2007	Non-operative treatment have successful results in resolving the syndrome ranging between 66% to 87%, no agreement for a standard, Quadriceps strengthening, patellar bracing and taping, soft tissue mobilization and stretching.
Cibulka and Watkins	2005	Strengthening exercises for the right hip abductor and internal rotators were performed while standing using a hip exercise machine.
Cosca and Navazio	2007	Relative rest and activity modification, icing, NSAIDs, patellar tracking exercise program (straight leg raises and short arc Quadriceps isometric exercises). Consideration of the use of knee sleeve or patellar taping. Sports specific adaptations.
Dixit <i>et al.</i> ,	2007	Rest, exercise, analgesics, taping, bracing, addressing underlying cause and surgery.
Ivkovic <i>et al.</i> ,	2007	Quadriceps muscle stretches, balanced strengthening, proprioceptive training, hip external rotator strengthening, orthotic devices, and effective bracing will relieve the pain in most of the patients. If a comprehensive rehabilitation program of at least 6-month duration fails, surgical treatment should be suggested to the patient.
Tyler <i>et al.</i> ,	2006	Quadriceps strengthening, patellar bracing and taping, soft tissue mobilisation, and stretching.

2.6 Comparison of PFPS and MFTPs

The Quadriceps femoris muscle group forms the bulk of the anterior thigh. It is the primary extensor of the leg and one of the strongest muscles in the body. This muscle is vital during activities such as stair-climbing, jumping and running. Similarly, the Hamstring muscle group forms the bulk of the posterior thigh. It is a primary component in extending the thigh and flexing the leg and is one of the largest and strongest muscles in the body. This muscle is vital during walking and running. The Adductor muscles play an important role in activities, such as running, and stair-climbing, by stabilising the muscles during flexion and extension. Collectively, these muscles work together to produce movement. The anterior muscles should balance the posterior muscles to achieve correct function. Imbalance and overload can lead to muscle dysfunction (Moore and Dalley, 1999; Callaghan and Oldham, 2004; Standring, 2008; Martini *et al.*, 2012), and the imbalance could be caused by MFTPs (Travell and Simons, 1993 (Section 2.6). This then results in the presentation of MFTP signs and symptoms as outlined generically in Table 2.4.

Similarly, muscles involved and thought to contribute to the pain include the Quadriceps femoris muscle group, the Hamstring muscle group and / or the Adductor muscle group. Furthermore, many authors concur that PFPS could be caused by an imbalance in timing between the vastus muscles (Yildiz, 2003; Crossley, Cowan, Bennell, and McConnell, 2004; Servi, 2008). In a study by Crossley *et al.*, (2004), it was confirmed that “individuals with PFPS reduce the amount of knee flexion during stair-climbing, presumably a reversible compensation to their knee condition”. This implies that there is an element of muscle dysfunction in the presentation of PFPS (Table 2.6), which is not dissimilar to the presentation of MFTPs (Table 2.4). Therefore, one possible cause for the symptoms and findings in PFPS is the presence of MFTPs (Grabiner, Koh, and Draganich, 1994; Witvrouw, Sneyers, Lysens, Victor, and

Bellemans, 1996; Neptune, Wright, and Van Den Bogert, 1999, Dippenaar, 2003; Daly, 2005).

This assertion is supported by Dippenaar (2003) and Dippenaar *et al.*, (2008) who did a comparison of PFPS and MFTPs and found a significant overlap between the two. Both syndromes presented with the following:

- Peri-patellar or retro-patellar pain.
- Pain on prolonged sitting.
- Pain worsened with ascending or descending stairs.
- Pain worsened with physical activity.
- Pain on deep squats.
- Pain on kneeling.
- Pain on isometric Quadriceps femoris contractions and
- Patella mobility restriction.

In addition to this, both syndromes also present with a feeling of giving way and or weakness of the knee (McConnell, 1986; Travell and Simons, 1993; McConnell, 1996; Magee, 2002).

In studies by Daly (2005) and Weyer-Henderson (2005), long distance runners with PFPS were treated by inactivation of active MFTPs in the Vastus lateralis. Daly (2005) and Weyer-Henderson (2005) reported on the imbalance between the individual components of Quadriceps femoris muscle group and found that the inactivation of MFTPs in the Vastus lateralis causes reflex inhibition of the Vastus medialis. Additionally, it was concluded that MPS seems to be a positive predictive and concomitant factor in PFPS.

Thus, the aim of this study was to investigate the role and relationship of the presence of MFTPs in the Quadriceps femoris muscle group, Hamstrings muscle group and Adductor muscle group in patients with PFPS.

Chapter Three

Methodology

3.1 Introduction

The following chapter will discuss all aspects related to the methodology of the study. It will discuss recruitment, data collection, and research design, and the study methods. Statistical analysis will also be mentioned.

3.2 Research design

In order to achieve the above, a cross-sectional, observational, quantitative non-intervention clinical assessment study was conducted at the Chiropractic Day Clinic (CDC) at Durban University of Technology (DUT). The study was approved by Faculty of Health Sciences Research and Ethics Committee (Appendix 1), indicating that the study complies with the principles as set out in the Declarations of Belmont, Helsinki and Nuremburg (Johnson, 2005).

3.3 Advertising

Permission was obtained from local gyms, sports clubs, offices, schools and the DUT campus to place advertising flyers on their notice boards. In addition adverts were placed in local newspapers and handed out at various sporting events (Appendix 2).

3.4 Telephonic interview

Before entering the clinical assessment a telephonic interview was conducted to assess eligibility of patients (Appendix 3). The following questions were asked:

1. Are you willing to consider participation in the study?
2. Are you willing to answer a few questions telephonically so that I can ensure that you are indeed eligible for the study?
3. Are you between the ages of 20 and 50?
4. Is the pain you are experiencing underneath or around the knee cap?
5. Do any of the following aggravate your pain?:
 - Squatting.
 - Stair climbing.
 - Kneeling.
 - Prolonged sitting and / or
 - Physical activity.
6. Have you had any history of any of the following?:
 - Traumatic kneecap dislocation.
 - Any neurological problem effecting the way you walk.
 - Knee surgery over the past 2 years.
 - A cartilage or meniscal tear.
 - Injury causing ligamentous instability - does your knee give way and / or
 - Arthritis in your knees.

Patients were included if they responded with a “yes” to questions one to six. Conversely, patients were excluded on account of a yes to any of the questions listed under point six.

3.5 Sampling

3.5.1 Sample size

The study included eighty patients with PFPS, who were recruited by convenience sampling (Mouton, 1996). There were no restrictions placed on ethnic group, gender, occupation, or activity,

3.5.2 Sample allocation and method

As this study required that data be taken from all patients, the patients were not allocated into sub-groups. The subgroup analysis only occurred in the statistical analysis of the data and will be further discussed under Section 3.8.

3.5.3 Sample characteristics

3.5.3.1 The inclusion criteria

- Males and females that were between 20-50 years of age were included. This age was selected to prevent the complexity of differentiating PFPS, with late apophysitis in adolescents (Naslund *et al.*, 2006), and to exclude PFPS from early onset of osteoarthritis in late adulthood (Yochum and Rowe, 2005; Naslund *et al.*, 2006).
- Patients that presented with gradual onset of poorly localised or peri-patellar knee pain were included (Dixit *et al.*, 2007).
- Patients that presented with pain complained of at least two of the following features (Rowlands and Brantingham, 1999):
 1. Prolonged sitting,
 2. Climbing stairs,
 3. Squatting,

4. Kneeling and / or
 5. Running.
- Patients that gave permission by signing letter of information and informed consent (Appendix 4).

3.5.3.2 The exclusion criteria

- Any previous knee surgery or severe trauma within the last 12 months (Naslund *et al.*, 2006).
- Pregnant patients were excluded due to increased anterior knee laxity caused by relaxin (Schultz, Sander, Kirk, and Perrin, 2005).
- Patients that presented with signs and symptoms of: meniscal tear, features indicative of osteoarthritis, osteochondritis dissecans, bursitis and / or patella tendonitis, and / or any systemic arthritides that affects the knee (Powers, Landel, and Perry, 1996; Kannus, Natri, Paakkala, and Jarvinen, 1999; Naslund *et al.*, 2006).
- Patients presenting with lower limb neurological deficits such as numbness, weakness and decreased reflexes, as this indicated pathology of nerve root entrapment or compartment syndrome origin (Rowlands and Brantingham, 1999; Morris, 2006).

3.6 The protocol for patients included into the study:

If the patient met the inclusion criteria, they were invited for an initial consultation at Durban University of Technology CDC, where they were asked to read and sign a Letter of Information and Informed Consent Form (Appendix 4). At this consultation and prior to signing the Letter of Information and Informed Consent Form, the patient had the opportunity to ask questions pertaining to the study. If after having been explained the study, the patient had the right to not participate, at which time the patient was thanked for their time and taken back to the CDC reception if they wished to make an outpatient appointment with another intern at the CDC.

If the patient agreed to participate, they were asked to complete a questionnaire on the duration of the condition (Appendix 5), the Patellofemoral Pain Severity Scale (PPSS) (Appendix 6) and the Numerical Rating Scale (NRS) (Appendix 5) to determine if they suffered from PFPS. Patients who fulfilled the inclusion criteria were included into the next phase of the assessment.

This assessment was used to confirm the subjective responses from the patient (Appendix 5 and Appendix 6) and to clinically diagnose PFPS. The patients underwent:

- A complete case history (Appendix 7),
- Physical examination (Appendix 8) and
- Orthopedic knee examination (Appendix 9).

Simultaneously, patients underwent a MFTPs examination (Appendix 5), as per Travell and Simons (1993).

If the patient met all the inclusion criteria, the researcher then administered:

- The Myofascial Diagnostic Scale (MDS) (Appendix 10),

- Inclinator reading (Appendix 5) (to assess Hamstring muscle group flexibility) and
- Algoter reading (Appendix 5) (pressure-pain threshold).

All the data was collected at this initial consultation and patients were not required to return for any further visits at the CDC as their participation in the study was completed. However, patients were eligible for free treatment as a result of their participation after the completion of the study. These treatment sessions did not, however, involve any data collection and were, therefore, not related to the data reported in this dissertation.

3.7 Measuring tools

This section includes explanation of subjective and objective measuring tools used in the study.

3.7.1 PFPS / MFTP pain.

3.7.1.1 The Numerical Pain Rating Scale (NRS)

The NRS (Jenson, Karoly, and Braver, 1986; Bolton and Wilkinson, 1998) assessed the patient's perception of their pain intensity. The patient was asked to allocate a number to their pain on a point scale from 0-10, 0 being no pain and 10 being the worst pain possible. Liggins (1982) and Jenson *et al.*, (1986), indicated that this subjective measurement is valid and reliable to record such findings (Liggins, 1982).

- The administration process for the use of the NRS included :
- The NRS was administered before the patient was clinically assessed for inclusion into the study, in order to avoid the influence of assessment increasing the patient's pain.

- The procedure started with the researcher explaining to the patient that this was a subjective questionnaire whereby the patient was required to estimate their levels of pain - indicating their pain levels at that time that the questionnaire was administered.
- The patient was asked to circle a number between 0 and 10 that most accurately reflected their pain at the time.
- The questionnaire was chosen due to the ease at which it could be administered and scored.

3.7.2 MFTP's.

Under the clinical definition of MFTPs, several subgroups are mentioned by Travell and Simons (1993). As a result this study, only noted active MFTPs as per their definition (Travell and Simons, 1993):

The minimal criteria for identification of a MFTP according to Gerwin *et al.*, (1997), Travell, Simons and Simons (1999), Chaitow and DeLany (2002) and Rickards (2006) are as follows:

Minimal criteria:

- Taut palpable band.
- Exquisite spot tenderness / focal tenderness of a nodule in a taut band.
- Patient's recognition of pain / referred pain in the zone of reference.

Confirmatory Observations:

- Visual or tactile identification of local twitch response.
- Pain or altered sensation on compression of the tender nodule.
- Painful limit to full range of motion.
- Pain on contraction of the muscle.
- Weakness of the muscle.

For the diagnosis of MFTPs all minimum criteria had to be present (Murphy, 1989; Travell, Simons and Simons, 1999; Chaitow and DeLany,

2002). The presence of the confirmatory signs served to reinforce the diagnosis. It was noted by Al-Shenqiti, Al-Munawarah and Oldham (2005), that the Kappa statistics for intra-examiner reliability for the identification of clinical signs of MFTP's in the rotator cuff muscles of 51 patients with rotator cuff tendonitis were as follows :

Spot tenderness	=	1
Jump sign	=	1
Pain recognition	=	1
Taut band	=	1
Referred pain	=	0.79-0.88
Local twitch response	=	0.75-1

The collective mean of the Kappa scores for all values was 0.92-0.98. This means that the clinical identification is clinically relevant, reliable and valid.

It is, however, noted that Al-Shenqiti, Al-Munawarah and Oldham (2005) referred to intra-examiner, whereas Simons and Mense (1997) found that inter-rater Kappa-values were lower and indicated as: taut band = 0.29; spot tenderness = 0.61; local twitch response = 0.16; referred pain = 0.40; and recognised pain = 0.30. Thus, the overall reliability for the identification of MFTP's between examiners was poor. Therefore, Simons and Mense (1997) indicated that specific training could lead to substantial increases in reliability between examiners. It was thus decided in this study, that only the researcher would be responsible for the identification of MFTP's.

Therefore, once found, the following data were recorded for purposes of this research:

- Their **characteristics (active / latent)** were noted and recorded (a myofascial diagnostic scale was used by Vaghmaria (2005) – outlined in Appendix 10). With only the **locations** of the active MFTP's being noted and recorded.

3.7.2.1 The Myofascial Diagnostic Scale

The MDS (Chettiar, 2001; Vaghmaria, 2005) was used to determine the extent to which a patient suffers from MFTPs. This is an objective and reliable tool according to Littlehale (2007). The Scale is divided into 4 categories, namely:

1. Soft tissue tenderness
2. Snapping palpation evoking a local twitch response
3. MFTP found in a palpable taut band
4. Pressure on the MFTP causes intensified pain in the reference zone

Within each of the 4 categories, a maximum of 4-5 points were allocated. According to Chattier (2001), a total value of 9 points or more was indicative of an active MFTP and, therefore, used as an inclusion when noting the location and presence of active MFTPs.

3.7.2.2 The Algometer measurement

The Algometer pressure-pain threshold reading (Fischer, 1986; Williamson *et al.*, 2005) was used to document the tenderness of MFTPs. The algometer [FDK20 force dial by Wagner Instruments (Address: P.O. Box 1217 Greenwich, CT, 06836, U.S.A)] was utilised to assess the level of the patients sensitivity and pain threshold. The device was calibrated to ensure maximum accuracy. Reeves *et al.*, (1986) demonstrated the reliability and validity of the pressure algometer in measuring MFTP sensitivity.

The procedure for the use of the algometer included:

- The dial was set to zero.
- The algometer was then placed over the active MFTP with the metal rod being perpendicular to the surface of the skin.

- The patient was then instructed to express the point at which first discomfort was felt / perceived.
- Pressure was then applied with an increasing rate of 1kg/second as recommended by Fischer (1986).
- The procedure was halted once the patient expressed the point at which the first discomfort was felt / perceived (the pain threshold).
- Three points was recorded in tables: the onset of pain (pressure pain threshold), the onset of referred pain (referred pain threshold), and when pressure is no longer tolerable (pain intolerance) (Travell and Simons, 1993) (Appendix 5).
- The reading on the algometer was then recorded in kg/cm²

3.7.3 PFPS

3.7.3.1 The Patellofemoral Pain Severity Scale (PPSS)

The PPSS (Yeomans, 2000; Dippenaar, 2003) was a subjective and objective questionnaire developed to assess to what extent the patient suffered from PFPS. Therefore, each question in the PPSS consists of a subjective component to be answered by the patient and an objective component to be answered by the researcher. It is suggested (Dippenaar, 2003) that the patient is allowed to answer the questions first to not be influenced by the researcher's answers. The subjective component consists of a Likert scale, which is used for statistical analysis, whereas the objective component consists of a simple "yes/no" answer, which was answered by the researcher. Therefore this scale complies with the determination by Triano *et al.*, (1992), which stated: "The principal value of instrumentation lies in its ability to focus on the patient's functional capacity and not the symptoms".

Therefore, the PPSS is divided into 3 categories, namely:

1. History.

2. Signs and
3. Symptoms.

The patient had to answer to 3 questions in each category with either “strongly agree”, “agree”, “unsure”, “disagree”, or “strongly disagree”. The researcher, in contrast, completed several tests in order to complete the objective section of the PPSS.

3.7.3.2 The inclinometer

The Inclinometer (Saunders, 1986) was used to objectively determine the flexibility of the Hamstring muscle group (White *et al.*, 2008; Liebensteiner *et al.*, 2008). According to Cornbleet and Woolsey (1996), this is an objective and reliable tool. The Inclinometer was zeroed at zero degrees of hip flexion, placed at the sacral midpoint aligned with the posterior superior iliac spines. The measurement was taken at end range of motion of straight leg raise (Saunders, 1986; Cornbleet and Woolsey, 1996).

Furthermore, a second measurement was taken in a supine position (Vizniak, 2010). The inclinometer was placed by the ankle, and the patient was asked to do a straight leg raise to the point of tension in the Hamstring muscle group. According to Witvrouw *et al.*, (2000), this is a reliable measurement when performed by the same examiner.

3.8 Statistical methodology:

The results were captured using Microsoft excel and SPSS version 15.0 was used to analyze the data. A p value <0.05 was considered as statistically significant. Correlations between measurements of objective and subjective pain was assessed using Pearson’s correlation analysis if the measurements are normally distributed or Spearman’s rank correlation coefficient if the data are non

parametric. The subjective and objective pain measurements was compared between those with and without active MFTPs using non parametric Mann Whitney tests, and Spearman's rank correlation was used to correlate the number of MFTPs with the pain measurements.

Spearman's rank correlation was used to assess the relationship between the number of MFTPs in the Hamstring muscle group and the flexibility measured using an inclinometer (Mouton, 1996; Esterhuizen, 2009).

Chapter Four

Results

4.1 Introduction

This chapter covers the results of the data obtained and evaluated the statistical analysis collected from the following criteria:

1. Demographics,
2. Numerical pain Rating Scale (NRS),
3. Patellofemoral Pain Severity Scale (PPSS),
4. Algometer readings,
5. Myofascial Diagnostic Scale (MDS) and
6. Inclinator readings.

All data was recorded prior to any treatment and was completed on visit one only.

4.2 The data

4.2.1 Primary data

The primary data was obtained using the following:

4.2.1.1 Subjective date

- NRS
- PPSS

4.2.1.2 Objective data

- Algometer
- MDS
- Inclinator

4.2.2 The secondary data

The secondary data was obtained from the following sources:

- Books
- Journals articles
- Unpublished and published Thesis
- Internet

4.3 Aim of the study

The aim of this study was to investigate the role and relationship of the presence of MFTPs in the Quadriceps femoris muscle group, the Hamstring muscle group, and Adductor muscle group in patients with PFPS.

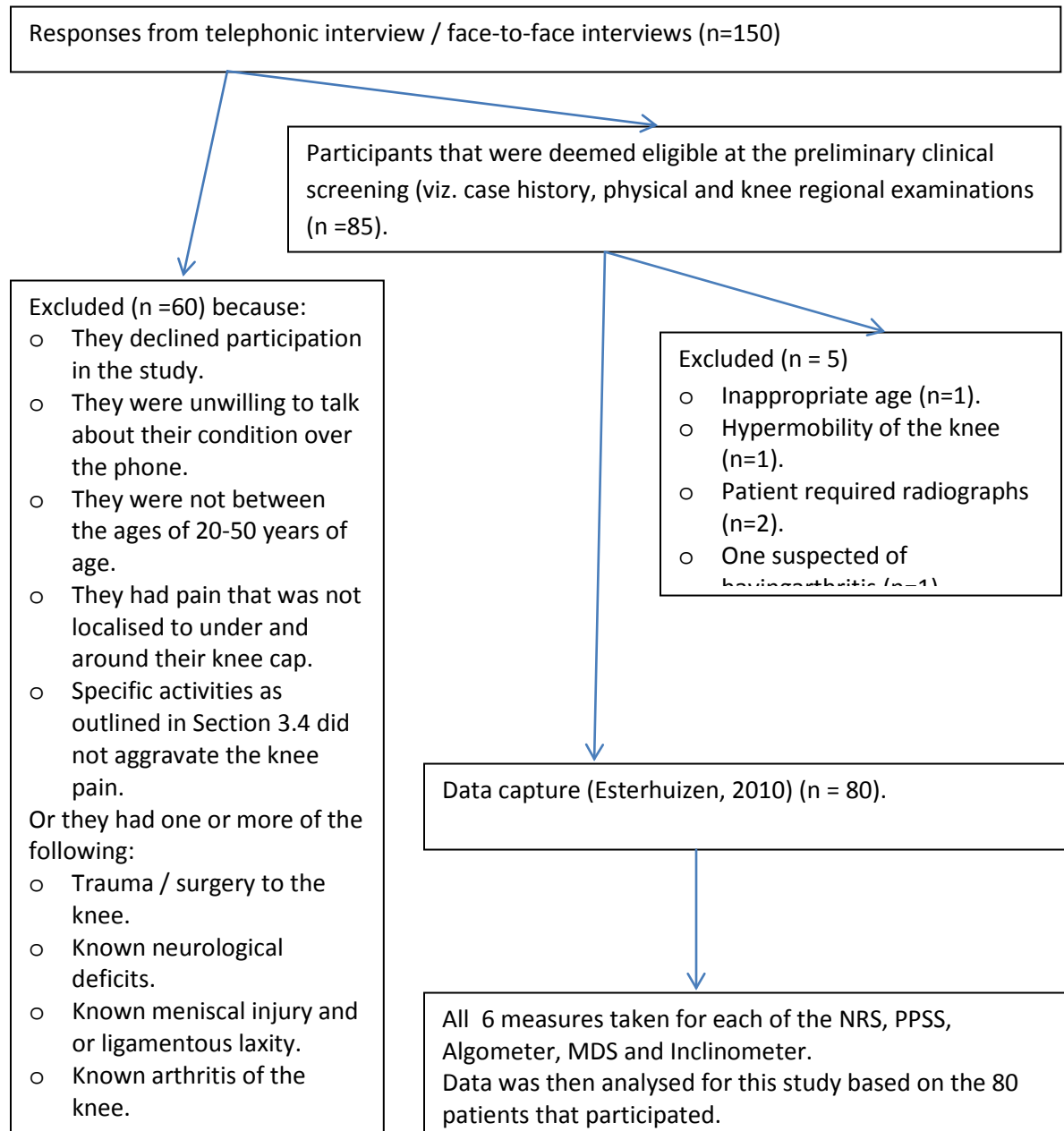
4.4 Abbreviations and definition of terms

Table 4.1 : Abbreviation pertinent to Chapter Four [as available from <http://www.statsoft.com/textbook/statistics-glossary/i/button/i/>, 2011 and <http://www.investopedia.com/terms/s/standarddeviation.asp>, 2011)]

F:	Female
Interquartile range:	Contains middle 50 percent of the distribution and is unaffected by extreme values.
L:	Left
M:	Male
Mean:	The mean is a particularly informative measure of the "central tendency" of the variable
Median:	Is the point that divides the distribution of scores in half.
N:	The number of people in a sample group. The full sample size
p :	The level of significance. If the p value is less than 0,05 the test is significant.
Pearson correlation:	Determines the extent to which values of two variables are "proportional" to each other.
Population:	The entire collection of items that is the focus of concern.
R:	Right
Significance:	A finding is described as statistically significant, when it can be demonstrated that the probability of obtaining such a difference by chance only, is relatively low.
Standard deviation:	A measure of the dispersion of a set of data from its mean. The more spread apart the data, the higher the deviation. Standard deviation is calculated as the square root of variance.
Standard error:	Is an estimate of the standard deviation of the sampling distribution of means, based on the data from one or more random samples.
t-Test:	Employs the statistic (t) to test a given statistical hypothesis about the mean of a population.
Variance:	Used to characterise the dispersion among the measures in a given population. To calculate the variance it is necessary to first calculate the mean and then measure the amount that each score deviates from the mean and then square that deviation.

4.5 Consort diagram

Figure 4.1 Flow diagram adapted from Moher, Schulz and Altman, (2001).



4.6 Results

A final number of eighty patients took part in the study, and were part of the cross-sectional, observational, quantitative non-intervention clinical assessment study was conducted at the Chiropractic Day Clinic at Durban University of Technology (DUT). The study involved only one group and all readings were done prior to any treatment, and were once off readings.

4.6.1 Demographics

4.6.1.1 Age

Amongst the eighty patients, the mean age was 34.3 years (standard deviation 9 years). The minimum age was 20 years of age and the maximum age was 50 years of age.

Table 4.1 Age distribution

N	Valid	80
	Missing	0
Mean		34.28
Standard Deviation		9.147
Minimum		20
Maximum		50

4.6.1.2 Gender

The majority of the patients were male (66,3%). Out of the total number of patients, 27 were females and 53 were males.

Table 4.2 Gender distribution

		Frequency	Percentage
Valid	F	27	33.8
	M	53	66.3
	Total	80	100.0

4.6.1.3 Ethnicity

It was recorded that majority of the patients were White (73,8%), 15% were Indian, 10% were Black, and 1,2% were Coloured.

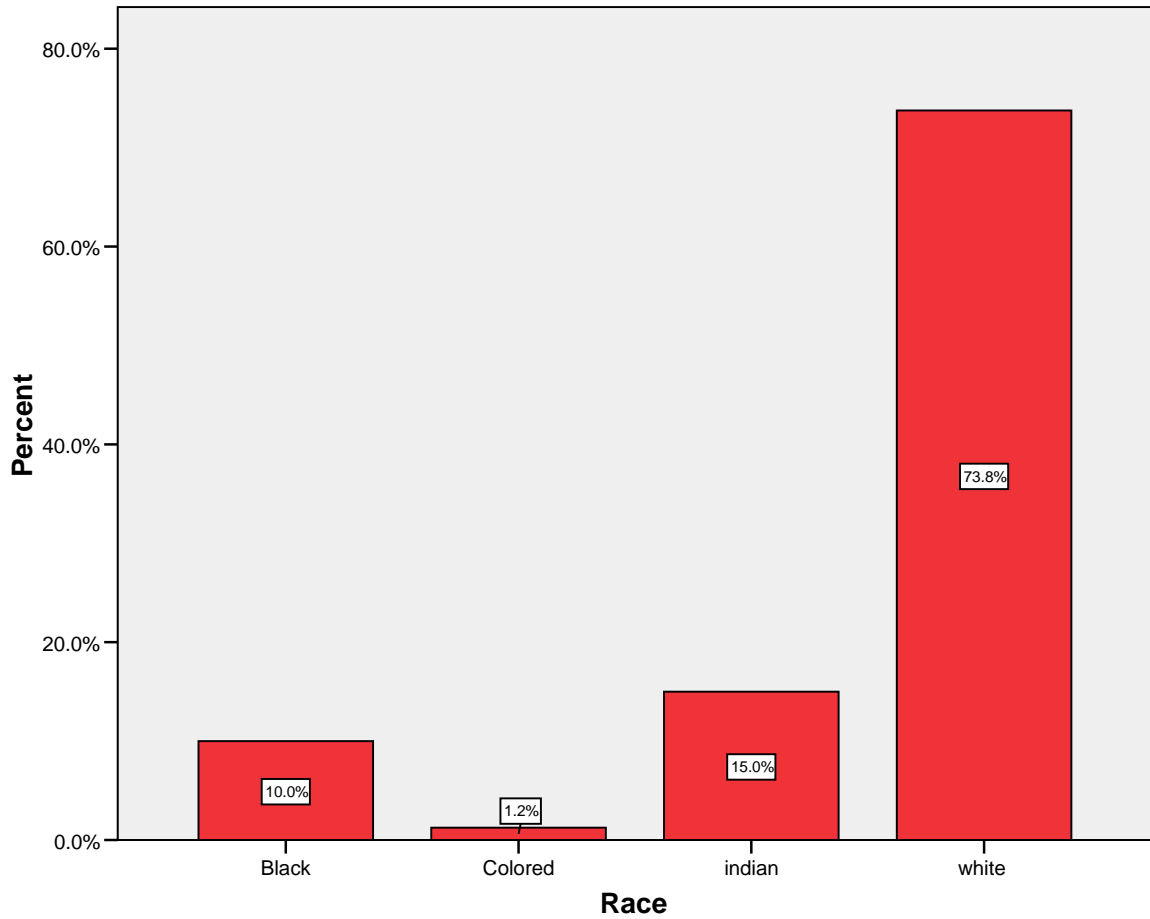


Figure 4.2 Ethnicity distribution

4.6.2 Clinical presentation

4.6.2.1 Leg predominance

In the majority of patients, the right knee was affected (63,8%) versus the left leg (36,2%).

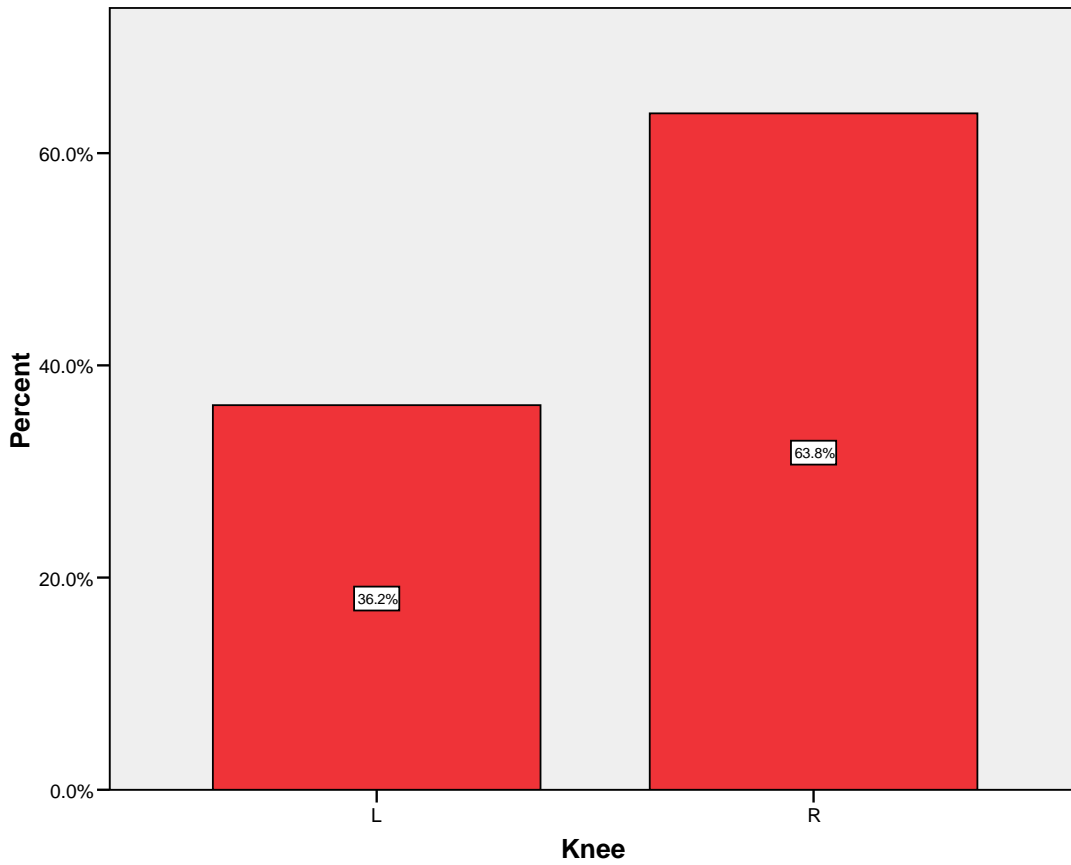


Figure 4.3 Predominance of right leg versus left leg

4.6.2.2 Duration of PFPS

The duration of PFPS was recorded as a minimum of 3 months and a maximum of 30 years. The trend was towards the more chronic presentation with the median duration being 21 months and the inter-quartile ranging from 8 to 69 months.

Table 4.3 Duration in months

N	Valid	80
	Missing	0
Minimum		3
Maximum		360
Percentiles	25	8.00
	50	21.00
	75	69.00

4.6.3 Presence of MFTP's in the related muscles

4.6.3.1 Presence of Quadriceps femoris muscle group MFTP's

Over all Quadriceps femoris muscle group, MFTP's were noted in 92.5% of the patients and only six patients presented with no MFTP's. The most prevalent MFTP being Vastus medialis TP 1 (63.8%), followed by Vastus lateralis TP 1 (33.8%), Vastus intermedius at 27,5% of the patients. The least common was Vastus lateralis TP 2 only presenting in 2,5% of the patients.

Table 4.4 Presence of Quadriceps femoris muscle group MFTP's

	No		Yes	
	Count (patients)	Row N %	Count (patients)	Row N %
Rectus femoris	73	91.3	7	8.8
Vastus medialis MFTP 1	29	36.3	51	63.8
Vastus medialis MFTP 2	68	85.0	12	15.0
Vastus intermedius	58	72.5	22	27.5
Vastus lateralis MFTP 1	53	66.3	27	33.8
Vastus lateralis MFTP 2	78	97.5	2	2.5
Vastus lateralis MFTP 3	62	78.5	17	21.5
Vastus lateralis MFTP 4	65	81.3	15	18.8
Vastus lateralis MFTP 5	65	81.3	15	18.8
Presence of any Quadriceps femoris MFTP's	6	7.5	74	92.5

4.6.3.2 Presence of Hamstring muscle group MFTPs

Hamstring muscle group MFTPs were found overall in 86.3% of patients. The most prevalent MFTP was Biceps femoris muscle (66%), and the least prevalent Semitendinosus muscle (11,3%).

Table 4.5 Presence of MFTPs in the Hamstring muscle group

	No		Yes	
	Count	Row N%	Count	Row N%
Biceps femoris TP	27	33.8%	53	66.3%
Semitendinosus TP	71	88.8%	9	11.3%
Semimembranosus TP	45	56.3%	35	43.8%
Presence of any Hamstring TPs	11	13.8%	69	86.3%

4.6.3.3 Presence of MFTPs in the Adductor muscle group

MFTPs were present in 64% overall of the Adductor muscle group and Adductor magnus muscle (51%) was the most common. The least common was Adductor brevis muscle, prevalent in 7,5% of the patients.

Table 4.6 Presence of Adductor muscle group MFTPs

	No		Yes	
	Count	Row N %	Count	Row N %
Adductor longus muscle TP	72	90.0	8	10.0
Adductor brevis muscle TP	74	92.5	6	7.5
Adductor magnus muscle TP	39	48.8	41	51.3
Presence of any Adductor MFTPs	29	36.3	51	63.8

4.6.4 MFTP severity in related muscles

As previously described, three measurements for MFTP severity were recorded, according to Travell and Simons (1993):

- Initial Pain (IP),
- Pain Referral (PR) and
- Pain Intolerance (PI).

The measurements were inversely proportionate (viz. the lower the measurement/ reading was, the smaller the amount of pressure that was applied thus indicating a greater severity of the MFTP). Therefore, it would be reasonable to indicate that the higher the measurement/ reading, the lesser the severity of the MFTP.

In addition, when considering the IP and PR, it must be remembered that the closer the readings, the more active the MFTPs, as the most active MFTPs would have a IP and PR of the same value.

4.6.4.1 MFTP severity in the Quadriceps femoris muscle group

The lowest measurement on initial pain, pain referral and pain intolerance measures were at the Vastus medialis 1 at 2,44 kg/cm², 3.35 kg/cm² and 4.35 kg/cm² respectively. The highest measurement on initial pain and pain referral measures were at the Rectus femoris at 3.49 kg/cm², 4.50 kg/cm², with the Vastus intermedius measuring pain intolerance at 5.56 kg/cm². It is noted from Table 4.7, that the most active MFTPs include: Vastus lateralis TP I, Vastus medialis, TP 1 and TP 2 and Vastus lateralis TP 2,3 and 4, whereas the least active include the Vastus intermedius, the Rectus femoris and the Vastus lateralis TP 5.

Table 4.7 Quadriceps femoris MFTP severity (Algometer)

	Mean	Standard Deviation		Mean	Standard Deviation
Rectus femoris IP	3.49	1.5	Vastus lateralis TP 2 IP	3.30	.1
Rectus femoris PR	4.50	1.5	Vastus lateralis TP 2 PR	4.25	.5
Difference PR and IP	1.01	-	Difference PR and IP	0.96	-
Rectus femoris PI	5.39	1.5	Vastus lateralis TP 2 PI	4.60	.6
<hr/>					
Vastus medialis TP 1 IP	2.44	.7	Vastus lateralis TP 3 IP	2.66	.6
Vastus medialis TP 1 PR	3.35	1.1	Vastus lateralis TP 3 PR	3.56	1.0
Difference PR and IP	.91	-	Difference PR and IP	0.90	-
Vastus medialis TP 1 PI	4.35	1.5	Vastus lateralis TP 3 PI	4.41	1.5
<hr/>					
Vastus medialis TP 2 IP	2.56	.8	Vastus lateralis TP 4 IP	2.93	.9
Vastus medialis TP 2 PR	3.47	.8	Vastus lateralis TP 4 PR	3.89	1.0
Difference PR and IP	0.91	-	Difference PR and IP	0.96	-
Vastus medialis TP 2 PI	4.19	1.1	Vastus lateralis TP 4 PI	5.39	1.8
<hr/>					

Vastus intermedius IP	2.99	.6	Vastus lateralis TP 5 IP	2.66	.7
Vastus intermedius PR	4.12	1.0	Vastus lateralis TP 5 PR	3.72	.8
Difference PR and IP	1.13	-	Difference PR and IP	1.06	-
Vastus intermedius PI	5.56	1.5	Vastus lateralis TP 5 PI	4.85	1.4
Vastus lateralis TP 1 IP	2.65	.8			
Vastus lateralis TP 1 PR	3.45	.9			
Difference PR and IP	0.80	-			
Vastus lateralis TP 1 PI	4.39	1.2			

4.6.4.2 MFTP severity in the Hamstring muscle group

The lowest measurement of IP was Semimembranosus at 2,84 kg/cm², and pain referral at 3,79 kg/cm², and pain intolerance at 5,02 kg/cm². The highest measurement of initial pain was Biceps femoris (3.27 kg/cm²), and pain referral (4.20 kg/cm²), and pain intolerance (5.28 kg/cm²).

Table 4.8 Hamstring muscle group MFTP severity (Algometer)

	Mean	Standard Deviation
Biceps femoris IP	3.27	.8
Biceps femoris PR	4.20	1.1
Difference PR and IP	0.93	
Biceps femoris PI	5.28	1.7
Semitendinosus IP	3.21	.7
Semitendinosus PR	4.10	1.0
Difference PR and IP	0.89	
Semitendinosus PI	5.16	1.6
Semimembranosus IP	2.84	1.1
Semimembranosus PR	3.79	1.2
Difference PR and IP	0.95	
Semimembranosus PI	5.02	1.7

4.6.4.3 MFTP severity in the Adductor muscle group

The lowest measurement of initial pain was Adductor brevis muscle (1,83 kg/cm²), and pain referral (2,45 kg/cm²) and pain intolerance (3,35 kg/cm²). The highest measurement of initial pain was the Adductor longus muscle (2.41 kg/cm²), and pain referral (3.29 kg/cm²) and pain intolerance (4.60 kg/cm²).

Table 4.9 Adductor MFTP severity (Algometer)

	Mean	Standard Deviation
Adductor longus muscle IP	2.41	1.4
Adductor longus muscle PR	3.29	1.4
Difference PR and IP	0.88	
Adductor longus muscle PI	<i>4.60</i>	1.4
Adductor brevis muscle IP	1.83	.9
Adductor brevis muscle PR	2.45	.9
Difference PR and IP	0.62	
Adductor brevis muscle PI	3.35	.9
Adductor magnus muscle IP	2.07	.6
Adductor magnus muscle PR	2.88	.9
Difference PR and IP	0.81	
Adductor magnus muscle PI	<i>3.84</i>	1.3

4.6.5 Comparison of Patellofemoral pain syndrome in terms of Patellofemoral pain severity scale versus numeric rating scale:

The mean PPSS allocation was 6.91 which was very close to the NRS rating at 6.08. However, the minimum point allocation for PPSS was 5 and the maximum was 9, whereas the minimum rating for NRS was 2 and the maximum was 10.

Table 4.10 PFPS in terms of PPSS and NRS

		PPSS points	NRS rating
N	Valid	80	80
	Missing	0	0
Mean		6.91	6.08
Standard deviation		1.046	1.719
Minimum		5	2
Maximum		9	10

4.6.6 Patellofemoral pain syndrome in terms of inclinometer readings

On the inclinometer assessment two measurements were taken;

- an erect straight leg raise (inclinometer 1) and
- a supine straight leg raise (inclinometer 2).

The mean results of inclinometer 1 on the right leg were lower (45.81 degrees) than the left leg (46.70 degrees). Furthermore, the results had a minimum of 16 degrees and a maximum of 85 degrees on the right leg and 87 degrees on the left leg.

The mean results of inclinometer 2 on the right leg were lower (65.33 degrees) than the left leg (67.74 degrees). Furthermore, the results showed a minimum of 25 degrees (right leg) and 36 degrees (left leg), and a maximum of 134 degrees (right leg) and 124 degrees (left leg).

Table 4.11 PFPS in terms of inclinometer readings

		Inclinometer1R	Inclinometer1L	Inclinometer2R	Inclinometer2L
		Standing		Supine	
N	Valid	80	80	80	80
	Missing	0	0	0	0
Mean		45.81	46.70	65.33	67.74
Standard deviation		14.072	13.945	17.699	17.493
Minimum		16	16	25	36
Maximum		85	87	134	124

As indicated in Figure 4.3, the right knee was affected in the majority of patients (63,8%) versus the left leg (36,2%) (Figure 4.3).

4.6.7 Comparison of mean inclinometer on each side by affected side

The results showed that there was a statistically significant difference between inclinometer 2 left readings between those with left and right sides affected ($p=0.013$). Those with right side affected had higher values for inclinometer 2 left than those with the left side affected. The trend was the same for the other inclinometer reading but they did not reach statistical significance.

Table 4.12 T-test to compare mean inclinometer on each side by affected side

	Knee	N	Mean	Std. Deviation	Std. Error Mean	p value
Inclinometer 1R	R	51	44.82	12.975	1.817	0.408
	L	29	47.55	15.912	2.955	
Inclinometer 1L	R	51	48.24	13.084	1.832	0.193
	L	29	44.00	15.203	2.823	
Inclinometer 2R	R	51	64.06	16.976	2.377	0.400
	L	29	67.55	19.005	3.529	
Inclinometer 2L	R	51	71.35	16.400	2.296	0.013
	L	29	61.38	17.815	3.308	

4.6.8 Association between MFTP in the Quadriceps femoris muscle group and the Hamstring muscle group

As mentioned above (Section 4.6.3.1), 92,5% of the patients presented with Quadriceps femoris muscle group MFTPs, and 86,3% with Hamstring muscle group MFTPs. Out of the 92,5% presenting with Quadriceps femoris muscle group MFTPs, 89% also had Hamstring muscle group MFTPs. However, in those without Quadriceps femoris muscle group MFTPs, only 50% had Hamstring muscle group MFTPs. Therefore, having both Quadriceps femoris muscle group and Hamstring muscle group MFTPs was more likely than just Quadriceps femoris muscle group or Hamstring muscle group MFTPs alone. There was a statistically significant association between the presence of Quadriceps femoris muscle group MFTPs and presence of Hamstring muscle group MFTPs ($p=0.031$).

Table 4.13 Cross-tabulation of Quadriceps femoris muscle group MFTPs and Hamstring muscle group MFTPs

			Presence of any Hamstring MFTPs		Total
			No	Yes	
Presence of Quadriceps femoris muscle group MFTPs	No	Count	3	3	6
		%	50.0	50.0	100.0
	Yes	Count	8	66	74
		%	10.8	89.2	100.0
Total		Count	11	69	80
		%	13.8	86.3	100.0

$p=0.031$ (Fisher's exact)

4.6.9 Association between MFTP in the Gastrocnemius muscle and the Hamstring muscle group

As mentioned above (Section 4.6.3.2), 86,3% of the patients presented with Hamstring muscle group MFTPs, and out of these 66% was Biceps femoris muscle MFTPs. Hamstring muscle group MFTPs in general were highly significantly associated with Gastrocnemius muscle ($p<0.001$) and 68% of people

with Hamstring muscle group MFTP had a lateral Gastrocnemius muscle MFTP. Furthermore, Biceps femoris muscle was more strongly associated with lateral Gastrocnemius muscle MFTPs ($p < 0.001$) since 85% of those with Biceps femoris muscle MFTPs also had a lateral Gastrocnemius muscle MFTP (see Table 4.14 and Table 4.15).

Table 4.14 Cross-tabulation of Hamstring muscle group MFTPs and lateral Gastrocnemius MFTPs

			Gastrocnemius MFTPs present		Total
			No	Yes	
Presence of any Hamstring muscle group MFTPs	No	Count	11	0	11
		%	100.0	.0	100.0
	Yes	Count	22	47	69
		%	31.9	68.1	100.0
Total		Count	33	47	80
		%	41.3	58.8	100.0

$p < 0.001$

Table 4.15 Cross tabulation of Biceps femoris and Gastrocnemius MFTPs

			Gastrocnemius MFTPs present		Total
			No	Yes	
Biceps femoris muscle MFTPs	No	Count	25	2	27
		%	92.6	7.4	100.0
	Yes	Count	8	45	53
		%	15.1	84.9	100.0
Total		Count	33	47	80
		%	41.3	58.8	100.0

$p < 0.001$

4.6.10 Correlation outcomes (NRS versus IP, PR PI)

Only Vastus medialis 1 and Vastus lateralis 5 severity correlated with NRS. It was a negative correlation, thus as NRS increased, so algometer readings decreased.

Table 4.16 Correlation between Quadriceps femoris muscle group severity and NRS					
NRS rating			NRS rating		
Rectus femoris IP	Pearson Correlation	.382	Rectus femoris PI	Pearson Correlation	.402
	Sig. (2-tailed)	.398		Sig. (2-tailed)	.372
	N	7		N	7
Rectus femoris PR	Pearson Correlation	.357			
	Sig. (2-tailed)	.431			
	N	7			
Vastus medialis 1IP	Pearson Correlation	-.281(*)	Vastus medialis 1 PR	Pearson Correlation	-.385(**)
	Sig. (2-tailed)	.046		Sig. (2-tailed)	.005
	N	51		N	51
Vastus medialis 1 PI	Pearson Correlation	-.400(**)			
	Sig. (2-tailed)	.004			
	N	51			
Vastus medialis 2 IP	Pearson Correlation	.300	Vastus medialis 2 PR	Pearson Correlation	.263
	Sig. (2-tailed)	.344		Sig. (2-tailed)	.408
	N	12		N	12
Vastus medialis 2 PI	Pearson Correlation	.079			
	Sig. (2-tailed)	.807			
	N	12			
Vastus intermedius IP	Pearson Correlation	-.084	Vastus intermedius PR	Pearson Correlation	-.283
	Sig. (2-tailed)	.709		Sig. (2-tailed)	.202
	N	22		N	22
Vastus intermedius PI	Pearson Correlation	-.385			
	Sig. (2-tailed)	.077			
	N	22			
Vastus lateralis 1 IP	Pearson Correlation	-.096	Vastus lateralis 1 PR	Pearson Correlation	-.264
	Sig. (2-tailed)	.634		Sig. (2-tailed)	.182
	N	27		N	27
Vastus lateralis 1 PI	Pearson Correlation	-.297			
	Sig. (2-tailed)	.132			
	N	27			

Table 4.16 Correlation between Quadriceps femoris muscle group severity and NRS continued ...

NRS rating			NRS rating		
Vastus lateralis 2 IP	Pearson Correlation	- 1.000(**)	Vastus lateralis 2 PR	Pearson Correlation	1.000(**)
	Sig. (2-tailed)	.		Sig. (2-tailed)	.
	N	2		N	2
Vastus lateralis 2 PI	Pearson Correlation	1.000(**)			
	Sig. (2-tailed)	.			
	N	2			
Vastus lateralis 3 IP	Pearson Correlation	-.325	Vastus lateralis 3 PR	Pearson Correlation	-.446
	Sig. (2-tailed)	.189		Sig. (2-tailed)	.064
	N	18		N	18
Vastus lateralis 3 PI	Pearson Correlation	-.390			
	Sig. (2-tailed)	.110			
	N	18			
Vastus lateralis 4 IP	Pearson Correlation	-.046	Vastus lateralis 4 PR	Pearson Correlation	-.190
	Sig. (2-tailed)	.872		Sig. (2-tailed)	.498
	N	15		N	15
Vastus lateralis 4 PI	Pearson Correlation	-.416			
	Sig. (2-tailed)	.123			
	N	15			
Vastus lateralis 5 IP	Pearson Correlation	-.111	Vastus lateralis 5 PR	Pearson Correlation	-.461
	Sig. (2-tailed)	.693		Sig. (2-tailed)	.084
	N	15		N	15
Vastus lateralis 5 PI	Pearson Correlation	-.681(**)			
	Sig. (2-tailed)	.005			
	N	15			

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

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

Only Semimembranosus severity was correlated with NRS. It was a negative correlation, thus, as NRS increased, so algometer readings decreased.

Table 4.17 Correlation between Hamstring muscle group severity and NRS

NRS rating			NRS rating		
Biceps femoris IP	Pearson Correlation	.007	Biceps femoris PR	Pearson Correlation	-.084
	Sig. (2-tailed)	.960		Sig. (2-tailed)	.550
	N	53		N	53
Biceps femoris PI	Pearson Correlation	-.207			
	Sig. (2-tailed)	.138			
	N	53			
Semitendinosus IP	Pearson Correlation	-.462	Semitendinosus PR	Pearson Correlation	-.305
	Sig. (2-tailed)	.211		Sig. (2-tailed)	.424
	N	9		N	9
Semitendinosus PI	Pearson Correlation	-.337			
	Sig. (2-tailed)	.375			
	N	9			
Semimembranosus IP	Pearson Correlation	.037	Semimembranosus PR	Pearson Correlation	-.134
	Sig. (2-tailed)	.833		Sig. (2-tailed)	.445
	N	35		N	35
Semimembranosus PI	Pearson Correlation	-.344(*)			
	Sig. (2-tailed)	.043			
	N	35			

No correlation was achieved for the Adductor muscle group with NRS. It is only noted that the Adductor magnus muscle approaches significance.

Table 4.18 Correlation between Adductor muscle group severity and NRS						
NRS rating			NRS rating			
Adductor longus muscle IP	Pearson Correlation	.215	Adductor longus muscle PR	Pearson Correlation	.157	
	Sig. (2-tailed)	.609		Sig. (2-tailed)	.711	
	N	8		N	8	
Adductor longus muscle PI	Pearson Correlation	-				
	Sig. (2-tailed)	.258				
	N	.537				
Adductor longus muscle PI	N	8				
	Adductor brevis muscle IP	Pearson Correlation	-	Adductor brevis muscle PR	Pearson Correlation	-.546
		Sig. (2-tailed)	.191		Sig. (2-tailed)	.263
N		.717	N		6	
Adductor brevis muscle PI	Pearson Correlation	-				
	Sig. (2-tailed)	.298				
	N	.566				
Adductor brevis muscle PI	N	6				
	Adductor magnus muscle IP	Pearson Correlation	-	Adductor magnus muscle PR	Pearson Correlation	-.245
		Sig. (2-tailed)	.235		Sig. (2-tailed)	.122
N		.139	N		41	
Adductor magnus muscle PI	Pearson Correlation	-				
	Sig. (2-tailed)	.285				
	N	.071				
Adductor magnus muscle PI	N	41				

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

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

Chapter Five

Discussion of results

5.1 Introduction

This chapter will discuss the results of the subjective and objective data obtained and evaluated in Chapter four. Each measurement will be compared to previous literature and analysed in a logical matter.

5.2 Discussion of Demographics

5.2.1 Age

Amongst the eighty patients, the mean age was 34.3 years of age, with a standard deviation of nine years (Table 4.1). The age range was noted as being from 20-50 years of age. The latter concurs with the inclusion criteria of the study which outlined that the patients were required to be within the age constraints of 20-50 years (as seen in Section 3.5.3.1).

According to Naslund *et al.*, (2006), PFPS is accounted to involve 21-45% of the active adolescent population and 15-33% of the active adult population. These statistics concur with Lindberg *et al.*, (1986); Thomeé *et al.*, (1999) Servi *et al.*, (2008) and Myer *et al.*, (2010), who indicated that young adults and adolescents most commonly suffer with PFPS. The only study to contrast this is Brantingham *et al.*, who indicated that PFPS is commonly found in the age range spanning 18-45 years of age. This latter assertion seems to correspond with the work of Paoloni *et al.*, (2011) as seen in Table 5.1 on the following page.

Table 5.1 : Comparison table

Table 2 Demographic and baseline characteristics of patients

Characteristic	
Patients, no.	44
Age, years (range)	28.5±9.2 (18–38)
Height, cm	171.8±12.8
Weight, kg	71.6±8.2
Gender, no.	
Male	15
Female	29
Duration of symptoms, months (range)	13.7±9.2 (4–21)
Side, no.	
Right	26
Left	18
KPQ, range 0–100	62.5±11
VAS, range 0–10, cm	7.5±1.7
Isometric knee strength, N/m	
Affected	146.2±36.5
Unaffected	166.6±51.9

Values are the mean ±SD

KPQ Kujala patellofemoral questionnaire, VAS visual analog scale

As taken from Paoloni *et al.*, (2011).

Therefore, the results in this study do not appear to correlate well with the earlier studies, but concur more with the more recent studies. Factors that may affect this comparison are the inclusion and exclusion criteria for each of the studies. The trend seems to suggest that the more complex the requirements for inclusion, the older the mean age of the participants and the greater the age range (Nakagawa *et al.*, 2008; Brantingham *et al.*, 2009; Paoloni *et al.*, 2011), which concurs with this study. Conversely, the less severe the inclusion criteria the younger the age mean achieved in the studies and the narrower the age ranges (Lindberg *et al.*, 1986; Thomeé *et al.*, 1999; Servi *et al.*, 2008).

From a local vantage point, it also needs to be recognised that the study data collection was completed at a time just prior to and after the Comrades Marathon, which is a double ultra-marathon that was run in 2010 from

Pietermaritzburg to Durban (a “ Down – Run ”) (<http://www.comrades.com/News/Press-Releases/CMA-Launches-85th-Anniversary.aspx>, 2011), which is well known in terms of the runners developing knee related problems in particular PFPS. Further to this the baseline limit in terms of age for entry into the race is 20 years of age (<http://www.comrades.com/Comrades/media/flash/Files/2012SouthAfricanEntryForm.pdf>, 2011), which means that the population available to take part in this study would have been slightly older than that which may have been found in other studies that had recorded a younger age mean than recorded here for this study.

This latter assertion is supported further by the fact that the Chiropractic Day Clinic reported in a study conducted by Thoresen (2006) [a patient satisfaction study on DUT chiropractic clinic was conducted], that the mean age of patients attending the clinic was 44 years of age. This would also impact on the slightly above average findings in this study.

5.2.2 Gender

In terms of the gender, the majority of the patients in this study were male (66.3%) (Table 4.2). In accordance with the discussion on age, it is noted that this may be influenced by the:

- Comrades Marathon participation in which there are generally about 4 times as many males that participate in the ultra-marathon as compared to females (<http://www.comrades.com/News/Press-Releases/CMA-Launches-85th-Anniversary.aspx>, 2011).
- May be influenced by the recruitment drives, which were principally through word of mouth and pamphlet distributions at running clubs, rugby clubs and various shopping malls. The latter having a varied mix of genders whereas the former having a higher predisposition to male patients.

- The influence of the DUT Chiropractic Day Clinic was limited, when looking at the data reported by Thoresen (2006), which concluded that the female: male ratio of patients at DUT Chiropractic Day Clinic was evenly spread between the genders (53,5%: 46,5%). Thoresen (2006) concurs with the gender distribution of KwaZulu Natal, which according to Brooks (2004) is 53%: 47% (M:F) and re-inforces that this would not have impacted on this study.

However, taking all the above into consideration, the results of this study do not concur with the, where it is reported that PFPS is more prevalent in females (Scruderi *et al.*, 1995; Salem and Powers, 2001; Nakagawa *et al.*, 2008; Myer *et al.*, 2010; Paoloni *et al.*, 2011; Dutton, 2012; (Table 5.1).

5.2.3 Ethnicity

Of the patients that were included in this study, 73,8% were White, 15% were Indian, 10% were Black, and 1,2% were Coloured. These findings would concur with the findings of Thoresen (2006), who concluded that 59.7% (the majority) of patients attending the DUT Chiropractic Day Clinic were White. In contrast however, the outcomes of this and Thoresen's (2006) study do not reflect the ethnic distribution of KwaZulu Natal province where 85% of the population are Black and only 5% are White (Brooks, 2004).

The only factors that may have influenced this study and the skewing to the demographics away from the population norm could include:

- Advertising was only done in English.
- As the research was conducted at a Chiropractic Day Clinic setting, it is entirely possible that the non-White population did not respond to the advert as chiropractic is not a concept understood among the Indigenous African population groups (Myburgh and Mouton, 2007).

5.3 Discussion of Clinical presentation

5.3.1 Involved leg

In this study, the majority of patients had PFPS involving the right knee (63.8%), whereas the left knee was only involved 36.2% of the time. This concurs with the work of Paoloni *et al.*, (2011) but disagrees with Clifton (2003), who found that the sidedness was almost equal. In other studies the sidedness was not recorded (Dippenaar, 2003; Daly, 2005). Further to these other studies (Wood, 1998) indicated that 75% of individuals who present PFPS have bilateral PFPS. In terms of this, no comparison with Wood (1998) can be made due to the fact that the leg with the most pain was assessed, and not both. Limited literature exists to suggest whether leg / side dominance has an impact on the presentation of PFPS, although it could be suggested that with the increased likelihood of right sided dominance that there is a causal link (Paoloni *et al.*, (2011). Further research in this regard is needed in order to determine whether there is indeed a link and whether the association is significant.

5.3.2 Duration

The median duration was 21 months with an inter-quartile range from 8 to 69 months. This compares favourably with Dippenaar (2003), who recorded a median duration of 3,3 years (40 months), and Rowlands (1999) recorded a mean duration of 3,7 years (45 months); especially when considered in light of the possibility that the majority of participants in this study may have been participants in the Comrades Marathon (making it more likely that they had PFPS of shorter duration and more likely related to overload).

This would suggest that the participants in this study would fit the PFPS criteria, which indicates an insidious onset, which often becoming chronic (Austermuehle, 2001; Naslund, 2006), in that the participants are more likely to have been early

in their pathogenesis as compared to those in Rowland's.(1999); Dippenaar's (2003); and Dippenaar et al.,'s (2008) studies.

5.4 The prevalence of MFTPs in related muscles

5.4.1 Discussion of MFTPs in the Quadriceps femoris muscle group

The Quadriceps femoris muscle group consists of four muscles, namely the Rectus femoris, Vastus medialis, Vastus intermedius, and Vastus lateralis muscles. During the clinical assessment the MFTPs in each of the muscles was examined according to Travell and Simons (1993). This meant Rectus femoris muscle was examined for one MFTP, Vastus medialis muscle for two, Vastus intermedius muscle for one, and Vastus lateralis muscle five MFTPs.

Over all Quadriceps femoris muscle, MFTPs were noted in 92.5% of the patients, with the most prevalent MFTP being Vastus medialis TP1 (63,8%), followed by Vastus lateralis TP1 (33,8%), Vastus intermedius TP at 27,5%. However, out of the 92,5%, 95% presented with MFTPs in the Vastus lateralis muscle in general, and 78,8% presented with MFTPs in the Vastus medialis, 27,5% in the Vastus intermedius and 8,8% in the Rectus femoris.

It is interesting to note that the numbers of MFTPs noted (by percentage) follow the trend where the majority of MFTPs lie closest to the knee, followed by middle thigh and upper thigh MFTPs respectively. The only exception to this is Vastus lateralis TP2. This would suggest that the lower fibers of the Quadriceps femoris muscle group, which are most responsible for maintaining patella congruency in the femoral groove (Grabiner *et al.*, 1994; Moore and Dalley, 1999; Lin *et al.*, 2004; Standing, 2008; Paoloni *et al.*, 2011; Pattyn *et al.*, 2011; Martini *et al.*, 2012), are also those muscle fibres within the Vastus medialis and Vastus lateralis which are most prone to the development of MFTPs.

Interestingly, it is also noted that the Vastus medialis muscle TP1 and Vastus lateralis TP1 are the two MFTPs in the Quadriceps femoris muscle group that refer directly over, around and “under the patella”, which correlates with the presentation of PFPS (described as the patient complaining of peri- and retro-patella pain). (Travel and Simons, 1993; Chaitow and DeLany, 2002). This contrasts with the Vastus intermedius, which refers to the central thigh region in a “chicken foot” pattern and the Vastus lateralis TPs 2,3,4 and 5, which are documented to refer principally to the lateral leg, lateral knee, lateral thigh and lateral hip regions, with very little referral if any to the anterior knee (in or around the patella) (Travel and Simons, 1993; Chaitow and DeLany, 2002). Similarly Vastus medialis TP2 refers principally to the medial knee, with a small spillover zone onto the anterolateral knee (Travel and Simons, 1993; Chaitow and DeLany, 2002). The only MFTP that does not follow this pattern is the Rectus femoris muscle TP, which is known to have a principle referral pattern to the anterior knee (Travel and Simons, 1993; Chaitow and DeLany, 2002). But, this latter finding may be complicated by the fact that of all the Quadriceps femoris muscles, the Rectus femoris is the only muscle that functions over two joint (viz. the femoro-acetabular joint and the tibio-femoral joint) (Moore and Dalley, 1999; Standring, 2008; Paoloni *et al.*, 2011; Pattyn *et al.*, 2011; Martini *et al.*, 2012).

This is consistent with the study by Dippenaar (2003) where the overall percentage of MFTPs was 95%, and 46,2% were active. It is also consistent with Daly (2005) who noted 80% of active MFTPs in the Quadriceps femoris muscle in patients with PFPS. Dippenaar (2003), however, noted the most prevalent active MFTPs were in the Vastus lateralis and not Vastus medialis, which consisted of the most latent MFTPs. In Dippenaar’s (2003) study, active MFTPs in Vastus lateralis were seen in 37,6% of patients and Vastus medialis only in 6,3% of patients. In this study, Vastus lateralis was represented in 33,8% individual MFTPs and Vastus medialis was 63,8% (the following section details the degree of activity of the MFTPs).

According to Travell and Simons (1993) and Chaitow and DeLany (2002), the Vastus medialis muscle is the muscle most often associated with referral to the knee and associated with anterior knee pain, therefore, this prevalence could be significant in terms of the knee pain with which individuals with PFPS are experiencing.

It is a generally accepted theory that PFPS occur due to some kind of patellofemoral mal-alignment subsequent to an extensor mechanism dysfunction or muscular imbalance (Insall, 1982; Scuderi, 1995; Naslund, 2006, Pribut, 2008). According to Grabiner *et al.*, (1994), the Vastus medialis and Vastus lateralis influence patellar tracking and if the firing of these muscles are not balanced, a lateral or medial pull would be applied and cause pain. This patella mal-alignment may in part be due to the potentially “hyperactive” MFTPs in Vastus lateralis and the “underactive” MFTPs in Vastus medialis. This may also support the findings in a study by Powers *et al.*, (1996), who found that the intensity of Vastus medialis decreases as the intensity of pain in individuals with PFPS increases. This may indicate that as the pain / spasm in the Vastus lateralis increases, that an inhibition of the Vastus medialis occurs (Hopkins and Ingersoll, 2000; Suter *et al.*, 2000; Arokoski *et al.*, 2002; Ingersoll, Palmieri and Hopkins, 2003). This would concur with the findings of Witvrouw *et al.*, (1996), who concluded that the Vastus lateralis muscle fired before Vastus medialis muscle in patients with PFPS. This could then lead to the relative inhibition and, therefore, weakness of the Vastus medialis muscle. This supports findings by McConnell (1986), Neptune *et al.*, (2000), and Dixit (2007), who believed PFPS could be treated by strengthening the Vastus medialis and counteract the lateral pull. However, it needs to be considered that the treatment of the Vastus lateralis muscle would facilitate an improvement in the treatment directed at the Vastus medialis muscle (Daly, 2005; Weyer-Henderson, 2005).

5.4.2 Discussion of MFTP's in the Hamstring muscle group

The Hamstring muscle group consists of three muscles, namely the Biceps femoris, Semitendinosus, and Semimembranosus muscles. These muscles were examined for one MFTP each. Similarly, the Hamstring muscle group MFTP's were found in 86.3% of patients. The most prevalent MFTP was Biceps femoris (66%), followed by Semimembranosus (43,8%), and Semitendinosus (11,3%). It is noted that the relative activity of the MFTP's will be noted in a subsequent section.

It would stand to reason that in patients with PFPS, where patella tracking is decreased and the patella is more laterally placed (Engle, 1991; Scruideri, 1995; Thomeé *et al.*, 1999; Piva *et al.*, 2005; Naslund, 2006), that the lateral portion of the Hamstring muscles would be involved (Smith *et al.*, 1991; Piva *et al.*, 2005) and would present with a greater number of MFTP's. This is particularly likely as the lateral Hamstring muscle / Biceps femoris muscle is known to insert along the length of the iliotibial band (Moore and Dalley, 1999; Standring, 2008, Martini *et al.*, 2012), which is also an attachment for the Vastus lateralis muscle (Moore and Dalley, 1999; Standring, 2008, Martini *et al.*, 2012) (which has also been shown to have higher numbers of MFTP's in this study (particularly near the insertion of the iliotibial band at the head of fibula)).

Thus, the presentation of higher numbers of MFTP's in the lower Vastus lateralis as well as the Biceps femoris muscles seems to support the possible involvement of these muscles as part of the lateral tracking phenomena of the patella in PFPS. This study is, however, was only able to make an association but not comment on the causality of the two (i.e. whether the MFTP's results in PFPS or whether PFPS results in increased MFTP's in these muscles). Further studies would need to determine this causality.

These findings support the suggestions by Neptune (1999), Clifton (2003) and

Dippenaar (2003) that MFTPs in the Hamstring muscle group may play a role in PFPS, particularly as Smith *et al.*, (1991) and White *et al.*, (2008) found Hamstring muscle group weakness and tightness (decreased length) in individuals with PFPS. This is more recently supported in studies by Rosene *et al.*, (2001) and Liebensteiner *et al.*, (2008), where it was shown that the Hamstring muscles were underactive in individuals with PFPS and that the Quadriceps/ Hamstrings ratio was relatively high.

In addition, it is noted that MFTPs in the Hamstring muscle group produce pain on walking and sitting, which is a commonly present symptom in individuals suffering from PFPS (Naslund, 2006). The presentation of MFTPs in Biceps femoris, are commonly associated with shortening of the muscle, which concurs with Smith *et al.*, (1991). According to Travell and Simons (1993) this shortening of the Hamstring muscle group leads to overload and consequently perpetuating MFTPs in the Quadriceps femoris muscle group (as a result of the satellite trigger point formation theory). This theory was supported by Gerwin (2005) who describes how MFTPs can lead to restriction of movement and weakening of the muscle, with subsequent compensation and overloading of other muscles in the functional unit, being agonists or antagonists.

5.4.3 Discussion of MFTPs in the Adductor muscle group

Finally, the Adductor muscle group in this research included the Adductor longus muscle, Adductor brevis muscle, and Adductor magnus muscle, which were examined for one MFTP in each muscle. MFTPs were present in 64% overall and Adductor magnus muscle (51%) was the most common. Limited literature exists as few have documented the presence of MFTPs in these muscles in patients with PFPS.

Following the discussion of the Hamstring muscle group, it is noted that the Adductor magnus (Hamstring component) has the highest percentage of MFTPs in the Adductor muscle group. This would seem to suggest that the high numbers of MFTPs in the Biceps femoris muscle group and the limited movement of this muscle around the tight iliotibial band, results in an increased use of the Adductor magnus muscle (Hamstring component) in order for the Hamstring muscle group to effectively discharge its ability in activities of daily living (Moore and Dalley, 1999; Standring, 2008; Martini *et al.*, 2012). The Adductor muscle group work as an agonist in assisting the Hamstring muscle group. The Adductor muscle group become active, and plays a role in activities, such as walking, stair-climbing and running, by stabilising the muscles during flexion and extension (Martini *et al.*, 2012). Furthermore, the Adductor magnus muscle is active during stair climbing and also helps to assist the Hamstring muscle group (Travell and Simons, 1993). Gerwin (2005) describes the spread through functional muscle units as a compensation mechanism. A muscle with a MFTP has a restricted range of motion, which leads to weakness and ultimately loads other muscles in the functional unit. Therefore, MFTPs in the Hamstring muscle group could ultimately cause the MFTPs present in the Adductor muscle group, more specifically the Adductor magnus muscle that is the most common in this particular study.

It would, therefore, be of interest to note whether the patients that present with this combination of MFTPs (*viz* Biceps femoris muscle and Adductor magnus muscle) have any rotation of their lower extremity independent of PFPS and whether this would correlate with the presentation of limb rotation in patients with PFPS. It is suggested that further research be conducted in this regard.

One limitation with regards to these muscles is the fact that these muscles are very difficult to differentiate and the Adductor magnus muscle can easily be mistaken for any of the Adductor muscle or even the Gluteal muscle group or Hamstring muscle group (Travell and Simons, 1993; Martini *et al.*, 2012). It is an area that is very sensitive in most people and men especially could have been

uncomfortable during the examination and thus have given a biased result to the reporting of pain. Furthermore, the area is palpated by pincer palpation and it is cumbersome to hold the trigger point in place and apply pressure on the algometer at the same time. Finally, it may also have made a difference if the head of the algometer tip was hard or soft, in this case it was hard and could be more painful. Therefore, it is suggested that the inferences made in this study are tested again with due consideration for some of the difficulties encountered in this study.

5.4.4 Discussion of MFTPs in the Gastrocnemius muscle

During the physical examination of the research process the Gastrocnemius muscle, via its medial and lateral heads, were examined. It was noted whether a MFTP was present and if the involvement was lateral or medial head. Out of the 80 patients in this study, 68% presented with lateral head MFTPs. The Gastrocnemius muscle was examined due to the fact that its contribution in PFPS was suggested by previous authors (Waryasz and McDermott, 2008).

5.5 The severity of MFTPs in related muscles measured by an algometer

Reeves *et al.*, (1986) demonstrated the reliability and validity of the pressure Algometer in measuring MFTP sensitivity. In a study by Jensen (2010), on clinical implications of pain, it was pointed out that the concept or process of pain stems from four areas, namely the prefrontal cortex, the anterior cingulate cortex, the sensory cortex, and the insula. Respectively, the areas are involved with evaluating the meaning of pain and how to cope, the emotional component of pain, the area of pain, and the extent of the pain. With regards to this, the pain perception of each patient would have been individually perceived from patient to patient and negative thoughts due to chronic pain or depression could lead to an increased pain response and tension. Therefore, patient influence (observer effect, Hawthorne effect, touch therapy (Wilder, Pope and Frymoyer, 1988; Maigne and Vautravers, 2003)) in this reporting mechanism needs to be acknowledged (Mouton, 1996).

In a study by Myburgh, Larsen, and Hartvigsen (2008) on critical review of manual palpation for identifying MFTPs, it was noted that the reproducibility of a MFTP relies not only on the skill of manual palpation, but also on observation, patient feedback and examiner judgment. Therefore, it can be very difficult to produce unbiased results all around. However, it is noted that this would be an internally consistent process, affecting all patients consistently across this study.

5.5.1 Quadriceps femoris muscle group

Table 4.7 would seem to suggest that the most active MFTPs are present in the in those areas that were noted as having a high percentage of MFTPs and include: Vastus medialis TP1; Vastus lateralis TP1 and Vastus lateralis TP3. The first two having referral pain patterns that mimic PFPS and the latter being associated with the “hornet’s nest” in the lateral thigh, which is commonly associated with a tight iliotibial band (Travel and Simons, 1993; Chaitow and DeLany, 2002) and iliotibial band syndrome commonly associated with PFPS (Boucher and Hodgdon, 1993; Powers, 1998; Sakai *et al.*, 2000; Austermuehle, 2001; Yildiz *et al.*, 2003; Pribut, 2008).

Notwithstanding this it is also noted that some of the lesser noted MFTPs (*viz.* Vastus lateralis TP2 and Vastus lateralis TP4, were also noted as being highly active. This would concur with the presence of the “hornet’s nest” as Vastus lateralis TP3 and TP4 are associated with one another around this nest. Additionally, it is to be expected that Vastus lateralis TP2 would be active in PFPS, as the lateral components of the thigh (Vastus lateralis and Biceps femoris muscles both shorten the iliotibial band and pull the patella laterally (Moore and Dalley, 1999; Standring, 2008; Martini *et al.*, 2012), predisposing the lower Vastus lateralis muscle TPs (*viz.* TP 1 and TP2) to developing MFTPs (Travel and Simons, 1993; Chaitow and DeLany, 2002).

It is, therefore, no surprise that those MFTPs most remote from the patella, were the least active (*viz.* Rectus femoris, Vastus intermedius and Vastus lateralis TP 5).

5.5.2 Hamstring muscle group

From the findings indicated in Table 4.8, it would seem to suggest that even though the most MFTP's (by percentage) were located in the Biceps femoris muscle (see Table 4.4), the most active MFTP's were located in the Semitendinosus muscle, followed by the Biceps femoris muscle and the Semimembranosus muscle. This would seem to suggest the tight Biceps femoris muscle overloads the Semitendinosus muscle in patients with PFPS and may, therefore, also account for the high number of MFTP's noted in the Adductor magnus muscle (Table 4.6).

It would also seem to suggest that the Semitendinosus muscle remains as the only real antagonist to the dysfunctional extensor component of the knee (Thomeé *et al.*, 1999; Naslund *et al.*, 2006) and this may, therefore, also be a causative agent for the higher numbers of active MFTP's in the Semitendinosus muscle.

5.5.3 Adductor muscle group

Within the Adductor muscle group, it was previously noted that the Adductor magnus muscle had the most number of MFTP's (by percentage), however, it would seem from Table 4.9, that the Adductor brevis muscle has the most active MFTP's. This is interesting to note as Travel and Simons (1993) found that the referral pain pattern of the Adductor brevis muscle includes pain referred to the anterior and lateral knee (viz. in and around the patella and medial thereto). These results would further suggest that the Adductor magnus muscle although less active than the Adductor brevis muscle, still has more active MFTP's than the Hamstring muscle group (Table 4.8), which suggests that the Adductor magnus muscle assists in trying to normalise function of the extensors of the hip (Martini *et al.*, 2012), whilst also dealing as antagonists to the extensor dysfunction of the knee (as noted in PFPS) (Thomeé *et al.*, 1999; Naslund *et al.*, 2006).

In summary, it would seem that the MFTP's in the three muscle groups, most likely to refer to the knee have a high number of active MFTP's as compared to those that do not refer to the knee. Those that have no referral pattern to the knee, but are located most closely to the knee, seem to have high numbers of latent MFTP's, with these numbers of MFTP's declining as the MFTP location is further away from the patella.

5.6 Association between MFTP's in the Quadriceps femoris muscle group and the Hamstring muscle group

As noted, 92,5% of the patients presented with Quadriceps femoris MFTP's, and 86,3% with Hamstring MFTP's. Out of the 92,5% presenting with Quadriceps femoris MFTP's 89% also had Hamstring MFTP's, but in those without Quadriceps femoris MFTP's only 50% had Hamstring MFTP's. Therefore having both Quadriceps Femoris and Hamstring MFTP's was more likely than just Quadriceps femoris or Hamstring MFTP's alone. There was a statistically significant association between the presence of Quadriceps femoris MFTP's and presence of Hamstring MFTP's ($p=0.031$).

This association could be due to the fact that the Hamstring muscle group is the antagonist of the Quadriceps femoris muscle group (Moore and Dalley, 1999; Standring, 2008; Martini *et al.*, 2012) and which develop MFTP due to compensation of the weakened or inhibited Quadriceps femoris muscle group, or the Quadriceps femoris muscle group developing satellite MFTP's (Travel and Simons, 1993; Chaitow and DeLany, 2002), where the problem was initiated in the Hamstring muscle group. The inverse, however, is also true.

Furthermore the presentation of MFTP's in Biceps femoris muscle is commonly associated with shortening of the muscle. According to Travell and Simons (1993) this shortening of the Hamstring muscle group leads to overload and consequently perpetuating MFTP's in the Quadriceps femoris muscle group.

Additionally, Travell and Simons (1993), state that “The Quadriceps femoris symptoms will not resolve until their cause, tension of the Hamstrings, has been eliminated”. In future research, it would be interesting to see if elimination of MFTP’s in the Hamstring muscle group would assist in resolving PFPS.

5.7 Association between MFTP’s in the Gastrocnemius muscle and the Hamstring muscle group

Hamstring muscle group MFTP’s in general were highly significantly associated with Gastrocnemius muscle ($p < 0.001$) and 68% of people with Hamstring muscle group MFTP’s had a lateral Gastrocnemius muscle MFTP. Furthermore, Biceps femoris muscle was more strongly associated with lateral Gastrocnemius muscle MFTP’s ($p < 0.001$) since 85% of those with Biceps femoris muscle MFTP’s also had a lateral Gastrocnemius muscle MFTP (see Table 4.13 and Table 4.14).

The Gastrocnemius muscle is an agonist to the Hamstring muscle group, and assists the Hamstring muscle group in walking, running, cycling, and stair-climbing (Travell and Simons, 1993; Moore and Dalley, 1999; Standring, 2008; Martini *et al.*, 2012). The Gastrocnemius muscle attaches to the femoral condyles, in close proximity to where the Hamstring muscle group attach (Moore and Dalley, 1999; Standring, 2008; Martini *et al.*, 2012). It has been suggested that it might have a role to play in PFPS (Waryasz and McDermott, 2008). Travell and Simons (1993) furthermore state that: “the Hamstring muscle group are likely to harbour MFTP’s when MFTP’s have developed in the Gastrocnemius muscle”.

The only association that can be made from this significant observation is that the Biceps femoris muscle refers pain to the lateral side of the leg (Travel and Simons, 1993; Chaitow and DeLany, 2002). No further research could be found to substantiate or repudiate this finding.

Further to the above however, it was noted that a fair amount of patients had pronated feet. This was, however, not recorded and it is suggested that it would be interesting to see in future studies if it is related to Gastrocnemius MFTPs and consequently Hamstring muscle group MFTPs, Quadriceps femoris muscle group MFTPs, and PFPS.

5.8 Comparison of Patellofemoral pain syndrome in terms of Patellofemoral pain severity scale versus numeric rating scale

It needs to be remembered that the PPSS was designed to measure the extent of suffering that a patient presented with when diagnosed with PFPS (Triano et al., 1992; Yeomans, 2000; Dippenaar, 2003); in contrast to this the NRS is a tool used to measure pain irrespective of the origin of the pain (Liggins, 1982; Jensen Karoly and Braver, 1986; Bolton and Wilkinson, 1998) (whether it be from MFTPs or from the PFPS that patients report). Thus a correlation between these two would assist in determining whether pain (NRS) is a principle a principle causative agent for the reported findings in PFPS or whether there is a possibility that the PPSS measures something other than the clinical entity of PFPS. In order to comment on this, the findings of this study first need to be discussed.

The mean PFPS scale (PPSS) score was 6.9 with a standard deviation of 1 and range 5 to 9. NRS ranged from 2 to 10 with a mean of 6.

It must be remembered that when patients answer these questions, that they report the pain irrespective of the origin of the pain. Therefore it needs to be considered that the reporting of the pain is either related to PFPS or MFTPs.

When piloted by Dippenaar (2003), this PFPS questionnaire was demonstrated to have face validity and correlated with NRS. The questionnaire was subjective and objective in the way that the patient would answer first, with an option of five different answers; 'highly agree', 'agree', 'unsure', 'disagree', and 'strongly

disagree' (Appendix 5). Thereafter, the researcher would objectively interpret that into a yes or no and allocate points accordingly.

In this particular study, the PPSS with a mean of 6,9, when compared to the NRS, with a mean of 6, were very similar and could indicate the relation between PFPS and MFPS. In previous research (Dippenaar, 2003) it was found that the results of the three scales (NRS, PPSS and MDS) were associated and indicated a relationship between PFPS and MFPS, where it was concluded that: "The pain recorded by the NRS was significantly related to the myofascial component of the syndrome (MDS) as opposed to the pain normally recorded as that for PFPS (PPSS)" and it was furthermore concluded that: "This therefore indicates that there is a high degree of overlap between the presence of MFTPs (MDS) and Patellofemoral Pain Syndrome (PPSS), when the patients present with diagnosed PFPS. Thus it can be concluded that Myofascial Pain Syndrome is a positive predictive factor in the development of Patellofemoral Pain Syndrome". Therefore, it stands to reason in this research where a similar relationship was found between the PPSS and the NRS, that the relationship to the MFTPs would be similar (see Section 5.11).

Based on the fact that the reporting of the NRS mimics the reporting on the PPSS, it could be suggested that the patient is indeed reporting on pain from a single origin. If one was, therefore, to consider Dippenaar's (2003) and Dippenaar *et al.*'s (2008) assertion that the PPSS measures to a large extent the activity / lack of activity and associated pain as related to MFTPs, it could be considered that the patients presenting in this study are actually reporting the pain and dysfunction as borne out by MFTPs.

This would concur with the fact that the patients presenting in this study presented with MFTPs in muscles that would (if they contained active MFTPs) refer to the knee and mimic the pain experienced by PFPS. In addition the

questions asked in the PPSS include (in brackets below, the effect of MFTPs on the outcome of the question):

History :

- I experience pain on prolonged sitting (which is a known aggravator of Hamstring muscle MFTPs (Travel and Simons, 1993; Chaitow and DeLany, 2002)).
- I experience pain on ascending and descending stairs (which is a known aggravator of Quadriceps femoris muscle MFTPs (Travel and Simons, 1993; Chaitow and DeLany, 2002)).
- I experience pain which is worse with physical activity (which is a known aggravator of MFTPs in general (Travel and Simons, 1993; Chaitow and DeLany, 2002)).

Signs

- Pain on a deep squat which is a known aggravator of Quadriceps femoris muscle MFTPs (Travel and Simons, 1993; Chaitow and DeLany, 2002)).
- Pain on kneeling (which is a known aggravator of Quadriceps femoris muscle MFTPs (Travel and Simons, 1993; Chaitow and DeLany, 2002)).
- Pain on tightening thigh muscles (which is a known aggravator of MFTPs in general (Travel and Simons, 1993; Chaitow and DeLany, 2002)).

Symptoms

- Pain behind or around the patella (associated with the active MFTPs (Travel and Simons, 1993; Chaitow and DeLany, 2002) found in this study as well as the PFPS (McConnell, 1986; McConnell, 1996; Duri *et al.*, 1999; Naslund *et al.*, 2006)).
- Pain mild / moderate and severe (this is generic and can be reported of pain of any origin).

Therefore, it is not unexpected that the PPSS correlates well with the NRS, but it does indicate that a significant component of PFPS may be due to MFTPs.

5.9 Patellofemoral pain syndrome in terms of inclinometer readings

It is mentioned that MFTPs can lead to shortening and tightness of muscles (Travell and Simons, 1993). Therefore, the inclinometer was used to assess if there was a difference between the affected leg and the unaffected leg with respect to Hamstring tightness and or shortening.

As mentioned above, the right knee was affected in the majority of patients (63,8%) versus the left leg (36,2%). However, it was not recorded which leg was the dominant leg, so a causal link to a dominant right leg may be possible for those with right sided symptoms (Paoloni *et al.*, 2011).

On the inclinometer assessment two measurements were taken:

- an erect straight leg raise (Inclinometer 1) and
- a supine straight leg raise (Inclinometer 2).

The mean results of Inclinometer 1 on the right leg were lower (45.81 degrees) than the left leg (46.70 degrees). Furthermore, the results had a minimum of 16 degrees and a maximum of 85 degrees on the right leg and 87 degrees on the left leg.

The mean results of inclinometer 2 on the right leg were lower (65.33 degrees) than the left leg (67.74 degrees). Furthermore, the results showed a minimum of 25 degrees (right leg) and 36 degrees (left leg), and a maximum of 134 degrees (right leg) and 124 degrees (left leg).

These findings support the fact that Biceps femoris MFTP's are very commonly associated with shortening of the Hamstrings (Naslund, 2006), and in this study the Biceps femoris muscle had the most MFTP's when considering the Hamstring muscle group. The differences in measurements have been attributed to the degree of pelvic tilt available to the participant when standing (Inclinometer 1) to lying supine (Inclinometer 2) (Martini *et al.*, 2012).

The results showed that there was a statistically significant difference between Inclinometer 2 readings of the left and right sides affected ($p=0.013$). Those with right side affected had higher values for Inclinometer 2 readings of the left than those with the left side affected. The trend was the same for the other inclinometer reading but they did not reach statistical significance.

A larger sample size may have allowed these values to reach statistical significance and it is, therefore, important that future studies consider larger samples, denote sidedness of the symptoms as well as the decreased Hamstring muscle length and its sidedness to confirm the suggestions / findings of this study.

5.10 Correlation between muscle group severity and NRS

When considering that all participants had PFPS (as per the inclusion criteria (see Section 3.5.3.1) and after having assessed the presentation of MFTPs in the various muscles and combination of various muscles, it is important to consider whether the presenting complaint has any relationship to the presence of MFTPs.

It is known / not known:

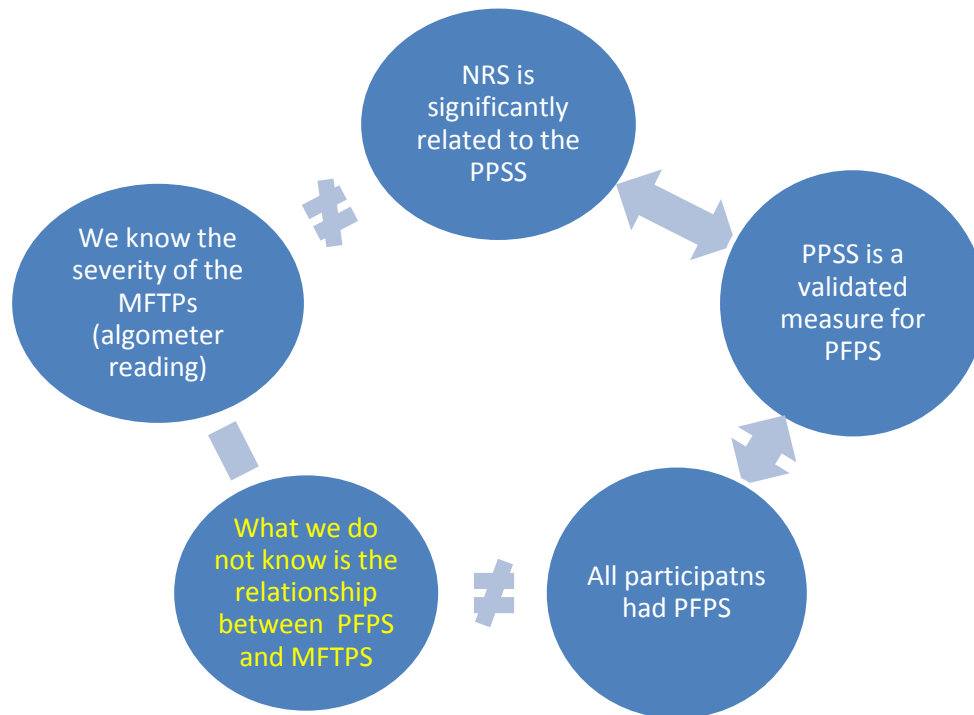


Figure 5.1 Summary cycle

Therefore, it is important to run correlation analyses to look at the final associations that are possible in this study. In order to do this, the algometer readings for the various MFTPs measured were correlated with the NRS readings reported by the participants.

It should be remembered that these correlations should be inversely related. This is because as the participant reports increased pain on the NRS, there should be

a decrease in the kg/cm^2 that is reported by the algometer (as the participant is less able to maintain increased pressures on an area that is reported to have a high pain intensity).

In summary, these correlations show that :

- a. There was a non-significant, negative correlation between the algometer and the NRS readings for the following MFTPs:
 - a. Rectus femoris muscle.
 - b. Vastus medialis TP2.
 - c. Vastus intermedius muscle.
 - d. Vastus lateralis TP1.
 - e. Vastus lateralis TP3.
 - f. Vastus lateralis TP4.
 - g. Semitendinosus muscle.
 - h. Adductor brevis muscle.

- b. There was a non-significant, positive and negative correlations between the algometer and the NRS readings for the following MFTPs:
 - a. Biceps femoris muscle (positive for initial pain).
 - b. Adductor longus muscle (positive for only for initial pain and pain referral).

- c. There was a significant, negative correlation between the algometer and the NRS readings for the following MFTPs:
 - a. Vastus medialis TP1 (significant at the 95% confidence interval).
 - b. Vastus lateralis TP2 (significant at the 99% confidence interval).
 - c. Vastus lateralis TP5 (only for pain intolerance) (significant at the 99% confidence interval).
 - d. Semimembranosus muscle (only for pain intolerance) (significant at the 95% confidence interval).

- e. Adductor magnus muscle (only for pain intolerance) (nears significance) (significant at the 95% confidence interval).

From the above it becomes apparent that the most significant relationship exists between the NRS and the algometer measurements that the Vastus lateralis TP2, followed by the Vastus medialis TP1 (again for all measures).

This indicates that there is a significant relationship between the Vastus lateralis TP2, Vastus medialis TP1 and the NRS. With this in mind, it needs to be considered that this relationship (by extension of the NRS-PPSS relationship that the Vastus lateralis TP2, Vastus medialis TP1, the NRS and the PPSS all seem to measure the same pain originator, which seems to be the MFTPs in the two muscles involved in this relationship)..

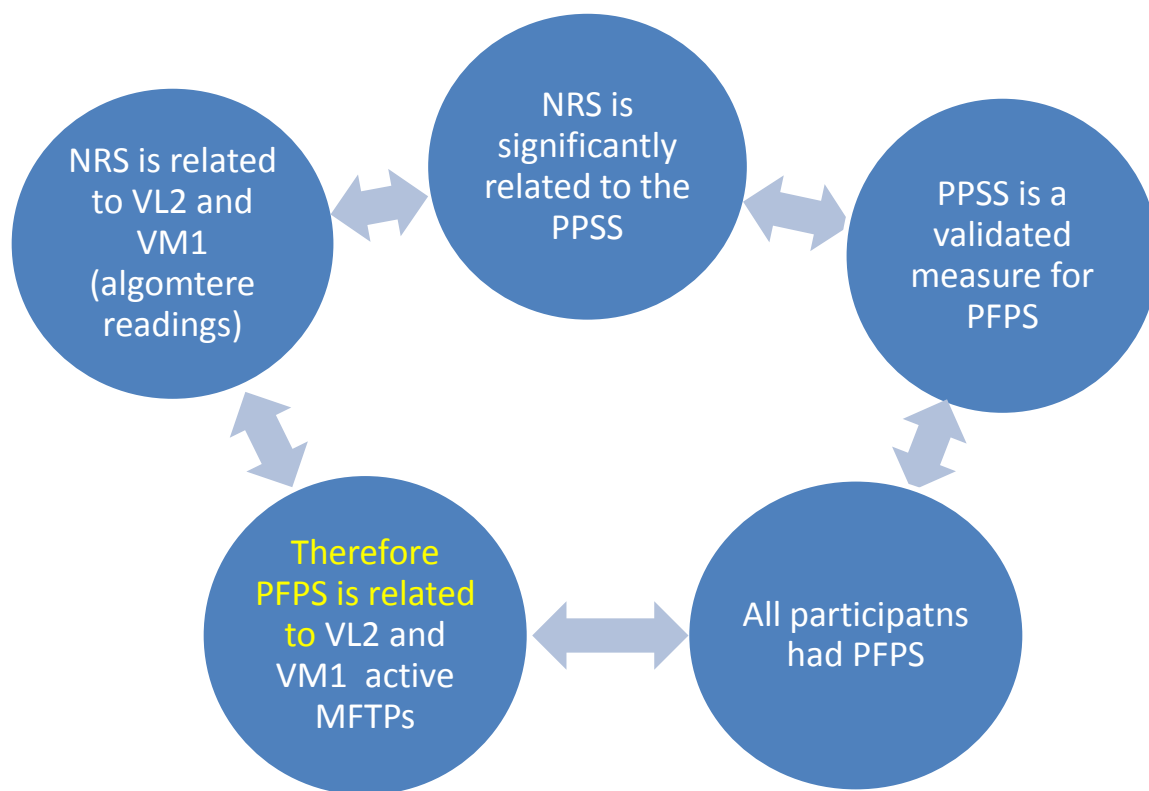


Figure 5.2 Summary cycle completed

This study, therefore, confirms the findings of Dippenaar (2003); Daly (2005); Weyer-Henderson (2005) and Dippenaar *et al.*, (2008) where it was indicated that MFTPs of the Vastus lateralis and Vastus medialis were implicated in PFPS. This also supports the previous literature (Engle, 1991; Scruideri, 1995; Thomeé *et al.*, 1999; Piva *et al.*, 2005; Naslund, 2006; Pribut, 2008) which proposes that the abnormal patellar tracking and thereby PFPS is caused by an extensor mechanism misalignment (Thomeé *et al.*, 1999), which may be related to inhibition of the Vastus medialis muscle by the Vastus lateralis muscle (Vastus lateralis muscle being more painful than the Vastus medialis muscle) (Hopkins and Ingersoll, 2000; Suter *et al.*, 2000; Arokoski *et al.*, 2002; Ingersoll, Palmieri and Hopkins, 2003).

The correlations also indicate that there is a significant relationship between the reported pain and the presence of MFTPs in the Semimembranosus muscle, which indicates that there is a higher than possibility chance that this portion of the Hamstring is associated with PFPS and that further research needs to be completed in order to determine the causality of this relationship.

The adductor magnus muscle may fall into this group as well, however, it only neared significance in this study. Therefore, it is suggested that future studies look more closely at this muscle and its association with PFPS. These studies should also consider increased participant numbers in order to increase the likelihood of significance (if it is present).

Also, based on these findings, it is suggested that the lateral tightness of the thigh and the iliotibial band like syndrome may not necessary be the principle cause of pain in patients with PFPS but may be secondary to the MFTPs found in the Vastus lateralis muscle (direct relationship), the Vastus medialis muscle (antagonist relationship), the Semimembranosus muscle (agonist to the Biceps femoris attached to the iliotibial band) and the adductor magnus muscle (antagonist) (Martini *et al.*, 2012).

5.11 Review of the objectives:

Objective 1

To record the location and severity of MFTPs in the Hamstring muscle group, Quadriceps femoris muscle group, and Adductor muscle group of patients with PFPS.

Sections :

Reported:

4.6.3 Presence of MFTPs in related muscles.

4.6.4 MFTP severity and related muscles.

Discussed:

5.4 The prevalence of MFTPs (5.4.1 - 5.4.4)

5.5 The severity of MFTPs in related muscles measured by algometer (5.5.1 - 5.5.3)

Objective 2

Subjectively measure the clinical presentation of PFPS in terms of Patellofemoral pain severity scale (PPSS) and Numerical pain scale (NRS).

Sections :

Reported:

4.6.5 PFPS in terms of a comparison between PPSS and NRS

4.6.6 PFPS in terms of inclinometer readings

Discussed:

5.6 Comparison of PFPS in terms of PPSS versus NRS

5.9 PFPS in terms of inclinometer readings

Objective 3

Objectively measure the flexibility of the Hamstring muscle group, to determine the relevance of this flexibility and association to PFPS and noted MFTPs.

Sections :

Reported:

4.6.6 PFPS in terms of inclinometer readings

Discussed:

5.9 PFPS in terms of inclinometer readings

Objective 4

To assess the association between location and severity of MFTPs and the clinical presentation of PFPS.

Sections :

Reported:

4.6.10 Correlation outcomes (NRS and Algometer IP, PI and PR).

Discussed:

5.11 Correlation between muscle group severity and NRS

5.12 Conclusion

Based on the above, it was indicated that the Quadriceps femoris muscle group MFTPs were noted in 92.5% of the patients (most prevalent being Vastus medialis TP1 (63.8%), Vastus lateralis TP1 (33.8%) and Vastus intermedius at 27,5%). Least common was Vastus lateralis TP2 only presenting in 2,5% of the patients. Hamstring muscle group MFTPs were found overall in 86.3% of patients

(most prevalent being in Biceps femoris muscle (66%), and least prevalent being in Semitendinosus muscle (11,3%)). MFTPs were present in 64% overall of the Adductor muscle group (Adductor magnus muscle being the most common). Significant associations were made between the presence of MFTPs in the Vastus lateralis TP2 ($p=0.00$), Vastus medialis TP1 ($p=0.046$; 0.005 ; 0.004), the NRS and the PPSS. Also significant was the relationship between the NRS, PPSS and the Semimembranosus and Adductor magnus muscles indicating that these muscles were the most likely causes of pain even though they had fewer MFTPs than other comparable muscles.

The outcomes of this study supports previous research indicating that an extensor dysfunction of the Quadriceps femoris muscle may be of MFTP origin and indicates that other muscles in thigh require further research indicating their role in the development of PFPS.

Chapter 6

Conclusion and recommendations

6.1 Introduction

This chapter will address all outcomes of this study and discuss recommendations for further studies on PFPS.

6.2 Conclusion

The following was observed from data analysed

- the Quadriceps femoris muscle group MFTPs were noted in 92.5% of the patients
 - Vastus medialis TP1 (63.8%).
 - Vastus lateralis TP1 (33.8%).
 - Vastus intermedius (27,5%).
 - Vastus lateralis TP2 (2,5%).
- Hamstring muscle group MFTPs were found overall in 86.3% of patients
 - Biceps femoris muscle (66%).
 - Semimembranosus muscle (48.3%).
 - Semitendinosus muscle (11,3%).
- MFTPs were present in 64% overall of the Adductor muscle group (Adductor magnus muscle being the most common).

Significant associations were made between the presence of MFTPs in the Vastus lateralis TP2 ($p=0.00$) and Vastus medialis TP1 ($p=0.046$; 0.005 ; 0.004) when correlated with the NRS.

The NRS and PPSS were found to correlated significantly. Therefore the NRS, PPSS and Vastus lateralis TP2 and Vastus medialis TP1, were found to have a

significant association (causality has been excluded as this study did not look at causation).

Other significant relationships occurred between the NRS, PPSS and the Semimembranosus and Adductor magnus.

As a result, the outcomes of this study supports previous research indicating that an extensor dysfunction of the Quadriceps femoris muscle (Engle, 1991; Scruideri, 1995; Thomeé *et al.*, 1999; Piva *et al.*, 2005; Naslund, 2006; Pribut, 2008) may be of MFTP origin (Dippenaar, 2003; Daly, 2005; Weyer-Henderson, 2005 and Dippenaar *et al.*, 2008) and be related to an inhibition process, whereby the MFTPs in Vastus lateralis (although few in number), inhibit Vastus medialis and Biceps femoris muscles, thereby overloading the Semitendinosus and adductor magnus muscles (Hopkins and Ingersoll, 2000; Suter *et al.*, 2000; Arokoski *et al.*, 2002; Ingersoll, Palmieri and Hopkins, 2003) and indicates that other muscles in thigh require further research indicating their role in the development of PFPS.

6.3 Recommendations

6.3.1 Methodological recommendations

In terms of the patient:

- Future studies need to consider the use of translated documents to ensure that all participants are able to access instructions in their home language. This would apply to the Letter of Information and Informed Consent Form as well as instructions for each of the measurement tools.
- The Hawthorne or observer effect cannot be discounted in a study such as this, where patients may have wanted to please the researcher by giving results they think he/she wants (Mouton, 1996).

In terms of the researcher:

- Due to the close proximity of the individual muscles, anatomically, it is possible that the researcher could have had difficulty in differentiating between certain muscles / muscle groups and the results could have been interpreted wrongly or allocated to a different muscle. It is suggested that future research consider having two examiners to identify the MFTPs in order to improve accuracy.

General recommendations:

- The use of a digital Algometer may allow for more specific readings than the analogue utilised in this study. It is suggested that future studies consider the use of a digital algometer.
- It would be better in a study like this to have a greater number of patients, both with and without PFPS.
- A larger sample size may have allowed some of the values obtained in this study to reach statistical significance and it is, therefore, important that future studies consider larger samples.
- Examiners of MFTPs and of the PFPS should ideally not communicate, so the use of a blinded examiner to measure the MFTPs outcomes ensures that they are measured accurately, in this study would have strengthened its outcome (viz. the researcher being the measurer of the PFPS).
- It has been suggested in the literature that there is a difference between males and females with regards PFPS (Davidson,1993; Dutton, 2012) and the possible etiological causes, therefore future research may wish to consider stratification for gender or include only one gender in order to negate the factors that may be associated with this etiology.
- A prospective observation may allow for the development of causation between the various muscle groups, which this “snapshot” observation, is unable to determine causation.
- In previous studies the amounts of exercise (Clifton, 2003) was recorded, this may have an impact on the rate of pathogenesis of a condition and

therefore future studies should include this as a possible statistical modifier.

- The use of focused or specific population groups, such as long-distance runners (Daly, 2005; Weyer-Henderson, 2005) have been considered in previous studies. This exploratory study was not focused on any specific athletic group, age or gender, and therefore, participants may have presented with a variety of etiological causative factors, this may have obscured significant involvement of different muscle groups and it is suggested that future studies consider stratification according to these criteria or limitation to specific groups of athletes.
- The role of leg dominance / sidedness was considered in the literature, but not for this study. In retrospect, this may have assisted in explaining certain findings and it is suggested that future research consider this as a “demographic” factor for use in the analysis of the data.
- Participants were not asked if they were on any anti-inflammatory / anti spasmodic / muscle relaxant medication at the time of the consultation. This would have adversely affected the pain measures taken at the reading. Therefore, it is important that future research consider a washout period as recommended by Seth (1999) of 72 hours prior to assessment of the participant. This was an oversight in the methodology of this paper, as it should have included a washout period or been part of the exclusion criteria.

6.3.2 Future studies

It would be of interest to note whether the patients that present with Biceps femoris muscle and Adductor magnus muscle MFTP combinations, have any rotation of their lower extremity independent of PFPS and whether this would correlate with the presentation of limb rotation in patients with PFPS. It is suggested that further research be conducted in this regard.

Further to the above, it was noted that a number of patients had pronated feet. This was however not recorded and it is suggested that it would be of interest to determine in future studies if:

- Pronation is related to PFPS.
- Pronation is related to an increased incidence in Gastrocnemius MFTPs (Grieve *et al.*, 2011).
- Pronation is related to an increased incidence in Hamstring muscle group MFTPs and Quadriceps femoris muscle group MFTPs.
- Pronation is related to the presentation of PFPS.

It was found that the MFTPs in Biceps femoris muscle is associated with shortening of the muscle. Travell and Simons (1993) state that “The Quadriceps femoris symptoms will not resolve until their cause, tension of the Hamstrings, has been eliminated”. In future research it would be interesting to see if elimination of MFTPs in the Hamstring muscle group would assist in resolving PFPS.

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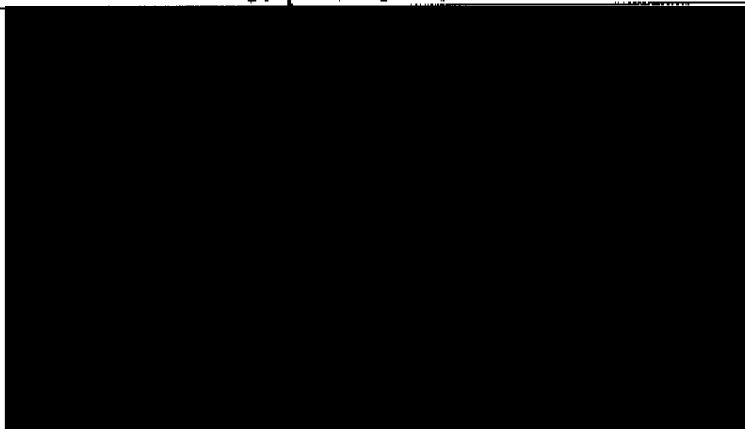
ETHICS CLEARANCE CERTIFICATE

Student Name	Louise Smith	Student No	205117-1
Ethics Reference Number	009110	Date of FRC Approval	07.04.2010
Qualification	M tech chiro		
Research Title:	the role of and relationship between hamstrings and quadriceps muscle myofascial trigger points in patients with patellofemoral pain syndrome		

In terms of the ethical considerations for the conduct of research in the Faculty of Health Sciences, Durban University of Technology, this proposal meets with Institutional requirements and confirms the following ethical obligations:

1. The researcher has read and understood the research ethics policy and procedures as endorsed by the Durban University of Technology, has sufficiently answered all questions pertaining to ethics in the DUT 105 and agrees to comply with them.
2. The researcher will report any serious adverse events pertaining to the research to the Faculty of Health Sciences Research Ethics Committee.
3. The researcher will submit any major additions or changes to the research proposal after approval has been granted to the Faculty of Health Sciences Research Committee for consideration.
4. The researcher, with the supervisor and co-researchers will take full responsibility in ensuring that the protocol is adhered to.
5. **The following section must be completed if the research involves human participants:**

	YES	NO	N/A
❖ Provision has been made to obtain informed consent of the participants	✓		
❖ Potential psychological and physical risks have been considered and minimised	✓		
❖ Provision has been made to avoid undue intrusion with regard to participants and community	✓		
❖ Rights of participants will be safe-guarded in relation to:	✓		
- Measures for the protection of anonymity and the maintenance of Confidentiality.	✓		
- Access to research information and findings.	✓		
- Termination of involvement without compromise	✓		
- Misleading promises regarding benefits of the research	✓		



SIGNATURE: CHAIRPERSON OF RESEARCH ETHICS COMMITTEE

24.03.10
DATE

23/03/10.
DATE

24/03/2010.
DATE

7/04/2010
D

Appendix 2:
ARE YOU INTERESTED IN PARTICIPATING IN RESEARCH?

Knee pain

Are you suffering from
Pain Around or Under your

Knee Cap

*when you run, climb stairs or sit for longer
duration of time?*

If you are between age 20-50

You may qualify for research being conducted at Durban University
of Technology
CHIROPRACTIC DAY CLINIC.

FREE TREATMENT is available to those who qualify to
take part in this study.

For more information please contact:

Louise Smith
031-373 2205

Appendix 3 :Telephonic Interview Question Sheet

Inclusion Criteria:

1. Are you between the ages of 20 and 50?
2. Is the pain you are experiencing underneath or around the knee cap?
3. Do any of the following aggravate your pain:
 - ❖ squatting,
 - ❖ stair climbing,
 - ❖ kneeling,
 - ❖ prolonged sitting.
 - ❖ physical activity

Exclusion Criteria:

Have you had any history of any of the following that you know of:

- ❖ Traumatic / non-traumatic kneecap dislocation,
- ❖ Any nerve related (neurological) problem effecting the way you walk,
- ❖ Have you undergone any knee surgery over the past 2 years,
- ❖ A cartilage or meniscal tear,
- ❖ Injury causing your ligaments or joints to become unstable (ligamentous instability),
- ❖ Arthritis in your knees.

Appendix 4: Letter of Information and Consent

Dear participant, thank you for your interest.

The title of my research study is: The role of and relationship between Hamstring and Quadriceps myofascial trigger points in patients with patellofemoral pain syndrome.

Name of supervisor:	Dr. B. Kruger MTech Chiropractic	Contact number 031 564 9091
Name of student:	Louise Smith	Contact number 031 373 2205
Name of institution:	Durban University of Technology	Contact number 031 373 2094

This study involves research on 80 patients with Patellofemoral pain syndrome/anterior knee pain, to examine the presence of myofascial trigger points.

Myofascial trigger points or tender spots within a muscle can lead to muscle dysfunction and associated pain. The extent to which this myofascial trigger point induced muscle dysfunction leads to the onset, presentation or exacerbation of patellofemoral pain syndrome is unknown. Therefore this research will provide information as to the extent to which myofascial trigger points of the hamstrings, adductors and quadriceps muscles play a role in PFPS. This information could provide a foundation for further research in identifying the cause of and possible treatment options for PFPS. This would give health care providers a guideline whether treatment of MFTP's could be helpful in the management of PFPS.

Outline of the Procedures:

All participants, including you, will undergo a consultation during which a case history, relevant physical and knee regional examinations will be completed. These examinations will help to identify myofascial trigger points and information will be gathered for the purpose of establishing prevalence of myofascial trigger points in patients with PFPS. All information will be gathered at initial consultation.

Risks or Discomforts to the Subject:

The participation is safe and is unlikely to cause any adverse side effects, other than slight discomfort during or after the examination, which is expected to last no longer than the duration of the exam.

Benefits:

Following the assessment you will be offered 2 free treatments for knee pain to be used within a month of initial assessment, at the Chiropractic Day Clinic at DUT.

Confidentiality:

All patient information will be kept confidential and will be stored in the Chiropractic Day Clinic for 5yrs, after which it will be shredded. All the results of the study will be made available in the Durban University of Technology library in the form of a mini-dissertation, but none of your personal information will be included.

Persons to Contact in the Event of Any Problems or Queries:

Should you wish you can contact my research supervisor at the above details or alternatively you could contact the Faculty of Health Sciences Research and Ethics Committee as per Mr. Vikesh Singh (031) 3732701.

I have read this document and understand its content. Where I had any questions or queries these have been explained to me to my satisfaction.

Patent name, signature, date, and ID number _____

Researchers name and signature _____

Supervisor's name and signature _____

Witness name and signature _____

Appendix 5 : NRS, Duration, Location of MFTP's, Algometer reading, and Inclinometer reading

NRS

0	1	2	3	4	5	6	7	8	9	10
---	---	---	---	---	---	---	---	---	---	----

Duration in months: _____

		TP1	TP2	TP3	TP4	TP5	Other
Rectus Femoris	PPT						
	RPT						
	PI						
	MDS						
Vastus Medialis	PPT						
	RPT						
	PI						
	MDS						
Vastus Intermedius	PPT						
	RPT						
	PI						
	MDS						
Vastus Lateralis	PPT						
	RPT						
	PI						
	MDS						
Biceps Femoris	PPT						
	RPT						
	PI						
	MDS						
Semitendinosus	PPT						
	RPT						
	PI						
	MDS						
Semimembranosus	PPT						
	RPT						
	PI						
	MDS						
Adductor Longus	PPT						
	RPT						
	PI						
	MDS						
Adductor Brevis	PPT						
	RPT						
	PI						
	MDS						
Adductor Magnus	PPT						
	RPT						
	PI						
	MDS						

Inclinometer reading for the Hamstring	
--	--

Appendix 6

Appendix G

Patellofemoral Pain Severity Scale:

Patellofemoral Pain Severity Scale	Points awarded by researcher	
	Yes	No
History:		
I experience pain on prolonged sitting (30-90 mins) Strongly agree 5 Agree 4 Unsure 3 Disagree 2 Strongly disagree 1	1	0
I experience pain on ascending or descending stairs Strongly agree 5 Agree 4 Unsure 3 Disagree 2 Strongly disagree 1	1	0
My pain is worsened with physical activity Strongly agree 5 Agree 4 Unsure 3 Disagree 2 Strongly disagree 1	1	0
Signs:		
I experience pain on deep squatting Strongly agree 5 Agree 4 Unsure 3 Disagree 2 Strongly disagree 1	1	0
I experience pain on kneeling Strongly agree 5 Agree 4 Unsure 3 Disagree 2 Strongly disagree 1	1	0
I experience pain on tightening my thigh muscle Strongly agree 5 Agree 4 Unsure 3 Disagree 2 Strongly disagree 1	1	0
Symptoms:		
I experience pain behind or around my knee cap Strongly agree 5 Agree 4 Unsure 3 Disagree 2 Strongly disagree 1	1	0
My pain is mild Strongly agree 5 Agree 4 Unsure 3 Disagree 2 Strongly disagree 1	1	0
My pain is moderate Strongly agree 5 Agree 4 Unsure 3 Disagree 2 Strongly disagree 1	1	0
My pain is severe Strongly agree 5 Agree 4 Unsure 3 Disagree 2 Strongly disagree 1	1	0

Appendix 10

Appendix I

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		



Patient: _____

Date: _____

File # : _____

Age: _____

Sex : _____

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:		
< Cause:		
< Duration		
< Frequency		
< Pain (Character)		
< Progression		
< Aggravating Factors		
< Relieving Factors		
< Associated S & S		
< Previous Occurrences		
< Past Treatment		
< Outcome:		

4. Other Complaints:

5. Past Medical History:

< General Health Status

< Childhood Illnesses

< Adult Illnesses

< Psychiatric Illnesses

< Accidents/Injuries

< Surgery

< Hospitalizations

6. Current health status and life-style:

- < Allergies
- < Immunizations
- < Screening Tests incl. x-rays
- < Environmental Hazards (Home, School, Work)
- < Exercise and Leisure
- < Sleep Patterns
- < Diet
- < Current Medication
- < Analgesics/week:
- < 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 8

Patient Name : _____ **File no :** _____ **Date :** _____
Student : _____ **Signature :** _____

VITALS:				
Pulse rate:		Respiratory rate:		
Blood pressure:	R	L	Medication if hypertensive:	
Temperature:			Height:	
Weight:	Any recent change? Y / N		If Yes: How much gain/loss	Over what period

GENERAL EXAMINATION:		
General Impression		
Skin		
Jaundice		
Pallor		
Clubbing		
Cyanosis (Central/Peripheral)		
Oedema		
Lymph nodes	Head and neck	
	Axillary	
	Epitrochlear	
	Inguinal	
Pulses		
Urinalysis		

SYSTEM SPECIFIC EXAMINATION:
CARDIOVASCULAR EXAMINATION
RESPIRATORY EXAMINATION
ABDOMINAL EXAMINATION
NEUROLOGICAL EXAMINATION
COMMENTS

Clinician: _____ **Signature :** _____

Appendix 9
DURBAN UNIVERSITY OF TECHNOLOGY
KNEE REGIONAL EXAMINATION

Patient: _____ File: _____ Date: _____

Intern: _____ Signature: _____

Clinician: _____ Signature: _____

! **OBSERVATION** (Standing, Seated and during gait cycle).

A. Anterior view

Genu Varum: _____

Genu Valgum: _____

Patellar position: _____

Tibial Torsion: _____

Skin: _____

Swelling: _____

B. Lateral view

Genu Recurvatum: _____

Patella Alta: _____

Patella Baja: _____

Skin: _____

C. Posterior view

Swelling: _____

Skin: _____

D. General

Movement symmetry: _____

Structures symmetry: _____

! **ACTIVE MOVEMENTS**

Flexion (0 - 135E) _____

Extension (0 - 15E) _____

Medial Rotation (20 - 30E) _____

Lateral rotation (30 - 40E) _____

! **PASSIVE MOVEMENTS**

Tissue approx _____

Bone-bone _____

Tissue stretch _____

Tissue stretch _____

Patellar movement _____

! **RESISTED ISOMETRIC MOVEMENTS**

Knee: Flexion: _____

Extension: _____

Internal rotation: _____

External rotation: _____

Ankle: Plantarflexion _____

Dorsiflexion _____

! **LIGAMENOUS ASSESSMENT**

One-Plane Medial Instability

Valgus stress (abduction)

Extended _____

Resting Position _____

One-Plane Lateral Instability

Varus stress (adduction)

Extended _____

Resting Position _____

One-Plane Anterior Instability

Lachman Test (0-30°) _____

Anterior Drawer Sign _____

One-Plane Posterior Instability

Posterior "sag" Sign _____

Posterior Drawer Test _____

Anterolateral Rotatory Instability

Slocum Test _____

Macintosh Test _____

Anteromedial Rotatory Instability

Slocum Test _____

Posterolateral Rotatory Instability

Jacob _____

Hughston's Drawer Sign _____

Reverse pivot shift test _____

Posteromedial Rotatory Instability

Hughston's Drawer Sign _____

! TESTS FOR MENISCUS INJURY

McMurray _____
 "Bounce Home" _____

Anderson med-lat grind _____
 Apley=s _____

! PLICA TESTS

Mediopatellar Plica _____
 Plica "Stutter" _____

Hughston's Plica _____

! TESTS FOR SWELLING

Brush/Stroke Test _____

Patellar Tap Test _____

! TESTS FOR PATELLA FEMORAL PAIN SYNDROME

Clarke's Sign _____
 Waldron test _____

Passive patella tilt test _____

! OTHER TESTS

Wilson's _____
 Fairbank's _____
 Noble Compression _____

Quadriceps Contusion Test _____
 Leg Length Discrepancy _____

! JOINT PLAY

Movement of the tibia on the femur
 Translation of the tibia on the femur
 Long axis distraction of the tibiofemoral joint
 Inf, sup, lat, + med glide of the patella
 Movement of the inf. tibiofibular joint
 Movement of the sup. tibiofibular joint
 Movement of the sup. tibiofibular joint

P | A: _____ A | P: _____
 M | L: _____ L | M: _____

 A | P: _____ P | A: _____
 A | P: _____ P | A: _____
 S | I: _____ I | S: _____

! PALPATION

Tenderness _____
 Joint line _____
 Ligaments _____
 Patella: _____
 Patella tendon: _____
 Bursae: _____

Swelling _____
 Nodules/exostoses _____
 Muscles: thigh: _____
 Leg: _____
 Popliteal artery: _____

! REFLEXES AND CUTANEOUS DISTRIBUTION

	R	L
Patellar Reflex (L3,L4)		
Medial Hamstring Reflex (L5,S1)		

! DERMATOMES

	R	L		R	L
L2			S1		
L3			S2		
L4			S3		
L5					