The presence and extent of quadriceps femoris weakness in individuals with patellofemoral pain syndrome.

By

STUART RONALD CLIFTON

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I, Stuart Clifton, do hereby declare that this dissertation is representative of my own work.

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Stuart Clifton Date

Approved for final submission

_________________ _________________

Dr Brian Kruger (Chief supervisor) Date
M. Tech. Chiro., C.C.S.P.

_________________ _________________

Jimmy Wright (Co- supervisor) Date
B. Hons (HMS) PU for CHE. Dipl. Sports Science NU

Dedication

I dedicate this work to my parents who have provided me with the love, support and guidance I have needed to grow mature and accomplish my goals. You have both given so much time, effort and sacrifice to help me achieve my goals and I could never thank you enough. I love you, Mom and Dad.

To the rest of my extended family, who have played such an important role in my life, thank you also.

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ABSTRACT

The purpose of the investigation was to evaluate the presence and extent of Quadriceps Femoris weakness in subjects with patellofemoral pain syndrome by the use of an isokinetic dynamometer.

This was a controlled quasi experiment (pilot study). Subjects presenting at the Chiropractic Day Clinic at the Durban Institute of Technology were considered. Subjects were diagnosed with patellofemoral pain syndrome by the researcher.

Objective assessment was by means of a concentric / eccentric, flexion / extension isokinetic test of the knee joint. Twenty subjects suffering from patellofemoral pain syndrome were evaluated in an experimental fashion, using standardized Isokinetic testing protocol on a Cybex “Norm” Dynamometer. Test velocity was fixed at 60 degrees per second. A pre-test was undertaken by each subject no less than 2 days and no more than 7 days prior to the actual test in order to enable subjects to become familiar with the machinery. Values from the actual test were then compared to established and accepted normative values attained on similar machinery.

Data were analyzed through the use of the SPSS statistical package. Inter-group comparisons were drawn using the one sample T-test. Male and female data was analyzed separately.

A statistically significant weakness of the quadriceps femoris muscle was noted among males (n = 16) in terms of peak torque values for both concentric and eccentric modes of contraction. Among females (n = 4) this weakness was statistically insignificant. However this lack of statistical significance could be attributed to the small sample size.

A statistically significant weakness of the hamstring muscles was noted among males in terms of peak torque values for the concentric mode of contraction. Among females this weakness was statistically insignificant, but this may be attributed to the small sample size.

A statistically significant weakness of the hamstring muscles was noted among males and females in terms of eccentric hamstring / concentric quadriceps ratio.

This study suggests the presence of both concentric and eccentric quadriceps femoris and hamstring weakness, in terms of peak torque values, at an isokinetic test velocity of 60 degrees per second. However further research is required in this field, especially with regard to the hamstring muscles.

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Definition of Terms

PATELLOFEMORAL PAIN SYNDROME

A syndrome consisting of: anterior knee pain, inflammation, imbalance, instability or any combination thereof (Wood, 1998).

ISOKINETIC EXERCISE

The term isokinetic exercise refers to a process in which a body segment accelerates to achieve a pre-selected fixed speed with totally accommodating resistance through out the range of motion (Cybex. 1996:p1-9,c-2).

CONCENTRIC CONTRACTION

The development of tension by muscle while the origin and insertion approximate each other (Davies. 1992:p25).

ECCENTRIC CONTRACTION

The development of tension that occurs as the origin and insertion move away from each (Davies. 1992:p25).

CHAPTER 1
INTRODUCTION

1.1 The Problem

Patellofemoral Pain Syndrome (PFPS) refers to a syndrome consisting of: anterior knee pain, inflammation, imbalance, instability or any combination thereof (Wood. 1998).

Patellofemoral pain syndrome (PFPS) is a term used to encompass a large number of conditions. These include runner's knee, chondromalacia patellae, extensor mechanism dysfunction and subluxing or dislocating patella (Herrington and Payton. 1997). The etiology of PFPS is poorly understood (Kannus et al. 1999). The many names used for the syndrome, as well as the variety of proposed etiological factors and different treatments, is an illustration of the complexity of the syndrome (Thomee et al. 1995).

PFPS is a common finding which affects a significant part of the population (Stakes. 2000). Meyer et al. (1990) mention that PFPS is particularly common in women, athletes and military recruits.

The patellofemoral joint must endure torquing and pivoting manoevures that produce forces exceeding the limits of supporting muscular structures. These large loads are placed over a small surface area, predisposing the joint to repetitive stress injury (Gotlin. 2000).

Numerous studies have been conducted attempting to determine the presence and the role of Quadriceps Femoris (QF) weakness in PFPS (Callaghan and Oldham. 1996). These studies have been unable to draw adequate consensus around the issue due to methodological issues related to measurement and hence outcomes (Callaghan and Oldham. 1996, Souza and Gross. 1991).

1.2 Isokinetic Dynamometry

The term isokinetic exercise refers to a process in which a body segment accelerates to achieve a pre-selected fixed speed with totally accommodating resistance through out the range of motion (Cybex. 1996:p1-9). Recent developments in Isokinetic Dynamometry have made it possible to isolate extensor muscle groups and determine the presence and extent of weakness (Davies. 1992: p362). Evidence suggests that this type of measurement is considered the most appropriate tool as a direct indicator of functional status. Consequently, the Quadriceps Femoris weakness theory can be rigorously evaluated (Callaghan et al. 2000, Wright. 2002).

1.3 The aim

The aim of the investigation was to evaluate:

1. Quadriceps torque at 60° per sec relative to patient's body weight
2. Average Power
3. Total work of the quadriceps

for both concentric and eccentric contractions, in subjects with patellofemoral pain syndrome.

The purpose of the study was to demonstrate and quantify any weakness in the quadriceps femoris muscle that was present in subjects with PFPS by comparison to normative ratios. Subsequent to beginning the study, review of literature suggested that hamstring weakness may also contribute to the problem of PFPS (Kobler. 1987). Any possible weakness of the hamstring was measured and quantified in a similar manner to that for the quadriceps.

The values from these parameters were then compared with normative values (see Chapter 3).

1.4 Potential benefits of the study

Previous electromyographic investigation has proven inconclusive as to the presence and extent of quadriceps femoris weakness in PFPS (Callaghan and Oldham. 1996). When tested using isokinetic dynamometry, subjects with PFPS have been shown to be weaker than their normal counterparts in terms of concentric peak torque values (Callaghan et al. 2000). Few researchers have reported on the relationship with eccentric contraction (Chan and Maffuli. 1996:p57). By more rigorous evaluation of the quadriceps femoris weakness theory using isokinetic dynamometry it is hoped that the significance of any weakness can be identified and quantified in order to determine the role the presence of any such weakness may play in this poorly understood syndrome.

By assessment of hamstring strength in this study, it is hoped to contribute to the limited body of knowledge relative to this muscle group in PFPS. It is hoped that this study will motivate further study with regard to the hamstring muscles in PFPS.

CHAPTER 2
LITERATURE REVIEW

2.1Patellofemoral Pain Syndrome: Introduction

2.1.1 Definition

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

Anterior knee pain, retropatella pain or PFPS are all medical terms for a complex clinical entity affecting the knee joint including many subgroups (Merchant. 1988). PFPS is now used in preference to the ambivalent term "Chondromalacia Patellae", which had in the past been used as a synonym for PFPS. PFPS refers to the clinical presentation of anterior knee pain related to changes in the patellofemoral joint (Tria, Palumbo and Alicea. 1992). PFPS is the diagnostic term most often chosen because it is descriptive, identifies the condition as a syndrome and does not presume more than is known about the problem (Meyer et al. 1990).

2.1.2 Incidence

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

Review of the National Collegiate Athletic Association Injury Surveillance System (USA) revealed that these types of injuries are significantly common in female athletes (Salem and Powers. 2001). Dehaven and Linter (1986) report the incidence of PFPS to be 19.6% among female collegiate athletes and 7.4% among males. In clinics dealing with musculoskeletal complaints, PFPS may account for almost 10% of visits and 20-40% of all knee complaints (Kannus et al. 1999). In a study of 196 consecutive injuries at a runner's clinic, Pinshaw et al. (1984) reported a 22% incidence of runner's knee.

Meyer et al. (1990) state that PFPS may make up as much as 25% of all running injuries for which medical attention is sought. Paluska and McKeag (1999) state that disorders of the Patellofemoral joint are common in recreational and competitive athletes. LaBrier and O'Neil (1993) state that PFPS is amongst the most common complaints of athletes. Athletes who participate in sports involving jumping and running activities are at the greatest risk for developing patellofemoral related injuries (Salem and Powers. 2001).

2.1.3 Natural history

In a 5.7 year follow up study of PFPS, Blond and Hansen (1998) reported on results of a group of subjects who had been instructed to perform Vastus Medialis muscle training. Subjects (mean age 21.1 years, 122 female, 128 male) were requested to complete and return a questionnaire. Of these 27% were pain free for an average of 8.1 months and 52% experienced a decrease in pain. However 35% remained unchanged and 13% experienced increased pain. Of all subjects 37% described the pain as mild, 48% as moderate and 15% as severe. Athletic activity was affected in 74% and employment was affected in 6%. In this study compliance was low in 2/3 of cases. Therefore the study approximates the natural course of PFPS in athletes fairly closely. The conclusion drawn by Blond and Hansen is that PFPS is not a self-limiting condition, which is in conflict with widespread opinion.

Kannus et al. (1999), in a 7 year follow up study, used bone densitometry, radiography and Magnetic Resonance Imaging (MRI) and found that PFPS did not lead to patellofemoral osteoarthritis or osteopenia. Mild abnormalities such as slight decease in patella cartilage thickness, slight increase in the signal density of the patella cartilage, indicating cartilagenous degeneration, or slight roughness of the patella surface were noted in 4% of subjects. Moderate abnormalities were noted in 2% and severe abnormalities in 3%. Only a slight reduction in bone mineral density of the affected knee was noted after 7 years. Few other long-term studies have been conducted in order to provide reliable evidence of any progression from PFPS to patellofemoral osteoarthritis or osteopenia.

Kannus et al. (1999) state that only a 10-20 year follow up study will provide a clear picture of the natural history of the disorder.

2.2 Anatomy and Biomechanics

The patella is a sesamoid bone contained and stabilized within the quadriceps tendon superiorly and the patella tendon inferiorly. The patella acts as a guide for the quadriceps mechanism, sliding in the sulcus between the femoral condyles, which hold it in place (Davidson. 1993). The patellofemoral articulation consists of the facets of the patella in contact with the sulcus of the femur. The patella surface can include up to 7 facets, with 3 each on the medial and lateral surfaces and on extra “odd’ facet on the medial side. The surface anatomy of each side, the overall rotational anatomy of the entire lower extremity and the relationship of the surrounding muscles affect the contact area between the two surfaces (Tria et al. 1992).

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

Laterally, the patella is stabilized by the lateral retinaculum, iliotibial tract and the vastus lateralis (VL). Medially, stability is provided by the vastus medialis obliquus (VMO) and the medial retinaculum (Bose et al. 1980). The knee has a valgus alignment, therefore tension in the quadriceps muscles tends to produce a lateral movement of the patella. This lateral movement is resisted by the VMO, the medial retinacular structures and the prominence of the lateral facet of the trochlea of the femur (Sakai et al. 2000). However during the last 30 degrees of knee extension the patella sits above the trochlear groove with little support offered by osseous structures (Bose et al. 1980).

The patellofemoral joint must endure torquing and pivoting manoevures that produce forces exceeding the limits of supporting muscular structures (Gotlin. 2000). Two forces act on the patella during knee movement. The first is a compression force between the patella and the femoral trochlea and the second is a tensile force exerted due to the pull of the quadriceps muscle (Outerbridge and Dunlop. 1975). The patellofemoral joint reaction force (PFJRF) is a measure of the compression of the patella against the femur and is dependant on the angle of knee flexion as well as on muscle tension. With increasing weight bearing load, the contact area of the patella against the trochlea broadens to accommodate the increase in PFJRF and to normalise the contact stress unit load (Hungerford and Lennox. 1983).

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

- The height of the femoral condyles and hence the depth of the sulcus which keeps the patella ‘seated’ and tracking properly.
- The shape of the facets on the undersurface of the patella which helps determine the ‘fit’ between the patella and the femoral groove.
- The medial and lateral retinacula keep the patella centered between the femoral condyles during movement.
- The composite angle of the pull of the quadriceps group referred to as the Q angle.
- Relative strength of individual muscles composing the quadriceps group.

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

Abnormal patella shape and size (eg. Wiberg type 1-3, Baugmaurti, Patella parva, pebble, half-moon and patella magna) led investigators to believe that abnormal facet anatomy caused incomplete contact between the patella and the trochlea which resulted in patellofemoral pain (Tria et al. 1992)

A high riding patella (patella alta) predisposes to malalignment because the patella is late in engaging the femoral trochlea during knee flexion (Singerman, Davy and Goldberg. 1994).

Sakai et al. (2000) state that variations in the attachment of the vastus lateralis muscle or iliotibial tract and imbalances of retinacular tension may play a role in the abnormal biomechanics of the development of PFPS. The iliotibial band is often tight in subjects with PFPS and has strong attachments to the lateral patella through the lateral retinaculum (Post. 1998). According to Blond and Hansen (1998) a tight lateral retinaculum is more likely to be associated with a positive movie goer's sign. The "movie goer's sign" is the phenomenon of peri- or retropatellar pain after being seated for a prolonged period (Reid. 1992:p349).

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

2.2.1 Sources of pain

When retropatella pain is experienced at the patellofemoral articulation the most likely explanation is that it originates from the richly innervated subchondral bone of the patella (Davidson. 1993).

In cases of peripatella (extra-articular) pain, strain on a laterally contracted retinaculum can produce inflammation and pain. Occasionally neuromatous degeneration analogous to the development of an interdigital (Morton's) neuroma in the foot can occur within the contracted retinaculum. In such cases of extra-articular pain, palpatory examination will reveal a consistently painful area involving the retinaculum, which is relieved on injection of a small amount of local anaesthetic (Davidson. 1993).

2.3 Pathophysiology and Etiology

2.3.1 Pathophysiology

The pathophysiology of PFPS is poorly undertood (Kannus et al. 1999) and is unclear. Although it has been related to malalignment of the patella and the femoral trochlea, which is thought to be the cause of the characteristic anterior knee symptoms (Cherf and Paulos, 1990). This is supported by Fulkerson and Hungerford (1990) who state that subjects with PFPS may have problems with the patella entering the trochlea of the femur, especially during the first 30 degrees of knee flexion.

2.3.2 Etiology

2.3.2.1 Miscellaneous Predisposing Factors

The etiology of PFPS is a poorly understood (Kannus et al. 1999) and an unsolved problem, but several biomechanical factors appear very likely. Predisposing factors include: tightness of the lateral retinaculum, Quadriceps insufficiency, increased Q angle, increased femoral anteversion, external rotation of the tibia, hyperpronation of the foot, patella dysplasia and patella rotation. However, according to Kannus et al. (1999), the most important predisposing factor appears to be peripatella tenderness. A history of trauma may also predispose to the problem (Blond and Hansen. 1998) (Singerman, Davy and Goldberg. 1994). Callaghan and Oldham (1996) suggest that certain gait abnormalities may also contribute to the etiology.

In addition to the aforementioned factors, genetic predisposition, excessive weight, prolonged synovitis, recurrent haemorrhage into the joint or repetitive intra-articular injection of corticosteriods may play a role (Kannus et al. 1999). Salem and Powers (2001) propose that anthropometric predispostion, pre- and mid-season fitness levels, sport specific training experience, hormonal fluctuations and resistance-training techniques may also play a role in causing PFPS. This study was concerned specifically with PFPS in females and hence addresses issues that are specific to this population.

According to Sakai et al. (2000) several anatomical factors may contribute to patella instability or maltracking. These include: dyspalsia in the femoral condyle groove, malposition of the tibial tubercle, high position of the patella relative to the joint line (patella alta), weakness of the vastus medialis obliquus muscle, variations in the attachment of the vastus lateralis muscle or iliotibial tract and imbalances of retinacular tension. Walsh (1994:p1163) believes that nearly all patellofemoral disorders relate to anatomic predispostion. He emphasises the importance of both the alignment of the patellofemoral joint and that of the entire lower limb. Whilst in some individuals malalignment may remain asymptomatic, it is usually a scenario of overuse or acute trauma that precipitates symptoms.

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

Singerman, Davy and Goldberg (1994) state that a high riding patella (patella alta) predisposes to malalignment of the extensor mechanism. This is because the patella is late in engaging the femoral trochlea during knee flexion.

Several researchers have reported that 3rd lumbar sclerotomal dysfunction may be a cause of PFPS (Chadwick.1987, Reid.1992;351, Dryburgh. 1998, Gelfound and DeVore. 1995, Wood. 1998).

2.3.2.2 Quadriceps Femoris Weakness

A commonly cited cause of PFPS is that of selective dysfunction or insufficiency of certain components of the quadricep (LaBrier and O'Neil. 1993). Although other anatomical factors obviously play a role in causing malalignment (Sakai et al. 2000) the cause of his proposed malalignment in the subjects who have normal anatomical structure remains controversial and centres around the presence and extent of Quadriceps Femoris weakness (Powers, Landel and Perry. 1996).

There has been much debate over the role of the quadriceps group in the etiology and treatment of PFPS. This has led to many misunderstandings in clinical practice. However there can be little doubt of the importance of normal quadriceps activity to the functional integrity of the knee joint (Powers, Landel and Perry. 1996). Weakness of the vastus medialis obliquus is thought to be a particularly important factor in the development of subluxation or partial dislocation of the patella (Sakai et al. 2000). According to Gotlin (2000) the VMO plays a crucial role in cushioning the forces directed to the anterior knee. The stronger the VMO the less stress is transferred to the patellofemoral joint.

Callaghan and Oldham (1996) state that numerous studies have been conducted failing in their attempt to determine the presence, extent and role of Quadriceps Femoris weakness in PFPS. Unfortunately there remains no reliable way of testing the balance between the VMO and VL.

Electromyography (EMG) could be considered to be semi-quantitative and there are thousands of studies examining the EMG ratio between VL and VMO (http//www.isokinetics.net).

Voight and Wieder (1991) measured reflex response time of the VMO and VL muscles for three sets of exercises. Subjects with PFPS demonstrated a significantly faster VL reflex response time than in normal subjects, while the VMO response time remained unchanged. These findings suggest a motor control problem in these subjects and that there may as yet be unidentified factors of muscle imbalance between the VMO and VL in PFPS. However in commenting on this study Powers, Landel and Perry (1996) argue that Voight and Wieder fail to comment on the magnitude of timing differences and lack evidence indicating that this phenomenon would be present during a voluntary contraction.

Gilleard, McConnell and Parson (1998) investigated the VMO versus VL ratio and its role in the symptoms associated with PFPS (n=14 females). They asked subjects to perform step up, step down tasks and used taping aimed at pulling the patella medially. They found that although taping altered timing, no timing delay of VMO relative to VL was demonstrated in subjects with PFPS relative to normal subjects ($p>0.05$). However the sample size in this study was small and limited to females only. Whether these findings are applicable to the general PFPS population must be questioned.

On comparing the VMO: VL ratio using electromyography (EMG), Souza and Gross (1991) found that the ratio in subjects with PFPS was significantly less than in normal subjects. Boucher et al. (1992) compared the same EMG ratios and described that in advanced PFPS the VMO was less active than the VL at 15 degrees of of knee flexion compared to at 90 degrees.

Powers, Landel and Perry (1996) used EMG and motion analysis to investigate the differences in intensity and timing of muscle activity in the quadriceps during voluntary contraction in PFPS (n=26) and healthy subjects (n=19). The study was controlled and unblinded. No differences in onset or cessation of activity was found for the vastus muscles regardless of the condition. Subjects with PFPS demonstrated less activity of all vastus muscles for level walking and ramp walking when compared to healthy subjects. This indicates subjects' anticipation of decreased muscular demand during loading due to a Quadriceps Femoris avoidance gait pattern similar to that seen in subjects with Anterior Cruciate Ligament injury. They propose this could have arisen due to a decreased external knee flexion moment or out of a conscious effort to walk slower. Perry (1992) states that subjects with weak quadriceps femoris muscles or painful knees avoid loading-response knee flexion as it is the point in the gait cycle where muscular demand and knee joint reaction forces are greatest. Powers, Landel and Perry (1996) even go to the point of stating that timing differences do not exist in subjects with PFPS and do not play a role in contributing to this disorder. Karst and Willet (1995) support this view.

Suter et al. (1998), in a study of subjects with unilateral PFPS, demonstrated that muscle inhibition was closely associated with anterior knee pain. The study concluded that there was substantial inhibition in the uninvolved leg as well as the involved leg. Hurley, Jones and Newman (1994) agree with this finding of bilateral inhibition and postulate that this was the result of abnormal afferent impulses from articular mechanoreceptors, which are perceived by the central nervous system as being bilateral. As a result excitability of spinal neurons controlling quadriceps activity is decreased bilaterally. Therefore the opposite leg may not be used as a control when assessing muscle inhibition.

Smith et al. (1995) failed to reveal differences in the onset of activity in different components of the quadriceps under a variety of conditions. Souza and Gross (1991) used electromyography and normalized data to identify differences in

VMO: VL ratio between normal subjects and those with PFPS. In this study no differences in ratio were observed. Kowall et al. (1996) used EMG and isokinetic dynamometry in a controlled trial and found no significant imbalance when comparing symptomatic and asymptomatic knees.

Comparison between previous studies has been difficult due to flaws in methodology. This has prevented clinical confirmation of some scientifically unproven theories or anatomical evidence concerning the efficacy of certain exercises in subjects with PFPS. This has caused delay in the formation of consensus concerning the appropriate rehabilitation of PFPS. Examples of methodological flaws likely to cause inconsistencies include: misinterpretation of data due to the recording of electrical activity from adjacent muscles, failure to account for the limitations of the recording apparatus (Callaghan and Oldham. 1996). Souza and Gross (1991) criticize many studies for failing to make use of normalized data. In such cases results should be viewed with scepticism.

In an in vitro study, where VMO weakness was simulated, Sakai et al. (2000) found that the magnitude of VMO weakness did not affect lateral patella shift caused by VMO weakness (p>0.05). This confounds the theory proposed by Gilleard, McConnel and Parson (1998) that VMO weakness caused the shift, leading to characteristic anterior knee pain associated with PFPS. However Sakai et al. (2000) did find that weakening of the VMO did cause a lateral patella shift at 0 and 90 degrees. Whether this method of investigation can be applied to actual function is a point of considerable debate.

The effect of long term weakening of the VMO on the integrity of the static stabilizers, such as the patellofemoral ligaments, is unclear (Sakai et al. 2000). The role of the VMO and VL may be secondary to that of passive structures in the pathology of PFPS (Herrington and Payton. 1997). The potential for gradual elongation and a loss of support exists in these structures (Sakai et al. 2000). However Herrington and Payton (1997) discuss the possibility that tightened passive structures may need to be lengthened in order to bring about recovery. A combination of both dynamic muscular stabilisers as well as static stabilisers, are probably essential to ensure proper long term patella alignment and correct patella motion patterns (Sakai et al. 2000).

Furthermore, Schaub and Warrell (1995) and Cerny (1995) state that VMO dominance may be a personal trait with inter-individual variance and that further studies are needed to investigate the presence of weakness in PFPS. Gilleard, McConnell and Parson (1998) propose that earlier activation of the VMO may alter movement of the patella, but that further research is needed to determine whether this is beneficial in PFPS.

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

Resolution of this issue is important with regard to rehabilitation of subjects suffering from PFPS when comparing isolated versus multiple muscle group strengthening. While both types of strengthening improve strength they provide differences with regard to functional performance, indicating the need to accurately determine the role and extent of quadriceps femoris weakness in PFPS (Gotlin, 2000).

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

Testing for patellofemoral joint dysfunction was influenced in the early years by the likes of Elton et al. (1985) as they carried out tests which revealed no significant differences in either concentric or eccentric strength. Unfortunately both studies involved the use of high angular velocities (180 and 200 degrees per second respectively). At high speed the joint is exposed for a much shorter time to the force which in turn creates a lower load on the joint and hence reduces potential inhibition. At high speeds it could also be argued that the reflex arc may be too fast for quadriceps inhibition to take effect at such high speeds (http//www.isokinetics.net).

Tests performed at the lower velocities revealed a different conclusion. Hoke et al. (1983) used a test velocity of 30 degrees/second and showed that quadriceps strength and curves were significantly different when compared to the uninvolved side. Nordgren et al. (1983) also performed tests at even lower velocities (6, 12 and 60 degrees/second). They found that both men and women demonstrated high reductions in quadriceps strength (22% in men and 34% in women). These findings were further confirmed by Dvir et al. (1990) who found strength reductions of 27% in men and 35% in women concentrically and 44% in women and 41% in men eccentrically.

Callaghan et al. (2000), while conducting a reliability study, demonstrated that PFPS subjects (n= 16) were significantly weaker than healthy counterparts (n= 20), at a test velocity 90 degrees per second, when examining peak torque values for concentric knee extension (level of significance set at 5%). However when drawing conclusions from this study it should be noted that the sample in both groups was rather small and that larger scale investigation is needed to confirm this finding. In this study a Biodex system 2 dynamometer with a multiple joint attachment was used. Kowall et al. (1996) found a statistically significant decrease in peak torque at 60 degrees per second when testing concentric strength in subjects with PFPS.

Dvir et al. (1990) conducted a controlled trial comparing concentric and eccentric quadriceps strength in "normal" subjects (n= 30) to those with PFPS (n= 55).

They showed a significant 30-40% reduction in the experimental group that was neither mode nor speed-specific.

Bennett and Strauber (1986) suggest that a loss of eccentric quadriceps torque may be specific to subjects with PFPS. Eccentric rather than concentric exercise may be better at selectively activating the VMO dependant on angular velocity (Callaghan and Oldham. 1996). Isokinetic eccentric exercise programs have been evaluated by few investigators (Chan and Maffuli. 1996:p57). Eccentric actions are an integral part of athletic and daily activities. Activities such as running downhill and lowering objects involve eccentric actions (Chan and Maffuli. 1996:p56).

Wright (2002) and Jackson (2002) agree that Isokinetic testing is more effective than EMG when evaluating the presence and extent of muscle weakness. The reason for this is that when using surface EMG to measure muscle activity, it is only possible to measure the potential of the most superficial fibers of superficial muscles. Therefore Isokinetic measurement is currently considered the most appropriate tool as a direct indicator of functional status.

The much debated role of the VMO, techniques to enhance its contraction, and its relationship to the VL, deserve further study (Callaghan and Oldham. 1996).

With so many postulated etiologies, it therefore is obvious that no single etiology has yet been definitively proven and validation awaits further research (Rowlands. 1999).

2.4 Presentation and Assessment

2.4.1 Disability

PFPS affects daily living only to a minor degree. When considering the influence of PFPS on sporting activities, many patients are more severely troubled. In some athletes the level of pain is related to the level of physical activity (Blond and Hansen. 1998).

Kannus et al. (1999) found that 24% of patients reported having had symptoms in the contralateral knee at a 7 year follow up confirming the concept that some subjects have a bilateral problem. These symptoms were reported as being qualitatively similar but less severe than in the initially affected knee and as having arisen 4 years to 3 months before the 7 year follow up evaluation.

2.4.2 Symptoms

Symptoms of PFPS include retropatellar pain (Kannus et al. 1999) on: squatting, stair climbing, kneeling, prolonged sitting (movie goer's sign) or isometric quadriceps femoris muscle contraction (Powers, Landel and Perry. 1996). Complaints of crepitus, effusions, intermittent catching during knee extension, a sense of insecurity or giving way (Blond and Hansen. 1998), patella pseudolocking and knee stiffness may occur (Kannus et al. 1999). In many subjects there appears to be no reason for symptoms (Kannus et al. 1999).

Subjects may also present with peripatella pain, mainly of insidious onset. This is also brought on by similar activities such as prolonged sitting, ascending and descending stairs or any athletic activity (Callaghan and Oldham. 1996).

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

2.4.3 Clinical Features

Patients usually present with retro- or peripatella knee pain. The pain is usually of a dull, aching nature, becoming sharp during activities that increase pressure over the patella (eg. Ascending or descending stairs, squatting, deep knee bends). Subjects may also complain of pain after prolonged sitting (movie goer's sign). Crepitus is common in young patients (Davidson. 1993).

Tria et al. (1992) distinguishes five groups in which PFPS occurs:

1. A non-specific anterior knee discomfort in a teenage girl is a common finding.
2. Patella instability with patella subluxations or dislocations occurs.
3. Direct trauma to the anterior knee.
4. Athletic overactivity.
5. Arthritis of the patellofemoral joint.

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

1. Tenderness of the medial and lateral facets on palpation.
2. Compression of the patella onto the femoral condyles may cause discomfort.
3. Where both sides of the patella are grasped while the patient contracts the quadriceps muscles, the pressure of the patella against the femoral condyles may cause discomfort.

In cases of extra-articular pain, palpatory examination will reveal a consistently painful area involving the retinaculum, which is relieved on injection of a small amount of local anaesthetic (Davidson. 1993).

A tightened lateral retinaculum will restrict medial glide of the patella. According to Blond and Hansen (1998) a tight lateral retinaculum is more likely to be associated with a positive movie goer's sign.

Examination should include screening for the following: Quadriceps insufficiency, increased Q angle, increased femoral anteversion, external rotation of the tibia, hyperpronation of the foot, patella dysplasia, patella rotation. (Blond and Hansen. 1998), restricted medial glide of the patella due to tightness of the lateral retinaculum and iliotibial band tightness (Herrington and Payton. 1997). However the most important feature appears to be peripatella tenderness (Blond and Hansen. 1998).

Increased Q angle has long been considered a cause of PFPS. An angle greater than 10 degrees in males and 15 degrees in females is considered abnormal and may be present due to external tibial torsion (Papagelopolous and Sim. 1997). However one must not place too much emphasis on the Q angle as it is only one of the many factors in PFPS and provides no direct correlation with PFPS (Wood. 1998).

The iliotibial band is often tight in subjects with PFPS, especially in those whose patella tilt does not tilt to neutral, and has strong attachments to the lateral patella through the lateral retinaculum (Post. 1998).

Assessment of hamstring flexibility is important in PFPS as hamstring tightness may contribute to the development of PFPS (Davidson. 1993). Reid (1992:p362) quotes a study by Kobler (1987), stating that absolute, or relative deficiency of the hamstring muscles can be seen in more than 80% of subjects with anterior knee pain when tested on an isokinetic dynamometer at 60 degrees per second, and more than 70% when tested at 240 degrees per second. Hamstring tightness was also seen in 20% of subjects.

In step up and step down tasks, subjects with PFPS often lack muscular control, which in turn may produce pain in subjects with PFPS (Walsh. 1994:p1171).

Kannus et al. (1999), in a 7 year follow up study, investigated for the presence abnormalities such as slight decease in patella cartilage thickness, slight increase in the signal density of the patella cartilage or slight roughness of the patella surface. Mild abnormalities were noted in 4% of subjects. Moderate abnormalities were noted in 2% and severe abnormalities in 3%. Although only present in a small number of patients these factors are nonetheless significant.

2.4.4 Physical Testing

The following orthopedic tests are indicative of factors associated with PFPS and were used in this study to determine the presence of such factors.

a) PERIPATELLA TENDERNESS: With the examiner pushing downwards on the lateral aspect of the patella the medial retinaclum can be brought under tension and then palpated for tenderness. The lateral retinaculum can be palpated in similar fashion with the examiner pushing down on the medial aspect of the patella. Pressing down on the patella is neccesary to separate the retinaculum from the underlying tissue (Magee. 1996:p578).

b) FACET TENDERNESS: Palpation of the medial and lateral facets may produce pain (Davidson. 1993).

c) THE WALDRON TEST: The examiner palpates the patella while the patient performs several deep knee bends. As the patient goes through the range of motion the examiner should note the amount of crepitus (which is significant only if accompanied by pain), where it occurs in the range of motion, the degree of pain and whether there is “catching” or poor tracking of the patella. This test indicates the presence of PFPS (Magee. 1996:p566).

d) CLARKE’S SIGN: The supine patient is instructed to relax the quadricep with the knee extended. The examiner places the web of the hand against the superior pole of the patella and depresses it distally. The patient then contracts the quadriceps as the examiner compresses the patella against the condyles of the distal femur. The sign is considered positive if the patient cannot maintain contraction without producing a sharp pain (Schafer and Faye. 1990). This test must be performed bilaterally, repeatedly and gradually with increasing pressure each time. The involved side should be more painful than the uninvolved side and indicates a number of patellofemoral conditions including PFPS (Reid. 1992:p342). However clinical experience has indicated that this test is often painful in asymptomatic patients.

e) PATELLA MOBILITY: The patella is divided longitudinally into 4 quadrants. The examiner attempts to displace the patella medially and laterally using the thumb and index finger. A lateral glide of 3 quadrants indicates an incompetent medial restraint, while a glide of 4 quadrants signifies a deficient medial restraint. A medial glide of 1 quadrant indicates a tight lateral restraint while a medial glide of 3-4 quadrants suggests a hypermobile patella (Kolowich et al. 1990).

f) TIBIAL TORSION: The patient is seated with the knees over the edge of the table. The examiner then places the thumb of one hand over the apex of one malleolus and the index finger over the apex of the other malleolus. The examiner then visualizes the axes of the knee and ankle. The axes should make an angle of 12°-18° owing to the external rotation of the tibia. An angle of greater than18° indicates an externally rotated tibia while an angle less than 12° indicates an internal rotation (Magee. 1996:p633).

g) PATELLA AND TIBIAL ROTATION: The patient lies supine with the limbs extended as the examiner looks at the patellae. If the patellae face in (squinting patellae), it is a possible indication of medial rotation of the femur or the tibia. If the patellae face up, out and away from each other (frog or grasshopper eyes), it is a possible indication of lateral rotation of the femur or the tibia. If the tibia is affected the feet face in (pigeon toes) for medial rotation and face out more than 10 degrees for lateral rotation. The feet are normally 5-10 degrees laterally rotated (Fick angle) (Magee. 1996:p476).

h) CRAIG'S TEST: This test measures for femoral anteversion and retroversion. The patient lies prone with the knee flexed to 90°. The examiner palpates the greater trochanter of the femur while rotating the hip internally and externally until the trochanter is parallel with the examining table. The degree of ante- or retroversion can then be estimated based on the angle of the lower leg to the vertical axis. In the adult the mean angle is 8°-15°. Anteversion is indicated by an angle greater than 15° and will lead to squinting patellae and toeing-in. Retroversion is indicated by an angle less than 8° or a negative angle and causes frog eyed patellae and toeing-out. This is also known as the Ryder method (Magee. 1996:p475).

i) LEG-HEEL ALIGNMENT: The patient lies prone with the feet hanging over the end of the examining table. The examiner marks the midline of the calcaneous at the insertion of the achilles tendon and at a point one centimeter distal to the 1st point as close to the midline of the calcaneous as possible. A calcaneal line is then made between the 2 points. A tibial line is then made by joining 2 points on the distal third of the leg in the midline. This line represents the longitudinal axis of the tibia. With the subtalar joint in neutral the examiner inspects the 2 lines. If the 2 lines are parallel or in slight varus (2°-8°), the leg-heel alignment is considered normal. An inverted heel indicates hindfoot varus and an everted heel indicates hindfoot valgus (Magee. 1996:p632).

j) FOREFOOT-HEEL ALIGNMENT: The patient lies supine with the feet over the edge of the examining table. The examiner places the subtalar joint in the neutral position and pronates the midtarsal joints maximally. The relationship between the vertical axis of the heel and the plane of the 2nd through 4th metatarsal heads. Normally the plane is perpendicular to the vertical axis. If the medial side of the foot is raised, the patient has a forefoot varus; while if the lateral aspect is raised, the patient has a forefoot valgus (Magee. 1996:p633).

k) FEISS LINE: The examiner marks the apex of the medial malleolus and the plantar aspect of the 1st metatarsal while the patient is not bearing weight. The navicular tuberosity is then palpated, and its position is noted relative to a line joining the previous 2 points. The patient is then instructed to bear weight (ie. stand up). The marks on the 1st metatarsal and medial malleolus must be checked to see that they still correspond with the appropriate bony landmarks. The navicular tuberosity is then again palpated. The navicular tuberosity normally lies on or very close to the line joining the 2 points. If the tuberosity falls one third of the distance to the floor, it represents a first degree flatfoot. A fall of two thirds, indicates a second degree flatfoot and if the navicular lies on the floor this represents a third degree flatfoot (Magee. 1996:p636).

2.4.5 Radiographic examination

Yochum and Rowe (1996:p181) state that the use of "skyline" projections and the combined use of measurements derived are important in evaluating contributing causes of patellofemoral pain syndromes. The use of lateral projections is valuable in assessing patella alta or patella baja as well as in assessing patella and patella tendon lengths.

In assessing patella tendon length relative to patella length, a lateral radiograph is taken. The greatest diagonal dimension from the superior pole to the inferior pole of the patella (patella length) is compared to the distance between the insertion points of the posterior surface at the inferior pole of the patella and the notch at the tibial tubercle (tendon length). The 2 lengths are usually equal or within 20% variation of each other. When the patella tendon is more than 20% longer, patella alta is present. Patella baja is present if the patella tendon is more than 20% shorter than the patella (Yochum and Rowe. 1996:p181).

2.5 Diagnosis

Diagnosis is currently based on the presence of localized peri- or retropatellar pain originating from the peripatella tissue or the patellofemoral joint (Davidson, 1993). Pain must be reproducible with at least two of the following: squatting, stair climbing, kneeling, prolonged sitting or isometric quadriceps femoris muscle contraction (Powers, Landel, Perry. 1996). In addition the examiner must provoke patella tenderness that is recognized as the same as that from which the subject complained of (Blond and Hansen. 1998). However, the crux of diagnosis relies mainly on history and characteristic symptoms (Blond and Hansen. 1998).

2.5.1 Differential Diagnosis

A differential diagnosis must include both Chondromalacia patellae and patella subluxation due to their similar presentation (Davidson. 1993). In Chondromalacia patellae, there is morphological change or damage to the cartilage on the cartilage on the posterior aspect of the patella. This may often present in a similar manner to PFPS. However there is no correlation between these morphological changes and symptomology. Many subjects with such degeneration are asymptomatic, while others with symptomatic knees have normal patella articular surfaces. Thus the use of the term chondromalacia patellae for patella pain syndrome in young people should be discontinued (Insal. 1979).

Anterior knee pain may be of referred origin, particularly in children and adolescents (eg. Perthes disease or slipped capital femoral epiphysis). In all age groups lumbar radiculopathy or peripheral nerve root entrapment may cause referred pain to the knee (Post. 1998). Inman and Saunders (1944) were the first to outline referred pain from skeletal structures, showing that L 2, 3, and 4 refer pain to the knee.

2.6 Management

PFPS has been shown to be unresponsive to treatment after long term patient review (Almekinders and Almekinders. 1994). There is also no consensus regarding the management of the subject who has chronic PFPS (Kannus et al. 1999).

2.6.1 Conservative Treatment

Meyer et al. (1990) recommend that a trial of conservative treatment be applied before surgery is considered in the management of PFPS. Davidson (1993) agrees stating that surgery should not be considered until conservative treatment has evoked no improvement after 3-6 months.

2.6.1.1 Activity Modification

Activity modification is important in the treatment of PFPS since virtually every patient presents with overuse. A change in activity from one that aggravates the problem to one that causes less pressure over the femoral trochlea should bring about a decrease in symptoms and allow the patient to continue exercising (Davidson. 1993).

2.6.1.2 Therapeutic Exercise

a) EXERCISES

Exercise is the most commonly chosen and is the first line method of conservative treatment, with rehabilitation focussing on the quadriceps femoris group (Callaghan and Oldham. 1996). However the best approach to strengthening invites considerable debate (Gotlin. 2000).

It is essential to train multiple muscle groups to ensure maximum muscle efficiency. Functional or skill training focuses not only on muscle strengthening but also on improving the co-ordination between nerve impulse firing and subsequent contraction of agonist and antagonist muscles. It has been reported that more than 80% of patients with anterior knee pain responded successfully to skill training and were able to return to sporting activities with no pain (Gotlin. 2000). However this study was uncontrolled and did not report on any follow-up findings.

Davidson (1993) claims that a rehabilitation program consisting of Quad setting, straight leg raises and terminal arc extensions seem to improve tracking and help prevent excessive pressure on the lateral facet.

Post (1998), in discussing possible options in rehabilitative exercise, states that co-contractions and weight bearing loads associated with closed-chain kinetic activities are generally tolerated better than open-chain exercise in most patents with patellofemoral disorders. However biomechanical arguments can be made in favour of open-chain exercise at different points in the range of motion. Often a trial and error approach works best in determining which exercises are best tolerated by individual patients.

Minimal research is available documenting the amount of muscle activity involved in closed kinetic chain exercises for rehabilitation of PFPS (Callaghan and Oldham. 1996).

According to Kannus et al. (1999) the outcome for patients who had been treated non-operatively for PFPS was usually good at a 7 year follow up with 2/3 patients having had full recovery. However the remaining 1/3 of subjects still had symptoms or objective signs of PFPS. At the 7-year follow up, fewer subjects were asymptomatic on patellar compression and apprehension tests and had no patella crepitation on patella compression than at 6 months. However good subjective and functional results were maintained over time. Treatment included glycosaminoglycan injection combined with quadriceps exercise, placebo injection and exercise or exercise alone. No significant difference in outcome was noted between treatment groups.

In review Callaghan and Oldham (1996) quote many authors stating that the straight leg raise exercise is not effective for rehabilitation of PFPS. Powers, Landel and Perry (1996) question the use of biofeedback and muscle re-education techniques used in rehabilitation of PFPS.

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

Exercise can still play a major role in the treatment of PFPS. However the exercise regimes currently used in most rehabilitation settings, should be modified and be more specific in light of recent advances in light of previous and recent studies (Callaghan and Oldham. 1996).

b) STRETCHING

The stretching of the hamstrings and adductors to facilitate quadriceps activity is recommended. The piriformis should be stretched because of its importance in eccentric hip control during gait and the iliotibial band because of its attachment to the lateral retinaculum (Scaringe. 1994).

2.6.1.3 Cryotherapy

Cryotherapy can be beneficial through its effects on both pain and inflammation. Use of ice packs or ice massage is recommended over the affected area for 15-20 minutes up to 6 times daily initially, and later only after exercise is prescribed (Davidson.1993).

2.6.1.4 External Support

a) TAPING AND BRACING

It has been proposed that taping used to effect earlier activation of the VMO may alter movement of the patella. This is done in a manner to effect a medial pull on the patella. However further research is needed to determine whether this is beneficial in PFPS (Gilleard, McConnel and Parson. 1998) and by what mechanisms the reduction in pain occurs (Callaghan. 1997).

In an uncontrolled study, including taping as well as other methods of treatment, McConnell (1986) claimed that 83% of her patients had complete cessation of pain, 8.3% had reduced pain and 3% had no change in pain after 8 treatments. She claimed that this was achieved through enhancement of VMO contraction as a result of the taping. This study was however uncontrolled and included many variables which may have affected outcomes.

Herrington and Payton (1997), in a controlled study of 20 subjects, investigated the effects of taping and showed that taping brought about a significant reduction in pain, however concluded that taping did not facilitate the VMO in the control group or the PFPS group. They state that evidence in support of the hypothesis that taping facilitates VMO contraction is largely based on non-experimental and uncontrolled clinical observations. Many questions remain as to how it achieves its indubitable success with regard to reduction of pain.

Three main areas are suggested as possible reasons for the reduction in pain brought about by this type of taping: repositioning of the patella in the trochlear groove, the effect on the afferent nervous system, the placebo effect of the tape (Herrington and Payton. 1997). Bockrath et al. (1993) discusses that theoretically, the tape may provide neural inhibition via large fiber input to the anterior knee. Because large fiber input signals are transmitted faster than pain signals, the large fiber input may override pain signals.

Chef and Paulos (1990) state that correct patella tracking can be achieved by using knee bracing or strapping to apply a medially directed force.

Gotlin (2000) comments on taping, stating that bracing the patellofemoral joint often helps to reduce pain and may help subjects progress more easily during rehabilitative exercise therapy.

In contrast to the results of these studies, a controlled trial by Kowall et al. (1996) found that the effect of adding taping to a standard conservative treatment program for PFPS had no beneficial effect. However they recommend longer term prospective studies to determine whether this is in fact so.

Tria at al. (1992) describes three types of braces meant to bring about a medial pull on the patella: the Levine strap (beneath the patella), Palumbo cut-out braces and newer techniques of taping the knee. The sleeve itself may also serve to compress the tissues and limit excessive patella movement (Paluska and McKeag. 1999). Many claims have been made regarding the efficacy of patellofemoral braces, however such claims have not been supported by scientific investigation and analysis (Greenwald et al. 1996).

b) ORTHOTICS

The routine use of orthoses in patients with flexible hindfoot pronation remains controversial. Because of the cost of such devices and this controversy, routine prescription should be avoided initially. Use of orthoses is reasonably reserved for patients who have not responded to flexibility and strengthening routines (Post. 1998).

2.6.1.5 Medication

a) NON-STEROIDAL ANTI-INFLAMMATORY DRUGS

Non-steroidal anti-inflammatory drugs (NSAIDS) are usually effective in the acute phase of treatment. However NSAIDS should be discouraged in prolonged treatment because of the potential for undesired reactions (Davidson. 1993).

All NSAIDS cause gastric irritation and can exacerbate peptic ulcers. Other complications include decreased renal blood flow, hypersensitivity, adverse cutaneous reactions and haematologic disorders (Tria et al. 1992).

Short-term use before and after activity may be beneficial once acute symptoms have subsided (Davidson. 1993). Suter et al. (1998), in a randomized controlled trial, showed that one-week of NSAID therapy did not affect muscle inhibition despite a reduction in pain. DeLee and Drez (1994:p1194) state that the use of NSAIDs is not nearly of the same importance as rehabilitative exercise.

b) STEROIDS

Steroid therapy does not have a role in the conservative therapy of PFPS Tria et al. 1992). Injection of steroids is generally discouraged because of the resultant articular cartilage degeneration and the physical damage to the tendon resulting in a high risk for subsequent tendon ruptures Shelton (1992).

2.6.1.6 Manual Therapy

a) PATELLA MOBILIZATION

In a randomized, placebo controlled study, patella mobilization has been reported to have a beneficial effect and should be included in a treatment protocol for PFPS ($p<0.05$) (Rowlands and Brantingham. 1999). McConnell (1986) describes the patellofemoral joint as being mainly a soft tissue joint implying that its position can be altered by appropriate mechanical means. One of the postulated benefits of mobilization is that of the stretching of a tightened retinaculum (Rowlands and Brantingham. 1999).

b) SPINAL MANIPULATION

Suter et al. (1998), in a randomized controlled trial, reported that Sacroiliac joint manipulation brought about a significant decrease in muscle inhibition. In a review of literature Scaringe (1994) prescribes the use of manipulation between the third lumbar and first sacral levels.

Scaringe (1994) advocates the use of manipulation of the Mortise joint in the treatment of PFPS. The improvement of lower limb biomechanics is said to be the result of this technique through the resultant decrease in pronation and internal tibial rotation.

2.6.2 Surgery

Numerous authors warn of the dangers of complications with patellofemoral surgery (Scaringe 1994, Davidson 1993, Shelton 1992).

Five surgical categories exist for malalignment:

i. Release of tightened lateral retinaculum.
ii. Proximal realignment of the extensor mechanism.
iii. Distal realignment of the extensor mechanism.
iv. Combined proximal and distal realignment of the extensor mechanism.
v. Patellectomy combined with realignment of the extensor mechanism.

Biedert et al. (1992) discusses that the high rate of failure for surgery in this condition may be due to the disruption of the proprioceptive and other neurological links between the patella and its guiding and controlling structures.

Every effort should be made to avoid surgery in a syndrome in which the cause of pain is so poorly understood (DeLee and Drez. 1994:p1193, Walsh. 1994:p1193).

2.7 Prognosis

Kannus and Niittymaki (1994) found age to be the only predictive parameter for the outcome of conservative treatment. Blond and Hansen (1998) as well as Doucette and Goble (1992) found no such predictive parameters. Kannus et al. (1999), in a 7 year follow up study, found the overall outcome to be satisfactory in 2/3 of subjects. However the remaining subjects still had symptoms or objective signs of PFPS.

Blond and Hansen (1998), in a 5.7 year follow up study, found that athletes with hypermobility of the patella had the least promising prognosis. While the prognosis was good in half the athletes, the other half showed inadequate results. If there is no improvement with self-training after 3-6 months, a more active approach is appropriate (particularly in the group characterized by moderate periodic or more frequent pain). The prognosis for males is more than twice as good as that of females with respect to becoming pain free (Blond and Hansen. 1998).

2.8 Isokinetic Dynamometry

2.8.1 Isokinetic Exercise

The term isokinetic exercise refers to a process in which a body segment accelerates to achieve a pre-selected fixed speed with totally accommodating resistance through out the range of motion. The subject can never exceed the speed no matter how much effort he exerts. The amount of force exerted by the subject is always matched by that of the machine. As a result, isokinetics has the capability to load a muscle maximally throughout the entire range of motion. Two types of isokinetic contractions are possible: concentric or eccentric contractions (Cybex. 1996:p1-9,c-2).

a) Concentric contractions: Defined as the development of tension by muscle while the origin and insertion approximate each other. This is also referred to as positive work (Davies. 1992:p25). This involves the shortening of the muscle fibres with the origin and insertion approximating (Cybex.1996:pc-2).

b) Eccentric contractions: Defined as the development of tension that occurs as the origin and insertion move away from each other. This is also referred to as negative work of the muscle (Davies. 1992:p25). This involves the lengthening of muscle fibres with the origin and insertion separating (Cybex. 1996:pc-2).

2.8.2 Advantages of Isokinetic Exercise

- Permits isolation of muscle groups.
- Provides accommodating resistance to maximal exercise throughout the Range of Motion.
- Presents quantifiable data for peak torque, work and power.

(Perrin. 1993:p7)

- Reduces chance of overload injury.
- Accommodation to pain and fatigue.
- Full range of speed for testing and exercise (within limits of machinery).
- Reproducible measurements.
- Physiological overflow of strength.

(Cybex. 1996:p1-10)

2.8.3 Limitations of Isokinetic Exercise

- Non-specificity of functional training for the lower extremity in the closed kinetic chain fashion.
- Angular velocity movements that do not approach functional speeds.

(Perrin. 1993:p7)

For example in throwing the shoulder can exceed an angular velocity of 5000 degrees per second, where most dynamometers do not exceed 650 degrees per second (Pappas, Zawacki and Sullivan. 1985). Nevertheless if the clinician is concerned with bilateral or reciprocal muscle group comparison, then Isokinetic Dynamometry should be the modality of choice for measurement (Pincivero, Lephart and Karunakara. 1997).

Nisell and Ericson (1999) state that patellar compression forces are almost 12 times higher than walking and 6 times higher than running at the functional Range of Motion during isokinetic knee extension. For this reason they argue that patients with PFPS should only perform submaximal efforts, which is at odds with the rationale of testing procedures requiring maximal contractions (Nisel, R. Ericson, M. 1999)

2.8.4 Contraindications to Isokinetic Sessions

<u>a) Absolute Contraindications</u>

- Soft tissue healing constraints
- Severe pain
- Extremely limited range of motion
- Severe joint effusion
- Unstable joint
- Acute strain

<u>b) Relative Contraindications</u>

- Pain
- Limited range of motion
- Effusion or synovitis
- Chronic third degree sprain
- Subacute sprain
- Pregnancy

(Cybex. 1996:p1-13)

2.8.5 Isokinetic dynamometry as a Tool

Davies (1992:p62) states that from studies with isokinetics and computerization the following factors appear to be the specific in demonstrating pathological "weakness" existing in a muscle:

1.Quadriceps torque at 60° per sec relative to patient's body weight

2.Average Power

3.Total work of the quadriceps

Isokinetic dynamometry also has the advantage of a limited diagnostic capability by analysis of torque curve characteristics. For example in anterior knee pain, the torque curve tends to flatten dramatically, with a drastically wavy pattern through the mid-range of motion. However a characteristic diagnostic curve may not always be present (Chan and Maffulli. 1996:p11, 43, 128). The machine can also be used as a tool in the rehabilitation of PFPS as well as other injuries involving muscular weakness (Perrin. 1993: p120-4) (Chan and Maffulli. 1996:p10) (Davies. 1992: p125-134).

2.8.6 Parameters from Isokinetic Testing

a) Quadriceps torque at 60° per second relative to patient's body weight.

This is the single highest point on the torque curve regardless of where in the range of motion it occurs (Davies. 1992:p53). Taking into account changes due to biomechanical leverage and the muscular tension-length relationship that occurs throughout the range of motion, peak torque is indicative of maximum muscular tension capability (Cybex. 1996:pc-4).

b) Average Power

This is a measurement of the total work divided by the time it takes to perform the work (Davies.1992:p59). This is an accurate indicator of the subject's actual work rate. This is computed separately for each direction of movement. Using average power one can determine the maximum intensity exercise speed for each tested muscle group (what is known as "peak power velocity") (Cybex. 1996:pc-6).

c) Total work of the quadriceps

The total area underneath the curve is the total work of the torque curve with each repetition regardless of speed, range of motion or time (Davies. 1992:p59). This is dependant on the subject's muscular power capability at the test velocity, as well as available anaerobic energy stores and pH tolerance in the working muscles. For work measurements to be comparable it is essential that the same range of motion be used for every test (Cybex. 1996:pc-7).

2.8.7 Interpretation of Isokinetic Data

a) Torques to Body Weight: Clinical experience has shown this ratio to be a valuable tool for inter-individual comparisons and for evaluation of the functional strength of an individual's weight-bearing musculature (Cybex. 1996:pc-4). Torque to body weight ratios may often be altered even though a subject has equal bilateral symmetry and normal unilateral ratios. Torque is evaluated relative to total body weight rather than lean body weight because an individual functions using his total body weight (Davies. 1992:p63). Use of these ratios enables comparison to normative data (Cybex.1996:pc-4).

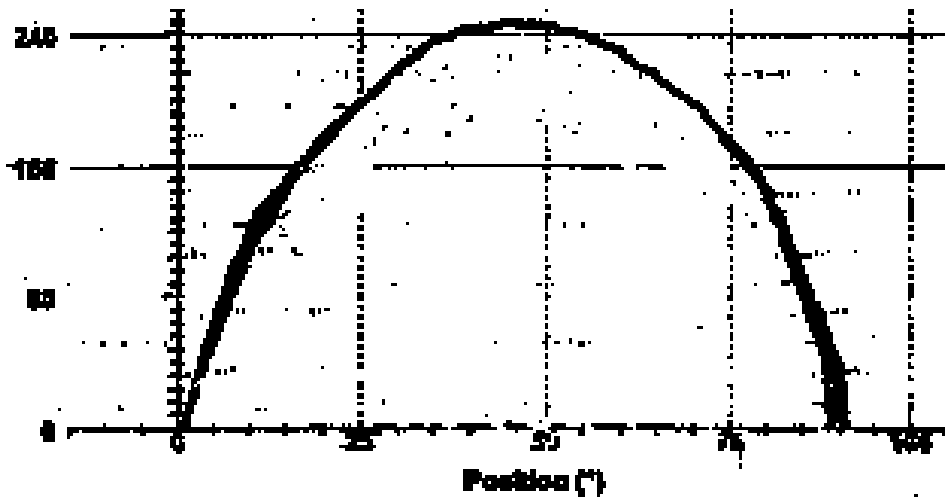
b) Normative data: Normative data can be used as guidelines for testing and rehabilitation when used relative to a specific population (Davies. 1992:p63). Through the use of normative data, clinicians can correlate isokinetic testing results with the physical demands of a specific population (Cybex. 1996:p1-9).

c) The shape of the torque curve: The shape of the curve can be analyzed subjectively by looking at the characteristics of the curve. The time rate of torque development (angle of the initial upward deflection of the slope of the curve to peak torque), the force decay rate (angle of the downward deflection of the slope of the curve from peak torque), and any irregularities in the curve may be correlated with various pathologies (Davies.1992:p61).

2.8.8 The Normal Moment Curve

Basically a perfect moment curve from an unaffected joint muscle unit with good neuromuscular facilitation should have a curve which looks like an inverted 'U' seen here (http//www.isokinetics.net).

Fig. 2.1 Concentric Quadriceps Graph



Graph adapted from Davies (1992;p6,14), Perrin (1993:p14), Chan and Maffulli (1996:p12) and http//www.isokinetics.net.

Research and clinical experience has revealed that a 5% deficit in muscular strength can be expected on the non-dominant lower limb. It is important to take this into account when assessing injuries on the dominant or non-dominant limb (Cybex. 1996:p1-3).

2.8.9. Abnormalities in Torque Curves

Chan and Maffulli (1996:p12) report the characteristic presence of dipping of the graph subsequent to the point of peak torque in the classic torque curve of PFPS.

Hart et al. (1985) determined the presence of a “break” curve in PFPS during eccentric contraction at slow test velocities (30 degrees per second). The break phenomenon is described as a perturbation in the curve which exceeded a drop of 10% or more. Most breaks can be seen at 30 degrees per second. Lower test velocities than this tend to have exceedingly long exposures and hence the velocity relationship is more constant masking the break. Concentric loads at 30 degrees/second are actually greater than eccentric loads at 60 degrees/second but concentric loads do not demonstrate breaks. (http//www.isokinetics.net).

If there is a sudden shut off of the contractile activity this curve assumes an irregular shape. Hart et al. (1985) has shown a common oscillatory phenomenon which results in a curve with more than one conspicuous peak (this could even be a double, triple etc.). This is known as a “shut off” curve.

2.8.10 Conclusion

Reproducibility and reliability of isokinetic testing for a desired protocol should be sufficient enough so that training or injury induced changes in muscle strength are not attributed to instrument or testing error. The ability to quantify reliable and relatively precise values for maximal strength and endurance, as measured by Isokinetic Dynamometry, would provide a valuable tool for the evaluation of muscular capability and injury assessment, especially in the Sports Medicine setting (Pincivero, Lephart and Karunakara.1997).

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2.9 Summary

The reviewed literature indicates the need for further investigation to determine the presence and extent of quadriceps femoris weakness in subjects with PFPS. The use of isokinetic dynamometry has been proven to be a valuable tool for assessment and evaluation of muscular function and pathology (Pincivero, Lephart and Karunakara. 1997) and is at present considered the most appropriate indicator of functional status in subjects with PFPS. Therefore this type of evaluation should be considered as an important tool by which this type of condition can be evaluated. Evaluation in this manner will provide clinicians with additional knowledge that will assist in resolving the debate with regard to the quadriceps femoris weakness theory in PFPS.

CHAPTER 3
MATERIALS AND METHODS

3.1 Methodology

3.1.1 Type of Study

A controlled quasi experiment (pilot study).

3.1.2 Sampling

The study was limited to subjects suffering from Patellofemoral Pain Syndrome. Subjects presenting at the Chiropractic Day Clinic at the Durban Institute of Technology were considered.

Non-probability based, purposive sampling was used to attract patients. Advertisements were placed in newspapers and sports magazines. Flyers (see Appendices A and B) were placed at Gymnasiums, sports shops and sports clubs. In addition advertisements were placed at sporting events. Flyers were also placed around the Durban Institute of Technology.

3.1.3 Inclusion Criteria

All subjects had to be between the ages of 18 and 60.

Subjects must have had:

- Localized peri- or retropatellar pain originating from the peripatella tissue or the patellofemoral joint (Davidson. 1993).

Pain was reproducible with at least two of the following:

- squatting,
- stair climbing,
- kneeling,
- prolonged sitting,

- isometric quadriceps femoris muscle contraction

(Powers, Landel, Perry. 1996).

At present diagnostic criteria cannot differentiate severity as there are no clear pathognomonic characteristics, therefore careful notes were taken in order to comment on homogeneity among subjects in the discussion of results.

3.1.4 Exclusion Criteria

Subjects were excluded if they had any history of:

- traumatic patella dislocation,
- any neurological involvement that influences their gait,
- or have undergone any knee surgery over the past 2 years

Subjects presenting with any of the following were excluded:

- bursitis,
- patella tendonitis,
- fat pad syndrome,
- any systemic arthritides if they affect the knee

(Powers, Landel, Perry. 1996).

- evidence of a meniscal tear,
- ligamentous instability,
- abnormalities indicative of osteoarthritis, osteochondritis dessicans or loose bodies,
- pregnant or breast-feeding mothers

(Kannus et al. 1999)

Patients presenting with acute, severe PFPS experiencing pain that prevented them from completing the isokinetic test were also excluded from the study (Cybex. 1996:p1-13).

Examination was carried out to assess for suitability and to determine the presence of other lower extremity dysfunction that may account for knee symptoms. Conditions screened for included: referred pain from the lumbar spine or hip joint; leg length difference; knee ligament, quadriceps tendon and meniscal pathologies; plica syndrome and Iliotibial Band Syndrome (Callaghan et al. 2000). Iliotibial Band (ITB) Syndrome was not considered as an exclusionary criterion as long as the problem was secondary to PFPS. This is because Iliotibial Band tightness is associated with PFPS (Post. 1998). The presence ITB syndrome being secondary to PFPS was determined from the history.

3.1.5 The Method

All respondents underwent a cursory telephonic discussion with the examiner to exclude subjects that obviously did not fit the criteria for the study (see Appendix C). Suitable subjects then underwent an initial consultation at the Durban Institute of Technology Chiropractic Day Clinic, consisting of a full Case History (see Appendix D), relevant Physical (see Appendix E) and Knee Regional Examination (see Appendix F). A series of standardized questions and orthopedic tests were also carried out by the researcher on each subject (see Appendix G: Research Patient Questionnaire). Prior to being accepted into the study all subjects received a letter of information (see Appendix H), completed an informed consent form (see Appendix I) and were given opportunity to ask questions.

20 suitable subjects were considered for Isokinetic testing. Two test sessions were performed, the first of which was for subject familiarization and the second being the actual test (Chan and Maffulli .1996:p80-1) (Pincivero, Lephart and Karunakara. 1997).

3.2 Measurement and Observation

3.2.1 The Data

The data contained in this study was both of the primary and secondary types.

3.2.1.1 The Primary Data

a) Objective Data

The objective data was obtained with the use of an isokinetic dynamometer, the Cybex "Norm" ™ unit at Kings Park Sports Medicine Center, by Cybex international, incorporated (see Appendix J: Declaration of Conformity). The isokinetic dynamometer was used to measure concentric and eccentric quadriceps and hamstrings peak torque, total work and average power.

3.2.1.2 The Secondary Data

The secondary data was obtained from journal articles, books and related internet sites.

3.2.2 Methods of Objective Measurement

3.2.2.1 Test Protocol

Subjects performed a concentric/ concentric knee flexion/ extension isokinetic test at a test velocity of 60° per second and an eccentric/ eccentric knee flexion/ extension isokinetic test at a test velocity of 60° per second.

Testing at low velocities (90° per second and slower) should be restricted to sets of no more than 6 repetitions performed maximally and reassessed every 2-3 weeks otherwise further symptoms may be invoked by testing (http//www.isokinetics.net).

3.2.2.2 Test Procedure

Isokinetic tests were performed at the Kings Park Sports Medicine Center. Sessions were not less than 2 days and not more than 7 days apart. Subjects were tested at similar times of the day to minimize diurnal variation (Callaghan et al. 2000). Mock and actual test data were compared to check for irregularity. In cases of irregularity, the actual test was repeated to ensure satisfactory data.

Computerized gravity correction was used in order to eliminate confounding errors due to the weight of the limb being tested [Perrin (1993:p39), Chan and Maffulli (1996:p16), Pincivero, Lephart and Karunakara (1997), Cybex (1996:p1-31)].

The machine was calibrated weekly for the duration of the study (see Appendix K).

a) Patient Positioning

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

b) Patient Procedure

Subjects completed a 5 minute warm up cycle, followed by 3 sets of a 15 second hamstring stretch, during which flexibility was noted.

The uninvolved side (or less severe side in cases of bilateral involvement) was always tested first.

i) Concentric-Concentric Test

- 4-6 Sub-maximal warm-up repetitions at 90 degrees/sec
- 1 min rest
- 2 trial repetitions of maximal effort at 60 degrees/sec
- 1 min rest
- 3-5 repetitions of maximal effort at 60 degrees/sec
- 4 min rest

ii) Eccentric-Eccentric Test

- 4-6 Sub-maximal warm-up repetitions at 45 degrees/sec
- 1 min rest
- 2 trial repetitions of maximal effort at 60 degrees/sec
- 1 min rest
- 3-5 repetitions of maximal effort at 60 degrees/sec

This protocol was adapted from: Davies (1992:p43-4), Perrin (1993:p48-50), Chan and Maffuli (1996:p10), Pincivero, Lephart and Karunakara (1997), Cybex (1996:p1-20).

3.3 The Isokinetic Dynamometer

The Cybex "NORM"™ Isokinetic Dynamometer (see Appendix J: Declaration of Conformity) at Kings Park Sports Medicine Center was used using standardized testing protocols, as discussed with Mr. J. Wright and adapted from Davies (1992:p43-44), Perrin (1993:p48), Chan and Maffuli (1996:p10), Pincivero, Lephart and Karunakara (1997) and Cybex (1996:p1-20). Values attained from these tests were compared to established, accepted normative values attained on similar machinery (see 3.4.3.2 Normative Values). Normative data can be used as guidelines for testing and rehabilitation when used relative to a specific population (Davies. 1992:p63).

3.3.1 Reliability and Validity of an Isokinetic Dynamometer

Over 20 years of independent clinical research have proven Cybex isokinetic testing to be accurate, objective, reproducible and safe. More than 1000 published articles, studies and presentations have shown Cybex systems to provide objective measurement of impairment and documentation of rehabilitation effectiveness (Cybex. 1996:p1-9).

Johnson and Siegel (1975) report high test, re-test reliability of knee extension when using the Cybex II dynamometer. Callaghan et al. (2000) conducted a study of both reliability and using a multiple joint attachment on the lower limb on a Biodex system 2 dynamometer, concluding high test-retest reliability validity (level of significance set at 5%). Chan and Maffulli (1996:p22-3) report correlation co-efficients between 0.93 and 0.99 when using an Isokinetic Dynamometer (no p-value stated). Pincivero, Lephart and Karunakara (1997) report intraclass correlation co-efficients of 0,88 to 0.97 at 60 degrees per second, demonstrating that isokinetic values are highly reproducible provided there is adequate calibration, gravity correction and patient positioning is recorded and standardized. Davies (1992:p35) states that several studies have been conducted confirming the reliability and validity of the Cybex (no p-values stated). It is thus only necessary to perform one actual test.

Pincivero, Lephart and Karunakara (1997), in a study of reliability, report intraclass reliability coefficients as follows:

Table 3.1 Intraclass Reliability Coefficients

	r=	Standard error measurement
Quadriceps peak torque	≥0.80	4.8-11.6%
Hamstring peak torque	0.93 to 0.97	4.8-11.6%
Average power	0.92 to 0.95	2.0-7.1%
Total work	0.88 to 0.95	7.4-11.6%
Peak torque / Body weight	0.86 to 0.92	5.1-7.5%

Callaghan et al. (2000) conducted a test re-test reliability study on healthy individuals as well as a group with PFPS ($p<0.05$) and reported the following correlation coefficients:

Table3.2 Test Re-test Reliability Coefficients

	Healthy Group	PFPS Group
Isokinetic Peak Torque	≥0.75	>082
Average Power and Total Work	>0.83	≥0.75
Isometric Peak Torque Extension	0.82	0.89

They concluded high reproducibility of lower limb multi-joint isokinetic testing for all values on both healthy and PFPS subjects. Therefore one is able to directly measure lower limb function in a patient group both pre and post treatment (Callaghan et al. 2000).

According to Chan and Maffulli (1996:p80-1) both reliability and validity of Isokinetic testing is enhanced by the performance of two tests, the first of which is in order for the patient to gain familiarization, and the second being the actual test. Data from the first test is then discarded. This is confirmed by a study by Pincivero, Lephart and Karunakara (1997) and Callaghan et al. (2000).

3.4 Object of the Study

The purpose of this study was to evaluate the presence and extent of quadriceps femoris weakness in subjects with patellofemoral pain syndrome.

Upon embarking on the study it was noted that hamstring weakness may also be present in the experimental group. The strength of the hamstring muscles was evaluated and analyzed in a similar manner to that of the quadriceps.

The study aimed to contribute to the current body of knowledge regarding patellofemoral pain syndrome and to compare findings to what has been proposed by previous research.

3.4.1 Demographic Data

Demographic data recorded included the following: average age, weight and height. The ratio of males to females was also recorded.

Individual subject characteristics such as activity level, whether they were a runner or not and the distance run per week were recorded at the initial consultation.

3.4.2 Hamstring Flexibility

Hamstring flexibility was recorded during the patient warm-up hamstring stretch by lying the subject supine and flexing the hip while maintaining full knee extension. The examiner then made a subjective, approximate judgement as to the flexibility of the subjects' hamstrings. Flexibility was considered less than below average if below 70° of hip flexion, below average if ranging between 70°-80°, average if between 80°-90°, above average if between 90°-100° and greater than above average if greater than 100°.

3.4.3 Isokinetic Data

<u>3.4.3.1 Recorded Data</u>

Isokinetic data was recorded at the second of 2 test sessions and analyzed using the SPSS version 9.0 statistical package for Windows® as well as by subjective visual analysis of both the concentric and eccentric torque curves.

Davies (1992:p62) states that from studies with isokinetics and computerization the following factors appear to be important in demonstrating pathological "weakness" existing in a muscle:

1. Quadriceps torque at 60° per sec relative to patient's body weight
2. Average Power
3. Total work of the quadriceps

These values from the experimental group were compared to established norms. Unfortunately the body of normative data is extremely limited. This meant that only certain of these parameters could be compared due to normative values. Those parameters for which no norms could be found were reported for future use.

3.4.3.2 Normative Values

Due to the fact that type and level of activity among subjects was not homogenous it was recommended that norms for the “normal” population be used. Despite the fact that other studies exist that claim to have produced norms for parameters other that peak torque, it was recommended that only norms applying to peak torque be used due to the wide discrepancies with regard to protocol and procedure (Kruger. 2002).

a) Peak torque values: concentric knee flexion and extension

Norms for these parameters among males were taken from a study by Kruger, van Wyk and Daehne (1992) on 536 “normal” male subjects, between ages 18-36, on a Cybex II isokinetic dynamometer. This study was chosen for 4 reasons. The large sample size added credibility to the study. The study was conducted on fairly similar machinery to this study, although from a previous generation. Kruger, van Wyk and Daehne (1992) also used an almost identical test procedure to the one used in this study, barring the fact that a Cybex II unit is not capable of eccentric testing. The fact that the study was conducted in South Africa on a population most likely that of this study was also considered.

Normative values for concentric knee flexion among females were taken from Lumex (1980) as there were very few sources that met the true definition of a normative value and this source appeared to be the most appropriate for use in this study.

The normative value for female knee extension was taken from a study, by Dvir et al. (1990), comparing 30 normal subjects to a PFPS group (n=55). The use of this previous study enabled direct comparison.

b) Peak torque values: eccentric knee extension
Norms were also taken from the study by Dvir et al. (1990). This appears to be the only available study reporting eccentric norms.

c) Eccentric hamstring to concentric quadricep ratio
Although not a true normative value, it was decided subsequent to beginning the study to compare this widely accepted ideal ratio (Wright. 2002) to the experimental group in an attempt to relate the presence of the apparent eccentric hamstring weakness.

3.4.4 Statistical Analysis Analysis of the Data
Data was recorded by computerized means on the Cybex "Norm" isokinetic dynamometer and printed out in a graphical and tabulated manner.

Male and female variables were analyzed separately using the SPSS version 9.0 for Windows® statistical package. This is because many isokinetic studies have shown that men are significantly and consistently stronger than women. Therefore different noms exist for each gender (http//www.isokinetics.net).

The one- sample T- test was used for analysis.
H_0: $\mu = \mu_0$ (The null hypothesis) (μ_0 is the mean)
$H_{1:}$ $\mu < \mu_0$ (The alternative hypothesis)
$\alpha = 0.05$

THE DECISION RULE
The decision rule for all procedures: If $p/2 < 0.05$, significant at 5%, accept H_1 where p is the reported p- value.

Procedure 1.1: Comparison between Male PFPS group and Normative values with respect to continuous variables for Concentric Extension: Peak Torque

The One sample T-test was used for comparison.

H_0: $\mu = 3.38$

H_1: $\mu < 3.38$

$\alpha = 0.05$

Procedure 1.2: Comparison between Male PFPS group and Normative values with respect to continuous variables for Concentric Flexion: Peak Torque

The One sample T-test was used for comparison.

H_0: $\mu = 1.83$

H_1: $\mu < 1.83$

$\alpha = 0.05$

Procedure 1.3: Comparison between Male PFPS group and Normative values with respect to continuous variables for Eccentric Hamstring / Concentric Quadriceps Ratio

The One sample T-test was used for comparison.

H_0: $\mu = 100$

H_1: $\mu < 100$

$\alpha = 0.05$

Procedure 1.4: Comparison between Male PFPS group and Normative values with respect to continuous variables for Eccentric Extension: Peak Torque

The One sample T-test was used for comparison.

H_0: $\mu = 3.65$

H_1: $\mu < 3.65$

$\alpha = 0.05$

Procedure 1.5: Comparison between Female PFPS group and Normative values with respect to continuous variables for Concentric Extension: Peak Torque

The One sample T-test was used for comparison.

H_0: $\mu = 2.08$

H_1: $\mu < 2.08$

$\alpha = 0.05$

Procedure 1.6: Comparison between Female PFPS group and Normative values with respect to continuous variables for Concentric Flexion: Peak Torque

The One sample T-test was used for comparison.

H_0: $\mu = 1.34$

H_1: $\mu < 1.34$

$\alpha = 0.05$

Procedure 1.7: Comparison between Female PFPS group and Normative values with respect to continuous variables for Eccentric Hamstring / Concentric Quadriceps Ratio

The One sample T-test was used for comparison.

H_0: $\mu = 100$

H_1: $\mu < 100$

$\alpha = 0.05$

Procedure 1.8: Comparison between Male PFPS group and Normative values with respect to continuous variables for Eccentric Extension: Peak Torque

The One sample T-test was used for comparison.

H_0: $\mu = 3.23$

$H_{1:}$ $\mu < 3.23$

$\alpha = 0.05$

The null hypothesis (H_0) stated that there was no difference between the PFPS group and normative values with respect to the continuous variable of comparison at the $\alpha = 0.05$ level of significance. The alternative hypothesis (H_1) stated that experimental group values were less than the norm at the $\alpha = 0.05$ level of significance.

Procedure 2: Comparison using Piecharts and Bargraphs

All results from statistical analysis were plotted on piecharts and bargraphs where necessary to give a visual overview of recorded and analysed data.

CHAPTER 4
THE RESULTS

4.1 Solving the Subproblem

4.1.1 The Subproblem

The objective was to determine the presence and extent of quadriceps femoris weakness in subjects with Patellofemoral Pain Syndrome in terms of objective clinical findings (Isokinetic Dynamometry).

The hypothesis for the experimental group in comparison to normative data were as follows:

H_0 : there was no difference between the experimental group and normative data with regard to objective clinical findings.

H_1 : there was a difference between the experimental group and normative data with regard to objective clinical findings.

4.2 The Analysed Data

4.2.1 The sample size

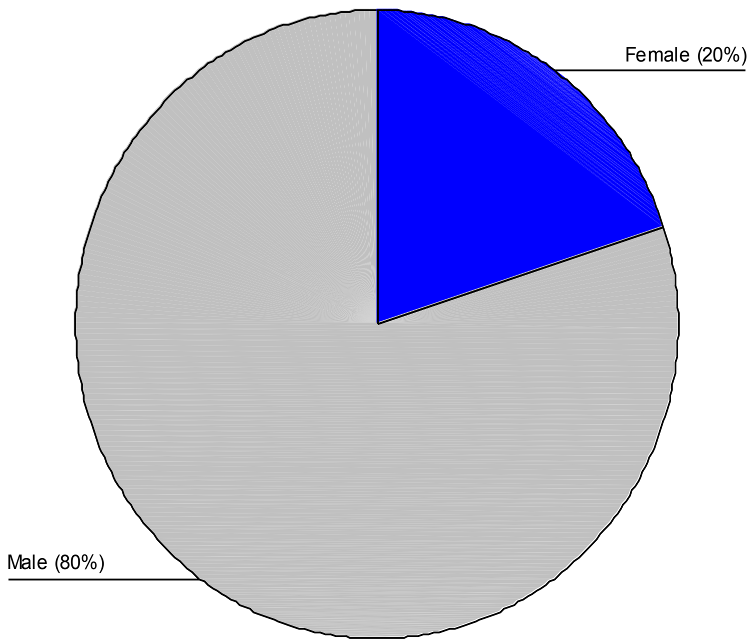
The sample size of the study was 20 subjects (n= 20). Of these subjects, 5 had bilateral involvement making n= 25 for the purpose of statistical analysis. Purposive sampling was used to ensure subjects were selected that satisfied the criteria for the study.

4.2.2 Demographic Data

a) Gender Distribution

The sample consisted of 16 males (80%) and 4 females (20%).

Fig. 4.1 Gender Distribution



b) Age

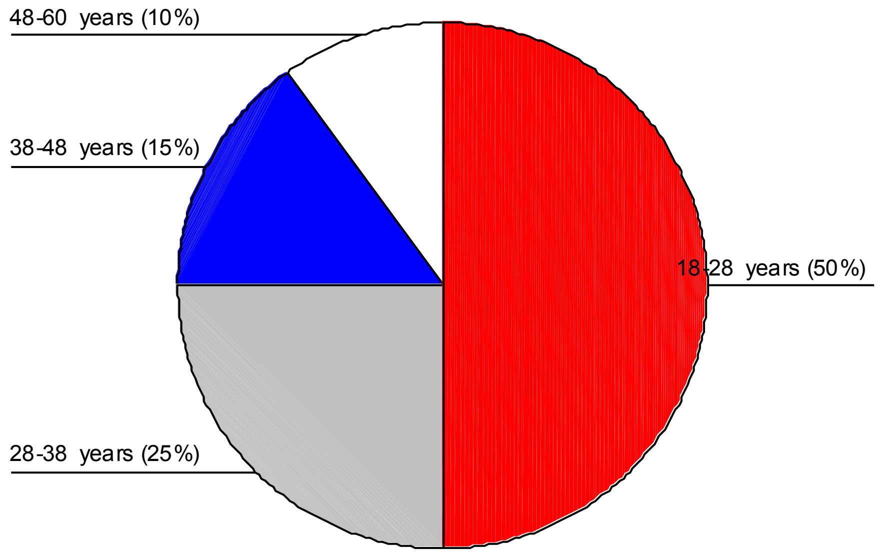
The mean age was 29.6 years.

The age range was 19-57.

The mean age of females was 31.75 years with a range of 21-43.

The mean age of males was 29.1 years with a range of 19-57.

Fig. 4.2 Age Distribution



c) Height and Weight

The average height of the sample was 1.72 meters (1.58-1.85m) and the average weight was 70.8 Kg (60-88Kg).

The average height of the females in the sample was 1.61 meters (1.58-1.68m) and the average weight was 53.0 Kg (44-60 Kg).

The average height of the males in the sample was 1.75 meters (1.63-1.85m) and the average weight was 75.25 Kg (60-88 kg).

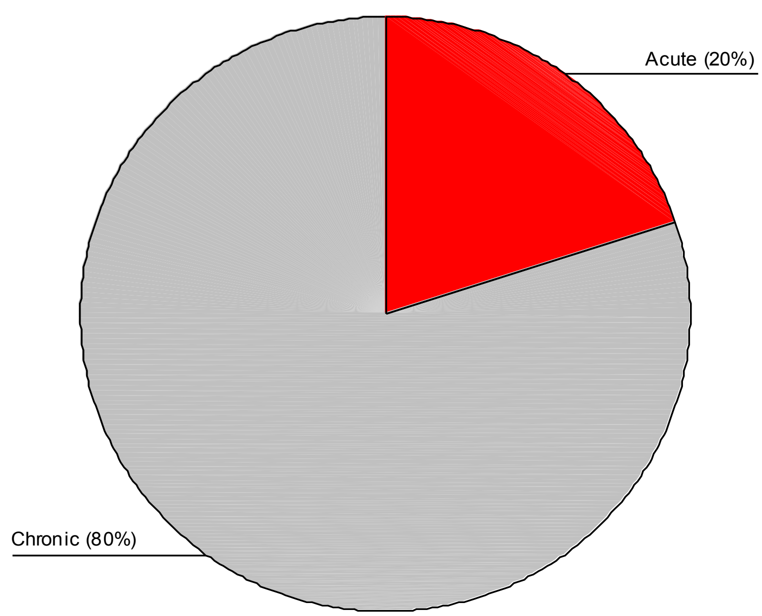
Table 4.1 Patient Demographic Data

Age Distribution	Males	Females	Total
18-28	9	1	10
28-38	3	2	5
38-48	2	1	3
48-60	2	0	2
Average Age	29.1 years	31.75 years	29.6 years
Gender Distribution	16	4	20
Average Height	1.75m	1.61m	1.72m
Average Weight	75.25Kg	53.0Kg	70.8Kg

d) Duration of Pain

Four subjects reported in the acute phase of PFPS (i.e. less than 6 weeks). The remaining 16 subjects were all in the chronic phase (i.e. longer than 6 weeks).

Fig. 4.3 Duration of Pain



4.2.3 Results of Statistical Analysis

One- sample T-test

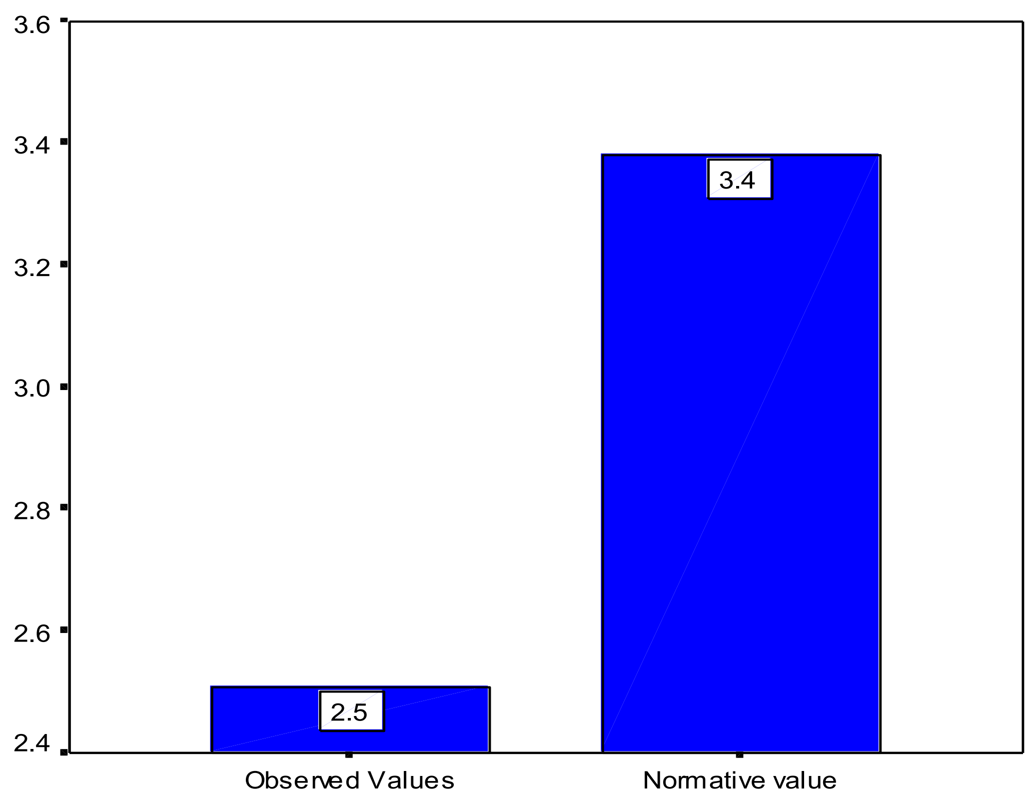
a) <u>Concentric Knee Extension (Quadricep)</u>

Table 4.2 Males- Concentric Knee Extension: Peak Torque Values

Test Value= 3.38

	N	Mean	p - Value
Concentric Extensors: Peak Torque (Nm) per Kg	20	2.5070	.000 $p < .001$

Fig. 4.4 Males- Concentric Knee Extension: Peak Torque Values



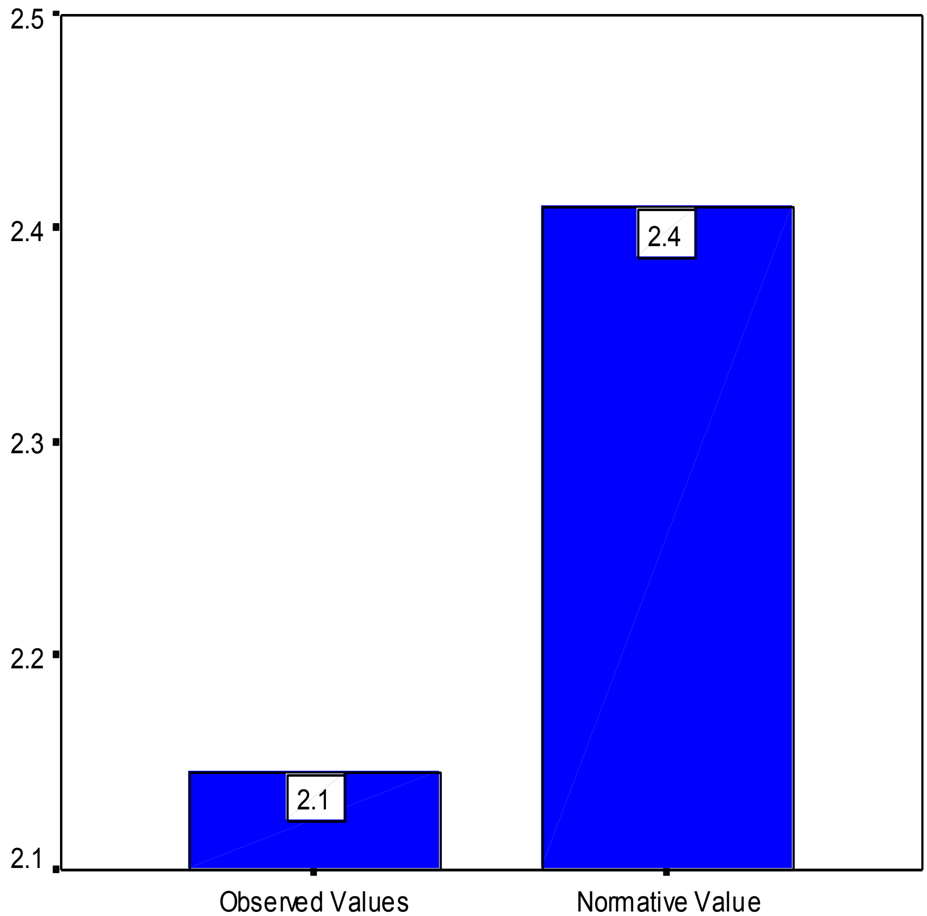
For the male sample, there was a statistically significant difference between the experimental group and normative data for peak torque values of concentric knee extension as $p < 0.05$ (α). Therefore the null hypothesis was rejected, and the alternative hypothesis was accepted, for this comparison.

Table 4.3 Females- Concentric Knee Extension: Peak Torque Values

Test Value= 2.41

	N	Mean	p - Value
Concentric Extensors: Peak Torque (Nm) per Kg	5	2.1460	.2430

Fig. 4.5 Females- Concentric Knee Extension: Peak Torque Values



For the female sample, there was no statistically significant difference between the experimental group and normative data for peak torque values of concentric knee extension as $p \geq 0.05$ (α). Therefore the null hypothesis was accepted for this comparison.

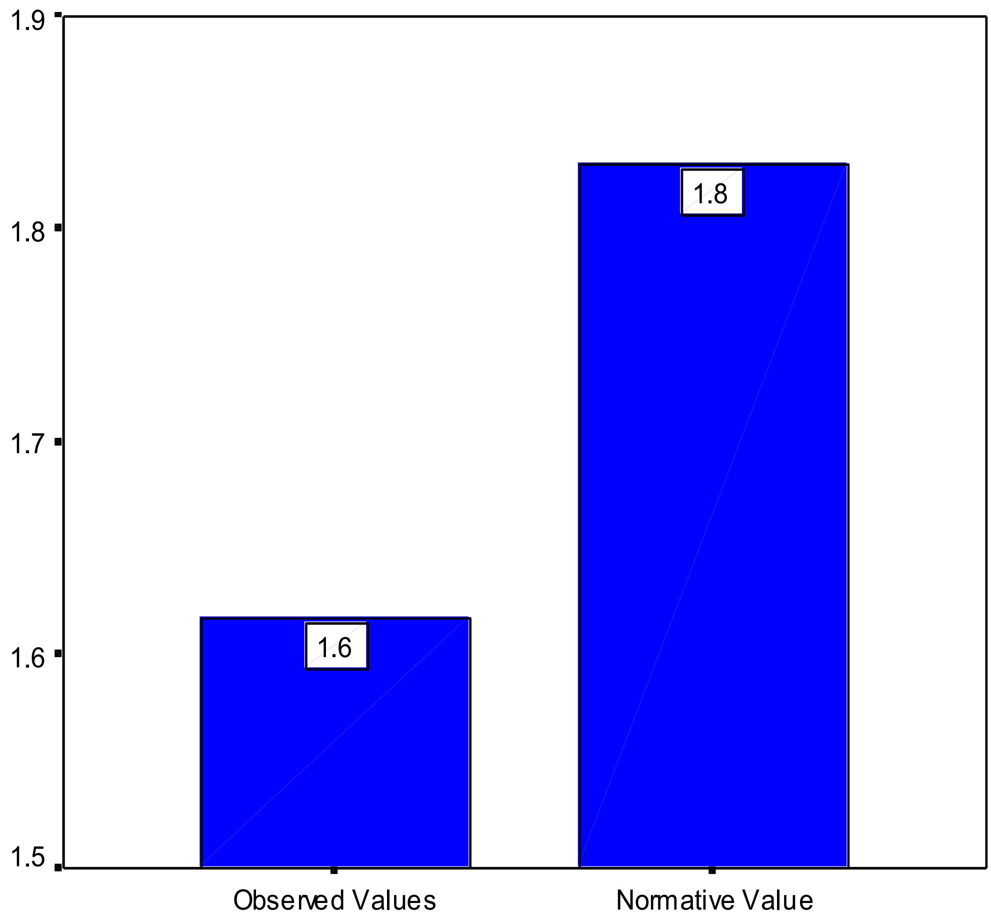
b) <u>Concentric Knee Flexion (Hamstring)</u>

Table 4.4 Males- Concentric Knee Flexion: Peak Torque Values

Test Value= 1.83

	N	Mean	p - Value
Concentric Flexors: Peak Torque (Nm) per Kg	20	1.6170	.000 $p < .001$

Fig. 4.6 Males- Concentric Knee Flexion: Peak Torque Values



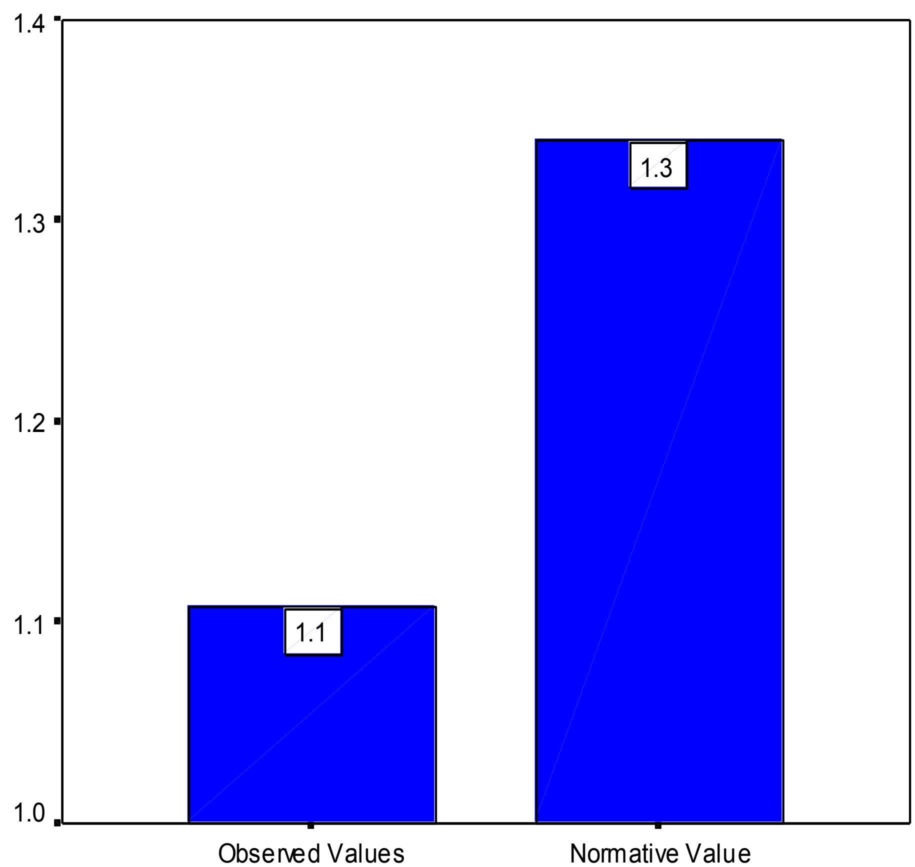
For the male sample, there was a statistically significant difference between the experimental group and normative data for peak torque values of concentric knee flexion as $p < 0.05$ (α). Therefore the null hypothesis was rejected, and the alternative hypothesis was accepted, for this comparison.

Table 4.5 Females- Concentric Knee Flexion: Peak Torque Values

Test Value= 1.34

	N	Mean	p - Value
Concentric Flexors: Peak Torque (Nm) per Kg	5	1.1080	.1320

Fig. 4.7 Females- Concentric Knee Flexion: Peak Torque Values



For the female sample, there was no statistically significant difference between the experimental group and normative data for peak torque values of concentric knee flexion as $p \geq 0.05$ (α). Therefore the null hypothesis was accepted for this comparison.

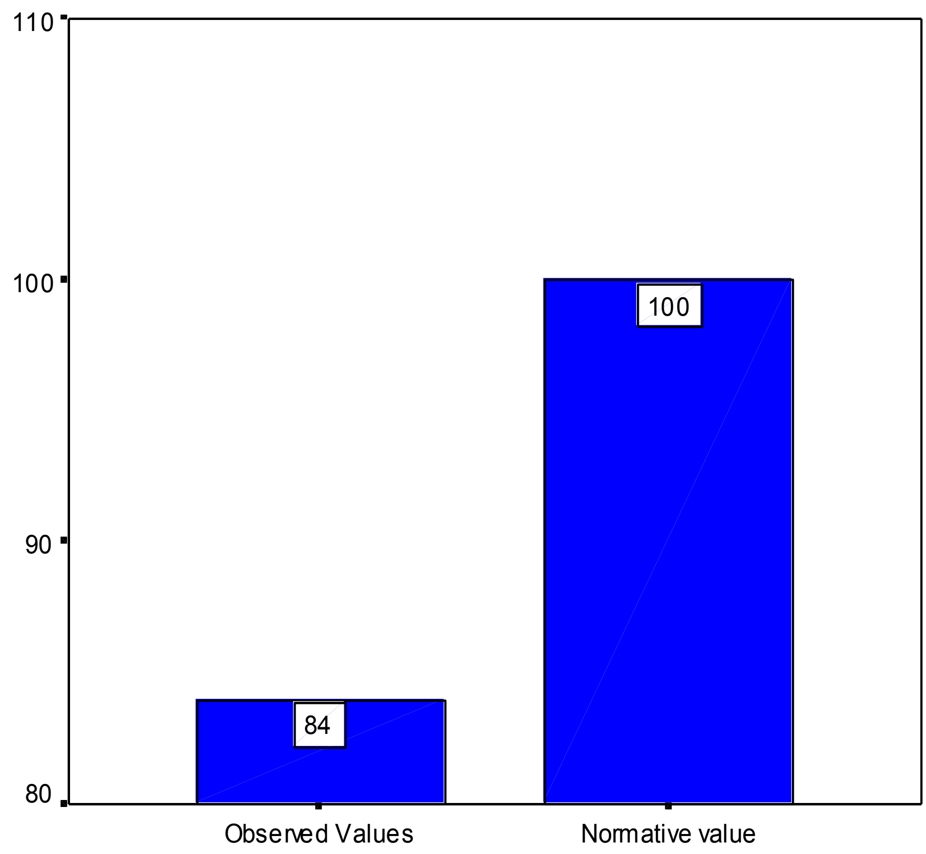
c) Eccentric Hamstring to Concentric Quadricep Ratio

Table 4.6 Males- Eccentric Hamstring to Concentric Quadricep Ratio

Test Value= 100

	N	Mean	p -Value
Eccentric Hamstring / Concentric Quadricep Ratio	20	83.965	.000 $p < .001$

Fig. 4.8 Males- Eccentric Hamstring to Concentric Quadricep Ratio



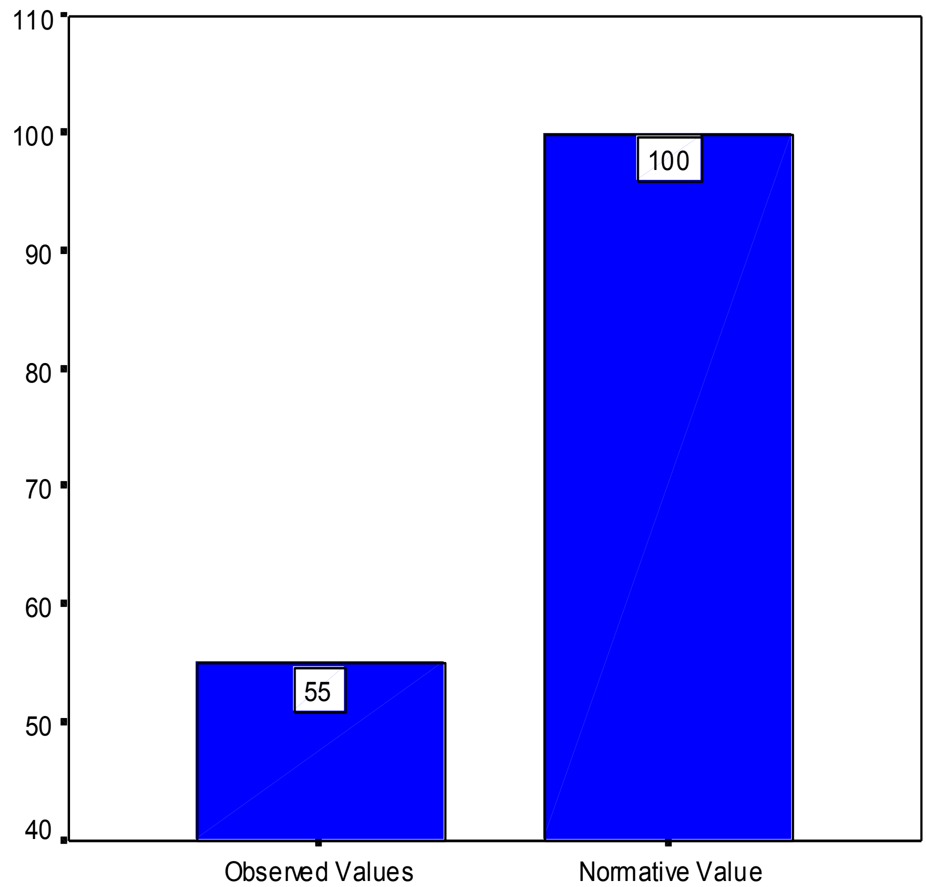
For the male sample, there was a statistically significant difference between the experimental group and normative data for Eccentric Hamstring to Concentric Quadricep Ratio as $p < 0.05$ (α). Therefore the null hypothesis was rejected, and the alternative hypothesis was accepted, for this comparison.

Table 4.7 Females- Eccentric Hamstring to Concentric Quadricep Ratio

Test Value= 100

	N	Mean	p -Value
Eccentric Hamstring / Concentric Quadricep Ratio	5	55.020	.000 p < .001

Fig. 4.9 Females- Eccentric Hamstring to Concentric Quadricep Ratio



For the female sample, there was a statistically significant difference between the experimental group and normative data for Eccentric Hamstring to Concentric Quadricep Ratio as $p < 0.05$ (α). Therefore the null hypothesis was rejected, and the alternative hypothesis was accepted, for this comparison.

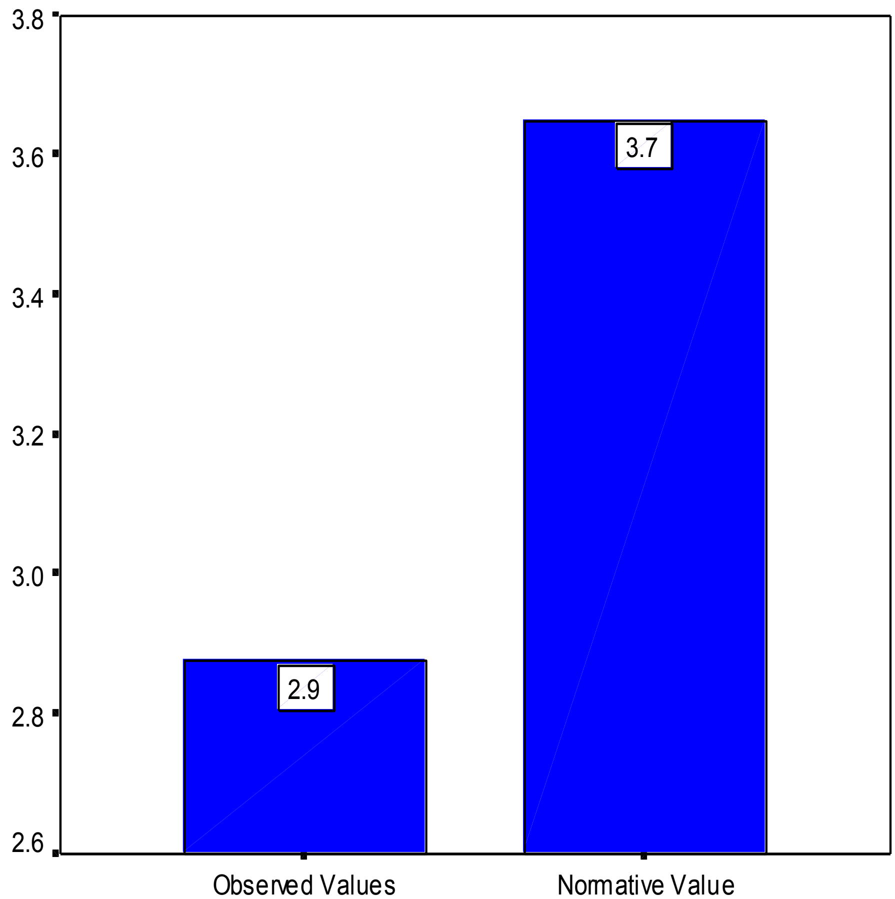
d) <u>Eccentric Knee Flexion (Quadricep)</u>

Table 4.8 Males- Eccentric Knee Flexion: Peak Torque Values

Test Value= 3.65

	N	Mean	p - Value
Eccentric Extensors: Peak torque (Nm) per Kg	20	2.8755	.000 $p < .001$

Fig, 4.10 Males- Eccentric Knee Flexion: Peak Torque Values



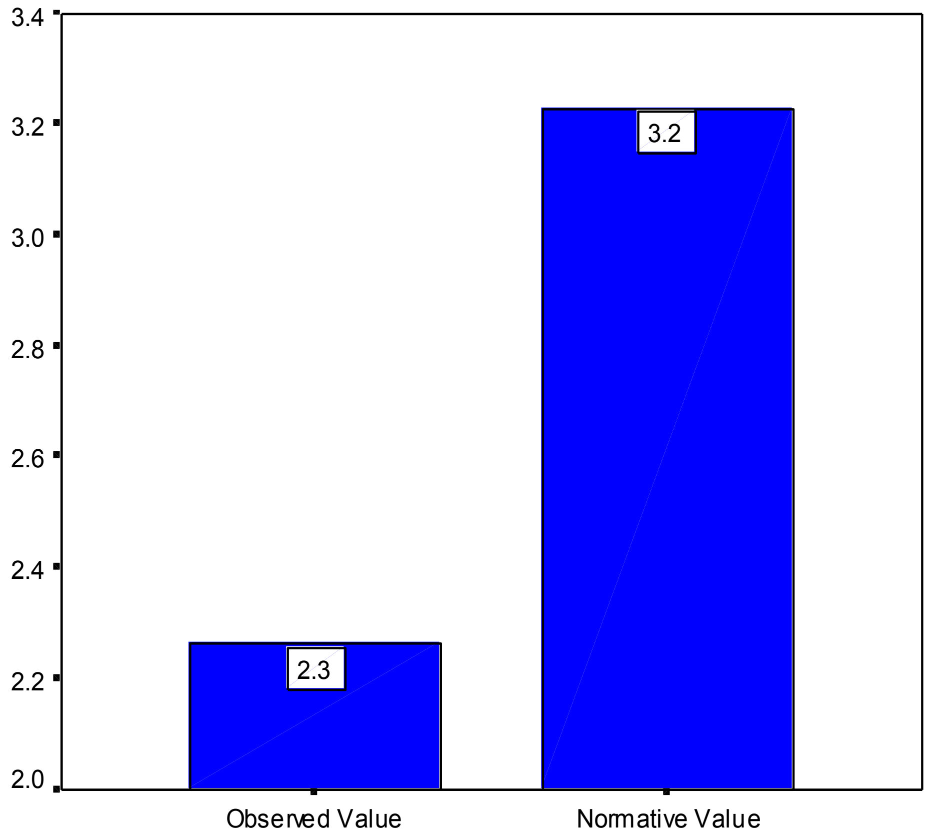
For the male sample, there was a statistically significant difference between the experimental group and normative data for peak torque values of eccentric knee flexion as $p < 0.05$ (α). Therefore the null hypothesis was rejected, and the alternative hypothesis was accepted, for this comparison.

Table 4.9 Females- Eccentric Knee Flexion: Peak Torque Values

Test Value= 3.23

	N	Mean	p - Value
Eccentric Extensors: Peak torque (Nm) per Kg	5	2.2620	.016

Fig 4.11 Females- Eccentric Knee Flexion: Peak Torque Values



For the female sample, there was no statistically significant difference between the experimental group and normative data for peak torque values of eccentric knee flexion as $p \geq 0.05$ (α). Therefore the null hypothesis was accepted for this comparison.

e) Descriptive Statistics

The following Isokinetic parameters are observed but could not be compared to normative data as no such adequate data exists at present. Data is presented in order that observations may be used for comparison in future research.

Table 4.10 Descriptive Statistics: Males

Males: Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Concentric Extensors: Total Work (J) per Kg	20	1.48	4.25	2.6685	.6169
Concentic Extensors: Average Power (W) per Kg	20	.90	2.72	1.6150	.4049
Concentric Flexors: Total Work (J) per Kg	20	1.00	2.77	1.7980	.4210
Concentric Flexors: Average Power (W) per Kg	20	.56	1.78	1.0980	.2925
Eccentric Extensors: Average Power (W) per Kg	20	.73	1.94	1.4445	.3037
Eccentric Extensors: Total Work (J) per Kg	20	2.08	4.23	2.9450	.5173
Eccentric Flexors: Peak Torque (Nm) per Kg	20	1.35	3.14	1.9945	.4305
Eccentric Flexors: Total Work (J) per Kg	20	1.33	3.32	2.0855	.4968
Eccentric Flexors: Average Power (W) per Kg	20	.48	1.38	.9681	.2583

Table 4.11 Descriptive Statistics: Females

Female Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Concentric Extensors: Total Work (J) per Kg	5	1.81	2.57	2.2180	.3232
Concentic Extensors: Average Power (W) per Kg	5	.92	1.52	1.2600	.2416
Concentric Flexors: Total Work (J) per Kg	5	.89	1.48	1.1860	.2639
Concentric Flexors: Average Power (W) per Kg	5	.46	2.32	.9580	.7738
Eccentric Extensors: Total Work (J) per Kg	5	1.80	2.98	2.2880	.4420
Eccentric Extensors: Average Power (W) per Kg	5	.89	1.42	1.1240	.2040
Eccentric Flexors: Peak Torque (Nm) per Kg	5	.87	1.55	1.1760	.2457
Eccentric Flexors: Total Work (J) per Kg	5	.94	1.62	1.2220	.2506
Eccentric Flexors: Average Power (W) per Kg	5	.43	.81	.5800	.1418
	5				

4.2.4 Hamstring Flexibility

Less than below average hamstring flexibility (<70°) was present in 3 cases. Below average hamstring flexibility (70°-80°) was noted in 4 cases. Eight subjects had average hamstring flexibility (80°-90°). Four subjects had above average hamstring flexibility (90°-100°) and one subject had greater than above average (>100°).

Fig. 4.12 Hamstring Flexibility Graph

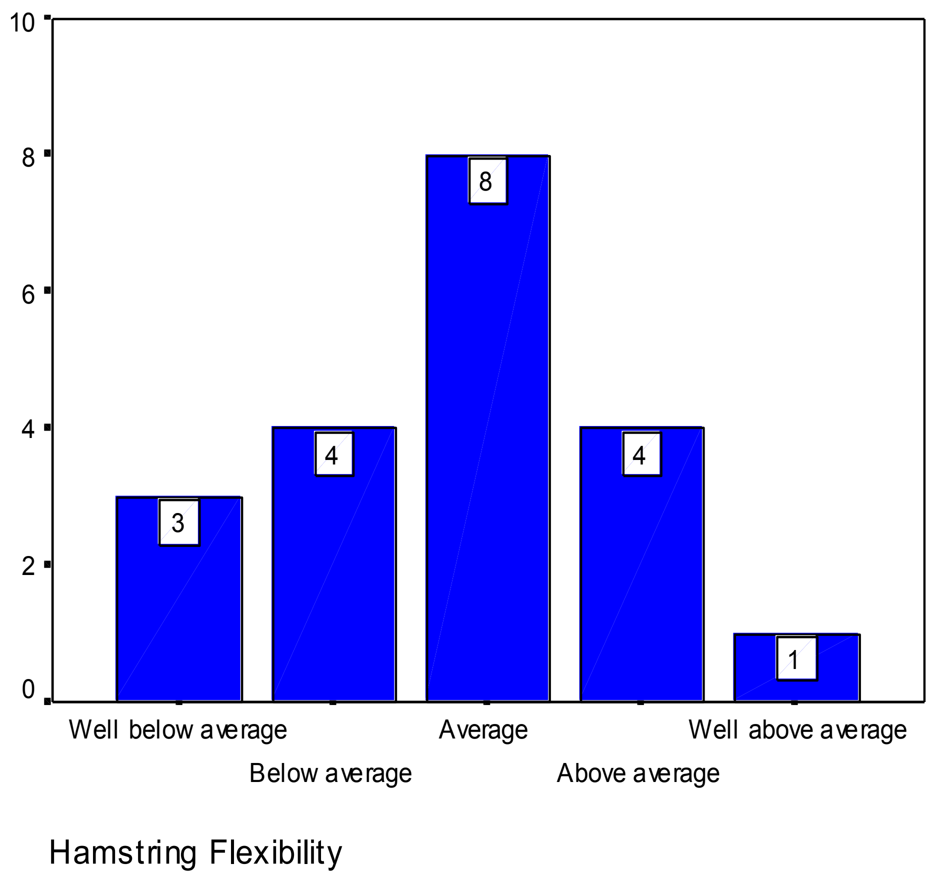
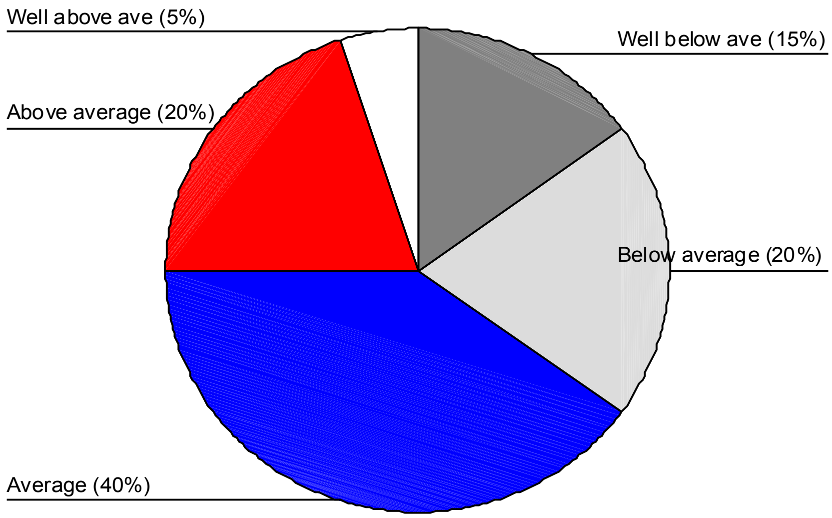


Fig. 4.13 Hamstring Flexibility Piechart



CHAPTER 5
DISCUSSION OF RESULTS

5.1Introduction

The following is a discussion of the results of statistical analysis as well as of other data that was gathered during the study.

5.2 Demographics

5.2.1 Gender Distribution

The sample consisted of 16 males (80%) and 4 females (20%). This is not true of the expected ratio in the PFPS population where female dominance is expected (Tria et al. 1992) (Salem and Powers. 2001). Review of the National Collegiate Athletic Association Injury Surveillance System (USA) revealed that these types of injuries are significantly common in female athletes (Salem and Powers. 2001). Apart from the small sample size exposing the probability of a type II error, there appears to be no obvious reason for male predominance in this study as recruitment did not favour males in any way.

5.2.2 Age

The mean age of the sample in this study was 29.6 years.
The age range was 19-57.
The mean age of females was 31.75 years with a range of 21-43.
The mean age of males was 29.1 years with a range of 19-57.
This is not typical of the PFPS population where the problem is most frequently seen in young adults (Kannus et al. 1999) with subjects mostly between the ages of 10 and 20 (Tria et al. 1992). This study did not show typical age distribution because upon consideration by the institute ethics committee it was decided to limit the age criteria to 18-60 years.

5.2.3 Activity Level of Subjects

A total of ten subjects (2 female and 8 male) reported being regular runners covering an average distance of 37.2 Km per week (12-80 Km per week).

Three subjects (1 female and 2 male) were regular cyclists covering an average of 233Km per week (200-300Km). Two of these subjects (1 female and 1 male) were elite tri-athletes.

Eight subjects (1 female and 7 male) were involved in other regular sporting or physical activities.

Five subjects (1 female and 4 male) were not involved in any regular physical or sporting activity.

It is the researcher's opinion that this predominantly sporting sample was, on average, of better physical condition than the general population. This made comparison and interpretation of results against norms difficult due to the increased strength of the experimental group. Due to the fact that type and level of activity among subjects was not homogenous it was recommended that norms for the "normal" population be used (Kruger. 2002).

5.2.4 Comment

The characteristics of this sample may be more representative of the type of subjects likely to be seen at a runner's clinic or a sports clinic. This is indicated by the fact that 10 subjects reported as being regular runners, 3 were cyclists and 8 subjects were involved in other sporting activities

Paluska and McKeag (1999) as well as LaBrier and O'Neil (1993) report the high incidence of PFPS in the athletic population. According to Salem and Powers (2001) athletes who participate in sports involving jumping and running activities are at the greatest risk for developing patellofemoral related injuries. Blond and Hansen (1998), in review report that many recent studies undertaken amongst an athletic population have shown males and females to be equally affected by PFPS. The results of this study may thus be more applicable to these types of subjects rather than the classic profile reported by Tria et al. (1992). In this typically sporting population a scenario of overuse is most commonly present in PFPS (Davidson. 1993). This study supports this opinion.

5.3 Duration of Pain

Of the 20 subjects who participated in the study, 4 subjects presented with acute PFPS (i.e. less than 6 weeks). The remaining 16 subjects were all in the chronic phase (i.e. longer than 6 weeks) with most having suffered with the problem for years. This is in support of the opinion of Kannus et al. (1999), who state that once PFPS has begun it frequently becomes chronic and may force subjects to limit physical activity. According to Blond and Hansen (1998) the chance of becoming pain-free is significantly less when a history of more than 4 months was present. Therefore when a patient presents with such a history of pain a more active approach to treatment should be considered.

5.4 Objective Measurement: Isokinetic measurement in comparison to Normative Values

5.4.1 Peak Torque Values: Concentric Knee Extension

This measurement determines the maximum amount of torque (measured in Nm) produced by the quadriceps during knee extension, regardless of at what point in the range of motion this may occur.

Males: Statistical analysis revealed a significant weakness of the quadriceps femoris muscle in terms of peak torque values.
Females: Although the experimental group was 12% weaker than normative values (see Chapter 3), this weakness was not statistically significant. A larger

female sample size may have made weakness statistically significant. A more uniform sample may also have had this effect, as one subject in particular demonstrated far superior strength to any of the others. With a sample of only 5, these factors had an undoubted effect on the result.

It is possible that the loss of concentric quadriceps peak torque could have been caused by either quadriceps inhibition or by frank quadriceps weakness. However, more specific investigation is required to differentiate the cause of quadriceps weakness.

5.4.2 Peak Torque Values: Concentric Knee Flexion

This measurement determines the maximum amount of torque (measured in Nm) produced by the hamstrings during knee flexion, regardless of at what point in the range of motion this may occur.

<u>Males:</u> Analysis revealed a statistically significant weakness of the hamstring muscles in terms of peak torque values.

<u>Females:</u> Statistical analysis revealed that although an 18% hamstring weakness was present in the experimental group, the weakness was not statistically significant. A larger female sample size may have made weakness more statistically significant. A more uniform sample may also have had this effect, as one subject in particular demonstrated far superior strength to any of the others. With a sample of only 5 these factors had an undoubted effect on the result.

The reasons for the loss of concentric hamstring peak torque are unclear. However it can be speculated that it may be secondary to eccentric quadriceps weakness. This may cause the concentric hamstring weakness due to inhibition. This inhibition would prevent the hamstrings overpowering the weakened quadriceps as the quadriceps exert eccentric control of knee flexion.

5.3.3 Eccentric Hamstring to Concentric Quadricep Ratio

This ratio compares the peak torque values of eccentric hamstring contraction to peak torque of concentric quadricep contraction. The ratio should ≥ 100% as an ideal value (Wright. 2002).

Both males and females in the experimental group showed a statistically significant reduction in eccentric hamstring to concentric quadricep ratio. This indicates marked eccentric hamstring weakness in this sample. However whether this is true specifically in PFPS must be questioned as eccentric weakness may indeed be present among the general population. The ideal ratio may only be present in those who train properly in order to achieve the ideal ratio.

The mechanism behind eccentric hamstring weakness may be secondary to concentric quadriceps weakness. This may cause the eccentric hamstring weakness due to inhibition. This inhibition would prevent the hamstrings overpowering the weakened quadriceps as the knee is being controlled through extension.

5.4.4 Peak Torque Values: Eccentric Knee Flexion

This measurement determines the maximum amount of torque (measured in Nm) produced by the quadriceps while resisting knee flexion, regardless of the point in the range of motion that this may occur.

<u>Males:</u> Statistical analysis revealed a statistically significant weakness of the quadriceps femoris muscle in terms of peak torque values.
<u>Females:</u> Although the experimental group was 30% weaker than normative values, this weakness was not statistically significant. A larger female sample size may have made weakness more statistically significant. A more uniform sample may also have had this effect, as one subject in particular demonstrated

far superior strength to any of the others. With a sample of only 5, these factors had an undoubted effect on the result.

Once again the mechanism for quadriceps weakness is debatable and requires further, more specific, investigation. From this study it is not possible to determine whether eccentric quadriceps weakness is due to inhibition or due to frank weakness.

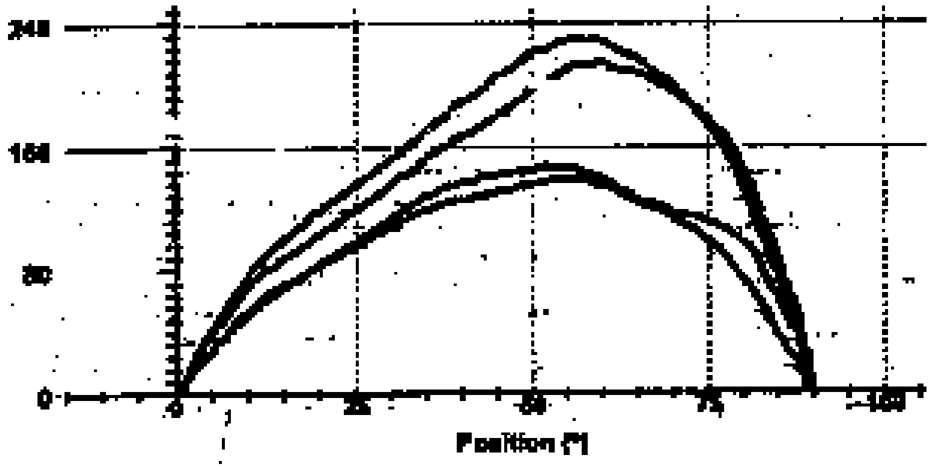
5.5 Subjective Analysis of the Torque Curve

5.5.1 The Concentric Quadricep Curve

Chan and Maffulli (1996:p12) identify the characteristic presence of dipping of the graph subsequent to the point of peak torque in the classic torque curve of PFPS. However this study has identified that more than one type of torque curve may exist for PFPS.

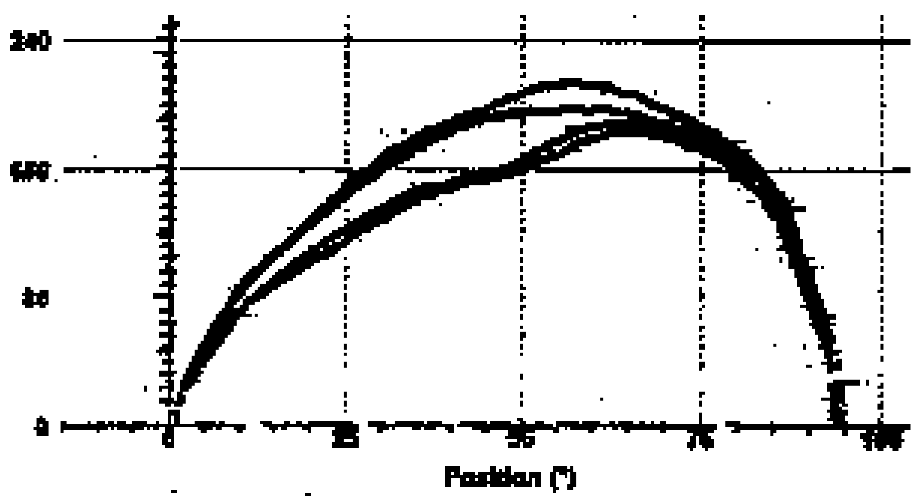
The most common type of graph in this study (11 of 25) shows a regular shape of the curve of the affected leg, but with a significantly decreased peak torque value in comparison to the other leg. In a significant number of these cases the possibility of substantial quadriceps inhibition exists rather than simple weakness. This is supported by the fact that very few of these subjects experienced any pain during testing. Other strong proponents of this theory are Powers, Landel and Perry (1996) who believe that a Quadriceps Femoris avoidance gait pattern may be present in PFPS indicated by subjects' anticipation of decreased muscular demand during loading. Total work and average power values were also reduced in these subjects due to the reduced ability of the quadriceps.

Fig. 5.1 Concentric Quadriceps Torque Curve- Decreased Peak torque



The second most common graph was the classic graph with characteristic dipping (8 of 25). This dipping occurred mostly in the range from 25-55 degrees of knee flexion. Such a dip in a torque curve had the effect of causing a deficit in total work values of the affected leg. The dipping through this range of motion may indicate the presence of quadriceps femoris component weakness. This would support the opinion of LaBrier and O’Neil (1993) who cite selective dysfunction or insufficiency of certain components of the quadricep. This however can only be investigated by other means.

Fig. 5.2 Concentric Quadriceps Torque Curve- Dipping Graph



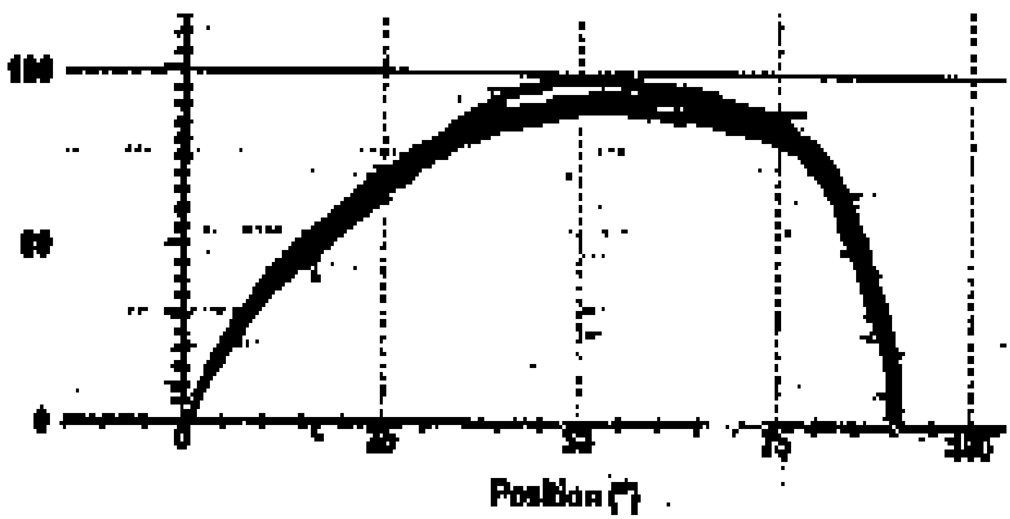
Such weakness does not exclude the presence of other concomitant causes of pain and careful examination is still neccesary in order to manage the syndrome.

It is possible that it is in this group that muscular timing differences are most likely to exist. Levels of pain may affect the timing of muscle activity. A possibility which seems to have been ignored by researchers since the work of de Andrade, Grant and Dixon (1965). It is not only the timing of quadriceps contraction that may be part of the problem in PFPS, but also the intensity of contraction of certain components of the quadricep that may be deficient.

Combinations of the above two graphs may occur.

The third type of graph (6 of 25) exhibited no significant deficiency or deviation from that which is seen as normal. It is the researcher’s opinion that this group of subjects would prove the most difficult to manage as it is far more difficult to identify the cause of PFPS in these subjects. In these subjects it is possible that patellofemoral pain may originate from passive support structures not loaded during isokinetic testing. An intimate knowledge of all the possible mechanisms of PFPS is required to identify and then treat the cause of the problem in such cases. The author believes that a situation of overuse or incorrect training may often be the precipitating factor in this group of subjects.

Fig. 5.3 Concentric Quadriceps Torque Curve- No Significant Deficiency



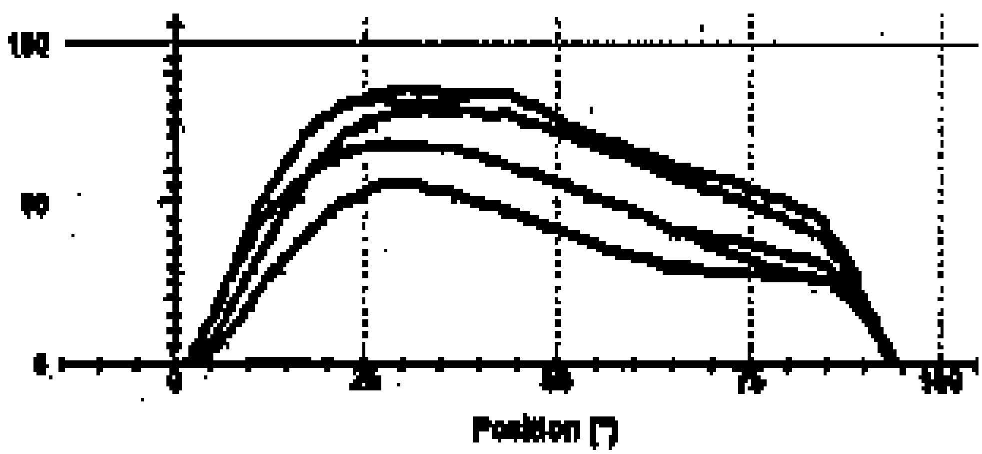
No other recognized curve shapes [eg. A “shut off” curve first reported by Hart et al. (1985)] were observed in this study.

It is recommended that in cases of inadequate improvement after treatment, clinicians should pay more attention to all possible aspects of the etiology of PFPS in each individual patient, and adjust protocols accordingly. This study indicates that in many subjects there is no significant quadriceps weakness (24%) or that weakness may be a secondary consequence of the other factors involved in the syndrome. This multi-factorial approach should always be adopted rather than attributing the problem to a single factor, such as quadriceps femoris weakness.

5.5.2 The Concentric Hamstring Curve

When compared to the "normal" leg, a deficient graph and decreased values for peak torque, total work and average power was present in just over half (13) of the subjects participating in this study.

Fig. 5.4 Concentric Hamstring Torque Curve- Deficient Graph



Reid (1992:p362) quotes a study by Kobler (1987), stating that absolute, or relative deficiency of the hamstring muscles can be seen in more than 80% of subjects with anterior knee pain when tested on an isokinetic dynamometer at 60 degrees per second, and more than 70% when tested at 240 degrees per second.

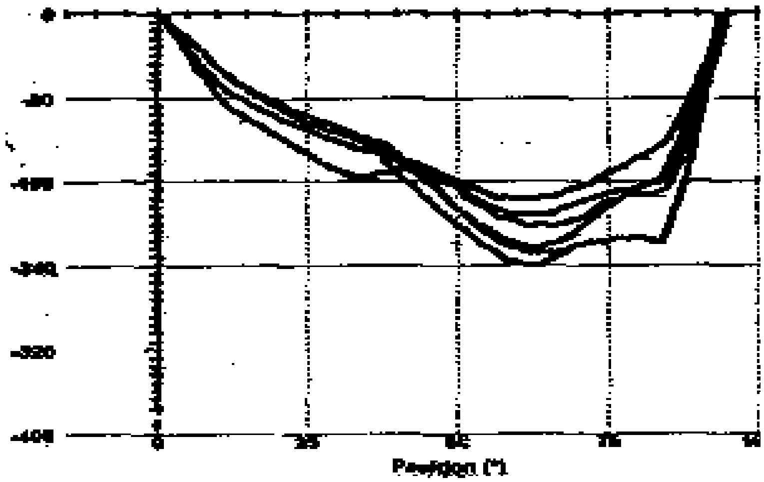
This study supports the findings Kobler and suggests that concentric hamstring weakness may play an important role in PFPS. It is proposed that this weakness may be secondary to eccentric quadricep weakness. However this is uncertain.

5.5.3 The Eccentric Quadricep Curve

A loss of peak torque, total work and average power was present in a large proportion of subjects (17 of 25) in comparison to the “normal” leg. This suggests the presence of weakness, either due to inhibition or simply due to frank weakness. Bennett and Strauber (1986) suggest that a loss of eccentric quadriceps torque may be specific to subjects with PFPS. They showed that a reduction in eccentric torque was particularly evident in the range of motion between 30-60 degrees. Dvir et al. (1990) demonstrated eccentric quadricep weakness at 60 degrees per second, as well as at 30 and 120 degrees per second. These two studies appear to be the only other studies to comment on eccentric muscle strength of the quadriceps in PFPS.

A number of subjects (10) demonstrated irregular eccentric curves indicating poor muscular control of knee flexion. This may provide reason for the fact that so many subjects experience pain on running downhill or walking downstairs. Irregular muscular control may create irregular patella movement in the femoral trochlea predisposing to PFPS. Walsh (1994:p1171) asked subjects to perform step up and step down tasks. In discussion, Walsh (1994:p1171) suggests that subjects with PFPS often lack muscular control, which in turn may produce pain in subjects with PFPS. Such activities demand a great deal of eccentric muscle activity.

Fig. 5.5 Eccentric Quadriceps Torque Curve- Irregular Graph



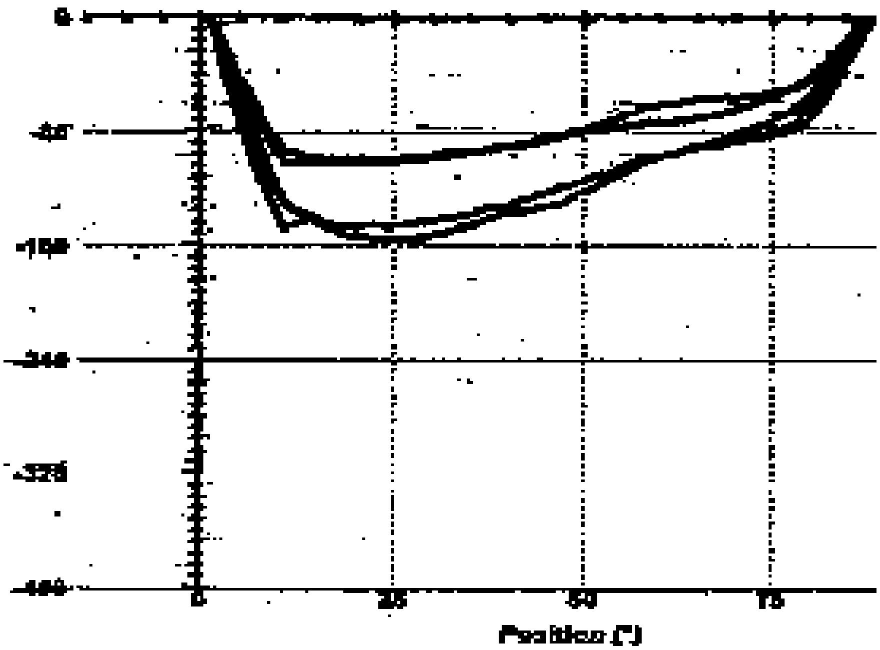
Further investigation of these eccentric phenomena is required to determine whether these observations are indeed true in PFPS.

Hart et al. (1985) determined the presence of a “break” curve in PFPS during eccentric contraction at slow test velocities (30 degrees per second). No such curves were observed during this study as the test velocity was 60 degrees per second. The break phenomenon is described as a perturbation in the curve which exceeded a drop of 10% or more. Concentric loads at 30 degrees/second are actually greater than eccentric loads at 60 degrees/second but concentric loads do not demonstrate breaks. Most breaks can be seen at 30 degrees/second. Lower test velocities than this tend to have exceedingly long exposures and hence the velocity relationship is more constant masking the break (http//www.isokinetics.net).

5.5.4 The Eccentric Hamstring Curve

A highly deficient graph showing a loss of peak torque, total work and average power was present in the overwhelming majority of subjects (20 of 25) in comparison to the “normal” leg. This study is highly suggestive of the presence of eccentric hamstring weakness in this sample, although statistical analysis was impossible due to the absence of normative data. Whether this weakness is a characteristic of PFPS needs to be questioned as this weakness may indeed be a characteristic in the general population. The ideal ratio may only be present in those who train properly in order to achieve the ideal ratio.

Fig. 5.6 Eccentric Quadriceps Torque Curve- Deficient Graph



Further investigation is required to confirm whether eccentric hamstring weakness is present in PFPS.

5.6 The Pain

5.6.1 Location of Pain

Bilateral involvement was present in 5 subjects (25%). Kannus et al (1999) found that 24% of patients reported having had symptoms in the contalateral knee at a 7 year follow up. This study seems to confirm this tendency toward bilateral involvement in PFPS. Wood (1998) believes that bilateral involvement may occur in up to 75% of subjects. In cases of unilateral involvement in this study, the right side was involved in 8 cases and the left in 7 cases. There was no correlation between the painful side and limb dominance.

5.6.2 Retropatella Pain

Retropatella pain is usually a presenting feature in subjects with PFPS (Davidson. 1993). No published research appears to be available reporting on the specific location of retropatella pain. During this study, retropatella pain was most frequently reported as being towards the superior pole (5 cases) or superolateral pole (4 cases) of the patella. Pain was also reported in relatively few cases as being towards the inferior, medial, inferolateral and inferomedial areas of the retropatella surface. Interestingly, 3 subjects reported no retropatella pain. In these subjects pain was most likely of extra-articular origin.

5.6.3 Peripatella Pain

Peripatella pain is similarly a common presenting feature in subjects with PFPS (Davidson. 1993) and is the most common predisposing factor to PFPS according to Kannus et al. (1999). As with retropatella pain, no research appears to be available reporting the specific location of peripatella pain. In this study, in cases of peripatella pain, a lateral location was most prevalent (8 cases) than any other peripatella location. Suprapatella (3 cases), medial (5 cases), and superolateral locations (2 cases) were also reported in relatively few cases. Five subjects reported suffering no peripatella pain. In these cases it is likely that pain was of articular origin.

5.6.4 Peripatella tenderness

Peripatella tenderness largely corresponded to the location of peripatella pain. The lateral retinaculum was most frequently tender, followed by the medial retinaculum. In PFPS the most important predisposing factor appears to be peripatella tenderness (Blond and Hansen. 1998) (Singerman, Davy and Goldberg. 1994).

5.6.5 Character of Pain

The character of pain was reported as being dull and aching by 6 subjects. An intermittent, sharp pain was reported by 7 subjects. Seven subjects reported the pain as being dull and aching at rest, and then sharp while performing aggravating activities such as running downhill, ascending or descending stairs, or squatting. This study shows a similar character of pain to that reported by Davidson (1993), who in review found that the pain is usually of a dull, aching nature, becoming sharp during activities that increase pressure over the patella.

5.7 Patella Mobility

Patella mobility was assessed using the same method as Kolowich et al. (1990) (see chapter 2). Normal symmetrical patella mobility was present in only 2 subjects.

Hypermobility of the patella was evident in 3 cases. In all cases this was due to retinacular insufficiency. Blond and Hansen (1998), in a 5.7 year follow up study, found that athletes with hypermobility of the patella had the least promising prognosis of all categories of subjects with PFPS.

Patella hypomobility was present in 15 subjects with restriction most commonly in the lateral to medial and medial to lateral directions. This is indicative of a tightened retinacular structure in these subjects.

This may indicate that a tightened medial or lateral retinaculum is most likely to be associated with PFPS in the sporting population. Imbalances in retinacular tension are said play a role in the abnormal biomechanics of the development of PFPS (Sakai et al. 2000).

A positive movie goer's sign corresponded to the presence of a tight lateral retinaculum in a large number of cases with 7 subjects with peripatella pain showing correlation. This is supportive of the opinion of Blond and Hansen (1998), who claim that a tight lateral retinaculum is more likely to be associated with a positive movie goer's sign.

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5.8 Anatomical Abnormalities

5.8.1 Tibial Rotation

External rotation of the tibial tubercle relative to the inferior pole of the patella was present in 3 subjects. According to Sakai et al. (2000) several anatomical factors may contribute to patella instability or maltracking. These include malposition of the tibial tubercle.

5.8.2 Patella Position

Patella alta (high riding patella) was present in 1 subject. Singerman, Davy and Goldberg (1994) state that patella alta predisposes to malalignment of the extensor mechanism. This is because the patella is late in engaging the femoral trochlea during knee flexion.

5.8.3 Pronation

a) Hindfoot Pronation

Heel-leg alignment was used to assess for hindfoot pronation. Mild hindfoot Pronation was noted in 4 subjects.

b) Forefoot Pronation

Feiss Line was used to assess for forefoot pronation.
First degree forefoot pronation was present in 6 subjects.
Second degree forefoot pronation was present in 6 subjects.
No third degree forefoot pronation was noted.

Hyperpronation of the foot has been identified as predisposing factor in PFPS (Blond and Hansen. 1998) (Singerman, Davy and Goldberg. 1994). According to Popagelopolous and Sim (1997) prolonged or excessive foot pronation results in excessive internal rotation of the tibia, which concentrates stress on the peri-articular soft tissues around the knee and produces anterior knee pain.

5.8.4 Iliotibial Band Tightness

Associated iliotibial band (ITB) involvement was noted in 2 subjects. The ITB is often tight in subjects with PFPS and has strong attachments to the lateral patella through the lateral retinaculum (Post. 1998). Variations in ITB attachment may be associated with the development of PFPS because of its strong attachment to the lateral retinaculum (Sakai et al. 2000).

5.9 Hamstring Flexibility

Less than below average hamstring flexibility (<70°) was present in 3 cases. Below average hamstring flexibility (70°-80°) was noted in 4 cases. Eight subjects had average hamstring flexibility (80°-90°). Four subjects had above average hamstring flexibility (90°-100° and one subject was greater than above average (>100°). This finding supports the opinion of Davidson (1993) and Kobler (1987) who state that hamstring tightness may play a role in PFPS. Rowlands (1999) found that 33% of subjects with PFPS had hamstring tightness in a study conducted at the same clinic as this study. Rowlands assessed flexibility by attempting to extend the knee with the hip flexed to 90 degrees. Kobler (1987) found that only 20% of subjects had hamstring tightness. No mention is made of how this was assessed.

5.10 Comparison to Previous Research

Callaghan et al. (2000) conducted a reliability study on the Biodex system 2 isokinetic dynamometer, using a multiple joint attachment. He tested 20 healthy subjects and 16 subjects with PFPS (average age 29.6 years) for knee flexion and extension strength at an angular velocity of 90 degrees per second. In addition to proving the high reproducibility of testing when using the unit, they showed that the PFPS group was significantly weaker than the control group when comparing isokinetic peak torque values for concentric knee extension

($p = 0.012$). The data was analyzed using the independent T-test. Although this study used a multiple joint attachment at a different test velocity, the results regarding concentric quadriceps femoris weakness showed a similar loss of peak torque values as was present in this study.

Dvir et al. (1990) conducted a study to determine the extent of quadriceps femoris weakness in PFPS in terms of peak quadriceps torque, for both concentric and eccentric modes of contraction. Twenty healthy subjects and 55 PFPS subjects performed isokinetic tests at test velocities of 30, 60 and 120 degrees per second. Results showed a significant 30-40% reduction in quadriceps strength in the experimental group ($p< 0.01$) that was neither speed nor mode-specific. These findings are consistent with those of this study.

Bennet and Strauber (1986) measured eccentric quadriceps torque at several points in the range of motion among 130 subjects with various problems causing knee pain. Of these subjects, 41 demonstrated suppression in torque production during eccentric exercise at a test velocity of 30 degrees per second. The level of significance of this weakness was as follows: $p < 0.05$ at 35 and 60 degrees; $p < 0.01$ at 40, 45 and 50 degrees. These subjects fitted the criteria for what the researchers called "anterior knee pain syndrome". This is one of the alternative terms for PFPS. Subjects with other known knee pathologies (eg. meniscal tears) showed no significant reduction in torque. The conclusion drawn was that poor motor control was a likely cause of PFPS, and that proper training could be used to bring about proper function. The results of this study suggest a similar conclusion.

CHAPTER 6
CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

This study confirms the presence of both concentric and eccentric quadriceps femoris weakness, in terms of peak torque values, at an isokinetic test velocity of 60 degrees per second. Among males, a 26% loss of peak torque was present for concentric knee extension and a 21% loss of peak torque was present for eccentric knee flexion. Among females a 12% concentric weakness was present with a 30% eccentric weakness.

While frank quadriceps weakness may be a plausible reason for loss of peak torque, it is also possible that this loss of peak torque may occur secondary to a partial neurological inhibition of the quadriceps muscles. This may explain the lack of pain experienced by subjects while performing maximal effort isokinetic repetitions (which were expected to be painful). This may have occurred because the nervous system had been "programmed" to avoid the possibility of pain caused by maximal quadriceps contraction.

Graphical analysis showed the presence of three distinct types of concentric quadriceps curves. The most common graph showed a regular shape with a decrease of peak torque. This indicates obvious quadriceps weakness and my support the theory of pain avoidance due to partial quadriceps inhibition.

The second most common curve showed a dip between 25°-55°. This type of graph supports the opinion that selective dysfunction of components of the quadriceps may be a cause of weakness. However this study clearly demonstrates that this is not always the case in PFPS. Partial inhibition may also have played a role in the attenuation of muscular force through specific parts of the range of motion, thus causing the dip in the graph.

The third most common graph exhibited no significant deficiency or deviation from what would be considered normal. In these subjects it is possible that patellofemoral pain may originate from passive support structures not loaded during isokinetic testing.

Analysis of the eccentric quadriceps curve is suggestive of either inhibition or frank weakness as discussed previously. Also evident is a lack of muscular control demonstrated by the irregularity of isokinetic curves. This may play a role in PFPS by creating irregular patella movement in the femoral trochlea when the quadricep is called upon to contract in an eccentric manner.

Further research is required in this field as this study was not designed to identify the mechanism of quadriceps femoris weakness.

While this study was not originally intended to be concerned with the hamstring muscles, the data gathered made analysis possible. This data confirms the presence of concentric hamstring weakness and is highly suggestive of eccentric hamstring weakness in terms of peak torque values.

A 12% loss of concentric peak torque was present in males with an 18% weakness in females. Eccentric hamstring torque was analyzed by comparison to concentric quadriceps torque. A 16% deficiency of eccentric hamstring to concentric quadricep ratio was present in males and a 45% deficiency was present among females.

Whether hamstring weakness is a cause or a consequence of PFPS is unclear from this study. It is suggested that hamstring weakness occurs secondary to quadriceps weakness as a result of neurological inhibition to prevent the hamstrings overpowering its antagonist in the initiation and control of knee movements. Graphical analysis raises similar questions with regard to the presence of frank or inhibitory weakness.

Hamstring involvement may play a role in PFPS through the poor eccentric control of knee extension. However questions must be raised as to whether presence of eccentric hamstring weakness is a characteristic finding in PFPS. As explained previously, this finding may indeed be present in the general population.

Further, more specific, investigation of concentric and eccentric hamstring strength is indicated by this study.

6.2 Recommendations

At present the body of normative data for isokinetic testing is very small and quite difficult to access. Peak torque values for concentric knee flexion and extension appear to be the only two parameters for which there are norms at most test velocities. Studies need to be conducted to accurately determine normative data for both concentric and eccentric modes at all testing speeds and for all isokinetic parameters. Such studies should be conducted in a standardized manner so that research can be conducted using identical protocols, enabling comparisons to be made. Such data, when determined should be divided into categories to enable homogeneity in comparison (eg. Normal, sporting, elderly etc.). The absence of such protocols provided a great obstacle to the use of norms in this study.

A larger sample should be considered for studies such as this. This would ensure that conclusions drawn are accurate and improve statistical validity, and thus would avoid a type II error. However budget considerations and the cost of using outside facilities was a limiting factor in this study.

The age group criteria should be expanded to include young adolescents as this is the age group among whom PFPS is most common (Tria et al. 1992). It was under recommendation of the research ethics committee that minors were excluded from this study.

The method of sampling could have been modified to attract a sample more representative of the population suffering from PFPS. Methods used in this study appear to have attracted a sample that is decidedly more athletic and more male predominant compared to what previous research suggests is ideal.

Studies could be conducted on both acute and chronic PFPS separately as the two groups may have characteristics that differ from one another and will therefore require specific treatment and rehabilitation goals. For example in chronic PFPS a shortened or lengthened retinaculum is probably more likely to be present and may require specific attention.

An effort should be made to accurately determine the extent of quadriceps femoris muscle inhibition that may be present in PFPS. The possibility of weakness existing due to inhibition, secondary to pain in the patellofemoral joint or peripatella tissues exists. It is important to determine whether this is so or whether frank quadriceps femoris weakness is present, as it will affect both treatment and rehabilitation protocols for the condition.

More rigorous evaluation of eccentric muscle weakness is undoubtedly indicated in PFPS. The role of poor muscular control in this condition is yet to be properly evaluated.

The investigation of concentric and eccentric hamstring weakness and tightness in PFPS is also indicated by this study. Hamstring involvement may play a role in PFPS through the poor control of knee extension.

Electromyographic testing (with the aid of normalized data) could be used as an adjunct to isokinetic testing in order to determine the timing of quadriceps femoris muscle contraction. This would help confirm or refute the much debated role of timing delays in combination with isokinetic measurement of the magnitude of weakness.

Closed chain kinetic exercise could be used to assess the presence of muscular weakness. This may be a better indicator of functional capacity than the open chain nature of testing used in this study. This is because subjects with PFPS most commonly complain of pain during weight bearing activities.

Patella mobility studies need to be carried out in order to determine the presence of tightened or incompetent retinacular structure and the role that it plays in PFPS.

Different treatment and rehabilitation protocols could be evaluated by the use of isokinetic dynamometry to test outcomes of each protocol and then comparing these outcomes to determine which protocol brings about the best functional result.

Radiological evaluation could be used to assist in the identification of certain anatomical predisposing factors that are said to predispose to PFPS. Once again a limited budget curtailed the use of such evaluations in this study and other means ere used to determine the presence of abnormalities as best as possible.

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APPENDICES

APPENDIX A
Recruitment Flyer

Do you have

Pain around or under your Knee cap?

Are you between age 18-60

You may qualify for research being conducted at Durban Institute of Technology

CHIROPRACTIC DAY CLINIC

FREE TREATMENT

is available on completion of the study

For more information contact:

Stuart

031-2042205 or **031-2042512**

APPENDIX B
Recruitment Flyer

Do you have pain around or under your knee cap?

You may suffer from

RUNNER'S KNEE

and may qualify for research being conducted at Durban Institute of Technology

CHIROPRACTIC DAY CLINIC

FREE TREATMENT

is available on completion of the study

The study includes FREE Isokinetic Testing

For more information contact:

Stuart

031-2042205 or **031-2042512**

APPENDIX C
Telephonic Interview Question Sheet

Inclusion Criteria:

Are you between the ages of 18 and 60?
Is the pain you are experiencing coming from underneath or around the knee cap?
Do any of the following exacerbate your pain:

- squatting,
- stair climbing,
- kneeling,
- prolonged sitting.

Exclusion Criteria:

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

- traumatic patella dislocation,
- any neurological problem causing a gait abnormality,
- have you undergone any knee surgery over the past 2 years,
- a meniscal tear,
- injury causing ligamentous instability,
- abnormalities indicative of osteoarthritis, osteochondritis dessicans or loose bodies.

Are you, or could you be pregnant or breast-feeding at the moment?

APPENDIX D
Case History Form

TECHNIKON NATAL CHIROPRACTIC DAY CLINIC
CASE HISTORY

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:**...................................

All Conditions met in Visit No.:...

To be signed into PTT:...

Signature:.. **Date:** ....

Signed off:...

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. xrays
- Environmental Hazards (Home, School, Work)
- Exercise and Leisure
- Sleep Patterns
- Diet
- Current Medication
  Analgesics/week:
- Tobacco
- Alcohol
- Social Drugs

7. **Immediate Family Medical History:**

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

8. **Psychosocial history:**

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

9. **Review of Systems:**

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

DURBAN INSTITUTE OF TECHNOLOGY 22/10/2002

A PENDIX E
Relevant Physical Examination Form

PHYSICAL EXAMINATION
SENIOR & RESEARCH

Patient:______________________________ **File#:**____________ **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

COMMENTS

NEUROLOGICAL EXAMINATION: See regionals

Clinician: **Signature:**

APPENDIX F
Knee Regional Form

KNEE REGIONAL EXAMINATION

Patient: ______________________ File No:: ________ Date: ________
Intern / Resident: ______________________ Signature: ______________________
Clinician: ______________________ Signature: ______________________

OBSERVATION:

- General:
  - posture and gait ______________________
  - skin (scars, bruises) ______________________
  - swelling / bony enlargements ______________________
- Anterior:
  - genu varum / valgum ______________________
  - patella position ______________________
  - tibial torsion ______________________
  - symmetrical extension ______________________
- Lateral
  - genu recurvatum ______________________
  - patella alta / baja ______________________
  - symmetrical extension ______________________
- Posterior:
  - swelling ______________________
- Seated:
  - patella position ______________________
  - tibial tubercle ______________________
  - tibial torsion (toe-in / toe-out) ______________________

PALPATION:

Anterior :

- patella - base, apex, pre-patella bursa ______________________
- retinaculum, cartilagenous surface ______________________
- patella tendon, infrapatella bursa, fat pad, tibial tuberosity ______________________
- quadriceps tendon, suprapatella pouch ______________________
- quadriceps and sartorious ______________________

Medial:

- MCL, medial joint line, pes anserinus ______________________

Lateral:

- LCL, lateral joint line, TFL, ITB, head of fibula ______________________

Knee flexed 45° + 90°:

- joint line, tibial plateaux, menisci, femoral condyles ______________________
- adductor tubercle and adductor muscles ______________________

Posterior:

- Popliteal artery ______________________
- Lateral
  - lateral meniscus, arcuate popliteus complex ______________________
  - lateral head gastrocnemius, biceps femoris ______________________
- Medial
  - medial meniscus, posterior oblique ligament ______________________
  - medial head gastroc, semimembranosis, semitendonosis ______________________

ACTIVE MOVEMENTS:

- Flexion (0-35°) ____________
- Extension (0-15°) ____________
- Medial rotation (20-30°) ____________
- Lateral rotation (30-40°) ____________

PASSIVE MOVEMENTS:

- Flexion (tissue approximation) ____________
- Extension (bone to bone) ____________
- Medial rotation (tissue stretch) ____________
- Lateral rotation (tissue stretch) ____________

RESISTED ISOMETRIC MOVEMENTS:

- Flexion (neutral, int rot, ext rotation) ____________
- Extension (0°, 30°, 60°, 90°) ____________
- Medial rotation ____________
- Lateral rotation ____________
- Ankle plantarflexion ____________
- Ankle dorsiflexion ____________

FUNCTIONAL TESTS: ____________

JOINT PLAY MOVEMENTS

- P-A / A-P movement of tibia on femur ____________
- Medial / lateral translation of tibia on femur ____________
- Long-axis distraction of tibio-femoral joint ____________
- Patella movement (sup-inf, med-lat) ____________
- P-A / A-P movement of superior tib-fib joint ____________

LIGAMENTOUS ASSESSMENT:

- <u>One-plane medial instability</u> (valgus stress)
  - extended ____________
  - resting position ____________
- <u>One-plane lateral instability</u> (varus stress)
  - extended ____________
  - resting position ____________
- <u>One-plane anterior instability</u>
  - Lachman (0-30°) ____________
  - anterior draw (90°) ____________
- <u>One-plane posterior instability</u>
  - posterior sag sign (90°) ____________
  - posterior draw (90°) ____________
- <u>Antero-lateral rotary instability</u>
  - Slocum ____________
  - Macintosh (lat. pivot shift) ____________
- <u>Antero-medial rotary instability</u>
  - Slocum ____________
- <u>Postero-lateral rotary instability</u>
  - Houghston's drawer ____________
- <u>Postero-medial rotary instability</u>
  - Houghston's Drawer ____________

TESTS FOR MENISCAL PATHOLOGY:

- McMurray ____________________
- Bounce-Home ____________________
- Anderson's Grind ____________________
- Apley's ____________________

PLICA TESTS

- Mediopatellar plica ____________________
- Plica stutter ____________________
- Houghston's Plica ____________________

SWELLING

- Brush / stroke test ____________________
- Patella tap test ____________________

TESTS FOR PATELLO-FEMORAL PAIN SYNDROME

- Clarke's sign ____________________
- Waldron test ____________________
- Passive patella tilt ____________________

OTHER TESTS:

- Wilson's test (osteochondritis dessicans) ____________________
- Fairbank's test (dislocated patella) ____________________
- Noble compression test (ITB friction) ____________________
- Quadriceps contusion test ____________________
- Leg length ____________________

NEUROLOGICAL:

- Reflexes - Patella (L3/4) R __________ L __________
  - Medial hamstring (L5/S1) R __________ L __________

- Dermatomes L1 ________ L2 ________ L3 ________ L4 ________ L5 ________
  S1 ________ S2 ________

RADIOLOGICAL EXAMINATION:

____
____
____

DIAGNOSIS:

____
____
____

MANAGEMENT PLAN:

____
____
____
____

APPENDIX G
Research Patient Questionnaire

Name:
Patient no.:
Clinic File no.:

Age:
Height:
Weight:
Gender:

Runner: Yes / No Distance per week:
Other physical activity:
Acute trauma:
Recent injection of Corticosteroids:
Uni/bilateral problem: Involved side:
Charectar and frequecy of pain:

Are the following painful

Retropatellar Pain:
Peripatellar Pain:
Stair Ascent:
Stair Descent:
Worse with Increased Activity:
Prolonged sitting:
Deep squatting:
Sense of insecurity/ Giving way:
Catching while extending knee:
Crepitus:
Effusions:

Orthopaedic Tests

Peri-patellar tenderness:
Clarke's test:
Waldron's test:
Craig's test:
Tibial torsion:
Patella rotation:
Leg-heel algnment:
Forefoot-heel alignment:
Patella mobility:
Hamstring flexibilty: NRS score:

APPENDIX H
Letter of Information

Dear Participant

Title of research project: The presence and extent of quadriceps femoris weakness in individuals with patellofemoral pain syndrome (also known as Runners' Knee).

Name of supervisor: Dr. B. Kruger (031-5649091)

Name of student: Stuart Clifton (031-2042205)

Name of institution: Durban Institute of Technology

Welcome to this study

This study involves research on 20 patients, testing whether people with a condition commonly known as Runners' Knee have any weakness in their Quadriceps Femoris (thigh) muscle.

You are required to undergo an initial examination at the Chiropractic Day Clinic, followed by 2 testing sessions at Kings Park Sports Medicine Centre, all within a period of 2 weeks and at no charge. The initial consultation will take approximately an hour and a half with the testing sessions taking approximately half an hour.

The initial consultation will include a history taking, relevant physical examination and knee regional examination. You will then undergo 2 Isokinetic strength tests no more than 1 week apart. This testing is relatively low risk, however you may experience some muscle soreness subsequent to the test.

You are asked not to change any lifestyle habits or take any medication for the period of participation in the study, as this may affect the results of the research.

Two free treatments are offered with 5th year interns at the Chiropractic Day Clinic subsequent to the completion of your participation in the study.

All patient information is confidential and the results will be used for research purposes only, although relevant authorities may be required to inspect records. You have the right to be informed of any new findings which are made. Your participation in this clinical trial is free of charge and your participation is voluntary. You may drop out at any stage without any adverse consequences and, if required, the researcher is entitled to end your participation in this trial at any stage. You have the right to access a knowledgeable person (my supervisor on the above number, or any other authority in this field: phone numbers of such authorities will be available through the researcher or the supervisor) other than the researcher and if required you may make a complaint to the Durban Institute of Technology Research Ethics Committee.

Thank you for participating.

Yours faithfully,

Stuart Clifton
(Chiropractic Intern)

APPENDIX I

Informed Consent Form

Date.......................................

Title of research project: The presence and extent of quadriceps femoris weakness in individuals with patellofemoral pain syndrome (also known as Runners' Knee).

Name of supervisor: Dr. B. Kruger (031-5649091)

Name of research student: Stuart Clifton (031-2042205)

Name of institution: Durban Institute of Technology

This study involves research on 20 patients, testing whether people with a condition commonly known as Runners' Knee have any weakness in their Quadriceps Femoris (thigh) muscle.

Please circle the appropriate answer

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

PATIENT/SUBJECT* Name_________________________ Signature________________
(in block letters)

WITNESS Name____________________________________ Signature________________
(in block letters)

RESEARCH STUDENT Name________________________ Signature_______________
(in block letters)

If you have answered NO to any of the above questions, please do not hesitate to contact my supervisor who will be able to assist you.
Please ensure that the researcher has adequately explained each of these questions to you.

NOTICE FOR EU: DECLARATION OF CONFORMITY

MET

Declaration of Conformity

Application of Council Directive(s): 73/23/EEC

Standard(s) to which Conformity is Declared: **IEC 601, including Amendment 1 and European Group Deviations**

Manufacturer's Name: **Cybex**

Manufacturer's Address: **2100 Smithtown Ave., P.O. Box 9003, Ronkonkoma, LI, NY 11779**

E.U. Representative: **Proxemed Medizitechnik GmbH**

E.U. Address: **Geltingerstrasse 14E, Wolfratshausen 82515 Germany**

Type of Equipment: **Physical Therapy "Testing and Rehabilitation System"**

Model No: **"NORM"**

Issue Date: **August 9, 1996**

I, the undersigned, hereby declare the equipment specified above conforms to the above Directive(s) and Standard(s)

PLACE:	Cybex International, Inc. Ronkonkoma, NY	**SIGNATURE:**	
Date:	August 20, 1996	**FULL NAME:**	Robert A. Coleman
		POSITION:	Quality Control

APPENDIX K
Calibration Logs

Speed Calibration

Date:10-02-2002 Time:08:35:06

Speed Slope: 1052 Speed Intercept: 464

	Reading1	Reading2	Reading3	Reading4
First Pt.	3884	3878	3887	3880
Second Pt.	20471	20470	20456	20457

Verification Results

	VReading1	VReading2	VReading3	VReading4
First Pt.	1555	1553	1553	1555

Calculated Speed: 29.6 Minimum Speed: 28.5
Maximum Speed: 31.5

	VReading1	VReading2	VReading3	VReading4
Second Pt.	6278	6276	6276	6283

Calculated Speed: 119.58 Minimum Speed: 118
Maximum Speed: 121.2

	VReading1	VReading2	VReading3	VReading4
Third Pt.	15714	15726	15714	15725

Calculated Speed: 299.4 Minimum Speed: 297
Maximum Speed: 302

Date:10-07-2002 Time:12:10:30

Speed Slope: 1052 Speed Intercept: 568

	Reading1	Reading2	Reading3	Reading4
First Pt.	3887	3884	3884	3885
Second Pt.	20470	20471	20472	20481

Verification Results

	VReading1	VReading2	VReading3	VReading4
First Pt.	1558	1557	1557	1557

Calculated Speed: 29.65 Minimum Speed: 28.5
Maximum Speed: 31.5

	VReading1	VReading2	VReading3	VReading4
Second Pt.	6276	6278	6278	6276

Calculated Speed: 119.56 Minimum Speed: 118

Maximum Speed: 121.2

	VReading1	VReading2	VReading3	VReading4
Third Pt.	15728	15716	15709	15719

Calculated Speed: 299.39 Minimum Speed: 297
Maximum Speed: 303

Date:10-15-2002 Time:08:43:25

Speed Slope: 1052 Speed Intercept: 112

	Reading1	Reading2	Reading3	Reading4
First Pt.	3881	3882	3884	3878
Second Pt.	20474	20476	20483	20477

Verification Results

	VReading1	VReading2	VReading3	VReading4
First Pt.	1568	1569	1567	1567

Calculated Speed: 29.84 Minimum Speed: 28.5
Maximum Speed: 31.5

	VReading1	VReading2	VReading3	VReading4
Second Pt.	6276	6280	6285	6281

Calculated Speed: 119.61 Minimum Speed: 118
Maximum Speed: 121.2

	VReading1	VReading2	VReading3	VReading4
Third Pt.	15709	15730	15729	15706

Calculated Speed: 299.39 Minimum Speed: 297
Maximum Speed: 303

Weight Calibration

Date:10-02-2002	Time:08:31:37	
Calibrated CW W	Slope CW	Constant C
152	277	0
Calibrated CCW CW	Slope CCW	Constant C
152	275	0
Date:10-07-2002	Time:12:08:26	
Calibrated CW W	Slope CW	Constant C
152	276	0
Calibrated CCW CW	Slope CCW	Constant C
151	274	0
Date:10-15-2002	Time:09:41:05	
Calibrated CW W	Slope CW	Constant C
151	276	0
Calibrated CCW CW	Slope CCW	Constant C
152	275	0