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**PHYT 752**

**Final Research Paper**

PICO question: In 18-35 year old women with patellofemoral pain, would a four-eight week regimen of hip strengthening be more effective than a four-eight week regimen of quadriceps strengthening in relieving pain?

**Introduction**

 Patellofemoral pain syndrome (PFPS) is one of the most common causes of knee pain with a higher incidence in women than in men1,2,9 and a higher prevalence in people who are very physically active1,5. In a recent study of 724 females between the ages of 18-35, the prevalence of anterior knee was found to be 12-13%, although previous studies have found it to be closer to 25%9. It has been reported that 20-40% of all physical therapy visits are due to knee pain and it is the most common injury in runners2.

There are many factors that lead to the insidious development of PFPS symptoms2 and it is often considered a multifactorial condition with no distinct cure1. Some theories of etiology include impairments of the quadriceps muscle1, biomechanical causes such as abnormal femoral transverse and frontal plane movements3,7 including dynamic malalignment in single leg stance through hip adduction and internal rotation 1,2,3. There are other theories in literature including poor proximal neuromuscle control2,7 and/or weakness of the hip musculature1,2,3,6,8, lateral malalignment of the patella potentially caused by atrophy of the vastus medialis oblique muscle (VMO)4,5 or delayed onset of the VMO compared to the vastus lateralis (VL)8, abnormal patellar tracking5,6,8, and decreased patellofemoral joint contact area5. With regards to hip muscle weakness as the main etiology, it is also questioned whether such weakness is the actual cause or the result of PFPS6.

There are also many daily activities that are associated with producing symptoms of PFPS and the pain that accompanies these tasks often limits participation in activities of daily living (ADLs) and sports. These activities include ascending and descending stairs1,2,3,4,6,7,8, squatting1,2,3,4,6,7,8, kneeling1,3,4,6,7,8, hopping/jumping1,3,4, prolonged sitting1,2,6,7,8, and running1,4. These commonly provocative activities are often part of the inclusion criteria for studies dealing with subjects who present with PFPS, which also includes isometric knee extension contraction at 60° of knee flexion3, and pain on palpation of the medial and/or lateral facet of the patella1,3,8 or with compression of the patella1,8.

There has been an abundance of research performed on evaluating the many interventions for PFPS, including quadriceps strengthening, generalized lower extremity strengthening, patella taping, and foot orthotics7. Quadriceps muscle impairment was historically thought to be the main link to PFPS1 and the cause of abnormal patellar tracking6, with quadriceps strengthening being the most common conservative treatment for PFPS8. The VMO is often targeted during rehabilitation programs, as it is believed to maintain medial stabilization and tracking of the patella during knee extension4. The VL pulls the patella laterally during knee extension, and the irregular timing of activation of the VMO and VL has also been proposed as the cause of abnormal patellar tracking8.

More recently, researchers have focused on the proximal strength deficits of the hip external rotators and hip abductors1,2,3,6,7,8. This weakness may cause an increase in hip internal rotation8 causing a decrease in patellofemoral contact area3 caused by lateral patella tilt and displacement7. It also may create an increased valgus force vector at the knee8 caused by hip adduction increasing the Q-angle6. To generalize, the weakness of hip abductors and hip external rotators results in dysfunctional lower extremity alignment during functional activities and has been determined to potentially lead to the development of PFPS1.

The purpose of this review is to summarize the current literature to answer the following clinical question: In 18-35 year old women with patellofemoral pain, would a four- eight week regimen of hip strengthening be more effective than a four- eight week regimen of quadriceps strengthening in relieving pain? The results of this clinical question will assist physical therapists in determining the optimal intervention strategy that is efficient and effective for patients who present with symptoms of PFPS.

**Quadriceps Strengthening**

In a prospective independent group comparison by Chiu et al.5, subjects with and without PFPS were tested to determine the effect of weight training on the patellofemoral joint contact area and lower-limb muscle strength. The 8-week program focused on leg press and knee extension exercises, and the PFPS group showed improvements in knee extension strength, patellofemoral joint contact area, and decrease in pain and increase in function as established by the Numeric Pain Rating Scale (NPRS) and by the Kujala Patellofemoral Scale (KPS)5. Two other studies by Song et al.4 and Bolgla et al.8 used a similar subjective pain rating scale for their studies, the Visual Analog Scale (VAS). The study by Chiu et al. concluded that strengthening the quadriceps muscle by both open and closed kinetic chain movements over an 8 week period created better patellar tracking and joint stability, with decreased pain and increased function due to the stronger knee extensors5. However, they also recommended the hip musculature to be considered in future studies since hip strengthening may have been the cause of the increase in patellofemoral joint contact area5.

 Although this study did not specifically examine the VMO, many other studies have used this muscle as their focus. A cross-sectional study conducted by Boling et al.8 utilized a 6-week rehabilitation program of progressive weight-bearing exercises focusing on quadriceps strengthening, gluteus medius strengthening, and lower extremity neuromuscular control. The subjects with PFPS had an earlier VL onset than VMO activation, resulting in a laterally tracking patella during stair stepping8. After completing this 6-week program, the subjects with PFPS had an earlier activating VMO than their VL (normalized to healthy subjects) which pontentially improved their patellar tracking8. The 6-week program decreased pain according to the VAS and increased function determiend by the Functional Index Questionnaire (FIQ)8. Another study focusing on the VMO by Song et al.4, investigated the role of added hip adduction to strengthen the VMO (since it is connected to the adductor magnus and longus muscles) to promote a more balanced VMO/VL ratio to maintain ideal tracking of the patella4. The 8-week program consisted of leg press training, with the conclusion that hip adduction did not change results4. The results of both groups did promote VMO hypertrophy, improved knee function as determined by the Lysholm Scale and decreased pain according to the VAS4. It is expected that hip adduction did not add further benefit to the results, given that weakened hip abduction resulting in increased hip adduction is commonly proposed as a factor in PFPS1,2,3,6,7,8.

**Hip Strengthening**

 There have been many more articles recently on the concept of hip strengthening for PFPS or the combination of hip and quadriceps strengthening to alleviate symptoms associated with this diagnosis. Isolated hip abductor and external rotator strengthening for females between the ages of 23-35 with PFPS was examined in an RCT by Khayambashi et al.7 over an 8-week training program. The VAS was once again used and produced evidence of decreased pain in the subjects who received the treatment over the placebo group7. The exercise group also exhibited an improvement in self-reported health status as determined by the WOMAC7. These improvements were retained after 6 months7 in the exercise group. These researchers promoted the idea that hip strengthening alone improved symptoms of PFPS long-term, and this type of intervention should strongly be considered for the female population in this age group with the diagnosis of PFPS. The theory that impaired hip muscle strength can affect patellofemoral joint kinematics and kinetics in different planes has been examined in a multitude of studies, and is contradicted by some.

While evidence suggests that excessive hip internal rotation and adduction, caused by weakness of hip abductors and external rotators, contributes to patellofemoral joint stress, a study by Bolgla et al. provides evidence that challenges this idea6. A group of females were recruited in a cross-sectional study to compare hip strength and hip and knee kinematics during stair descent in subjects with no obvious cause of PFPS, except for overuse, to matched controls6. The subjects with PFPS did have lower hip abduction and external rotation strength than the controls, but did not have excessive hip adduction, hip internal rotation, or knee valgus angle during stair descent compared to controls6. The results suggest that although there is an association between hip weakness and PFPS, it is unclear whether hip weakness is the cause or the result6.

 A case series single-cohort observational study looking into the same population by age and gender explored the effect of a proximal stability program focusing on progressive core and hip strengthening and improving dynamic malalignment2. Earl et al. discovered that through an 8-week program that increased hip abduction and external rotation strength and core endurance, pain was decreased (determined by the VAS) and function improved as detected by the self-reported Anterior Knee Pain Scale (AKPS)2. As discussed previously, whether hip weakness is the cause or the result, hip strengthening has been revealed in many studies to decrease pain and improve function in those with symptoms of PFPS.

**Direct comparison of the two interventions**

Two RCTs were reviewed that compared the differences between the two types of interventions for females with PFPS. A study by Fukuda et al.3 focused on sedentary women with PFPS to determine if adding hip-strengthening exercises to a traditional knee exercise program for four weeks would produce better long-term outcomes. Both groups had decreased pain, according to the NPRS, and improved function as indicated by the AKPS and Lower Extremity Functional Scale (LEFS) after 3 and 6 month follow-ups3. The knee and hip exercise group had significanly better function and less pain at the 3 and 6 month follow-ups over the other group, and also maintained these improvements at 12 months unlike the knee-only exercise group3. This is important information for long-term results of rehabilitation programs to avoid recurrence of PFPS.

 With the same purpose but different approach, Dolak et al.1 compared the effects of hip strengthening to quadriceps strengthening for four weeks prior to weight-bearing exercises for another four weeks in the treatment of females with PFPS. The investigators utilized the commonly seen assessements for this population, the VAS and LEFS, and determined the hip strengthening group had a decrease in pain faster than the quadriceps strengthening group1. Unlike the study by Bolgla et al.6, the researchers in this study state that the posterolateral hip musculature can contribute to the dynamic valgus alignment of the lower extremity during daily activities1.

**Limitations of the evidence**

 There were many limitations regarding the studies reviewed in terms of weaknesses in sample size, lack of a control group, unknown contributing factors to the diagnoses, and no long-term follow-up to name a few. Four of the eight studies reviewed were RCTs, with two performing long-term follow-up investigations. There was a lack of follow-up information at 6 months in the study by Khayambashi7 and the Fukuda3 study did not control or monitor whether the subjects performed their rehabilitation exercises during the 1-year follow-up. Long-term changes were not determined in the RCTs by Dolak1 and Song4. The majority of the studies had a small sample size and only one article (Fukuda et al.3) justified the sample size. The investigators explained the calculations based on detecting a 10-point difference in the LEFS based on an MCID of 9 points, and a sample size of 20 women per group being justified for this study3. Dolak1 also used the LEFS and only had a sample size of 13 per group, without justification. There was only a control group in half of the studies reviewed. Many of the studies had inclusion criteria to include pain during particular provocative activities, with no specific etiology for the diagnoses of PFPS. This is a limitation of the studies, although reasonable, considering the complexity of the causes for PFPS-related symptoms, and the continued misunderstanding of its etiology. PFPS has been described as “an orthopedic enigma” by an orthopedic surgeon in the Bolgla6 article.

**Need for further research**

 Due to the complicated and misunderstood etiology of the commonly diagnosed PFPS, there is a need for continued research on the optimal rehabilitation program to improve impairments and reduce recurrence. There is evidence that both quadriceps and hip strengthening programs improve function and decrease pain in patients with PFPS. The duration of comprehensive rehabilitation programs, specific exercises and precautions, and long-term follow-up requires much more investigation. Although hip strengthening has an overwhelmingly positive outcome in the articles studying this intervention, the question remains as to whether this will resolve the symptoms related to PFPS. As the dilemma is posed in the Bolgla6 article, it is uncertain whether hip weakness is the cause or the result of PFPS. If it is the result, then the underlying issues have potential to remain even after the hip musculature is strengthened.

**Conclusions**

 PFPS is a diagnosis with an unknown etiology and is one of the most common causes of knee pain in patients with a wide range of physical activity. There is a need for further research to determine the most effective rehabilitation program to ensure long-term results. This may include isolating a muscle group, or strengthening the involved lower extremity in general along with core endurance. It has not been determined through the studies reviewed if strengthening particular muscles in the lower extremity has potential to cause additional pain and/or dysfunction. According to current evidence, strengthening the quadriceps and hip musculature both produce positive results for patients with PFPS. This will be the foundation of my capstone project in determining the ideal rehabilitation program for women between the ages of 18-35 with PFPS.

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