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Bilateral Patellofemoral Pain Syndrome and the Effects of Physical Therapy in the Outpatient Setting: A Case Study

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BILATERAL PATELLOFEMORAL PAIN SYNDROME AND THE EFFECTS OF PHYSICAL THERAPY IN THE OUTPATIENT SETTING: A CASE STUDY

By

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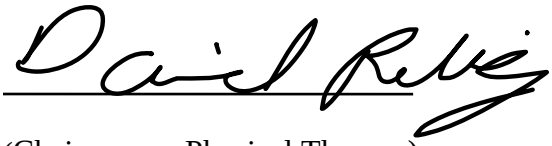
(Graduate School Advisor)



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Signature Paige Mriden

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Abstract

Background and Purpose: Patellofemoral pain syndrome (PFPS) is characterized by musculoskeletal-related knee pain localized to the anterior retropatellar and/or peripatellar area of the knee. This case study describes the physical therapy management of bilateral PFPS. The results can be used to understand examination, evaluation, and interventions to treat PFPS. **Case Description**: The patient was a 76-year-old female that reported progressive pain in both knees. She demonstrated weak hip abductors and extensors, tenderness upon palpation to bilateral pes anserine, bilateral ITB, and bilateral medial joint line with increased lateral tibial torsion on the left and a positive Hamstring 90-90 test. **Intervention:** Therapy emphasized functional hip and knee targeted exercises in weight bearing and non-weightbearing positions. Exercises included strengthening and stretching of the lower extremities that would facilitate the patient's return to prior level of function. **Outcomes:** Upon discharge, the patient had increased hip and knee strength bilaterally, decreased pain, and improved her functional mobility as indicated by her decrease in disability score on the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC). **Discussion:** Interventions aimed at increasing posterolateral hip musculature and improving functional mobility However, more research must be done regarding specific modes of exercise in order to develop and distinguish the best treatment protocol for PFPS.

CHAPTER I

BACKGROUND AND PURPOSE

Patellofemoral pain syndrome (PFPS) is a clinical diagnosis that is characterized by an insidious onset of musculoskeletal-related knee pain localized to the anterior retropatellar and/or peripatellar area of the knee.[1] It has been estimated that 126.6 million Americans suffer from a musculoskeletal disorder, adding a burden onto the economy at an estimated cost of $213 billion through healthcare and sickness absence annually.[2] According to Crossley et al[3] knee pain is the second most prevalent musculoskeletal condition. Patellofemoral pain (PFP), which is sometimes referred to as anterior knee pain, is one of the most common forms of knee pain with a prevalence noted between 15% to 45%.[4] PFPS affects the general population, trained athletes, young active adults, and the elderly. Currently, there is no gold standard to clinically diagnose or treat PFPS. Variations in populations assessed, inconsistencies in diagnosis criteria, lack of high quality evidence on which to base assessment, and lack of any gold standard contribute to the differences reported for incidence and prevalence of PFPS.[5]

These inconsistencies may be contributed to the varying degree of signs and symptoms each patient presents with. Symptom onset may be traumatic or develop slowly with a worsening of pain during physical activities such as squatting, sitting with flexed knees, and ascending and descending stairs.[6] Literature discussing PFPS collectively states that there is no one specific cause of PFPS, but one of the most commonly accepted hypotheses of the cause of PFP is due to abnormal patellar tracking which increases patellofemoral joint (PFJ) stress and causes

subsequent wear on the articular cartilage.[7] Factors contributing to the cause of knee pain may be direct trauma, faulty patellar tracking, joint degeneration; soft tissue length and strength imbalances in the hip, knee, or ankle/foot; or a combination of factors.[6]

By identifying underlying problems as local, distal, and/or proximal factors, the physical therapist can more easily organize and identify etiologic factors to facilitate treatment interventions.[8] Local structures that may contribute to PFP include those around the knee joint itself, such as the infrapatellar fat pad, quadriceps tendon, ligaments, subchondral bone and retinaculum. Subluxation or dislocation of the patella, as well as painful biomechanical malalignment due to a weak vastus medialis obliquus (VMO) are examples of local factors with malalignment. Soft tissue lesions (tendonitis, bursitis, friction), osteochondritis dissecans of the patella, osteoarthritis, and apophysitis are examples of local PFP without malalignment.[6,8]

Proximal factors are those that arise from the hip and pelvis region. Witvrouw et al[9] reports women who have PFPS generally have greater hip adduction ROM. A substantial number of studies have also revealed that individuals with PFP pain demonstrate increased hip adduction as well as internal rotation during weight-bearing activities that involve knee flexion such as squatting, ascending or descending stairs, or landing from a jump.[6]

Biomechanical or imbalanced muscles of the foot make up distal factors that may be contributing to PFPS. The patient may demonstrate an externally rotated foot in standing, delayed rearfoot eversion during walking and running, and rearfoot eversion at heel strike.[6,8]

Studies have identified the female gender as being a factor for developing PFPS.[7,11] More specifically, DeHaven and Lintner12 have found that PFPS is also diagnosed at a higher frequency in female athletes when compared to male athletes. Evidence suggests that females

with PFP are also found to have hip weakness, particularly with isometric strength training.[1,13] Souza and colleagues[14] found that females with PFPS had decreased strength of hip extensors and abductors, along with increased hip internal rotation during movement tests such as step downs, a drop-jump, and running, but no increase in hip adduction.Conversely, Bolgla and colleagues[15] did identify weakness of hip abductors and external rotators, but no evidence of abnormal hip kinematics during stair descent. When considering the interdependence that may exist between the knee and more proximal or distal regions of the body, it is important to realize these studies represent associations—not a cause and effect relationship.[6]

Due to the typical presentation of a progressive, insidious onset of symptoms, diagnosis is often delayed, and describing the typical clinical course can be difficult.[1] Historically, PFPS diagnoses have been made based off detailed objective and subjective assessments, including presence of pain on special tests including the patellofemoral compression test, palpation of the patella, and pain during resisted knee extension.[5] Since many patients with PFP will reduce or withdraw from their aggravating activity, it is likely that these methods of diagnosis may be under-estimating the true incidence or prevalence rates.[10] Diagnoses must be based on a cluster of signs and symptoms only after ruling out other pathoanatomic diagnoses while attaining a detailed history and complete examination.[1,6]

Prognosis for PFPS with non-surgical treatment is uniformly good.[16] Typically, resolution of symptoms may occur between a time period of four to six weeks.[17] There are few long term studies on prognosis and outcomes of PFPS. However, two studies have found that seventy-five to eighty-five percent of patients with PFPS who were instructed in a home exercise program reported successful outcomes.[17.18] In a prospective follow- up study of 179 patients with PFPS, Collins et al[19] found that long symptom duration was the most consistent predictor of poor

outcome over fifty two weeks when rated on the Kujala Patellofemoral Score and the Functional index Questionnaire. Additionally, a low KPS score at baseline was predictive of poorer outcome at six, twelve and fifty-two weeks, irrespective of their age, gender, and morphometry.These results suggest that strategies should be aimed at preventing chronicity in more severe PFPS in order to optimize outcomes.[19]

Nonoperative treatment is most commonly used to treat PFPS, and physical therapy is the first line of choice for conservative intervention. The lack of specific understanding of the etiology and pathology of PFPS and its resulting dysfunctions is reflected by the numerous treatment options that can be provided by physical therapists. Interventions provided by the physical therapist involve strengthening of lower extremity musculature and performance of functional exercises in order to more easily complete activities of daily living (ADLS) and improve quality of life. Strengthening exercises may target local muscles such as the quadriceps and hamstrings, or proximal and distal muscles such as those of the hip and ankle. Current Clinical Practice Guidelines (CPG) for PFPS suggest that the combination of hip- and knee-targeted exercises are preferred over solely knee-targeted exercises to optimize patient outcomes.[1] These exercises include traditional and non-traditional variations of quadricep sets, straight leg raises, short-arc quads, hip abduction, and hip extension in both closed-chain and open-chain positions, as well as concentric, eccentric, and isometric components. Functional exercises include single leg step up/down, gait training, stair training, and specifically transferring from sit to stand without collapsing of the knee inward, also known as knee valgus (See Figure 1).

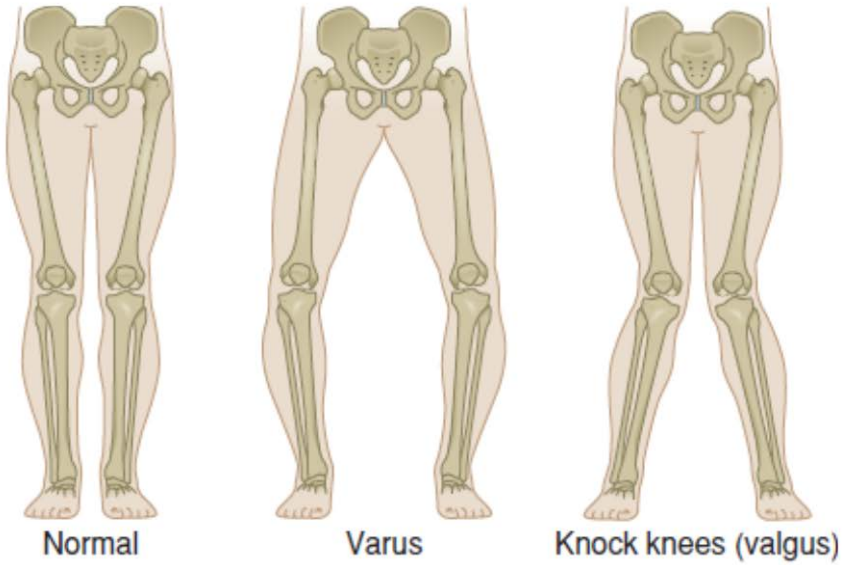


Figure 1. Limb malalignment in the frontal plane: excess stress across the lateral compartment of the knee results in valgus.[20]

This case study focuses on the non-operational management of bilateral PFPS aimed at increasing bilateral hip and knee strength in a patient with knee osteoarthritis. The lack of any gold standard to both diagnose and treat PFPS has created opportunities to compare and contrast methods used throughout this case study, to current CPG guidelines and suggestions in literature. The purpose of this case study is to describe the evaluation, diagnostic, and intervention techniques used as well as analyze the role of physical therapy services in an outpatient setting in the treatment of PFPS. This case study aimed to demonstrate that physical therapy can improve lower extremity strength, range of motion, and quality of life after physical therapy intervention, and has suggested that physical therapy can lead to decreased overall medical costs and risk of future injury.

CHAPTER 2

CASE DESCRIPTION

The patient is a seventy-six year old female who had been suffering from knee pain for four months prior to initial evaluation. She had been diagnosed with osteoporosis of both knee joints three years prior, but reported that this knee pain “felt different”. Her chief complaint was pain in her knees while squatting. She was retired, but remained active by riding her bike, volunteering as a janitor at the church, and mowing the lawn. She lives alone in her two story home that requires four steps to enter, with access to a handrail. The patient reported that she utilizes a grab bar near the shower and stool and has had no falls at home or in the community. According to the patient, she is reluctant to access the second floor basement due to the pain in her knees.

Prior to physical therapy, the patient had one injection to the right knee several years ago which did provide short term relief. The short term relief is consistent with findings in a recent systematic review that found intra-articular cortisone injections are more beneficial than placebo with respect to pain reduction (standardized mean difference [SMD] -0.40, 95% CI -0.58 to -0.22) as well as functional improvement (SMD -0.33, (5% CI -0.56 to -0.99), yet these improvements only lasted less than 6 months, and decreased over time.[21] Chiropractic care helped to relieve some pain but did not have lasting effects. Although sometimes painful, she remained active and reported that she iced intermittently at home, applied topical pain relieving ointments, and still had no success. No oral pain medications were taken.

The patient had no prior surgical history and her medical history was as follows: hypertension, high cholesterol, acid reflux, thyroid dysfunction, and osteoarthritis. Medications that directly influence physical therapy care include diltiazem and atorvastatin. Diltiazem is used to treat hypertension and angina which can result in adverse side effects of dizziness as a result of postural hypotension and reflex tachycardia. Atorvastatin lowers cholesterol and triglycerides levels in the blood yet can also produce a rare but serious side effect of rhabdomyolysis.[22] The physical therapist must be aware of a progression of low blood pressure over a period of two weeks as well as proximal musculoskeletal pain and flu like symptoms. No psychological health conditions were noted. Family medical history was negligible with no reports of osteoarthritis or other pertinent medical conditions with the exception of her father who had hypertension but was well controlled by medications.

Following the history and subjective assessment, the patient was deemed appropriate to receive physical therapy intervention. The patient demonstrates behavioral risk factors that may contribute to success in physical therapy including: active lifestyle, non-smoker, does not use drugs or alcohol, and has social and family support from church community and her daughter. Examination was then performed to assess the patient's strength, range of motion (ROM), and posture in order to determine the primary impairments so that a comprehensive and effective intervention plan could be established.

Examination

The patient was able to walk independently and safely to the examination room without use of an assistive device and reported that she is independent in all functional activities of daily living. Upon observation of gait she demonstrated decreased trunk rotation and increased out-toeing of right lower extremity. In standing, the patient demonstrated mild "grasshopper eye" position of the patella on the left, meaning that the patella is located more superior and lateral than normal. There was increased tibial torsion on the left as compared to the right and genu valgus was evident in the right knee. Although genu valgus during dynamic movements such as a step down have been linked to PFPS[6], Park and Stefanyshyn[23] report that static genu valgus is not predictive of PFPS.

When performing systems review, there were no complications to the neurological system. Cardiopulmonary complications were managed by hypertension medication and there were no musculoskeletal impairments other than the patient's osteoarthritis and chief complaint of pain. Upon examination of the integumentary system there was slight bruising around the right knee joint, which the patient attributed to kneeling while performing her janitorial duties. She also reported chronic swelling of bilateral knee joints that were approximately equal side to side. The patient also demonstrated lower extremity edema bilaterally. Vital signs were not taken for this patient during initial evaluation or following sessions.

On a scale of 0-10 (0 = no pain, 10 = worst pain ever experienced), the patient rated her pain 4/10 in both knees. The patient reported an increase in pain after ascending and descending stairs, but it has since improved. At best, her pain is 1/10 and at its worst is 5/10. She described the pain as a "pull from the knees and upward," that was terribly noticeable when going from a

sit to stand and during long periods of sitting. A retrospective review of 4 separate studies including 459 total participants found that 54.4 percent of persons with PFPS reported increased knee pain with prolonged sitting.[24] Cook et al[25] reports that pain with prolonged sitting is found to have moderate diagnostic accuracy, suggesting that its presence may be a diagnostic indicator for PFP. Furthermore, Cook[25], along with Nunes et al[26] have determined that the most accurate diagnostic clinical test for PFP is reproduction of pain with squatting, such is the primary complaint of this patient. The test has a high -LR of .10 to .20 (95% CI: 0.1, 0.4), indicating that when there is a negative test, the probability of PFPS being present is decreased.

Next, the physical therapist assessed strength and range of motion (ROM) of the lower extremities and palpated soft tissue structures. Active range of motion (AROM) of the hips and knees were assessed with a goniometer in a supine position on the examination table and were within normal limits as reported by Van Ost.[27] Knee and ankle strength were tested with resisted isometrics in a sitting position at the edge of the table. Hip strength was tested in this same position for hip flexion, in a side-lying position for hip abduction, and prone for hip extension. Hip adduction was not tested during his case, for no known reason. Nonetheless, various authors have suggested that hip weakness may be an impairment associated PFPS, with weak hip abductors and external rotators being associated with poor eccentric control of femoral adduction and internal rotation during weight-bearing activities.[7]

Lower extremity strength of the hip, knee, and ankle were as follows. (See Tables 1, 2, and 3)

Table 1. Initial Hip Strength

	Right	Left
Flexion	4+/5	5/5
Extension	4+/5	4-/5
Abduction	4+/5	4-/5

Table 2. Initial Knee Strength

	Right	Left
Flexion	5/5	5/5
Extension	5/5	5/5

Table 3. Initial Ankle Strength

	Right	Left
Ankle Dorsiflexion	5/5	5/5
Ankle Plantarflexion	5/5	5/5

Special tests were performed for the knee and hip to test specific structures and musculature. The Thessaly test at twenty degrees of knee flexion was negative and ruled out meniscal pathology. Karachalios et al[28] found that performance of this test at twenty degrees of knee flexion had 94 percent detection of tears in the medial meniscus, 96 percent detection in lateral meniscus, and had a low rate of false-positive and false-negative recordings.

The Thomas Test and Modified Thomas test were negative for decreased flexibility in the rectus femoris or iliopsoas muscles or both. Neither the original test nor the suggested variation have ever been substantiated for reliability, sensitivity, or specificity.[29] However, the

patient was tender to palpation bilaterally along the iliotibial tract. The patient also reported tenderness to palpation near medial hamstring tendons, pes anserine, and bilateral medial joint line. One study aimed to investigate if differences exist in lower extremity muscle strength and soft tissue length between patients with PFPS and those without. Results concluded that patients with PFPS demonstrated significantly less flexibility of the gastrocnemius, soleus, quadriceps, and hamstrings compared to control subjects.[30]

The Hamstring 90-90 test (active knee extension test, AKE) was positive bilaterally, indicating shortened hamstrings. Sensitivity and specificity for the AKE test has been found to have high reliability for intra-rater agreement (ICC = .86 - .99) and moderate inter-rater reliability (ICC = .76 - .89).[31]

Evaluation, Diagnosis, Prognosis

After excluding medical conditions that require referral of the patient to a physician (tumors, dislocation, fracture, septic arthritis) the physical therapist and student physical therapist (SPT) ruled out other musculoskeletal conditions that could be causing anterior knee pain. Differential diagnoses should not only consider those conditions localized to the knee itself, but conditions located proximal and distal to the knee that may refer pain to the knee, including lumbar radiculopathy, peripheral nerve entrapment, or hip osteoarthritis (OA).[1] Upon examination, these conditions were ruled out as the patient had no presenting neurological signs or symptoms or signs of hip (OA).

The anterior retropatellar region of knee may also have musculoskeletal conditions other than PFP that cause knee pain based on the anatomical site.[32,33] Patellar tendinopathy, also known as jumper's knee, can be differentiated from PFPS by pain specifically located over the patellar tendon, tenderness to direct palpation of the patellar tendon, and pain that is aggravated by activities that require higher rates of knee extensor loading, such as jumping.[34] When considering the patient's age and history, as well as participation activities and physical examination test, patellar tendinopathy was ruled out. The patient did not present with pain directly to the patellar tendon nor participates in activities that require knee extensor loading. There was no reported history of patellar instability but was confirmed negative with the patellar apprehension test. There was no facial or verbal expression of apprehension when the physical therapist applied a lateral glide of the patella, a typical response that would have resulted in a positive apprehension test.[35] Tibial apophysitis (Osgood-Schlatter lesion) and Patellar apophysitis (Sinding-Larsen-Johansson disease) were ruled out as these conditions typically

present in adolescents with presence of tenderness to palpation over the tibial tubercle or inferior pole of the patella.[36,37]

Differential diagnoses were excluded and evaluation of the patient's initial subjective and objective symptoms, as well as examination findings were found to be consistent with the physical therapy diagnoses of PFPS.[1] The impairments in structure and function were as follows: pain in the retropatellar region, altered lower extremity alignment with increased knee valgus during non-weight bearing and weight bearing activities, weakness of the hip external rotators, abductors, or extensor muscles, decreased flexibility of the tensor fascia latae, ITB, and hamstrings (See table 4.)

Table 4. Problem list

Problems
• Pain • Decreased hip strength (abduction, extension, flexion) • Decreased flexibility of hamstrings • Tenderness to palpation • Postural malalignment

Due to these impairments, the patient has limited her activity and participation in various settings. The International Classification of Functioning (ICF) is a disablement model that demonstrates how the patient's health condition relates to her following impairments. (See Appendix 1.) She is unable to complete janitorial work at the church that involves functional movements such as squatting, kneeling, and ascending and descending stairs. There is decreased performance in her ADL's such as cleaning the house, doing the laundry, and mowing the lawn.

For leisure she enjoyed riding her bike to the local coffee shop, but has not done so lately. Due to the inability to maintain prolonged knee flexion because of pain, the patient is unable to attend weekly church services due to the pain in her knees.

The physical therapist determined the clinical presentation of this patient as evolving/changing, and the clinical decision making as moderate, resulting in classification of a moderate complexity evaluation according to APTA's tiered evaluation and reevaluation CPT guidelines for determining complexity and corresponding CPT code.[38] By utilizing the Guide to Physical Therapy Practice, this patient was placed in Pattern 4B: Impaired posture, and Pattern 4C: impaired muscle performance. These practice patterns include impairments of body structures and functions such as the inability to tolerate prolonged sitting, muscle imbalance, muscle weakness, decreased functional work capacity, and the inability to perform repetitive work tasks.[39] More specifically, the patient was diagnosed with ICD-10 code M22.2x9 Patellofemoral disorders, unspecified knee.[40]

The prognosis was deemed to be good, the patient had the potential to reach established goals as reflected by her initial strength measurements and her high motivation (as verbalized to the physical therapist). The plan of care (POC) and the patient's goals were expected to be met within approximately four weeks. Goals for this patient include increasing hip strength, decreasing pain, decreasing tone in pes anserine, and decreasing or eliminating tightness in suprapatellar area.

Short term goals revolved around patient education on diagnosis and prognosis, understanding of self-symptom management strategies such as correct icing technique, and understanding of the home exercise program of strengthening and stretching. Due to the POC

being scheduled for approximately 4 weeks, specific short-term goals were not developed; only long term goals were developed in detail.

Long term goals discussed and set with the patient were as follows: increase left hip abduction and left hip extension to a manual muscle test of 4/5 and increase right hip abduction and right hip extension to a manual muscle test of 5/5 as compared to initial evaluation. Another long term goal, and most important to the patient, is that she will be able to report 0/10 pain in bilateral knees with daily functional activities including sit to stand transfers and/or squatting so that she may return to prior level of function including biking and volunteer work. (See appendix 2.)

Following conclusion of examination and evaluation, the patient still remained an appropriate candidate for physical therapy intervention. Interventions will consist of increasing bilateral hip strength and decreasing tightness in pes anserine. The patient's goals were focused on returning to her normal activities of daily living (ADLs) and increase tolerance to activity during volunteering activities such as standing and squatting. Adaptations to the exercise interventions were anticipated as necessary based on patient response and progress.

CHAPTER 3

INTERVENTIONS

Interventions chosen for this patient included traditional and functional hip and knee strengthening and stretching exercises as well as weight bearing and non-weight bearing exercises. This method is consistent with CPG for PFPS that prefer hip- and knee- targeted exercises over solely knee-targeted exercises[1]. While neither weight-bearing nor non-weight-bearing knee targeted therapy demonstrates superiority compared to one another in the short, medium and long term, Herrington and Al-Sherhi[41] have reported equivalent reductions in pain and improvement in function at 6 weeks in those who completed a weight-bearing vs non-weight bearing exercises. Even more important, both exercise groups had better outcomes compared to control.[41] The goal of hip, thigh, and lower extremity strengthening and stretching exercises is to address specific muscle performance deficits, movement coordination deficits, and mobility impairments.[1] Combined interventions consist of 3 or more adjunctive interventions such as foot orthoses, manual therapy, patellar taping, and exercise therapy.[1] Due to the variability in etiology and presentation of PFPS, combined interventions are often used. However, based on signs, symptoms, and examination, it was determined that orthoses, manual therapy, and patellar taping were not appropriate for treatment of this patient.

Physical therapy interventions were performed twice a week, Mondays and Wednesdays for approximately 45-60 minutes each session. At the start of the first treatment session, the patient performed a supine butterfly stretch and a sideling IT band stretch to decrease tightness in

the muscles contributing to knee pain. Evidence does not support the use of stretching over exercise in the treatment of PFPS but CPG recommends that lower extremity stretching is a part of the comprehensive plan of care.[1] Muscles to be stretched in PFPS include the hamstrings, quadriceps, gastric, soleus, and iliotibial band.[1] The butterfly stretch consists of the patient in supine with heels together and bent knees that slowly open and lower towards the mat table. The ITB stretch was completed by having the patient on her side with the leg to be stretched abducted and extended over the top of the other leg. Each stretch was held for 20 seconds with a 30 second rest in between for a total of 3 sets each.

Although the patient's initial knee strength was measured to be 5/5 for flexion and extension, the patient performed variations in quadriceps sets to help maintain proper patellar tracking and knee strength. Quadricep sets were performed in supine with a bilateral 20 second contraction and 10 repetitions. Long- arc quads were performed in a seated position. The patient sits on the edge of the mat table with knees and hips creating a 90 degree angle, the patient straightens out her knees and holds the contraction at the top for 10 seconds and 20 repetitions.

Exercises for hip musculature included side-lying hip abduction, incline hip extension, and mini-squats. The side-lying hip abduction exercise was performed in order to strengthen the patient's right and left hip abductors. In side-lying, the patient straightens one leg and raises it into the air while maintaining alignment with shoulder, hip and ankle. The patient held this position for 5 seconds and completed 15 repetitions. Randomized controlled trials (RCT) have compared exercises that target posterolateral hip musculature such as side-lying hip abduction, to knee-targeted exercises focusing on the quadriceps. All three RCTs reported that hip-targeted exercises resulted in more favorable outcomes in pain and function compared to quadriceps exercises.[42,43,44] Bilateral incline hip extension was performed for 20 repetitions to target the hip

extensors standing at an elevated mat table. This exercise was completed in standing because she was too weak to perform proper technique in a prone position. For proper technique, verbal and tactile cues were utilized so that the patient maintained only hip extension, not lumbar extension.

Partial or mini squats, were performed with use of the parallel bars. This closed chain exercise was included in order to further promote the patient's dynamic control of the knee and hip while improving neuromuscular control and balance. The patient held onto the bar with both hands and after instruction and demonstration by the physical therapist, she slowly descended into a partial squat by driving her hips backward for one set of twenty repetitions. Postural education on biomechanics to prevent overload of the PFJ during squatting became a consistent part of treatment during exercise interventions. The patient was consistently instructed to keep her knees pointing slightly outwards and to keep them in line with her ankle to correctly load the PFJ. For example, verbal cues such as "sit back into a chair" were used to facilitate correct direction of hip and knee movement. The physical therapist placed her hands just outside of the knee joint as a tactile cue to prevent knee valgus.

During the second week of treatment the number of repetitions and sets for exercises mentioned previously remained the same, but adjustments were made while performing min-squats. A green TheraBand was placed just proximal around the patient's knees to facilitate lateral hip musculature and prevent knee valgus. Addition of the TheraBand reduced exacerbation of her pain. Tenderness in pes anserine and medial joint line had begun to decrease, which the physical therapist verbally suggested was a sign of decreased tightness in hamstrings, tensor fascia lata, and ITB. Additional functional exercises including single leg step up/down and stair training were performed. Single leg step ups were implemented to improve lower extremity strength and balance because the patient is often maneuvering up and down a variety of surfaces

to reach objects in her janitor's closet. Ayotte et al[45] has reported greater than 40% maximal voluntary contraction (MVC) in gluteus medius and gluteus maximus during performance of forward step ups. These alternating step ups were performed by stepping onto a solid wooden box approximately six inches in height with emphases to prevent knee valgus during the eccentric step down phase. Step ups were progressed in future weeks to ascending and descending stairs in the hospital hallway. This exercise was performed at the end of the treatment session to promote increased endurance so that the patient is able to safely ambulate stairs in the future when she is tired during work.

The third week of treatment sessions began with the patient warming up for 10 minutes on the Nu-Step machine at a resistance of level 3. This was incorporated to mimic the patient riding her bike. Long-arc quads and side-lying hip abduction were progressed by adding a 1.5 lb. ankle weight and completing 1 set of 20 repetitions bilaterally. The patient was now able to perform prone hip extension for 1 set of 20 repetitions with verbal cues to keep pelvis flat. Monster walks and side-lying clamshells were introduced to further strengthen glutes and lateral hip musculature. A red TheraBand (RTB)was placed around her ankles during monster walks to add an external rotation component to the hips. She was instructed to take as big and wide of steps as she could while keeping the resistance between her feet (See Figure 2). Placing the band around the lateral aspect of the ankle was consistent with findings of electromyography (EMG) evidence that revealed a significant increase in gluteus medius and gluteus maximus activation when the band is moved from just above the knee to the ankles.[46] Side-lying clamshells were performed by having the patients hips and knees in a flexed position. She was then asked to lift her top knee and squeeze her glutes while keeping her ankles together. Hip external rotation and

abduction occur simultaneously. The patient performed 1 set of 20 repetitions with a RTB at the knees.

Figure 2. Demonstration of lateral monster walks with resistance band.[47]

Current literature suggests variations about the efficiency of clamshells to activate the gluteus medius vs the external rotators and or gluteus maximus. Clamshells performed with 30 degrees of hip flexion have demonstrated gluteus medius MVC greater than 40% whereas clamshells performed with hip flexion of 60 degrees produced less than 40% MVC.[45] However, when comparing various gluteus medius exercises that did produce a MVC greater than 40%, the clamshell at 30 degrees hip flexion was last on the list and generated the same gluteus medius contraction during exercises such as the sideways hop, transverse hop, transverse lung, forward hop and forward lung.[6] Gluteus maximus performance for both clamshell variations of hip flexion produced less than 40% of a MVC.[45] It might be of importance to note that side-lying hip abduction generated the strongest gluteus medius MVC over 40%, and tied with gluteus

maximus activation for MVC under 40% with clamshell at 60 degrees of hip flexion.[6] Due to the nature of external rotation and hip abduction that occurs simultaneously with clamshells, it could be possible that this exercise directly targets external rotators more than it does the gluteus medius, a hip abductor. A systematic review completed in 2015 also found that the majority of both side-lying and standing variations of hip abduction achieved greater glute med activation (>60% MVC) compared to clamshell exercises.[48] However, further research is warranted to assess activity of external rotators during clamshell performance.

The volume (sets x reps x weight) for each exercise increased throughout the physical therapy plan of care. Weight was adjusted more often rather than increasing the number of reps or number of sets. When comparing high volume to low volume knee targeted exercises such as quad sets, long arc quads, and mini-squats Østerås et al[49] reported greater short- and medium-to-long-term reduction in pain and improvements in function during step-down exercise (3 sets of 30 or more repetitions, 3x a week for 1 weeks) compared to unweighted knee-targeted exercises at a low volume (3 sets of 10 repetitions, 3 times a week for 12 weeks). However, additional research is needed to make a clear recommendation regarding high-versus low-volume knee-targeted exercise therapy because the cited evidence was from a single cohort that lacked a control group.[49]

The final treatments during week four focused on continued progression of exercise and discussion and review of proper form as the patient prepared for discharge from physical therapy. Resistance of side-lying hip abduction, prone hip extension, and seated leg extension were increased to 2 lb. ankle weights and resistance in clamshells and monster walks increased from a red band to a green band. At that time, the patient reported that she felt “85% better”

since starting physical therapy and had no pain other than when performing a sit to stand from an especially low surface.

After each treatment session, including initial evaluation, the patient was provided with a home exercise program (HEP) that was consistent with what was being done in therapy. The HEP included typed directions from the facilities' home program software, images, as well hand written notes specified for our patient which included cues, adaptations to make at home, and more specific instructions where necessary. Modifications were made each week as necessary based on patient response.

Re-evaluation consisted of assessing the patients hip strength, hamstring length, and palpation of pes anserine. No referral to another discipline was required. Through discussion with the patient, it was decided to discontinue physical therapy as she had reached almost all of her long term goals for hip strength. No formal short term goals were established. Moreover, the physical therapist explained to the patient that she would keep her chart open for approximately one month, and if the patient had any questions or concerns that she could schedule an appointment. Additionally, the patient was given a complete list of all exercises she had completed thus far and was organized into a HEP in which she would select a variety of stretching and strengthening exercises to be completed 2 times a day, 3 days a week (See table 5).

Table 5. Initial Home Exercise Program

Exercise	**Reps/leg, sets**
Supine butterfly stretch	20 second hold, then rest 30 seconds for 3 sets
Side-lying ITB stretch	20 second hold each leg, 3 sets
Quad sets	Bilateral 10 second hold 20 reps, 1 set
Long arc quads	20 reps each leg, 1 set
Side-lying hip abduction	20 reps each leg, 1 set
Mini-squats	20 reps, 1 set

CHAPTER 4

OUTCOMES

Overall, physical therapy treatment was a success for the patient. Subjective measures such as pain level and objective measures such as knee and hip strength were used to analyze effectiveness of interventions. Pain was her primary complaint, and, at discharge, she was able to report that at its worst the pain was 2/10 compared to 5/10 at initial evaluation. Additionally, the patient increased all hip strength measurements by at least 1/2 score for manual muscle testing bilaterally and reported no tenderness to palpation along the medial joint line and pes anserine.

Another tool used to objectively measure her functional outcome was the Western Ontario McMaster Universities Osteoarthritis Index (WOMAC). The WOMAC contains 24 questions with three subscales of pain, stiffness, and physical function. Not only is the tool used for knee and hip osteoarthritis, but as shown significant correlation to an outcome measure specifically designed for PFPS.[50] There was a clear improvement in her functional disability as indicated by the patient's decrease in WOMAC outcome measure from 10% disability at initial evaluation to 6.25% disability at discharge. Salaffi et al[50] has determined that these subscales demonstrate favorable values for internal consistency (.91, .8, .84), test-retest reliability (ICC 8.6, .68, .89) and discriminant validity (.235, .195, .211). This decrease in score and increase in functional ability is attributed to the patient's consistency with her HEP that reinforced the exercises completed in physical therapy.

All long term goals were met by discharge. Right hip flexion, extension, and abduction all achieved a 5/5. Left hip extension and abduction increased to a 4+/5. See Table 6 for final

strength measurements. More importantly, the patient had a reduction in pain and demonstrated no functional limitations. Together, the physical therapist and patient were able to meet their goal of creating a HEP in which the patient could be independent and successful for the short and long term future.

Table 6. Initial and Final Hip Strength Measurements

	Initial		**Final**	
	Right	**Left**	**Right**	**Left**
Flexion	4+/5	5/5	5/5	5/5
Extension	4+/5	4-/5	5/5	4+/5
Abduction	4+/5	4-/5	5/5	4+/5

The patient experienced no harmful or injurious side effects from intervention and tolerated each progression well as indicated by her ability to seamlessly progress exercises. The only concern was pain (1/10) in her knees when performing sit to stands or variations of this exercise. However, this resolved when verbal cues were used to remind her how to correctly load the PFJ. It is inferred that the patient was very compliant with her HEP. Each session she arrived at the clinic and presented the physical therapist with questions on how to perfect her form and how she can adjust the exercises based on her living environment. As mentioned previously, each week she was able to progress the majority of exercises either by increasing resistance or increasing the number of repetitions. The patient verbally expressed her thanks to the physical

therapist for the work that she had done, bringing herself to tears on the day of discharge. She was overjoyed at how little changes here and there could make such a big difference in her life. For the first time in months, she was able to get on the floor to play with her great grandson, sit through a full church service, and return to her volunteer janitorial work.

CHAPTER 5

DISCUSSION AND REFLECTIVE PRACTICE

Results of this case study have implications that, when examining for proximal and local factors contributing to PFPS, as well as implementing interventions that address these factors, must be utilized when treating PFPS. Throughout the course of physical therapy treatment, the patient not only increased her strength, but improved her functional ability tremendously. The patient was able to return to her normal ADL's, volunteering, and community outings. This is attributed to the patient's high level of motivation, compliance, and willingness to accomplish her goals. However, it is important to be reminded that not at all patients will demonstrate this same motivation and/or may present with fear of reinjury and anxiety.

Although psychological issues were not formally screened for this patient other than the patient providing subjective information, clinicians should screen for the presence of psychological issues that would require a referral to a health care provider along with physical therapy, such as a psychologist.[51] In future PFPS cases, an appropriate screening tool such as the Pain Catastrophizing Scale, Fear-Avoidance Beliefs Questionnaire, or the OSPRO yellow flag assessment tool should be used.[1] This is especially important because in some cases the physical therapist will need to incorporate specific education strategies and techniques to improve patient outcomes such as cognitive-behavioral treatment, reassurance, and graded exposure to activity.[52] Fortunately, there were no physical, psychological, or environmental setbacks that affected or redirected treatment.

Physical therapists utilizing outcome measures used in the treatment of PFPS in future cases may want to consider utilizing a patient reported outcome measure other than the WOMAC. Clinical practice guidelines suggest utilizing the Anterior Knee Pain Score (AKPS), Knee Injury and Osteoarthritis Outcome Score-Patellofemoral Subscale (KOOS-PF), or the Visual Analog Scale to measure pain and function in patients with PFPS.[1] Furthermore, the clinician may want to utilize the AKPS, also known as the Kujala Patellofemoral scale (KPS), to help predict short and long term outcomes. A study by Collins et al[53] concluded that patients who presented with PFP of longer duration who score worse on the KPS had a poorer prognosis, regardless of age, gender, and morphometry. This study suggests that it may be beneficial to utilize strategies that minimize or prevent chronicity in order to improve results.

Specific examination procedures chosen for a patient with potential diagnoses of PFPS will change to better reflect current literature and CPGs including both physical performance measures and physical impairment measures. During this examination, special tests included: active knee extension test, Thomas test, Modified Thomas test and the Thessaly test. These were common and familiar tests to the physical therapists who performed them, and although these tests are consistent with identifying soft tissue length imbalances in the hip and knee that may be contributing to PFPS,[6] additional physical tests and measures such as the eccentric step-down test could also help diagnose PFPS.

Physical performance measures like the eccentric step-down test demonstrates moderate specificity (2.3; 95% CI: 1.9, 2.9), which indicate that the probability of having PFPS with a positive test is moderately increased.[54] Additionally, the frontal plane projection angle (FPPA) which is a measure of knee valgus has shown to have acceptable between-day reliability for women (ICC = .72; 95% CI: 0.56, 0.82) during single leg stance.[55] These tests will be beneficial

in assessing the patient's baseline status but may be more time consuming than performing squatting and kneeling performance measures. In this case, no physical performance measures were actually performed as the patient was not even asked to perform a sit to stand during the examination and only subjective history of pain with prolonged sitting and moving from a sit to stand were taken into account. In the future, therapists should implement tests that reproduce pain and assess dynamic lower limb movement that include squatting and or kneeling, step-downs, and single leg stance to better understand the patient's biomechanics and movement patterns.

Physical impairment measures were not utilized during this episode of care. Patellar Provocation tests such as the patellar apprehension test, Waldron's test phases 1 and 2, and Clarke's test have been used to diagnose PFPS but have shown low diagnostic value in regard to sensitivity, specificity, and likelihood ratios.[56] However, patellar mobility test such as the lateral patellar mobility test (a measure of lateral retinacular tightness) has reports of high specificity (0.92; 95% CIL 0.75, 0.98) and a moderate positive likelihood ratio of 5.4 which suggests a positive finding would assist in ruling in favor of a PFPS diagnoses.[56] Muscle strength tests for the hip were performed via manual muscle testing. Future muscle strength tests performed for physical impairment measures may include The Hip Stability Isometric Test (HipSIT). This test is designed specifically for assessment of posterolateral hip musculature, that of which is often weak in patients diagnosed with PFPS.[14,15] The diagnostic value of the HipSIT is favorable, demonstrating moderate to good concurrent validity compared to individual posterolateral hip muscles and excellent intratester and intertester reliability (ICC = 0.98-0.99).[57] With regards to this data, changes would be made in the examination procedure to include the lateral patellar mobility test and HipSIT test which may help drive diagnoses and save valuable time.

The results of this episode of care reflect similar outcomes in a systematic review and meta-analysis regarding effectiveness of proximal musculature training. This evidence supports rehabilitating proximal areas of the knee such as the hip, trunk, and pelvis, with or without quadriceps training, using both open- and closed- chain found reduced pain and improved function in patients with PFPS at one year.[58] These findings have implications that are congruent with the recommended examination and assessment of proximal factors for weakness of hip abduction, extension and external rotation and that the clinician must include exercises to address these deficits along with local factors in order to optimize outcomes.[1,6]

It is undeniable that there are benefits to including hip and knee targeted exercises in the plan of care to reduce pain in the short, medium, and long-term. However, optimal dosage is unclear at this time, in part due to inadequate exercise reporting.[59] Dosage parameters such as session duration, frequency, and exercise intensity must be analyzed in future studies in order to address which parameters are associated with improved pain, function, and quality of life.[1] Furthermore, when comparing combined hip and knee targeted exercises, to knee-exercises alone, research must develop a better understanding of outcomes in patients who receive one treatment over the other. It is suggested that randomized control trials should match exercise volume between combined hip and knee exercises to only knee targeted exercises in order to develop a more standardized approach for research and interventions.[1]

Interventions such as patellar taping, orthoses, biofeedback, manual therapy, and needling therapies were not utilized during this course of treatment but available research offers some insight that may be applicable for future cases. Injunction with exercise therapy, tailored patellar taping may demonstrates improved outcomes in the short term, but long term research of taping for PFPS is required.[1] It is recommended that knee braces including patellofemoral knee

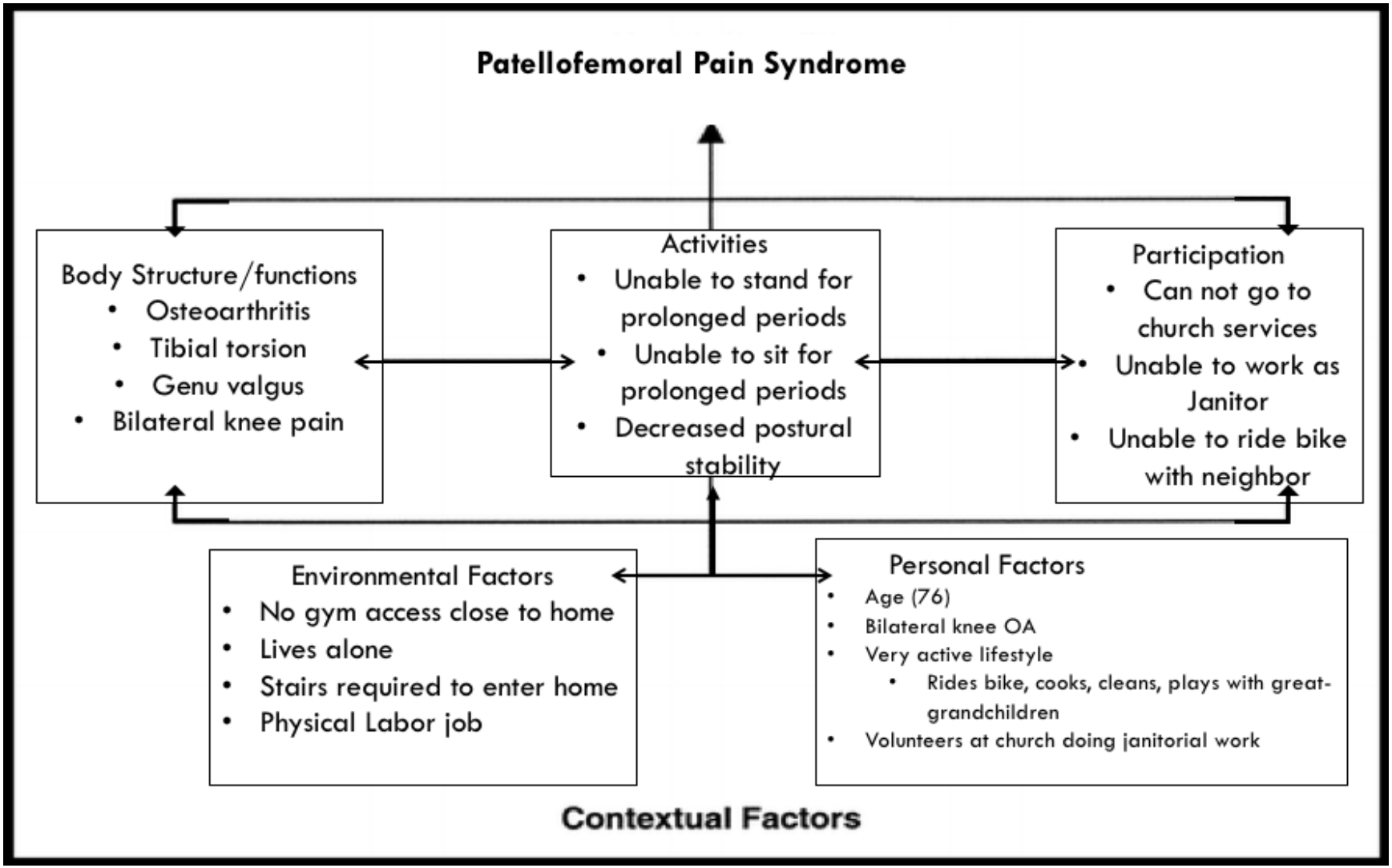
orthoses, braces, sleeves, or straps should not be utilized in treatment of PFPS. In regard to foot orthoses, the 2016 international expert consensus meeting agreed that only prescription of prefabricated foot orthoses should be prescribed for individuals with PFP who have a greater than normal pronation.[3] Moreover, foot orthoses should only be used in the short term (6 weeks) and in conjunction with exercise therapy.[1]

When considering the current movement towards a pay for performance for physical therapy services, it is of value to reflect on the cost benefit analysis for this patient's course of physical therapy. The South Dakota Medicare rate for the entire plan of care totaled approximately $437.31 with each treatment session costing $87.50. At a twenty percent reduction, the final cost per patient was $109.38. This is a reasonable cost based on the successful outcomes the patient had. Moreover, the patient was retired so she was not missing any work or losing money while at physical therapy. The patient was able to see results very early during the course of treatment, and she often verbalized her thanks and gratitude to the physical therapist. Based on my current level of knowledge of coding, billing, and reimbursement, costs could have possibly been reduced by charging for a cheaper therapy code. In this case, 14 units of therapeutic exercise were billed, 1 unit of therapeutic activities, and one unit for evaluation of moderate complexity.

Production and reflection of this case study has allowed me to enhance my professional and clinical skills regarding evidence based practice, critical reasoning, and understanding of the development of best practice guidelines. Throughout this process, I have developed somewhat of a passion and likeness to this specific topic due to the nature of the syndrome. In the future, I will be able to apply what I have learned throughout this process for similar PFPS cases, but also apply and adapt these concepts to a variety of age groups and knee or hip diagnoses. During the

examination, I may probe more on family history of knee injuries, not just asking about osteoarthritis or PFPS. Additionally, it might have been beneficial to ask if the patient was active in her younger years. For example, if she played volleyball or participated in running or jumping activities throughout her life, the physical therapist would better understand the length of time the patient has been suffering with faulty biomechanics or where they originated from. I would like to identify continuing education and research that is specific to adolescents with PFPS, to compare and contrast what I have identified during this case study. I look forward to seeing future research regarding the topics discussed above and utilizing contemporary and up and coming examination and intervention procedures.

Appendix A


Patellofemoral Pain Syndrome
Body Structure/functions
• Osteoarthritis
• Tibial torsion
• Genu valgus
• Bilateral knee pain
Activities
• Unable to stand for prolonged periods
• Unable to sit for prolonged periods
• Decreased postural stability
Participation
• Can not go to church services
• Unable to work as Janitor
• Unable to ride bike with neighbor
Environmental Factors
• No gym access close to home
• Lives alone
• Stairs required to enter home
• Physical Labor job
Personal Factors
• Age (76)
• Bilateral knee OA
• Very active lifestyle
• Rides bike, cooks, cleans, plays with great-grandchildren
• Volunteers at church doing janitorial work
Contextual Factors

Appendix B

Clinician Established Goals: Long Term Goals
1. Patient will report no pain (0/10) in bilateral knees with daily functional activities including sit to stand transfers and/or squatting facilitating return to prior level of function by 9/16/2019.
2. Patient will demonstrate left hip abduction improved to a manual muscle test grade of 4/5 since initial evaluation facilitating improved knee joint stability and decreased pain with daily functional activities by 9/16/2019.
3. Patient will demonstrate left hip extension improved to a manual muscle test grade of 4/5 since initial evaluation facilitating improved knee joint stability and decreased pain with daily functional activities by 9/16/2019.
4. Patient will demonstrate right hip abduction improved to a manual muscle test grade of 5/5 since initial evaluation facilitating improved knee joint stability and decreased pain with daily functional activities by 9/16/2019.
5. Patient will demonstrate right hip extension improved to a manual muscle test grade of 5/5 since initial evaluation facilitating improved knee joint stability and decreased pain with daily functional activities by 9/16/2019.
6. Patient will demonstrate improved functional knee strength as evidenced by patient's ability to progress with difficulty of exercises, number of repetitions, and/or addition of resistance facilitating decreased knee pain with daily functional activities by 9/16/2019.
7. Patient will be independent and compliant with a home exercise program of hip and knee strengthening exercises, lower extremity stretches, and self-symptom management strategies in order to maintain gains made in physical therapy and facilitating return to prior level of function by 9/26/2019.

Appendix C

PATELLOFEMORAL PAIN SYNDROM DECISION MAKING MODEL

Diagnosis of Patellofemoral Pain Syndrome

Retro patellar or peripatellar pain AND

- Reproduction of retropatellar or peripatellar pain with squatting, stair climbing, proglonged sitting, or other functional activities with the knee flexed
- Exclusion of all other sources of anterior knee pain

No

Differential Diagnoses

- Knee conditions and symptoms referred from hip or lumbopelvic region
- Systemic or medical conditions that my impact diagnoses and management
- Psychological issues that might require referral to primary care provider

Examination and Diagnostic Tests

- Reproduction of pain with squatting and other functional activities that load the PFJ in a flexed position (stair climbing)
- Patellar tilt test with presence of hypomobility

Overuse Without Other Impairment

- Eccentric step-down test
- Reproduction of anterior knee pain

Muscle Performance Deficits

- (+) HipSIT
- Lower Extremity muscle performance in
  - Abductors
  - Extensors
  - External Rotators
  - Quadriceps

Movement Coordination Deficits

- Dynamic valgus lateral step-down test
- Frontal plane valgus

Mobility Impairments

- Muscle Length Testing
  - Hamstrings
    - SLR
  - Gastrocnemius
    - Ankle DF <7.4
  - Soleus
    - Ankle DF <14.8
  - Quadriceps
    - Prone knee flexion <134.0
  - Iliotibial band
    - Ober test (knee flexed to 90 degrees)
- HIP IR and ER ROM Testing

Assessment

Patient Reported Outcome Measures

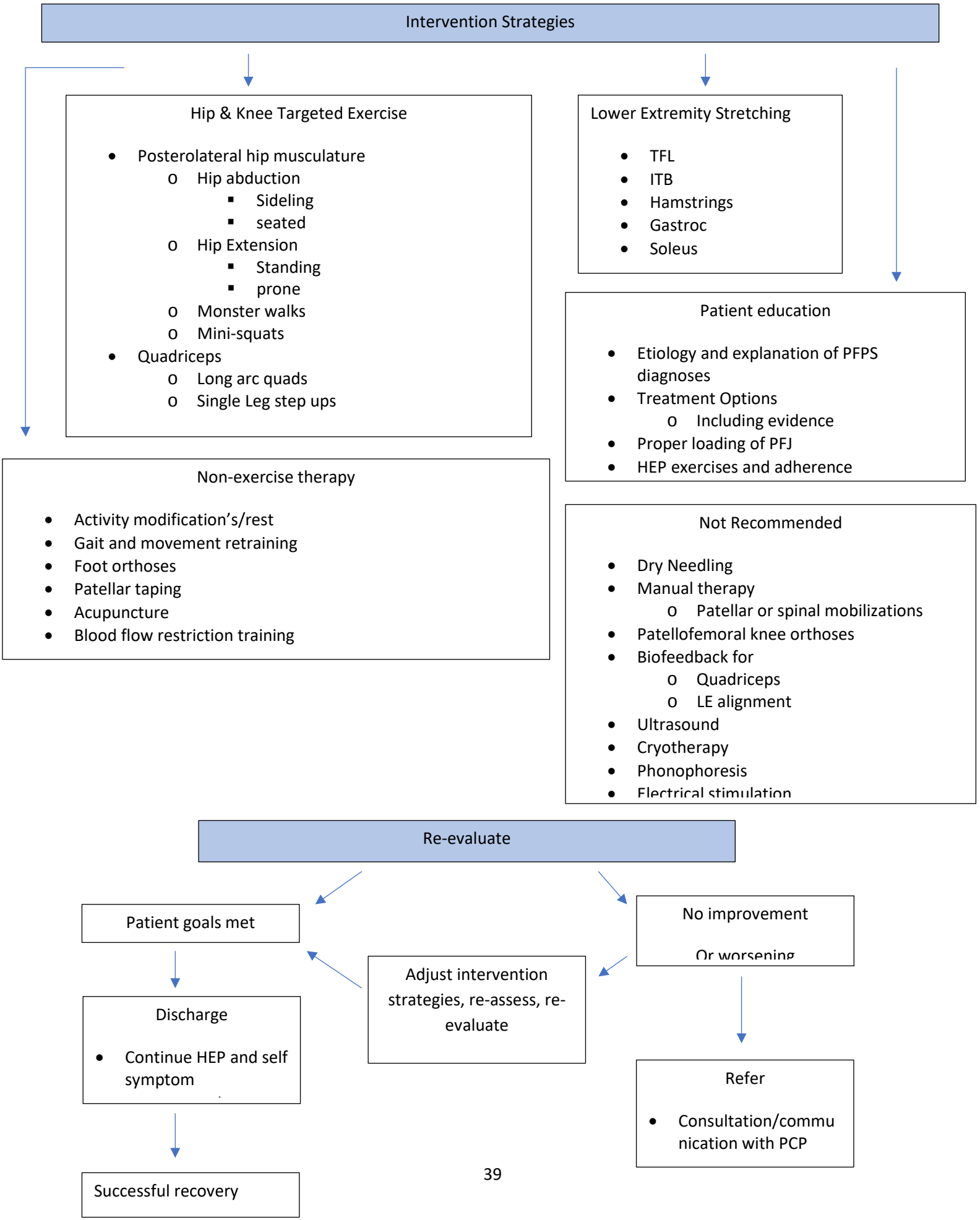
- WOMAC
- AKPS
- KOOS-PF

Physical Impairment Measures

- Muscle length
- Muscle Strength
- Patellar Mobility
- Tenderness to palpation
  - Pes anserine
  - Patellar tendon

Physical Performance Measures

- Reproduction of pain
  - Squatting
  - Stairs
  - Step-downs



Adapted from: Willy RW, Hoglund LT, Barton CJ, et al. Patellofemoral pain. Journal of Orthopaedic & Sports Physical Therapy. 2019;49(9):CPG1-CPG95. doi:10.2519/jospt.2019.0302[1]

References

1. Willy RW, Hoglund LT, Barton CJ, et al. Patellofemoral pain. J Orthop Sports Phys Ther. 2019;49(9):CPG1-CPG95. doi: 10.2519/jospt.2019.0302.

2. Watkins-Castillo S, Andersson G. United States Bone and Joint Initiative: The Burden of Musculoskeletal Diseases in the United States (BMUS). Burd Musculoskelet Dis Int He United States 2014.

3. Crossley KM, Stefanik JJ, Selfe J, et al. 2016 Patellofemoral pain consensus statement from the 4th International Patellofemoral Pain Research Retreat, Manchester. Part 1: Terminology, definitions, clinical examination, natural history, patellofemoral osteoarthritis and patient-reported outcome measures. Br J Sports Med. 2016;50(14):839-843. doi:10.1136/bjsports-2016-096384

4. Roush JR, Curtis Bay R. Prevalence of anterior knee pain in 18-35 year-old females. Int J Sports Phys Ther. 2012;7(4):396-401.

5. Smith BE, Selfe J, Thacker D, et al. Incidence and prevalence of patellofemoral pain: A systematic review and meta-analysis. PLoS One. 2018;13(1):e0190892. Published 2018 Jan 11. doi:10.1371/journal.pone.0190892

6. COLBY L, KISNER C, BORSTAD J. The Knee. In: Kisner C, Colby L, Borstad J. eds.Therapeutic Exercise: Foundations and Techniques, 7e New York, NY: McGraw-Hill;. http://fadavispt.mhmedical.com.ezproxylr.med.und.edu/content.aspx?bookid=2262&sectionid=176767009. Accessed November 14, 2019.

7. Robinson RL, Nee RJ. Analysis of hip strength in females seeking physical therapy treatment for unilateral patellofemoral pain syndrome. J Orthop Sprts Phys Therapy. 2007;37(5):232238. https://www.ncbi.nlm.nih.gov/pubmed/17549951. doi: 10.2519/jospt.2007.2439.

8. Davis, IS, and Powers, C: Patellofemoral pain syndrome: proximal, distal, and local factors. J Orthop Sports Phys Ther 40(3):A3–A9, 2010.

9. Witvrouw E, Callaghan MJ, Stefanik JJ, et al. Patellofemoral pain: consensus statement from the 3rd International Patellofemoral Pain Research Retreat held in Vancouver, September 2013. Br J Sports Med. 2014;48(6):411-414. doi:10.1136/bjsports-2014-093450

10. Rathleff MS, Rasmussen S, Olesen JL. Utilfredsstillende langtidsresultater efter konservativ behandling af patellofemoralt smertesyndrom [Unsatisfactory long-term prognosis of conservative treatment of patellofemoral pain syndrome]. Ugeskr Laeger. 2012;174(15):1008-1013.

11. Lankhorst, NE, Bierma-Zeinstra, SMA, Van Middlekpoop, M: Risk factors for patellofemoral pain syndrome: a systematic review. J Orthop Sports Phys Ther 42(2):81–93, 2012. [PubMed: 22031622]

12. DeHaven KE, Lintner DM. Athletic injuries: comparison by age, sport, and gender. Am J Sports Med. 1986;14(3):218-224. doi:10.1177/036354658601400307

13. Rathleff MS, Rathleff CR, Crossley KM, et al. Is hip strength a risk factor patellofemoral pain? A systematic review and meta-analysis. Br J Sports Med. 2014;48:1088.

14. Souza RB, Powers CM. Differences in hip kinematics, muscle strength, and muscle activation between subjects with and without patellofemoral pain. J Orthop Sports Phys Ther. 2009;39(1):12-19. doi:10.2519/jospt.2009.2885

15. Bolgla LA, Malone TR, Umberger BR, Uhl TL. Hip strength and hip and knee kinematics during stair descent in females with and without patellofemoral pain syndrome. J Orthop Sports Phys Ther. 2008;38(1):12-18. doi:10.2519/jospt.2008.2462

16. Chapter 9. The Knee Joint Complex. In: Dutton M. eds. Dutton's Orthopedic Survival Guide: Managing Common Conditions New York, NY: McGraw-Hill; 2011. http://accessphysiotherapy.mhmedical.com.ezproxylr.med.und.edu/content.aspx?bookid=467&sectionid=40079851. Accessed June 05, 2020.

17. Karlsson J, Thomeé R, Swärd L. Eleven year follow-up of patello-femoral pain syndrome. Clin J Sport Med. 1996;6(1):22-26. doi:10.1097/00042752-199601000-00006

18. Kannus P, Natri A, Paakkala T, Järvinen M. An outcome study of chronic patellofemoral pain syndrome. Seven-year follow-up of patients in a randomized, controlled trial. J Bone Joint Surg Am. 1999;81(3):355-363. doi:10.2106/00004623-199903000-00007

19. Collins NJ, Crossley KM, Darnell R, Vicenzino B. Predictors of short and long term outcome in patellofemoral pain syndrome: a prospective longitudinal study. BMC Musculoskelet Disord. 2010;11:11. Published 2010 Jan 19. doi:10.1186/1471-2474-11-11

20. KNEE OSTEOARTHRITISse, Shamus E. *The Color Atlas of Physical Therapy;* 2015. Available at: https://accessphysiotherapy.mhmedical.com/content.aspx?bookid=1491&ctionid=90325812 Accessed: June 09, 2020

21. Khan M, Bhandari M. Cochrane in CORR®: Intra-articular Corticosteroid For Knee Osteoarthritis. Clin Orthop Relat Res. 2018;476(7):1391-1392. doi:10.1097/CORR.0000000000000358

22. Ezad S, Cheema H, Collins N. Statin-induced rhabdomyolysis: a complication of a commonly overlooked drug interaction. Oxf Med Case Reports. 2018;2018(3):omx104. Published 2018 Mar 14. doi:10.1093/omcr/omx104

23. Park SK, Stefanyshyn DJ. Greater Q angle may not be a risk factor of Patellofemoral Pain Syndrome. Clin Biomech (Bristol, Avon). 2011;26:392- 396. https://doi.org/10.1016/j.clinbiomech.2010.11.015

24. Collins NJ, , Vicenzino B, , van der Heijden RA, , van Middelkoop M. and Pain during prolonged sitting is a common problem in persons with patellofemoral pain. J Orthop Sports Phys Ther. 2016; 46: 658– 663.

25. Cook C, , Mabry L, , Reiman MP, , Hegedus EJ. and Best tests/clinical findings for screening and diagnosis of patellofemoral pain syndrome: a systematic review. **Physiotherapy**. 2012; 98: 93–100. https://doi.org/10.1016/j.physio.2011.09.001

26. Nunes GS, Stapait EL, Kirsten MH, de Noronha M, Santos GM. Clinical test for diagnosis of patellofemoral pain syndrome: Systematic review with meta-analysis. Phys Ther Sport. 2013;14(1):54-59. doi:10.1016/j.ptsp.2012.11.003

27. Van Ost L. Cram session in goniometry and manual muscle testing: A handbook for students & clinicians Throfare, NJ: SLACK Incorporated; 2013.

28. Karachalios T, Hantes M, Zibis AH, Zachos V, Karantanas AH, Malizos KN. Diagnostic accuracy of a new clinical test (the Thessaly test) for early detection of meniscal tears. J Bone Joint Surg Am. 2005;87(5):955-962. doi:10.2106/JBJS.D.02338

29. Hip Joint Complex. In: Dutton M. eds. Dutton's Orthopaedic Examination, Evaluation, and Intervention, 5e New York, NY: McGraw-Hill; . http://accessphysiotherapy.mhmedical.com.ezproxylr.med.und.edu/content.aspx?bookid=2707&sectionid=224681946. Accessed May 5th, 2020.

30. Piva SR, Goodnite EA, Childs JD. Strength around the hip and flexibility of soft tissues in individuals with and without patellofemoral pain syndrome. J Orthop Sports Phys Ther. 2005;35(12):793-801. doi:10.2519/jospt.2005.35.12.793

31. Hansberger BL, Loutsch R, Hancock C, Bonser R, Zeigel A, Baker RT. Evaluating the relationship between clinical assessments of apparent hamstring tightness: A correlational analysis. Int. J. Sports Phys. 2019;14(2):253-263. https://www.ncbi.nlm.nih.gov/pubmed/30997277. doi: 10.26603/ijspt20190253.

32. Gardner K. Tiered Physical Therapy Evaluation and Reevaluation CPT Codes. APTA. http://www.apta.org/EvalCodes/. Accessed June 11, 2020.

33. Kobayashi S, Pappas E, Fransen M, Refshauge K, Simic M. The prevalence of patellofemoral osteoarthritis: a systematic review and meta-analysis. Osteoarthritis Cartilage. 2016;24:1697-1707. https://doi.org/10.1016/j. joca.2016.05.011

34. Calmbach WL, Hutchens M. Evaluation of patients presenting with knee pain: part II. Differential diagnosis. Am Fam Physician. 2003;68:917-922

35. Matthews M, Rathleff MS, Claus A, et al. Can we predict the outcome for people with patellofemoral pain? A systematic review on prognostic fac- tors and treatment effect modifiers. Br J Sports Med. 2017;51:1650-1660. https://doi.org/10.1136/bjsports-2016-096545

36. Koh JL, Stewart C. Patellar instability. Orthop Clin North Am. 2015;46:147- 157. https://doi.org/10.1016/j.ocl.2014.09.011

37. Wolf M. Knee pain in children: part I: evaluation. Pediatr Rev. 2016;37:18- 23; quiz 24, 47. https://doi.org/10.1542/pir.2015-0040

38. Tiered Physical Therapy Evaluation and Reevaluation CPT Codes. APTA. https://www.apta.org/your-practice/payment/medicare-payment/coding-billing/tiered-physical-therapy-evaluation-and-reevaluation-cpt-codes. Accessed June 20, 2020.

39. *Guide to Physical Therapist Practice 3.0*. Alexandria, VA: American Physical Therapy Association; 2014. Available at: http://guidetoptpractice.apta.org/. Accessed June 5th, 2020.

40. Icdlist.com. 2020. ICD-10-CM Code M22.2X9 - Patellofemoral Disorders, Unspecified Knee. [online] Available at: <https://icdlist.com/icd-10/M22.2X9> [Accessed 11 June 2020].

41. Herrington L, Al-Sherhi A. A controlled trial of weight-bearing versus non– weight-bearing exercises for patellofemoral pain. J Orthop Sports Phys Ther. 2007;37:155-160. https://doi.org/10.2519/jospt.2007.2433

42. Dolak KL, Silkman C, Medina McKeon J, Hosey RG, Lattermann C, Uhl TL. Hip strengthening prior to functional exercises reduces pain sooner than quadriceps strengthening in females with patellofemoral pain syndrome: a randomized clinical trial. J Orthop Sports Phys Ther. 2011;41:560-570. https://doi.org/10.2519/jospt.2011.3499

43. Ferber R, Bolgla L, Earl-Boehm JE, Emery C, Hamstra-Wright K. Strength- ening of the hip and core versus knee muscles for the treatment of patel- lofemoral pain: a multicenter randomized controlled trial. J Athl Train. 2015;50:366-377. https://doi.org/10.4085/1062-6050-49.3.70

44. Khayambashi K, Fallah A, Movahedi A, Bagwell J, Powers C. Postero- lateral hip muscle strengthening versus quadriceps strengthening for patellofemoral pain: a comparative control trial. Arch Phys Med Rehabil. 2014;95:900-907. https://doi.org/10.1016/j.apmr.2013.12.022

45. Ayotte NW, Stetts DM, Keenan G, Greenway EH. Electromyographical analysis of selected lower extremity muscles during 5 unilateral weight-bearing exercises. J Orthop Sports Phys Ther. 2007;37(2):48-55. doi:10.2519/jospt.2007.2354

46. Cambridge ED, Sidorkewicz N, Ikeda DM, Mcgill SM. Progressive hip rehabilitation: The effects of resistance band placement on gluteal activation during two common exercises. Clinical Biomechanics. 2012;27(7):719-724. doi:10.1016/j.clinbiomech.2012.03.002.

47. Tips & Tricks to Strengthen Legs Without Squats! Guelph Performance Therapy. http://www.guelphperformancetherapy.com/tips--tricks/tips-tricks-to-strengthen-legs-without-squats. Accessed June 21, 2020.

48. Macadam P, Cronin J, Contreras B. AN EXAMINATION OF THE GLUTEAL MUSCLE ACTIVITY ASSOCIATED WITH DYNAMIC HIP ABDUCTION AND HIP EXTERNAL ROTATION EXERCISE: A SYSTEMATIC REVIEW. Int J Sports Phys Ther. 2015;10(5):573-591.

49. Østerås B, Østerås H, Torstensen TA. Long-term effects of medical exercise therapy in patients with patellofemoral pain syndrome: results from a single-blinded randomized controlled trial with 12 months follow-up. Phys- iotherapy. 2013;99:311-316. https://doi.org/10.1016/j.physio.2013.04.001

50. Salaffi F, Leardini G, Canesi B, et al. Reliability and validity of the western ontario and McMaster universities (WOMAC) osteoarthritis index in italian patients with osteoarthritis of the knee. Osteoarthritis and Cartilage. 2003;11(8):551-560. http://dx.doi.org/10.1016/S1063-4584(03)00089-X. doi: 10.1016/S1063-4584(03)00089-X

51. Maclachlan LR, Collins NJ, Matthews MLG, Hodges PW, Vicenzino B. The psychological features of patellofemoral pain: a systematic review. Br J Sports Med. 2017;51:732-742. https://doi.org/10.1136/ bjsports-2016-096705

52. Bergbom S, Boersma K, Overmeer T, Linton SJ. Relationship among pain catastrophizing, depressed mood, and outcomes across physical therapy treatments. Phys Ther. 2011;91:754-764. https://doi.org/10.2522/ ptj.20100136

53. Collins NJ, Crossley KM, Darnell R, Vicenzino B. Predictors of short and long term outcome in patellofemoral pain syndrome: A prospective longitudinal study. BMC musculoskeletal disorders. 2010;11(1):11. https://www.ncbi.nlm.nih.gov/pubmed/20082723. doi: 10.1186/1471-2474-11-11.

54. Nunes GS, Stapait EL, Kirsten MH, de Noronha M, Santos GM. Clinical test for diagnosis of patellofemoral pain syndrome: systematic review with meta-analysis. Phys Ther Sport. 2013;14:54-59. https://doi.org/10.1016/j. ptsp.2012.11.003

55. Munro A, Herrington L, Carolan M. Reliability of 2-dimensional video as- sessment of frontal-plane dynamic knee valgus during common athletic screening tasks. J Sport Rehabil. 2012;21:7-11. https://doi.org/10.1123/ jsr.21.1.7

56. Haim A, Yaniv M, Dekel S, Amir H. Patellofemoral pain syndrome: validity of clinical and radiological features. Clin Orthop Relat Res. 2006;451:223- 228. https://doi.org/10.1097/01.blo.0000229284.45485.6c

57. Almeida GPL, das Neves Rodrigues HL, de Freitas BW, de Paula Lima PO. Reliability and validity of the Hip Stability Isometric Test (HipSIT): a new method to assess hip posterolateral muscle strength. J Orthop Sports Phys Ther. 2017;47:906-913. https://doi.org/10.2519/jospt.2017.7274

58. Lack S, Barton C, Sohan O, Crossley K, Morrissey D. Proximal muscle rehabilitation is effective for patellofemoral pain: a systematic review with meta-analysis. Br J Sports Med. 2015;49(21):1365-1376. doi:10.1136/bjsports-2015-094723

59. Holden S, Rathleff MS, Jensen MB, Barton CJ. How can we implement exercise therapy for patellofemoral pain if we don't know what was pre- scribed? A systematic review. Br J Sports Med. 2018;52:385. https://doi. org/10.1136/bjsports-2017-097547