Introduction

Patellofemoral Pain Syndrome (PFPS) causes anterior knee pain and can be defined as pain around or behind the patella (kneecap).\(^1\) A high incidence of PFPS has been reported in military cohorts.\(^2,3\) This article covers factors associated with PFPS along with diagnosis, treatment, and prevention information. Most often, the cause of PFPS is multifactorial, so many potential factors should be considered. Factors associated with PFPS in physically active individuals include static and dynamic factors such as lower extremity malalignment, muscular weakness and imbalance of muscles around the hip and knee, and tightness of specific lower-extremity musculature.\(^4\) It is believed that abnormal patellar movement or “tracking” (Figure 1) within the patellofemoral joint might play a key role in the development of PFPS.\(^5,6\) Instead of moving centrally in the groove, the patella tracks and/or tilts laterally against the femur, causing increased stress to be placed on the patellofemoral joint surface and underlying cartilage, the patellar and quadriceps tendons, and the surrounding soft tissue. Over time, this can lead to tissue irritation and pain, especially during activities such as squats or deep knee bends, going up and down stairs, and downhill walking/running. Compression forces within the patellofemoral joint have been estimated to be three times body weight during stair climbing, eight times body weight during deep squatting, and upwards of 20 times body weight during jumping.\(^7\)

You can watch a video with the recording and slide show from HPRC’s Rx3 webinar about PFPS: https://www.youtube.com/watch?v=GIT3j5DHCzk.

Potential Risk Factors

Contrary to popular belief, anthropometric measurements such as height, mass, body mass index (BMI), and percent body fat might not be associated with incidence of PFPS\(^8,9\), although there is some disagreement and more research needs to be done. The factors below, however, are established risk factors.

**Age.** PFPS has been shown to occur in both young and old physically active individuals, with the highest prevalence in adolescents (ages 12–17).\(^10,11\) Other populations with high prevalence rates include “weekend warriors”—active adults completing high volumes of irregularly patterned physical activity—and military recruits undergoing basic training.\(^12,9\)

**Gender.** Females appear to be more prone to PFPS than males.\(^12,13\) For example, a 2010 study of U.S. Naval Academy midshipmen reported a PFPS prevalence of 12% in males and 15% in females at the time of study enrollment.\(^12\) Notably, females were more than twice as likely to develop PFPS compared with males during the 2.5-year follow-up.\(^12\)

**Quadriceps-muscle weakness.** The quadriceps muscle group, in particular the vastus medialis oblique (VMO), plays a pivotal role in stabilizing the patella during functional activities.\(^14\) Research has suggested that quadriceps muscle weakness is a risk factor for the development of PFPS syndrome.\(^15\) Other studies have shown that patients with PFPS typically present with atrophy of the VMO.\(^16,17\) Furthermore, several authors have reported that patients with PFPS have an imbalance in quadriceps muscle firing patterns.\(^16,19\) Specifically, patients tend to display a delayed onset of VMO firing in comparison to the vastus lateralis muscle. This delayed firing can contribute to abnormal lateral tracking of the patella during knee flexion and extension and is especially problematic when it occurs during weight-bearing functional activities such as stair climbing and squatting.
**Hip-muscle weakness.** It is common for patients with PFPS to present with weakness in the muscles that abduct and externally rotate the hip.\(^{20,21}\) In addition to acting as prime movers for these actions at the hip, the gluteal muscles play a pivotal role in maintaining pelvic stability during performance of functional activities. Recently, researchers have shown an association between decreased strength of the hip external rotators and abductors and increased hip and trunk movement in participants with PFPS during a jump-lifting task. Authors suggested that this movement might result in additional faulty patterns further down the lower leg and foot during functional activities.\(^{22}\) Furthermore, a recent prospective study reported an association between knee abduction moments during performance of a jump-landing task and new PFPS incidence in high-school female athletes.\(^{23}\)

**Lower-extremity malalignment.** A number of “static” malalignments of the lower extremity—such as an increased standing Q-angle, leg-length discrepancy, genu valgum (“knock-knees”), pes planus (decreased or absent medial longitudinal arch), and subtalar pronation—have been suggested as probable causes of PFPS.\(^{24}\) Although these factors can be assessed, careful consideration should also be given to more dynamic malalignments: those that present with performance of functional activities (see more in the section on diagnosis below). Similar to abnormal valgus collapse of the knee, recent evidence suggests that patients with PFPS might have any number of abnormal mechanics occurring at the foot during weight-bearing activities, such as increased rear-foot eversion at heel strike.\(^{25}\)

**Lower-extremity muscle tightness.** Decreased quadriceps flexibility has been identified as a potential risk factor for future incidence of PFPS\(^{26}\), as well as has been reported in patients already diagnosed with this condition.\(^{27}\) Tight quadriceps can lead to higher-than-normal patellofemoral stresses and abnormal lateral tracking during performance of sport and everyday activities. A prospective study has also identified an association between gastrocnemius tightness and the development of PFPS\(^{28}\), whereas results from cross-sectional studies indicate a link between both hamstring muscle\(^{29-30}\) and iliotibial band tightness in patients presenting with PFPS.\(^{31}\)

**Training errors and overuse.** Over-activity, especially the kind that can occur in endurance sport or military basic training, has been demonstrated to be a risk factor for PFPS. High weekly running mileage (≥ 40 miles per week) has been linked with increased risk of injury in long-distance runners.\(^{32}\) Similarly, a high incidence of PFPS has been reported in military cohorts.\(^{12,32}\)

**Psychological factors.** Although the majority of research on PFPS has focused on identifying biomechanical and/or anatomical risk factors associated with anterior knee pain, recent studies have suggested the potential influence of psychological factors on this condition.\(^{33,34}\) For example, patients with chronic PFPS have been shown to have greater levels of self-reported mental distress than healthy individuals.\(^{34}\)

**Diagnosis**

**Diagnostic algorithm.** Before beginning any type of rehabilitation program, it is important to correctly diagnose PFPS. The algorithm from HPRC’s Rx3 program can help eliminate other potential major injuries of the knee: [https://www.hprc-online.org/docs/Knee-Pain-Algorithm-PDF](https://www.hprc-online.org/docs/Knee-Pain-Algorithm-PDF).

**Functional Movement Assessments.** (FMAs) are commonly used by sports medicine practitioners to help identify movement impairments that are associated with MSK-I risk. In particular, tests provide a means for clinicians to quickly identify deficiencies in balance, core stability, flexibility, mobility, and overall neuromuscular control. Some research has shown an association between performance in some FMAs—such as the Functional Movement Screen\(^5,16\), the Star Excursion Balance (or V-Balance) Test\(^24,37\), and the Landing Error Scoring System\(^18\)—and injury in some military and athletic populations. Despite this association with injury, it is important to note that current evidence does not support their use in predicting future injury.\(^{39,40}\) The single-leg squat (SLS; Figure 2) is a commonly performed FMA that attempts to identify faulty lower-extremity biomechanics. In particular, it is used to identify medial knee displacement, or knee valgus collapse—a common mechanism of injury and a risk factor for noncontact knee injuries.\(^{41}\)

Several neuromuscular factors—including decreased hip abduction and external rotator (gluteal) muscle strength and activation patterns, increased hip adductor activity, and restricted ankle dorsiflexion range of motion—can...
influence knee valgus collapse. Importantly, these factors are potentially modifiable, and once the case-specific factors are identified, clinicians can prescribe appropriate corrective exercises targeting the deficiencies that present during the SLS task.

**Prevention and Treatment**

*Relative rest.* Decreasing the load on the knee is an important step in recovering from PFPS. Modifying present training/activity demands to manage and/or prevent PFPS can sometimes be indicated. Substituting activities such as swimming or biking for jogging/running can aid in this effort. If strengthening exercises such as lunges or full squats are part of the overall strengthening program but they aggravate the knee pain, they should be temporarily discontinued until pain subsides. Several training factors—such as implementing gradual increases in weekly training mileage, allowing adequate recovery between training sessions, and limiting hill running—have been suggested to help prevent PFPS and other chronic lower-extremity injuries.

*Rehabilitation.* It is important that clinicians address both strength and overall neuromuscular control of the hip when assessing and managing patients with PFPS syndrome. Strengthening and stretching exercises should be included as part of any comprehensive rehabilitation or injury prevention program. Rx3 includes resources for both providers and patients at https://www.hprc-online.org/page/Rx3-Rehab-Refit-Return-to-Duty/Knee-Pain. Providers can direct patients to the program by using the Rx3 Prescription Pad at https://www.hprc-online.org/page/Rx3-Rehab-Refit-Return-to-Duty/For-the-Provider.

**Patellar taping and bracing.** Patellar taping and bracing has been suggested to be an effective conservative treatment in the overall management of patients with PFPS. Typically, the goal of taping is to stabilize the patella against abnormal lateral tracking that can occur during physical activity. The most commonly performed application in the sports-medicine setting utilizes McConnell taping (Figure 3) to stabilize the patella. Specifically, several strips of adhesive tape are applied to the patella with a medially directed force in an attempt to prevent irregular lateral patellar movement. Early findings supported the use of medially directed tape as a means to mitigate symptoms of PFPS when combined with an exercise intervention. Data from a recent meta-analysis also supports the link between patellar taping and pain reduction, although authors caution that results were limited to studies consisting of a 3-month-or-less follow-up and small sample sizes. Similar to patellar taping, patellar braces also aim to limit abnormal lateral patellar movement by applying a medially directed force to the patella. Although several studies have suggested a link between the use patellar bracing and decreased pain in patients with PFPS, a recent systematic review has questioned the overall strength of the evidence. Consequently, authors have suggested that further research on the potential effect of bracing on pain reduction and functional improvement is warranted.

**Conclusions**

Numerous risk factors have been associated with PFPS in physically active individuals, including a high incidence in military populations. Consequently, sports-medicine practitioners need to first identify any underlying biomechanical or physiological factors specific to an individual that could increase the risk for initial or recurrent PFPS. Once identified during this overall lower-extremity evaluation, an exercise program such as Rx3’s https://www.hprc-online.org/page/Rx3-Rehab-Refit-Return-to-Duty/Knee-Pain as referred to in the section above on treatment and prevention, aimed at correcting these potential risk factors, can be implemented in an effort to minimize return-to-duty time.
References


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