Exercise Prescription and Patellofemoral Pain: Evidence for Rehabilitation

Lori Bolgla and Terry Malone

Objective: To provide evidence regarding the therapeutic effects of exercise on subjects with patellofemoral-pain syndrome (PFPS). Data Sources: Evidence was compiled with data located using the Medline, CINAHL, and SPORTDiscus databases from 1985 to 2004 using the key words patellofemoral pain syndrome, exercise, rehabilitation, and strength. Study Selection: The literature review examined intervention studies evaluating the effectiveness of exercise in subjects specifically diagnosed with PFPS. Articles were selected based on clinical relevance to PFPS rehabilitation that required an intervention of a minimum of 4 weeks. Data Synthesis: The review supports using exercise as the primary treatment for PFPS. Conclusions: Evidence exists regarding the use of isometric, isotonic, isokinetic, and closed kinetic chain exercise. Although clinicians have advocated the use of biofeedback and patella taping, there is limited evidence regarding the efficacy of these interventions on subjects diagnosed with PFPS. Key Words: anterior knee pain, quadriceps, intervention, strength

Patellofemoral-pain syndrome (PFPS) is a common problem experienced by active adults and adolescents. Most often, patient complaints are of diffuse peripatellar and retropatellar pain, limiting the patient’s activities of daily living that require loading on a flexed knee. Such activities include ascending and descending stairs, squatting, and sitting for prolonged periods of time.  

Most patients with PFPS respond favorably to conservative intervention, and researchers have supported the use of quadriceps strengthening as a key component of the rehabilitation program. Natri et al conducted a 7-year prospective study and reported that restoration of adequate quadriceps strength and function is necessary for recovery. Therefore, health-care practitioners should develop and implement a rehabilitation program that promotes normal quadriceps strength and function.

Many researchers have investigated the efficacy of various exercises in promoting quadriceps activity using surface electromyography (EMG).

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The premise of these studies has been that exercises resulting in higher quadriceps EMG activity would benefit patients diagnosed with PFPS. These studies included normal subjects with no history of PFPS, which brings into question the effectiveness of these exercises for the treatment of PFPS. Undoubtedly, researchers should examine the effect of these exercises on subjects with PFPS.

The concept of evidence-based practice means that providing high-quality care depends on the ability to prescribe an intervention confirmed by scientific data. Clinicians must understand the “whys” of exercise prescription and the scientific rationale for making specific decisions. The purpose of this literature review is to provide a scientific basis for the therapeutic effects of exercise on subjects with PFPS.

**Inclusion Criteria**

As mentioned previously, many studies have determined quadriceps activation during a single exercise session using asymptomatic subjects; however, a limited number of studies have examined the effect of exercise on reducing symptoms associated with PFPS. Based on this limited evidence, we chose to include studies using subjects who were diagnosed with PFPS and participated in an exercise-based intervention for a minimum period of 4 weeks. Based on this criterion, using the MEDLINE, CINAHL, and SPORTDiscus databases from 1985 to 2004, we found 16 acceptable articles.

**Evaluation of Evidence**

Rather than using the meta-analysis process of evidence classification, we used a relevance-to-clinical-practice process for evidence or article selection. Patients with PFPS are often provided rehabilitation programs through outpatient interventions. These often are visit-based, with 12 visits over 4 weeks or some permutation of this sequence. Thus, for the selection process, included articles were required to emulate the normal practice of treatment lasting a minimum of 4 weeks. We used the last 20 years of literature as representative of contemporary practice. Table 1 provides a synopsis of each article, including the requisites for article inclusion (sample, subjects, duration, intervention, calculated effect size, and implication for practice).

**Open Kinetic Chain Exercise**

**Isometric Quadriceps Exercise**

Pain-free quadriceps exercise is a key component of successfully treating patients with PFPS. Researchers think that isometric quadriceps exercises,
<table>
<thead>
<tr>
<th>Study, type</th>
<th>Sample</th>
<th>Participants</th>
<th>Duration</th>
<th>Intervention</th>
<th>Effect size for pain†</th>
<th>Implication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alaca, 18 QE</td>
<td>N = 22</td>
<td>Mean age: 27 ± 6 y; Symptoms: 24 ± 11 d</td>
<td>Duration: 6 wk; Follow-up: none</td>
<td>All subjects performed the same isokinetic strengthening protocol.</td>
<td>Pretreatment vs posttreatment: 1.37</td>
<td>Isokinetic exercise can improve extensor-mechanism strength.</td>
</tr>
<tr>
<td>Clark, 19 RCT</td>
<td>N = 81</td>
<td>Age range: 16–40 y; Symptoms: &gt;3 mo</td>
<td>Duration: 3 mo; Follow-up: 1 y</td>
<td>Group 1: exercise, tape, and exercise. Group 2: exercise and education. Group 3: tape and education. Group 4: education.</td>
<td>Group 1 vs 2, .06; 2 vs 3, .73; 1 vs 3, .77</td>
<td>Exercise most beneficial in reducing pain, tape having no significant effect.</td>
</tr>
<tr>
<td>Crossley, 20 RCT</td>
<td>N = 71</td>
<td>Age range: 12–40 y; Symptoms: 1–144 mo</td>
<td>Duration: 6 wk; Follow-up: none</td>
<td>Group 1: McConnell-based program. Group 2: “sham” program.</td>
<td>Mean differences between groups: .75</td>
<td>Physical therapy intervention is efficacious in reducing PFPS symptoms.</td>
</tr>
<tr>
<td>Doucette, 1 QE</td>
<td>N = 56 (knees)</td>
<td>Mean age: group 1, 22.9 ± 11.2 y; group 2, 21.8 ± 9.7 y; group 3, 16 ± 2.6 y; Symptoms: ≥6 wk</td>
<td>Duration: 11 physical therapy visits over 8 wk; Follow-up: none</td>
<td>Subjects participated in an individualized, comprehensive, 5-stage intervention focused on VMO strengthening.</td>
<td>Group differences in pain at posttesting: 1.22</td>
<td>Therapeutic exercise can be effective in decreasing pain associated with lateral patellar compression syndrome.</td>
</tr>
<tr>
<td>Author</td>
<td>N</td>
<td>Age range</td>
<td>Duration</td>
<td>Group 1</td>
<td>Group 2</td>
<td>Attrition</td>
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<tr>
<td>Dursun, 21</td>
<td>60</td>
<td>17–50 y</td>
<td>&gt;an average of 10.8 ± 7.7 mo</td>
<td>Group 1, biofeedback and exercise; group 2, exercise only</td>
<td>N/A: no significant differences in VAS at post-testing (P = .14)</td>
<td>Biofeedback did not result in more decreases in pain than exercise alone.</td>
</tr>
<tr>
<td>Eburne, 22</td>
<td>75</td>
<td>10–35 y</td>
<td>monthly until pain-free or for 3 mo</td>
<td>Group 1, isometric exercise; group 2, McConnell regimen</td>
<td>Insufficient information to calculate</td>
<td>Both programs benefited all participants.</td>
</tr>
<tr>
<td>Gaffney, 23</td>
<td>72</td>
<td>11–65 y</td>
<td>daily PT and supervised program 1 x wk x 6 wk</td>
<td>Group 1, OKC exercise; group 2, CKC exercise with tape</td>
<td>Insufficient information to calculate</td>
<td>Both forms of exercise benefited subjects.</td>
</tr>
<tr>
<td>Harrison, 24</td>
<td>113</td>
<td>12–35 y</td>
<td>3 x wk x 4 wk</td>
<td>Group 1, home exercise/education; group 2, traditional PT program; group 3, VMO exercise, taping, biofeedback</td>
<td>N/A: no significant differences in VAS at 1-y follow-up</td>
<td>All treatments effective and home exercise program should be implemented initially; progress to more formal rehabilitation if needed; comprehensive program might provide faster improvements initially.</td>
</tr>
<tr>
<td>Kowall, 25</td>
<td>25</td>
<td>14–40 y</td>
<td>2 x wk x 4 wk</td>
<td>Group 1, standard PT intervention; group 2, standard PT intervention with McConnell taping</td>
<td>N/A: no significant differences in VAS</td>
<td>No additional benefit with the addition of patella taping.</td>
</tr>
<tr>
<td>Study, type</td>
<td>Sample</td>
<td>Participants</td>
<td>Duration</td>
<td>Intervention</td>
<td>Effect size for pain†</td>
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<tr>
<td>Maschal, N = 2 CS</td>
<td>N = 2</td>
<td>Ages: 20- &amp; 37-y-old women</td>
<td>Duration: 9 &amp; 2 y, respectively</td>
<td>Recruitment and endurance training of hip, pelvis, and trunk muscles</td>
<td>Unable to compute secondary to experimental design</td>
<td>Patients with abnormal lower extremity kinematics might benefit from an intervention focused on proximal hip/trunk muscles.</td>
</tr>
<tr>
<td>McMullen, N = 29 QE</td>
<td>N = 29</td>
<td>Age range: 10–40 y</td>
<td>Duration: 1–6 mo</td>
<td>Group 1, control; group 2, isometric exercise; group 3, isokinetic exercise</td>
<td>Insufficient information to calculate</td>
<td>Both programs provided functional improvements. Traditional home exercise and Muncie home exercise.</td>
</tr>
<tr>
<td>Roush, N = 77 PR</td>
<td>N = 77</td>
<td>Average age range: 22–32 y</td>
<td>Duration: N/A</td>
<td>Group 1, home exercise; group 2, traditional PT program; group 3, Muncie home exercise</td>
<td>Insufficient information to calculate</td>
<td>Traditional home exercise and Muncie home exercise programs benefited subjects with PFPS.</td>
</tr>
<tr>
<td>Study</td>
<td>N</td>
<td>Attrition</td>
<td>Average age</td>
<td>Duration</td>
<td>Group</td>
<td>Exercise</td>
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<td>Stiene, 29</td>
<td>33</td>
<td>10</td>
<td>19 y</td>
<td>3 x wk x 8 wk</td>
<td>Group 1, CKC</td>
<td>isokinetic exercise</td>
</tr>
<tr>
<td>Thomee, 30</td>
<td>40</td>
<td>none</td>
<td>20 y</td>
<td>3 x wk x 12 wk</td>
<td>Group 1, isometric</td>
<td>eccentric exercise (OKC &amp; CKC)</td>
</tr>
<tr>
<td>Witvrouw, 31</td>
<td>60</td>
<td>not reported</td>
<td>14–33 y</td>
<td>3 x wk x 5 wk</td>
<td>Group 1, OKC</td>
<td>CKC exercise</td>
</tr>
<tr>
<td>Witvrouw, 32</td>
<td>60</td>
<td>not reported</td>
<td>14–33 y</td>
<td>3 x wk x 5 wk</td>
<td>Group 1, OKC</td>
<td>CKC exercise</td>
</tr>
</tbody>
</table>

*QE indicates quasiexperimental; RCT, randomized control trial; VAS, visual analog scale; RCC, randomized control comparison; OKC, open kinetic chain; CKC, closed kinetic chain; CS, case study; PR, prospective randomized; PFPS, patellofemoral-pain syndrome.
†Effect size for pain chosen because this parameter was common to all studies and is considered an important impairment according to the Philadelphia Panel evidence-based clinical-practice guidelines.
including straight-leg raises (SLR), benefit these patients because exercising the knee in a fully extended position minimizes patellofemoral-joint reaction forces.\textsuperscript{23,27} Therefore, these exercises can facilitate quadriceps activation without stressing the patellofemoral joint, because the patella has no contact with the femoral condyles.\textsuperscript{27}

Roush et al\textsuperscript{28} investigated the efficacy of 3 interventions. One included a home exercise program with traditional “T” SLR exercise and the pillow squeeze (to facilitate quadriceps contraction in combination with hip adduction). Subjects in the second group received weekly physical therapy sessions, which incorporated a combination of open and closed kinetic chain exercises. Subjects in the third group performed an exercise program referred to as the Muncie method, a modification of the traditional SLR exercise. All participants performed the exercises over a 6-week period.

The investigators assessed pain, perceived functional activity, and isokinetic knee torque at the beginning of the study, at the end of the 6-week intervention, and 6 weeks after the end of the intervention. They reported that subjects who performed the quadriceps-strengthening home program and Muncie method reported statistically significant improvements regarding pain and function.

Roush et al\textsuperscript{28} concluded that a 6-week intervention using either the home program or Muncie SLR exercise program was effective for patients diagnosed with PFPS. Eburne and Bannister,\textsuperscript{22} Thomee,\textsuperscript{30} and McMullen et al\textsuperscript{27} found similar results in comparable studies, and subjects in the McMullen study even reported improvement in impairments as soon as 4 weeks after initiating the intervention.

Conclusion/Clinical Implication: Results from these studies demonstrate that patients with PFPS can benefit from isometric quadriceps-strengthening and SLR exercises. It appears that a variety of approaches using isometric and SLR exercises could positively enhance function in these patients.

**Isokinetic Exercise**

Isokinetic exercise differs from isometrics in that it allows subjects to move the tibia over the femur through a specified range of motion at a constant velocity. This form of open kinetic chain (OKC) exercise has been used in traditional PFPS rehabilitation,\textsuperscript{23} and researchers have investigated the effect of isokinetic exercise in decreasing impairments associated with patients with PFPS.

Alaca et al\textsuperscript{18} investigated this effect in symptomatic subjects who participated in a 6-week (3 sessions a week) isokinetic training program. Subjects performed 3 sets of 10 repetitions at angular speeds of 60°/s and 180°/s and reported no pain during exercise sessions. Results from this study demonstrated that subjects had statistically significant decreases in pain, increases in functional-testing scores, and increases in peak torque, total work, and
power at 60°/s and 180°/s. The researchers concluded that isokinetic exercise can promote extensor-mechanism strength in a pain-free manner.

McMullen et al\(^{27}\) also reported subject improvement with isokinetic exercise. Their study implemented a 2-phase program. Phase I included low-speed (30°, 60°, 90°, and 120°/s), short-arc (30° to 0°) angular velocities. Subjects then progressed to phase II, which incorporated high-speed (180°, 240°, and 300°/s), full-arc (90° to 0°) exercises if subjects could do them without pain. The researchers did not report how many subjects progressed to phase II but stated that patients who could not tolerate this phase continued working at the phase I program. This finding suggests that some subjects did not tolerate a more aggressive isokinetic program.

Based on the McMullen study, clinicians should consider the potential for excessive pressure when performing active exercise near terminal knee extension. Steinkamp et al\(^{33}\) reported increased patellar pressure over a smaller contact area as the knee moved toward terminal extension during OKC exercise. These findings imply that some patients with PFPS might not tolerate a full-range-of-motion isokinetic-exercise program.

**Conclusion/Clinical Implication:** Results from these studies demonstrate that patients with PFPS can benefit from isokinetic exercise. Oftentimes, 3 sets of 10 repetitions at 2 or 3 speeds have been used successfully, but clinicians should use caution to ensure that patients can perform all exercise in a pain-free range of motion.

### Closed Kinetic Chain Exercise

Many clinicians prefer closed kinetic chain (CKC) exercise because of its functional manner and decreased stress to the patellofemoral joint, particularly in the terminal ranges of 40° to full extension.\(^{34}\) Steinkamp et al\(^{33}\) documented the fact that patellofemoral joint-reaction forces are minimized during CKC exercise performed from 0° to 40° of knee flexion. They think that patients with PFPS might tolerate a CKC rehabilitation program, performed from 0° to 40° knee flexion, better than one focusing on OKC exercise, because of lower patellofemoral-joint stresses.

Witvrouw et al\(^{31}\) evaluated the efficacy of OKC versus CKC exercise in patients with PFPS. Sixty subjects participated in this study and were randomly assigned to either the OKC or CKC group. All subjects performed the rehabilitation program for 5 weeks and were evaluated at the beginning of the study, immediately after the end of the rehabilitation intervention, and 3 months after the beginning of the study. The researchers evaluated patients using the Kujala patellofemoral scale, functional tests, isokinetic muscle-strength testing, and flexibility measures. They reported that subjects in both groups improved functionally, and they found no differences in the amount of improvement between the 2 groups.
Stiene et al\textsuperscript{29} compared the effects of CKC and isokinetic exercise in patients diagnosed with PFPS. Subjects performed the prescribed exercise regimen for an 8-week period and were assessed periodically over a 1-year period. Although only 70\% of the subjects participated in the final assessment, the researchers found that all had improved with respect to strength measures. Subjects who participated in the CKC-exercise program, however, scored higher on measures related to functional improvements and perceived functional status.

Thomee\textsuperscript{30} compared isometric exercise with exercise focusing on eccentric muscle contractions. Subjects in the first group performed a program that emphasized isometric contractions, whereas those in the second group performed a program that focused on eccentric contractions during OKC and CKC exercises. All subjects reported a decline in pain level and demonstrated improved knee-torque measurements, vertical-jumping ability, and physical activity level at the end of a 12-week intervention. The author concluded that no difference existed between the effectiveness of the 2 exercise programs.

**Conclusion/Clinical Implication:** Results from these studies demonstrate that patients with PFPS can benefit from both OKC and CKC exercise. Clinicians must consider the biomechanical influences of joint position and the effect on patellofemoral-joint stresses. A key point is that patients perform all exercises in a pain-free manner. If patients are unable to tolerate CKC exercise, then OKC exercise might be a viable option. Selection of range of motion will dictate whether open (40° to 90° flexion) or closed (0° to 40° flexion) kinetic chain might be most appropriate.

**Biofeedback**

Many clinicians use biofeedback in combination with exercise to facilitate quadriceps activity. Biofeedback is thought to help patients develop improved voluntary control over quadriceps activation.\textsuperscript{21} Although many researchers have reported increased quadriceps activity using this modality in healthy subjects,\textsuperscript{35-37} fewer studies have specifically examined the benefits of biofeedback for patients with knee pathology.\textsuperscript{21}

Dursun et al\textsuperscript{21} investigated the relationship between biofeedback, exercise, and quadriceps function in patients with PFPS. Sixty subjects participated in the study and were assigned to 1 of the following groups: biofeedback and exercise or exercise only. All subjects performed a traditional exercise program 5 days a week for 4 weeks and then 3 days a week for another 8 weeks. The exercise program consisted of isometric strengthening, as well as flexibility, proprioceptive, and endurance training.

The researchers measured changes in visual-analog-scale (VAS) scores, Functional Index Questionnaire (FIQ) scores, and mean quadriceps contraction at the end of each month. VAS and FIQ scores improved
significantly for both groups at each measurement interval. Subjects in the biofeedback group also demonstrated significant increases in mean quadriceps-contraction values when compared with those in the exercise group. Although the researchers found statistically significant increases in certain mean quadriceps-contraction values, these findings might lack clinical significance because of effect sizes ranging from .27 to .33. Cohen has interpreted this range as representing a small effect size.

The diagnosis of PFPS depends primarily on a patient’s subjective history of pain and functional limitations; therefore, the effectiveness of an intervention might rely more on changes in patient complaints. All subjects in the Dursun et al study demonstrated equally significant improvements on VAS and FIQ scores. Based on these improvements, the authors concluded that biofeedback did not result in clinical improvement beyond that of traditional exercise alone.

Conclusion/Clinical Implication: Biofeedback might not provide benefit for patients with PFPS additional to that of exercise alone. Clinicians should consider the cost:benefit ratio when deciding whether or not to use biofeedback in the rehabilitation process.

**McConnell-Based Patella Taping**

Soft-tissue structures, quadriceps activity, and neuromotor systems can affect patella tracking, and imbalances of any of these factors can contribute to abnormal patella tracking.

Historically, practitioners have hypothesized that vastus medialis oblique (VMO) and vastus lateralis (VL) muscle-activation timing differences might lead to abnormal lateral patella tracking and PFPS. They think that techniques that can decrease VMO/VL timing differences by improving patella tracking might decrease PFPS symptoms.

McConnell has advocated the use of patella taping to promote pain-free exercise for patients with PFPS, reporting that patella taping places the patella in a more medial position and decreases compressive forces caused by excessive lateralization. McConnell has reported success rates as high as 96% in patients with PFPS who performed exercise in combination with this taping technique.

Eburne and Bannister compared the McConnell regimen with an isometric quadriceps-exercise program in patients with PFPS. One group of subjects performed quadriceps isometric and SLR exercises; subjects in the other group performed VMO-strengthening exercises with McConnell taping. All participants performed the exercises over a 3-month period. The researchers measured improvements using a VAS, McConnell critical test, and a modified Clark test. At the end of the 3-month period, subjects in both groups demonstrated improvements in these parameters, and statistical analyses did not reveal any between-group differences. Overall, the
results showed that both exercise programs benefited all patients by 50%, far less than the 96% success rate reported by McConnell. Clark et al\textsuperscript{19} conducted a randomized controlled trial that examined the effect of exercise, patient education, and taping on strength, pain, and function in patients diagnosed with PFPS. The researchers assigned participants to 1 of the following intervention groups: exercise, taping, and education; exercise and education; taping and education; and education regarding the etiology and prevention of further knee irritation (shoe wear, ice, stress relaxation, and diet/weight advice). Subjects assigned to the exercise groups performed activities that resulted in strong eccentric contractions of the lower limb extensors (gluteal and quadriceps muscles). These subjects performed wall squats, step-downs, and proprioceptive balance work on a minitramp daily and were monitored by the investigators 6 times over a 3-month period. Subjects assigned to the taping groups were instructed in tape application in which they applied the tape from the lateral border of the patella, pulling upward and medially over the medial femoral condyle.

The researchers measured pain, perceived function, and strength before the intervention and at 3 and 12 months after the beginning of the study. All subjects demonstrated improvements in all parameters at the 3-month retesting period. In addition, those in the exercise and education groups achieved greater strength gains than did subjects who only did taping. For the 12-month retesting, the researchers sent a questionnaire on pain and perceived function. Sixty-nine percent of subjects responded, and results showed that subjects who performed exercises had significantly lower pain scores and higher perceived function. The researchers concluded that taping did not add greater value than exercise alone.

Kowall et al\textsuperscript{25} reported similar results in their study examining the efficacy of patella taping in the conservative management of PFPS. Two groups of subjects performed identical exercises 2 times a week for 4 weeks in addition to a daily home-exercise program. Groups differed only in that 1 group performed the exercises with McConnell taping. Dependent variables included VAS scores, isokinetic knee peak-torque values, and integrated EMG for the VMO and VL. At the end of the study, all subjects demonstrated a decrease in symptoms, although there was no difference between groups. The researchers also reported similar findings with respect to the isokinetic and EMG parameters. They concluded that the addition of patella taping to a standard physical therapy program did not alter outcomes for subjects in either group.

As mentioned previously, many investigators have reported VMO/VL timing differences that might contribute to abnormal patella tracking. Although some researchers believe that timing differences exist and that taping can affect them,\textsuperscript{41} other researchers have not reported VMO/VL timing differences in patients with PFPS.\textsuperscript{32,44,45} Findings from the preceding studies suggest that exercise can increase quadriceps strength, decrease
pain, and improve function, but the role of patella taping remains elusive. Further studies should examine this phenomenon.

**Conclusion/Clinical Implication:** Taping has been a popular treatment modality for patients diagnosed with PFPS, and researchers have examined the efficacy of taping in combination with exercise. Results from the current review of the literature support the notion that the exercise component, and not necessarily the tape application, benefited patients with PFPS. These findings imply that further research is needed in determine the therapeutic effects of patella taping.

**Combination of Treatments**

Other researchers have examined the efficacy of physical therapy intervention on patients with PFPS using a combination of the preceding techniques. Harrison et al\textsuperscript{24} studied 3 treatment approaches: 1) a home strengthening and flexibility program, 2) a physical therapist–monitored program (3 times a week for 4 weeks) similar to group 1’s home exercise program, and 3) a comprehensive exercise program that employed biofeedback and patella taping. The researchers monitored pain, perceived function, and strength over a 1-year period. Results from this study showed that subjects in the comprehensive treatment program attained more improvement in impairments initially at the first 3-month retesting date. Long-term evaluation, however, indicated that all subjects benefited from their particular interventions and that no difference existed between groups regarding the amount of improvement.

Crossley et al\textsuperscript{20} conducted a randomized, placebo-controlled trial studying the effectiveness of physical therapy interventions. These researchers also used a combination of all interventions discussed previously. This study differed from that of Harrison et al\textsuperscript{24} in that 1 group of subjects received a placebo intervention. Specifically, the treatment group participated in a program consisting of patella taping, VMO biofeedback, gluteal strengthening, and soft-tissue stretching. Those in the placebo group received placebo taping, sham ultrasound, and light application of a nontherapeutic gel. To determine differences between groups, the researchers examined VAS scores, FIQ scores, anterior knee-pain scores, and patients’ perceived response to treatment. At the end of the 6-week intervention, subjects receiving the “true” intervention demonstrated a greater reduction in the parameters measured. Results from this study had high effect sizes\textsuperscript{38} related to the VAS and anterior knee-pain scores (ranges from .75 to .91), although the FIQ scores had a small effect size (.33).

Although the Crossley et al\textsuperscript{20} study provided evidence on the efficacy of physical therapy, it might not provide additional information regarding the most effective intervention. Many researchers\textsuperscript{9,29-31} have established a relationship between quadriceps strengthening and decreased impairments
in patients with PFPS. This study employed exercise and other techniques. One might infer that exercise contributed the most to reducing the patients’ symptoms. Therefore, additional randomized clinical trials that can make direct comparisons between specific interventions would provide much-needed evidence regarding the most important intervention strategy.

**Conclusion/Clinical Implication:** All of the research findings discussed throughout this review support the findings of the Harrison et al.\textsuperscript{24} and Crossley et al.\textsuperscript{20} studies. A potential flaw with these “combination of treatment” studies relates to the difficulty in drawing definitive conclusions regarding which part of the rehabilitation program might be the most beneficial.

**Influences From Hip Musculature**

Information has recently been reported on a relationship between proximal hip-muscle weakness and the incidence of PFPS.\textsuperscript{26,46} Although few researchers have provided quantitative data on proximal hip weakness in the PFPS population, clinicians have included gluteal strengthening as part of a comprehensive PFPS intervention.\textsuperscript{3,19,20,26,28} Powers et al.\textsuperscript{47} have provided information that patellofemoral-joint kinematics differ during weight-bearing and non-weight-bearing lower extremity positions. Using kinematic magnetic-resonance imaging, they found that the patella rotates on the femur during non-weight-bearing knee-extension exercise. Alternatively, they described patellofemoral-joint kinematics as the femur rotating underneath the patella during weight-bearing knee-extension exercise. Findings from this study support the influence of the proximal hip musculature’s role in controlling femoral internal rotation. In addition, Powers et al.\textsuperscript{48} have reported that subjects with PFPS demonstrated less femoral internal rotation than did subjects in a control group during normal gait and speculated that the PFPS subjects maintained less femoral internal rotation to decrease the Q angle.

Mascal et al.\textsuperscript{45} recently reported on the effectiveness of an intervention that focused on the hip, pelvis, and trunk muscles. Dependent variables examined included pain, functional status, quadriceps and hip strength, PFPS-provocation tests (apprehension test and patella compression), and an observational gait assessment for 2 subjects. In addition, the researchers performed motion analysis on 1 subject to determine changes in lower extremity kinematic factors. The subjects participated in a progressive 14-week exercise program. Both reported improvements in all measured variables. Furthermore, the subject who underwent motion analysis demonstrated a $1.2^\circ$ decrease in femoral internal rotation and a $5.4^\circ$ decrease in ipsilateral hip adduction after participating in the intervention. The researchers concluded that both
subjects responded favorably to the treatment and that factors proximal to the knee might influence PFPS pain. Although this study was only a report of 2 case studies, it has provided important information regarding the direction in which researchers might focus new investigations.  

Conclusion/Clinical Implication: Investigations relating to the role of the musculature proximal to the knee are limited. Clinicians have inferred that the hip might contribute to PFPS but without specific data to support this theory. Current studies support the role of hip stabilization with respect to knee pathology; however, additional studies are needed to better understand this relationship.

Conclusion

This review of the literature supports the idea that a variety of strengthening exercises have a therapeutic effect on subjects with PFPS. Although clinicians might have a bias toward either OKC or CKC exercise, either type of exercise can benefit this patient population, particularly when applied in pain-free and appropriately matched portions of the range of motion. Clinicians have also popularized the use of biofeedback and patella taping; however, limited research has supported these interventions. In summary, this literature review has compiled relevant clinical findings that clinicians can use to facilitate the decision-making process in prescribing an intervention founded on sound scientific data for this patient population.

Table 1 presents the summarized findings of the selected articles that met our inclusion criteria (published in peer-reviewed journals in the last 20 years and having a clinical intervention of at least 4 weeks related to patients with patellofemoral-pain syndrome). To give meaning to these interventions, a calculated effect size was generated in an attempt to demonstrate the level of impact seen in each study, which might serve as a guide to intervention selection for patients with this condition.

References


