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Chyrsten L. Regelski
Old Dominion University

Brittany L. Ford
Old Dominion University

Matthew C. Hoch
Old Dominion University

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Hip Strengthening Compared With Quadriceps Strengthening in Conservative Treatment of Patients With Patellofemoral Pain: A Critically Appraised Topic

Chyrsten L. Regelski, ATC, Brittany L. Ford, ATC, and Matthew C. Hoch, PhD, ATC • Old Dominion University

Clinical Scenario: Patellofemoral pain is a common injury that affects both athletic and sedentary populations. Clinicians may treat patellofemoral pain more effectively through a comprehensive understanding of the most effective exercise protocols. **Clinical Question:** In patients with patellofemoral pain, are hip abductor and external rotator muscle strengthening exercises more effective in reducing pain and improving patient-reported function compared with isolated quadriceps strengthening? **Summary of Key Findings:** A comprehensive and systematic database search was conducted for studies of level 2 evidence or higher. The search yielded 253 studies; of these studies, four randomized control trials and one comparative control trial fit the inclusion and exclusion criteria. A combination of quadriceps and hip strengthening exercises or hip strengthening exercises alone reduced pain and improved patient-reported function compared with quadriceps strengthening alone. **Clinical Bottom Line:** There is strong evidence to support the use of hip strengthening or hip strengthening combined with quadriceps strengthening in the treatment of patellofemoral pain to decrease pain and improve patient reported function. **Strength of Recommendation:** The Strength of Recommendation Taxonomy recommends a grade of A for level 1 evidence with consistent patient-oriented findings.

Clinical Scenario

Patellofemoral pain (PFP) is a common overuse injury in physically active populations, with the highest prevalence in women.[1] Typically, patients with PFP have increased pain, activity limitations, and participation restrictions associated with activities of daily living and physical activity; such as ascending and descending stairs, squatting, kneeling, running, jumping and prolonged sitting.[2–5] Traditionally, rehabilitation protocols for PFP have focused on quadriceps strengthening. However, current research supports the incorporation of hip strengthening exercises which focus on the abductors and external rotators.[2–6] Examining the evidence related to interventions involving the hip muscles versus traditional quadriceps strengthening may provide new insights into clinical practice and patient care for this condition.

Focused Clinical Question

In patients with PFP, are hip abductor and external rotator muscle strengthening exercises more effective in reducing pain and improving patient-reported function compared with isolated quadriceps strengthening exercises?

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Search Strategy

Terms Used to Guide Search Strategy

- **P**atient/client group: patellofemoral pain OR anterior knee pain
- **I**ntervention (or assessment): hip strengthening
- **C**omparison: quadriceps strengthening
- **O**utcome(s): pain AND function

Sources of Evidence Searched

- PubMed
- Medline
- CINAHL
- SPORTDiscus
- Additional resources obtained via review of reference lists and hand search

Inclusion and Exclusion Criteria

Inclusion Criteria

- Studies identified as level 2 evidence or higher (Strength of Recommendation Taxonomy[7])
- Patients who were diagnosed with PFP
- Studies that compared traditional quadriceps strengthening to an intervention program which focused on hip abductor and external rotator strengthening
- Studies investigating patient-reported pain (e.g., visual analog scale, numerical pain rating scale) or patient-reported function as outcome measures
- Limited to English
- Limited to publications within the last 10 years (2005 to 2014)

Exclusion Criteria

- Studies that included participants with other knee, hip, or ankle pathologies
- Studies that did not include pain and self-reported function as outcome measures
- Studies that did not incorporate or directly compare quadriceps or hip abductor and external rotator strengthening programs
- Studies that included therapeutic interventions or modalities outside of quadriceps or hip abductor and external rotator strengthening

Results of Search

Summary of Search, Best Evidence Appraised, and Key Findings

- The literature search produced 253 studies; four randomized control trials and one comparative control trial[2–6] met the inclusion and exclusion criteria (Table 1). Five studies examined pain and four studies examined patient-reported function (Figure 1).[8]
- Each study compared hip strengthening to quadriceps strengthening or combined hip and quadriceps strengthening to quadriceps strengthening alone.
- The PEDro scale[9] was used by two independent reviewers to critically appraise all studies because this instrument is designed specifically for randomized control trials. Both reviewers came to a consensus on all scores, which ranged from 5 to 9/10.
- Hedge's g effect sizes (pooled standard deviation) with 95% confidence intervals were calculated for all outcomes to examine the magnitude of group differences based on the postintervention data. Effect sizes were interpreted as weak (0 to 0.39), moderate (0.40 to 0.69), or strong (≥ 0.70) and are presented in Figures 2 and 3.
- Collectively, studies reported that a combination of hip and quadriceps strengthening exercises or hip strengthening alone reduced pain and improved patient-reported function compared with quadriceps strengthening alone.

Clinical Bottom Line

There is strong evidence to support the use of hip strengthening or hip strengthening combined with quadriceps strengthening in the treatment of PFP to decrease pain and improve patient-reported function.

Strength of Recommendation

There is grade A evidence that hip strengthening or hip strengthening combined with quadriceps strengthening results in greater reductions in pain and increases in patient-reported function compared with isolated quadriceps strengthening for patients with PFP. The Strength of Recommendation Taxonomy[7] recommends a grade of A for level 1 evidence with consistent patient-oriented findings.

Table 1. Summary of Articles

Study Design	Nakagawa et al.[2] (2008) Randomized Control Trial	Fukuda et al.[3] (2010) Randomized Control Trial	Dolak et al.[5] (2011) Randomized Control Trial	Fukuda et al.[4] (2012) Randomized Control Trial	Khayambashi et al.[6] (2014) Comparative Control Trial
Participants	14 patients, 10 women and 4 men (age 23.6 ± 5.9); 7 were placed in the control group and 7 were placed in the intervention group	70 female patients between 20 and 40 years of age; 25 in the control group (age 24.0 ± 7.0) not receiving treatment, 22 participants in the quad group (age 25.0 ± 6.0), and 23 participants in the hip group (age 25.0 ± 7.0)	33 female patients between 16 and 35 years of age; 17 in the hip group (age 25 ± 5) and 16 in the quad group (age 26 ± 6)	54 female patients; 49 participants completed the study, 24 in knee exercise group (age 23.0 ± 3.0) and 25 in knee and hip exercise group (age 22.0 ± 3.0)	36 patients, 18 male and 18 female assigned in alternating fashion to posterolateral hip exercise group (28.2 ± 7.9) or quadriceps exercise group (27.3 ± 6.7)
Inclusion criteria	Clinically diagnosed with PFP; anterior or retropatellar knee pain; insidious onset of symptoms being unrelated to a traumatic incident and persistent for at least four weeks; presence of pain on palpation of the patellar facets	History of anterior knee pain for at least the past 3 months and reported pain in 2 or more daily activities; sedentary for at least the past 6 months	Anterior or retropatellar knee pain during at least 2 activities of daily living; insidious onset of symptoms not related to trauma; pain with compressions of the patella; and pain on palpation of patellar facets	Women 20–40 years of age; history of anterior knee pain for at least 3 months; reported an increase of pain with 2 or more activities that commonly provoke PFP; unilateral PFP; sedentary for at least 6 months before the study	Included if diagnosed with unilateral or bilateral PFP by a physician
Exclusion criteria	Intra-articular pathologic conditions; cruciate or collateral ligament involvement; tenderness over patellar tendon, iliotibial band, or pes anserinus tendon; patellar apprehension; Osgood-Schlatter or Sinding-Larsen-Johansson syndromes; hip or lumbar referred pain; a history of patellar dislocation; knee effusion; or previous patellofemoral joint surgery	Pregnant or had any neurological disorders; hip, knee, or ankle injuries; low back or sacroiliac joint pain; rheumatoid arthritis; used corticosteroids or anti-inflammatory drugs; a heart condition that prohibited performing the exercises; or previous surgery involving the lower extremities	Symptoms present for less than one month; self-reported other knee pathology; history of knee surgery within the last year; a self-reported history of patella dislocations or subluxations; and other concurrent significant injury affecting the lower extremity	Neurological disorder; injury to the lumbosacral region, hip, knee, or ankle; rheumatoid arthritis; a heart condition; other knee pathologies; a history of surgery involving the lower extremities; and excluded if pregnant, using corticosteroids, or anti-inflammatory medication	Ligamentous laxity; meniscal injury; pes anserine bursitis; iliotibial band syndrome; patella tendinitis; or a history of patella dislocation, patella fracture, knee surgery, previous physical therapy, or symptoms that had been present for ≤ 6 months

Study Design	Nakagawa et al.[2] (2008) Randomized Control Trial	Fukuda et al.[3] (2010) Randomized Control Trial	Dolak et al.[5] (2011) Randomized Control Trial	Fukuda et al.[4] (2012) Randomized Control Trial	Khayambashi et al.[6] (2014) Comparative Control Trial
Intervention investigated	• The exercise protocol for the control group consisted of patellar mobilization, stretching of the quadriceps, gastrocnemius, iliotibial band, and hamstrings, and open and closed kinetic chain exercises for quadriceps strengthening. • The intervention group received the same exercise protocol as the control group as well as additional time for strengthening and functional training exercises focused on the transversus abdominis muscle, hip abductors, and lateral rotator muscles. • All patients performed the rehabilitation exercises once a week under the supervision of the principal investigator and four times a week at home.	• The quad and hip groups completed 3 treatment sessions per week for 4 weeks, totaling 12 sessions. • The quad group emphasized stretching and strengthening of the knee musculature. • The hip group was treated using the same protocol, with the addition of exercises to strengthen the hip abductor and lateral rotator muscles. • Load during training was standardized to 70% of the 1-repetition maximum. • Exercises utilizing elastic resistance were standardized to the maximum resistance that each patient was able to complete 10 repetitions. • Stretching of hamstrings, ankle plantar flexors, quadriceps, and IT band.	• Both groups performed flexibility exercises before strengthening exercises. • All participants received an exercise DVD, instruction booklet, and log to document home exercise compliance. • Rehabilitation exercises were performed 1 day a week with an investigator and 2 days a week at home. • Individuals were progressed through exercises individually per exercise protocol within the guidelines of the outlined exercise program. • For the first 4 weeks, exercises targeted either the hip or quadriceps muscles. • Participants progressed in the initial phase performing exercises with a resistance equal to 7% body weight.	• Exercise protocols were completed 3 times per week for 4 weeks during physical therapy. • The quad group performed stretching of hamstrings, plantar flexors, quadriceps, and iliotibial band. Strength exercises: leg press, squatting, single leg calf raises, and prone knee flexion. • Quad and hip exercise group completed same protocol as quad group with the addition of hip exercises: side-lying hip abduction with weights, standing hip abduction against elastic band, sitting hip lateral rotation against elastic band, and hip extension machine. • Load during exercise was 70% of estimated 1-repetition max. NWB exercises progressed from ankle weights to knee extension machine.	• Groups completed exercises 3 times a week for 8 weeks. • Exercise sessions were supervised by a physical therapist. • Patients completed exercises bilaterally if they had bilateral symptoms or on the symptomatic leg if unilateral symptoms existed. • Sessions consisted of a 5-min warm-up, 20 min of exercise, and a 5-min cool-down. • Resistance and repetitions were progressed in 2 week intervals. • Patients in the hip group performed 1 hip abductor strengthening exercise and 1 hip external rotator strengthening exercise. • Patients in the quadriceps group performed 2 quadriceps strengthening exercises.

(continued)

Table 1. *(continued)*

Study Design	Nakagawa et al.[2] (2008) Randomized Control Trial	Fukuda et al.[3] (2010) Randomized Control Trial	Dolak et al.[5] (2011) Randomized Control Trial	Fukuda et al.[4] (2012) Randomized Control Trial	Khayambashi et al.[6] (2014) Comparative Control Trial
Outcome measures	Worst and usual pain; pain and discomfort during stair climbing and descending stairs, squatting, and prolonged sitting, measured on VAS	Numerical Pain Rating Scale was used to measure pain; LEFS and AKPS	Worst pain on the VAS and LEFS	11-point numeric pain scale, LEFS, AKPS	VAS and Western Ontario and McMaster Universities Osteoarthritis Index
Main findings	Hip group showed a significant difference ($P < .05$) between the baseline and final assessments for all the visual analog scales, except for prolonged sitting.	The quad and hip groups had statistically lower ratings of pain during ascending stairs in comparison with the control group (both, $P < .05$); no significant difference between the quad and hip groups postintervention ($P < .05$).	• A significant time-by-group interaction was present for knee pain ($P = .04$); the hip group (2.4 ± 2.0) had less pain than the quad group (4.1 ± 2.5) at week 4. • There was no significant group-by-time interaction ($P = .65$) for the LEFS score; however scores significantly increased over time for both groups ($P < .001$).	• Both groups had significantly decreased pain with ascending stairs at 6 months and descending stairs at 3 and 6 months. • The hip group had significantly decreased pain and better function for all outcome measures on all 3 occasions than the knee group at 3, 6, and 12 months ($P < .05$).	• VAS scores for the hip group were significantly lower than VAS scores for the quadriceps group at postintervention ($P = .039$) and at 6 month follow-up ($P > .004$). • WOMAC scores for the hip group were significantly lower than the quadriceps group at postintervention ($P < .001$) and 6 month follow-up ($P < .001$).
Level of evidence	1	1	1	1	2
Evidence quality score	PEDro 9/10	PEDro 8/10	PEDro 6/10	PEDro 8/10	PEDro 5/10
Support for the answer	Yes	Does not support or refute	Yes	Yes	Yes

Note. PFP = patellofemoral pain; IT = iliotibial; NWB = non-weight-bearing; VAS = visual analog scale; LEFS = Lower Extremity Functional Scale; AKPS = Anterior Knee Pain Scale; WOMAC = Western Ontario and McMaster Universities Osteoarthritis Index.

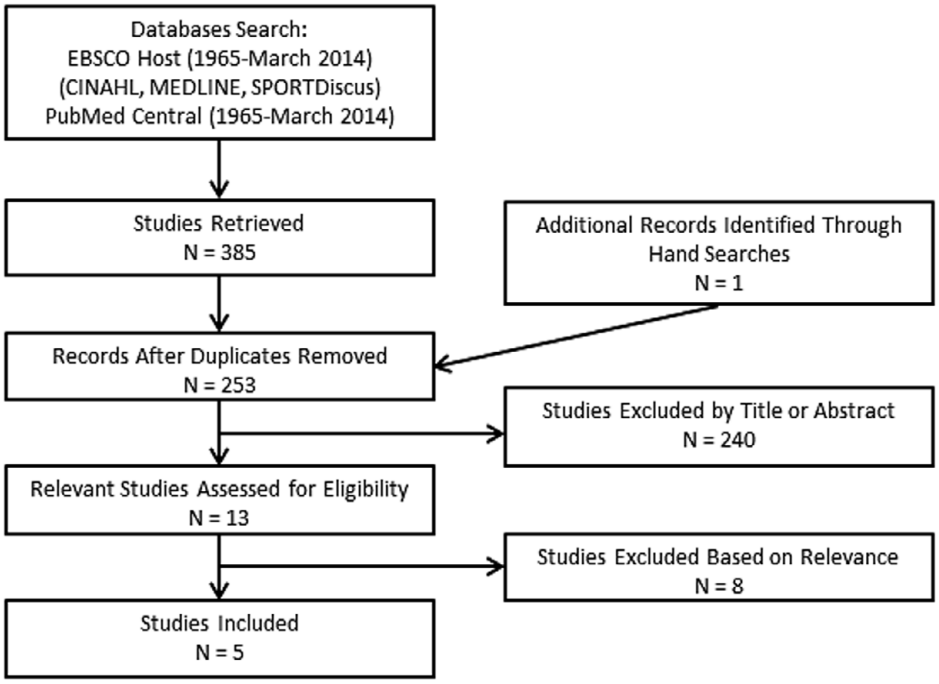

Figure 1 Search diagram.[8]

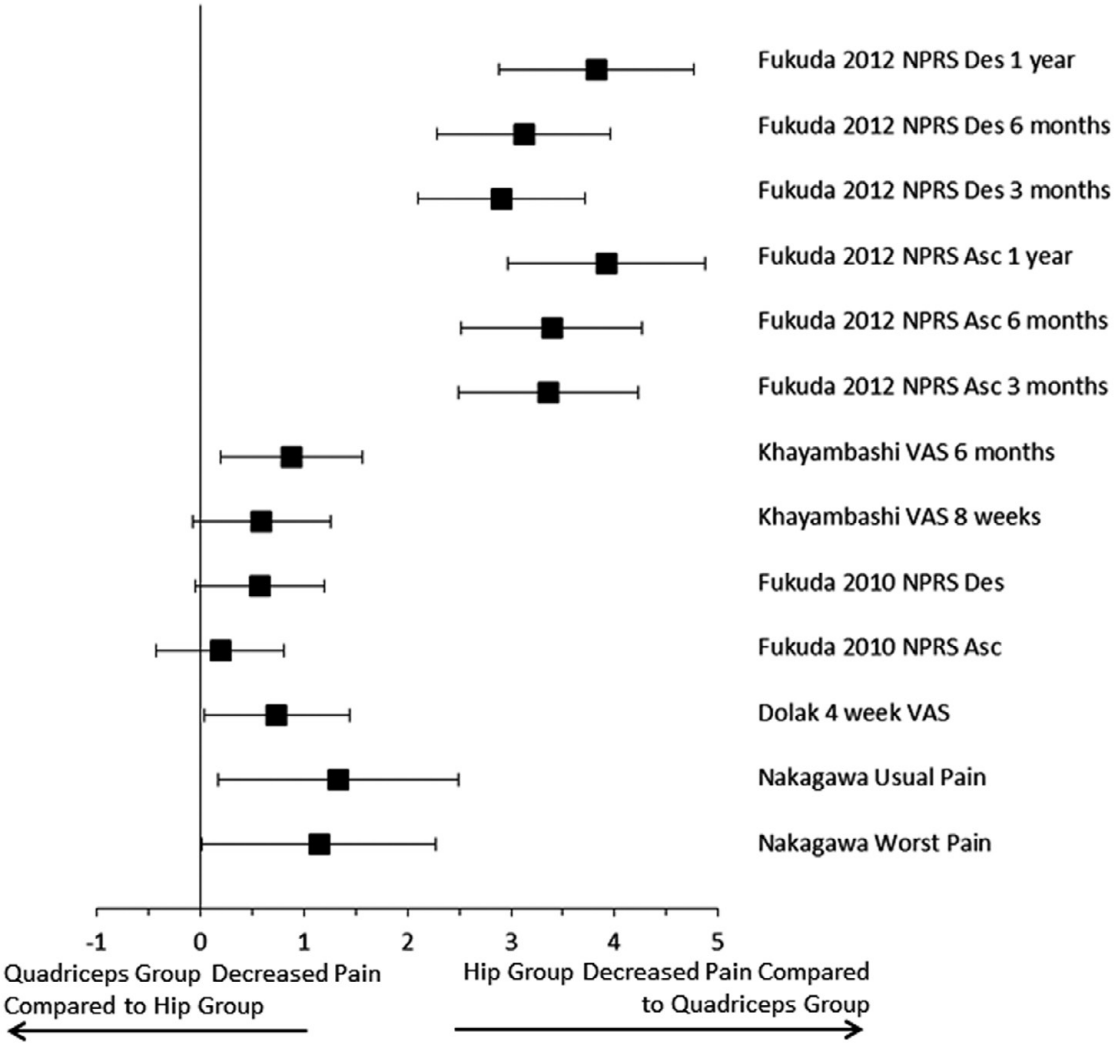

Figure 2 Postintervention effect sizes (95% confidence interval) between the hip strengthening and quadriceps strengthening groups for pain.[2–6] Greater effect sizes indicated greater reductions in pain in the hip strengthening group. NPRS = numeric pain rating scale; Des = descending; Asc = ascending; VAS = visual analog scale.

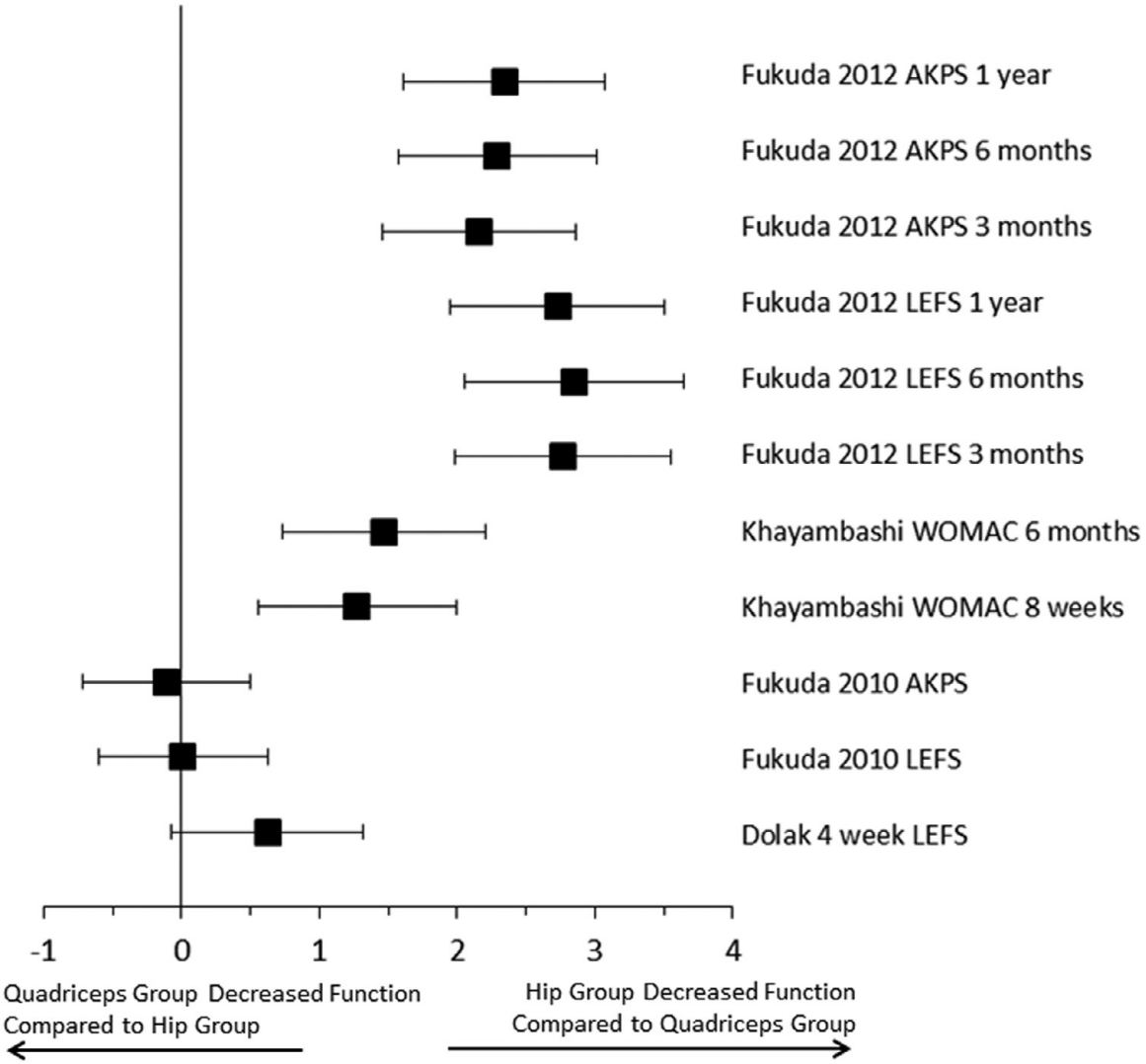

Figure 3 Postintervention effect sizes (95% confidence interval) between the hip strengthening and quadriceps strengthening groups for patient-reported function.[3–6] Greater effect sizes indicated greater improvements in patient-reported function in the hip strengthening group. AKPS = Anterior Knee Pain Scale; LEFS = Lower Extremity Functional Scale; WOMAC = Western Ontario and McMaster Universities Osteoarthritis Index.

Implications for Practice, Education, and Future Research

The current evidence supports using hip strengthening exercises alone or in combination with quadriceps strengthening exercises for PFP patients, as these protocols produced greater reductions in pain and greater improvements in patient-reported function compared with quadriceps strengthening alone. This recommendation was based on consistent high-quality evidence with mostly moderate-to-strong effect sizes which indicated the hip strengthening groups demonstrated greater improvements, particularly with longer follow-up (Figures 2 and 3). Weak hip musculature is a common finding in PFP patients and has been associated with changes in lower extremity kinematics, especially at the hip and knee.[10,11] Therefore, hip strengthening may be a more efficient rehabilitation strategy for improving lower extremity function and reducing PFP symptoms.[10,12]

The studies reviewed in this critically appraised topic (CAT) used similar hip strengthening protocols. The majority of studies used a protocol in which patients performed exercises three times per week for four weeks.[3–5] Khayambashi et al.[6] and Nakagawa et al.[2] required patients to perform exercises three times per week for eight weeks and five times per week for six weeks, respectively. Side-lying hip abduction was used by all five studies in the hip strengthening protocol.[2–6] Three of the studies[3–5] also used a stand-

ing hip abduction exercise. Some protocols chose to advance the side-lying and standing hip abduction exercises by incorporating an elastic band or ankle weight.[3,4,6] Additionally, seated hip external rotation with or without the use of an elastic band was used to strengthen the lateral rotators of the hip.[3–6] Dolak et al.[5] and Nakagawa et al.[2] combined hip abduction and external rotation while side-lying to strengthen both abductors and external rotators. Nakagawa et al.[2] used isometric exercises while the other studies used isotonic exercises. All studies incorporated stretching of the hamstrings, quadriceps, and triceps surae as part of the PFP protocols.[2–6] The similarities and variances in exercise protocols provide a strong basis to incorporate hip strengthening into clinical practice for treatment of PFP.

All studies measured patient perceptions of pain using a visual analog scale or a numeric pain rating scale.[2–6] Several studies measured patient-reported function using the Lower Extremity Functional Scale[3–5] and the Anterior Knee Pain Scale,[3,4] while Khayambashi et al.[6] used the Western Ontario and McMaster Universities Osteoarthritis Index to measure health status. While all the patient-reported function scales can measure the impact of knee injury, it should be noted that these instruments are designed to measure different dimensions of health-related quality of life. Generally, postintervention effect sizes were moderate-to-strong, indicating that the hip strengthening group demonstrated greater improvements in pain (Figure 2) and patient-reported function (Figure 3) compared with the quadriceps strengthening group. The short-term effects of hip strengthening compared with quadriceps strengthening were associated with smaller effect sizes compared with studies measuring long-term effects. This indicates that hip strengthening and quadriceps strengthening had a fairly equal effect on the pain and patient-reported function outcomes immediately following each respective intervention. Fukuda et al.[4] had the strongest effect sizes at 3, 6, and 12 months post treatment, particularly for pain. This is in contrast to the weakest effect sizes in the Fukuda et al.[3] study, which measured pain immediately after intervention. Similar trends can be seen in the patient-reported function outcomes.[3,4] The results of the included studies are supported by other studies that did not meet inclusion criteria because they compared hip strengthening to a control group which did not receive an intervention.[13,14] Cumulatively, there is strong evidence that hip strengthening is associated with greater improvements in pain and patient-reported function for patients with PFP, particularly when examined at later follow-up periods.

This CAT is not without limitations. While five studies were identified that addressed the clinical question, additional evidence in different patient populations would be beneficial. The studies presented in this CAT focused on primarily sedentary individuals as the target population. Future research should investigate the comparative effectiveness of hip and quadriceps strengthening on PFP in a sample of athletic or physically active individuals. Furthermore, studies often focus on the immediate reduction of PFP symptoms; however, the two studies that examined long-term follow-up were able to better discriminate between individuals receiving different interventions. While the studies included in this CAT indicate that traditional quadriceps strengthening can improve symptoms and function immediately, including hip strengthening appears to be an advisable treatment approach for PFP because of the long-term benefits reported by the patients receiving these interventions. More studies that include long-term follow-up after intervention may be beneficial for further studying the best approaches for treating PFP patients. Finally, this CAT focused on patient-reported outcomes. Broadening the scope of the question to include other clinical- and laboratory-oriented outcomes may be warranted in the future.

The high methodological quality of the studies contributed to the strong recommendation that hip strengthening should be included in the treatment of PFP. In all but one study subjects were randomly assigned to groups in a concealed manner. The inclusion and exclusion criteria used across the studies were similar, which allows for a fairly even comparison of subjects included in each study. Reports of dropouts were reported and intention-to-treat analyses were performed in studies that experienced dropouts. Although the studies included in the CAT had high methodological quality, as noted by the associated PEDro scores for each study, an area of concern was blinding within the studies. All but one of the studies stated that the assessors responsible for collecting baseline and post intervention outcomes were blinded to group assignment. However, the clinicians and subjects were not able to be blinded to the group assignment in all but one study. These areas of methodological quality should be considered in future studies. This CAT should be reviewed in two years to determine whether there is additional best evidence that may change the clinical bottom line for this clinical question. ▮

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Chyrsten L. Regelski, Brittany L. Ford, and ***Matthew C. Hoch*** are with Old Dominion University, Norfolk, VA.

Scott Cheatham, PT, DPT, OCS, ATC, CSCS, California State University Dominguez Hills, is the report editor for this article.