Is Isolated Hip Strengthening or Traditional Knee-Based Strengthening More Effective in Patients With Patellofemoral Pain Syndrome?

A Systematic Review With Meta-analysis

Yuyan Na,* MD, Changxu Han,* MD, Yuting Shi,† MD, Yong Zhu,‡ MD, Yizhong Ren,*§ MD, and Wanlin Liu,§|| MD

Investigation performed at the Department of Arthroscopy and Sports Medicine, the Second Affiliated Hospital of Inner Mongolia Medical University, Hohhot, Inner Mongolia Autonomous Region, China

Background: Focus on the importance of hip muscle strength in patients with patellofemoral pain syndrome (PFPS) has recently increased. It is unknown whether patients with PFPS will benefit more from hip strengthening compared with traditional knee-based strengthening.

Purpose: To compare the efficiency of isolated hip strengthening versus traditional knee-based strengthening for patients with PFPS.

Study Design: Systematic review; Level of evidence, 2.

Methods: We conducted a search for studies comparing isolated hip strengthening and knee-based strengthening by using the MEDLINE, Embase, and Cochrane Library electronic databases. The methodological quality of included studies was assessed using the PEDro scale. Predetermined variables from each study were extracted and analyzed.

Results: A total of 5 comparative studies were included in this review; all studies were of moderate to high quality and reflected good internal and external validity. Pain (visual analog scale [VAS]) and function (Anterior Knee Pain Scale) scores improved in both the hip and knee groups after strengthening intervention, although no statistically significant differences were seen between groups in the pooled analysis. In 2 studies, VAS pain scores were reduced earlier for patients in the hip group than for those in the knee group (P < .05). In 1 study, improvement in Western Ontario and McMaster Universities Osteoarthritis Index function scores in the hip group was statistically superior compared with those in the knee group after intervention and at 6-month follow-up (P < .05). In 2 studies, patients in the hip group exhibited statistically greater hip abductor and extensor strength than did those in the knee group after intervention (P < .05).

Conclusion: The best-available evidence suggests that overall, isolated hip strengthening and knee strengthening were equivalent for treatment of PFPS.

Keywords: PFPS; hip; knee; muscle strengthening; rehabilitation

Patellofemoral pain affects a large proportion of the population, from adolescents (annual prevalence, approximately 29%) to adults (annual prevalence, approximately 23%), and carries a substantial personal and societal burden. Patellofemoral pain syndrome (PFPS) is caused by a complex interplay among various anatomic, biomechanical, psychological, social, and behavioral factors. Patellofemoral pain syndrome (PFPS) is caused by a complex interplay among various anatomic, biomechanical, psychological, social, and behavioral factors. Patellofemoral pain syndrome (PFPS) is caused by a complex interplay among various anatomic, biomechanical, psychological, social, and behavioral factors. Patellofemoral pain syndrome (PFPS) is caused by a complex interplay among various anatomic, biomechanical, psychological, social, and behavioral factors. Patellofemoral pain syndrome (PFPS) is caused by a complex interplay among various anatomic, biomechanical, psychological, social, and behavioral factors. Patellofemoral pain syndrome (PFPS) is caused by a complex interplay among various anatomic, biomechanical, psychological, social, and behavioral factors.
More recently, PFPS has been proposed to be related to strength deficits of the hip musculature and core endurance. A dynamic weightbearing imaging study suggested that increased femoral internal rotation results in increased lateral patellar displacement and lateral tilt and resultant increased stress in the patellofemoral joint. This suggests that unbalanced hip muscle performance may be a contributing factor to PFPS. In biomechanical studies, persons with PFPS have demonstrated excessive hip internal rotation and hip adduction as well as weak muscle performance of the hip abductors, external rotators, and hip extensors compared with pain-free individuals.

Recent studies have reported promising results when hip muscle strengthening for PFPS is used before traditional programs of knee-strengthening training. Ismail et al reported that the addition of hip muscle strengthening to a knee-strengthening program resulted in better improvement in pain control during functional activities compared with the knee program alone. Nakagawa et al found that additional strengthening of the hip abductor and lateral rotator muscles improved perceived pain during functional activities and increased gluteus medius electromyographic activity during isometric voluntary contraction after 6 weeks of treatment compared with a control condition that entailed quadriceps strengthening.

Hip and knee strengthening are both advocated in treating PFPS. However, the relative contributions of the components have yet to be elucidated. In recent years, many studies have compared the effectiveness of isolated hip strengthening versus knee-based strengthening in terms of improving pain, function, and strength, with inconsistent conclusions. Considering the recent therapeutic interest and controversy regarding isolated hip strengthening for PFPS, we conducted this review to examine the current evidence and to determine the effectiveness of isolated hip strengthening compared with traditional knee-based strengthening for patients who have PFPS. Information obtained from this review will assist clinicians in better prescribing strengthening exercises for PFPS.

**METHODS**

**Search Strategy**

A literature search was conducted using MEDLINE, Embase, and Cochrane Library databases on September 10, 2019. This study was reported in line with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) and AMSTAR (Assessing the Methodological Quality of Systematic Reviews) guidelines. The following keywords were used for searches: “patellofemoral pain,” “hip,” “knee,” and “physical therapy and/or rehabilitation.” Reference lists of included studies were searched to ensure that no eligible studies were missed.

**Inclusion and Exclusion Criteria**

The inclusion criteria were as follows: (1) participants: patients with diagnosed PFPS and a minimum 3-month history of anterior or retropatellar knee pain during activities and present on at least 1 clinical test; (2) outcomes: pain relief, functional improvement, and muscle strength; and (3) study design: comparative clinical studies (randomized controlled trials [RCTs] and prospective comparative studies) that compared isolated hip strengthening versus traditional knee-based strengthening for PFPS.

The exclusion criteria were (1) studies that included patients with recent knee surgery, trauma, or coexisting osteoarthritis and (2) studies that entailed a multijoint strengthening program.

**Quality Assessment**

Methodological quality of included studies was assessed using the PEDro scale, developed for the Physiotherapy Evidence Database. "Yes" is equivalent to 1 point on the scale and is assigned only if the criteria are specifically stated within the text. "No" is assigned to categories not specifically stated within the text. Articles with more "yes" scores on the PEDro scale are of higher quality given the scale of the assessment. For such articles, the analysis was performed independently by 2 evaluators (Y.N. and C.H.).

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9Address correspondence to Wanlin Liu, MD, Department of Pediatric Orthopedics, the Second Affiliated Hospital of Inner Mongolia Medical University, Hohhot 010020, Inner Mongolia Autonomous Region, China (email: 18004876325@163.com) or Yizhong Ren, MD, Department of Arthroscopy and Sports Medicine, the Second Affiliated Hospital of Inner Mongolia Medical University, Hohhot 010020, Inner Mongolia Autonomous Region, China (email: 15024979153@163.com).

1Cardiac Function Department, Cadre Health Care Center, Inner Mongolia Autonomous Region People’s Hospital, Hohhot, Inner Mongolia Autonomous Region, China.

2Department of Spinal Surgery, the Second Affiliated Hospital of Inner Mongolia Medical University, Hohhot, Inner Mongolia Autonomous Region, China.

3Department of Pediatric Orthopedics, the Second Affiliated Hospital of Inner Mongolia Medical University, Hohhot, Inner Mongolia Autonomous Region, China.

4Address for correspondence: Y.N. and C.H. contributed equally to this study.

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and disagreements were resolved via discussion and consensus.

Data Collection

The following data were collected from each included study by 2 reviewers (Y.S. and Y.Z.) independently: first author, publication year, study design, sample size, mean age of patients, level of evidence, rehabilitation duration, muscle strengthening protocol, and major outcomes. The following clinical outcome measures were collected and compared: visual analog scale (VAS) for pain, Anterior Knee Pain Scale (AKPS), and hip and knee muscle strength endurance.

The reviewers were not blinded to information on authors, journal of publication, or source of financial support. Methodological quality was evaluated for each study. Disagreements were discussed and resolved by referencing the original article. The full text of articles was read, with a focus on authors and methods, to identify studies that involved the same group of patients.

Statistical Analysis

Data analysis was performed via Cochrane Review Manager 5.3 (Cochrane Collaboration, Nordic Cochrane Centre). Continuous data (VAS and AKPS scores) were measured as mean difference (MD) with 95% confidence interval (CI). *P* < .05 was considered statistically significant. Heterogeneity among included studies was assessed using the *Q* statistic and *I*² test. If *P* > .05 or *I*² < 50%, the included studies were considered to have low heterogeneity, and the fixed-effects model was applied to outcome data; otherwise, the random-effects model was applied.

RESULTS

Search Results

The search strategy produced 507 records on this topic. A total of 494 articles were excluded after screening of titles and abstracts according to predetermined topic and inclusion criteria. Of the remaining 13 studies identified for
TABLE 1
Characteristics of the Included Studies\

| Lead Author (Year) | Study design | Intervention | No. of Patients | Patient Age, y, Mean ± SD | BMI, Mean ± SD | Sex, n | Rehabilitation Time, wk |
|--------------------|--------------|--------------|-----------------|---------------------------|---------------|--------|------------------------|
| Dolak (2011)\textsuperscript{10} | RCT | Hip strengthening | H: 17 | H: 25 ± 5 | H: 24 ± 4 | 33 F | 8 |
| | | Knee strengthening | K: 16 | K: 26 ± 6 | K: 27 ± 6 | | |
| Khayambashi (2014)\textsuperscript{16} | PCS | Hip strengthening | H: 18 | H: 28.2 ± 7.9 | H: 23.8 ± 2.4 | H: 9M, 9F | 8 |
| | | Knee strengthening | K: 18 | K: 27.3 ± 6.7 | F: 22.7 ± 3.6 | K: 9M, 9F | |
| Ferber (2015)\textsuperscript{11} | RCT | Hip strengthening | H: 111 | 29.0 ± 7.1 | 23.4 | 66M, 133F | 6 |
| | | Knee strengthening | K: 88 | | | | |
| Saad (2018)\textsuperscript{27} | RCT | Hip strengthening | H: 10 | H: 22.5 ± 1.08 | H: 22.0 ± 2.0 | 20 F | 8 |
| | | Knee strengthening | K: 10 | K: 23.2 ± 2.53 | F: 21.80 ± 1.72 | | |
| Hott (2019)\textsuperscript{16} | RCT | Hip strengthening | H: 39 | H: 27.8 ± 8.6 | – | H: 14M, 25F | 12 |
| | | Knee strengthening | K: 37 | K: 28.5 ± 6.2 | – | K: 13M, 24F | |

\textsuperscript{a}Dash indicates that corresponding information was not given. BMI, body mass index; F, female; H, hip-strengthening group; K, knee-strengthening group; M, male; PCS, prospective comparative study; RCT, randomized controlled trial.

Characteristics of the Included Studies

Detailed information regarding the included studies is presented in Table 1. The 5 articles included in this systematic review involved 364 patients; there was a predominance of female patients in all studies. The mean age of patients ranged from 22.5 to 29.0 years. Details of the intervention and outcomes of the included studies are presented in Table 2.

Methodological Quality

The methodological quality of the included studies was assessed using the PEDro scale (Table 3). All of the studies received a score of at least 6, which indicated that the included studies were of moderate to high quality and reflected good internal and external validity.

VAS Pain Scores

All included studies assessed pain using the VAS scale. In all of the studies, significant improvements in VAS score were observed for both hip-strengthening exercise and knee-based exercise groups from baseline to postintervention ($P < .05$). One study reported lower VAS pain score in the hip group ($2.0 \pm 2.0$) than the knee group ($4.1 \pm 2.5$) after 4 weeks of exercise ($P = .035$).\textsuperscript{10} One study found that the hip group had a significant reduction in self-reported pain starting at week 3 of exercise, which was 1 week earlier than self-reported pain reduction in the knee group.\textsuperscript{11} One study observed that improvement in VAS pain score in the hip group was superior to that in the knee group after the intervention and at 6-month follow-up ($P < .05$).\textsuperscript{10} All included studies were analyzed with regard to VAS pain score; however, a statistically significant improvement in VAS score was not reported in favor of the hip group over the knee group (MD, –0.04 [95\% CI, –0.41 to 0.33]; $P = .83$). Heterogeneity for the VAS score in the included studies was low ($I^2 = 12\%$) (Figure 2).

Subjective and Objective Functional Tests

The self-reported Lower Extremity Functional Scale (LEFS), which is a reliable way to assess function, significantly improved from baseline to 4 weeks or 8 weeks ($P < .05$), regardless of the protocol.\textsuperscript{10} The objective step-down test, which was established to assess functional strength in the PFPS population, also significantly improved over the course of rehabilitation, regardless of the group.\textsuperscript{10} One study observed that improvement in self-reported Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) was superior in the hip group compared with the knee group after the intervention and at 6-month follow-up ($P < .05$).\textsuperscript{11} A total of 3 studies analyzed self-reported AKPS function score and did not demonstrate statistically significant improvements in favor of the hip group over the knee group (MD, 0.32 [95\% CI, –2.06 to 2.70]; $P = .79$).\textsuperscript{11,16,27} Heterogeneity for the AKPS function score in the included studies was low ($I^2 = 0\%$) (Figure 3).

Hip and Knee Muscle Strength

Dolak et al\textsuperscript{10} measured strength of the hip abductor, hip external rotator, and knee extensor using a handheld dynamometer and found that the hip group demonstrated a 21\% increase ($P < .001$) in hip abductor strength whereas hip strength remained unchanged in the knee group from baseline to 8 weeks. Ferber et al\textsuperscript{11} used a force dynamometer to measure hip abductor, hip external rotator, hip internal rotator, hip extensor, and knee extensor strength output.
of the maximal voluntary isometric contraction force and observed that patients in the hip group gained more in hip abductor strength (\( P = .01 \)) and extensor strength (\( P = .01 \)) compared with the knee group. Saad et al\(^{27} \) used a load cell (Kratos) adapted to a digital reader to measure hip abductor, adductor, extensor, flexor, external rotator, and internal rotator strength as well as knee extensor and flexor strength; the investigators found significant improvements in hip abductor, adductor, extensor, external rotator, and internal rotator strength in the hip group and significant improvements in hip flexor and knee flexor strength in the hip group from baseline to postintervention (\( P < .01 \)). Hott et al\(^{16} \) measured strength using a force sensor (300 kg; MuscleLab 6000 ML; Ergotest Innovation), which is considered a superior measurement device, and found a significant difference in knee extension strength in the hip group (\( P < .05 \)) compared with the knee group from baseline to 12-wk follow-up. We did not attempt to quantify the amount of hip and quadriceps strength improvement because of the heterogeneity of measuring methods and instruments.

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**TABLE 2**

| Lead Author (Year) | Intervention | Outcomes |
|--------------------|--------------|----------|
| **Dolak (2011)**\(^{10} \) | Hip abduction and external rotation strengthening for the first 4 wk; functional weightbearing resistance and balance exercises for an additional 4 wk. Quadriceps strengthening for the first 4 wk and functional weightbearing resistance and balance exercises for an additional 4 wk. | All participants demonstrated improved subjective LEFS function (\( P = .006 \)), objective step-down test function (\( P < .001 \)), and hip external rotator strength (\( P = .004 \)) from baseline to testing at 8 wk. VAS pain scores were lower in the hip group (2.4 ± 2.0) than in the knee group (4.1 ± 2.5) after 4 wk (\( P = .035 \)). From baseline to 8 wk, the hip group demonstrated a 21% increase in hip abductor strength, whereas hip abductor strength remained unchanged in the knee group (\( P < .001 \)). |
| **Khayambashi (2014)**\(^{18} \) | Hip abduction and external rotation strengthening for 8 wk. Quadriceps strengthening using seated and partial squat against resistance for 8 wk. | Significant improvements in VAS pain and WOMAC function scores were observed in both groups from baseline to postintervention and baseline to 6-mo follow-up (\( P < .001 \)). Improvements in VAS and WOMAC scores in the posterolateral hip exercise group were superior to those in the quadriceps exercise group after the intervention and at 6-mo follow-up (\( P < .05 \)). |
| **Ferber (2015)**\(^{11} \) | Nonweightbearing hip muscle-strengthening exercises for the first week, progressing to weightbearing exercises, including core-strengthening and balance exercises for 5 wk. Nonweightbearing quadriceps strengthening for the first week, progressing to weightbearing quadriceps-strengthening exercises for 5 wk. | VAS and AKPS scores improved in both the hip and knee groups compared with baseline (\( P < .001 \)), but VAS scores for those in the hip group were reduced 1 wk earlier than were those in the knee group. Both groups increased in strength (\( P < .001 \)) compared with baseline, but those in the hip group gained more hip abductor (\( P = .01 \)) and extensor (\( P = .01 \)) strength compared with those in the knee group. |
| **Saad (2018)**\(^{27} \) | Exercises to strengthen hip stabilizing muscles for 8 wk. Quadriceps strengthening for 8 wk. | VAS and AKPS scores improved in both the hip and the knee groups (\( P < .01 \)) after intervention, with no statistically significant differences between groups. Significant improvements were observed in hip abductor, adductor, extensor, external rotator, and internal rotator strength in the hip group and hip flexor and knee flexor in the knee group from baseline to postintervention (\( P < .01 \)). |
| **Hott (2019)**\(^{16} \) | Side-lying hip abduction, hip external rotation, and prone hip extension for 12 wk. Straight-leg raises in the supine position, supine terminal knee extensions, and a mini-squat (45 of flexion) with the back supported against the wall for 12 wk. | VAS and AKPS scores improved in both the hip and the knee groups (\( P < .05 \)) after intervention, with no statistically significant differences between groups. Significant improvements were observed in hip abductor and external rotator strength in both the hip group and the knee group (\( P < .05 \)). Significant difference in knee extension strength was observed in the hip group (\( P < .05 \)) compared with the knee group from baseline to 12-wk follow-up. |

\(^{a}\)AKPS, Anterior Knee Pain Scale; LEFS, lower extremity functional scale; VAS, visual analog scale; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.
The main finding of this systematic review was that muscle strengthening for the hip and the knee joints was effective in decreasing pain and improving function, although no statistically significant difference between groups was observed using pooled analysis. The VAS score was reduced earlier for patients in the hip group than for patients in the knee group in 2 studies.\textsuperscript{10,11} Khayambashi et al\textsuperscript{18} found that improvement in WOMAC score in the hip group was statistically superior to that in the knee group after the intervention and at 6-month follow-up. In 2 studies, patients in the hip group exhibited statistically greater gains in hip abductor and extensor strength than did patients in the knee group after the intervention.\textsuperscript{10,11}

The included studies showed good internal and external validity according to the overall PEDro scale, as they satisfied most of the items. Two studies did not describe the method of allocation concealment and thus did not satisfy item 3 on the PEDro scale.\textsuperscript{11,18} Blinding of patients and physical therapists was difficult in the included studies because the purpose was to investigate the effect of physical therapy. Therefore, none of the included studies satisfied items 5 and 6.

Crossley et al\textsuperscript{9} reported that VAS and AKPS (ie, the Kujala score) are the most reliable outcome assessments for patients with PFPS. The VAS pain score was evaluated by all of the studies included in this review. Significant reductions in VAS pain score were observed in both groups from baseline to postintervention. To compare which

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**TABLE 3**

| Lead Author (Year) | LoE | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | Total Score |
|--------------------|-----|---|---|---|---|---|---|---|---|---|----|----|-------------|
| Dolak (2011)\textsuperscript{10} | 2   | Y | Y | Y | Y | N | N | Y | N | Y | Y | Y | 8            |
| Khayambashi (2014)\textsuperscript{18} | 3   | Y | Y | N | Y | N | N | N | Y | N | Y | Y | 6            |
| Ferber (2015)\textsuperscript{11} | 1   | Y | Y | N | Y | N | N | Y | Y | Y | Y | Y | 8            |
| Saad (2018)\textsuperscript{27} | 2   | Y | Y | Y | Y | N | N | Y | Y | Y | Y | Y | 9            |
| Hott (2019)\textsuperscript{16} | 1   | Y | Y | Y | Y | N | N | Y | Y | Y | Y | Y | 9            |

*Key to item numbers: 1 = eligibility criteria specified; 2 = random allocation of patients; 3 = concealed allocation of patients; 4 = groups similar at baseline; 5 = patient blinding; 6 = therapist blinding; 7 = assessor blinding; 8 = outcome measures obtained from >85% of patients; 9 = treatment received or gave intention to treat; 10 = between-group statistical comparison; 11 = within-group statistical comparison. LoE, level of evidence; N, no; Y, yes.*

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physical therapy was more effective for pain relief, we performed a pooled analysis for the VAS score and found that neither group was superior to the other. Of the 5 studies included, 3 studies used the AKPS function score,\textsuperscript{11,16,27} 1 study used the subjective LEFS function score,\textsuperscript{10} and 1 study used the WOMAC function score.\textsuperscript{15} There appeared to be more improvements in pain and function scores using hip intervention than using knee intervention, although no statistically significant difference was found after pooled analysis. For example, Khayambashi et al\textsuperscript{10} demonstrated that improvements in pain and function scores in the hip group were statistically superior to those in the knee group after the intervention and at 6-month follow-up.

Biomechanical research on PFPS has demonstrated that potential contributors include excessive hip internal rotation and hip adduction as well as weak muscle performance of the hip abductors, external rotators, and hip extensors in participants who report pain compared with pain-free individuals.\textsuperscript{23,31} In the study by Dolak et al,\textsuperscript{10} female patients with PFPS performed hip strengthening (hip abduction and external rotation strengthening) or quadriceps strengthening for the first 4 weeks before the addition of functional weightbearing resistance and balance exercises for the next 4 weeks; the investigators found that the hip group demonstrated a 21% increase \((P < .001)\) in hip abductor strength whereas hip abductor strength remained unchanged in the knee group from baseline to 8 weeks. Participants in the study by Ferber et al\textsuperscript{11} performed nonweightbearing hip (hip abduction and external rotation strengthening) or knee muscle-strengthening exercises for the first week and progressed to weightbearing hip (hip abduction, internal rotation, external rotation, and balance exercises) or knee muscle-strengthening exercises for an additional 5 weeks. The investigators demonstrated that hip exercises exhibited statistically greater improvements in hip abductor and extensor strength than did the baseline condition or knee exercises. Both of these studies reported rehabilitation protocols that entailed a combination of nonweightbearing and weightbearing exercises and showed efficiency in increasing hip abductor and extensor strength, the lack of which both have been confirmed as potential contributors to PFPS. A weightbearing position requires a contribution of both hip and quadriceps musculature, which may contribute to the positive findings. Scali et al\textsuperscript{29} showed that a multijoint-strengthening program (involving hip and knee joints) for reducing pain and improving functional performance was superior to a traditional knee-strengthening program.

Harvie et al\textsuperscript{14} suggested that effective strengthening for patients with PFPS entailed performing 2 to 4 sets of 10 or more repetitions daily for 6 or more weeks. Scali et al\textsuperscript{29} reported that duration and dosage of exercise were major factors in improving pain, function, and muscle strength. All of the studies included in the review by Scali et al involved an exercise duration of >6 weeks and obtained significant improvements from baseline to final follow-up. Ferber et al\textsuperscript{11} designed a 6-week hip- and knee-strengthening protocol in which participants performed 3 sets of 10 or more repetitions per week; the investigators observed significant improvements in VAS score, AKPS score, and hip abductor-extensor strength in both groups from baseline to postintervention. The rest of our included studies used protocols with a slightly increased number of repetitions and exercise progression.

This review had some limitations. The method of diagnosing PFPS varied among the included studies, being based on symptom location and reproduction of pain with activities or assessment via radiography and magnetic resonance imaging; this inconsistency might bring about confusion. There were differences in rehabilitation protocols, including intervention programs (such as different positions [side-lying, sitting, and standing] and different testing procedures), rehabilitation duration, and exercise dosage. Heterogeneity of sexes among the included studies is an important variable in this analysis because female patients have a higher prevalence of PFPS than do their male counterparts. Despite these limitations, this review is a synthesis of the available high-quality studies on PFPS and provides useful information to researchers.

CONCLUSION

The best-available evidence suggests that overall, isolated hip and knee strengthening were equivalent for PFPS. In some of the included studies, isolated hip muscle strengthening was more effective in increasing hip abductor and extensor strength and reducing pain earlier compared with knee-based strengthening.

REFERENCES

1. Baldon Rde M, Serrão FV, Scattone Silva R, Piva SR. Effects of functional stabilization training on pain, function, and lower extremity biomechanics in women with patellofemoral pain: a randomized clinical trial. J Orthop Sports Phys Ther. 2014;44(4):240-251, A1-A8.
2. Barton CJ, Lack S, Hemmings S, Tufail S, Morrissey D. The “best practice guide to conservative management of patellofemoral pain”: incorporating level 1 evidence with expert clinical reasoning. Br J Sports Med. 2015;49(14):923-934.
3. Bolgla LA, Boling MC. An update for the conservative management of patellofemoral pain syndrome: a systematic review of the literature from 2000 to 2010. Int J Sports Phys Ther. 2011;6(2):112-125.
4. Bolgla LA, Earl-Boehm J, Emery C, Hamstra-Wright K, Ferber R, Pain, function, and strength outcomes for males and females with patellofemoral pain who participate in either a hip/core- or knee-based rehabilitation program. Int J Sports Phys Ther. 2016;11(6):926-935.
5. Collins NJ, Barton CJ, van Middelkoop M, et al. 2018 Consensus statement on exercise therapy and physical interventions (orthoses, taping and manual therapy) to treat patellofemoral pain: recommendations from the 5th International Patellofemoral Pain Pain Research Retreat, Gold Coast, Australia, 2017. Br J Sports Med. 2018;52(18):1170-1178.
6. Collins NJ, Bisset LM, Crossley KM, Vicenzino B. Efficacy of nonsurgical interventions for anterior knee pain: systematic review and meta-analysis of randomized trials. Sports Med. 2012;42(1):31-49.
7. Cowan SM, Bennell KL, Hodges PW, Crossley KM, McConnell J. Delayed onset of electromyographic activity of vastus medialis obliquis relative to vastus lateralis in subjects with patellofemoral pain syndrome. Arch Phys Med Rehabil. 2001;82(2):183-189.
8. Cowan SM, Hodges PW, Bennell KL, Crossley KM. Altered vastii recruitment when people with patellofemoral pain syndrome complete a postural task. Arch Phys Med Rehabil. 2002;83(7):989-995.
9. Crossley KM, Bennell KL, Cowan SM, Green S. Analysis of outcome measures for persons with patellofemoral pain: which are reliable and valid? Arch Phys Med Rehabil. 2004;85(5):815-822.

10. Dolak KL, Silkman C, Medina McKeon J, et al. 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(8):560-570.

11. Ferber R, Bolgla L, Earl-Boehm JE, Hamstra-Wright K. Strengthening of the hip and core versus knee muscles for the treatment of patellofemoral pain: a multicenter randomized controlled trial. J Athl Train. 2015;50(4):366-377.

12. Fukuda TY, Melo WP, Zaffalon BM, et al. Hip posterolateral musculature strengthening in sedentary women with patellofemoral pain syndrome: a randomized controlled clinical trial with 1-year follow-up. J Orthop Sports Phys Ther. 2012;42(10):823-830.

13. Fukuda TY, Rossetto FM, Magalhaes E, et al. Short-term effects of hip abductors and lateral rotators strengthening in females with patellofemoral pain syndrome: a randomized controlled clinical trial. J Orthop Sports Phys Ther. 2010;40(11):736-742.

14. Harvie D, O’Leary T, Kumar S. A systematic review of randomized controlled trials on exercise parameters in the treatment of patellofemoral pain: what works? J Multidiscip Healthc. 2011;4:383-392.

15. Heintjes E, Berger MY, Bierma-Zeinstra SM, et al. Exercise therapy for patellofemoral pain syndrome. Cochrane Database Syst Rev. 2003;4:CD003472.

16. Hott A, Brox JL, Pripp AH, et al. Effectiveness of isolated hip exercise, knee exercise, or free physical activity for patellofemoral pain: a randomized controlled trial. Am J Sports Med. 2019;47(6):1312-1322.

17. Ismail MM, Gamaleldein MH, Hassa KA. Closed kinetic chain exercises with or without additional hip strengthening exercises in management of patellofemoral pain syndrome: a randomized controlled trial. Eur J Phys Rehabil Med. 2013;49(5):687-698.

18. Khayambashi K, Fallah A, Movahedi A, Bagwell J, Powers C. Posterolateral hip muscle strengthening versus quadriceps strengthening for patellofemoral pain: a comparative control trial. Arch Phys Med Rehabil. 2014;95(5):900-907.

19. Mascal CL, Landel R, Powers C. Management of patellofemoral pain targeting hip, pelvis, and trunk muscle function: 2 case reports. J Orthop Sports Phys Ther. 2003;33(11):647-660.

20. Nakagawa TH, Muniz TB, Baldon Rde M, et al. The effect of additional strengthening of hip abductor and lateral rotator muscles in patellofemoral pain syndrome: a randomized controlled pilot study. Clin Rehabil. 2008;22(12):1051-1060.

21. Nimon G, Murray D, Sandow M, Goodfellow J. Natural history of anterior knee pain: a 14- to 20-year follow-up of nonoperative management. J Pediatr Orthop. 1998;18(1):118-122.

22. 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.

23. Powers CM. The influence of abnormal hip mechanics on knee injury: a biomechanical perspective. J Orthop Sports Phys Ther. 2010;40(2):42-51.

24. Powers CM, Ward SR, Fredericson M, Guillett M, Shellock FG. Patellofemoral kinematics during weight-bearing and non-weight-bearing knee extension in persons with lateral subluxation of the patella: a preliminary study. J Orthop Sports Phys Ther. 2003;33(11):677-685.

25. Powers CM, Witvrouw E, Davis IS, Crossley KM. Evidence-based framework for a pathomechanical model of patellofemoral pain: 2017 patellofemoral pain consensus statement from the 4th International Patellofemoral Pain Research Retreat, Manchester, UK, part 3. Br J Sports Med. 2017;51(24):1713-1723.

26. Robinson RL, Nee RJ. Analysis of hip strength in females seeking physical therapy treatment for unilateral patellofemoral pain syndrome. J Orthop Sports Phys Ther. 2007;37(5):232-238.

27. Saad MC, Vasconcelos RA, Mancinelli LVO, et al. Is hip strengthening the best treatment option for females with patellofemoral pain? A randomized controlled trial of three different types of exercises. Braz J Phys Ther. 2018;22(5):408-416.

28. Sahin M, Ayhan FF, Borman P, Atasoy H. The effect of hip and knee exercises on pain, function, and strength in patients with patellofemoral pain syndrome: a randomized controlled trial. Turk J Med Sci. 2016;46(2):265-277.

29. Scali K, Roberts J, McFarland M, Marino K, Murray L. Is multi-joint or single joint strengthening more effective in reducing pain and improving function in women with patellofemoral pain syndrome? A systematic review and meta-analysis. Int J Sports Phys Ther. 2018;13(3):321-334.

30. 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.

31. 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.

32. Van Tiggelen D, Cowan S, Coorevits P, Duvigneaud N, Witvrouw E. Delayed vastus medialis obliquus to vastus lateralis onset timing contributes to the development of patellofemoral pain in previously healthy men: a prospective study. Am J Sports Med. 2009;37(6):1099-1105.

33. Verhagen AP, de Vet HC, de Bie RA, et al. The Delphi list: a criteria list for quality assessment of randomized clinical trials for conducting systematic reviews developed by Delphi consensus. J Clin Epidemiol. 1998;51(12):1235-1241.

34. Witvrouw E, Lynes R, Bellemans J, Peers K, Vanderstraeten G. Open versus closed kinetic chain exercises for patellofemoral pain: a prospective, randomized study. Am J Sports Med. 2000;28(5):687-694.