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## Hip Posterolateral Musculature Strengthening in Sedentary Women With Patellofemoral Pain Syndrome: A Randomized Controlled Clinical Trial With 1-Year Follow-up



Patellofemoral pain syndrome (PFPS) is a common overuse disorder that can limit daily activity and participation in sports. A variety of treatment approaches have been described for this condition, with a traditional program consisting of knee-strengthening and -stretching exercises.<sup>4,12</sup> More recently, strengthening the hip musculature has been suggested to be an important consideration.<sup>29</sup> However, the long-term outcome of a program that includes hip-strengthening exercises in addition to conventional knee-strengthening and -stretching exercises still needs to be determined.

Biomechanical causes of anterior knee pain or PFPS have been the focus of recent studies. Researchers have shown that

● **STUDY DESIGN:** Randomized controlled trial.

● **OBJECTIVES:** To determine if adding hip-strengthening exercises to a conventional knee exercise program produces better long-term outcomes than conventional knee exercises alone in women with patellofemoral pain syndrome (PFPS).

● **BACKGROUND:** Recent studies have shown that a hip-strengthening program reduces pain and improves function in individuals with PFPS. However, there are no clinical trials evaluating long-term outcomes of this type of program compared to conventional knee-strengthening and -stretching exercises.

● **METHODS:** Fifty-four sedentary women between 20 and 40 years of age, with a diagnosis of unilateral PFPS, were randomly assigned knee exercise (KE) or knee and hip exercise (KHE). The women in the KE group (n = 26; mean age, 23 years) performed a 4-week conventional knee-stretching and -strengthening program. The women in the KHE group (n = 28; mean age, 22 years) performed the same exercises as those in the KE group, as well as strengthening exercises for the hip abductors, lateral rotators, and extensors. An 11-point numeric pain rating scale, the Lower Extremity Functional Scale, the Anterior Knee Pain Scale, and a single-hop test were used as outcome measures at baseline (pretreatment) and 3, 6, and 12 months posttreatment.

● **RESULTS:** At baseline, demographic, pain, and functional assessment data were similar between groups. Those in the KHE group had a higher level of function and less pain at 3, 6, and 12 months compared to baseline ( $P < .05$ ). In contrast, the KE group had reduced pain only at the 3- and 6-month follow-ups ( $P < .05$ ), without any changes in Lower Extremity Functional Scale, Anterior Knee Pain Scale, or hop testing ( $P > .05$ ) through the course of the study. Compared to the KE group, the KHE group had less pain and better function at 3, 6, and 12 months posttreatment ( $P < .05$ ). For the Lower Extremity Functional Scale, the between-group difference in change scores from baseline at 3, 6, and 12 months posttreatment favored the KHE group by 22.0, 22.0, and 20.8 points, respectively.

● **CONCLUSION:** Knee-stretching and -strengthening exercises supplemented by hip posterolateral musculature-strengthening exercises were more effective than knee exercises alone in improving long-term function and reducing pain in sedentary women with PFPS.

● **LEVEL OF EVIDENCE:** Therapy, level 1a.  
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● **KEY WORDS:** anterior knee pain, chondromalacia, knee, patella

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with PFPS. We hypothesized that the group that included hip strengthening would demonstrate significantly better results at 3-, 6-, and 12-month follow-up assessments.

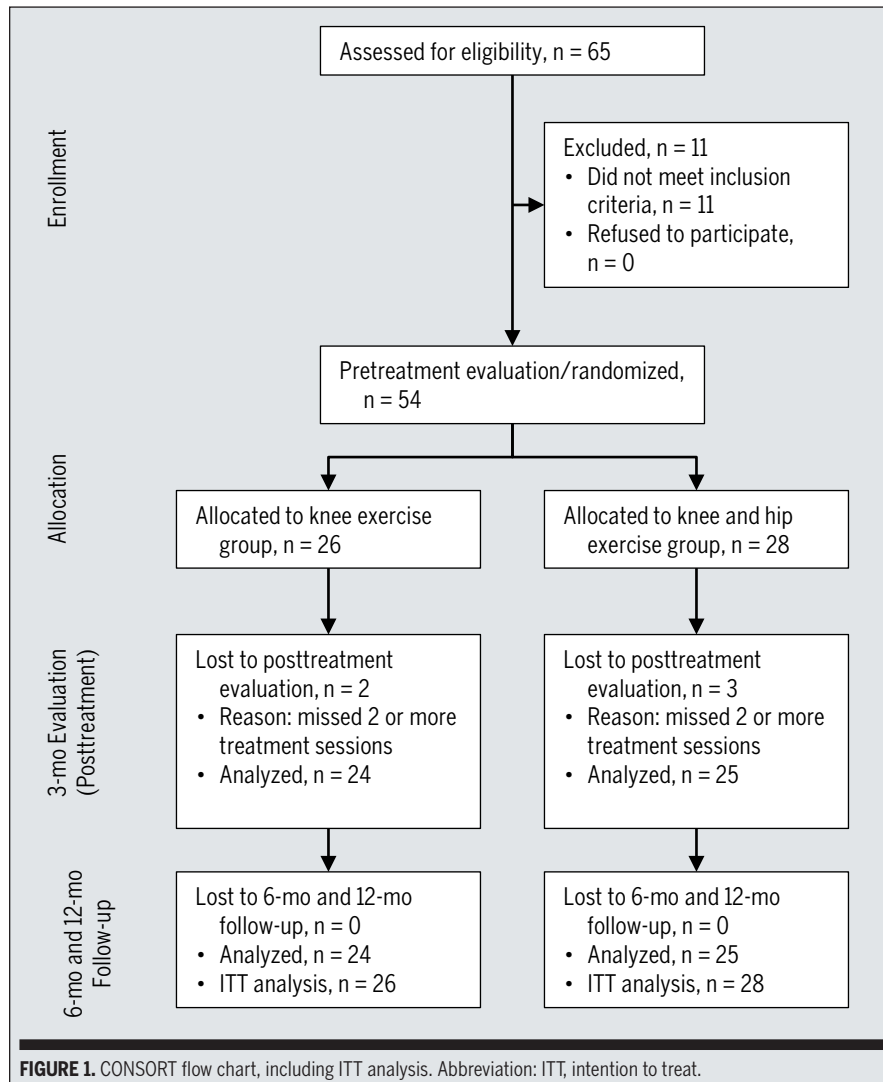
## METHODS

### Participants

**F**IFTY-FOUR WOMEN WITH UNILATERAL PFPS participated in the study and were randomly assigned to 1 of 2 groups, a knee exercise group (KE; n = 26) or a knee and hip exercise group (KHE; n = 28). Two patients in the KE and 3 patients in the KHE group did not complete the study (FIGURE 1). All volunteers were informed about the study procedures and signed informed consent forms in accordance with the National Health Council Resolution No. 196/96. The study was approved by the Research Ethics Committee of Irmandade da Santa Casa de Misericórdia de São Paulo (ISC-MSP), Brazil.

Sample-size estimation calculations were based on detecting a 10-point difference in the Lower Extremity Functional Scale (LEFS), which was based on a previously reported minimal clinically important difference (MCID) of 9 points,<sup>3,36</sup> assuming a standard deviation of 13 points, 2 tailed, an alpha level of .05, and 80% power. A sample size of 20 women per group was determined. Allowing dropout, 54 subjects were recruited for this study.

The study sample included women 20 to 40 years of age who had a history of anterior knee pain for at least 3 months and reported increasing pain in 2 or more activities that commonly provoke PFPS, as outlined by Thomeé et al.<sup>34</sup> These activities included ascending and descending stairs, squatting, kneeling, jumping, long sitting, isometric knee extension contraction at 60° of knee flexion, and pain on palpation of the medial and/or lateral facet of the patella. The participants were recruited from the Rehabilitation Service, ISCMSp, Brazil by a single physical therapist with more than



**FIGURE 1.** CONSORT flow chart, including ITT analysis. Abbreviation: ITT, intention to treat.

the patellofemoral joint can be influenced by abnormal femoral transverse and frontal plane movements.<sup>6,25,30</sup> Dynamic valgus, consisting of hip medial rotation, adduction, and flexion, is a potential contributor to PFPS.<sup>29</sup> Excessive medial femoral rotation has been shown to decrease patellofemoral contact area and lead to increased patellofemoral joint stress.<sup>30</sup> In several studies, women with symptomatic PFPS were noted to have excessive hip medial rotation and adduction when compared to controls.<sup>16,23,29,32</sup> This is consistent with the strong evidence indicating that hip abduction, lateral rotation, and extension strength deficits exist in women with PFPS.<sup>18,24</sup> Additionally,

studies have noted successful short-term treatment outcomes when including hip-strengthening exercises in the treatment of these individuals.<sup>7,9,13,20,25,26</sup>

Recently, Fukuda et al<sup>15</sup> noted that in sedentary women with PFPS the addition of hip strengthening to a knee-stretching and -strengthening exercise program was more effective in improving function and pain than knee exercises alone. However, the authors only reported short-term outcomes. Therefore, the purpose of this study was to determine if adding hip-strengthening exercises to a conventional knee exercise program would produce better long-term outcomes than conventional knee exercises alone in women

10 years of clinical experience in knee rehabilitation. All patients included in the trial were sedentary, defined as not having practiced physical activity (aerobic and strengthening exercises) any day of the week for at least 6 months previously.<sup>38</sup> Participants were excluded if they had a neurological disorder; injury to the lumbosacral region, hip, or ankle; rheumatoid arthritis, a heart condition, or previous surgery involving the lower extremities; or were pregnant or using corticosteroids or anti-inflammatory medication. Women who had other knee pathologies, such as patellar instability, patellofemoral dysplasia, meniscal or ligament tears, osteoarthritis, or tendinopathies, were also excluded. A standard knee clinical examination was performed to rule out concomitant pathology of the lower extremities.

A single examiner was responsible for the administration of all clinical tests and questionnaires before the initiation of treatment (baseline) and at 3, 6, and 12 months after intervention. The examiner was blind to the group assignment of the patients and did not participate in the intervention.

The assignment of subjects to the 2 groups was performed randomly using opaque, sealed envelopes, each containing the name of one of the groups (KE or KHE). The envelopes were picked by an individual not involved in the study. Group assignment was performed following the initial evaluation but prior to the initial treatment session. Three therapists were trained in delivering the exercise protocols used for the study and provided all treatment.

### Interventions

The KE and KHE groups completed 12 treatment sessions, provided 3 times per week for 4 weeks. The treatment for the individuals in the KE group emphasized stretching and strengthening of the knee musculature. Individuals in the KHE group were treated using the same protocol, but with the addition of exercises to strengthen the hip abductor, lateral

TABLE 1	TREATMENT PROTOCOL PERFORMED BY THE KE GROUP AND KHE GROUP
<p>KE group</p> <ul style="list-style-type: none"> <li>• Stretching (hamstrings, plantar flexors, quadriceps, and iliotibial band), 3 repetitions of 30 s</li> <li>• Seated knee extension from 90° to 45°, 3 sets of 10 repetitions*</li> <li>• Leg press from 0° to 45°, 3 sets of 10 repetitions*</li> <li>• Squatting from 0° to 45°, 3 sets of 10 repetitions*</li> <li>• Single-leg calf raises, 3 sets of 10 repetitions*</li> <li>• Prone knee flexion,<sup>†</sup> 3 sets of 10 repetitions*</li> </ul> <p>KHE group</p> <ul style="list-style-type: none"> <li>• Same protocol as the KE group</li> <li>• Hip abduction with weights (sidelying), 3 sets of 10 repetitions*</li> <li>• Hip abduction against elastic band (standing), 3 sets of 10 repetitions<sup>‡</sup></li> <li>• Hip lateral rotation against elastic band (sitting), 3 sets of 10 repetitions<sup>‡</sup></li> <li>• Hip extension (machine), 3 sets of 10 repetitions*</li> </ul>	
<p><i>Abbreviations: KE, knee exercise; KHE, knee and hip exercise.</i></p> <p><i>*Load is 70% of the 1-repetition maximum.</i></p> <p><i>†Maintaining the patella off the table.</i></p> <p><i>‡Maximum resistance that enables 10 repetitions.</i></p>	

rotator, and extensor muscles (the hip posterolateral musculature).

The load during training was standardized to 70% of the estimated 1-repetition maximum, defined as the maximum load with which 1 repetition of the exercise could be completed without pain. Non-weight-bearing exercises were initiated using ankle weights and progressed to a knee extension machine, based on the patient's tolerance. These criteria were based on the protocol of a previous study.<sup>21</sup> Exercises utilizing elastic resistance were standardized to the maximum resistance at which each patient was able to perform 10 repetitions of the exercise. The maximum load and resistance for all strengthening exercises were evaluated during the first treatment session and reviewed weekly to adjust as needed. Stretching of the hamstrings and ankle plantar flexors (performed using a straight leg raise in the supine position), quadriceps, and iliotibial band (in sidelying) consisted of three 30-second stretches for each structure, with the therapist's assistance. The patients performed exercises solely during physical therapy and did not perform exercises at home (TABLE 1, FIGURE 2). After the 4-week treatment program, the patients were instructed to maintain their normal daily activi-

ties without performing a home exercise program.

### Evaluation

An 11-point numeric pain rating scale (NPRS),<sup>8</sup> where 0 corresponded to no pain and 10 to the worst imaginable pain, was used to measure pain during ascending and descending stairs. The NPRS has been shown to be reliable and valid, with an MCID of 2 points.<sup>14</sup>

The LEFS<sup>3</sup> and Anterior Knee Pain Scale (AKPS)<sup>22</sup> have been used to measure function in clinical outcome studies and are recommended for use for individuals with PFPS. The LEFS is a 20-item functional assessment questionnaire that rates the level of difficulty of functional tasks from 0 (extreme difficulty) to 4 (no difficulty), yielding a maximum score of 80 points, with higher scores indicating better function. The MCID of the LEFS has been reported to be 9 points in patients with PFPS.<sup>3,36</sup> The AKPS is a 13-item assessment tool with items differentially weighted for a maximum score of 100, with higher scores indicating better function. The MCID of the AKPS has been reported to be 13 points.<sup>22,36</sup> Both scales show high test-retest reliability, moderate responsiveness, and adequate validity.<sup>36</sup> The single-hop test<sup>1</sup> was used as

a functional test. All outcome measures were administered before intervention and at 3, 6, and 12 months posttreatment.

### Statistical Analysis

Data were analyzed with SPSS Version 13.0 (SPSS Inc, Chicago, IL). Descriptive statistics for demographic data and all outcome measures were expressed as averages and standard deviations. Comparison between the groups was performed using independent *t* tests for age, body mass, height, pain score, and functional scales to determine homogeneity of the groups at baseline (pretreatment). The data for the 2 functional scales (AKPS and LEFS), the single-limb single-hop test, and the NPRS were analyzed using separate 2-by-4 (group-by-time) mixed-model analyses of variance. The factor of group had 2 levels (KE and KHE) and the repeated factor of time had 4 levels (preintervention and 3, 6, and 12 months posttreatment). An intention-to-treat analysis was performed using the last-value-carried-forward method to impute values for all missing data.

## RESULTS

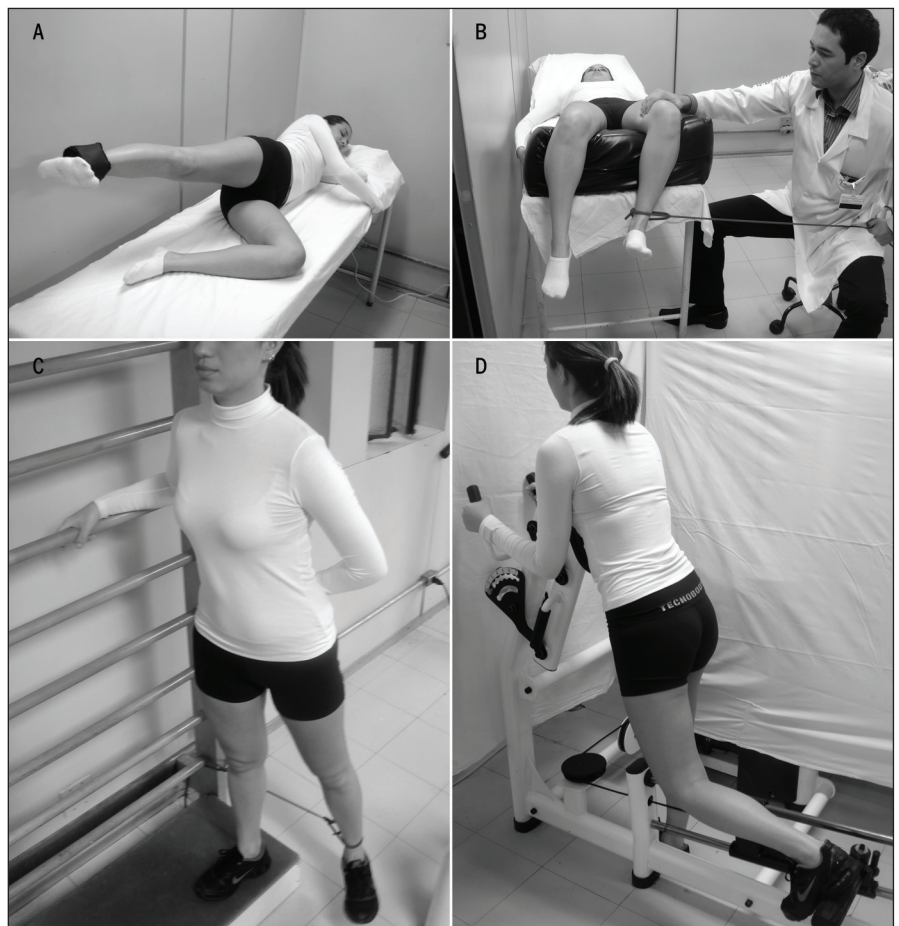
**T**WO SUBJECTS IN THE KE GROUP AND 3 subjects in the KHE group were lost to follow-up at 3, 6, and 12 months, due to missing 2 or more treatment sessions. Therefore, all per-protocol data analyses were performed with 24 subjects in the KE group and 25 subjects in the KHE group.

### Baseline Data

There was no statistically significant difference ( $P>.05$ ) for age, height, body mass, and duration of symptoms between the participants in the KE and KHE groups (TABLE 2). There was also no statistically significant difference ( $P>.05$ ) between groups for any of the outcome variables at baseline (pretreatment) (TABLE 3).

### Pain and Function

There was a statistically significant



**FIGURE 2.** Strengthening exercises for the posterolateral hip musculature. (A) Hip abduction in sidelying. (B) Hip lateral rotation. (C) Hip abduction in standing position. (D) Hip extension using mechanical resistance.

**TABLE 2**

**DEMOGRAPHIC DATA OF THE KE AND KHE GROUPS\***

	KE (n = 24)	KHE (n = 25)	P Value
Age, y	23.0 ± 3.0	22.0 ± 3.0	.870
Body mass, kg	61.5 ± 3.6	60.0 ± 2.6	.791
Height, m	1.60 ± 0.30	1.59 ± 0.10	.913
Body mass index, kg/m <sup>2</sup>	24.5 ± 3.0	23.6 ± 2.7	.801
Duration of symptoms, mo	21.0 ± 177	23.2 ± 19.0	.763

Abbreviations: KE, knee exercise; KHE, knee and hip exercise.

\*Values are mean ± SD. Only data for the participants who remained to the end of the study are included. There were no differences between groups ( $P>.05$ ).

group-by-time interaction for the 2-by-4 mixed-model analysis of variance for pain and all functional assessment measures ( $P<.001$ ). Planned pairwise comparisons for the LEFS, AKPS, single-hop test, and NPRS during ascending and descending

stairs indicated that the patients in the KHE group had better function and decreased pain at 3, 6, and 12 months posttreatment compared to baseline ( $P<.05$ ). The same analysis indicated that the only significant differences for the patients in

**TABLE 3**

**OUTCOME MEASURES PRETREATMENT AND 3, 6, AND 12 MONTHS POSTTREATMENT FOR SUBJECTS IN THE KE (N = 24) AND KHE (N = 25) GROUPS WHO COMPLETED THE STUDY**

Analysis/Measures	Pretreatment	3 mo Posttreatment	6 mo Posttreatment	12 mo Posttreatment
<b>Outcomes*</b>				
LEFS (0-80) <sup>†</sup>				
KE group	49.0 ± 13.0	49.4 ± 11.2	47.7 ± 10.5	46.1 ± 10.9
KHE group	51.7 ± 10.4	74.1 ± 5.6	72.4 ± 6.1	69.6 ± 5.2
AKPS (0-100) <sup>†</sup>				
KE group	61.8 ± 9.0	64.6 ± 10.2	62.0 ± 9.3	60.0 ± 8.3
KHE group	65.9 ± 8.5	85.7 ± 9.0	81.7 ± 7.6	79.0 ± 7.7
Single-hop test, cm <sup>†</sup>				
KE group	61.7 ± 22.6	69.9 ± 21.8	67.3 ± 21.5	65.6 ± 21.2
KHE group	69.9 ± 10.4	85.7 ± 10.2	84.0 ± 10.9	82.3 ± 10.2
NPRS ascending stairs <sup>‡</sup>				
KE group	6.6 ± 1.2	5.3 ± 1.3	5.5 ± 1.2	6.5 ± 1.0
KHE group	6.2 ± 1.1	1.2 ± 1.1	1.7 ± 1.0	2.9 ± 0.8
NPRS descending stairs <sup>‡</sup>				
KE group	6.4 ± 1.4	5.0 ± 1.2	5.6 ± 1.4	6.4 ± 1.1
KHE group	5.8 ± 1.2	1.6 ± 1.1	2.0 ± 0.8	2.5 ± 0.9
<b>Within-group change score from baseline<sup>§  </sup></b>				
LEFS (0-80) <sup>†</sup>				
KE group		0.4 ± 5.2 (-1.7, 2.5)	-1.3 ± 5.3 (-3.4, 2.1)	-2.9 ± 4.9 (-4.9, -0.9)
KHE group		22.4 ± 10.5 (18.4, 26.4)	20.7 ± 11.0 (16.5, 24.9)	17.9 ± 9.7 (14.2, 21.6)
AKPS (0-100) <sup>†</sup>				
KE group		2.8 ± 8.9 (-0.7, 6.3)	0.2 ± 8.4 (-3.2, 3.6)	-1.8 ± 8.4 (-5.1, 1.5)
KHE group		19.8 ± 9.1 (16.2, 23.4)	15.8 ± 8.1 (12.6, 19.0)	13.1 ± 8.3 (9.8, 16.4)
Single-hop test, cm <sup>†</sup>				
KE group		8.2 ± 5.7 (5.9, 10.5)	5.5 ± 5.2 (3.4, 7.6)	3.8 ± 4.4 (2.0, 5.6)
KHE group		15.8 ± 3.9 (14.3, 17.3)	14.1 ± 3.9 (12.6, 15.6)	12.4 ± 3.8 (10.9, 13.9)
NPRS ascending stairs <sup>‡</sup>				
KE group		-1.3 ± 1.2 (-2.9, 0.3)	-1.1 ± 1.1 (-1.6, -0.6)	-0.1 ± 1.0 (-0.7, 0.5)
KHE group		-5.0 ± 1.5 (-5.6, -4.4)	-4.5 ± 1.4 (-5.0, -4.0)	-3.3 ± 1.1 (-3.7, -2.9)
NPRS descending stairs <sup>‡</sup>				
KE group		-1.4 ± 0.9 (-1.7, -1.1)	-0.8 ± 0.9 (-1.2, -0.4)	0.0 ± 0.9 (-0.3, 0.3)
KHE group		-4.2 ± 1.7 (-4.9, -3.5)	-3.8 ± 1.4 (-4.4, -3.2)	-3.3 ± 1.1 (-3.7, -2.9)
<b>Between-group difference in change score<sup>¶  </sup></b>				
LEFS (0-80) <sup>†</sup>		22.0 (16.9, 27.1)	22.0 (17.1, 26.9)	20.8 (15.9, 25.7)
AKPS (0-100) <sup>†</sup>		17.0 (11.7, 22.3)	15.6 (10.7, 20.5)	14.9 (11.2, 18.6)
Single-hop test, cm <sup>†</sup>		7.6 (4.8, 10.4)	8.6 (5.9, 11.3)	8.6 (6.2, 11.0)
NPRS ascending stairs <sup>‡</sup>		-3.7 (-4.4, -3.0)	-3.4 (-4.0, -2.8)	-3.2 (-3.7, -2.7)
NPRS descending stairs <sup>‡</sup>		-2.8 (-3.5, -2.1)	-3.0 (-3.7, -2.3)	-3.3 (-4.0, -2.6)

Abbreviations: AKPS, Anterior Knee Pain Scale; KE, knee exercise; KHE, knee and hip exercise; LEFS, Lower Extremity Functional Scale; NPRS, numeric pain rating scale.

\*Values are mean ± SD.

<sup>†</sup>Higher scores on the LEFS, AKPS, and the single-hop test represent better function.

<sup>‡</sup>Scored from 0 to 10, where 0 is no pain and 10 is the worst imaginable pain.

<sup>§</sup>Values are mean ± SD (95% confidence interval).

<sup>||</sup>Compared to pretreatment.

<sup>¶</sup>Group levels were KHE and KE.

\*Values are mean (95% confidence interval).

the KE group were decreased pain with ascending stairs at 6 months and descending stairs at 3 and 6 months posttreatment, as well as improvement on the single-hop test at 3, 6, and 12 months posttreatment.

The analysis of differences between groups at 3, 6, and 12 months posttreatment indicated that the KHE group, when compared to the KE group, had significantly less pain and better function for all outcome measures on all 3 occasions ( $P < .05$ ). **TABLE 3** summarizes within- and between-group differences, with associated 95% confidence intervals.

The results of the intention-to-treat analysis were consistent with the per-protocol analysis, providing evidence that the missing data had no substantial influence on the overall results. It is important to highlight that we did not control for the use of pain-relief medication during the 1-year follow-up; however, no patient reported the use of anti-inflammatory or analgesic drugs during this period.

## DISCUSSION

**T**HE RESULTS OF THIS PROSPECTIVE, randomized, and evaluator-blinded clinical trial demonstrated the long-term effectiveness of hip-strengthening exercises to supplement a conventional knee exercise program for improving function and reducing pain in sedentary women with PFPS. The group that performed a combination of hip and knee exercises showed improvements for all outcome measures at 3, 6, and 12 months posttreatment, in contrast to the group that performed knee exercises alone, which only showed improvement in pain at 3 and 6 months posttreatment.

The MCID is 9 points for the LEFS, 13 points for the AKPS, and 2 points for the NPRS.<sup>10,19</sup> Mean changes on the LEFS at 3, 6, and 12 months posttreatment were 22.4, 20.7, and 17.9 in the KHE group and 0.4, -1.3, and -2.9 in the KE group, respectively. Mean changes on the AKPS at follow-up assessments were 19.8, 15.8, and 13.1 in the KHE group and 2.8, 0.2,

and -1.8 in the KE group, respectively. Changes in pain, as measured with the NPRS, during ascending and descending stairs were above the MCID (range, 3.3-5.0) in the KHE group. There were no changes in pain in the KE group that surpassed the MCID (range, 0.0-1.4).

For functional evaluation using the single-hop test, the KHE group had a significant improvement in all follow-up measures compared to pretreatment, which did not occur in the KE group. A possible explanation for these findings is that the strengthening of the posterolateral hip musculature might have improved motor control or balance, facilitating single-hop test performance. In addition, the strengthening of the gluteus maximus might have increased jump propulsion, as this muscle can act as a synergistic muscle of the quadriceps during knee extension.

Some authors have shown an association between hip muscle weakness, especially of the abductors and lateral rotators,<sup>5,24</sup> and changes in kinematic patterns of the lower extremity. Some evidence suggests that these strength deficits may lead to excessive medial rotation and adduction of the femur, which in turn may lead to excessive dynamic valgus alignment of the knee in symptomatic patients with PFPS when compared to controls.<sup>16,23,30,32</sup> Mechanically, weakness of the hip musculature could lead to increased femoral adduction, flexion, and medial rotation during dynamic weight-bearing activities, which would increase the lateral patellofemoral joint vector, leading to patellar facet overload.<sup>7,23,25,29,31</sup>

It is noted that most major muscle groups at the hip control movements in 2 or 3 planes (sagittal, frontal, and transverse).<sup>27</sup> The gluteus maximus, for example, can produce hip abduction, extension, and lateral rotation. For this reason, we developed a protocol composed of strengthening exercises for hip abductor, lateral rotator, and extensor musculature, which we referred to as the “posterolateral hip musculature.”

While it has been demonstrated that

hip weakness is associated with excessive dynamic valgus of the knee, it is noteworthy that few clinical trials have investigated the effectiveness of programs to strengthen the hip musculature as part of the treatment strategy for PFPS.<sup>13,26,35</sup> A recent study conducted by Fukuda et al<sup>15</sup> compared the short-term effect of specifically strengthening the muscles around the knee with a group that also performed exercises to strengthen the hip abductors and lateral rotators. In addition, the study included a control group that neither received treatment nor performed exercises. The authors concluded that, in the short term, both treatment approaches were more effective than no treatment for improving function and reducing pain. However, improvements were greater in the group that performed a combination of hip- and knee-strengthening exercises.<sup>15</sup>

An interesting finding was that the individuals in the KE group did not have a clinically meaningful or significant improvement on any measure of pain (with the exception of pain at 3 and 6 months) or function over the 1-year study. This is in contrast to the short-term (4 weeks) improvements noted in patients with PFPS who performed a conventional knee-strengthening and -stretching program in a similar study<sup>15</sup> and other studies.<sup>6,9,13,26</sup> However, it is well documented that the recurrence rate of PFPS can be as high as 91%.<sup>28,33</sup> These findings would suggest that, although a conventional knee-stretching and -strengthening program may produce successful short-term outcomes, the inclusion of hip strengthening may be needed to prevent recurrence of future symptoms. Also, though previous reviews have not been able to find evidence to support one form of exercise over the other,<sup>4,11,17</sup> this study provides strong evidence for a program that includes hip-strengthening exercises.

We did not control or monitor whether the patients performed their rehabilitation exercises during the 1-year follow-up. However, immediately after treatment, all patients were instructed to

maintain their normal daily activities as they would have performed them before treatment. In addition, they were not instructed to initiate any type of physical activity during this period. Another limitation is that data were obtained from a population of sedentary women (those who did not perform repetitive or high-impact activities), which might have limited the generalizability of the findings. However, in the authors' experience, sedentary women often present with excessive dynamic knee valgus, which can lead to patellofemoral overload in daily activities such as negotiating stairs, squatting, or walking.

Based on the obtained results, it is thought that the muscles that directly influence the hip also affect the knee.<sup>2,30</sup> Specifically, the posterolateral hip musculature can contribute to control ground reaction forces and the dynamic valgus alignment of the lower extremity during daily activities.<sup>29,37</sup> It is noteworthy that the present study aimed to strengthen the specific muscles involved, without concern for sensorimotor training, as education on proper movement patterns could have positively influenced the results. Additionally, it is not known if similar results would have been obtained with hip exercises alone, or if continuing the exercises as a home exercise program after the 4-week treatment was completed would have been beneficial.

## CONCLUSION

**F**OUR WEEKS OF KNEE-STRENGTHENING exercises, supplemented by strengthening exercises for the hip abductors, lateral rotators, and extensors, was more effective in improving function and reducing pain over a 1-year period than knee strengthening alone in sedentary women with PFPS. In contrast to the long-term functional and pain benefits of those performing the combination of knee and hip exercises, those performing only knee-strengthening exercises showed no improvement at 12 months posttreatment. ●

## KEY POINTS

**FINDINGS:** A treatment approach consisting of a combination of hip- and knee-strengthening exercises was more effective in improving function and reducing pain over a 1-year period than knee-strengthening exercises in sedentary women with PFPS.

**IMPLICATIONS:** Treatment programs for patients with anterior knee pain should incorporate strengthening of the posterolateral hip musculature.

**CAUTION:** This study included sedentary women, and the level of activity performed by the patients after treatment was not monitored.

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