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Hip-Abductor Strength and Endurance in Individuals With Recent and Long-Standing Patellofemoral Pain

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Context: Numerous researchers have reported deficits in hip-muscle performance in individuals with patellofemoral pain (PFP). However, the exact stage at which these deficits emerge and the impact of symptom duration remain unclear.

Objective: To compare hip-abductor strength and endurance based on the presence or absence of PFP and its duration.

Design: Cross-sectional study.

Patients or Other Participants: Sixty-eight individuals with PFP and 29 pain-free controls.

Main Outcome Measure(s): We evaluated the isometric maximal strength, isometric endurance, and dynamic endurance of hip abductors. Comparisons were made between participants with PFP and pain-free controls and among different PFP duration subgroups ($<$12 months, $\geq$12 months, $\leq$6 months, $>$24 months) and pain-free controls.

Results: Hip-abductor isometric strength (% body mass) was significantly lower in the PFP group (203.8 $\pm$ 46.8) and all PFP subgroups ($<$12 months = 203.9 $\pm$ 57.0, $>$12 months = 203.7 $\pm$ 42.2, $\leq$6 months = 205.1 $\pm$ 59.6, $>$24 months = 207.7 $\pm$ 41.9) compared with pain-free controls (254.6 $\pm$ 60.3). However, no significant differences were found between PFP subgroups. There were also no significant differences in hip-abductor isometric or dynamic endurance between the PFP group and pain-free controls or between PFP subgroups and pain-free controls.

Conclusions: Hip-abductor strength deficits emerge early in the course of PFP. However, further studies are needed to understand the observed lack of difference in endurance.

Key Words: muscle performance, knee pain, symptoms duration

Key Points

- Individuals with patellofemoral pain demonstrate early deficits in hip-abductor isometric strength, regardless of symptom duration.
- Clinicians should consider assessing and addressing hip-abductor strength in individuals with both recent and long-standing patellofemoral pain.

Patellofemoral pain (PFP) is one of the most common knee conditions, with a prevalence of 22.7% in the general population and up to 28.9% in active adolescents and young adults.[1] Patellofemoral pain is characterized by anterior, retropatellar, or peripatellar pain during loaded activities, such as squatting, kneeling, sitting, climbing or descending stairs, running, and jumping.[2,3] Individuals with PFP report significant limitations in their daily activities, during physical activities, and at work.[4] Patellofemoral pain is 2.2 times more likely to occur in women than in men.[5]

Numerous cross-sectional studies have reported hip-muscle strength and endurance deficits in individuals with PFP compared with their unaffected side or pain-free controls. These deficits specifically concern the hip abductors, extensors, and external rotators.[6–9] Prospective studies suggested that hip-muscle deficits should be considered as consequences of PFP rather than risk factors.[9,10] However, the relationship between hip-muscle deficits and PFP symptoms is still poorly understood. Recently, Van Cant et al highlighted that hip-abductor strength and endurance deficits are more pronounced in individuals with more severe and frequent symptoms of PFP.[11] Although symptom severity appears to affect hip-muscle function, the exact stage at which these deficits emerge remains unknown. Furthermore, no researchers have investigated the effect of the duration of PFP symptoms on hip-muscle impairments.

Previous authors have suggested that individuals with long-standing PFP tend to reduce their level of physical activity,[12] which can affect muscle properties and sensory inputs.[13] It could therefore be hypothesized that the decreased isometric hip-muscle strength and endurance observed in individuals with PFP might stem from long-standing symptoms. We aimed to investigate whether such changes in hip-muscle function are already evident in individuals experiencing PFP for a relatively short duration or if they become more pronounced over time with persistent symptoms. Our primary objective was to assess whether hip-abductor function (isometric strength and isometric and dynamic endurance) differs between individuals with recent and long-standing PFP. Additionally, we sought to compare both subgroups with pain-free controls to determine if hip-abductor deficits reported in the literature are specific to long-standing PFP rather than recent PFP. Hip abductors were chosen because significant deficits have been reported in individuals with PFP.[6,7,9,14] These muscles play a crucial role in controlling frontal-plane motion and stabilizing the pelvis during weight-bearing activities, such as walking, running, and stair climbing, that are often associated with PFP.[7] Focusing on this muscle group allows for a targeted investigation of potential impairments that may contribute to functional limitations in individuals with PFP. Our hypothesis was that individuals with recent PFP would have stronger and more enduring hip abductors in comparison with those with long-standing PFP. Furthermore, we anticipated that, in comparison with pain-free controls, these muscular deficits would be evident in individuals with long-standing PFP but not in those with recent PFP.

METHODS

Study Design

In this cross-sectional study, we investigated the impact of symptom duration on hip-abductor function (strength, isometric endurance, and dynamic endurance) in individuals with PFP. Participants were divided into 2 groups: individuals with PFP and pain-free controls. Within the PFP group, participants were further classified twice based on symptom duration. The first classification divided participants into those with a symptom duration of $<$12 months and $\geq$12 months, and the second classification divided them into those with a symptom duration of $\leq$6 months and $>$24 months. This approach allowed the analysis of 4 distinct symptom periods while maintaining sufficient sample sizes in each subgroup. Each participant in the PFP group was classified into 2 subgroups across the 2 classification schemes when eligible. However, some participants ($n = 10$) had symptom durations between 6 and 24 months, which did not meet the inclusion criteria for the second classification and were therefore only included in the first classification. The independent variables were group (PFP vs pain-free controls) and symptom duration ($<$12 months and $\geq$12 months; $\leq$6 months and $>$24 months). Dependent variables included hip-abductor strength, isometric endurance, and dynamic endurance.

Participants

Participants were recruited on a voluntary basis through advertisements posted at the university, local hospital, sports halls, fitness rooms, local physiotherapy clinics, and physicians' offices and the institutional mailing list of Laval University. For the PFP group, inclusion criteria were age 18 to 45 years, insidious onset of symptoms for at least 4 weeks, and anterior, retropatellar, or peripatellar pain in at least 2 of the following activities: climbing or descending stairs, running, kneeling, maintaining a prolonged sitting position, skipping, and isometric contraction of the quadriceps. Finally, participants had to have pain on palpation of the medial or lateral face of the patella.[14] Exclusion criteria for both PFP and pain-free controls included history of patella dislocation, lower limb surgery, meniscal or ligament injury of the knee in the past 6 months confirmed by a health professional, and concomitant lower limb injury or hip pain in the last 3 months, as well as rheumatic, neurologic, or degenerative diseases and pregnancy.[14] The present study was approved by the Erasme-ULB Hospital-Faculty Ethics Committee (Belgian registration number: B4062022000212) and the Sectorial Rehabilitation and Social Integration Research Ethics Committee of the CIUSSS-CN (Registration number: 2020-1910).

Sample Size

An a priori sample size calculation was conducted to determine the minimum number of participants required to detect a clinically meaningful difference in hip-abductor isometric strength with a statistical power of 80% and a significance level of .05. Based on data from previous studies,[11,15] it was estimated that at least 20 participants per group were necessary to achieve robust statistical power.

Procedures

Participants interested in this study were first screened by phone for eligibility. Eligibility was verified before the experiment by physiotherapists with over 15 years of clinical experience at the research laboratories of the Rehabilitation Sciences (Université Libre de Bruxelles, Brussels) and at the Centre for Interdisciplinary Research in Rehabilitation and Social Integration (Université Laval, Québec). Participants were scheduled for an appointment, and subsequently the experiment was conducted. Before the experiment, all participants provided written informed consent. The experiment took place from February 2020 to March 2023.

Demographics and Self-Reported Function

Sociodemographic data were first collected, including age, weight, height, affected leg, dominant leg, participation and frequency of physical activity during the week, and duration of symptoms. Then, knee functional capacity was assessed using the French version of the Anterior Knee Pain Scale (AKPS) questionnaire, a self-reported questionnaire that evaluates the impact of knee pain on various functional activities such as walking, running, and jumping.[16] The reliability of the French version of the AKPS questionnaire is considered excellent (intraclass correlation coefficient [ICC] = 0.97).[17] The total score ranges from 0 to 100, with higher scores indicating lower levels of disability.[16] The severity of pain was evaluated using the Numeric Pain Rating Scale, ranging from 0 (*no pain*) to 10 (*the most intense pain imaginable*). Pain ratings were recorded for usual pain, worst pain, and worst pain experienced during physical activity, and the mean of these 3 scores was used for analysis.[11]

Figure 1. Isometric strength assessment of hip abductors.

Assessment of Hip Strength and Endurance

After the general assessment, hip strength and endurance were assessed. The assessment began with participants viewing an explanatory video showing the different tests and completing a 5-minute warm-up on a cycle ergometer at a perceived effort of 3 to 4 of 10 on the Borg Rating of Perceived Exertion Scale. The Borg Rating of Perceived Exertion Scale is a 1-dimensional scale ranging from 1 (*no effort*) to 10 (*maximum effort*).[18] Afterward, in the PFP group, hip-abductor function (isometric strength, isometric endurance, and dynamic endurance) was assessed for the injured limb. In the case of bilateral symptoms, the most symptomatic limb was used. In the control group, the evaluated lower limb corresponded to the limb dominance observed in the PFP group. The dominant leg was identified by asking participants which leg they primarily used to kick a ball. Participants carried out the various tests in the same order: first the isometric strength test, then the isometric endurance test, and finally the dynamic endurance test. All tests were separated by a 2-minute rest.[11] Participants were instructed to report any pain during the tests, which would result in the immediate interruption of the procedure; however, no participant reported pain during or after the testing sessions.

Isometric Strength Assessment. The maximum isometric strength of the hip abductors was measured with a handheld dynamometer (BioFET, Dynamometer V3/Bluetooth 4.0; Mustec, Muscle Dynamic Technology bv), in a side-lying position on an examination table (Figure 1).[11,19] An inelastic strap was placed around the waist to fix the trunk and avoid compensation of the upper body.[20,21] A second strap was placed 5 cm above the external malleolus of the evaluated leg and was used for external fixation of the dynamometer.[11] Participants were required to abduct against the dynamometer in a neutral hip position, ensuring no flexion, extension, or rotation of the hip, to standardize the testing procedure and minimize compensatory movements.[20,21] After 2 submaximum trials, participants performed 3 trials at their maximum force. Each test was spaced by 1 minute of rest. Participants were asked to start the contraction slowly until they reached their maximum effort and hold the contraction for 3 to 4 seconds. For each of the 3 tests, a Newton value representing the maximum force performed by the participant was recorded. The highest value was then multiplied by the lever arm (distance between the greater trochanter and the external malleolus) to give the moment of force. The result was averaged and normalized to the participant's body mass (BM): (N·m/kg) $\times$ 100 = % BM.[21] This procedure has been shown to be reliable (ICCs ranging from 0.86 to 0.94).[22]

Isometric Endurance Assessment. Isometric endurance was assessed in a side-lying position, with the nonevaluated limb positioned at 45° of hip and knee flexion and the trunk stabilized against a wall (Figure 2).[23] Based on previous studies, the evaluated side was placed at 30° of hip abduction and full extension of the knee.[24] During the isometric endurance test, the participant was asked to hold the evaluated lower limb in 30° of hip abduction for as long as possible, with an extended knee, while keeping the pelvis, shoulders, and head against the wall. A height-adjustable device with 2 rods was placed next to the participant at the ankle level to mark the 30°-of-hip-abduction position. During the test, the foot of the evaluated limb had to remain between the 2 rods at the same distance from the floor. The test ended when the participant could no longer control the initial position of the limb and stepped over the lower rod. Isometric endurance performance was determined by the maximum holding time (in seconds).[24] The test demonstrates good test-retest reliability (ICC = 0.73).[24]

Figure 2. Isometric endurance assessment of hip abductors.

Dynamic Endurance Assessment. Dynamic endurance was also assessed in a side-lying position with the nonevaluated limb positioned at 45° of hip and knee flexion (Figure 3). The same height-adjustable device with 2 rods was placed next to the participant at the ankle level. The upper rod was adjusted to correspond to 30° of hip abduction, whereas the lower rod was placed to correspond to 10° of hip abduction. Participants were asked to perform their maximum number of hip-abduction repetitions between 10° and 30° (see Figure 3A and 3B), guided by the pace of a metronome (1 abduction every 2 seconds: 1 second of concentric movement and 1 second of eccentric movement).[24] Dynamic endurance was determined as the maximum number of hip abductions that the participant could perform. As in the isometric endurance assessment, participants were asked to indicate their subjective exertion every 30 seconds using the Borg scale.[18] The test was stopped if participants were unable to perform the test in the rhythm of the metronome, or could no longer maintain the initial position of the lower limb, or if their back was no longer against the wall.[24] The maximal number of successful repetitions was obtained and used for statistical analysis. The dynamic endurance test demonstrates good test-retest reliability (ICC = 0.78).[24]

Statistical Analysis

Data were collected in a Microsoft Excel 2013 spreadsheet and analyzed using RStudio (version 2023.03.1; RStudio).

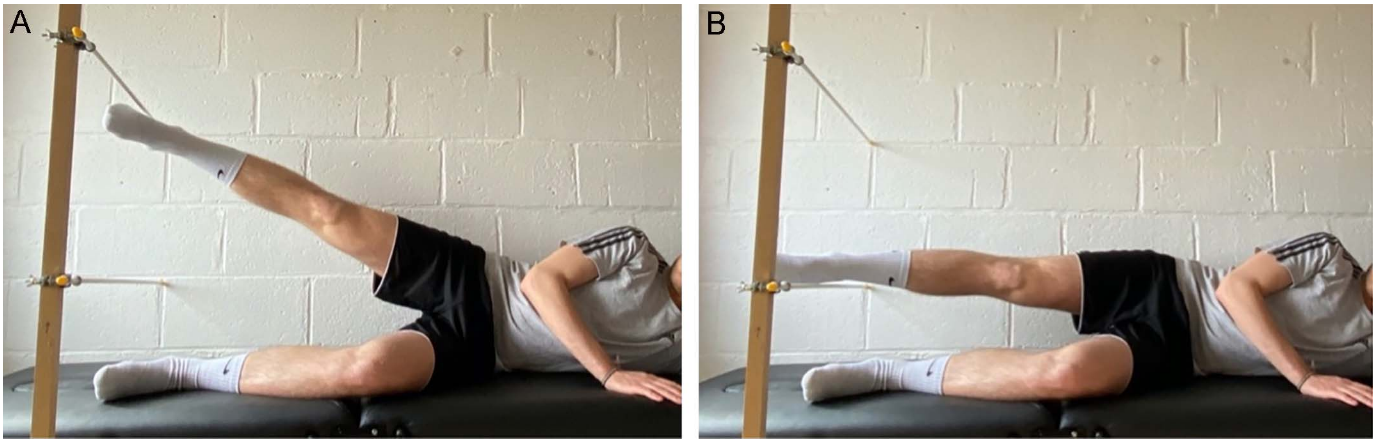

Figure 3. Dynamic endurance of hip abductors. A, Position at 30° of hip abduction (upper limit of the movement). B, Position at 10° of hip abduction (lower limit of the movement).

Demographics, self-reported outcomes, isometric strength, isometric endurance, and dynamic endurance were compared between the PFP group and the pain-free group. A Shapiro-Wilk test was used to assess the normal distribution of the variables. As data were normally distributed, independent Student t tests for continuous variables were performed. Chi-square tests were performed for dichotomous variables.

To analyze the effect of symptom duration on muscular strength and endurance, the PFP group was divided twice into 2 subgroups: duration of symptoms $<$12 months and $\geq$12 months, and duration of symptoms $\leq$6 months and $>$24 months. This approach enabled the investigation of 4 distinct symptom periods while ensuring a sufficient number of participants in each subgroup. A priori sample size calculation was performed to determine the number of participants required to detect a clinically meaningful difference in outcome, with a power of 80% and an α of .05. Based on previous study,[11] a minimum of 15 participants per group was required. One-way analyses of variance and Tukey-Kramer post hoc tests were performed to compare the subgroups with each other and with the healthy group. The significance level was set at .05.

RESULTS

Participant Demographics

Ninety-seven participants were included in the study (68 with PFP, 29 healthy). Means and standard deviations of the demographics and clinical characteristics of all participants are presented in Table 1. The PFP group had an average symptom duration of 45 $\pm$ 38.50 months and a mean AKPS score of 78.60 $\pm$ 10.78. Participants with PFP and healthy controls were similar except for height ($P = .035$) and limb length ($P < .01$).

Symptom Duration

Participants' demographics are presented in subgroups in Tables 2 and 3. Participants in the PFP $>$12 months and PFP $>$24 months groups were significantly different in height. Borg scores for isometric and dynamic endurance were not significantly different between groups.

Comparisons Between the PFP Group and Pain-Free Control Group

Hip-abductor isometric strength (% BM) of the PFP group was significantly lower compared with the pain-free control group ($P < .01$; mean difference [95% CI] = −50.83 [−83.89, −17.77]). Isometric endurance and dynamic endurance were not significantly different between the 2 groups (Table 4).

Comparison Between the PFP ≤12 Months Subgroup, PFP >12 Months Subgroup, and Healthy Group

The 2 PFP subgroups ($\leq$12 months and $>$12 months) had lower hip-abductor maximal strength (% BM = 203.92 $\pm$ 56.97 and 203.73 $\pm$ 42.16, respectively) than the pain-free control group (% BM = 254.62 $\pm$ 60.28) ($P < .01$), but there was no significant difference between the 2 subgroups. Isometric endurance and dynamic endurance were not significantly different between the subgroups or between the subgroups and the pain-free controls (Table 5).

Comparisons Between the PFP ≤6 Months and >24 Months Subgroups and the Healthy Group

Compared with the pain-free control group (% BM = 254.62 $\pm$ 60.28), both PFP subgroups ($\leq$6 months and

Table 1. Baseline Characteristics of the PFP Group and Healthy Group

	PFP Group (n = 68)	Pain-Free Group (n = 29)	P Value
Female, No. (%)	48 (70)	14 (48)	.303
Age, mean ± SD, y	24.15 ± 5.55	23.45 ± 3.15	.527
Symptom duration, mean ± SD, mo	45.22 ± 38.50	N/A	N/A
Weight, mean ± SD, kg	66.34 ± 13.81	68.43 ± 11.50	.475
Height, mean ± SD, cm	170.10 ± 9.09	174.31 ± 8.40	.035[a]
Limb length, mean ± SD, m	0.88 ± 0.06	0.94 ± 0.05	<.01[a]
Sport time per week, mean ± SD, h	4.15 ± 2.24	3.74 ± 2.15	.411
AKPS score, mean ± SD (of 100)	78.60 ± 10.78	N/A	N/A
NPRS, mean ± SD (of 10)	3.6 ± 1.1	N/A	N/A

Abbreviations: AKPS, Anterior Knee Pain Scale; N/A, not applicable; NPRS, Numeric Pain Rating Scale; PFP, patellofemoral pain.
[a] Significant ($P < .05$).

Table 2. Participant Demographics Categorized by Symptom Duration (≤12 Months and >12 Months)

	Group		
	PFP Duration		
	≤12 mo (n = 21)	>12 mo (n = 47)	Pain-Free Control (n = 29)
Female, No. (%)	11 (52)	37 (78)	14 (48)
Age, mean ± SD, y	25.19 ± 7.09	23.68 ± 4.72	23.45 ± 3.45
Weight, mean ± SD, kg	71.00 ± 11.23	64.25 ± 14.44	68.43 ± 11.50
Height, mean ± SD, cm	173.67 ± 9.15	168.49 ± 8.69[a]	174.31 ± 8.40
Limb length, mean ± SD, m	0.89 ± 0.06[a]	0.87 ± 0.07[a]	0.94 ± 0.05
Sport time per week, mean ± SD, h	4.86 ± 2.41	3.83 ± 2.11	3.74 ± 2.15
AKPS score, mean ± SD (of 100)	77.43 ± 13.14	79.13 ± 9.66	N/A
NPRS, mean ± SD (of 10)	3.5 ± 1.3	3.3 ± 1.3	N/A

Abbreviations: AKPS, Anterior Knee Pain Scale; N/A, not applicable; NPRS, Numeric Pain Rating Scale; PFP, patellofemoral pain.
[a] Significant ($P < .05$).

>24 months) had lower hip-abductor maximal strength (% BM = 205.12 ± 59.61 and 207.67 ± 41.92, respectively) ($P < .01$). However, there was no significant difference in hip-abductor maximal strength between the 2 PFP subgroups. Isometric endurance and dynamic endurance were not significantly different between the subgroups and the healthy controls (Table 6).

DISCUSSION

Summary of the Findings

The aim of this study was to determine the potential impact of pain duration on hip-abductor function (strength, isometric, and dynamic endurance). First, our findings revealed that individuals with PFP exhibited significantly weaker hip-abductor maximal strength compared with healthy individuals. This result aligns with prior research highlighting hip-abductor strength deficits in individuals with PFP.[6,7,9,14] These differences were evident across all symptom duration subgroups (≤12 months, >12 months, ≤6 months, and >24 months), indicating that hip-abductor strength deficits appear early in the course of PFP and remain stable over time, even up to 2 years after the onset of symptoms. Finally, no differences in isometric or dynamic endurance were detected between individuals with PFP and pain-free controls, nor among the subgroups based on symptom duration. These results indicate that although strength deficits are evident, endurance does not seem to be affected by PFP duration or presence.

Hip-Abductor Strength Deficit

Previously, Rathleff et al[9] hypothesized that decreased isometric muscle strength of the lower extremity in individuals with PFP could be a consequence of long-standing PFP. This assumption was verified in a recent cross-sectional study concerning quadriceps muscle strength.[25] The authors reported that both severity and duration of anterior knee pain were inversely associated with quadriceps function and self-reported function. Moreover, a combination of high severity and long duration of symptoms caused further deficits in quadriceps function. In light of our results, this does not seem to be the case for the hip-abductor muscles. Although Van Cant et al[11] reported that hip-abductor strength deficits were more pronounced in individuals with PFP who present with higher pain severity and frequency, we found that the duration of symptoms does not influence hip-abductor muscle function. Studies involving patients with PFP, spanning both severe and less severe symptoms, are needed to determine whether the interplay between symptom severity and duration influences strength and endurance, or whether only symptom severity influences hip-abductor strength. In our study, functional capacity was assessed using the AKPS questionnaire and was similar between subgroups, which may suggest that symptoms severity was comparable despite different durations of symptoms.

Hip-Abductor Endurance in Individuals With PFP

Although the aims of the present study did not specifically target this question, our results restart the debate on

Table 3. Participant Demographics Categorized by Symptom Duration (≤6 Months and >24 Months)

	Group		
	PFP Duration		
	≤6 mo (n = 16)	>24 mo (n = 42)	Pain-Free Control (n = 29)
Female, No. (%)	8 (50)	34 (79)	14 (48)
Age, mean ± SD, y	26.44 ± 7.74	23.81 ± 4.81	23.45 ± 3.15
Weight, mean ± SD, kg	70.52 ± 10.67	63.01 ± 12.01	68.43 ± 11.50
Height, mean ± SD, cm	172.59 ± 8.89	168.00 ± 8.57[a]	174.31 ± 8.40
Limb length, mean ± SD, m	0.88 ± 0.06[a]	0.87 ± 0.06a	0.94 ± 0.05
Sport time per week, mean ± SD, h	4.75 ± 2.43	3.58 ± 1.92	3.74 ± 2.15
AKPS score, mean ± SD (of 100)	77.12 ± 14.56	79.12 ± 9.82	N/A
NPRS, mean ± SD (of 10)	4.2 ± 1.2	3.2 ± 1.1	N/A

Abbreviations: AKPS, Anterior Knee Pain Scale; N/A, not applicable; NPRS, Numeric Pain Rating Scale; PFP, patellofemoral pain.
[a] Significant ($P < .05$).

Table 4. **Strength and Isometric and Dynamic Endurance Measures of the PFP Group and Healthy Group**

	Mean ± SD			
	PFP Group (n = 68)	Healthy Group (n = 29)	Mean Difference (95% CI)	*P* Value
% BM, mean ± SD[a]	203.79 ± 46.79	254.62 ± 60.28	−50.83 (−83.89, −17.77)	<.01[b]
Isometric endurance, mean ± SD, s	178.10 ± 58.59	198.48 ± 67.21	−20.38 (−58.77, 18.01)	.136
Dynamic endurance, mean ± SD, reps	62.25 ± 27.41	76.14 ± 40.33	−13.89 (−35.08, 7.30)	.052

Abbreviations: BM, body mass; PFP, patellofemoral pain; reps, repetitions.
[a] % BM = (force [N·m]/BM [kg]) × 100.
[b] Significant ($P < .05$).

the presence or not of a lack of hip-muscle endurance in individuals with PFP. Contradictory findings are reported in the literature. Several authors found no difference in hip-abduction endurance between individuals with and without PFP,[15,26] whereas others reported that females with PFP had lower hip-abduction endurance.[23] The cause of the current discrepancies among studies is unclear, but could stem from interindividual variability in the performance of muscular endurance testing.[27] For example, a coefficient of variation around 50% was reported for static performance.[27] Such substantial variability would require larger samples to limit the type 1 error. In addition, as Nunes et al argued, inconsistencies among studies may underscore the multifactorial nature of PFP and the possibility of subgroups within individuals with PFP, some exhibiting hip-abductor muscle endurance deficits whereas others do not.[25] In this respect, our results emphasize that PFP subgrouping based on symptom duration does not allow reporting of differences in isometric and dynamic endurance across subgroups.

Clinical Perspectives

Clinical practice guidelines for PFP management recommend multimodal intervention programs including gluteal and quadriceps strengthening, patellar taping, and an emphasis on education and activity modification.[28,29] Concerning gluteal strengthening, a systematic review highlighted that, in the early stages of rehabilitation (first 6 months), hip-focused exercise may improve pain and function to a greater extent than knee-targeted exercise, particularly in patients in whom knee-targeted exercises may exacerbate symptoms.[30] Our results support the notion that exercise prescription in the early stages (<6 months) should prioritize proximal rehabilitation to enhance hip strength, as deficits are evident within the initial months after symptom onset. Moreover, researchers have reported that a substantial proportion of people with PFP experience an unfavorable outcome over 12 months and that a longer duration of PFP symptoms (>4 months) is the most consistent prognostic factor of a poor outcome.[31] The present study highlights that hip-abductor deficits are present at an early stage of the onset of PFP symptoms, which suggests it might be important to target these deficits as quickly as possible to decrease the risk of recurrent or persistent PFP symptoms. Additional studies are needed to better understand this specific period of the condition.

Limitations

The present study has some limitations. Firstly, the assessors were not blinded to participants' symptom duration, which may have introduced biases during the evaluations. However, bias might have been minimized by using standardized protocols and external fixation. Secondly, recruitment of individuals with recent PFP was more complicated than recruiting patients with long-standing PFP. These small sample sizes in recent PFP subgroups (n = 16 and 21 for PFP ≤6 months and ≤12 months, respectively) compared with long-standing PFP subgroups (n = 47 and 43 for PFP >12 months and >24 months, respectively) may have influenced our results. Additionally, the inclusion criterion of a minimum symptom duration of 4 weeks was selected to capture participants at the early stages of PFP while avoiding variability associated with very acute symptoms. However, this choice may have influenced the subgroup analyses, as it remains unclear how early deficits in hip-abductor function develop or evolve over time. Future researchers using a longitudinal design could provide deeper insights into these aspects. Lastly, this study included mixed-sex samples, and although different muscle groups were assessed, sex differences in neuromuscular function have been reported in PFP research.[6,7,9,14] This factor may have introduced variability into our findings and should be further investigated in future studies with sex-stratified analyses.

Table 5. **Strength and Isometric and Dynamic Endurance Measures Categorized by Pain Duration (≤12 and >12 Months)**

	Group			
	PFP Duration			
	≤12 months (n = 21)	PFP >12 months (n = 47)	Healthy Control (n = 29)	*P* Value
% BM, mean ± SD[a]	203.93 ± 56.97	203.73 ± 42.16	254.62 ± 60.28	<.01[b]
Isometric endurance, mean ± SD, s	175.43 ± 61.64	179.23 ± 57.82	198.48 ± 67.21	.322
Dynamic endurance, mean ± SD, reps	60.24 ± 29.24	63.15 ± 26.83	76.14 ± 40.33	.143

Abbreviations: BM, body mass; PFP, patellofemoral pain; reps, repetitions.
[a] % BM = (force [N·m]/BM [kg]) × 100.
[b] Significant ($P < .05$).

Table 6. Strength and Isometric and Dynamic Endurance Measures of the ≤6 Months PFP Subgroup, >24 Months PFP Subgroup, and Healthy Control Group

	Group			
	PFP Duration			
	≤6 months (n = 16)	>24 months (n = 42)	Healthy Control (n = 29)	*P* Value
% BM, mean ± SD[a]	205.12 ± 59.61	207.67 ± 41.92	254.62 ± 60.28	.01[b]
Isometric endurance, mean ± SD, s	163.19 ± 47.55	180.74 ± 59.00	198.48 ± 67.21	.301
Dynamic endurance, mean ± SD, reps	56.16 ± 25.49	63.35 ± 26.56	76.14 ± 40.33	.199

Abbreviations: BM, body mass; PFP, patellofemoral pain; reps, repetitions.
[a] % BM = (force [N·m]/BM [kg]) × 100.
[b] Significant ($P < .05$).

CONCLUSIONS

Although individuals with PFP presented with lower hip-abductor strength compared with pain-free controls, we did not find significant differences in hip-abductor strength between individuals with recent and long-standing PFP. These findings suggest that hip-abductor strength deficits are present early in the course of PFP. However, further studies are needed to understand the relationship between PFP and hip-abductor endurance.

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