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Description

STUDY DESIGN: Cross-sectional. **OBJECTIVES:** To investigate whether females seeking physical therapy treatment for unilateral patellofemoral pain syndrome (PFPS) exhibit deficiencies in hip strength compared to a control group. **BACKGROUND:** Decreased hip strength may be associated with poor control of lower extremity motion during weight-bearing activities, leading to abnormal patellofemoral motions and pain. Previous studies exploring the presence of hip strength impairments in subjects with PFPS have reported conflicting results. **METHODS AND MEASURES:** Twenty females aged 12-35 years participated in the study. Ten subjects with unilateral PFPS were compared to 10 control subjects with no known knee pathologies. Hip abduction, extension, and external rotation strength were tested using a hand-held dynamometer. A limb symmetry index (LSI) was used to quantify physical performance for all tests. **RESULTS:** The symptomatic limbs of subjects with PFPS exhibited impairments in hip strength for all variables tested. LSI values in subjects with PFPS (range, 71%-79%) were significantly lower than those in control subjects (range, 93%-101%) ($P \leq .007$). A secondary analysis of data normalized to body mass demonstrated that the symptomatic limbs of subjects with PFPS had 52% less hip extension strength ($P < .001$), 27% less hip abduction strength ($p = .007$), and 30% less hip external rotation strength ($P = .004$) when compared to the weaker limbs of control subjects. **CONCLUSIONS:** Females aged 12-35 presenting with unilateral PFPS demonstrate significant impairments in hip strength compared to control subjects when LSI values or body mass normalized values are used to quantify physical performance of the symptomatic limb.

Keywords

anterior knee pain, hip abduction, hip extension, hip external rotation, limb symmetry index

Disciplines

Physical Therapy

Comments

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Analysis of Hip Strength in Females Seeking Physical Therapy Treatment for Unilateral Patellofemoral Pain Syndrome

Patellofemoral pain syndrome (PFPS) is a common orthopedic condition and is diagnosed at a higher frequency in female athletes when compared to male athletes.[5,7,26] During a 5-year span, Devereaux and Lachman[7] demonstrated that 25% of all individuals with knee pain evaluated in a sports injury clinic were diagnosed with PFPS. The clinical diagnosis of PFPS typically encompasses retropatellar and/or peripatellar knee pain that is aggravated by prolonged sitting or activities that load the patellofemoral joint, such as ascending or descending stairs, squatting, running, jumping, or kneeling.[4,27] The most commonly accepted hypothesis of the cause of PFPS is that abnormal patellar tracking increases patellofemoral joint stress and causes subsequent wear on the articular cartilage.[9,11,24] However, retropatellar pain and crepitus may also occur when the patella articulates against the femoral condyles, even in the absence of any measurable damage to the articular cartilage.[9]

STUDY DESIGN: Cross-sectional.

OBJECTIVES: To investigate whether females seeking physical therapy treatment for unilateral patellofemoral pain syndrome (PFPS) exhibit deficiencies in hip strength compared to a control group.

BACKGROUND: Decreased hip strength may be associated with poor control of lower extremity motion during weight-bearing activities, leading to abnormal patellofemoral motions and pain. Previous studies exploring the presence of hip strength impairments in subjects with PFPS have reported conflicting results.

METHODS AND MEASURES: Twenty females, aged 12 to 35 years, participated in the study. Ten subjects with unilateral PFPS were compared to 10 control subjects with no known knee pathologies. Hip abduction, extension, and external rotation strength were tested using a handheld dynamometer. A limb symmetry index (LSI) was used to quantify physical performance for all tests.

RESULTS: The symptomatic limbs of subjects with PFPS exhibited impairments in hip strength for all variables tested. LSI values in subjects with PFPS (range, 71%-79%) were significantly lower than those in control subjects (range, 93%-101%) ($P \leq .007$). A secondary analysis of data normalized to body mass demonstrated that the symptomatic limbs of subjects with PFPS had 52% less hip extension strength ($P < .001$), 27% less hip abduction strength ($P = .007$), and 30% less hip external rotation strength ($P = .004$) when compared to the weaker limbs of control subjects.

CONCLUSION: Females aged 12 to 35 presenting with unilateral PFPS demonstrate significant impairments in hip strength compared to control subjects when LSI values or body mass normalized values are used to quantify physical performance of the symptomatic limb. *J Orthop Sports Phys Ther 2007;37(5):232-238. doi:10.2519/jospt.2007.2439*

KEY WORDS: anterior knee pain, hip abduction, hip extension, hip external rotation, limb symmetry index

Various authors have suggested that hip weakness may be an impairment associated with PFPS, because poor hip control may lead to abnormal lower extremity or patellofemoral motions.[17,21,24,25] Theoretically, weakness of the hip abductors and external rotators may be associated with poor control of eccentric femoral adduction and internal rotation during weight-bearing activities, leading to misalignment of the patellofemoral joint as the femur medially rotates underneath the patella.[21,22] Consequently, to reduce excessive lateral patellar deviations during weight-bearing activities and potentially reduce anterior knee pain, physical therapy intervention may need to address hip muscle performance to facilitate greater control of weight-bearing femoral adduction and internal rotation. Specific activities targeting performance of the lateral hip musculature have been incorporated into physical therapy intervention programs for improving pain, disability, and function in patients with PFPS.[4,17,29]

In spite of the fact that intervention programs for the management of patients with PFPS include exercises

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aimed at improving the performance of the lateral hip musculature, we are aware of only 2 research reports that have investigated whether differences in hip strength exist between patients with PFPS and a control group.[12,20] Ireland et al[12] found that 15 female subjects with PFPS demonstrated 26% less hip abduction strength and 36% less hip external rotation strength when compared to 15 age-matched control subjects. In contrast, Piva et al[20] reported that there were no statistically significant differences in hip abduction or external rotation strength when 30 subjects with PFPS (17 females and 13 males) were compared with 30 age- and gender-matched control subjects. Different methods for stabilizing the dynamometer and different positions for testing hip external rotation strength may account for these conflicting results.

The aforementioned research reports have compared hip strength of the symptomatic limbs in subjects with PFPS to the corresponding limbs of a control group, but clinicians are not able to make comparisons to control group data when interpreting their examination findings in daily clinical practice. In patients with unilateral PFPS, the clinician will typically quantify physical performance in the involved limb through comparison with the uninvolved limb. This type of pragmatic comparison can be expressed through a limb symmetry index (LSI), which has been used to quantify the physical performance of the involved limb in subjects with PFPS.[16] The formula for the LSI is: (performance in the involved limb/performance in the uninvolved limb) × 100. Thus physical performance in the involved and assumed-weak limb is expressed as a percentage of the physical performance in the uninvolved assumed-strong limb.[1] In asymptomatic subjects the formula for calculating the LSI is: (performance in the nondominant, assumed-weak limb/performance in the dominant, assumed-strong limb) × 100.[1,8,10,18] A lower LSI value indicates decreased function in the symptomatic (subjects with PFPS) or nondominant (asymptomatic subjects) limb.

The primary purpose of this study was to determine whether females seeking physical therapy treatment for unilateral PFPS exhibited deficiencies in hip extension, abduction, and external rotation strength compared to an asymptomatic control group, when using the LSI to quantify muscle performance. Given the contradictory results from previous reports,[12,20] we also performed a secondary analysis where data from the involved limbs of symptomatic subjects were compared to the corresponding limbs of asymptomatic subjects. We hypothesized that females with unilateral PFPS would exhibit lower LSI values during strength testing compared to asymptomatic subjects. We also hypothesized that, when data were normalized to body mass, females with unilateral PFPS would exhibit impairments in strength of the hip musculature of their involved limbs when compared to the corresponding limbs of asymptomatic subjects.

METHODS

Subjects

This cross-sectional study included 20 subjects. Consecutive female patients referred for physical therapy with a physician diagnosis of unilateral PFPS were approached to participate in data collection. Additional inclusion criteria for the PFPS group (n = 10) were as follows: (1) age 12 to 35 years to limit the possibility that anterior knee pain over age 35 may have been complicated by tibiofemoral osteoarthritis; (2) insidious onset of symptoms unrelated to a traumatic event; and (3) anterior/retropatellar pain associated with either sports, ascending/descending stairs, or sitting for prolonged periods of time. Female control subjects between 12 and 35 years of age, with no known knee pathologies, were recruited from the local community (n = 10). There were no attempts to match PFPS and control subjects specifically for age, height, or activity level.

Subjects from both the PFPS and control groups were excluded if they had a history of patellar dislocation, knee surgery or trauma, or confirmed meniscal, ligamentous, or muscular pathology of either knee. Presence of neurological involvement, use of anti-inflammatory medications, or involvement in physical therapy treatment during the previous 30 days were additional exclusion criteria. Prior to participation in this study, all subjects signed an informed consent document approved by the Institutional Review Board at Pacific University. Subjects less than 18 years of age had a parent sign the consent form.

Procedure

Self-Administered Anterior Knee Pain Scale (AKPS) To better describe our patient population, each subject with PFPS independently completed the AKPS prior to hip strength testing.[15] The AKPS is a 13-item questionnaire that has been used to describe subjects with PFPS and contains questions related to various levels of current knee function that are typically asked during a standardized clinical history intake for a patient with anterior knee pain. This tool has demonstrated high test-retest reliability[28] and is a valid and responsive outcome measure of treatment for patellofemoral pain.[3] Response scores are summed and higher scores indicate greater function and lower levels of pain. A score of 100 indicates no disability and has been validated in control groups.[15] A score of 70 on the AKPS and 6 cm on a 0-to-10 visual analog scale (VAS) would imply a moderate amount of pain and disability.[3]

Hip Strength Testing Each subject's isometric strength for hip abduction, extension, and external rotation was measured with a handheld dynamometer (HHD), as described by Kendall et al.[14] HHD has been shown to be reliable,[2] and similar isometric strength testing procedures with HHDs have reported intraclass correlation coefficient ($ICC_{2,1}$) values ranging from 0.80 to 0.95.[13] In subjects with PFPS, Piva et al[19] reported acceptable levels of interrater reliability with $ICC_{2,2}$ values (95% confidence interval) of 0.85 (0.68-0.93) for HHD measurements of hip abduction strength in sidelying and 0.79 (0.56-0.91) for HHD measurements of hip external rotation strength in prone.

We conducted a pilot study to establish intrarater reliability for the examiner administering the HHD tests. Five subjects were tested on 2 occasions separated by 24 to 48 hours. Intrarater reliability for all lower extremity strength testing procedures described below was excellent, with $ICC_{3,3}$ values (95% confidence interval [CI]) of 0.97 (0.87-0.99) for abduction, 0.97 (0.90-0.99) for extension, and 0.94 (0.79-0.99) for external rotation. Because the examiner demonstrated excellent reliability for HHD testing, data from the first trial of these 5 pilot study subjects were incorporated into the control group. The same examiner, who had 7 years of orthopedic clinical experience treating patients with PFPS, tested all subjects during the pilot study and final data collection. The examiner was not blinded to each subject's status as a member of the PFPS or control group.

Each subject's body mass was recorded in kilograms (kg) prior to testing to allow the secondary analysis of strength (kg) normalized to body mass (kg). Testing was completed in the same order for all subjects (hip abduction, extension, external rotation).[14] To familiarize the subjects with the strength-testing procedures, 2 submaximal trials and 1 maximal trial of each test were given just before their respective maximal strength tests. The average of 3 maximal strength tests was used with a 15-second rest between each trial. Maximal resistance was measured by the HHD as the force required to break the isometric contraction. The assumed-weak limb was tested first for all subjects (eg, control group nondominant side and PFPS group symptomatic side). Limb dominance in control group subjects was based on self-report of which lower extremity the subject would use to kick a ball.[10,18]

Hip abduction isometric strength testing was performed with the subject in the sidelying position on a treatment table. The underneath leg was flexed at the hip and knee with the pelvis rotated slightly forward. The upper arm grasped the edge of the table to increase the stability of the trunk. The subject abducted the upper leg to 30°, with slight external rotation. The examiner stabilized the pelvis and applied pressure, with the HHD just proximal to the lateral malleolus, in the direction of adduction and slight flexion.

Testing for hip extension was completed with the subject positioned prone on a treatment table with the knee flexed 90°. The subject was allowed to grasp the treatment table with the upper extremities to stabilize the trunk. The subject was asked to extend the hip in slight external rotation. The examiner stabilized the pelvis and applied pressure, with the HHD against the distal posterior thigh, in the direction of hip flexion.

Hip external rotation isometric strength testing was performed with the subject sitting on the edge of a treatment table with the hips and knees flexed 90°. The subject was asked to hold onto the table and to rotate the lower extremity so that the medial malleolus was aligned with the midline of the body (ie, hip in slight external rotation). The examiner stabilized the lateral surface of the knee and applied pressure into internal rotation with the HHD just proximal to the medial malleolus.

Data Reduction The LSI was calculated according to the previously described formulas and was used to normalize all data collected from hip isometric strength testing. The LSI allowed comparison of the PFPS group to the control group to determine if the amount of asymmetry between limbs in the PFPS group was different than the control group for hip strength measurements.

Dynamometry results were normalized to body mass using the following equation: (kg force/kg body mass) × 100. This allowed us another method of investigating whether between-group differences existed for HHD strength results when comparing the symptomatic limbs of subjects with PFPS to the corresponding limbs of control subjects. This secondary analysis enabled us to compare our results to those from 2 previous studies that employed similar methodology to examine hip abduction and external rotation isometric strength in subjects with PFPS.[12,20]

Data Analysis

We did not perform a priori calculations for sample size. Mann-Whitney *U* tests were used to detect between-group differences for the primary analysis of the LSI data and the secondary analysis of data normalized to body mass. The alpha level for both of these analyses was set at .05. Nonparametric testing was indicated because of our small sample size and the fact that LSI data were not all normally distributed according to a Shapiro-Wilk test (control group hip extension LSI, $P = .035$).

RESULTS

Demographic information and the results of the AKPS are presented in **TABLE 1**. The mean score of 69.7 on the AKPS implies that subjects in the PFPS group were experiencing a moderate amount of disability related to their symptoms. Six of the 10 subjects with PFPS were experiencing symptoms in their dominant limb.

Results of the primary analysis of LSI data for hip strength measurements are summarized in **TABLE 2**. LSI values for all measurement variables were significantly less in the PFPS group ($P \leq .007$). Differences between group means for LSI values during HHD testing were greatest for extension, followed by abduction and external rotation.

TABLE 3 summarizes the results for the secondary analysis of data normalized to body mass. Because PFPS and control

TABLE 1 Demographic Characteristics of Control Subjects and Subjects With PFPS

Patient Description	PFPS (n = 10)	Control (n = 10)
Age (y)*	21.0 (12-34)	26.6 (16-35)
Body mass (kg)*	63.5 (41.2-106.8)	66.5 (48.8-80.4)
Dominant LE	Right, 10	Right, 10
Symptomatic LE	Right, 6; left, 4	n/a
AKPS score*†	69.7 (54-89)	n/a
Symptom duration (mo)*	34.7 (1-120)	n/a

Abbreviations: AKPS, Anterior Knee Pain Scale; LE, lower extremity; n/a, not applicable; PFPS, patellofemoral pain syndrome.
**Mean (range).*
†Anterior Knee Pain Scale (range, 0-100, with higher score indicating greater function and lower pain levels).[3]

TABLE 2 Limb Symmetry Index Data

Hip Strength	Control Mean (SD)	PFPS Mean (SD)	*P* Value*	Difference (95% CI)†
Abduction (%)	101 (9)	78 (16)	<.001	23 (11-35)
Extension (%)	100 (8)	71 (15)	<.001	29 (18-42)
External rotation (%)	93 (5)	79 (14)	.007	14 (4-25)

Abbreviations: CI, confidence interval; PFPS, patellofemoral pain syndrome.
** Mann-Whitney U test for difference between the 2 groups.*
† Difference between group means.

TABLE 3 Hip Strength Between-Group Comparison*

Hip Strength	Control Mean (SD)	PFPS Mean (SD)	*P* Value†	Difference (95% CI)‡
Abduction (%)	22 (3)	16 (8)	.007	6 (1-12)
Extension (%)	48 (13)	23 (9)	<.001	25 (14-36)
External rotation (%)	23 (4)	16 (6)	.004	7 (2-12)

Abbreviations: CI, confidence interval; PFPS, patellofemoral pain syndrome.
** Comparison between the weaker limbs of control subjects and the symptomatic limbs of subjects with PFPS for force data (kg) expressed as a percentage of body mass (kg).*
† Mann-Whitney U test for difference between the 2 groups.
‡ Difference between group means.

group subjects were not matched specifically for age, height, or activity level, we compared the symptomatic limbs of subjects with PFPS to the weaker limbs of subjects in the control group. Normalized hip strength values were significantly less in the symptomatic limbs of subjects with PFPS for all HHD measurements ($P \leq .007$). Differences between group means were greatest for extension, followed by external rotation and abduction.

DISCUSSION

The results of our primary analysis indicated that female subjects with unilateral PFPS exhibited greater asymmetry between limbs during isometric strength testing of the hip musculature when compared to a control group. The secondary analysis also demonstrated that these subjects had impairments in hip muscle strength when their symptomatic limbs were compared to the weaker limbs of asymptomatic subjects. The potential bias associated with the examiner not being blinded to each subject's status as a member of the PFPS or control group and the relatively small sample are study limitations that warrant caution when generalizing these results to other patients with PFPS. In spite of these limitations, the findings of this study have potential implications for clinical practice and future research addressing the issues of hip strength in patients with unilateral PFPS.

By using the LSI, we replicated the common clinical practice of comparing the involved and uninvolved limbs of a patient to quantify impairments and functional limitations.[16] The symptomatic limbs of subjects with PFPS exhibited hip strength values that were only 71% to 79% of the physical performance of their uninvolved limbs (**TABLE 2**). This degree of asymmetry was significantly greater than the asymmetry found between limbs in the control group subjects. Different methods have been used to determine limb dominance when calculating LSI values for asymptomatic subjects. While we classified limb dominance in control subjects according to self-report of which lower extremity each subject would use to kick a ball,[10,18] other authors have identified limb dominance according to actual performance during the physical test, so that LSI in asymptomatic subjects is (actual weak limb/actual strong limb) × 100.[1,8] A post hoc analysis (data not shown) using this latter method for calculating LSI values in control group subjects did not change our results. Mann-Whitney *U* tests still revealed that subjects with PFPS exhibited significantly lower LSI values than asymptomatic subjects (hip abduction, $P = .015$; hip extension, $P < .001$; hip external rotation, $P = .009$).

The overall results of the analysis of LSI data lend support to the clinical practice of using the uninvolved limb as a standard for comparison when attempting to quantify impairments in hip strength in patients with unilateral PFPS. Future clinical studies on this population may be able to consider using LSI values as an option for quantifying physical performance of the hip musculature in the symptomatic limb. It still needs to be determined whether changes in hip strength LSI values can take place in response to physical therapy interventions, and whether any changes in hip strength LSI values correspond to changes in self-reported pain or disability in patients with unilateral PFPS.

The purpose of our secondary analysis of data normalized to body mass was to enable a comparison of our results to those of previously published reports.[12,20] These previous studies compared normalized isometric hip strength values from the symptomatic limbs of subjects with PFPS to the corresponding limbs of age-matched asymptomatic subjects. Because we did not specifically match subjects with PFPS to control group subjects, as in the 2 previous studies, we compared normalized hip strength values from the symptomatic limbs of subjects with PFPS to the weaker limbs of control group subjects. We felt that this type of comparison would provide the most conservative estimate as to whether subjects with unilateral PFPS in the present study exhibited impairments in hip strength when compared to asymptomatic subjects.

The results of our secondary analysis (**TABLE 3**) are in agreement with the findings of Ireland et al.[12] Normalized hip strength measurement values were significantly less in female subjects with unilateral PFPS, and the deficits in strength for hip abduction and external rotation were similar to those reported by Ireland et al.[12] Subjects in our study with PFPS exhibited 27% less strength in hip abduction and 30% less strength in hip external rotation compared to control group subjects. The symptomatic subjects in the study by Ireland et al[12] displayed 26% less hip abduction strength and 36% less hip external rotation strength than age-matched control subjects. The symptomatic limbs of subjects with PFPS in our study also had 52% less hip extension strength than the weaker limbs of control subjects.

Lack of matching subjects for height or activity level may have contributed to the results of our secondary analysis, particularly the marked difference in hip extension strength. HHD strength measurements were expressed in terms of force as opposed to torque (force × perpendicular distance of point of force application from the axis of motion[23]), so the differences in hip strength normalized to body mass could have been partly due to differences in leg length between the 2 groups. We cannot provide a definitive answer to this question as we did not measure the height or limb length of our subjects.

Subjects with PFPS in our study had experienced symptoms for an average of nearly 35 months (range, 1-120 months) and reported a moderate amount of disability according to the AKPS (**TABLE 1**). Given the duration and magnitude of their symptoms, it is conceivable that subjects with PFPS in our study had decreased activity levels leading to less hip strength bilaterally than control subjects, which could magnify the amount of difference found between groups for hip strength normalized to body mass. A post hoc analysis (data not shown) comparing the uninvolved limbs of subjects with PFPS to the weaker limbs of control subjects may provide a partial answer to this question. The uninvolved limbs of subjects with PFPS had significantly less hip extension strength than the weaker limbs of control subjects ($P = .011$). This bilateral hip extension weakness may partly explain the marked difference in hip extension strength found in our secondary analysis. In contrast, the uninvolved limbs of subjects with PFPS had similar levels of hip abduction ($P = .165$) and external rotation ($P = .190$) strength compared to the weaker limbs of control subjects, so the magnitude of the differences found in the secondary analysis for hip abduction and external rotation strength normalized to body mass were not affected by bilateral weakness in subjects with PFPS.

Previous reports exploring hip strength in patients with PFPS[12,20] have not measured hip extension strength, and our finding that subjects with PFPS had 52% less hip extension strength in their symptomatic limbs when compared to control subjects was somewhat unexpected. While bilateral weakness may have contributed to the magnitude of this difference in hip extension strength, it is also possible that an order effect from testing hip abduction prior to hip extension was a confounding factor. Because the gluteus maximus is a secondary abductor of the hip,[6,14] symptomatic subjects may have experienced greater fatigue from testing hip abduction strength with 3 maximal trials than control subjects, resulting in lower strength values during hip extension testing, with a subsequent overestimation of the difference between groups for hip extension strength normalized to body mass. In spite of these confounding factors, it is also plausible that the impairments found in hip extension strength indicate that deficits in gluteus maximus function may have a significant impact on femoral alignment in patients experiencing anterior knee pain. Three-dimensional computer modeling of the hip musculature suggests that underactivity of the gluteus maximus may be associated with increased amounts of femoral internal rotation during weight-bearing activities, especially when the hip is in greater amounts of flexion.[6] Future investigations that randomize the order of testing are necessary to determine whether our results for hip extension strength normalized to body mass can be replicated in female patients with PFPS.

We only quantified performance of the posterior and lateral hip musculature with isometric strength testing and did not make any attempts to measure the endurance of these muscles. Future investigations should consider measuring hip muscle endurance to determine whether impairments in this aspect of muscle performance are present in subjects with PFPS. Additionally, although it has been hypothesized that weakness in the posterior and lateral hip musculature may be associated with poor control of the femur during weight-bearing activities,[6,21] we are not aware of any studies that have specifically explored this relationship. Because the findings of our study and those of Ireland et al[12] have demonstrated that females with PFPS exhibit impairments in hip strength, future studies could investigate whether there are any correlations between impairments in hip muscle performance and kinematic variables associated with lower extremity alignment during weight-bearing activities in this symptomatic population.

While our primary and secondary analyses demonstrated that subjects with unilateral PFPS exhibit impairments in isometric hip strength, the cross-sectional nature of our study design does not permit us to discern whether these impairments are a potential cause of PFPS or are secondary to disuse and/or pain after the onset of symptoms. The identification of these impairments would seem to support the incorporation of hip strengthening exercises into the rehabilitation of patients with unilateral PFPS. Previously mentioned clinical trials[4,29] and case reports[17] that included hip strengthening exercises in their multimodal rehabilitation programs have been successful in reducing the pain and disability associated with PFPS. Further research is warranted to determine whether hip strengthening and/or endurance exercises are a necessary component of a multimodal rehabilitation program for patients with PFPS and to identify which subgroup of patients with PFPS is most likely to respond to these types of therapeutic activities.

CONCLUSION

The results of our research indicate that females between 12 and 35 years of age presenting with unilateral PFPS demonstrate significant impairments in the isometric strength of their symptomatic limbs for hip abduction, extension, and external rotation compared to control subjects when LSI values are used to quantify performance. Consequently, LSI values may be an option for quantifying outcomes in future studies of patients with unilateral PFPS. The impairments in hip strength were also evident when the symptomatic limbs of subjects with PFPS were compared to the weaker limbs of control group subjects, a finding that is consistent with a previous report.[12] Further research is needed to identify which subgroup of patients with PFPS is most likely to benefit from the incorporation of hip strengthening and/or endurance exercises into a multimodal rehabilitation program. In addition, further studies are needed to establish if an association exists between hip strength and lower extremity kinematics, and whether hip muscle rehabilitation can alter kinematic variables associated with lower extremity alignment during weight-bearing activities.

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