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People With Patellofemoral Pain Have Bilateral Deficits in Physical Performance Regardless of Pain Laterality

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Context: People with patellofemoral pain (PFP) may have lower performance during the forward step-down and single-leg hop with their painful (unilateral complaints) or most painful (bilateral complaints) limb when compared with pain-free controls. However, no authors have investigated the appropriateness of using the pain-free or less painful limb as a reference standard in clinical practice or whether deficits might be present depending on the laterality of pain.

Objective: To compare performance scores and proportion of side-to-side limb symmetry during the forward step-down and single-leg hop tests among people with unilateral and bilateral PFP and pain-free controls.

Design: Cross-sectional study.

Setting: Laboratory.

Patients or Other Participants: Fifty-two young adults (18–35 years old) with unilateral PFP, 72 with bilateral PFP, and 76 controls.

Main Outcome Measure(s): Group × limb interactions on performance during the step-down (repetitions) and single-leg hop (distance [cm] normalized by the limb length) tests were investigated using a repeated-measures analysis of covariance controlling for sex. Pairwise comparisons were interpreted using effect sizes. A χ^2 test was used to compare the proportion of symmetry/asymmetry (cutoff point of ≥90% for symmetry indices) across groups and tests.

Results: Main effects for groups (small to medium effects) but not limbs indicated lower performance of both limbs of individuals with unilateral and bilateral PFP than controls during forward step-down and single-leg hop tests. No significant differences for the proportion of symmetry/asymmetry were identified across groups ($P \geq .05$), which further suggests an impaired physical performance of the contralateral limb.

Conclusions: Our results indicate bilateral deficits in the physical performance of people with unilateral and bilateral PFP when compared with pain-free controls during the forward step-down and single-leg hop tests. Limb symmetry indices greater than 90% should be interpreted with caution, as they may overstate physical performance by not assuming bilateral deficits.

Key Words: anterior knee pain, assessment, clinical tests, functional capacity, objective function

Key Points

- People with patellofemoral pain, regardless of the presence of unilateral or bilateral pain, have lower physical performance in both limbs during step-down and single-leg hop tests than pain-free controls.
- Limb symmetry indices greater than 90% are not uncommon in the patellofemoral pain population during physical performance tests and may indicate worsening performance of the contralateral limb.
- Reference values (from pain-free controls) or cutoff points may be helpful for clinicians to estimate deficits and rehabilitation progress of physical performance in people with patellofemoral pain. In the absence of reference values, pre-post intervention comparisons may be used.

Chronic knee pain is a common musculoskeletal complaint in sports medicine practice. Patellofemoral pain (PFP), characterized by peripatellar or retropatellar pain during knee-flexion-based tasks, is one of the leading causes of chronic knee pain due to its high prevalence and recurrence rates.[1–3] Patellofemoral pain alters individuals' sports, recreational, and social participation and has a meaningful impact on individuals' perceived function and physical performance.[3,4] Worse self-reported function has been reported as a key determinant of PFP patient prognosis and as one of the primary targets of rehabilitation.[3,5] Performance-based measures of function can complement information from self-reported measures of function, although they remain understudied.

Physical performance can be assessed through clinician-friendly tests, which are efficient, low cost, and require minimal training.[6] Physical performance tests such as forward step-down (FSDT) and single-leg hop (SLHT) tests are reliable and recommended to assess knee-related performance in people with PFP.[6–8] Authors of previous studies have revealed lower FSDT and SLHT scores in people with PFP than pain-free controls.[8,9] However, this form of comparator (ie, pain-free controls) is not available in a clinical setting, and clinicians regularly use the contralateral limb as the reference standard.[10] Yet no authors have investigated the appropriateness of using the pain-free or less painful limb (ie, contralateral limb) as a reference standard or whether deficits might be also present.

Determining the appropriateness of the contralateral limb in the PFP population considering the presence of unilateral and bilateral PFP is also important. Although it is estimated that 60% to 70% of people with PFP may report bilateral complaints, studies in which authors investigated performance-based measures during FSDT and SLHT were limited to people with unilateral PFP or included people with unilateral or bilateral complaints in the same group.[7–9,11–17] The FSDT and SLHT are similar to common pain-provoking tasks (eg, stepping, jumping, landing) where people with PFP seem to use strategies to decrease or prevent pain and maintain function.[4] In this scenario, bilateral deficits in physical performance may be not surprising, especially in those with bilateral complaints. However, bilateral deficits in physical performance of people with unilateral PFP would also present a problem when using the pain-free limb as a comparator.

Therefore, the purpose of this cross-sectional study was to compare (i) performance during the FSDT and SLHT of people with unilateral PFP, bilateral PFP, and pain-free controls and (ii) the proportion of the dichotomized Limb Symmetry Index (LSI; ie, symmetrical or asymmetrical) during the FSDT and SLHT of people with unilateral PFP, bilateral PFP, and pain-free controls. We hypothesized that (i) both limbs of people with bilateral PFP would present with lower performance than people with unilateral PFP and controls; (ii) the painful limb but not the pain-free limb of people with unilateral PFP would present worse performance than pain-free controls; and (iii) a higher proportion of limb asymmetries (ie, <90% LSI) in the unilateral PFP group than the bilateral PFP and pain-free controls would exist but no difference between bilateral PFP and pain-free controls.

METHODS

We conducted a cross-sectional study adhering to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guideline recommendations.[18] All procedures were approved by the University Ethics Committee, and all participants provided written informed consent before enrollment.

Participants

We enrolled 124 participants with PFP (52 with unilateral pain; 72 with bilateral pain) and 76 pain-free controls aged 18 to 35 years for this study. At least 44 participants per group were required for an α of .05 and statistical power of 80% to identify a minimum difference of 3 repetitions ($\pm$5 repetitions) in the FSDT and 23 cm ($\pm$29 cm) in the SLHT.[8] We recruited participants through advertisements at universities, fitness centers, and via posts on social media. An experienced physiotherapist (>7 years assessing people with PFP) assessed participants for eligibility. Participants with PFP had to meet established criteria: (i) PFP symptoms aggravated during at least 2 activities that load the patellofemoral joint (eg, squatting, walking up or down stairs, running, jumping); (ii) insidious symptoms lasting at least 3 months; and (iii) worst knee pain level of at least 20 mm on a 0 to 100 mm Visual Analog Scale (VAS) in the previous month.[19] Pain-free controls did not present any signs or symptoms of PFP. We excluded participants with a diagnosis of any other knee (eg, meniscal injury, patellar tendon pathology, osteoarthritis) or lower limb disorder or history of knee injury or surgery.

Procedures

After diagnosing PFP and determining laterality, we collected demographic information (ie, age, sex, body mass, and height) and self-reported measures according to the REPORT-PFP to characterize our sample.[20] Participants were instructed to report their (i) sport and leisure physical activities using the Baecke Questionnaire of Habitual Physical Activity; (ii) self-reported function using the Anterior Knee Pain Scale; (iii) worst knee pain in the previous month using a VAS (0–100 mm); and (iv) symptom duration by verbally reporting how many months they have been feeling PFP symptoms.[21,22] We then instructed participants to perform the FSDT and SLHT. Both limbs were randomly tested; the order of tests and limbs were randomized using a coin toss. All participants wore athletic shorts and remained barefoot.

Forward Step-Down Test. Participants stood on a 20-cm-high step in single-leg support with the nonstance leg positioned in front of the step and their hands on their hips (starting position).[8,16] The step height was standardized so that all participants achieved 60° of knee flexion during testing. Participants practiced for the test until they felt comfortable and were instructed to perform the test when they felt prepared or recovered for it. For the test, participants performed a single-leg step or squat down using the tested leg (ie, stance leg), lightly tapped the floor with the heel of the nontested leg, and then returned to the starting position. Participants repeated this movement as many times as possible in a 30-second period. Each leg was tested once (ie, a single trial for each one), and we determined the test performance as the maximal number of successful repetitions performed for 30 seconds.[9,16] Images depicting this test can be found elsewhere.[23]

Single-Leg Hop Test. Before testing, we obtained participants' limb length bilaterally using a measuring tape (cm) with participants in a bipodal standing position. For the test, participants stood in a single-leg position with the heel at a mark on the floor and placed their hands behind their back. Participants practiced the test until they felt comfortable and were instructed to perform the trials when they felt prepared or recovered for it. They started in an upright position and then jumped horizontally as far as possible, landing on the same leg. A successful trial required participants to hold the final landing for at least 2 seconds. Participants performed 3 successful tests with each leg, and we determined the test performance as the average horizontal distance (ie, from the start line to the heel upon landing), normalized by the limb length (cm/cm $\times$ 100).[9] Images depicting this test can be found elsewhere.[23]

Data Analysis and Performance-Based Outcomes

We divided the PFP group into 2 subgroups according to the presence of unilateral or bilateral PFP. For analyses, the painful (unilateral PFP) and most painful (bilateral PFP) limbs were considered the *affected* limbs, whereas the pain-free (unilateral PFP), less painful (bilateral PFP), and dominant limbs were considered *contralateral* limbs. For a more conservative approach, the dominant limb of controls was also considered the contralateral limb. Limb dominance was determined by asking the participants with which limb they would prefer to kick a ball for maximal distance.[24] The LSI was then calculated for each test as

$$\text{LSI} = \frac{\text{Average performance in the affected/nondominant limb}}{\text{Average performance in the contralateral limb}} \times 100.$$

Participants were then dichotomized as symmetric or asymmetric as per recent publication (ie, LSI cutoff point of $\geq$90% to determine symmetry).[25]

Statistical Analysis

Statistical analyses using the Statistical Software for Social Sciences (IBM SPSS Statistics for Windows; v. 23.0; IBM Corp; Released 2015). We checked data for normality using the Shapiro-Wilk test and found it to be normally distributed. Demographics and self-reported measures were compared among groups using a 1-way between-groups analysis of variance (ANOVA). Group × limb interactions on the performance during the FSDT and SLHT were investigated using a repeated-measures analysis of covariance (ANCOVA) controlling for sex and interpreted using estimation methods based on an α level of $P < .05$ and partial η^2 effects sizes (*no effect*: $\eta_p^2 < 0.010$; *small*: $\eta_p^2 = 0.010–0.059$, *medium*: $\eta_p^2 = 0.060–0.139$; and *large*: $\eta_p^2 \geq 0.140$).[26] Bonferroni post hoc tests were used for pairwise comparisons with adjusted familywise *P* values, and estimation methods were performed based on effect sizes and their confidence intervals (Cohen d [95% CI]) as per recent recommnedations.[26,27] Effects sizes were interpreted as *no effect* (<0.19 or ES CI values including zero), *small* (0.20–0.49), *medium* (0.50–0.79), and *large* ($\geq$0.80).[27,28] A χ^2 test was used to compare the proportion of symmetry and asymmetry ($P < .05$).

RESULTS

None of the tests used in this study violated the statistical assumption of sphericity based on the Mauchly test. We observed no significant differences among groups for age, body mass, height, and body mass index, nor were sport and leisure physical activity levels different (Table 1). We observed lower self-reported function in people with unilateral and bilateral PFP than pain-free controls but no significant differences between the PFP groups (d = 0.23–0.26, 95% CI = −3.42, −2.30; Table 1). People with bilateral PFP had greater symptom duration but not pain severity than those with unilateral PFP (d = −0.35, 95% CI = −0.71, −0.01; Table 1).

Table 1. Mean ± SD for Demographics and Self-Reported Measures[a]

	Groups (Mean ± SD[b])			One-Way ANOVA		Mean Difference (95% CI)		
Variables	Unilateral PFP	Bilateral PFP	Controls	*F* Value	P Value	Unilateral PFP × Bilateral PFP	Unilateral PFP × Controls	Bilateral PFP × Controls
Demographics								
No. (%)	52 (26%)	72 (36%)	76 (38%)	NA	NA	NA	NA	NA
Sex (F, M)	29F, 23M	53F, 19M	40F, 36M	NA	NA	NA	NA	NA
Proportion of dominant limb as tested limb (%)	61%	50%	0%	NA	NA	NA	NA	NA
Age (y)	23.65 ± 4	23.19 ± 3.97	22.08 ± 3.09	3.15	.45	.45 (−1.15, 2.07)	1.57 (−0.03, 3.18)	1.11 (−0.35, 2.58)
Body mass (kg)	73.14 ± 17.57	67.87 ± 14.55	66.97 ± 15.41	2.60	.076	5.27 (−1.62, 12.18)	6.17 (−0.69, 13.03)	0.89 (−5.38, 7.17)
Height (m)	1.69 ± 0.08	1.67 ± 0.08	1.67 ± 0.09	1.19	.305	0.02 (−0.01, 0.06)	0.01 (−0.02, 0.05)	−0.006 (−0.04, 0.02)
BMI (kg/m^2)	25.39 ± 5.73	24.15 ± 3.87	23.64 ± 4.23	2.29	.103	1.24 (−0.76, 3.24)	1.75 (−0.24, 3.74)	0.50 (−1.31, 2.33)
Self-reported measures, physical activity level								
Sport activity index	2.84 ± 0.81	2.84 ± 0.85	2.90 ± 0.85	0.113	.893	−0.01 (−0.37, 0.36)	−0.06 (−0.42, 0.30)	−0.05 (−0.27, 0.39)
Leisure activity index	2.66 ± 0.54	2.70 ± 0.61	2.65 ± 0.52	0.150	.861	−0.03 (−0.28, 0.21)	0.01 (−0.22, 0.26)	0.05 (−0.17, 0.27)
Self-reported function	80.52 ± 9.43	78.31 ± 10.42	98.81 ± 2.39	137.71	<.001	2.21 (−1.33, 5.75)	**−18.29 (−21.81, −14.76)**	**−20.50 (−23.72, −17.28)**
Worst pain last month[c]	49.62 ± 21.75	51.11 ± 20.09	NA	202.12	<.001	−1.49 (−8.82, 5.83)	NA	NA
Symptom duration	40.69 ± 44.19	57.91 ± 52.14	NA	42.64	<.001	**−17.21 (−34.24, −0.19)**	NA	NA

Abbreviations: ANOVA, analysis of variance; BMI, body mass index; F, females; M, males; NA, not applicable; PFP, patellofemoral pain.

[a] Units of measure of the self-reported outcomes: (i) physical activity level: sport and leisure-time physical activity using the Baecke Questionnaire of Habitual Physical Activity, with higher scores indicating higher levels of physical activity; (ii) subjective function: Anterior Knee Pain Scale total score, ranging from 0 to 100, with higher scores indicating better function; (iii) worst pain last month: Visual Analog Scale ranging from 0 to 100, with higher scores indicating higher pain; (iv) symptom duration: self-reported time in months. Bolded values indicate significant differences in pairwise comparisons ($P \leq .05$).

[b] Mean ± SD not adjusted by sex and height.

[c] Worst knee pain was assessed for the painful limb of people with unilateral PFP and the most painful of people with bilateral PFP.

Table 2. Mean of the Performance During Forward Step-Down and Single-Leg Hop Tests Using Both Limbs of People With Unilateral and Bilateral Patellofemoral Pain and Controls[a]

	Mean (95% CI)[b]		Results		
	Affected[c] or Nondominant Limb	Contralateral Limbs[d]	Group	Limb	Group × Limb
FSDT (repetitions)					
Unilateral PFP	16.40 (14.48, 18.31)	18.16 (16.36, 19.97)	NA	NA	**F = 6.24 (P = .002)**
Bilateral PFP	17.16 (15.52, 18.81)	17.32 (15.77, 18.87)			
Controls	21.76 (20.17, 23.35)	21.31 (19.81, 22.80)			
SLHT (% of limb length)[e]					
Unilateral PFP	100.02 (93.28, 106.77)	100.70 (94.16, 107.23)	**F = 3.49 (P = .032)**	F = 0.208 (P = .649)	F = 0.935 (P = .394)
Bilateral PFP	103.06 (97.27, 1.09)	101.74 (96.13, 107.35)			
Controls	111.15 (106, 116.74)	110.11 (105.69, 115.54)			

Abbreviations: FSDT, forward step-down test; NA, not applicable; PFP, patellofemoral pain; SLHT, single-leg hop test.
[a] Bolded values indicate significant main effects or interactions ($P < .05$).
[b] Mean adjusted by sex.
[c] Affected limbs of the PFP groups: painful (unilateral PFP), most painful (bilateral PFP) limbs.
[d] Contralateral limbs: pain-free (unilateral PFP), less painful (bilateral PFP), dominant (controls) limbs.
[e] Values normalized by limb length.

Forward Step-Down Test

We observed a significant interaction for FSDT ($\eta_p^2 = 0.060$; Table 2). People with unilateral and bilateral PFP demonstrated lower performance with both painful or most painful (d = −0.65 to −0.76, 95% CI = −1.13, −0.32) and pain-free or less painful limbs (d = −0.47 to −0.59, 95% CI = −0.92, −0.12) than pain-free controls, based on small to medium effects (Table 3). We observed no significant differences in FSDT performance between PFP groups (d = −0.11 to 0.12, 95% CI = −0.47, 0.48; Table 3). Also, no significant differences were found in the proportion of symmetrical/asymmetrical participants across groups (P = .058; Figure A).

Single-Leg Hop Test

We observed no significant interaction or limb main effect for SLHT ($\eta_p^2 = 0.009$–0.016), but we found a significant group main effect ($\eta_p^2 = 0.034$; Table 2). People with unilateral and bilateral PFP demonstrated lower performance with both painful or most painful (d = −0.33 to −0.46, 95% CI = −0.81, −0.02) and pain-free or less painful limbs (d = −0.35 to −0.39, 95% CI = −0.75, −0.03) than pain-free controls (Table 4). We observed no significant differences in SLHT performance between PFP groups (d = −0.12 to −0.04, 95% CI = −0.48, 0.31; Table 4). Also, significant differences were found in the proportion of symmetrical/asymmetrical participants across groups (P = .817; Figure B).

DISCUSSION

Our results showed lower performance of both limbs of people with PFP when performing the FSDT and SLHT than pain-free controls. This is partially in agreement with our initial hypotheses, as we expected worse performance in both limbs of people with bilateral PFP but not bilaterally in those with unilateral PFP. The lack of differences for the proportion of limb asymmetries among groups further supports the impaired performance of the pain-free and less painful limbs of people with PFP. These results highlight the limitations of using the contralateral limb as the reference standard when assessing performance-based measures of function such as FSDT and SLHT in people with PFP, regardless of PFP laterality.

We observed that both limbs of people with PFP, regardless of the presence of unilateral or bilateral complaints, have lower FSDT (15%–25%) and SLHT (10%–12%) performance. These results support previous reports of impaired performance of the painful or most painful limbs of people with PFP as compared with pain-free controls during both tests and reinforce the impact of PFP on step-down and hop performance.[9,16] Even though between-groups differences had small to medium effect sizes, physical performance of people with PFP can become worse over time as an effect of pain chronicity and age.[8] As FSDT and SLHT are capable of differentiating people with and without PFP, clinicians may benefit from such performance-based measures to complement their assessment of physical function of patients with PFP.

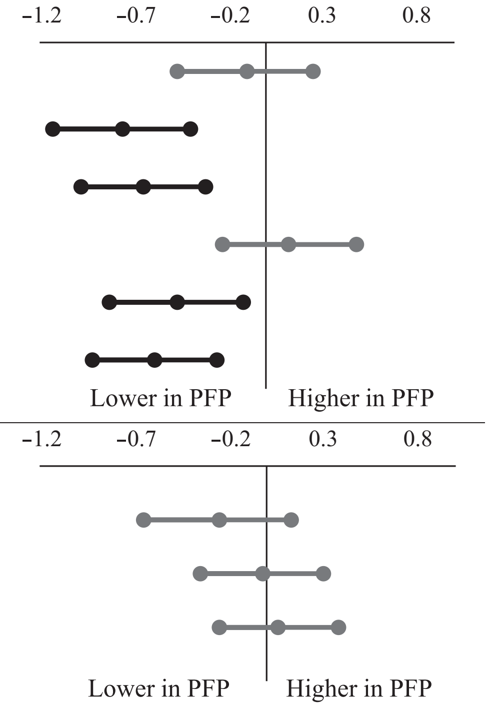
A novel finding from our results is that not only the performance of the painful or most painful limbs but also of the contralateral limbs (ie, pain-free and less painful) of people with PFP are reduced when compared with pain-free controls. Our results are in accordance with recent reports that women with both unilateral and bilateral PFP displayed lower muscle volume of the bilateral hips and knees than pain-free women.[29] Together, these findings suggest that the pain-free and less painful limbs may not be equivalent controls for clinical or field-based assessments. We recommend clinicians assess and prioritize rehabilitation of both painful or most painful and pain-free or less painful limbs when targeting performance-based measures of function using FSDT or SLHT in people with PFP. In the absence of reference values for FSDT and SLHT performance in young adults with PFP, preintervention and postintervention differences (ie, within-limbs comparisons) may be used to track progress or estimate gains.[30]

Limb symmetry during physical performance tests has been primarily recommended to interpret and benchmark injured limb deficits or performance recovery in people after anterior cruciate ligament (ACL) injuries, but its practical use has been questioned, first, because LSI values tend to fluctuate slightly from person to person, and asymmetries observed in those without pain is not surprising, and secondly, because it has been reported that LSI may overestimate functional

Table 3. Pairwise Comparisons Among Groups for the Performance During the Forward Step-Down Test[a]

	FSDT (repetitions)	Mean Difference (95% CI)
	Between-groups comparisons	
Affected or nondominant limbs	Unilateral PFP × bilateral PFP	−0.76 (−3.86, 2.34)
	Unilateral PFP × controls	−5.36[b] (−8.40, −2.32)
	Bilateral PFP × controls	−4.59[b] (−7.41, −1.77)
Contralateral limbs	Unilateral PFP × bilateral PFP	0.84 (−2.08, 3.76)
	Unilateral PFP × controls	−3.14[c] (−6.00, −0.28)
	Bilateral PFP × controls	−3.98[b] (−6.64, −1.33)
	Between-limbs comparisons	
Affected or nondominant limb × contralateral limbs	Unilateral PFP	−1.76 (−2.73, −0.80)
	Bilateral PFP	−0.15 (−0.98, 0.67)
	Controls	0.45 (−0.35, 1.25)

Effect Size (95% CI)



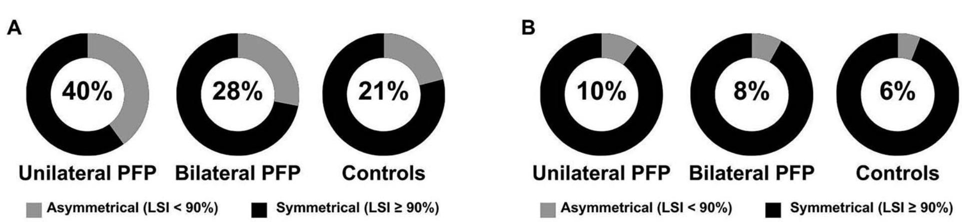
Abbreviations: FSDT, forward step-down test; PFP, patellofemoral pain.

[a] Affected limbs of the PFP groups: painful (unilateral PFP), most painful (bilateral PFP) limbs. Contralateral limbs: pain-free (unilateral PFP), less painful (bilateral PFP), dominant (controls) limbs.

[b] Effect size interpretation (Cohen d): medium effect (0.51–0.79).

[c] Effect size interpretation (Cohen d): small effect (0.20–0.50).

improvements due to worsening contralateral limb performance over time of those with ACL reconstruction.[10,31–33] A similar interpretation can be used for the results found for our sample of young adults with PFP in which the nondifferences in proportion of symmetries across groups may indicate that this method of measurement may overstate patients' physical performance. In the PFP population, a worsening performance of the pain-free and less painful limbs may reflect bilateral pain-related movement adaptations, deconditioning, lower hip and knee muscle strength or muscle volume, as well as an overall perception of incapacity.[4,8,16,29,34–36] Although more research is needed to confirm or refute this, we recommend caution when interpreting LSI as a benchmark of FSDT and SLHT performance in people with unilateral and bilateral PFP.

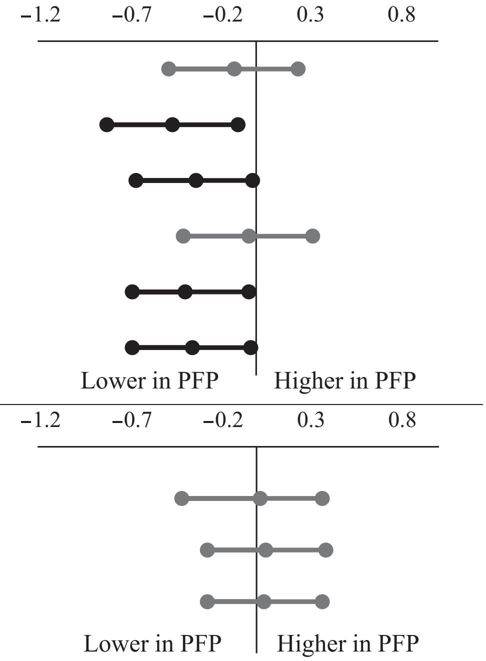


Groups (N)				X^2	*P* value
FSDT (repetitions)	**Unilateral PFP**	**Bilateral PFP**	**Controls**		
Symmetrical	31	52	60	5.69	0.058
Asymmetrical	21	20	16		
SLHT (% of limb length)	**Unilateral PFP**	**Bilateral PFP**	**Controls**		
Symmetrical	47	66	71	0.40	0.817
Asymmetrical	5	6	5		

Figure. Proportion of symmetrical and asymmetrical participants across groups. A, FSDT and B, SLHT. Abbreviations: FSDT, forward step-down test; LSI, Limb Symmetry Index; PFP, patellofemoral pain; SLHT, single-leg hop test. Percentages represent the proportion of asymmetrical participants.

Table 4. Pairwise Comparisons Among Groups for the Performance During the Single-Leg Hop Test[a]

	SLHT (% of Limb Length)	Mean Difference (95% CI)	Effect Size (95% CI)
	Between-groups comparisons		
Affected or nondominant limbs	Unilateral PFP × bilateral PFP	−3.03 (−14, 7.89)	
	Unilateral PFP × controls	−11.12[b] (−21.82, −0.5)	
	Bilateral PFP × controls	−8.10[b] (−18.02, 1.83)	
Contralateral limbs	Unilateral PFP × bilateral PFP	−1.04 (−11.64, 9.55)	
	Unilateral PFP × controls	−9.41[b] (−19.80, 0.95)	
	Bilateral PFP × controls	−8.37[b] (−18.00, 1.20)	
	Between-limbs comparisons		
Affected or nondominant limb × contralateral limbs	Unilateral PFP	−0.67 (−2.98, 1.63)	
	Bilateral PFP	1.31 (−0.66, 3.30)	
	Controls	1.03 (−0.87, 2.95)	



Abbreviations: PFP, patellofemoral pain; SLHT, single-leg hop test.

[a] Affected limbs of the PFP groups: painful (unilateral PFP), most painful (bilateral PFP) limbs. Contralateral limbs: pain-free (unilateral PFP), less painful (bilateral PFP), dominant (controls) limbs.

[b] Effect size interpretation (Cohen d): small effect (0.20–0.50).

The proportion of asymmetry between limbs during the FSDT was 12% higher for participants with unilateral PFP (40% of asymmetry) than participants with bilateral PFP (28% of asymmetry), despite the lack of significant differences between groups. However, it is important to acknowledge that not all participants with unilateral PFP presented an impaired performance of the pain-free limb. Still, most of them (60%) were symmetrical (ie, painful and pain-free limbs had similar outcomes), which reinforces that researchers and clinicians should avoid using the pain-free limb of people with unilateral PFP as a reference standard of their physical performance during the FSDT. Future studies are needed to investigate why some people with unilateral PFP have both limbs affected and others not.

Research in performance-based measures is still precarious in PFP compared with the literature of other knee disorders. Authors of recent systematic reviews including 30 to 42 studies and less than 13 000 participants have recognized the importance and appropriateness of using clinical tests to assess performance recovery and to predict future self-reported or knee-related outcomes after ACL or meniscal injuries.[6,31] On the other hand, even recognizing the importance of measures of function in the PFP population, no recommendations have been made from the International Patellofemoral Research Network for the inclusion of performance-based measures of function on the essential items that should be reported in PFP studies according to the most recent REPORT-PFP.[20] The lack of in-depth investigations into the physical performance of people with PFP may have played a role in this lack of recommendations. Further evidence on reference values or cutoff points, measurement properties (eg, responsiveness), and interventions addressing improvements in performance-based outcomes are encouraged to strengthen future recommendations.

Limitations

Limitations of our study should be acknowledged. Our analyses were focused on FSDT and SLHT, as they are common clinical tests used to assess performance-based measures of function in PFP research. Authors of future studies may expand on our results for other available tests (eg, 1-leg rise or bridge tests). We only included young adults with and without PFP; our results may not be generalizable to adolescents and older people with PFP. Although our analyses were controlled for sex, our cohort did not include the same number of males and females per group or aim at analyzing groups dividing by sex. More research is warranted to further understand the effects of PFP and sex on FSDT and SLHT outcomes.

CONCLUSIONS

People with PFP, regardless of the presence of unilateral or bilateral pain, present with lower FSDT and SLHT performance on both painful or most painful and pain-free or less painful limbs than pain-free controls. Also, no differences were found in the proportion of symmetrical/asymmetrical (ie, LSI $\geq 90\%$ or $< 90\%$, respectively) participants across groups and tests. Our results suggest that the pain-free or less painful limb of people with PFP should not be used as a reference standard during clinical or field-based assessments of performance-based measure of function using FSDT and SLHT. Side-to-side symmetries should also be interpreted with caution, as they may overstate the physical performance of people with PFP by not assuming bilateral deficits during FSDT and SLHT. Determining reference values or cutoff points may be helpful to estimate deficits and rehabilitation progresses on performance-based measures of limbs in young adults with both unilateral and bilateral PFP.

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