

# Pain and disability were related to Y-balance test but not with proprioception acuity and single-leg triple-hop test in patients with patellofemoral pain: A cross-sectional study

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## ABSTRACT

**Introduction:** Patellofemoral pain is a common complaint between physically active subjects. Patients with patellofemoral pain present limitations to performing daily activities. Pain could alter proprioceptive acuity and lead to movement impairment. The aim of this study was to investigate the relationship of pain and disability with proprioception acuity and physical performance in patients with patellofemoral pain. **Methods:** Forty-eight patients with patellofemoral pain [age 31.15 (5.91) years; 30 (62.50%) males] were recruited. Data collected included pain intensity, pain duration, disability, joint position sense (JPS) test at 20° and 60° of knee flexion, and physical performance tests (Single-Leg Triple-Hop Test and Y-Balance Test). Spearman's rank correlation coefficient ( $r_s$ ) and 95% confidence intervals (CI) were computed to assess the relationship between the variables. **Results:** Pain intensity was correlated with Y-Balance Test posteromedial component ( $r_s = -0.32$ , 95%CI =  $-0.55$  to  $-0.03$ ,  $p = 0.029$ ) and the composite score ( $r_s = -0.35$ , 95%CI =  $-0.58$ ,  $-0.07$ ,  $p = 0.015$ ). Pain duration was correlated with Y-Balance Test posterolateral component ( $r_s = -0.23$ , 95% CI =  $-0.53$  to  $-0.01$ ,  $p = 0.047$ ). Disability was correlated with Y-Balance Test posteromedial component ( $r_s = 0.41$ , 95% CI =  $0.14$  to  $0.62$ ,  $p = 0.004$ ). Pain and disability were not correlated with JPS and the Single-Leg Triple-Hop Test. **Conclusion:** Pain and disability were related to Y-Balance Test but not to proprioceptive acuity and Single-Leg Triple-Hop Test in patients with patellofemoral pain.

## 1. Introduction

Patellofemoral pain (PFP) is a musculoskeletal disorder that has received considerable attention due to its prevalence. PFP affects approximately 23% of the general population (Smith et al., 2018). Patients with PFP usually present pain in the anterior aspect of the knee during weight-bearing activities (Barton et al., 2021; Crossley et al., 2016). PFP commonly affects physically active people, including adolescents, runners, and militaries (Kakouris et al., 2021; Neal et al., 2019). Likewise, PFP can precede knee osteoarthritis and lead to disability (Crossley et al., 2016; Thomas et al., 2010). Although there is

no consensus about the origin of PFP (Lankhorst; Bierma-Zeinstra; Van Middelkoop, 2012; Neal et al., 2019), identifying factors associated with PFP would benefit clinical practice.

Risk factors for patellofemoral pain have been investigated. These factors are related to biomechanics (dynamic knee valgus and foot pronation), strength (quadriceps and hip abductors) (Neal et al., 2019), anthropometric (sex, and body mass index), and proprioception (Lankhorst; Bierma-Zeinstra; Van Middelkoop, 2013). Proprioception is the body's capacity to detect joint movement and position through information from muscles and joint mechanoreceptors (Gandevia; Refshauge; Collins, 2002). Because maltracking and damage of the

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patellofemoral joint could be presented in PFP, knee proprioception has been investigated in patients with PFP (Guney et al., 2016; Naseri; Pourkazemi, 2012). Even though pain may play a role in knee proprioception, it is unknown whether pain is related to proprioception and physical performance in patients with PFP.

Although there is a rationale for impaired proprioception in patients with PFP, the current literature is controversial. Conflicting results were found when proprioception between patients and healthy subjects was investigated (Baker et al., 2002; Coelho et al., 2021; Rhode et al., 2021; Yosmaoglu et al., 2013). Although proprioception is assessed through weight-bearing and non-weight-bearing tests, these tests usually do not represent functional movements (Guney et al., 2016). Moreover, higher pain intensity was reported during jumping, landing, and lunge tasks (Herrington, 2014; Nunes; Barton; Viadanna Serrão, 2019). Conversely, there was no difference in pain intensity during a dynamic balance test between patients with patellofemoral pain and asymptomatic controls (Aminaka; Gribble, 2008; Goto; Aminaka; Gribble, 2018). Investigating whether pain is related to proprioception and physical performance tests could elucidate this issue.

Despite pain and functional limitation being markedly aspects of PFP, it is unclear if different pain levels and functional limitations are related to proprioception and functional limitation. Therefore, the current study aimed to analyse the relationship of pain and disability with proprioception acuity and physical performance in patients with PFP. We hypothesised that higher levels of pain intensity and disability would be related to diminished proprioception acuity and physical performance in patients with PFP.

## 2. Methods

### 2.1. Design

This is a cross-sectional study conducted and reported following the consensus from the International Patellofemoral Research Network to improve the REPORTing of quantitative PatelloFemoral Pain studies (Barton et al., 2021) and the requirements of Strengthening the Reporting of Observational Studies in Epidemiology (STROBE). We used data from a previous study by our group (Coelho et al., 2021), which was approved by an Institutional Review Board (CAAE: 65274017.3.0000.5256). Patients' informed consent was obtained. In brief, the previous study was a matched case-control study designed to compare the proprioceptive function of the knee and two physical performance tests between patients with PFP and controls matched for several characteristics, including physical activity level. The sample size of 96 patients was calculated, counting 48 patients with PFP.

### 2.2. Study participants

Patients from a Physical Functional Rehabilitation Service were recruited. The inclusion criteria for patients with PFP were: (1) age between 18 and 45 years old; (2) unilateral knee pain with pain intensity between 3 and 9 on the numerical pain rating scale; (3) insidious onset of pain symptoms; (4) retropatellar or peripatellar pain during at least two of the following functional activities: stair ambulation, running, riding, kneeling, squatting, isometric contracting of the quadriceps and palpation of the medial and/or lateral patellar facet. Exclusion criteria were: (1) lower limb surgery within six months before the study; (2) presence of low back pain or any lower limb injury; (3) concurrent psychological or psychiatric treatment; (4) previous patellar dislocation; or (5) pregnancy. (6) bilateral knee pain (7) chronic musculoskeletal disorders (i.e., fibromyalgia, rheumatoid arthritis, widespread chronic pain) due to the possible presence of the central sensitization mechanism (Woolf, 2011). The period of recruitment was between April and August 2017.

### 2.3. Procedures

Demographic characteristics (age and sex), health status data (weight, height, exercise level, and previous treatment), pain characteristics (pain duration and severity), and physical examination information were obtained by a questionnaire. Pain intensity and knee disability due to PFP were acquired through the numerical pain rating scale and Kujala Scoring Questionnaire, respectively. The exercise level was calculated as the product of the duration and frequency of moderate-intensity aerobic exercise (in minutes per week). An examiner carried out the proprioceptive assessment with an isokinetic dynamometer, and another examiner conducted the physical performance tests (single-leg triple-hop test and Y-Balance Test). The physical performance tests were carried out bilaterally, but only the affected side of the patients with PFP was used for the current analysis. The patients took 5 min of rest between the tests. The whole procedure was performed on the same day. All examiners had at least 12 years of clinical experience in knee rehabilitation.

### 2.4. Knee proprioception assessment

Proprioception was assessed by joint position sense (JPS) with an isokinetic dynamometer (Biodex 4 Multi-joint System Pro, 850–000; New York, USA) during active knee extension. To eliminate visual and auditory input, patients wore a mask and headphones. Ninety degrees of knee flexion was the start position, and the target positions were 20° and 60° of knee extension (Guney et al., 2016).

First, the patients had their knees passively moved to the target positions as a reference. Five trials were completed by each participant for each target position, followed by 1-min rest intervals. Values from the last three attempts were averaged to determine the absolute angular accuracy. The absolute difference between the target and the participant's final positions was used to calculate the absolute error.

### 2.5. Single-leg triple-hop test

Before the physical performance test assessment, the patients made a 3-min general warm-up on a stationary bike. Patients stood on their affected limbs with the toes positioned at the initial point. The final score was the distance from the initial point to where the patients touched the ground after completing three consecutive forward hops. The patients were instructed to stand on one foot and hop as far as possible. Upper limb swing was allowed, and individuals had three trials before testing. The test was repeated if the contralateral limb touched the floor or extra hops were observed. Patients wore self-selected footwear and received no verbal stimuli during the test. Maximum distance was recorded, and the relative distance was calculated using the following equation: (maximum reached distance/leg length \* 3) \* 100. This test showed an excellent intra-rater reliability [ICC2,2: 0.96 (95% CI: 0.95 to 0.98)]. A detailed description of the procedures was reported previously (Coelho et al., 2021).

### 2.6. Y-balance test

The Y-Balance Test measures the lower extremity dynamic balance. During the test, patients stood on the affected lower limb and were asked to reach three directions (anterior, posterolateral, and posteromedial) with the non-stance foot. (Powden; Dodds; Gabriel, 2019). Patients kept their hands on their hips and pushed a board using the nonstance foot. The test was repeated if the participant touched the floor before returning to the starting position, moved the support foot, or kicked the indicator plate forward (Bulow et al., 2019). The patients executed the test in the following order: anterior, posteromedial, and posterolateral. The maximum distance was recorded in centimetres and normalized using the participant's leg length, the distance from the anterior superior iliac spine (ASIS) to the medial malleolus (Bulow et al., 2019). We

calculated the relative score (maximum reached distance/limb length \* 100) and the composite score (sum of the three reach directions/three times the limb length \* 100). Excellent intra-rater reliability was reported for the Y-Balance Test (Powden; Dodds; Gabriel, 2019).

2.7. Statistical analysis

Double entry techniques (entering the same data in two separate spreadsheets) were adopted to avoid data insert errors. Patients' characteristics were presented as means (standard deviations) for continuous variables with normal distribution, median (interquartile range) for non-normal distribution and absolute (percentages) for categorical variables. The Shapiro-Wilk test verified the data distribution for each outcome variable (pain, proprioceptive acuity, physical performance tests). Since most of the data were not normally distributed, Spearman's rank correlation coefficient ( $\rho$ ) and 95% confidence intervals (CI) were computed to assess the relationship between the variables. The correlation coefficient was classified as weak (below 0.3), moderate (between 0.3 and 0.7), and strong (above 0.7) (Hinkle; Wiersma; Jurs, 2003). The significance level was set at 0.05. The data were analysed using JASP software (version 0.16, Netherlands).

3. Results

The first screening selected eighty-three patients with PFP, and thirty-five were excluded for having bilateral knee pain, previous knee injury or surgery (Fig. 1). The procedures were completed without adverse events.

Patients included had a mean of 31.15 (5.91) years old, 30 (62.50%) were male, body mass index of 25.26 (3.56) kg/m<sup>2</sup>, and a mean exercise level of 310.42 (255.89) minutes per week. Patients showed a median pain intensity of 3.50 (3.00–4.00) at the initial screening and a median pain duration of 24.00 (8.00–48.00) months. The mean self-reported disability was 76.08% (9.18).

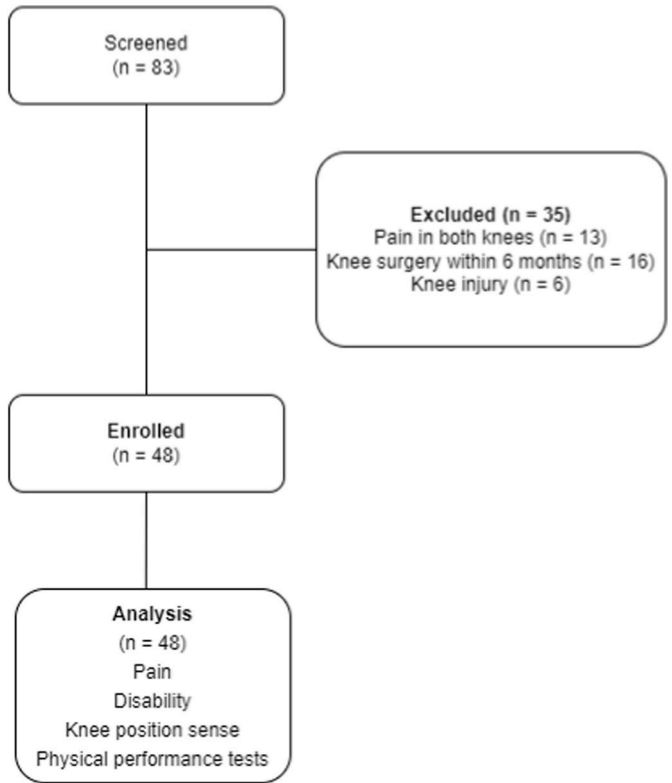


Fig. 1. Flowchart of the study procedure.

The median absolute error of the knee proprioception acuity at 60° and 20° were 4.70 (2.60–7.65) degrees and 3.90 (1.35–5.50) degrees, respectively. The mean relative distance reached on the single-leg triple hop test was 156.49% (33.83). The median distance reached on component anterior, posteromedial, and posterolateral, and the composite score of the Y-Balance Test were 59.20% (54.22–63.85), 95.62% (90.27–101.11), 99.71% (92.98–105.76) and 84.42% (80.30–89.18), respectively.

Pain intensity at the screening was correlated with Y-Balance Test posteromedial component ( $r_s = -0.32$ , 95% CI =  $-0.55$  to  $-0.03$ ,  $p = 0.029$ ) and the composite score ( $r_s = -0.35$ , 95% CI =  $-0.58$ ,  $-0.07$ ,  $p = 0.015$ ). Pain duration was correlated with Y-Balance Test posterolateral component ( $r_s = -0.23$ , 95% CI =  $-0.53$  to  $-0.01$ ,  $p = 0.047$ ). Disability was correlated with Y-Balance Test posteromedial component ( $r_s = 0.41$ , 95% CI =  $0.14$  to  $0.62$ ,  $p = 0.004$ ). Pain and disability were not correlated with the anterior component of the Y-Balance Test. Pain was not correlated with proprioceptive acuity and the Single-Leg Triple-Hop Test. Self-reported disability was not significantly correlated with proprioceptive acuity and Single-Leg Triple-Hop Test. The correlation coefficients with a 95% confidence interval are presented in Table 1.

4. Discussion

This study investigated the relationship between self-reported pain and knee disability with proprioceptive acuity and lower limb physical performance in patients with PFP. Pain and knee disability were correlated with dynamic balance. On the other hand, pain characteristics and knee disability were not correlated with proprioceptive acuity and the Single-Leg Triple-Hop Test. Our findings suggest that higher pain intensity and greater knee disability are associated with poor dynamic balance in patients with PFP.

This is the first study that investigated the association of pain and disability with proprioception (measured using an isokinetic dynamometer). Patients were assessed through standard physical performance tests to ensure they reproduced daily activities. On the other hand, our findings must be considered with caution since only military personnel were included. Moreover, physically active patients with PFP were included. It seems a physical activity routine could improve proprioceptive acuity (Venancio et al., 2016). This study cohort may not represent people with PFP since most of the patients were men, and PFP is more prevalent in women (Glaviano et al., 2015). Moreover, as a

Table 1  
Correlation coefficients between pain and function, joint position sense and physical performance tests.

|                  | Pain intensity at the screening<br>$r_s(95\%CI)$ | Pain duration (months)<br>$r_s(95\%CI)$ | Kujala score<br>$r_s(95\%CI)$ |
|------------------|--------------------------------------------------|-----------------------------------------|-------------------------------|
| JPS              |                                                  |                                         |                               |
| 20° target angle | $-0.26 (-0.51, 0.03)$                            | $0.12 (-0.17, 0.39)$                    | $-0.10 (-0.37, 0.20)$         |
| 60° target angle | $0.07 (-0.22, 0.35)$                             | $0.03 (-0.26, 0.31)$                    | $0.14 (-0.15, 0.41)$          |
| SLTHT (m)        | $0.05 (-0.24, 0.33)$                             | $0.11 (-0.19, 0.38)$                    | $0.19 (-0.10, 0.45)$          |
| Y-BT (%)         |                                                  |                                         |                               |
| Anterior         | $-0.24 (-0.49, 0.05)$                            | $-0.14 (-0.41, 0.15)$                   | $-0.18 (-0.44, 0.11)$         |
| Posterolateral   | $-0.22 (-0.48, 0.07)$                            | $-0.23^* (-0.53, -0.01)$                | $0.22 (-0.07, 0.47)$          |
| Posteromedial    | $-0.32^* (-0.55, -0.03)$                         | $-0.13 (-0.40, 0.16)$                   | $0.41^* (0.14, 0.62)$         |
| Composite score  | $-0.35^* (-0.58, -0.07)$                         | $-0.24 (-0.49, 0.05)$                   | $0.27 (-0.02, 0.51)$          |

Note: Values represented as correlation coefficient and confidence intervals. Abbreviations: CI, confidence intervals. JPS, joint position sense. SLTHT, Single-Leg Triple-Hop Test. m, metres. Y-BT, Y-Balance Test. %, relative distance. \* $p < 0.05$ .

secondary analysis, this sample size could not be satisfactory for reaching significant results.

Pain and disability may affect dynamic balance. Moreover, this finding needs to be interpreted with caution. The significant correlations involved the posteromedial and posterolateral components and the composite score of the Y-Balance Test. Likewise, the anterior component is more meaningful for injury prediction. (Smith; Chimera; Warren, 2015). Our findings suggest pain and disability did not influence the Single-Leg Triple-Hop Test performance. These controversial findings can be explained because physical performance tests assess different constructs (Hamilton et al., 2008; Powden; Dodds; Gabriel, 2019). While the Y-Balance Test mainly involves neuromuscular control and range of motion (Bulow et al., 2019), the Single-Leg Triple-Hop Test assess strength (Reid et al., 2007).

Although the present study's findings suggest a relationship between pain and dynamic balance, pain may not affect physical performance. According to a recent systematic review, there is limited evidence that pain level is higher during functional tasks in patients with patellofemoral pain (Glaviano; Bazett-Jones; Boling, 2022). Similar results were found when different functional tests were included. Pain and self-reported disability were not correlated to the 6-min step test (Zamboti et al., 2021). Since findings in the literature comparing physical performance between patients with patellofemoral pain and controls are conflicting (Coelho et al., 2021; Priore et al., 2019), investigating the influence of pain on physical performance is important for future research.

The lack of association between pain and JPS observed in the present study corroborates the findings of previous studies (Baker et al., 2002; Yosmaoglu et al., 2013). Also, there was no correlation between pain level and JPS during weight-bearing and non-weight-bearing assessments (Baker et al., 2002). On the other hand, one study found a weak correlation between proprioception and self-reported disability (Yosmaoglu et al., 2013). Although it has been advocated that PFP could contribute to proprioception deficit (Guney et al., 2016), we did not observe a link between pain and JPS.

The current study's findings showed that the use of the JPS to evaluate proprioception in patients with PFP did not provide relevant data since it was not related to pain and disability. Other mechanisms could affect movement performance instead of pain and self-reported disability. Clinicians are encouraged to assess lower limb strength due to the remarkable impairment in patients with PFP (Guney et al., 2016; Hazneci et al., 2005). The sample of our study was physically active. Thus, it could influence the functional test performance rather than the presence of pain or decreased JPS. Hence, we suggest that future studies examine the effects of pain on proprioception and physical performance tests in a general population sample.

## 5. Conclusion

Pain and disability were related to the Y-Balance Test but not to proprioceptive acuity and the Single-Leg Triple-Hop Test in patients with PFP.

## Author contributions

Dângelo José de Andrade Alexandre: Software, Methodology, Formal analysis, Conceptualization. Bruno Senos Gomes: Writing – review & editing, Writing – original draft, Visualization, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. Leticia Amaral Corrêa: Writing – review & editing, Writing – original draft, Visualization, Methodology, Formal analysis. Leandro Alberto Calazans Nogueira: Writing – review & editing, Writing – original draft, Visualization, Supervision, Resources, Project administration, Methodology, Formal analysis, Conceptualization. Vanessa Knust Coelho: Writing – review & editing, Writing – original draft, Visualization, Resources, Project administration,

Methodology, Investigation, Formal analysis, Data curation, Conceptualization. Gustavo Telles: Writing – review & editing, Writing – original draft, Visualization, Resources, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization

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## Ethics approval

This study was approved by an Institutional Review Board (CAAE:65274017.3.0000.5256)

## Patient consent statement

Patients' informed consent was obtained.

## Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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