

Original Article

Patellofemoral Pain Syndrome and its Association with Balance and Proprioception: A Cross-Sectional Study

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ABSTRACT

Background: Patellofemoral Pain Syndrome (PFPS) is a prevalent condition characterized by anterior knee pain, significantly affecting individuals' balance and proprioception. Despite its commonality, the relationship between PFPS and these functional impairments remains inadequately explored. Previous studies have suggested a link, but comprehensive analyses incorporating balance, proprioception, and PFPS are scarce.

Objective: This study aimed to investigate the association between PFPS and deficits in balance and proprioception, emphasizing the potential for rehabilitation focused on these areas to improve patient outcomes.

Methods: A cross-sectional study was conducted with 103 participants diagnosed with PFPS, utilizing non-probability convenience sampling at the Out-Patient Department of Physical Therapy, Akbar Medical Complex, Mardan, Pakistan. Participants underwent assessments for balance (using static and dynamic balance tests) and proprioception (via joint position sense testing). Data analysis was performed using SPSS version 22, with chi-square tests to assess statistical associations between PFPS and the measured variables.

Results: Among the participants, 60.2% were males, and 39.8% were females, with an injured limb distribution of 30.1% for both the left and right legs and 39.8% for both legs. The duration of symptoms varied, with 51.5% experiencing symptoms for 1-3 months. Proprioception degree angles showed mean values of 37.5728 (SD=3.76933) for the right limb and 38.4272 (SD=5.81681) for the left limb. Chi-square tests revealed significant impairments in balance and proprioception among individuals with PFPS ($p < 0.05$).

Conclusion: The study confirmed a significant association between PFPS and impairments in balance and proprioception. These findings support the integration of balance and proprioceptive training into rehabilitation programs for PFPS patients, potentially improving symptoms and functional outcomes.

Keywords: Patellofemoral Pain Syndrome, PFPS, balance, proprioception, rehabilitation, joint position sense, static balance, dynamic balance.

INTRODUCTION

Patellofemoral pain syndrome (PFPS) is a prevalent musculoskeletal disorder characterized by pain and discomfort in the anterior aspect of the knee, particularly around the patella, affecting a broad demographic irrespective of age and activity level (1,2). This condition manifests predominantly during activities that involve knee flexion, such as running, squatting, or climbing stairs, leading to symptoms such as stiffness and sensations of grinding or catching within the knee (3,4). The prevalence of PFPS varies, affecting between 22% and 40% of the general population and up to 70% in athletes engaged in running and jumping sports, with a higher incidence reported among females and individuals aged 15-30 years (6,7,8). The economic impact of PFPS, along with other musculoskeletal conditions, is significant, with the United Kingdom and the United States reporting annual costs related to lost productivity and healthcare expenses in the billions (9).

The multifactorial etiology of PFPS involves biomechanical, anatomical, and environmental factors. Biomechanically, the quadriceps angle (Q angle) is a critical determinant, where a higher Q angle can lead to increased lateral tracking of the patella, contributing to PFPS (5). Muscle imbalances, including weakness or tightness in the quadriceps, hamstrings, or hip muscles, also play a role in patellar tracking and PFPS development (5). Anatomically, factors such as patella alta, patellar tilt, and trochlear dysplasia are associated with increased patellar pressure, instability, and altered tracking, respectively, predisposing individuals to PFPS (7). Environmental aspects, including training errors, inadequate footwear, and hard training surfaces, alongside psychosocial factors such as fear-avoidance beliefs and stress, contribute to the risk and persistence of PFPS (10,11).

The diagnostic process for PFPS primarily involves a clinical examination focused on identifying tenderness in the patellofemoral joint, assessing patellar alignment and tracking, and evaluating the strength and flexibility of the lower limb musculature (13,14,15). Physical tests, such as the patellar tilt test and McConnell taping technique, alongside imaging modalities like X-rays and MRI scans, aid in diagnosing PFPS by excluding other conditions and providing detailed insights into the knee's soft tissue structures (14,15).

Treatment strategies for PFPS encompass a range of conservative approaches, including physical therapy aimed at reducing pain and restoring knee joint function through exercises to strengthen the surrounding musculature and improve flexibility. In cases where conservative treatment proves ineffective, more invasive interventions, such as corticosteroid injections or surgery, may be considered (16,17). Physical therapy plays a pivotal role, incorporating strengthening and stretching exercises, patellar mobilization, and proprioceptive training to address muscle imbalances and enhance joint stability (18,19,20).

The pathophysiology of PFPS is understood to involve impaired balance and proprioception as intrinsic factors, with studies indicating that individuals with PFPS exhibit significant deficits in these areas compared to healthy controls, especially during dynamic tasks (21,22). The impaired balance and proprioception are hypothesized to result from altered neuromuscular control, decreased muscle strength, or changes in sensory feedback, which are crucial for maintaining stability and control over movements (2,25). The association between PFPS and proprioceptive deficits underscores the importance of incorporating interventions targeting balance and proprioception into the management plan for PFPS, as these can significantly improve outcomes concerning pain, function, and quality of life for affected individuals (23,26,27,28,32).

MATERIAL AND METHODS

The study utilized a cross-sectional design to explore the relationship between patellofemoral pain syndrome (PFPS), balance, and proprioception, conducted at the Out-Patient Department of Physical Therapy, Akbar Medical Complex in Mardan, Pakistan. The sample size, calculated via OpenEpi based on a 7.2% anticipated frequency of PFPS among adolescents, was determined to be 103 participants, ensuring a 95% confidence interval and a 5% margin of error (34).

Selection of participants was achieved through non-probability convenience sampling. Inclusion criteria specified individuals aged 18-35 years, who were physically active without any comorbid conditions such as rheumatoid arthritis, osteoarthritis, or gout. Eligibility extended to both genders with a confirmed diagnosis of PFPS by a senior physiotherapist, based on clinical presentation, history, and physical examination. The diagnosis encompassed individuals experiencing unilateral or bilateral anterior knee pain, categorized as either acute (pain duration less than three months) or chronic (pain duration more than three months) (34). Exclusion criteria ruled out participants with a Body Mass Index (BMI) over 30 kg/m², diagnosed musculoskeletal, neurological dysfunctions, vision or vestibular impairments, recent trauma to the lower limb, spinal deformities, or those who underwent surgery on the lower limb joints in the past three months (35).

Data collection proceeded after obtaining informed consent from participants who met the study criteria and were willing to participate. A senior physiotherapist with extensive experience performed the PFPS diagnosis, relying on a thorough assessment of each participant's clinical signs, history, and physical examination results. Detailed demographic information, including age, weight, height, occupation, activity level, affected limb, and duration of symptoms, was recorded. Balance and proprioception assessments employed static and dynamic balance tests and Continuous Passive Motion (CPM), respectively. The dominant leg was identified by the leg participants used to kick a ball (34,35).

Ethical adherence was paramount, following the Declaration of Helsinki guidelines. Participants were fully briefed on the study's aims, methods, potential risks, and benefits, with confidentiality strictly maintained and data exclusively used for research purposes. Data analysis utilized SPSS version 25, applying statistical tests to assess the association between PFPS and balance and proprioception measures. This analysis aimed to unveil significant correlations, contributing to the targeted intervention strategies for PFPS sufferers and enriching the understanding of the syndrome's effect on balance and proprioception.

RESULTS

In this study, a total of 103 patients suffering from patellofemoral pain syndrome (PFPS) were analyzed, with a gender distribution showing 62 males (60.2%) and 41 females (39.8%), indicating a slightly higher prevalence of PFPS among males in the sample population (Summary Table 1). The injured limb analysis revealed an equal distribution between the left and right legs, each accounting for 30.1% of the cases, whereas a higher proportion, 39.8%, reported pain in both legs, highlighting the bilateral nature of PFPS in a significant portion of the participants (Table 1).

Regarding the duration of symptoms among the participants, the study found that the majority, 53 individuals (51.5%), experienced symptoms for 1-3 months. Meanwhile, 28 participants (27.2%) reported symptoms lasting less than a month, and 22 individuals (21.4%) experienced symptoms for 3-6 months, indicating a wide range of symptom duration among those affected by PFPS (Summary Table 2). The assessment of proprioception degree angles yielded mean values of 37.5728 (with a standard deviation of 3.76933) for the right limb and 38.4272 (with a standard deviation of 5.81681) for the left limb. These results suggest slight variability in proprioception impairment between limbs among individuals with PFPS (Summary Table 2).

Table 1: Participant Demographics and Injured Limb Distribution

Characteristic	Frequency (n=103)	Percent (%)
Gender		
Males	62	60.2
Females	41	39.8
Injured Limb		
Left Leg	31	30.1
Right Leg	31	30.1
Both Legs	41	39.8

Table 2: Duration of Symptoms and Proprioception Degree Angles

Characteristic	Total (n=103)	Mean	Standard Deviation
Duration of Symptoms			
Less than a month	28		
1-3 months	53		
3-6 months	22		
Proprioception Degree Angle			
Right Limb	103	37.5728	3.76933
Left Limb	103	38.4272	5.81681

Table 3: Chi-Square Tests for Balance and Proprioception

Tested Aspect	Pearson Chi-Square	Degrees of Freedom (DF)	Asymptotic Significance (2-sided)
Right Limb Proprioception	111.690	20	0.000
Left Limb Proprioception	149.506	22	0.000
Static Balance (Eyes Open)	186.674	38	0.000
Static Balance (Eyes Closed)	169.176	28	0.000
Dynamic Balance (Right)	194.756	40	0.000
Dynamic Balance (Left)	176.067	30	0.000

The chi-square tests for balance and proprioception revealed significant findings across various assessments. The right limb proprioception showed a Pearson chi-square value of 111.690 with 20 degrees of freedom, and the left limb proprioception had a Pearson chi-square value of 149.506 with 22 degrees of freedom, both yielding an asymptotic significance of .000, indicating strong statistical significance (Summary Table 3). Similarly, static balance assessments with eyes open and eyes closed demonstrated significant disparities, with Pearson chi-square values of 186.674 (38 degrees of freedom) and 169.176 (28 degrees of freedom), respectively, underscoring the considerable impact of PFPS on static balance (Summary Table 3). Dynamic balance tests further confirmed the significant effects of PFPS on balance, with Pearson chi-square values of 194.756 for the right and 176.067 for the left (40 and 30 degrees of freedom, respectively), again showing high statistical significance (Summary Table 3). These results collectively

emphasize the profound association between PFPS and impairments in balance and proprioception, highlighting the importance of incorporating balance and proprioceptive training in the management and rehabilitation of individuals with PFPS.

DISCUSSION

The findings from this study underscore the association between patellofemoral pain syndrome (PFPS) and impairments in balance and joint proprioception, aligning with previous research that highlights similar deficits among individuals with PFPS compared to healthy controls (36). Notably, this study found that factors such as age, sex, body mass index (BMI), and knee range of motion did not significantly influence the relationship between PFPS and proprioception or balance deficits, suggesting that PFPS may independently contribute to postural instability and impaired joint proprioception. These results echo the notion that rehabilitation of PFPS could potentially address patients' postural and proprioceptive challenges, thereby enhancing treatment outcomes.

Consistent with the literature, proprioceptive deficits in individuals with PFPS, particularly assessed through joint position sense (JPS) testing, indicate a marked difference from healthy controls (37). This systematic review, which included twelve studies, found that a majority reported significant JPS deficits in individuals with PFPS. Moreover, the study by Souza et al. (38) identified balance and proprioception as significant predictors of PFPS, accounting for 45% of the variance, further supporting the statistical association between PFPS, balance, and proprioception observed in the present study. These findings suggest that the impaired balance control and diminished proprioceptive acuity in PFPS patients might contribute to maladaptive movement patterns, altered joint loading, and increased stress on the patellofemoral joint, thereby exacerbating pain symptoms.

The clinical relevance of these findings is substantial, highlighting the potential benefits of therapeutic interventions targeting balance and proprioception in managing PFPS. Balance training programs designed to enhance stability and postural control, alongside proprioceptive training aimed at improving joint position sense, have demonstrated efficacy in alleviating pain and improving functional outcomes in PFPS patients (18). Such interventions could be instrumental in restoring normal movement patterns and reducing pain, thereby addressing the underlying impairments associated with PFPS.

Despite these insights, the study's cross-sectional design precludes establishing causality between PFPS and balance or proprioception deficits, warranting further longitudinal research to elucidate the temporal relationship and identify potential risk factors for PFPS development (23). The study's findings are supported by a cross-sectional assessment using the Berg Balance Scale and joint position sense testing, which identified significant impairments in balance and proprioception among individuals with PFPS compared to controls ($p < 0.05$) (39). Additionally, a randomized controlled trial highlighted the efficacy of balance and proprioception training in significantly improving these measures among PFPS patients compared to a control group ($p < 0.01$), lending further credence to the therapeutic potential of targeted interventions (40).

However, it's crucial to acknowledge the study's limitations, including the reliance on a single medical center for patient recruitment, which may affect the generalizability of the findings. The gender imbalance within the participant pool and the relatively small sample size further limit the study's applicability to the broader population. Future research should aim for larger sample sizes, standardized assessment protocols, and a balanced gender distribution to enhance the findings' generalizability.

CONCLUSION

In conclusion, this study contributes to the growing body of evidence indicating a significant association between PFPS and impairments in balance and proprioception. The bidirectional relationship between these factors underscores the importance of incorporating balance and proprioception training into rehabilitation programs for individuals with PFPS. Addressing these deficits may not only improve symptoms associated with PFPS but also reduce the risk of further injury and enhance overall knee function. Future studies with larger sample sizes, detailed objective evaluations, and experimental designs are recommended to further investigate each variable's impact on PFPS and to establish a more comprehensive understanding of the condition's pathophysiology and optimal management strategies.

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