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Publisher of open access books and journals
PJMLS OPEN ACCESS
Print ISSN: 2707-4471. Online ISSN: 2707-448X

Research Article	Pak-Euro Journal of Medical and Life Sciences
DOI: 10.31580/pjmls.v8i1.3424	Copyright © All rights are reserved by Corresponding Author
Vol. 8 No. 1, 2025: pp. 238x-238xvi	
www.readersinsight.net/pjmls	**Revised:** January 01, 2025 **Accepted:** March 13, 2025
Submission: September 09, 2023	**Published Online:** March 31, 2025

EVALUATION OF QUADRICEPS STRENGTH AMONG MIDDLE AGED PATIENTS WITH PATELLOFEMORAL PAIN SYNDROME: A CROSS-SECTIONAL STUDY

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Abstract

Background: *Patellofemoral pain syndrome (PFPS) is a prevalent musculoskeletal disorder marked by anterior knee pain and functional impairment. Although quadriceps weakness is considered a key contributor, evidence regarding its association with clinical factors in middle-aged adults remains limited. This study aimed to assess quadriceps muscle strength in individuals with PFPS and examine its relationship with body mass index (BMI), working hours, and symptom laterality.*

Methods: *A cross-sectional study was conducted involving 303 adults aged 35–60 years with clinically diagnosed PFPS, recruited from a tertiary care outpatient department. Quadriceps strength was evaluated bilaterally using Manual Muscle Testing (MMT). Demographic data, BMI, occupational status, working hours, and the affected limb were recorded. Descriptive statistics and comparative analyses between affected and unaffected limbs were performed.*

Results: *The mean age of participants was 44.67 ± 5.72 years, with females comprising 63.4% of the sample. A majority of participants were overweight or obese (77.2%). Quadriceps strength was significantly reduced in the affected limb (mean MMT 1.97 ± 0.78) compared with the unaffected side (left: 4.21 ± 0.81; right: 4.18 ± 0.74). Symptoms were most commonly observed in the left limb (38.0%), followed by the right (32.3%) and bilateral involvement (29.7%). Higher BMI and longer working hours were significantly associated with decreased quadriceps strength ($p < 0.05$).*

Conclusion: *Middle-aged adults with PFPS demonstrate significant quadriceps strength deficits in the affected limb. Increased BMI and prolonged working hours further contribute to strength reduction, highlighting the importance of individualized rehabilitation programs addressing these modifiable risk factors. Future studies employing objective strength assessment methods are warranted.*

Keywords: *Anterior knee pain, BMI, Manual muscle testing, Middle-aged adults, Occupational factors, Patellofemoral pain syndrome, Quadriceps strength*

INTRODUCTION

Patellofemoral pain syndrome (PFPS) is one of the most prevalent causes of anterior knee pain, affecting physically active individuals as well as the general population across a wide age range. It is characterized by retropatellar or peripatellar pain aggravated by activities that increase patellofemoral joint loading, such as stair climbing, squatting, running, kneeling, and prolonged sitting with flexed knees (1–3). PFPS accounts for up to 25–40% of knee-related consultations in sports and orthopedic clinics, making it a significant clinical and public health issue (4, 5).

The etiology of PFPS is multifactorial, involving biomechanical, muscular, and structural contributors. Among these, quadriceps muscle dysfunction particularly of the vastus medialis obliquus (VMO) has been repeatedly identified as a central mechanism leading to patellar maltracking and increased joint stress (6–9). Quadriceps weakness may reduce patellar stability, alter joint loading patterns, and compromise shock absorption, thereby worsening pain and functional performance (10). Several studies have demonstrated 20–40% deficits in quadriceps strength among individuals with PFPS compared with asymptomatic controls (11–13).

Middle-aged adults may be particularly vulnerable due to age-related muscle changes, occupational demands, and increased prevalence of overweight or obesity factors known to influence lower-limb biomechanics and joint loading (14, 15). Higher BMI is associated with increased patellofemoral joint reaction forces, leading to exacerbation of symptoms and reduced quadriceps performance (16, 17). Similarly, prolonged working hours, especially in occupations requiring standing, stair climbing, or repetitive lower-limb loading, may aggravate pain and contribute to muscle fatigue, yet evidence on occupational influences remains limited (18).

Although numerous studies have examined PFPS in athletes and young adults, fewer investigations have explored quadriceps strength deficits specifically among middle-aged populations. Understanding these relationships is essential because this demographic often presents with long-standing symptoms, reduced physical activity levels, and co-morbidities that may alter rehabilitation outcomes. Furthermore, many existing studies rely on isokinetic dynamometry, while routine clinical environments commonly use Manual Muscle Testing (MMT). Evaluating quadriceps strength using widely accessible clinical tools is therefore important for real-world applicability.

This study aimed to evaluate quadriceps strength in middle-aged individuals diagnosed with PFPS, to compare strength between affected and unaffected limbs and to determine associations between quadriceps strength, BMI, working hours, and symptomatic laterality. Identifying these factors can help guide individualized rehabilitation programs and highlight modifiable contributors to PFPS severity.

MATERIALS AND METHODS

STUDY DESIGN

A cross-sectional observational study was conducted to evaluate quadriceps muscle strength and associated clinical factors among middle-aged adults diagnosed with patellofemoral pain syndrome (PFPS). The study was carried out over a four-month period in the outpatient physiotherapy and orthopedic departments of Aziz Bhatti Teaching Hospital, Gujrat. Ethical approval was obtained from the Research Ethical Committee of the University of Lahore, Gujrat Campus, and written informed consent was secured from all participants prior to data collection.

A total of 303 participants aged 35–60 years with a clinical diagnosis of PFPS confirmed by an orthopedic consultant or physiotherapist were recruited using a non-probability convenience sampling technique. Participants reported anterior or peripatellar knee pain during activities such as stair climbing, squatting, or prolonged sitting. Individuals were excluded if they were younger than 35 or older than 60 years, had a history of patellar dislocation or subluxation, sustained a lower-limb fracture or underwent lower-extremity surgery within the preceding three months, or had neurological or other conditions affecting muscle strength independent of PFPS. These criteria ensured that observed strength deficits were primarily attributable to PFPS.

The sample size was calculated using the standard formula for prevalence studies:

$$n=\frac{Z^2P(1-P)}{d2}$$

where Z was set at 1.96, P represented assumed prevalence, and d denoted the margin of error. The final sample size met STROBE recommendations for observational studies.

Demographic and clinical data including age, gender, body mass index (BMI), occupation, daily working hours (<3 hours, 3–6 hours, >6 hours), and laterality of PFPS (right, left, or bilateral) were recorded. BMI was categorized as healthy (18.5–24.9 kg/m²), overweight (25.0–29.9 kg/m²), or obese (≥30 kg/m²).

Quadriceps muscle strength was assessed bilaterally using Manual Muscle Testing (MMT) following standardized procedures. Participants were seated with knees flexed to 90°, and resistance was applied at the distal tibia during active knee extension. Muscle strength was graded on a 0–5 MMT scale, where 0 indicated no contraction and 5 represented normal strength. Both affected and unaffected limbs were evaluated to allow intra-individual comparison.

DATA ANALYSIS

Data were analyzed using descriptive statistics, including mean ± standard deviation for continuous variables and frequencies and percentages for categorical variables. Comparisons of quadriceps strength between affected and unaffected limbs were performed using appropriate paired statistical tests. Associations between quadriceps strength, BMI, working hours, and symptom laterality were analyzed, with statistical significance set at $p < 0.05$. Participant confidentiality and data anonymity were strictly maintained throughout the study.

RESULTS AND DISCUSSION

PARTICIPANT CHARACTERISTICS

A total of 303 middle-aged adults with clinically diagnosed PFPS were included. The mean age was 44.67 ± 5.72 years, with females representing 63.4% (n = 192) of the sample. Most participants fell within the overweight or obese BMI categories, and over half reported working **3**–6 hours daily (Table I)**.**

Table I. Demographic and clinical characteristics of participants (n = 303**)**

Variable	Mean ± SD / Frequency (%)
Age (years)	44.67 ± 5.72
Gender	Female: 192 (63.4%)
	Male: 111 (36.6%)
BMI Category	Healthy: 69 (22.8%)
	Overweight: 183 (60.4%)
	Obese: 51 (16.8%)
Occupation	Housewife: 121 (39.9%)
	Health worker: 12 (4.0%)
	Laborer: 24 (7.9%)
	Teacher: 15 (5.0%)
	Salesperson: 7 (2.3%)
	Others: 124 (40.9%)
Working Hours	<3 hours: 81 (26.7%)
	3–6 hours: 164 (54.1%)
	>6 hours: 58 (19.1%)

DISTRIBUTION OF SYMPTOMATIC LIMB

PFPS involvement was slightly more prevalent in the left leg, followed by the right and bilateral involvement (Table II).

Table II. Symptomatic limb distribution

Symptomatic side	Frequency (%)
Right	98 (32.3%)
Left	115 (38.0%)
Bilateral	90 (29.7%)

QUADRICEPS STRENGTH ASSESSMENT

Quadriceps strength determined through Manual Muscle Testing (MMT) demonstrated clear deficits in the affected limb compared to the unaffected side. The mean MMT score for the affected limb was 1.97 ± 0.78, while the unaffected limbs demonstrated substantially higher strength on both sides (Table III).

Table III. Quadriceps strength (MMT scores)

Variable	Mean ± SD
Affected Limb (PFPS)	**1.97 ± 0.78**
Unaffected Left Quadriceps	4.21 ± 0.81
Unaffected Right Quadriceps	4.18 ± 0.74

MANUAL MUSCLE TESTING FREQUENCY DISTRIBUTION

Most participants demonstrated normal to good quadriceps strength in the unaffected limbs, while the affected limb commonly scored in the fair to poor range.

Table IV presents the Manual Muscle Testing (MMT) grades for the left, unaffected quadriceps. Most participants demonstrated normal (42.2%) or good strength (38.6%), indicating preserved muscle performance on the non-symptomatic side. Only a small proportion showed fair strength (18.5%), and none was reported in 0.7% of cases, reflecting minimal true weakness in this limb.

Table IV. MMT strength grades: Left quadriceps (Unaffected)

MMT Grade	Frequency (%)
None	2 (0.7%)
Fair	56 (18.5%)
Good	117 (38.6%)
Normal	128 (42.2%)

Table V shows the MMT distribution for the right, unaffected quadriceps. Similar to the left side, the majority of participants recorded good (41.6%) or normal strength (38.3%), confirming intact quadriceps function in the non-affected limb. A smaller proportion (20.1%) demonstrated fair strength, with no participants falling into poor or absent strength categories.

Table V. MMT strength grades : Right quadriceps (Unaffected)

MMT Grade	Frequency (%)
Fair	61 (20.1%)
Good	126 (41.6%)
Normal	116 (38.3%)

KEY STATISTICAL FINDINGS

Participants with patellofemoral pain syndrome demonstrated a statistically significant reduction in quadriceps strength in the affected limb compared with the unaffected limb ($p < 0.05$). A progressive decline in muscle strength was observed with increasing body mass index, with overweight and obese individuals exhibiting lower quadriceps strength than those with a healthy BMI. Additionally, participants working more than six hours per day showed significantly reduced quadriceps strength compared with those working fewer hours ($p < 0.05$). In cases of bilateral PFPS, a moderate yet consistent reduction in quadriceps strength was noted across both limbs, indicating widespread functional impairment associated with the condition.

DISCUSSION

This study investigated quadriceps muscle strength deficits and associated clinical factors among middle-aged adults with patellofemoral pain syndrome (PFPS). The findings clearly demonstrate a substantial reduction in quadriceps strength in the affected limb compared with the unaffected side, supporting existing evidence that quadriceps weakness is a fundamental component of PFPS pathophysiology (1–3). The markedly low mean MMT score of the affected limb (1.97 ± 0.78) reflects clinically significant functional impairment, which likely contributes to pain persistence, altered movement patterns, and reduced tolerance to daily weight-bearing activities.

Quadriceps dysfunction particularly diminished activation of the vastus medialis obliquus (VMO) has been widely implicated in impaired patellar tracking and increased lateral patellofemoral joint stress (4–6). Biomechanical studies have reported quadriceps strength deficits ranging from 20% to 40% in individuals with PFPS compared with healthy controls (7–9), a magnitude consistent with the impairment observed in the present study. Reduced quadriceps strength also compromises shock absorption during functional movements such as stair climbing and squatting, thereby increasing joint loading and perpetuating a cycle of pain, avoidance, and muscular deconditioning (10).

Importantly, the observed unilateral strength deficits suggest that quadriceps weakness in PFPS is not merely a consequence of generalized deconditioning but is closely linked to the symptomatic limb. Previous investigations have documented significant side-to-side differences in quadriceps muscle volume, strength, and neuromuscular activation in PFPS populations (11, 12). These findings underscore the

importance of incorporating unilateral strengthening, neuromuscular control exercises, and targeted VMO activation strategies into rehabilitation programs.

A key finding of this study was the strong association between elevated body mass index (BMI) and reduced quadriceps strength. More than three-quarters of participants were classified as overweight or obese, and increasing BMI was consistently associated with poorer muscle performance. Elevated body mass has been shown to increase patellofemoral joint reaction forces, thereby exacerbating compressive stress and contributing to pain and functional limitation (13–15). Additionally, obesity is linked to compromised muscle quality, including greater intramuscular fat infiltration and reduced contractile efficiency, which may further impair strength generation (16–18).

Previous research has proposed an inverted U-shaped relationship between BMI and quadriceps strength, wherein optimal muscle force is observed at moderate BMI levels, while both underweight and overweight individuals demonstrate reduced strength (19). The present findings align with this concept and highlight BMI as a modifiable risk factor that should be addressed alongside strengthening interventions in PFPS management.

The study also identified a relationship between occupational workload and quadriceps strength, with longer daily working hours associated with diminished muscle performance. Although limited literature exists on occupational factors in PFPS, prolonged standing, repetitive squatting, kneeling, and frequent stair use have been recognized as contributors to anterior knee pain in occupational settings (20–22). Extended working hours may promote cumulative quadriceps fatigue, reduced neuromuscular efficiency, and sustained patellofemoral joint loading, potentially aggravating symptoms and impairing recovery.

These findings emphasize the importance of considering occupational demands during clinical assessment and rehabilitation planning. Individualized strengthening protocols, ergonomic modifications, task-specific education, and scheduled rest periods may help minimize muscle fatigue and reduce symptom exacerbation in working populations.

Overall, the results highlight the need for comprehensive, multifactorial rehabilitation strategies for PFPS, including:

- Targeted quadriceps strengthening with emphasis on the affected limb
- VMO activation and neuromuscular retraining
- Weight management and BMI optimization
- Activity modification and occupational adjustments

Recent consensus statements advocate multimodal rehabilitation approaches combining strengthening, movement retraining, orthotic support, and patient education to optimize outcomes in PFPS (23–25). The present study adds to this evidence base by reinforcing the importance of integrating strength-focused and lifestyle-related interventions, particularly in middle-aged adults.

While PFPS research has traditionally focused on adolescents and young athletes, the current findings highlight comparable impairments in middle-aged adults—an understudied population despite the high likelihood of symptom chronicity. Prior studies have demonstrated that PFPS is often not self-limiting and may persist for years in the absence of targeted intervention (26). The pronounced quadriceps deficits observed in this study suggest that chronic PFPS in middle-aged individuals may lead to long-term muscular deconditioning and functional decline if left unaddressed.

CONCLUSION

Middle-aged adults with PFPS show clear quadriceps strength deficits in the affected limb, confirming muscle weakness as a key contributor to patellofemoral dysfunction. Higher BMI and longer working hours further reduce strength, indicating meaningful lifestyle influences. Targeted rehabilitation focusing on unilateral strengthening, neuromuscular control, and weight management is essential. Early intervention may prevent chronic functional decline. Future longitudinal studies with objective strength measurements are recommended.

Limitations:

This study has several limitations that should be considered when interpreting the findings:

1. While clinically practical, MMT is less sensitive than objective biomechanical tools such as handheld dynamometry or isokinetic dynamometers. This may have limited the precision of strength measurement.
2. Causal relationships cannot be established between quadriceps strength, BMI, working hours, and PFPS severity. Longitudinal studies are required to determine temporality.
3. Participants were recruited from a single hospital setting, which may limit generalizability to broader populations.
4. Although necessary to isolate PFPS, excluding individuals with other knee conditions limits understanding of strength patterns across related disorders.
5. Incorporating validated tools such as the Kujala Score or Visual Analog Scale (VAS) could strengthen associations between strength deficits and functional disability.
6. Findings cannot be applied to younger athletic populations or older adults with degenerative knee conditions.

Authors' contribution:

HA conceived the study & performed experiments; RK supervised the overall project; AA assisted in data collection; SI analyzed the data

References:

1. Witvrouw E, Werner S, Mikkelsen C, Van Tiggelen D, Vanden Berghe L, Cerulli G. Clinical classification of patellofemoral pain syndrome: guidelines for non-operative treatment. Knee Surg Sports Traumatol Arthrosc. 2005;13:122–30.
2. Foss KDB, Myer GD, Chen SS, Hewett TE. Expected prevalence from the differential diagnosis of anterior knee pain in adolescent female athletes during preparticipation screening. J Athl Train. 2012;47(5):519–24.
3. Pereira PM, Baptista JS, Conceição F, Duarte J, Ferraz J, Costa JT. Patellofemoral pain syndrome risk associated with squats: a systematic review. Int J Environ Res Public Health. 2022;19(15):9241.
4. Guney H, Yuksel I, Kaya D, Doral MN. Relationship between quadriceps strength, joint position sense, functional outcomes and painful activities in PFPS. Knee Surg Sports Traumatol Arthrosc. 2016;24:2966–72.
5. Kaya D, Citaker S, Kerimoglu U, et al. Women with PFPS have quadriceps femoris volume and strength deficiency. Knee Surg Sports Traumatol Arthrosc. 2011;19:242–7.
6. Scafoglieri A, Van den Broeck J, Willems S, et al. Local exercise therapy vs spinal manual therapy in PFPS: RCT with medium-term follow-up. BMC Musculoskelet Disord. 2021;22:1–9.
7. Collins NJ, Barton CJ, van Middelkoop M, et al. 2018 Consensus statement on exercise therapy & physical interventions for PFPS. Br J Sports Med. 2018;52(18):1170–8.
8. Crossley KM, Callaghan MJ, van Linschoten R. Patellofemoral pain. Br J Sports Med. 2016;50(4):247–50.
9. Rixe JA, Glick JE, Brady J, Olympia RP. A review of PFPS management. Physician Sportsmed. 2013;41(3):19–28.
10. Rathleff MS, Rathleff CR, Olesen JL, Rasmussen S, Roos EM. Is adolescent knee pain self-limiting? Am J Sports Med. 2016;44(5):1165–71.
11. BaHammam AS, Al-Rajeh MS, Al-Ibrahim FS, Arafah MA, Sharif MM. Prevalence of symptoms and risk of sleep apnea in middle-aged women. Saudi Med J. 2009;30(12):1572–6.
12. Kaya D, Güney H, Akseki D, Doral MN. Strengthening quadriceps in PFPS: mechanisms & strategies. In: Sports Injuries: Prevention, Diagnosis, Treatment. Springer; 2012.
13. Khayambashi K, Fallah A, Movahedi A, Bagwell J, Powers C. Hip vs quadriceps strengthening for PFPS: RCT. Arch Phys Med Rehabil. 2014;95(5):900–7.
14. Wada O, Kurita N, Kamitani T, Mizuno K. Leg muscle vs fat mass and quadriceps strength in knee OA. Clin Rheumatol. 2020;39:1655–61.
15. Ueda Y, Matsushita T, Shibata Y, et al. Predictors of quadriceps recovery after ACL reconstruction. Knee Surg Sports Traumatol Arthrosc. 2023;1–9.

16. Neal BS, Lack S, Lankhorst N, Van Middelkoop M, Crossley KM. Risk factors for PFPS: systematic review. Br J Sports Med. 2019;53:270–81.
17. Dolak KL, Silkman C, Fehr J, et al. Hip strengthening vs quadriceps strengthening for PFPS: RCT. J Sport Rehabil. 2011;20(3):296–311.
18. Willy RW, Hoglund LT, Barton CJ, et al. Patellofemoral pain clinical practice guidelines. J Orthop Sports Phys Ther. 2019;49(9):CPG1–95.
19. Callaghan MJ, Selfe J. Patellofemoral pain syndrome: clinical diagnosis and modern management. Man Ther. 2007;12(1):37–45.
20. Petersen W, Ellermann A, Gösele-Koppenburg A, et al. Patellofemoral pain in athletes. Knee Surg Sports Traumatol Arthrosc. 2014;22(10):2264–74.
21. Glaviano NR, Kew M, Hart JM, Saliba S. Association between BMI and PFPS incidence. Clin J Sport Med. 2015;25(3):e1–7.
22. Lankhorst NE, Bierma-Zeinstra SMA, Van Middelkoop M. Factors involved in the progression of PFPS: prospective study. Am J Sports Med. 2016;44(1):234–42.
23. Crossley KM, van Middelkoop M, Callaghan MJ, Collins NJ, Rathleff M, Barton CJ. Patellofemoral pain consensus statement. Sports Med. 2016;46(7):997–1015.
24. Maclachlan LR, Collins NJ, Matthews MLG, et al. Psychological and lifestyle factors in PFPS. J Pain. 2017;18(11):1294–306.
25. Boling M, Padua D, Marshall S, et al. Gender differences in PFPS incidence. J Sports Rehabil. 2010;19(1):57–70.
26. Thomas MJ, Wood L, Selfe J, Peat G. Long-term prognosis of anterior knee pain. Pain. 2010;150(3):571–7.
27. Barton CJ, Lack S, Hemmings S, Tufail S, Morrissey D. The "Best Practice Guide" for PFPS rehabilitation. Br J Sports Med. 2015;49:923–34.
28. Salavati M, Akhbari B, Takamjani IE, et al. Postural control deficits in PFPS. Gait Posture. 2011;34(3):391–6.
29. Diebal AR, Gregory R, Alitz C, Gerber JP. Running modification as PFPS treatment. N Am J Sports Phys Ther. 2011;6(4):192–201.
30. Crossley K, Thomee R, Ireland ML, McConnell J. Patellofemoral pain consensus overview. J Orthop Sports Phys Ther. 2002;32(3):A1–A8.