

Exercise Rehabilitation and Football Shoe Modification For Patellofemoral Pain in Female Soccer Players: A Narrative Review

Mohamed Abdelrahman Mohamed^{1*}, Amel Mohamed Yousef², Dalia Mohamed Kamel^{1,2}

^{1.} Ph.D. Candidate, Department of Women's Health, Faculty of Physical Therapy, Cairo University, Egypt.

^{2.} Professor of Women's Health, Faculty of Physical Therapy, Cairo University & Dean of Faculty of Physical Therapy, Cairo University, Egypt.

^{3.} Dean of the Faculty of Physical Therapy, British University in Egypt, Egypt.

Corresponding author email: Mohamed_elasuoty@hotmail.com

Abstract

Background: Patellofemoral pain syndrome (PFPS) is one of the most prevalent overuse knee disorders among female soccer players and is associated with pain, functional limitations, impaired athletic performance, and reduced participation in sport. Both intrinsic biomechanical deficits and extrinsic factors such as footwear characteristics have been implicated in the development and persistence of PFPS.

Objective: This review critically examines current evidence regarding exercise-based rehabilitation and football shoe modification in the management of PFPS among female soccer players, with particular emphasis on pain reduction, balance performance, and sport-specific functional outcomes.

Methods: A narrative review was developed from the literature synthesized within the thesis framework. Relevant themes included PFPS epidemiology, biomechanical risk factors, rehabilitation interventions, football footwear characteristics, musculoskeletal ultrasound assessment, and performance monitoring. Evidence was critically analyzed to identify major findings, limitations, and future research needs.

Results: Current evidence indicates that increased Q-angle, hip muscle weakness, dynamic knee valgus, quadriceps dysfunction, and impaired neuromuscular control contribute substantially to PFPS development. Exercise programs incorporating hip and knee strengthening, balance training, and movement retraining demonstrate positive effects on pain and function. Footwear characteristics may influence lower-limb biomechanics and injury risk. However, studies evaluating combined exercise rehabilitation and footwear modification remain limited. Furthermore, relatively few investigations have assessed balance performance, and sport-specific outcomes simultaneously.

Conclusion: Exercise rehabilitation remains the cornerstone of PFPS management. The integration of footwear modification with structured rehabilitation may provide additional benefits by addressing both intrinsic and extrinsic contributors to PFPS. Further research is required to establish the effectiveness of combined interventions in female soccer players.

Keywords: Patellofemoral pain syndrome; female soccer players; exercise rehabilitation; footwear modification; musculoskeletal ultrasound; balance performance; sports biomechanics.

1. Introduction

Women's football has experienced substantial growth worldwide over the past two decades, resulting in increased participation, professionalism, and competitive demands. Alongside this expansion, the incidence of musculoskeletal injuries has become an important concern for athletes, coaches, and healthcare professionals. Among these injuries, Patellofemoral Pain Syndrome (PFPS) represents one of the most frequently reported causes of anterior knee pain in female athletes (1).

PFPS is characterized by diffuse retropatellar or peripatellar pain that is aggravated by activities involving repetitive knee loading, including running, jumping, squatting, stair negotiation, and prolonged sitting. The condition is particularly relevant in soccer because the sport requires repeated accelerations, decelerations, cutting maneuvers, kicking actions, and landing tasks that increase patellofemoral joint stress (2).

The etiology of PFPS is multifactorial. Existing evidence suggests that biomechanical factors such as excessive dynamic knee valgus, increased Q-angle, hip abductor weakness, quadriceps dysfunction, and impaired neuromuscular control contribute to altered patellofemoral joint loading. In female athletes, anatomical and hormonal characteristics may further influence injury susceptibility (3).

While exercise-based rehabilitation is widely accepted as the primary treatment approach, increasing attention has been directed toward external biomechanical factors, particularly footwear and lower-limb alignment, thereby affecting both injury risk and athletic performance (4).

Consequently, combining exercise rehabilitation with footwear modification may represent a comprehensive strategy for addressing both intrinsic and extrinsic contributors to PFPS. This review aims to critically evaluate current knowledge regarding PFPS mechanisms, rehabilitation approaches, football footwear influences, and relevant outcome measures in female soccer players (5).

2. Methodology for Literature Selection

This review synthesizes literature presented within the thesis framework and associated background materials. The reviewed evidence encompasses studies related to female football participation, PFPS epidemiology, lower-extremity biomechanics, exercise rehabilitation, musculoskeletal ultrasound assessment, balance evaluation, and performance monitoring.

The literature was analyzed thematically to identify recurring concepts, areas of agreement, conflicting findings, methodological limitations, and potential directions for future research. Given the narrative nature of the review, no formal systematic-review protocol was applied.

3. Patellofemoral Pain Syndrome in Female Soccer Players

PFPS is considered one of the most common overuse conditions affecting physically active populations. The syndrome is often associated with pain during sport participation and activities of daily living, resulting in reduced athletic performance and diminished quality of life (6).

Female athletes appear to experience PFPS at higher rates than males. Several factors have been proposed to explain this observation, including increased Q-angle, altered lower-limb alignment, reduced hip strength, and differences in movement patterns during dynamic activities. In soccer, repetitive high-load movements further increase patellofemoral joint stress and may accelerate symptom development (7).

Beyond pain, PFPS has been associated with deficits in balance, neuromuscular control, muscle activation, and functional performance. These impairments can compromise athletic performance and increase the likelihood of recurrent symptoms (8).

4. Exercise Rehabilitation for PFPS

Exercise therapy remains the cornerstone of conservative PFPS management. The primary objective of rehabilitation is to reduce pain while restoring normal movement patterns, muscular strength, neuromuscular control, and functional performance (9).

4.1 Hip and Knee Strengthening

Weakness of the hip abductors and external rotators has been linked to excessive femoral internal rotation and dynamic knee valgus. Consequently, strengthening programs targeting both proximal and distal musculature are commonly recommended (10).

Quadriceps strengthening, particularly involving the vastus medialis muscle, remains an important component of rehabilitation. Improved quadriceps function may enhance patellar tracking and reduce abnormal joint stress (11).

4.2 Balance and Neuromuscular Training

Balance deficits have been consistently reported among individuals with PFPS. Neuromuscular training interventions seek to improve proprioception, postural control, and movement efficiency. Such adaptations may contribute to pain reduction and improved functional performance (12).

4.3 Functional and Field-Based Rehabilitation

Successful return to sport requires progression beyond clinical exercises toward football-specific activities. Functional rehabilitation typically incorporates running drills, agility exercises, directional changes, and sport-specific movement retraining. These interventions aim to bridge the gap between symptom improvement and performance restoration (13).

5. Football Shoe Modification and PFPS

Football footwear represents an important extrinsic factor influencing lower-limb biomechanics. Modern football shoes have evolved considerably in response to demands for enhanced performance, comfort, and injury prevention (4).

5.1 Clinical Implications

Although evidence directly examining footwear modification in PFPS remains limited, biomechanical principles support its potential role as an adjunct to exercise-based rehabilitation. Future investigations should determine whether individualized footwear strategies improve clinical and functional outcomes.

6. Outcome Measures for Evaluating Intervention Effectiveness

6.1 Pain Assessment

The Visual Analog Scale (VAS) remains one of the most commonly used instruments for quantifying pain intensity and monitoring treatment response (14).

6.2 Balance Assessment

Balance testing provides insight into neuromuscular function, postural stability, and movement control. Improvements in balance may reflect successful rehabilitation outcomes (15).

7. Discussion

The literature strongly supports exercise rehabilitation as an effective intervention for PFPS management. Strengthening, balance training, and functional retraining consistently demonstrate improvements in pain and physical function (16).

In contrast, evidence regarding footwear modification remains comparatively limited. Most available studies focus on general biomechanical effects rather than PFPS-specific outcomes. Furthermore, few investigations have evaluated female soccer players exclusively (5, 17).

The proposed integration of exercise rehabilitation and football shoe modification addresses both intrinsic and extrinsic contributors to PFPS. Such an approach may provide synergistic benefits by simultaneously improving neuromuscular function and optimizing external loading conditions (18).

Nevertheless, substantial methodological limitations remain. Existing studies frequently employ heterogeneous populations, variable intervention protocols, and inconsistent outcome measures, making direct comparisons difficult.

8. Future Directions

Several important gaps remain within the literature:

1. Limited studies focusing exclusively on female soccer players.
2. Lack of research combining exercise rehabilitation and footwear modification.
3. Scarcity of studies incorporating balance assessment and pain quality outcomes simultaneously.
4. Absence of long-term follow-up investigations.

Future randomized controlled trials should evaluate integrated rehabilitation and footwear interventions using multidimensional outcome measures, including pain, patellar tendon morphology and balance performance.

9. Conclusion

Patellofemoral Pain Syndrome remains a prevalent and clinically significant condition among female soccer players. Current evidence supports exercise rehabilitation as the primary management strategy, particularly interventions targeting strength, neuromuscular control, and functional movement quality. Football footwear may also influence lower-limb biomechanics and injury risk, although direct evidence regarding PFPS remains limited. Integrating exercise rehabilitation with footwear modification offers a promising approach for addressing both intrinsic and extrinsic risk factors. Future research should focus on high-quality clinical trials examining the effectiveness of combined interventions and their impact on pain, tendon morphology and balance.

References

1. John, G., AlNadwi, A., Georges Abi Antoun, T., & Ahmetov, I. I. (2025). Injury Prevention Strategies in Female Football Players: Addressing Sex-Specific Risks. *Sports (Basel, Switzerland)*, 13(2), 39. <https://doi.org/10.3390/sports13020039>
2. Halabchi, F., Abolhasani, M., Mirshahi, et al. (2017). Patellofemoral pain in athletes: clinical perspectives. *Open access journal of sports medicine*, 8, 189–203. <https://doi.org/10.2147/OAJSM.S127359>

3. Carvalho, R. A. G. d., Pizzolato, B. B., Souza, G. P. A. d., et al. (2026). The Strengthening of Quadriceps, Abductors, and External Rotator Muscles of the Hip to Alter Axial Alignment of the Lower Limbs in University Students with Patellofemoral Pain Syndrome: A Prospective Cohort Study. *Journal of Functional Morphology and Kinesiology*, 11(2), 225. <https://doi.org/10.3390/jfmk11020225>
4. Demeco, A., Marotta, N., Megna, M., Racinelli, A., Pansera, B., Frizziero, A., Yosypchuk, I., Palermi, S., Vecchiato, M., Lopresti, E., de Sire, A., & Ammendolia, A. (2026). Functional Design and Clinical Implications of Modern Soccer Footwear: A Comprehensive Narrative Review. *Journal of functional morphology and kinesiology*, 11(1), 62. <https://doi.org/10.3390/jfmk11010062>
5. Chen, Z., Wu, J., Wang, X., & Ren, Z. (2022). The effect of foot orthoses for patients with patellofemoral pain syndrome: A systematic review and meta-analysis. *Heliyon*, 8(6), e09656. <https://doi.org/10.1016/j.heliyon.2022.e09656>
6. Powers, C. M., Bolgla, L. A., Callaghan, M. J., Collins, N., & Sheehan, F. T. (2012). Patellofemoral pain: proximal, distal, and local factors—2nd international research retreat, August 31–September 2, 2011, Ghent, Belgium. *Journal of orthopaedic & sports physical therapy*, 42(6), A1-A54. <https://doi.org/10.2519/jospt.2012.0301>
7. Pontoh, L. A., Queiroz, M., Fiolin, J., Hadisoebroto Dilogo, I., Purbasari, U., & Herdman, J. A. (2026). Pelvic width is not associated with patellofemoral alignment in Asian patients with anterior knee pain: A cross-sectional study. *Journal of ISAKOS*. Advance online publication. <https://doi.org/10.1016/j.jisako.2026.101067>
8. Nunes, G. S., Rodrigues, D. Z., Hörbe, L., Prates, I., Tessarin, B. M., Serrão, F. V., & de Noronha, M. (2022). Is Postural Control Affected in People with Patellofemoral Pain and Should it be Part of Rehabilitation? A Systematic Review with Meta-analysis. *Sports medicine - open*, 8(1), 144. <https://doi.org/10.1186/s40798-022-00538-4>
9. Morri, M., Contri, A., Peccerillo, V., Venturini, E., Guerrini, C., Berardo, I., & Ruisi, R. (2025). Conservative treatment of patellofemoral pain: effectiveness of strength exercises compared to other treatments. a systematic review with meta-analysis. *BMC sports science, medicine & rehabilitation*, 17(1), 303. <https://doi.org/10.1186/s13102-025-01297-x>
10. Rabelo, N. D. D. A., & Lucareli, P. R. G. (2018). Do hip muscle weakness and dynamic knee valgus matter for the clinical evaluation and decision-making process in patients with patellofemoral pain?. *Brazilian journal of physical therapy*, 22(2), 105–109. <https://doi.org/10.1016/j.bjpt.2017.10.002>
11. Hosseini, S. H., & Farahmand, F. (2024). Effect of two quadriceps strengthening protocols on morphological characteristics of knee vastus muscles in patients with lateral patellar compression syndrome. *Journal of bodywork and movement therapies*, 40, 726–732. <https://doi.org/10.1016/j.jbmt.2024.05.017>
12. Motealleh, A., Mohamadi, M., Moghadam, M. B., Nejati, N., Arjang, N., & Ebrahimi, N. (2019). Effects of Core Neuromuscular Training on Pain, Balance, and Functional Performance in Women With Patellofemoral Pain Syndrome: A Clinical Trial. *Journal of chiropractic medicine*, 18(1), 9–18. <https://doi.org/10.1016/j.jcm.2018.07.006>
13. Joreitz, R., Fine, J., Eshelman, T., Mock-Grubbs, S., & Witherspoon, Z. (2025). Sport-specific training and return to sport after ACL reconstruction in elite athletes: a narrative review. *Annals of joint*, 10, 36. <https://doi.org/10.21037/aoj-25-27>
14. Delgado, D. A., Lambert, B. S., Boutris, N., McCulloch, P. C., Robbins, A. B., Moreno, M. R., & Harris, J. D. (2018). Validation of Digital Visual Analog Scale Pain Scoring With a Traditional Paper-based Visual Analog Scale in Adults. *Journal of the American Academy of Orthopaedic Surgeons*. Global research & reviews, 2(3), e088. <https://doi.org/10.5435/JAAOSGlobal-D-17-00088>
15. Zech, A., Hübscher, M., Vogt, L., Banzer, W., Hänsel, F., & Pfeifer, K. (2010). Balance training for neuromuscular control and performance enhancement: a systematic review. *Journal of athletic training*, 45(4), 392–403. <https://doi.org/10.4085/1062-6050-45.4.392>
16. Crossley, K. M., van Middelkoop, M., Barton, C. J., & Culvenor, A. G. (2019). Rethinking patellofemoral pain: Prevention, management and long-term consequences. *Best Practice & Research Clinical Rheumatology*, 33(1), 48–65. <https://doi.org/10.1016/j.berh.2019.02.004>
17. Chi, P. W., Paterson, K. L., Hinman, R. S., Wu, W., McNamara, S., Maniar, N., ... & Bryant, A. L. (2026). Effects of modifiable footwear features on anterior cruciate ligament force in young females during a drop-lateral-jump task. *Medicine & Science in Sports & Exercise*, 58(5), 1062-1072. <https://doi.org/10.1249/MSS.0000000000003920>

18. Ashtiani, M. B., Daneshmandi, H., & Raeisi, Z. (2025). Effectiveness of combining a proximal strengthening exercise program and foot orthosis on pain and performance among women with patellofemoral pain syndrome and a pronated foot: study protocol for a randomized clinical trial. *Trials*, 26(1), 81. <https://doi.org/10.1186/s13063-025-08787-w>