International Journal of Community Medicine and Public Health
Alaffari NS et al. Int J Community Med Public Health. 2025 Jan;12(1):560-564
http://www.ijcmph.com
pISSN 2394-6032 | eISSN 2394-6040

DOI: https://dx.doi.org/10.18203/2394-6040.ijcmph20244073

Review Article

Effectiveness of strength training in managing patellofemoral pain syndrome

Naif Salem Alaffari[1]*, Rabie Abdulhakim Shihab[2], Mohammed Abdullah Alshehri[3], Safiyah Saeed Altalidi[4], Ibtihal Atef Kamal[5], Aisha Abdullah Alshahrani[6], Bodour Ali Alshehri[6], Hisham Ahmed Almassaud[7], Ahmed Ibrahim Asiri[8]

[1]Department of Orthopaedics, King Fahad General Hospital, Jeddah, Saudi Arabia
[2]Department of Pediatrics, Aziziyah Children Hospital, Jeddah, Saudi Arabia
[3]Department of Rehabilitation & Physiotherapy, Abha Private Hospital, Abha, Saudi Arabia
[4]College of Applied Medical Sciences, King Khalid University, Bisha, Saudi Arabia
[5]Department of Rehabilitation & Physiotherapy, Batterjee Medical College, Jeddah, Saudi Arabia
[6]Department of Rehabilitation & Physiotherapy, Khamis Mushayt General Hospital, Khamis Mushayt, Saudi Arabia
[7]Department of Internal Medicine, Ministry of Health, Taif, Saudi Arabia
[8]Department of Rehabilitation & Physiotherapy, Aseer central hospital, Abha, Saudi Arabia

Received: 24 December 2024
Accepted: 27 December 2024

***Correspondence:**
Dr. Naif Salem Alaffari,
E-mail: Dr.star111@gmail.com

ABSTRACT

Patellofemoral pain syndrome (PFPS) is a prevalent musculoskeletal condition, often affecting active individuals and linked to biomechanical imbalances, muscle weakness, and poor neuromuscular control. Among various treatment strategies, strength training has emerged as a cornerstone approach for managing pain and improving function. Strengthening exercises targeting the quadriceps, hip abductors, and external rotators directly address the muscle imbalances responsible for patellar maltracking and joint stress. Evidence demonstrates that progressive resistance training not only alleviates symptoms but also enhances neuromuscular coordination and functional stability, particularly during dynamic activities. Comparisons between strength training and alternative therapies such as manual therapy, taping, and electrical stimulation reveal the superior long-term benefits of active interventions. While passive approaches offer temporary relief, strength training achieves sustained improvements by targeting the underlying causes of PFPS. Moreover, integrating strength exercises into regular physical activity routines amplifies the therapeutic effects and promotes overall musculoskeletal health. The long-term sustainability of strength training outcomes is influenced by adherence, patient education, and the inclusion of progressive overload in exercise regimens. Studies indicate that patients who maintain consistent training routines experience fewer recurrences of symptoms and better quality of life. Combining strength training with aerobic activities further enhances overall physical and psychological well-being. The mechanisms by which strength training exerts its benefits include improved muscle strength, joint alignment, and reduced patellofemoral joint stress. These adaptations result in enhanced functional capacity and pain relief, supporting the role of strength training as a durable and effective intervention for PFPS. Through its multifaceted impact, strength training remains a vital component in the conservative management of PFPS, offering long-lasting relief and functional recovery for affected individuals.

Keywords: Patellofemoral pain syndrome, Strength training, Muscle imbalances, Neuromuscular control, Pain management

INTRODUCTION

Patellofemoral pain syndrome (PFPS) is a common musculoskeletal condition characterized by anterior knee pain, often exacerbated by activities such as climbing stairs, squatting, and prolonged sitting. It predominantly affects young and active individuals, with a higher prevalence in females than males. The condition is multifactorial, involving biomechanical, anatomical, and neuromuscular factors that contribute to abnormal patellofemoral joint loading and dysfunction.[1] Despite its prevalence, the management of PFPS poses a significant challenge, as it often requires a tailored approach to address the underlying causes.

One of the primary contributing factors to PFPS is muscle imbalance or weakness, particularly in the quadriceps and hip muscles. Weakness in the hip abductors, external rotators, and extensors can lead to poor control of femoral movement, resulting in increased stress on the patellofemoral joint.[2] Similarly, reduced strength in the quadriceps, especially the vastus medialis oblique, has been associated with altered patellar tracking and increased joint stress. This understanding has underscored the importance of strength training as a core component of PFPS management.

Strength training aims to improve the muscular strength and coordination of the lower extremity, thereby addressing the biomechanical imbalances implicated in PFPS. It encompasses exercises targeting the quadriceps, hamstrings, gluteal muscles, and core stabilizers. Such interventions not only enhance muscle performance but also contribute to improved joint alignment and reduced pain during functional activities.[3] Notably, strength training is often combined with flexibility exercises, taping, and other modalities to achieve optimal outcomes.

Clinical studies have demonstrated the efficacy of strength training in reducing pain and improving function in individuals with PFPS. For instance, programs emphasizing hip and knee strengthening have shown significant improvements in pain scores and functional performance measures. Additionally, these benefits are often sustained in the long term, highlighting the potential of strength training as a durable intervention for PFPS management.[4]

However, variations in training protocols, exercise selection, and patient adherence remain critical factors influencing outcomes. The integration of strength training into PFPS management aligns with a broader trend toward conservative, non-invasive treatment modality for musculoskeletal conditions. As healthcare systems prioritize cost-effective and patient-centered care, understanding the role of strength training in PFPS treatment is essential. This review explores the effectiveness of strength training in managing PFPS, examining its underlying mechanisms, comparative benefits, and long-term outcomes.

LITERATURE REVIEW

Strength training plays a crucial role in managing PFPS by addressing the muscular weaknesses that contribute to patellar maltracking and joint stress. Recent studies have demonstrated the effectiveness of targeted muscle strengthening in reducing symptoms and improving function in PFPS patients. For instance, Fukuda et al**,** conducted a randomized controlled trial where females with PFPS underwent hip abductor and lateral rotator strengthening exercises.[5] The results indicated significant reductions in pain and enhancements in functional performance compared to a control group, highlighting the importance of hip muscle strength in stabilizing the patellofemoral joint.

Similarly, Khayambashi et al, found that isolated strengthening of the hip abductors and external rotators not only alleviated pain but also improved overall hip strength and health status in females with PFPS.[6] This study underscores the necessity of incorporating specific hip-focused exercises into rehabilitation programs. The collective findings from these studies suggest that strength training is effective in addressing the underlying biomechanical issues associated with PFPS. By improving muscle strength and joint stability, strength training offers a non-invasive and sustainable approach to managing PFPS, emphasizing its importance in both clinical practice and patient self-management strategies.

Mechanisms of strength training in alleviating patellofemoral pain

The therapeutic effects of strength training in PFPS are rooted in its ability to improve muscle performance and correct biomechanical imbalances that contribute to pain and dysfunction. Strength training primarily targets the quadriceps, hip abductors, and external rotators, addressing the dynamic factors that influence patellar tracking and joint stress. Several studies highlight how these mechanisms collectively reduce symptoms and enhance functional capacity. A critical factor in PFPS is the weakness of the quadriceps muscle group, particularly the vastus medialis oblique. This imbalance often leads to lateral tracking of the patella and increased compressive forces on the joint.

Hansen et al, explored the role of quadriceps-focused exercises in improving patellar alignment and reducing pain in PFPS patients.[7] Their findings emphasized that eccentric strengthening exercises specifically targeted at the quadriceps significantly improve neuromuscular control, which is vital for stabilizing the knee during dynamic activities. In addition to the quadriceps, hip musculature plays an essential role in maintaining patellofemoral joint stability. Weakness in the hip abductors and external rotators can result in excessive femoral internal rotation and adduction, increasing lateral patellar stress. A study by Ferber et al, demonstrated that hip abductor strengthening reduces excessive femoral

movement and improves gait mechanics in individuals with PFPS.[8] These improvements are particularly important in weight-bearing activities such as walking and running, where optimal alignment minimizes joint stress.

Neuromuscular adaptations are another key mechanism by which strength training alleviates PFPS. Training-induced changes in proprioception and motor control enhance the coordination between the quadriceps and hip muscles. Baldon et al, observed that combining strength training with proprioceptive exercises yields superior outcomes in pain reduction and functional performance.[9] Their work underscores that improvements in muscle strength are complemented by better sensory feedback, allowing for more efficient movement patterns and reduced strain on the patellofemoral joint.

Furthermore, strength training helps address the kinetic chain deficits commonly associated with PFPS. Power stated that interventions targeting multiple muscle groups along the kinetic chain-from the core to the lower extremities-improve the overall biomechanics of the knee.[3] By ensuring that forces are distributed more evenly during movement, such training strategies alleviate the localized stresses contributing to pain. This broader approach reflects the interconnected nature of musculoskeletal function in PFPS.

Comparative outcomes of strength training versus alternative therapies

When considering interventions for managing PFPS, strength training often stands out due to its direct focus on addressing underlying muscular imbalances. However, alternative therapies such as manual therapy, taping, and modalities like electrical stimulation are also commonly utilized. Comparing the outcomes of strength training with these alternatives provides valuable insight into the most effective strategies for managing PFPS.

Strength training has shown consistent efficacy in improving pain and function, particularly when compared to passive treatments. Bagheri et al evaluated patients with PFPS who underwent an 8-week hip and knee strength training program.[10] Their results demonstrated significant improvements in functional capacity and pain reduction compared to a control group receiving only patellar taping. Although taping provided short-term relief, strength training yielded sustained benefits, highlighting its role in addressing the root causes of PFPS.

In contrast, manual therapy aims to improve joint mobility and alleviate discomfort through techniques like soft tissue mobilization and patellar manipulation. A randomized controlled trial by Barton et al, compared manual therapy combined with quadriceps strengthening to strengthening exercises alone.[11] While manual therapy provided an initial boost in pain relief, the long-term outcomes were similar for both groups. This suggests that while manual therapy may serve as a useful adjunct, the core benefits of treatment stem from the strengthening component. Other alternative therapies, such as neuromuscular electrical stimulation (NMES), have been investigated for their potential to improve quadriceps activation. Callaghan et al, examined the effects of NMES on patients with PFPS and found modest improvements in muscle strength and pain.[12] However, these outcomes were less pronounced compared to those achieved through volitional strength training. Additionally, NMES lacked the functional improvements associated with active exercise, which enhances dynamic stability and joint control during daily activities.

Biomechanical retraining has also emerged as a complementary approach, focusing on gait and movement pattern correction. Willy et al, explored the effects of gait retraining on PFPS symptoms in runners and found that it reduced pain and improved running mechanics.[13] However, the intervention required a high degree of compliance and specialized equipment, limiting its applicability in broader clinical settings.

Strength training, on the other hand, offers a more accessible and scalable solution, with benefits extending beyond symptom relief to include overall musculoskeletal health. While alternative therapies can provide valuable adjunctive benefits, strength training remains a cornerstone intervention for PFPS. Its ability to address muscular deficits, enhance neuromuscular control, and promote biomechanical alignment makes it a superior choice for long-term management.

Long-term benefits and sustainability of strength training programs

One of the key considerations in managing PFPS is the sustainability of treatment outcomes over the long term. Strength training has been highlighted not only for its short-term benefits but also for its potential to deliver prolonged symptom relief and functional improvement. These benefits arise from the ongoing adaptations in muscle strength, neuromuscular coordination, and joint stability achieved through consistent exercise.

A notable investigation by Ferber et al, followed patients with PFPS who completed strength training program targeting the hip and knee musculature.[14] The participants maintained significant reductions in pain and improvements in functional scores compared to baseline levels. This durability of benefits was attributed to the participants' ability to integrate strength training into their regular physical activity, suggesting that fostering adherence is essential for long-term success.

Another important factor influencing sustainability is the incorporation of progressive overload in training regimens. Nakagawa et al emphasized that gradual increases in resistance and complexity of exercises ensure

continuous muscular adaptations, which are critical for maintaining knee joint stability over time.[15] Their study demonstrated that patients who adhered to progressively challenging programs experienced superior long-term outcomes compared to those following static or generalized routines. Patient education and engagement also play pivotal roles in sustaining the benefits of strength training. Providing patients with clear guidance on self-management and exercise progression increases adherence and empowers them to continue their routines independently. Patients who are actively involved in setting their training goals and schedules reported higher satisfaction and maintained improved functionality even after the supervised intervention period had ended.

The integration of strength training into broader physical activity habits further enhances its sustainability. Crossley et al, explored the long-term outcomes of combining strength training with general physical activity, such as walking or cycling.[16] They found that participants who engaged in regular aerobic activities alongside targeted strength exercises had better overall musculoskeletal health and fewer recurrences of PFPS symptoms. This dual approach not only supported joint stability but also contributed to cardiovascular and general well-being. The evidence underscores the multifactorial advantages of strength training for PFPS, emphasizing its potential for lasting impact when paired with adherence strategies and complementary physical activities.

CONCLUSION

Strength training offers a comprehensive approach to managing patellofemoral pain syndrome, addressing underlying biomechanical, muscular, and neuromuscular factors. Its long-term benefits are supported by sustained symptom relief, functional improvements, and its adaptability into daily routines. While alternative therapies provide supplementary value, strength training remains the cornerstone intervention due to its effectiveness and scalability. Promoting adherence and integrating complementary activities can further enhance its outcomes.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: Not required

REFERENCES

1. Fulkerson JP, Arendt EA. Anterior knee pain in females. Clinical Orthopaedics and Related Research®. 2000;372:69-73.
2. Bolgla LA, Boling MC. An update for the conservative management of patellofemoral pain syndrome: a systematic review of the literature from 2000 to 2010. Int J Sports Phys Ther. 2011;6(2):112.
3. Powers CM. The influence of altered lower-extremity kinematics on patellofemoral joint dysfunction: a theoretical perspective. J Orthop & Sports Phys Ther. 2003;33(11):639-46.
4. Ferber R, Kendall KD, Farr L. Changes in knee biomechanics after a hip-abductor strengthening protocol for runners with patellofemoral pain syndrome. J Athl Train. 2011;46(2):142-9.
5. Fukuda TY, Rossetto FM, Magalhães E, Bryk FF, Garcia LPR, de Almeida Carvalho NA. Short-term effects of hip abductors and lateral rotators strengthening in females with patellofemoral pain syndrome: a randomized controlled clinical trial. J Orthopaed Sports Phys Ther. 2010;40(11):736-42.
6. Khayambashi K, Mohammadkhani Z, Ghaznavi K, Lyle MA, Powers CM. The effects of isolated hip abductor and external rotator muscle strengthening on pain, health status, and hip strength in females with patellofemoral pain: a randomized controlled trial. J Orthop Sports Phy Ther. 2012;42(1):22-9.
7. Hansen R, Rathleff MS, Brushøj C, Magnusson SP, Henriksen M. Differential Effects of Quadriceps and Hip Muscle Exercises for Patellofemoral Pain: A Secondary Effect Modifier Analysis of a Randomized Trial. J of Orthopaed Sports Phys Ther. 2024;54(11):732-42.
8. Ferber R, Noehren B, Hamill J, Davis I. Competitive female runners with a history of iliotibial band syndrome demonstrate atypical hip and knee kinematics. J Orthopaed Sport Phys Ther. 2010;40(2):52-8.
9. Baldon RDM, Serrão FV, Scattone Silva R, Piva SR. Effects of functional stabilization training on pain, function, and lower extremity biomechanics in women with patellofemoral pain: a randomized clinical trial. J Orthopaed & Sports Phys Ther. 2014;44(4):240-51.
10. Bagheri S, Bayat MR, Halabchi F. The effect of 8-week exercise program on patellofemoral pain syndrome. J Res Rehabil Sci. 2011;7(3):345-9.
11. Barton CJ, Lack S, Hemmings S, Tufail S, Morrissey D. The 'Best Practice Guide to Conservative Management of Patellofemoral Pain': incorporating level 1 evidence with expert clinical reasoning. British J Sports Med. 2015;49(14):923-34.
12. Callaghan MJ, Oldham JA. Electric muscle stimulation of the quadriceps in the treatment of patellofemoral pain. Archives of Phys Med and Rehabil. 2004;85(6):956-62.
13. Willy RW, Davis IS. The effect of a hip strengthening program on mechanics during running and single leg squatting. JOSPT. 2011;41(9)625-63.
14. Ferber R, Bolgla L, Earl-Boehm JE, Emery C, Hamstra-Wright K. Strengthening of the hip and core versus knee muscles for the treatment of patellofemoral pain: a multicenter randomized controlled trial. J Athl Train. 2015;50(4):366-77.
15. Nakagawa TH, Muniz TB, Baldon RdM, Dias Maciel C, de Menezes Reiff RB, Serrão FV. The effect of additional strengthening of hip abductor and lateral rotator muscles in patellofemoral pain

syndrome: a randomized controlled pilot study. Clinical Rehab. 2008;22(12):1051-60.
16. Crossley KM, Middelkoop M, Barton CJ, Culvenor AG. Rethinking patellofemoral pain: prevention, management and long-term consequences. Best Practice & Res Clin Rheumatol. 2019;33(1):48-65.

Cite this article as: Alaffari NS, Shihab RA, Alshehri MA, Altalidi SS, Kamal IA, Alshahrani AA, et al. Effectiveness of strength training in managing patellofemoral pain syndrome. Int J Community Med Public Health 2025;12:560-4.