



# Development of Progressive Lower-Limb Strengthening Program for Patellar Tendinopathy in Long Jump Athletes: A Pilot Study

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## ABSTRACT

Patellar tendinopathy is a common load-related condition among jumping athletes and may substantially affect training participation and performance. This study aimed to develop an integrated lower-limb strengthening exercise model and preliminarily evaluate its feasibility and changes in pain intensity among long jump athletes with patellar tendinopathy. The development process consisted of problem analysis, data collection, exercise design, design validation, revisions, expert validation, and small-scale pilot implementation. The initial trial was conducted on five long jump athletes using a pilot study. Pain levels were measured using the Visual Analog Scale (VAS) before and after the implementation of the exercise program. The development results produced four exercise models, including single-leg eccentric squat, control exercises, single-leg standing balance exercises, and tiptoe standing exercises. Mean of VAS scores decreased from  $7.20 \pm 0.84$  to  $3.00 \pm 0.71$ , corresponding to a mean reduction of  $4.20 \pm 1.30$  points ( $57.50 \pm 12.29\%$ ). The findings indicate that a progressive leg muscle strengthening program can help reduce pain associated with patellar tendinitis. Isometric contractions, low-load dynamic movements, and functional training may improve the strength of the quadriceps, hamstrings, and supporting knee muscles. The developed exercise model can support athletes with patellar tendinitis as part of physiotherapy rehabilitation. This model is expected to improve knee function, reduce pain, and support better quality of life and athletic performance.

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## INTRODUCTION

Patellar tendinopathy, commonly referred to as jumper's knee, is a load-related tendon disorder characterized primarily by activity-related pain at the patellar tendon and is particularly prevalent among athletes who participate in jumping and other explosive sports (Weiss & Whatman, 2015). Repetitive jumping, landing, and forceful knee-extension activities impose high and repeated mechanical demands on the patellar tendon, making athletes in sports such as volleyball and basketball especially susceptible to this condition. Clinically, patellar tendinopathy is characterized by localized tendon pain that increases with loading of the knee extensor mechanism and may be accompanied by impaired lower-limb function (Codorean & Codorean, 2023; Kasaeian et al., 2023). These symptoms can substantially interfere with training and competition by limiting an athlete's ability to perform jumping, landing, sprinting, and other high-load movements, ultimately reducing participation and negatively affecting athletic performance (Muaidi, 2020).

Injuries to the front of the knee, especially to the patellar tendon, pose a major challenge in the world of sports and physical activity (Theodorou et al., 2023). Previous studies have consistently demonstrated that eccentric decline squat training and heavy slow resistance are effective in improving tendon structure and reducing pain; however, the optimal combination of lower-limb strengthening exercises remains controversial (Escriche-Escuder et al., 2020). Research shows that repetitive loads without adequate recovery can lead to microtrauma to the muscle-tendon units, then progress to anterior knee pain, decreased performance, and even more serious risk of injury (Mostoufi et al., 2022). Although it is popularly called tendinitis, recent research shows that in many cases it is more appropriately called tendinopathy because the process is more degenerative, involving micro-tearing and structural changes of the tendons, rather than purely inflammatory.

In athletes or individuals with high activity that involves frequent jumping, including basketball, volleyball, and long jump, the incidence of patellar tendinopathy is reported to be quite high (Jellad et al., 2024). Factors that contribute to increasing risk include a sudden increase in load, increased frequency or volume of exercise without sufficient recovery time, poor quadriceps and hamstring muscle flexibility, knee malalignment, and harsh training surface conditions (Padasala et al., 2020; Zumwalt, 2023).

When the patellar tendon is subjected to repeated loads without enough time to recover, it accumulates microtrauma (Fouda et al., 2017; Luttrell, 2024), which, if left untreated, can develop into chronic pain, decreased exercise performance, or even more serious injuries such as tendon tears. Given the functional impact that can be quite significant, effective interventions are needed. In the framework of prevention and treatment, strengthening of the leg muscles, especially the extensor muscle groups of the knee (quadriceps) and supporting muscles such as the hamstrings and gluteus, is considered an important part of rehabilitation and prevention strategies (Bourne et al., 2018; Mischke et al., 2022). Although eccentric loading protocols are widely recommended, there is still no consensus regarding the most effective lower-limb strengthening model integrating quadriceps, hamstrings, gluteal, and neuromuscular components for reducing patellar tendinopathy symptoms.

Despite these encouraging findings, previous studies have primarily focused on evaluating isolated exercise modalities, such as eccentric training, isometric contractions, or heavy slow resistance, rather than developing an integrated lower-limb strengthening approach (Li et al., 2024; Zhong et al., 2026). Furthermore, most intervention studies have emphasized pain reduction as the primary outcome while providing limited consideration of coordinated strengthening involving the quadriceps, hamstrings, gluteal muscles, and functional

movement patterns that collectively contribute to optimal knee load distribution during dynamic activities.

Therefore, an important research gap remains regarding the development of a comprehensive strengthening model that integrates multiple lower-extremity muscle groups into a structured and progressive exercise program for individuals with patellar tendinopathy. Although several rehabilitation protocols have demonstrated positive outcomes, there is still limited evidence regarding exercise models that simultaneously address pain reduction, muscular function, and biomechanical optimization through an integrated lower-limb strengthening strategy (Yang et al., 2025).

Although previous rehabilitation studies have examined tendon loading strategies and strengthening exercises, these approaches have predominantly focused on individual components of rehabilitation rather than on an integrated lower-limb strengthening model. In particular, limited attention has been given to a comprehensive model that combines quadriceps strengthening, movement control, balance and proprioceptive training, and calf-muscle strengthening while addressing the specific functional demands of long jump athletes. This gap is important because effective rehabilitation for patellar tendinopathy in jumping athletes requires not only adequate tendon loading capacity but also coordinated lower-limb function during dynamic movements such as jumping and landing.

In recent years, exercise-based rehabilitation has become the cornerstone of conservative management for patellar tendinopathy (Muaidi, 2020; Núñez-Martínez & Hernández-Guillen, 2021). Previous studies have demonstrated that eccentric exercise, heavy slow resistance (HSR), and isometric exercise can effectively reduce pain and improve functional outcomes in individuals with patellar tendinopathy (Vander Doelen & Jelley, 2020). These loading-based interventions are believed to promote tendon remodeling, improve tendon mechanical properties, and gradually restore functional capacity (Guan et al., 2026; Inman et al., 2026). Nevertheless, current evidence suggests that no single exercise protocol consistently demonstrates superior effectiveness across different populations, indicating that exercise prescription should consider both tendon loading principles and individual functional characteristics.

Therefore, this study aimed to develop an integrated lower-limb strengthening exercise model specifically designed for long jump athletes with patellar tendinopathy. The proposed model integrates quadriceps strengthening, movement control, balance and proprioception, and calf strengthening within a progressive and function-oriented training framework. The developed model was validated for content through expert assessment and preliminarily evaluated for feasibility through an eight-week pilot implementation involving long jump athletes with patellar tendinopathy. Changes in pain intensity were assessed using a 0 to 10 visual analog scale (VAS) before and after the pilot intervention. This study contributes an evidence-informed and function-oriented strengthening model that addresses the functional demands of the long jump, providing preliminary evidence regarding feasibility and pain reduction rather than establishing definitive clinical effectiveness.

## METHODS

This study employed a Research and Development (R&D) design adapted from the Borg and Gall model, followed by expert validation and a small-scale pilot implementation. During the pilot phase, the developed exercise model was preliminarily evaluated using a one-group pretest and posttest design involving five long jump athletes with patellar tendinopathy. This design was selected because the study aimed to develop an integrated lower-limb strengthening exercise model and obtain preliminary evidence regarding its feasibility and

changes in pain intensity following implementation. Pain intensity was measured before and after the 8-week pilot implementation using a 0 to 10 visual analog scale (VAS). Accordingly, the study should be understood as an R&D study with expert validation and preliminary small-scale evaluation, rather than as a large-scale effectiveness trial.

### Participants

This pilot study involved five long jump athletes to evaluate the feasibility, safety, and preliminary effectiveness of the developed intervention prior to large-scale validation. The inclusion criteria were: (1) active long jump athletes aged 18–30 years; (2) a history of clinically diagnosed patellar tendinopathy or anterior knee pain associated with the patellar tendon for at least four weeks; (3) a pain intensity score of 3 or higher on the Visual Analog Scale (VAS) during sports activities; (4) regular participation in long jump training for at least three sessions per week; and (5) willingness to participate throughout the study and provide written informed consent. The exclusion criteria included: (1) a history of knee surgery within the previous 12 months; (2) concomitant knee injuries such as anterior cruciate ligament (ACL) rupture, meniscal injury, or severe osteoarthritis; (3) neurological or systemic musculoskeletal disorders affecting lower-limb function; (4) corticosteroid injection or other invasive treatment for patellar tendinopathy within the previous three months; and (5) inability to complete the exercise program due to medical or personal reasons.

**Table 1.** Baseline Participant Characteristics

| No. | Age (years) | Sex  | Height (cm) | Weight (kg) | BMI   | Training Experience (months) |
|-----|-------------|------|-------------|-------------|-------|------------------------------|
| 1.  | 19          | Male | 170         | 65          | 22.49 | 12                           |
| 2.  | 18          | Male | 168         | 63          | 22.32 | 18                           |
| 3.  | 21          | Male | 165         | 60          | 22.04 | 16                           |
| 4.  | 19          | Male | 168         | 68          | 24.09 | 24                           |
| 5.  | 20          | Male | 172         | 69          | 23.32 | 8                            |

### Ethical Considerations

Institutional approval for participant involvement in the study was obtained through the applicable research approval procedure. Permission for the athletes to participate as research respondents was documented in an institutional approval sheet under document number IC/Training-TP/001. Prior to participation, the athletes were informed about the purpose and procedures of the study, the nature of the exercise program, the duration of the 8-week pilot implementation, and the pain assessment procedures. Participation was voluntary, and the athletes provided their agreement to participate before data collection commenced. The study procedures were conducted in accordance with the institutional requirements applicable to research involving human participants.

### Procedures

The research procedure followed the sequential stages of exercise model development, beginning with a problem analysis to identify patellar tendinopathy pain and functional limitations in long jump athletes through direct observation, interviews, and preliminary examinations of knee conditions. This was accompanied by initial data collection involving a comprehensive literature review on lower-limb muscle-strengthening protocols, including eccentric loading, isometric contractions, and gradual progressive resistance. Based on these theoretical insights, the exercise model was formulated by detailing the exercise selection, duration, intensity, frequency, and progressive loading parameters. The resulting

intervention incorporated four core exercise modes: single-leg eccentric squats, controlled step exercises, single-leg standing balance exercises, and standing calf raise, structured into an 8-week intervention program scheduled for three 45-minute sessions per week.

**Table 2.** Exercise Prescription and Progression Protocol

| No. | Training Component                    | Intensity (%) | Repetitions | Sets | Duration (min) | Information                                                                                |
|-----|---------------------------------------|---------------|-------------|------|----------------|--------------------------------------------------------------------------------------------|
| 1   | Single-leg eccentric squat            | 65-70         | 25          | 5    | 45             | Adjustments are made weekly by increasing the number of repetitions by 5 and the sets by 2 |
| 2   | Controlled step exercise              | 65-70         | 25          | 5    | 45             |                                                                                            |
| 3   | One-legged standing balance exercises | 65-70         | 25          | 5    | 45             |                                                                                            |
| 4   | Standing calf raise                   | 65-70         | 25          | 5    | 45             |                                                                                            |

The preliminary exercise model was evaluated by five experts comprising two sports physiotherapists, two strength and conditioning specialists, and one sports medicine physician using the Content Validity Index (CVI). Based on expert recommendations, the exercise design was systematically revised to ensure that all protocols were safe, well structured, and ready for empirical testing. The refined model was then implemented in a small-scale trial involving five long jump athletes over an eight-week period, during which sessions were monitored regularly to verify movement technique, training intensity, and individual physiological responses. To evaluate preliminary effectiveness, pain levels were measured before, during, and after the exercise program using the Visual Analog Scale (VAS) instrument to track objective changes in pain intensity. Finally, measurement outcomes were analyzed to evaluate overall program effectiveness and refine the model for potential implementation in larger-scale experimental trials in future research,

### Research Instrument

The primary instrument used in this study was the Visual Analog Scale (VAS) to assess pain levels across a score continuum from 0 to 10, where 0 represented no pain and 10 represented very intense pain. This instrument was selected because of its high clinical practicality, established reliability, and sensitivity to acute changes in pain intensity.

### Data Analysis

Data obtained from pain intensity assessments were analyzed using quantitative descriptive statistics by calculating mean changes and percentage reductions in VAS scores before and after the application of the exercise model. Interpretation of the outcomes was grounded in the reduction of pain scores as a functional indicator of the effectiveness of the developed leg muscle strengthening program. To evaluate paired differences between pre- and post-intervention scores within the same subjects, the Wilcoxon signed-rank test was utilized, which is well suited for paired non-parametric data derived from a very small pilot sample.

## RESULTS

### Development of The Exercise Model

Based on the research and development process, four progressive leg muscle strengthening exercise models were formulated to alleviate patellar tendinopathy pain, as detailed in Table 3.

**Table 3.** The Resulting Form of Exercise Models

| No | Training Model                    | Main Objectives                                                                               |
|----|-----------------------------------|-----------------------------------------------------------------------------------------------|
| 1  | Single-leg eccentric squat        | Eccentrically strengthens the quadriceps and lowers mechanical stress on the patellar tendons |
| 2  | Controlled step exercise          | Train joint motion control and knee stability                                                 |
| 3  | One-leg standing balance exercise | Improves pelvic proprioception and neuromuscular stability                                    |
| 4  | Standing calf raise               | Strengthens the triceps surae complex and improves force absorption at the knee               |

### Expert Validation

The content validity of the preliminary exercise model was evaluated by five experts across six appraisal criteria, as summarized in Table 4.

**Table 4.** Content Validity Index (CVI) by Expert Panel

| Rated Items                        | Expert 1 | Expert 2 | Expert 3 | Expert 4 | Expert 5 | I-CVI |
|------------------------------------|----------|----------|----------|----------|----------|-------|
| Relevance                          | 3        | 4        | 3        | 3        | 4        | 1.00  |
| Scientific Basis                   | 4        | 3        | 3        | 4        | 4        | 1.00  |
| Safety                             | 3        | 3        | 4        | 3        | 4        | 1.00  |
| Feasibility                        | 4        | 2        | 3        | 3        | 4        | 0.80  |
| Progression and Loading            | 3        | 3        | 4        | 4        | 3        | 1.0   |
| Clarity of Exercise Instructions   | 3        | 4        | 3        | 3        | 4        | 1.0   |
| S-CVI (Total I-CVI/Total of Items) |          |          |          |          |          | 0.96  |

The evaluation results demonstrated that the expert panel gave very favorable ratings to the proposed exercise models. The overall program achieved high content validity with an S-CVI score of 0.96 (exceeding the standard 0.80 threshold), confirming that the exercise model was well suited for small-scale pilot implementation.

### Final Exercise Model Description

The final exercise model consists of four integrated movements. First, the single-leg eccentric squat support focuses on the eccentric work of the quadriceps muscles, which is the phase of slowly lowering the body using one leg as support, aiming to improve the load tolerance of the patellar tendon and strengthen the structure of collagen tissue. Second, the controlled step-down exercise trains knee and pelvic motion control skills, especially when the legs receive weight during landing, which is effective for improving joint stabilization and reducing excessive pulling on the patellar tendon. Third, the one-leg standing balance exercise serves to improve neuromuscular stability, coordination, and proprioceptive control, where knee support muscles such as the gluteus medius, hamstrings, and calf muscles contribute greatly to maintaining balance. Fourth, the standing calf raise strengthens the gastrocnemius and soleus muscles, which play an important role in the jumping landing mechanism and stabilize the knee, thereby increasing the distribution of the load more evenly in the lower extremities. These four exercises are applied in the form of a progressive program over several weeks consisting of isometric contractions to reduce initial pain and increase muscle activation, light weight dynamic exercises to increase muscle strength without putting too

much stress, and functional exercises to increase muscle readiness in real sports activities such as running and jumping.

### Pilot Testing

The pilot study involved five long jump athletes who met the predefined inclusion criteria. All five participants completed the intervention, and no serious exercise-related adverse events were reported, providing preliminary evidence of intervention feasibility and tolerability.

### Preliminary Effectiveness

**Table 5.** Change in VAS Score

| Participant                     | Pre-Intervention                  | Post-Intervention                 | Change                             | Percentage Reduction (%)            |
|---------------------------------|-----------------------------------|-----------------------------------|------------------------------------|-------------------------------------|
| Athlete 1                       | 8                                 | 3                                 | -5                                 | 62.5                                |
| Athlete 2                       | 7                                 | 4                                 | -3                                 | 42.8                                |
| Athlete 3                       | 7                                 | 3                                 | -4                                 | 57.2                                |
| Athlete 4                       | 8                                 | 2                                 | -6                                 | 75.0                                |
| Athlete 5                       | 6                                 | 3                                 | -3                                 | 50.0                                |
| <b>Mean <math>\pm</math> SD</b> | <b>7.20 <math>\pm</math> 0.84</b> | <b>3.00 <math>\pm</math> 0.71</b> | <b>-4.20 <math>\pm</math> 1.30</b> | <b>57.50 <math>\pm</math> 12.29</b> |

The mean pain intensity decreased from  $7.20 \pm 0.84$  before the intervention to  $3.00 \pm 0.71$  after the intervention. The average change in VAS score was  $-4.20 \pm 1.30$  points, corresponding to a mean pain reduction of  $57.50 \pm 12.29\%$ . The Wilcoxon signed-rank test confirmed that this decrease was statistically significant ( $Z = -2.023$ ,  $p = .043$ ). These findings indicate a clinically meaningful reduction in pain following implementation of the developed lower-limb strengthening exercise program. The observed pattern is illustrated in the graph of measurement results below:

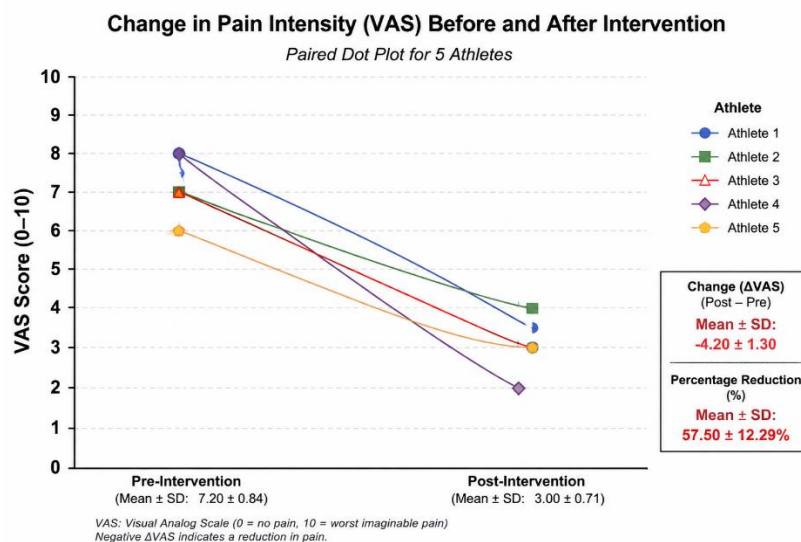


**Figure 1.** Change in Pain Intensity

### DISCUSSION

The results showed that the application of a leg muscle strengthening exercise model consisting of a one-legged eccentric squat, control steps, one-legged balance exercises, and standing calf raise was associated with a significant reduction in patellar tendon pain in long jump athletes. This training program is prepared based on progressive principles, starting

from isometric exercises to lightweight dynamics to functional exercises that are close to the actual sports needs.

The present pilot study demonstrated that the developed lower-limb strengthening exercise model was feasible and showed promising preliminary effectiveness in reducing patellar tendon pain among long jump athletes. The mean VAS score decreased from  $7.20 \pm 0.84$  before the intervention to  $3.00 \pm 0.71$  after the intervention, corresponding to a mean reduction of  $4.20 \pm 1.30$  points ( $57.50 \pm 12.29\%$ ). These findings suggest that the proposed exercise model may provide clinically meaningful pain relief while supporting functional rehabilitation.

The observed reduction in pain intensity following the application of the exercise model may have several plausible physiological and neuromuscular explanations. However, the present study did not directly assess muscle strength, tendon morphology, collagen organization, biomechanics, proprioception, or neuromuscular activity. Therefore, these mechanisms should be regarded as potential explanations supported by previous literature rather than mechanisms demonstrated by the present findings.

Previous research suggests that eccentric exercise may contribute to tendon adaptation by increasing the tendon's capacity to tolerate mechanical loading and promoting changes in tendon structure and collagen organization (Martínez et al., 2022; Mascaró et al., 2018). Similarly, isometric muscle contractions have been proposed to produce short-term analgesic effects through neuromuscular mechanisms that may modulate pain perception (Stefanska & Jurek, 2025). These mechanisms could potentially contribute to the reduction in pain observed in the present study; however, because tendon structure and pain-modulation responses were not directly measured, this interpretation remains hypothetical.

The strengthening of the quadriceps, hamstrings, and gluteal musculature may also potentially influence the distribution of mechanical loads across the lower-extremity kinetic chain. Previous literature has suggested that improvements in lower-limb muscle function and movement control may reduce excessive mechanical stress on the patellar tendon and improve tolerance to physical activity (Halabchi et al., 2017). Nevertheless, the present study did not measure muscle strength, joint loading, knee valgus, proprioception, or biomechanical parameters. Consequently, the observed reduction in pain cannot be directly attributed to increased muscle strength, tendon adaptation, improved proprioception, reduced valgus, or enhanced kinetic-chain function.

The findings of the present pilot study are generally consistent with previous research demonstrating that progressive tendon-loading exercises, particularly eccentric strengthening, are effective in reducing pain associated with patellar tendinopathy (Breda et al., 2021; Núñez-Martínez & Hernández-Guillen, 2021). Recent rehabilitation studies have also reported that progressive loading interventions can improve tendon load tolerance and facilitate a gradual return to sports participation (Cardoso et al., 2019; Silva et al., 2023). The reduction in pain observed in the present study further supports the concept that structured lower-limb strengthening represents an essential component of conservative management for athletes with patellar tendinopathy.

Patellar tendinopathy in jumping athletes is usually affected by poor landing quality, imbalance of muscle strength, and suboptimal control of knee and pelvic motion. One-legged balance exercises play an important role in improving proprioception or the ability of muscles and joints to recognize body positions (Cardenas et al., 2026). As proprioception increases, muscle movements become more coordinated, making the knee more stable when landing or resisting when jumping. This lowers valgus stress, where the knee collapses inward, which is often the cause of excess pressure on the patellar tendon (Filardi, 2015). Thus, this model

of exercise not only strengthens the muscles but also improves the basic movement patterns that are the root cause of patellar tendinopathy in jumping athletes.

In the long jump, the knee receives a huge load during the take-off and landing phases. The load can reach several times the weight of the athlete's body. The standing calf raise exercise helps optimize the contribution of the calf muscles, which act as a force reducer during landing. The combination of strengthening the quadriceps, hamstrings, gluteus, and calves results in a kinetic chain that works more harmoniously (Adeel et al., 2024). The more efficient the chain of motion, the less the patellar tendon is subjected to overpressure (Zellmer et al., 2019). Thus, this training model is biomechanically relevant and in accordance with the specific movement demands of long jump athletes.

An important contribution of the present study is the development of an integrated lower-limb strengthening model specifically designed for long jump athletes. Unlike many previous rehabilitation programs that primarily emphasized isolated eccentric loading, the proposed model combines eccentric strengthening, controlled stepping, neuromuscular balance training, and calf strengthening within a progressive exercise framework. This integrated approach may provide a more comprehensive strategy for reducing tendon loading while simultaneously improving movement control during take-off and landing phases.

In addition to reduced pain, athletes also reported increased comfort when training, increased confidence when doing push-offs and landings, and the ability to participate in training sessions without having to stop training due to pain. This illustrates that the training program is not only therapeutic but also preventive and performative, as it supports the achievement of maximum performance without the risk of repetitive injuries.

The developed training model is easy to implement, does not require special tools, and can be performed in regular training situations. This is especially important in the context of athlete coaching programs, sports physiotherapy programs, and injury prevention in intensive training environments. Therefore, the model may have potential as a structured exercise framework within rehabilitation settings; however, its clinical effectiveness and safety across different severity levels require confirmation in larger controlled studies.

This study has several limitations that should be considered when interpreting the findings. First, the study involved only five participants because it was designed as a pilot study; therefore, the results cannot be generalized to broader athletic populations. Second, the absence of a control group limits the ability to attribute the observed reduction in pain solely to the developed exercise model. Third, the effectiveness evaluation relied primarily on the Visual Analog Scale (VAS) without additional functional outcome measures such as the Victorian Institute of Sport Assessment Patella (VISA-P), muscle strength testing, or biomechanical analysis. Consequently, the findings should be regarded as preliminary and interpreted with appropriate caution.

Future studies should include larger sample sizes and randomized controlled trial designs to further evaluate the effectiveness of the proposed exercise model. Additional outcome measures, including functional performance, lower-limb muscle strength, jump biomechanics, and long-term follow-up assessments, are also recommended to provide more comprehensive evidence regarding the clinical effectiveness and sustainability of the intervention.

## CONCLUSION

This study developed a lower-limb strengthening exercise model aimed at reducing pain associated with patellar tendinopathy, particularly among long jump athletes. These exercises were designed based on progressive loading principles to improve lower-limb muscle strength while minimizing excessive mechanical stress on the patellar tendon.

The preliminary findings from the pilot study demonstrated that all participants successfully completed the intervention program, indicating good feasibility and acceptability of the developed exercise model. Pain intensity, measured using the Visual Analog Scale (VAS), decreased from  $7.20 \pm 0.84$  before the intervention to  $3.00 \pm 0.71$  after the intervention, with a mean reduction of  $4.20 \pm 1.30$  points, corresponding to an average pain reduction of  $57.50 \pm 12.29\%$ . These findings suggest that the proposed exercise model has promising potential for reducing pain associated with patellar tendinopathy in long jump athletes.

Although the preliminary results are encouraging, this study was conducted as a pilot study involving a limited number of participants and without a control group. Therefore, the findings should be interpreted with caution. Further studies involving larger sample sizes, randomized controlled designs, and additional functional outcome measures are required to confirm the effectiveness and broader clinical applicability of the proposed exercise model.

Overall, the developed lower-limb strengthening model is practical; however, it cannot yet serve as a standard reference for the general management of patellar tendinopathy, as it remains in the preliminary trial stage.

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## AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

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