REABILITACIJOS MOKSLAI
Slauga, kineziterapija, ergoterapija
LSU LITHUANIAN SPORTS UNIVERSITY

Reabilitacijos mokslai: slauga, kineziterapija, ergoterapija, *2*(33) 2025, 119–128, eISSN 2538-8673; DOI: https://doi.org/10.33607/rmske.v2i33.1744

Effects of Therapeutic Exercise on Pain, Range of Motion, and Patellar Tendon in Volleyball Players With Jumper's Knee

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Abstract

Background. Jumper's knee is a common overuse injury in athletes, characterised by activity-related pain and impaired patellar tendon function due to microtears. Therapeutic eccentric and isometric exercises have been shown to alleviate symptoms and improve lower-limb function.

Aim. To evaluate the effects of an 8-week targeted exercise programme on pain, range of motion, and patellar tendon biomechanical properties in volleyball athletes with patellar tendinopathy.

Methods. Twenty-one male volleyball players with patellar pain were randomly assigned to an intervention group (n = 10) or a control group (n = 11). The intervention group completed a structured physiotherapy programme twice weekly for eight weeks, consisting of bodyweight-based isometric and eccentric exercises, including wall sits, tibialis raises, calf raises, split squats, Patrick step exercises, etc. Outcome measures were symptom severity and functional status assessed via the VISA-P questionnaire, lower-limb range of motion (knee flexion and hip flexion/extension) measured with a goniometer, and patellar tendon biomechanical properties (tone, stiffness, elasticity) measured with the Myoton PRO myotonometer. Assessments were conducted at baseline and post-intervention. Data were analysed using nonparametric tests, with significance set at $p < 0.05$.

Results. After eight weeks, the intervention group demonstrated a significant improvement in VISA-P scores (55 vs 89; $p < 0.01$), whereas the control group showed no change (61 vs 62; $p > 0.05$). Between-group differences were significant (89 vs 62; $p < 0.001$). Minimal changes in range of motion were observed, except for greater right hip flexion gains in the control group ($p < 0.05$). In the intervention group, patellar tendon tone and stiffness decreased significantly in the relaxed left leg ($p < 0.05$), indicating improved tendon mechanical properties.

Conclusions. An 8-week structured exercise programme effectively reduces pain, enhances functional status, and improves patellar tendon biomechanics in volleyball players with jumper's knee, supporting its use as a non-invasive management strategy.

Keywords: jumper's knee; physiotherapy; exercise programme; biomechanics

1. INTRODUCTION

During both competitions and training sessions, volleyball players are subjected to substantial physical loads due to the high frequency of jumps and spikes. The average number of jumps performed varies by playing position: outside hitters execute approximately 55 jumps, setters 36 jumps, opposite

hitters 63 jumps, and middle blockers 77 jumps per match or training session (García-de-Alcaraz et al., 2020). In volleyball, acute injuries commonly occur near the net, where players frequently jump in close proximity during attacking and blocking actions. Consequently, the most frequent injuries involve the shoulder and upper limb (rotator cuff tendinopathy, finger sprains and dislocations), the ankle (ligament sprains, tears, fractures), and the knee (patellar tendon tendinopathy and ligament injuries) (Young et al., 2023).

Among these, patellar tendinopathy, commonly referred to as jumper's knee, is a prevalent overuse injury characterised by progressive, activity-related pain and functional impairment of the patellar tendon resulting from microtears (Santana et al., 2023). This condition most frequently affects adolescents and young adults (Lian et al., 2003) and typically manifests as localised pain at the inferior pole of the patellar tendon. Epidemiological data indicate that up to 14% of recreational athletes and 45% of elite athletes participating in jumping sports experience symptoms at any given time (Sprague et al., 2019). Psychological factors, including athletes' beliefs about tendon pathology, can influence the clinical course and management of tendinopathy. For instance, concerns about tendon degeneration due to microtears may provoke fear, leading to avoidance of full range-of-motion exercises, which can negatively affect motor function and long-term recovery (Santana et al., 2023).

Current treatment strategies for jumper's knee include physiotherapy, exercise-based rehabilitation, load management, injections, and, in select cases, surgical intervention (Dan et al., 2018). Eccentric and isometric loading exercises remain the primary modalities for pain management and functional improvement (Challoumas et al., 2021). However, athletes often perceive physiotherapeutic interventions, such as shockwave therapy or injections, as more effective than exercise-based rehabilitation (Santana et al., 2023). Individualised exercise programmes that incorporate full-range eccentric and isometric exercises can effectively enhance muscle strength, tendon and ligament functional capacity, and joint range of motion. These interventions are considered fundamental not only for strengthening musculoskeletal structures but also for reducing injury risk, alleviating symptoms of tendinopathy, and improving overall functional readiness in athletes (Breda et al., 2020).

2. METHODS

Ethical approval and informed consent. The study was approved by the Lithuanian Sports University Committee for the Assessment of Compliance of Biomedical Research with Research Ethics (No. 2024 10 30 BNL-KIN (B)-2024-712). All participants provided written informed consent prior to participation. The study was conducted in the main sports hall of the Lithuanian Sports University.

Participants. The study included 21 highly trained male volleyball athletes who reported patellar pain (Table 1). Inclusion criteria were written informed consent, at least one year of volleyball experience, presence of patellar pain, ability to attend all physiotherapy sessions during the 8-week intervention, and age between 19 and 25 years. Exclusion criteria included neurological disorders, knee fracture or other knee pathologies within the preceding six-month period.

Table 1. **Characteristics of the participants**

Variables	Intervention group (n = 10)	Control group (n = 11)	p between groups
Age (yrs.)	21.4 ± 1.9	21.6 ± 2.4	0.809
Height (cm)	185.5 ± 6.5	185.0 ± 5.9	0.654
Weight (kg)	76.8 ± 9.7	80.8 ± 11.6	0.130
BMI (kg/m^2)	22.4 ± 2.8	23.6 ± 3.0	0.029

Note: BMI – body mass index.

Outcome measures and instruments

Symptom severity and functional status. The Victorian Institute of Sport Assessment-Patellar (VISA-P) questionnaire was used to assess patellar tendon symptoms and functional limitations. VISA-P is a self-administered, patient-reported outcome measure comprising eight items. Six items evaluate pain and function during daily activities and simple functional tests (scored 0–10), and two items assess sports participation, with the final item weighted up to 30 points. Total scores range from 0 to 100, with higher scores indicating better function and fewer symptoms (Çelebi et al., 2016).

Range of motion (ROM). ROM of the lower extremities, including knee flexion, hip flexion and extension, was measured using a SAEHAN goniometer (*South Korea*) before and after the intervention. The anatomical zero position was used as the reference point. Normal ROM values can vary according to age, sex, and whether movements are performed actively or passively (Swann & Harrelson, 2012).

Biomechanical properties of the patellar ligament. The Myoton PRO myotonometer (*Tallinn, Estonia*) was used to assess muscle tone (F, Hz), stiffness (S, N/m) and elasticity (D, unitless) of the patellar ligament. Measurements were taken with the knee flexed at 35°, with a Sissel roller under the popliteal fossa. The midpoint of the patellar ligament was palpated and marked. Three repetitions were performed for each leg under relaxed and tensioned conditions, and the mean values were calculated.

Interventions

Participants were randomly assigned to an intervention group (n = 10), which completed an 8-week physiotherapy programme, or a control group (n = 11), which received no intervention.

Intervention group participants completed 16 sessions over a period of eight weeks, with each session lasting 30 minutes. Testing was conducted twice: outcome assessments were performed at baseline (first day) and after completion of the physiotherapy programme (final day).

The physiotherapy programme consisted of bodyweight-based isometric and eccentric exercises with a total duration of 30 minutes per session (Figure 1). Each session included: jogging backwards (5 min), wall sit (1 min), and two sets of the following exercises: tibialis raises (20 reps), calf raises (20 reps), soleus raises (20 reps), Patrick step (20 reps), split squats (7 reps), and Bulgarian split squats (7 reps).

Figure 1. **Exercises from the physiotherapy programme**

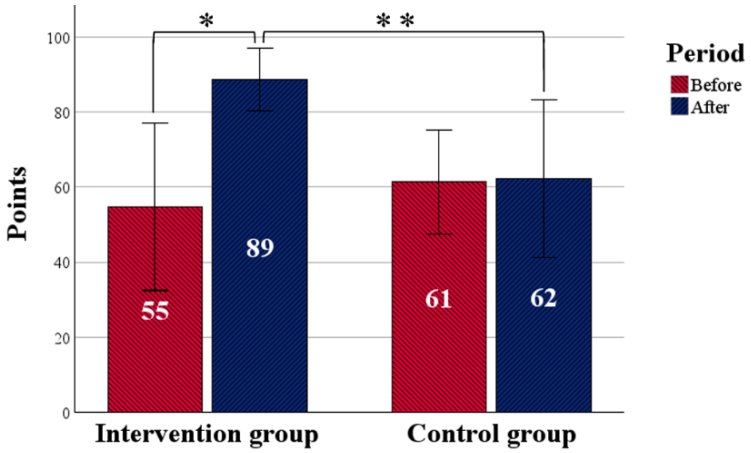
Statistical analysis. Data was analysed using SPSS Statistics version 29.0. Due to the small sample size, the nonparametric Wilcoxon signed-rank test was applied for within-group comparisons,

and the Mann–Whitney U test was used for between-group comparisons. Statistical significance was set at $p < 0.05$.

3. RESULTS

Symptom severity and functional status

Figure 2 presents the changes in symptom severity and functional status in both the intervention and control groups before and after the intervention period. Participants in the intervention group demonstrated a statistically significant reduction in symptom severity and a marked improvement in functional status following the implementation of the exercise programme ($p < 0.05$). In contrast, the control group exhibited minimal or no improvement during the same timeframe. When comparing the two groups after the intervention, the differences were highly significant ($p < 0.001$), indicating that the targeted exercise programme was effective in reducing pain and enhancing overall knee function. These findings suggest that structured, progressive exercise interventions can play an important role in improving clinical outcomes in individuals with patellar tendinopathy.



Note: * $p < 0.05$, comparing pre- and post-intervention periods within the intervention group; ** $p < 0.001$, comparing between groups after the intervention period.

Figure 2. **Symptom severity and functional status in the intervention and control groups**

Range of motion

Table 2 presents the range of motion (ROM) measurements for both the intervention and control groups before and after the intervention period. No statistically significant differences were found between the groups in most joint movements. In the left leg, hip flexion, hip extension, and knee flexion showed minimal changes after the intervention, with p values above 0.05. Similarly, for the right leg, hip extension and knee flexion remained relatively stable across both groups. However, a significant difference in right hip flexion was observed between the groups after the intervention ($p = 0.029$), indicating a slight improvement in the control group. Overall, the intervention did not produce major changes in joint range of motion, suggesting that the exercise programme primarily influenced pain and functional outcomes rather than flexibility measures.

Table 2. **Range of motion in both groups before and after the interventions**

Leg	ROM	Timeline	Intervention group (n = 10)	Control group (n = 11)	p value
Left	Hip flexion (mean ± SD, degree)	Before	112.4 ± 10.4	115.1 ± 7.0	0.654
		After	110.7 ± 7.5	114.6 ± 8.7	0.197
	Hip extension (mean ± SD, degree)	Before	18.7 ± 2.8	17.5 ± 4.8	0.863
		After	18.6 ± 2.8	18.5 ± 3.3	0.809
	Knee flexion (mean ± SD, degree)	Before	126.6 ± 6.3	129.3 ± 7.0	0.314
		After	128.8 ± 5.3	128.8 ± 6.8	0.973
Right	Hip flexion (mean ± SD, degree)	Before	118.3 ± 8.1	115.9 ± 6.2	0.314
		After	116.5 ± 4.5	120.9 ± 8.3	**0.029**
	Hip extension (mean ± SD, degree)	Before	18.2 ± 1.9	16.0 ± 4.6	0.605
		After	17.2 ± 3.6	17.6 ± 3.0	0.654
	Knee flexion (mean ± SD, degree)	Before	126.0 ± 6.9	129.3 ± 8.6	0.314
		After	127.9 ± 6.8	129.6 ± 7.1	0.468

Note: ROM – range of motion; SD – standard deviation.

Biomechanical properties of the patellar ligament

Table 3 presents the comparison of patellar tendon biomechanical properties between the intervention and control groups before and after the 8-week period. At baseline, no significant differences were observed between the groups for any measured variable ($p > 0.05$), indicating comparable initial tendon characteristics. After the intervention, the intervention group showed a tendency towards lower tendon tone (F) and stiffness (S) values compared with the control group, particularly in the right leg under tense conditions. A statistically significant difference was found in right leg tendon tone (F) under tension ($p = 0.024$), suggesting improved tendon adaptability and decreased mechanical loading following the physiotherapy programme. Although other parameters – such as stiffness (S) and elasticity (D) – did not reach statistical significance ($p > 0.05$), their consistent downwards trend in the intervention group indicates potential beneficial effects of the exercise programme on tendon mechanical properties. The control group, by contrast, displayed no improvement and in some cases higher post-intervention values, likely reflecting the absence of targeted loading and recovery stimulus. Overall, these results suggest that the 8-week physiotherapy programme produced measurable positive effects on patellar tendon tone and stiffness, especially under active tension, reflecting improved tendon function and load tolerance compared with the control group.

Table 3. **Patellar tendon characteristics' comparison between both groups**

Leg	Leg state	Units	Timeline	Intervention group (mean ± SD)	Control group (mean ± SD)	p value between groups
Left	Relaxed	F (Hz)	Before	22.0 ± 1.7	21.7 ± 1.8	0.756
			After	20.8 ±1.4 *	19.9 ± 1.8 *	0.223
	Tense		Before	26.5 ± 4.0	26.1 ± 5.7	0.863
			After	24.3 ± 2.3	23.1 ± 2.7 *	0.099
	Relaxed	S (N/m)	Before	624.1 ± 84.1	604.7 ± 94.6	0.756
			After	576.6 ± 71.5 *	538.3 ± 102.0	0.251
	Tense		Before	861.6 ± 88.6	848.0 ± 148.6	0.863
			After	856.0 ± 71.0	770.2 ± 143.2	0.223
	Relaxed	D	Before	0.9 ± 0.1	0.9 ± 0.1	0.756
			After	0.9 ± 0.1	0.9 ± 0.1	0.756
	Tense		Before	1.0 ± 0.3	1.0 ± 0.2	1.000
			After	1.0 ± 0.2	1.0 ± 0.1	0.756
Right	Relaxed	F (Hz)	Before	21.3 ± 2.3	21.1 ± 2.0	0.654
			After	20.8 ± 1.8	20.0 ± 1.4	0.387
	Tense		Before	25.7 ± 3.3	24.6 ± 2.9	0.314
			After	24.7 ± 2.6	22.9 ± 1.8	**0.024**
	Relaxed	S (N/m)	Before	581.5 ± 118.8	578.0 ± 121.0	0.654
			After	566.5 ± 92.3	523.7 ± 114.4 *	0.387
	Tense		Before	844.5 ± 110.0	805.9 ± 135.5	0.387
			After	834.1 ± 74.0	759.4 ± 128.7	0.051
	Relaxed	D	Before	0.9 ± 0.1	0.9 ± 0.1	0.557
			After	0.9 ± 0.1	0.9 ± 0.1	0.099
	Tense		Before	1.0 ± 0.2	1.0 ± 0.1	1.000
			After	1.0 ± 0.2	1.0 ± 0.1	0.387

Notes: SD – standard deviation; F – muscle tone; S – stiffness; D – elasticity; * – $p < 0.05$ within group.

4. DISCUSSION

The present study aimed to evaluate the effects of an eight-week physiotherapy programme on pain, patellar tendon biomechanical properties, and knee function in male volleyball athletes with patellar tendinopathy. The results demonstrate that the exercise programme effectively reduced pain in the intervention group, whereas the control group, which did not participate in the intervention, reported persistent symptoms. Additionally, the intervention maintained or slightly improved tendon tone and stiffness, while the control group experienced declines in these parameters.

Consistent with previous literature, these findings support the efficacy of eccentric and isometric exercise programmes in reducing patellar tendinopathy-related pain. Challoumas et al. (2021), in their review of 37 studies, concluded that such exercises effectively decrease patellar tendon pain as measured by VAS and VISA-P scales. Similarly, van Ark et al. (2015) demonstrated that isometric and isotonic exercise interventions significantly reduce pain and improve VISA-P scores in basketball and volley-

ball athletes, even during the competitive season. The observed improvements in VISA-P scores in this study confirm that the intervention programme is suitable for alleviating pain and enhancing functional outcomes.

Patellar tendon stiffness and tone are important indicators of tendon health and functional capacity. In this study, the Myoton PRO device was used to assess these properties, and all measurements were performed by a single examiner to reduce variability, addressing concerns raised by van Dam et al. (2024) regarding inter-rater reliability. The intervention maintained or improved tendon tone and stiffness, suggesting that the physiotherapy programme positively influenced tendon mechanical properties. These results align with findings by Kyung and Park (2024), who reported that structured strength and plyometric training enhance tendon stiffness and neuromuscular responses in athletes.

Breda et al. (2020) emphasised that individualised, progressive tendon-loading programmes yield superior outcomes compared with standard eccentric protocols. While this study employed a standardised isometric and eccentric exercise programme, the improvements in pain and tendon function indicate that targeted exercise interventions can be effective even over a relatively short eight-week period. Further functional benefits might be achieved with longer intervention durations, individualised progression, and temporary reductions in sports load.

Overall, the study demonstrates that structured physiotherapy programmes incorporating full-range isometric and eccentric exercises effectively reduce pain and maintain tendon properties in volleyball athletes with patellar tendinopathy. While exercise remains a first-line conservative treatment, some athletes may continue to experience symptoms, highlighting the need to individualise treatment based on disease severity, duration, and prior interventions (Santana et al., 2023; Theodorou et al., 2023).

The results indicate that the eight-week exercise programme significantly improved clinical outcomes, including symptom severity and functional status, compared with the control group. Joint range of motion remained largely unchanged, except for a significant improvement in right hip flexion in the control group, suggesting that flexibility was not the primary driver of functional gains. Importantly, biomechanical assessment revealed a significant reduction in tendon tone under tension in the right leg of the intervention group, reflecting enhanced tendon adaptability and reduced mechanical load. Trends towards lower stiffness and maintained elasticity further suggest beneficial effects on tendon mechanical properties, even if not all changes reached statistical significance. Conversely, the control group exhibited no improvement and, in some cases, worsened tendon characteristics, likely due to the absence of targeted loading.

Limitations of this study include a small sample size and the use of a single examiner for biomechanical assessments, which may affect the generalisability and reliability of the results.

5. CONCLUSIONS AND PERSPECTIVES

The findings of this study support the use of a structured, progressive exercise programme as a safe and effective intervention for reducing pain, improving knee function, and enhancing patellar tendon mechanical properties in athletes with jumper's knee. These results highlight the role of therapeutic exercise as a first-line conservative strategy for patellar tendinopathy, offering both functional and biomechanical benefits. Future research should involve larger sample sizes, incorporate multiple assessors to improve measurement reliability, and include additional functional or performance-based outcome measures. Furthermore, controlling environmental factors such as training conditions and competition schedules will help to more accurately evaluate and validate the effectiveness of physiotherapy interventions.

Author Contributions: Conceptualisation, A.G.; methodology, S.S.; validation, S.S.; formal analysis, S.S.; investigation, A.G.; data curation, A.G.; original draft preparation, A.G. and S.S.; writing—review and editing, A.G. and S.S.; visualisation, A.G.; supervision, S.S.; project administration, S.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Informed Consent: Informed consent was obtained from all participants involved in the study.

Conflicts of Interest: The authors declare no conflict of interest.

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Gydomųjų pratimų poveikis skausmui, judesių amplitudės ir girnelės sausgyslės būklei tinklininkams su „šuolininko keliu“

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Santrauka

Tyrimo pagrindimas. „Šuolininko kelis“ yra dažna per didelio krūvio sukelta sportininkų trauma, pasireiškianti skausmu fizinės veiklos metu ir sutrikusia girnelės sausgyslės funkcija dėl mikroplyšimų. Tyrimai rodo, kad ekscentriniai ir izometriniai pratimai padeda mažinti simptomus ir gerinti apatinių galūnių funkciją.

Tyrimo tikslas. Įvertinti aštuonių savaičių tikslingos pratimų programos poveikį skausmui, judesių amplitudei ir girnelės sausgyslės biomechaninėms savybėms tinklininkams, turintiems girnelės tendinopatiją.

Tyrimo metodika. Tyrime dalyvavo 21 tinklininkas, jaučiantis girnelės srities skausmą. Dalyviai atsitiktinai suskirstyti į intervencinę grupę (n = 10) ir kontrolinę grupę (n = 11). Intervencinė grupė aštuonias savaites, du kartus per savaitę, atliko struktūruotą kineziterapijos programą, sudarytą iš pratimų su kūno svoriu: izometrinių ir ekscentrinių pratimų, įskaitant sėdėjimą atsirėmus į sieną, priekinių ir galinių blauzdos raumenų kėlimus, pritūpimus viena koja žengus į priekį bei Patriko žingsnio pratimą. Vertinimo rodikliai: simptomų sunkumas ir funkcinė būklė pagal VISA-P klausimyną, apatinių galūnių judesių amplitudė (kelio lenkimas ir klubo lenkimas / tiesimas; matuota goniometru), girnelės sausgyslės biomechaninės savybės (tonusas, standumas, elastingumas; matuota „Myoton PRO“ miotonometru). Vertinimai atlikti tyrimo pradžioje ir po intervencijos. Duomenys analizuoti taikant neparametrinius testus, reikšmingumo lygis – $p < 0,05$.

Rezultatai. Po aštuonių savaičių intervencinėje grupėje reikšmingai pagerėjo VISA-P balai (55 ir 89; $p < 0,01$), tuo tarpu kontrolinėje grupėje pokyčių nenustatyta (61 ir 62; $p > 0,05$). Skirtumas tarp grupių buvo statistiškai reikšmingas (89 ir 62; $p < 0,001$). Judesių amplitudės pokyčiai buvo minimalūs, išskyrus didesnį dešinio klubo lenkimo pagerėjimą kontrolinėje grupėje ($p < 0,05$). Intervencinėje grupėje reikšmingai sumažėjo girnelės sausgyslės tonusas ir standumas atpalaiduotoje kairėje kojoje ($p < 0,05$), o tai rodo pagerėjusias sausgyslės mechanines savybes.

Išvados. Aštuonių savaičių struktūruota pratimų programa veiksmingai mažina skausmą, gerina funkcinę būklę ir girnelės sausgyslės biomechanines savybes tinklininkams, turintiems „šuolininko kelį“, todėl tai gali būti laikoma veiksminga neinvazine gydymo strategija.

Reikšminiai žodžiai: „šuolininko kelis“; kineziterapija; pratimų programa; biomechanika

Received 2025 10 09
Accepted 2025 10 30