Disability and Rehabilitation

ISSN: 0963-8288 (Print) 1464-5165 (Online) Journal homepage: www.tandfonline.com/journals/idre20

Increasing or decreasing load during resistance training is not associated with changes in pain among individuals with patellar tendinopathy: a randomized crossover study

Jesper Lykkegård Toustrup, Kristian Damgaard Lyng, Steffen Strøager Hunniche, Kenneth Mølgaard, Jens Lykkegaard Olesen & Henrik Riel

To cite this article: Jesper Lykkegård Toustrup, Kristian Damgaard Lyng, Steffen Strøager Hunniche, Kenneth Mølgaard, Jens Lykkegaard Olesen & Henrik Riel (2025) Increasing or decreasing load during resistance training is not associated with changes in pain among individuals with patellar tendinopathy: a randomized crossover study, Disability and Rehabilitation, 47:12, 3167-3172, DOI: 10.1080/09638288.2024.2417765

To link to this article: https://doi.org/10.1080/09638288.2024.2417765

DISABILITY AND REHABILITATION
2025, VOL. 47, NO. 12, 3167–3172
https://doi.org/10.1080/09638288.2024.2417765

Taylor & Francis
Taylor & Francis Group

RESEARCH ARTICLE

OPEN ACCESS Check for updates

Increasing or decreasing load during resistance training is not associated with changes in pain among individuals with patellar tendinopathy: a randomized crossover study

Jesper Lykkegård Toustrup[a], Kristian Damgaard Lyng[b,c], Steffen Strøager Hunniche[a], Kenneth Mølgaard[a], Jens Lykkegaard Olesen[b] and Henrik Riel[a,b,c]

[a]Department of Physiotherapy, University College of Northern Denmark, Aalborg, Denmark; [b]Center for General Practice at Aalborg University, Aalborg University, Aalborg, Denmark; [c]Department of Health Science and Technology, Faculty of Medicine, Aalborg University, Aalborg, Denmark

ABSTRACT

Objectives: This study investigated whether exercising with different relative loads would be associated with different experienced pain intensities in individuals with patellar tendinopathy.

Materials and Methods: We recruited 14 individuals with patellar tendinopathy for this randomized crossover study. In a randomized order, participants performed one set of single-legged leg presses during one session with three relative loads (6 repetition maximum (RM), 10RM, and 14RM). The primary outcome was pain during exercise measured on a 0–10 Numerical Rating Scale (NRS) (0 = no pain, 10 = worst pain), which participants rated after performing the exercise set with each relative load.

Results: No differences in pain during either of the three relative loads were observed ($F(2, 26) = 0.06$, $p = 0.942$). The participants' experienced pain was 4.5 NRS (SD1.7), 4.5 NRS (SD1.7), and 4.6 NRS (SD2.0) during the 6RM, 10RM, and 14RM loads, respectively. A secondary analysis revealed no statistically significant difference in pain intensity between the performance of the first, second, or third exercise set regardless of the load ($F(2, 26) = 1.06$, $p = 0.367$).

Conclusions: There was no difference in pain intensity during either relative load among individuals with patellar tendinopathy. Therefore, higher loads may be applied, associated with enhanced tendon adaptation.

➤ IMPLICATIONS FOR REHABILITATION

- Clinicians may tend to decrease the load if the patient suffering from patellar tendinopathy expresses pain despite no evidence supporting that reducing the load will change the pain intensity during exercise.
- This study found that all loads (6RM, 10RM, and 14RM) were associated with the same pain experience.
- Pain did not vary with different exercise loads and, therefore, should not be used as the primary guide for load selection.

ARTICLE HISTORY
Received 14 May 2024
Revised 10 October 2024
Accepted 11 October 2024

KEYWORDS
Tendon; pain measurement; exercise; tendon injuries; exercise therapy

Introduction

Patellar tendinopathy is a musculoskeletal condition with pain localized at the proximal tendon attachment of the patella tendons to the patella [1]. Patellar tendinopathy is considered a tendon-overuse injury, most seen in relatively young athletes (15–30 years old), with a prevalence twice as common in male athletes than female athletes [2]. Furthermore, the prevalence is especially high in sports with repetitive jumping, landing, and cutting movements, such as volleyball and basketball, where the prevalence is reported as high as 45% and 32%, respectively [2]. Patellar tendinopathy is a challenging condition to treat and is associated with longstanding symptoms and prolonged absence from sports participation [3,4]. Load management and progressively developing tendon and musculoskeletal unit load tolerance are central to rehabilitation [5,6]. Heavy-slow resistance training (HSR) has been suggested as part of a four-stage progressive tendon loading exercise program in rehabilitating patients with patellar tendinopathy [5]. Breda et al. found a clinically meaningful superiority of HSR compared to an eccentric exercise program traditionally used for patellar tendinopathy [7]. Still, the exercise descriptors, including acceptable pain during exercise, are debatable and often not reported sufficiently to allow for replication [8]. Several studies investigating the effect of resistance training accept pain during exercise [7,9]. A systematic review by Smith et al. has shown that exercising into pain offers a small but significant short-term effect over pain-free exercise for chronic musculoskeletal pain [10]. Trying to avoid pain during exercise by decreasing the load may hamper the effectiveness of the exercise, as tendons in healthy subjects need heavy loads to adapt *via*

CONTACT Henrik Riel heri@ucn.dk Department of Physiotherapy, University College of Northern Denmark, Selma Lagerlöfs Vej 2, Aalborg 9220, Denmark.
Supplemental data for this article can be accessed online at https://doi.org/10.1080/09638288.2024.2417765.

mechanotransduction [11]. A systematic review found that pain is often the primary criterion for adjusting load in exercise programs, based on a historical inheritance of previous protocols, but it is not supported by strong evidence [6]. Yet, clinicians may tend to decrease the load if the patient expresses pain despite no evidence supporting that reducing the load will change the pain intensity during exercise.

This study investigated whether different relative loads used during the same exercise would be associated with different pain intensities in individuals with patellar tendinopathy. This study hypothesized that higher relative loads in a resistance training exercise would be associated with increased pain intensity compared to lower loads.

Methods

Study design

This study was a randomized crossover study, where the participants were blinded to the study hypothesis. The participants were recruited *via* advertisements on social media, local sports clubs, and the University College of Northern Denmark. Three physiotherapists enrolled participants, instructed in the exercise protocol and performed the statistical analyses under the supervision of an experienced physiotherapist and researcher (HR). The clinical assessment for eligibility, baseline data collection, and exercise protocol were done in a single session. All procedures were conducted at the University College of Northern Denmark and were pilot-tested in 10 healthy participants before including the first participant. The reporting of this study follows the CONSORT statement for randomized crossover trials [12]. Ethical approval was waived by the Ethics Committee of the North Denmark Region (2021-000438) as the study was not considered interventional. All the participants were provided with written information about the test procedure 24 h before the test. During the initial assessment for eligibility, the participants gave written informed consent. The participants were informed that they could withdraw from the study at any time.

Participants

Participants were eligible if diagnosed with patellar tendinopathy, had symptoms for over two weeks, and were aged between 18 and 40. Potential participants underwent a telephone screening and subsequent clinical examination to establish the patellar tendinopathy diagnosis and rule out other sources of the participant's anterior knee pain (e.g., patellofemoral pain). The eligibility criteria were similar to previous studies on patellar tendinopathy [13,14], with inclusion criteria as follows: pain localized to the patella tendons attachment at the inferior pole of the patella during loading activities such as jumping and landing; pain at palpation; a minimum pain during testing on the single leg decline squat (SLDS) of 3/10 on an 11-point numeric rating scale (NRS, ranging from 0 indicating no pain to 10 indicating worst pain imaginable) and worst pain during the last week of ≥3 on NRS. The exclusion criteria were any concurrent knee pain (e.g., more diffuse pain presentation indicating patellofemoral pain), previous knee surgery, taking painkillers within 24 h, or having received a corticosteroid injection within the last six months. The initial assessment for eligibility was done by a physiotherapist (JLT). If the participants were eligible, demographic data were recorded, including sex, age, body mass index (BMI), weekly frequency of sports participation (including type of sport), previous contact with healthcare professionals, and whether they had unilateral or bilateral symptoms. Additionally, the participants fulfilled the Victorian Institute of Sport Assessment-Patella (VISA-P). They were asked to rate the average and worst pain intensity during the past week on NRS and pain during SLDS.

Randomization

The participants were randomized to a load sequence after collecting demographic data and performing the 10-repetition maximum (RM) test (see Exercise protocol). With three different loads, there were six possible load sequences (e.g., 6, 10, 14 or 10, 6, 14). The load sequence was block-randomized using the Williams Design, generating three blocks of six sequences in random order. Each number from 1 to 6 was paired with a letter (A, B, C, D, E, F), indicating in which order the loads should be performed. The allocation of the load sequence was generated using a random number generator on www.sealedenvelope.com and was conducted by an independent individual not involved in the study. The individual prepared concealed envelopes containing a letter indicating the allocated load sequence, which the participants opened before performing the first exercise set.

Exercise protocol

The exercise protocol consisted of a warmup, a test of the 10-RM, and an exercise session with the performance of three different loads on a resistance training exercise. This protocol was carried out based on a standardized protocol. The selected resistance training exercise was a leg-press machine, performed unilaterally on the symptomatic leg (or most symptomatic leg in participants who experienced bilateral pain) so that the participants could not compensate with the contralateral leg. The leg press is an exercise commonly used in a rehabilitation program for patellar tendinopathy [5,7]. The three relative loads for this study were 6RM, 10RM, and 14RM, defined as high, moderate, and low loads, respectively. These three loads were based on previously published exercise protocols, where the loads start at 15RM and progress to 6RM [7,9]. Firstly, the participants performed a 5-min warmup on an exercise bike with low to moderate intensity corresponding to 10–12 on a Borg 6–20 Rating Scale of Perceived Exertion. Secondly, the participant's 10RM (the maximum load that can be lifted for ten repetitions) was determined at 4 s per repetition through a minimum of 90° range of motion (ROM). The 10RM test was performed following the guidelines for RM-testing provided by the National Strength and Conditioning Association (NSCA) [15], where the load was progressively increased toward the 10RM through two to three sets. The 6RM and 14RM were estimated based on the 10RM using Brzycki's formula [16]. Subsequently, the participants performed the three different loads in accordance with the randomized sequence they were assigned. The starting position in the leg press was with extended knees, and participants were allowed to use their arms on their knees to assist in reaching the starting position. The exercise was performed with a ROM of 90° of knee flexion and a pace of two seconds per eccentric contraction, zero seconds isometric, and two seconds concentric contraction (pace guided verbally). Each set was performed to failure (meaning that the participants were allowed to perform more reps than the estimated RM), with a three-minute rest interval between each set.

Outcomes

The primary outcome measure was pain intensity during the leg press. Pain intensity was measured using NRS, a reliable and valid

measure of pain intensity in clinical practice [17]. NRS has been used as the primary outcome in other trials of patients with patellar tendinopathy [13,14,18], and the minimal clinical important difference (MCID) is 2 in patients suffering from chronic musculoskeletal pain [19]. The NRS score was anchored with 0 indicating "no pain" and 10 indicating "worst pain imaginable". The participants were asked, "On a scale from 0 to 10, how would you rate the pain intensity during the exercise?" immediately after completing each set with the prescribed load. The secondary outcome was perceived exertion during the exercise set measured using the BORG Scale, a 15-point scale ranging from 6, indicating no exertion, to 20, indicating absolute maximum exertion. This outcome was primarily included to strengthen the blinding of the study hypothesis for the participants rather than to address the study's objective.

Sample size

We used G*Power (vers. 3.1.9.6. Heinrich-Heine-Universität Düsseldorf, Germany) to calculate the sample size. The study was powered to detect a between-load difference corresponding to a medium effect size of 0.5. Using a significance level of 0.05 and a power of 0.9, the sample size required for this crossover study was 12 participants. To account for potential dropouts during the study, we included 14 participants.

Statistical analysis

The primary investigator who performed the statistical analyses was not blinded to the group allocation. The analysis was done in collaboration with an experienced researcher (HR). The data were visually checked for normality by visually examining histograms and Q-Q plots. Descriptive statistics were used to summarize the participants' demographic characteristics. The assumption of negligible carryover effects was investigated with preliminary unpaired t-tests of the participants' NRS scores [20]. A one-way repeated measures analysis of variance (ANOVA) was used to determine the within-subject mean difference of the primary outcome. The independent variable (within-subject factor) was exercise loads, with pain intensity being the dependent variable. The one-way repeated measures ANOVA was also used for the secondary outcome. A significance level of 0.05 was set, and if the assumption of sphericity was violated, as indicated by the results of Mauchly's sphericity test, the Greenhouse-Geisser adjustment was applied. Post-hoc pairwise comparisons of means were conducted using Tukey's method. To explore the effect of the sequence in which exercises were performed regardless of the load, we also used a one-way repeated measures ANOVA. The conclusion was based only on the result of the primary outcome. All statistical analyses were conducted using Stata (vers. 17.0., Stata Corp., College Station, Tx), and descriptive data are presented as mean (±SD) or frequencies.

Results

From October 2021 to October 2022, we screened 23 potential participants, first by telephone and then by physical examination. Reasons for exclusion were: worst pain intensity last week below 3 ($n=4$), no pain during SLDS ($n=1$), concurrent knee pain ($n=2$), and logistical issues [2]. None of the 14 participants dropped out during the exercise protocol. Participant characteristics are presented in Table 1. 13 out of 14 participants were participating in at least one sports or training activity on a weekly basis. These activities were: strength training ($n=3$), CrossFit ($n=3$), or weightlifting ($n=3$), with others participating in running ($n=2$), basketball ($n=1$), football ($n=1$) and rope skipping ($n=1$). The mean (SD) reps performed for 6RM, 10RM, and 14RM were 5.7 (1.4), 10.2 (2.4), and 14.5 (3.0), respectively. The mean (SD) kilograms used during the leg press were 127.4 (60.8), 112.2 (55.0), and 95.1 (47.2) for the 6RM, 10RM, and 14RM, respectively.

Table 1. Participant demographics and characteristics[a].

Male (%)	10 (71%)
Age, years	25.7 (6.3)
BMI (kg/m^2)	26 (3.3)
VISA-P score (0–100, 100 being best)	65.5 (9.7)
Symptom duration, median (IQR), months	3 (2–12)
Symptom duration. *n*(%)	
<3 months	5 (36%)
>3 months	2 (14%)
>6 months	7 (50%)
Bilateral pain (% Yes)	6 (42%)
Contact with healthcare professionals due to patellar tendon pain (% Yes)	7 (50%)
Worst pain last week (NRS, 0–10)	5.9 (1.4)
Average pain last week (NRS, 0–10)	3.9 (1.1)
Pain during SLDS (NRS, 0–10)	4.8 (1.4)
Weekly sports participation (number of days per week)	3.8 (2.6)

BMI: Body Mass Index; VISA-P: Victorian Institute of Sport Assessment-Patella; NRS: Numeric Rating Scale; SLDS: Single-Leg Decline Squat; IQR: Interquartile Range.
[a]Values are reported as mean (standard deviation), unless otherwise stated.

Between-load differences

For the primary outcome, there were no statistically significant differences in pain intensity between the three loads ($F(2, 26) = 0.06$, $p=0.942$). The mean (±SD) pain intensity NRS score was 4.5 (± 1.70) for high load, 4.5 (± 1.74) for moderate load, and 4.6 (± 2.0) for low load (Figure 1). Post-hoc pairwise comparisons revealed no significant mean difference between high compared to moderate load (0.00, 95% CI: −1.65 to 1.65, $p=1.000$), no significant mean difference between high compared to low load (0.14, 95% CI: −1.5 to 1.8, $p=0.976$), and no significant mean difference between low compared to high and moderate (0.14, 95% CI: −1.5 to 1.8, $p=0.976$). The individual NRS scores for each participant are shown in Figure 2.

For the secondary outcome, a statistically significant difference was observed on the BORG Scale among the three loads ($F(2, 26) = 10.69$, $p<0.001$). The mean (±SD) scores on the BORG scale were 12.3 (± 1.65), 13.57 (± 1.28), and 14 (± 0.99) for high, moderate, and low loads, respectively. Post-hoc pairwise comparisons revealed a significant mean difference between high (6RM) and low loads (14RM) (1.57, 95% CI: 0.34 to 2.8, $p=0.010$), with higher scores during the 14RM load. No significant mean differences were found between high and moderate loads (1.07, 95% CI: −0.16 to 2.30, $p=0.099$) or between moderate and low loads (0.5, 95% CI: −0.73 to 1.73, $p=0.588$). The exploratory analysis revealed no statistically significant difference in pain intensity between the performance of the 1st, 2nd, and 3rd exercise sets ($F(2, 26) = 1.06$, $p=0.367$).

Discussion

This randomized crossover study investigated whether different relative loads during a resistance training exercise would result in different pain intensities in individuals with patellar

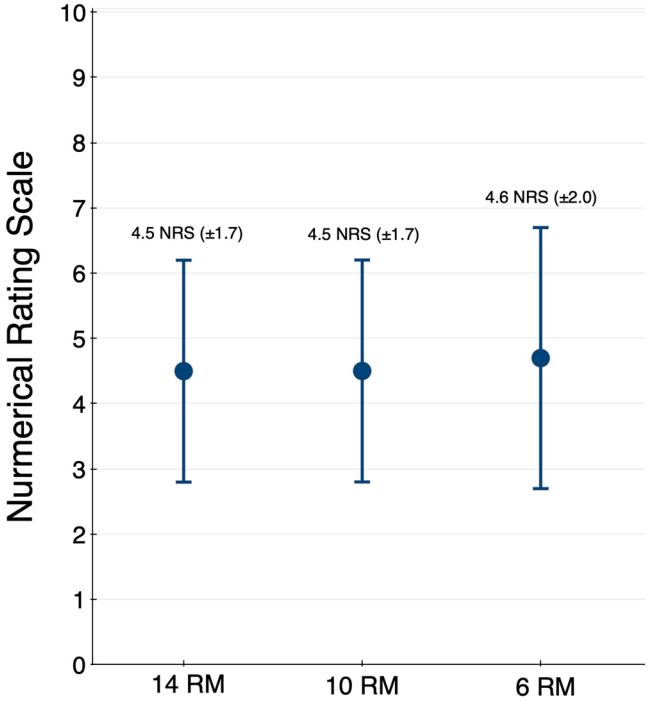

Figure 1. Means and standard deviations of pain ratings during each relative load measured on a 0–10 Numerical Rating Scale.

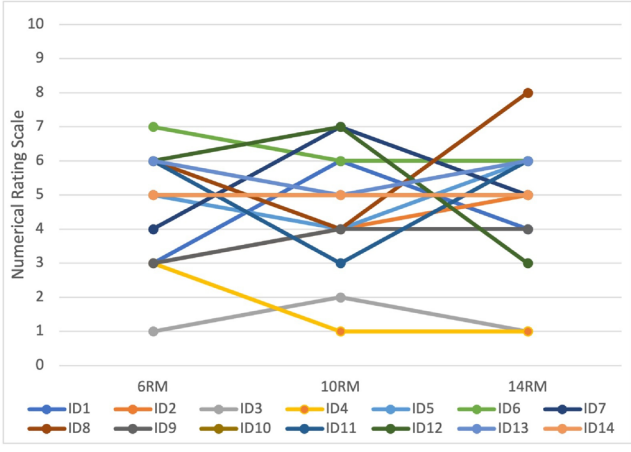

Figure 2. Individual participant ratings of pain during each relative load measured on a 0–10 Numerical Rating Scale.

tendinopathy. Contrary to our predefined hypothesis, higher loads were not associated with increased pain intensity when compared to lower loads. This was the first study to compare the pain-provoking effects of 14RM, 10RM, and 6RM on NRS during resistance training in individuals with patellar tendinopathy.

Explanation of findings

A study in runners diagnosed with Achilles tendinopathy investigated how different common rehabilitation exercises (such as heel raises and jumping exercises) affected the Achilles tendon and the relationship between Achilles tendon forces and pain during these exercises [21]. The study reported no to a small correlation between tendon load and pain intensity, highlighting that tendon load and pain do not follow a linear relationship. This may help to explain our findings. The number of repetitions could play a role as participants performed as many repetitions as possible with any given load, meaning that participants performed the fewest repetitions with the 6RM load and the most with the 14RM load. This would not have been a factor if participants had been asked to perform 6 repetitions with all loads. However, this would not have reflected clinical practice as patients are typically asked to perform exercises to failure or near failure. Our secondary analysis, which explored pain during the 1st versus 2nd versus 3rd set regardless of the load, found no difference. Therefore, the accumulated volume during an exercise session does not seem to influence pain during exercise.

Clinical and research implications

Current guidelines for managing tendinopathy recommend using an approach in clinical practice in which the prescription of exercise load is adjusted according to the individual's symptoms [5,22]. The approach of using a pain-based criterion for load progression is shown to be the most used in lower-limb tendinopathy by a systematic review including 30 studies [6]. In the systematic review, the authors stated that load progression was influenced by pain experience and not by tendon capacity, which is not supported by the literature [6]. The results of our study do not support the use of pain during exercise as a tool to determine an acceptable load for patients during an isolated exercise session. Additionally, caution should be taken when considering a reduction in load solely based on the patient's pain experience during resistance training. An increasing body of literature suggests that pain during exercise may be beneficial compared to pain-free exercises in increasing function and recovery in musculoskeletal disorders [10]. Interestingly, our findings highlight that both high, moderate, and low-load exercise can be applied to patients' rehabilitation despite being painful. However, it is important to note that these results pertain solely to the acute response to exercise. Clinically, our findings may be used to reassure patients to accept various loads in their rehabilitation regardless of their pain levels and thereby more confidently return to or maintain loading activities.

A pain experience is influenced by biological mechanisms [23], and treatment has often been focused on addressing tendon structure and physical factors [24,25]. Contemporary research has highlighted how psychological and social factors influence the pain experience [26], and a recent consensus paper has stated the importance of measuring psychological factors [27] due to their possible effect on treatment outcomes and prognosis [26,28]. Our findings may suggest that the pain experience is affected by factors other than the biomechanical load on the tissue. Vaegter et al. found that negative information before an exercise influenced exercise-induced hypoalgesia in pain-free individuals [29]. This emphasizes the importance of how clinicians inform patients about exercises.

Our study only measured pain intensity during a single exercise session. In patients with patellar tendinopathy, pain may improve during exercise but often increases the day after exercise [30]. In assessing load tolerance during rehabilitation, studies have suggested that pain up to 24 h after pain-provoking exercises may be acceptable [9,31]. Therefore, future studies could investigate how different loads affect pain intensity 24 h after exercise.

Strengths and limitations

One of the study's main strengths is in the crossover design, as each participant was compared to themselves during the different loads as opposed to recruiting participants who would then be

randomized to the loads in three groups. Other strengths to mention are the use of the leg press exercise, as this is a commonly used exercise in the rehabilitation of individuals with patellar tendinopathy, and the fact that the participants were participating in several different sports. Both factors increase the transferability of our findings to clinical practice.

This study was not without limitations. The study's primary limitation was the lack of blinding of the intervention, outcome assessors, and statistical analyses. The nature of the interventions makes it difficult to blind the participants; however, the assessment of perceived exertion was an attempt to blind participants toward the study's aim. Another limitation arises from the lack of precision in estimating 6RM and 14RM based on a 10RM. For some participants, there was only a two-repetition difference between loads (i.e., participants performing 8 repetitions with their estimated 6RM). This unintended lack of load differentiation may have affected the possibility of detecting a notable difference in NRS between the loads.

Conclusion

There was no difference in pain intensity during resistance training between low, moderate, and high exercise loads among individuals with patellar tendinopathy. These findings suggest that reducing exercise load is not necessarily required to alleviate pain during exercises performed to failure, as pain reduction does not consistently correlate with load modification, and vice versa. Hence, future research should consider investigating the effect of different relative loads on pain intensity more prospectively hours or days after exercise.

Acknowledgements

This study did not receive external funding. The authors state no conflicts of interest.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This study did not receive external funding.

References

[1] Rudavsky A, Cook J. Physiotherapy management of patellar tendinopathy (jumper's knee). J Physiother. 2014;60(3):122–129. https://www.clinicalkey.es/playcontent/1-s2.0-S1836955314000915 doi: 10.1016/j.jphys.2014.06.022.

[2] Lian ØB, Engebretsen L, Bahr R. Prevalence of jumper's knee among elite athletes from different sports: a cross-sectional study. Am J Sports Med. 2005;33(4):561–567. doi: 10.1177/0363546504270454.

[3] Kettunen JA, Kvist M, Alanen E, et al. Long-term prognosis for jumper's knee in male athletes: prospective follow-up study. Am J Sports Med. 2002;30(5):689–692. doi: 10.1177/03635465020300051001.

[4] Zwerver J, Bredeweg SW, van den Akker-Scheek I. Prevalence of jumper's knee among nonelite athletes from different sports a cross-sectional survey. Am J Sports Med. 2011;39(9):1984–1988. https://www.narcis.nl/publication/RecordID/oai:pure.rug.nl:publications/904f16c6-c2d1-47da-ab0f-03911e2b5dc6 doi: 10.1177/0363546511413370.

[5] Malliaras P, Cook J, Purdam C, et al. Patellar tendinopathy: clinical diagnosis, load management, and advice for challenging case presentations. J Orthop Sports Phys Ther. 2015;45(11):887–898. https://www.ncbi.nlm.nih.gov/pubmed/26390269 doi: 10.2519/jospt.2015.5987.

[6] Escriche-Escuder A, Casaña J, Cuesta-Vargas AI. Load progression criteria in exercise programmes in lower limb tendinopathy: a systematic review. BMJ Open. 2020;10(11):e041433. doi: 10.1136/bmjopen-2020-041433.

[7] Breda SJ, Oei EHG, Zwerver J, et al. Effectiveness of progressive tendon-loading exercise therapy in patients with patellar tendinopathy: a randomised clinical trial. Br J Sports Med. 2021;55(9):501–509. https://www.narcis.nl/publication/RecordID/oai:pure.rug.nl:publications/091ce7ed-4bd7-4ce9-9260-ae562b71a0bd doi: 10.1136/bjsports-2020-103403.

[8] Smith BE, Riel H, Vicenzino B, et al. Elephant in the room: how much pain is ok? If physiotherapy exercise RCTs do not report it, we will never answer the question. Br J Sports Med. 2020;54(14):821–822. doi: 10.1136/bjsports-2019-101289.

[9] Kongsgaard M, Kovanen V, Aagaard P, et al. Corticosteroid injections, eccentric decline squat training and heavy slow resistance training in patellar tendinopathy. Scand J Med Sci Sports. 2009;19(6):790–802. https://api.istex.fr/ark:/67375/WNG-PGS2NQDK-3/fulltext.pdf doi: 10.1111/j.1600-0838.2009.00949.x.

[10] Smith BE, Hendrick P, Smith TO, et al. Should exercises be painful in the management of chronic musculoskeletal pain? A systematic review and meta-analysis. Br J Sports Med. 2017;51(23):1679–1687. doi: 10.1136/bjsports-2016-097383.

[11] Bohm S, Mersmann F, Arampatzis A. Human tendon adaptation in response to mechanical loading: a systematic review and meta-analysis of exercise intervention studies on healthy adults. Sports Med Open. 2015;1(1):7. doi: 10.1186/s40798-015-0009-9.

[12] Dwan K, Li T, Altman DG, et al. CONSORT 2010 statement: extension to randomised crossover trials. BMJ. 2019;366:l4378. doi: 10.1136/bmj.l4378.

[13] Holden S, Lyng K, Graven-Nielsen T, et al. Isometric exercise and pain in patellar tendinopathy: a randomized crossover trial. J Sci Med Sport. 2020;23(3):208–214. doi: 10.1016/j.jsams.2019.09.015.

[14] Rio E, Kidgell D, Purdam C, et al. Isometric exercise induces analgesia and reduces inhibition in patellar tendinopathy. Br J Sports Med. 2015;49(19):1277–1283. doi: 10.1136/bjsports-2014-094386.

[15] Baechle T, Earle R. Essentials of strength training and conditioning. 3rd ed. Champaign, IL: Human Kinetics; 2008. p. 641.

[16] Brzycki M. Strength testing-predicting a one-rep max from reps-to-fatigue. J Phys Educ Recreat Dance. 1993;64(1):88–90. doi: 10.1080/07303084.1993.10606684.

[17] Karcioglu O, Topacoglu H, Dikme O, et al. A systematic review of the pain scales in adults: which to use? Am J Emerg Med. 2018;36(4):707–714. doi: 10.1016/j.ajem.2018.01.008.

[18] van Ark M, Cook JL, Docking SI, et al. Do isometric and isotonic exercise programs reduce pain in athletes with patellar tendinopathy in-season? A randomised clinical trial. J Sci Med Sport. 2016;19(9):702–706. https://www.clinicalkey.es/playcontent/1-s2.0-S1440244015002315 doi: 10.1016/j.jsams.2015.11.006.

[19] Salaffi F, Stancati A, Alberto Silvestri C, et al. Minimal clinically important changes in chronic musculoskeletal pain

intensity measured on a numerical rating scale. Eur J Pain. 2004;8(4):283–291. doi: 10.1016/j.ejpain.2003.09.004.

[20] Wellek S, Blettner M. On the proper use of the crossover design in clinical trials: part 18 of a series on evaluation of scientific publications. Dtsch Arztebl Int. 2012;109(15):276–281. http://www.ncbi.nlm.nih.gov/pubmed/22567063 doi: 10.3238/arztebl.2012.0276.

[21] Sancho I, Willy RW, Morrissey D, et al. Achilles tendon forces and pain during common rehabilitation exercises in male runners with Achilles tendinopathy. A laboratory study. Phys Ther Sport. 2023;60:26–33. doi: 10.1016/j.ptsp.2023.01.002.

[22] Grävare Silbernagel K, Crossley KM. A proposed return-to-sport program for patients with midportion achilles tendinopathy: rationale and implementation. J Orthop Sports Phys Ther. 2015;45(11):876–886. doi: 10.2519/jospt.2015.5885.

[23] Cook JL, Purdam CR. Is tendon pathology a continuum? A pathology model to explain the clinical presentation of load-induced tendinopathy. Br J Sports Med. 2009;43(6):409–416. doi: 10.1136/bjsm.2008.051193.

[24] Malliaras P, Barton CJ, Reeves ND, et al. Achilles and patellar tendinopathy loading programmes: a systematic review comparing clinical outcomes and identifying potential mechanisms for effectiveness. Sports Med. 2013;43(4):267–286. doi: 10.1007/s40279-013-0019-z.

[25] Cook J, Rio E, Purdam CR, et al. Revisiting the continuum model of tendon pathology: what is its merit in clinical practice and research? Br J Sports Med. 2016;50(19):1187–1191. doi: 10.1136/bjsports-2015-095422.

[26] Slagers AJ, van Veen E, Zwerver J, et al. Psychological factors during rehabilitation of patients with Achilles or patellar tendinopathy: a cross-sectional study. Phys Ther Sport. 2021;50:145–152. https://www.sciencedirect.com/science/article/pii/S1466853X2100081X doi: 10.1016/j.ptsp.2021.04.010.

[27] Stubbs C, McAuliffe S, Chimenti RL, et al. Which psychological and psychosocial constructs are important to measure in future tendinopathy clinical trials? A modified international delphi study with expert clinician/researchers and people with tendinopathy. J Orthop Sports Phys Ther. 2024;54(1):14–25. doi: 10.2519/jospt.2023.11903.

[28] Stubbs C, Mc Auliffe S, Mallows A, et al. The strength of association between psychological factors and clinical outcome in tendinopathy: A systematic review. PLOS One. 2020;15(11):e0242568. doi: 10.1371/journal.pone.0242568.

[29] Vaegter HB, Thinggaard P, Madsen C, et al. Power of words: influence of preexercise information on hypoalgesia after exercise – randomized controlled trial. Med Sci Sports Exerc. 2020;52(11):2373–2379. doi: 10.1249/MSS.0000000000002396.

[30] Rio E, Moseley L, Purdam C, et al. The pain of tendinopathy: physiological or pathophysiological? Sports Med. 2014;44(1):9–23. doi: 10.1007/s40279-013-0096-z.

[31] Silbernagel KG, Thomeé R, Thomeé P, et al. Eccentric overload training for patients with chronic Achilles tendon pain – a randomised controlled study with reliability testing of the evaluation methods. Scand J Med Sci Sports. 2001;11(4):197–206. https://api.istex.fr/ark:/67375/WNG-13PB3HRJ-V/fulltext.pdf doi: 10.1034/j.1600-0838.2001.110402.x.