

Effects of Eccentric Exercise Associated with Patellofemoral Tendinopathy: A Systematic Review

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Background: Patellofemoral tendinopathy is a common condition that is associated with anteromedial knee pain due to chronic repetitive tendon overloading. Physical therapy in combination with an eccentric exercise program has been thought to be the gold standard of treatment for patellofemoral tendinopathy. The aim of this study was to examine the literature regarding the effectiveness of treating patellofemoral tendinopathy with eccentric exercise and other interventions.

Methods: A literature search of Medline Complete, PubMed, CINAHL Complete, and Journal of Science and Medicine in Sports was conducted using PEDro guidelines.

Results: Eight articles met our selection criteria. The 8 articles investigated individuals who all had pain at the inferior pole of the patella or were diagnosed via ultrasound for patellar tendinopathy. The articles investigated the effects of eccentric exercise versus other treatments such as, progressive tendon-loading exercise therapy (PTLE), extracorporeal shock wave therapy (ESWT), percutaneous electrolysis (PNE), dry needling (DN), and concentric hip muscle strengthening. Ultimately, each treatment resulted in decreased pain and patellar stiffness, along with improvement in outcome measures, but it was found that no intervention was more effective than eccentric exercise alone, besides progressive tendon-loading exercise therapy.

Conclusions: Moderate to strong mixed evidence exists to show the effect of eccentric exercise in combination with other interventions decreases patellofemoral pain and increased functional mobility in individuals with patellofemoral tendinopathy. Progressive tendon-loading exercise therapy was the one treatment that showed more significant improvements in outcome measures compared to eccentric exercise therapy and requires further research to back this finding.

Key Words: Patellar tendinopathy, Eccentric, Patellar tendinosis, Eccentric exercise, Concentric exercise, Tendinopathy

Introduction

Patellar tendinopathy is a common condition affecting a variety of individuals. Characteristics of this condition involve pain on the anteromedial aspect of the knee between patella and tibial tuberosity[1-7]. Additionally, research has shown mechanical properties of tendons can become dysfunctional in individuals with tendinopathies[1-4, 8-10]. Eccentric exercise is an intervention believed to specifically target tendons via the tension loading of musculotendinous units in an elongated position[11-15]. Moreover, eccentric exercise has long

been held as the gold standard in managing patellar tendinopathies.

While many hold eccentric exercise as the gold standard, research has yet to show whether other forms of exercise are equally or possibly more beneficial. Additionally, the question still remains whether other forms of exercise change pain levels in addition to eccentric exercise. Recent research appears to dissuade the belief that eccentric exercise truly triumphs other forms of exercise in addressing pain and/or tendon mechanical properties[8, 11, 16].

Isometric exercise, for example, can theoretically

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improve tendon properties, as the muscle unit must generate significant tension on a tendon at a fixed load, thus improving tendon stiffness. While eccentric exercise theoretically should increase loading of the tendon, in reality, the muscle is simply contracting to decrease velocity of the weight lowering[17]. In concentric-based exercise, the muscle must produce sufficient force to overcome load, and so, transfer of the force through its tendinous unit to the bone. The physiological function of concentric exercise, therefore, could yield an improved outcome of tendon properties and pain, as the tendon should experience less repetitive strain[18].

This systematic review sought to investigate the relationship between various forms of exercise with pain and function of patellar tendinopathies. The purpose of this review is identifying the most effective exercise for addressing (1) pain, (2) tendon properties, or (3) both. There has not been a systematic review conducted on this topic recently, and newer research on this topic has emerged. Due to that fact, we believe this systematic review was critical to perform at this time.

Materials and Methods

A literature review was performed across four databases: MEDLINE Complete, PubMed, CINHAL Complete, and Journal of Science and Medicine in Sports. The search limits required peer-reviewed articles, full text availability, timeline of 2018-2022, and written in English. Selection criteria included RCTs, subjects 18+ years old, and intervention including eccentric exercises. Each article was evaluated to have greater than a 6/10 on the PEDro scale by investigators.

Results

Of the 145 articles identified during research, only 11 met the standard for further investigation, and only 8 met our selection criteria. All 8 studies were randomized control trials with sample sizes ranging from 20-76 participants(n=378) who all had pain at the inferior pole of the patella or were diagnosed via

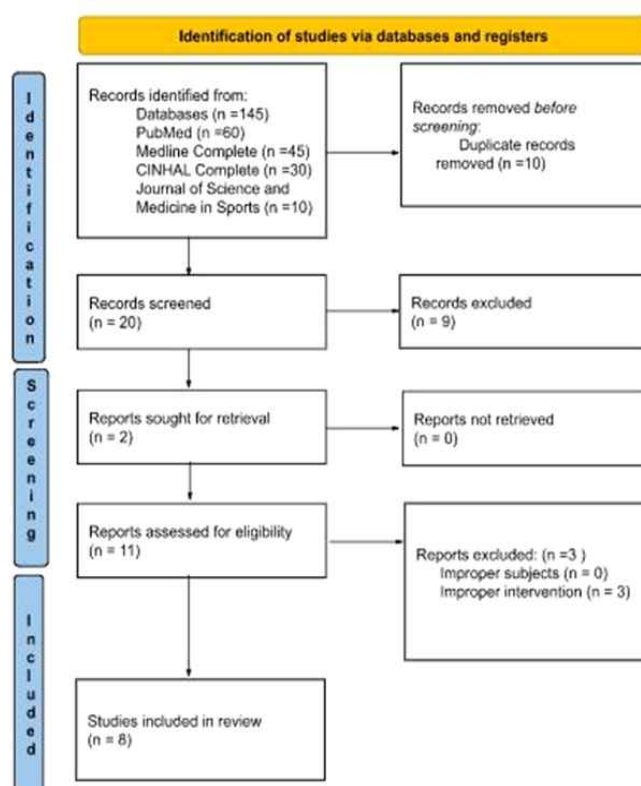


Chart 1. PRISMA Flowchart

Table 1. Summary Table

Articles	Interventions	Outcome Measures	PEDro Scores
Abián-Vicén J, Martínez F, Jiménez F, Abián P [22]	Single leg eccentric drop squat: slow, fast, or no training	<ul style="list-style-type: none"> • TMG assessment • 5RM • Isometric and Isokinetic testing 	8/12
Acaröz Candan S, Sözen H, Arı E [20]	EMG activity of quadricep muscles during eccentric exercise	<ul style="list-style-type: none"> • Percent of muscle recruitment 	8/12
Breda SJ, de Vos RJ, Krestin GP, Oei EH G [16]	Progressive tendon-loading exercise therapy(PTLE) vs eccentric exercise therapy(EET)	<ul style="list-style-type: none"> • VISA-P 	9/12
Breda SJ, Oei EH G, Zwerver J, et al [11]	Progressive tendon loading(PTLE) vs pain-provoking eccentric exercise (EET)	<ul style="list-style-type: none"> • VISA-P • Return rate to sports • Patient Satisfaction • Exercise adherence 	9/12
Lee W-C, Ng GY-F, Zhang Z-J, Malliaras P, Masci L, Fu S-N[8]	Eccentric squats	<ul style="list-style-type: none"> • VISA-P 	7/12
López-Royo MP, Gómez-Trullén EM, Ortiz-Lucas M,etal[23]	Eccentric exercises with percutaneous needle electrolysis, dry needling, or placebo needling	<ul style="list-style-type: none"> • VISA-P • VAS • SF-36 • Jump Test 	11/12
López-Royo MP, Ríos-Díaz J, Galán-Díaz RM, Herrero P, Gómez-Trullén EM [19]	Dry needling vs percutaneous electrolysis vs eccentric exercise	<ul style="list-style-type: none"> • VISA-P • VAS • SF-36 	9/12
MacDonald K, Day J, Dionne C [21]	Eccentric exercise vs eccentric exercise and hip strengthening	<ul style="list-style-type: none"> • VISA-P • LEFS • VAS • Jump distance 	9/12

ultrasound for patellar tendinopathy. The average PEDro score for this review was 8.75/12. The following peer-reviewed articles were examined for patella tendinopathy.

Breda et al. found that the progressive tendon-loading exercise therapy (PTLE) significantly decreased patellar tendon stiffness after 12 and 24 weeks[11]. Compared to the eccentric exercise therapy (EET), both groups showed significant improvements in their VISA-P scores at 12 and 24 weeks, however the PTLE group showed larger improvements overall. In Breda SJ et al., they found that both the PTLE and EET groups showed significant improvements in VISA-P scores at 24 weeks but favored the PTLE group. The return to sports was not statistically significant at 12 or 24 weeks for either group. VAS pain scores were also significantly lower in the PTLE group at 24 weeks compared to the EET group[16].

In Lee W-C et al. they could not find that com-

paring exercise and extracorporeal shock wave therapy was more effective than eccentric exercise alone[8]. Lopez-Royo et al. found that eccentric exercise combined with percutaneous needle electrolysis group demonstrated significant improvements 1 month post treatment and improved symptoms for 10+ years compared to the eccentric group only. They also found that dry needling or percutaneous needling combined with eccentric training were not statistically significant when compared to eccentric therapy alone[19]. Acaroz et al discovered that maximal voluntary isometric contractions displayed increased muscle activation throughout the quadriceps muscle group[20].

Macdonald et al. demonstrated that eccentric exercises combined with concentric hip strengthening was not more effective than eccentric exercise alone[21]. Both groups showed significant improvements in LEFS and VISA-P scores at 24 weeks. The eccentric group

was found to have improved triple hop jump distance scores at 4 and 12 weeks unlike the combination group. In Abian-Vicen, they used 80% 1RM single leg squat to measure improvement. Groups were broken down into no treatment, 6 second eccentric holds and 3 second eccentric holds. It was found that neither the 6 second-hold or 3 second-hold group produced statistically significant increases in muscle strength or recruitment. Therefore, the authors concluded that hold time was nebulous and that eccentric strengthening was effective versus the control group in this patient population[22].

Discussion

All the participants in the chosen studies were between the ages of 18 and 50 years old with a diagnosis of patellar tendinopathy. All but one study looked at VISA-P as an outcome measure for the evaluation of symptom severity, knee function, and athletes' ability to play sports. Additional outcome measures analyzed in the studies included pain via the VAS, quality of life via the SF-26, return to sport, patellar tendon stiffness, and patient satisfaction. All the articles had an intervention of eccentric exercise therapy(EET) for the treatment of the participants' patellar tendinopathy. Each article compared EET to a combination of treatments. Different combinations that were analyzed included EET with progressive tendon loading exercise therapy(PTLE), EET with dry needling(DN), EET with percutaneous needle electrolysis (PNE), EET with extracorporeal shock wave therapy (ESWT), and EET with concentric hip muscle strengthening. The majority of the articles stated the combination of interventions had no significant difference in outcomes compared to EET alone. All groups showed significant improvements in outcome measures, but no significant differences between combinations and EET. The only exception is when comparing EET with PTLE. There were two articles comparing these intervention groups, and both of those articles found the same results. It was found that both EET and PTLE groups showed significant improvements, but the PTLE group showed better improvements in multiple different outcome measures, including VISA-P, patellar tendon

stiffness, and VAS ratings, all following 24 weeks of treatment.

Eccentric exercise has long been held as the gold standard treatment for patellar tendinopathies[7, 9]. Therefore, the findings supporting the benefits of eccentric exercise alone weren't surprising. However, it was surprising that combination treatments didn't result in more improvement than EET alone as it was expected for multiple treatments in addition to eccentric exercise to show more improvements. It was also interesting that the intervention of PTLE showed better improvements compared to EET, which goes against EET being the best treatment for patellar tendinopathy. Overall, EET is a beneficial treatment of patellar tendinopathy. PTLE may be an even better treatment for patellar tendinopathy than EET, but further research is needed to support this. Additional research should also include a combination intervention of PTLE with EET to determine if the combination of those would produce better results.

There were limitations in some of the articles that also would suggest a need for further research. One article only included males in their study, and other articles included mostly male participants, affecting the generalizability to females with patellar tendinopathy. There were also three articles that potentially had bias by there being a lack of blinding and having one person conduct all treatments with a preference for one working over the other(s). Further research can pick up on these limitations which would allow for more significant interpretation and generalization of the findings. There were also strengths to this systematic review, including the selection of only randomized control trials, which allowed for more reliable interpretation of results. It was also beneficial to look at multiple different types of combination treatments with EET to broaden the findings and have a better feel on the comparative benefits of eccentric exercise alone.

Conclusions

There is moderate to strong mixed evidence to show the effect of eccentric exercise in combination with other interventions decreases patellofemoral pain and increased functional mobility in individuals with pate-

llofemoral tendinopathy. However, additional benefits of eccentric exercise in combination with supplemental interventions compared to eccentric exercise alone need to be studied. Progressive tendon-loading exercise therapy showed more significant improvements in outcome measures compared to eccentric exercise therapy and requires further research to back this finding.

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We have no acknowledgments.

Declaration of Interest

We declare no conflict of interest.

Ethical Statement

Ethical approval was not required for this systematic review. All authors followed the PEDRo guidelines during the article search process.

Reference

- Schwartz A, Watson JN, Hutchinson MR. Patellar Tendinopathy. *Sports Health*. 2015 Sep-Oct;7(5): 415-20. doi: 10.1177/1941738114568775.
- Challoumas D, Pedret C, Biddle M, et al. Management of patellar tendinopathy: A systematic review and network meta-analysis of Randomised Studies. *BMJ Open Sport & Exercise Medicine*. 2021;7(4). doi:10.1136/bmjsem-2021-001110
- Scott A, Squier K, Alfredson H, et al. Icon 2019: international scientific tendinopathy symposium consensus: clinical terminology. *Br J Sports Med* 2020;54:260-2.
- Hopkins C, Fu S-C, Chua E, et al. Critical review on the socioeconomic impact of tendinopathy. *Asia Pac J Sports Med Arthrosc Rehabil Technol* 2016; 4:9-20.
- Ian OB, Engebretsen L, Bahr R. Prevalence of jumper's knee among elite athletes from different sports: a cross-sectional study. *Am J Sport Med* 2005;33:561-7.
- Doelen TV, Jelly W. Non-surgical treatment of Patellar tendinopathy: a systematic review of randomised controlled trials. *JSAMS* 2020;23:118-24.
- Gaida JE, Cook J. Treatment options for Patellar tendinopathy: critical review. *Curr Sports Med Rep* 2011;10:255-70.
- Lee W-C, Ng GY-F, Zhang Z-J, Malliaras P, Masci L, Fu S-N. Changes on Tendon Stiffness and Clinical Outcomes in Athletes Are Associated With Patellar Tendinopathy After Eccentric Exercise. *Clinical journal of sport medicine/official journal of the Canadian Academy of Sport Medicine*. 2020; 30(1):25-32. doi:10.1097/JSM.0000000000000562
- Lim HY, Wong SH. Effects of isometric, eccentric, or heavy slow resistance exercises on pain and function in individuals with Patellar tendinopathy: a systematic review. *Physiother Res Int* 2018;23:e1721.
- Higgins JPT, Altman DG, Gøtzsche PC, et al. The Cochrane collaboration's tool for assessing risk of bias in randomised trials. *BMJ* 2011;343:d5928.
- 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. doi:10.1136/bjsports-2020-103403
- Guyatt GH, Oxman AD, Vist GE, et al. Grade: an emerging consensus on rating quality of evidence and strength of recommendations. *BMJ* 2008;336:924-6.
- Puhan MA, Schünemann HJ, Murad MH, et al. A grade Working group approach for rating the quality of treatment effect estimates from network meta-analysis. *BMJ* 2014;349:g5630.
- Ma J, Liu W, Hunter A, et al. Performing meta-analysis with incomplete statistical information in clinical trials. *BMC Med Res Methodol* 2008;8:56.
- Abat F, Sánchez-Sánchez JL, Martín-Nogueras AM, et al. Randomized controlled trial comparing the effectiveness of the ultrasound-guided galvanic electrolysis technique (USGET) versus conventional electro-physiotherapeutic treatment on Patellar tendinopathy. *J Exp Orthop* 2016;3:34.
- Breda SJ, de Vos RJ, Krestin GP, Oei EHG. Decreasing patellar tendon stiffness during exercise therapy for patellar tendinopathy is associated with

- better outcome. *J Sci Med Sport*. 2022;25(5):372-378. doi:10.1016/j.jsams.2022.01.002
17. Agergaard A-S, Svensson RB, Malmgaard-Clausen NM, et al. Clinical outcomes, structure, and function improve with both heavy and moderate loads in the treatment of Patellar tendinopathy: a randomized clinical trial. *Am J Sports Med* 2021;49:982-93.
 18. Bahr R, Fossan B, Løken S, et al. Surgical treatment compared with eccentric training for Patellar tendinopathy (jumper's knee). A randomized, controlled trial. *J Bone Joint Surg Am* 2006;88:1689-98.
 19. López-Royo MP, Ríos-Díaz J, Galán-Díaz RM, Herrero P, Gómez-Trullén EM. A comparative study of treatment interventions for patellar tendinopathy: A randomized controlled trial. *Arch Phys Med Rehabil*. 2021;102(5):967-975. doi:10.1016/j.apmr.2021.01.073.
 20. Acaröz Candan S, Sözen H, Arı E. Electromyographic activity of quadriceps muscles during eccentric squat exercises: implications for exercise selection in patellar tendinopathy[published online ahead of print, 2021 Dec 2]. *Res Sports Med*. 2021;1-11. doi:10.1080/15438627.2021.2010200.
 21. MacDonald K, Day J, Dionne C. Effect of Eccentric Exercises at the Knee with Hip Muscle Strengthening to Treat Patellar Tendinopathy in Active Duty Military Personnel: A Randomized Pilot. *Orthopaedic Physical Therapy Practice*. 2019;31(1):8-16. Accessed September15, 2022.
 22. Abián-Vicén J, Martínez F, Jiménez F, Abián P. Effects of Eccentric Single-Leg Decline Squat Training Performed With Different Execution Times on Maximal Strength and Muscle Contraction Properties of the Knee Extensor Muscles[published online ahead of print, 2021 Jun 2]. *J Strength Cond Res*. 2021;10.1519/JSC.0000000000004063. doi:10.1519/JSC.0000000000004063.
 23. López-Royo MP, Gómez-Trullén EM, Ortiz-Lucas M, et al. Comparative study of treatment interventions for patellar tendinopathy: A protocol for a randomised controlled trial. *BMJ Open*. 2020;10(2). doi:10.1136/bmjopen-2019-034304.