Received: 26th January 2022
For correspondence: ianburton_10@hotmail.co.uk

Interventions for Prevention and In-season Management of Patellar Tendinopathy in Athletes: A scoping review

Ian Burton MSc, CSCS

Specialist Musculoskeletal Physiotherapist, MSK Service, Fraserburgh Physiotherapy Department, Fraserburgh Hospital, NHS Grampian, Aberdeen.

For correspondence: ianburton_10@hotmail.co.uk

Aisling McCormack, Aberdeen City Council

Please cite as: Burton I & McCormack A. (2022). Interventions for Prevention and In-season Management of Patellar Tendinopathy in Athletes: A scoping review

All authors have read and approved this version of the manuscript.
This article was last modified on January 26th 2022.

ABSTRACT

Introduction: Patellar tendinopathy has a significant prevalence in athletes and presents a tremendous burden on athletes and clinicians due to its long-lasting duration, persistent symptoms, and lack of available effective treatments. This scoping review aimed to summarise current evidence on prevention and in-season management interventions for patellar tendinopathy in athletes, evaluating intervention parameters and outcomes.

Methods and analysis: The recommended methodological framework described by the Joanna Briggs Institute was used to structure this review, with reporting in accordance with the PRISMA-ScR. Databases searched included MEDLINE, CINAHL, AMED, EMBase, SPORTDiscus, and the Cochrane library (Controlled trials, Systematic reviews). All primary study designs investigating prevention or in-season management interventions for patellar tendinopathy, while maintaining athletes in sport were considered for inclusion.

Findings: 5987 articles were identified with 29 included in the review. Despite a dearth of studies to date on preventative interventions for athletes with patellar tendinopathy, evidence suggests that resistance training is an effective prophylactic method. There is a significant body of evidence suggesting that resistance training is effective for managing patellar tendinopathy in-season, with evidence greater for eccentric training, followed by heavy slow resistance training and isometric training. Inertial flywheel and blood-flow restricted resistance training may also be effective in-season management strategies. There is currently no evidence to suggest that ESWT offers any additional benefit over resistance training in competing athletes. Patellar strapping and taping may offer short-term pain relief during training and competition. High risk athletes, particularly those participating in jumping sports, should be required to undergo progressive resistance training as a preventative method for patellar tendinopathy. Similarly, athletes diagnosed with patellar tendinopathy should undergo a progressive resistance training intervention while maintaining sports participation, prior to considering sport withdrawal.

Keywords: Prevention; Tendinopathy; Resistance training; Patellar; Physiotherapy; Tendon

INTRODUCTION

Tendinopathy is a chronic degenerative condition, associated with changes to the structural tendon collagen matrix, presence of various inflammatory cells and clinical symptoms of pain and impaired performance (Millar et al. 2021). Patellar tendinopathy is common in athletes with high training demands and is caused by repetitive patellar tendon microtrauma (Malliaras et al. 2015). Patellar tendinopathy is most common in jumping athletes competing in sports such as basketball and volleyball which require repetitive patellar tendon loading, leading to the condition being labelled as 'jumper's knee' (Janssen et al. 2018). Prevalence data suggest up to 22% of elite athletes will report patellar tendon pain at least once during their sporting careers, with up to 50% of elite volleyball and basketball players being diagnosed with the condition during their careers (Lian et al. 2005, Saithna et al. 2012, Zwerver et al. 2011). Symptoms of patellar tendinopathy include persistent pain and physical dysfunction, particularly with patellar tendon loading, leading to impairments in athletic performance (Rosen et al. 2021, Scott et al. 2019). Diagnosis is typically based on the presence of pain at the insertion of the patellar tendon under the apex of the patella, provoked by palpation or loading tests such as the loaded decline squat test (Sanchez-Gomez et al. 2022). A plethora of risk factors specific to jumping athletes have been identified, highlighting their vulnerability and predisposition for developing patellar tendinopathy (Fendri et al. 2021, Harris et al. 2020, Sprague et al. 2018, Van der Worp et al. 2012, 2011, Witvrouw et al. 2001). In the initial stages of patellar tendinopathy, athletes can often continue with sports participation, however with progressive tendon degeneration symptoms can worsen, with the average duration of the condition lasting up to 32 months (Doelen and Jelley 2020).

There are a range of available treatment modalities available for patellar tendinopathy, with often conflicting findings on their efficacy in the literature such as extracorporeal shockwave therapy (ESWT), corticosteroid injections, platelet-rich-plasma injections, topical glyceryl trinitrate, laser therapy, and anti-inflammatory medications (Challoumas et al. 2021, van Rijn et al. 2019). More invasive approaches such as percutaneous electrolysis and surgery may be required if conservative treatment fails (Mendonca et al. 2020). Eccentric resistance training using decline squat exercises to load the patellar tendon has been the gold standard first-line management approach for patellar tendinopathy in recent years, due to its documented beneficial clinical effects for improving pain and function (Irby et al. 2020). Despite the best evidence existing for eccentric training, recently heavy slow resistance training (HSRT), which does not eliminate concentric actions, and isometric training have been shown to have comparable beneficial effects (Breda et al. 2021, Sprague et al. 2021, Kongsgaard et al. 2009; Lim et al. 2018). Despite resistance training having the best evidence of effectiveness out of all available treatments for patellar tendinopathy, estimates suggest they may be only up to 50% effective for improving clinical symptoms at three to six months, suggesting other strategies should be investigated (Gaida and Cook 2011, Challoumas et al. 2021). Withdrawing athletes from sport and the decision to undergo rehabilitation in isolation should not be taken lightly and the decision should involve consideration of the evidence for intervention options to maintain athletes in sport with a risk/benefit ratio analysis of the consequences required (Saithna et al. 2012). Withdrawing competitive athletes from sport is associated with negative psychological consequences such as depression, anxiety, low mood, and self-esteem (Scully et al. 1998; Ford et al. 2017). Physiological consequences can include de-training and loss of fitness and sport specific skills, potentially affecting an athlete's employment and career prospects, leading to financial losses (Arvinen-barrow et al. 2017, Wiese-Bjornstal 2010, Secrist et al. 2016).

Given the burden of patellar tendinopathy in athletic populations, its often-long-lasting duration, and inconsistencies in the effects of treatment modalities, efforts should be made to ascertain the availability of methods for preventing and manging the condition during the competitive season, to prevent the deleterious consequences of withdrawing athletes from sport (Saithna et al. 2012). Despite the importance of identifying such methods, there have been a paucity of studies investigating interventions for prevention and in-season management of patellar tendinopathy in competing athletes, with a lack of recommendations currently available (Peters et al. 2016). Therefore, the objective of this scoping review is to evaluate current research on the use of prevention and in-season management interventions for patellar tendinopathy in athletes. The scoping review will be guided by addressing the following review questions on specific aspects of prevention and in-season management interventions for patellar tendinopathy:1. What interventions have been reported for prevention and in-season management for patellar tendinopathy in athletes? 2. What intervention parameters and outcome measures have been used in published studies? 3. What outcomes have been reported for prevention and in-season management interventions for patellar tendinopathy in athletes?

METHODS

Due to the exploratory nature of the research questions of this review, a scoping review was conducted as they are recommended for mapping key concepts, evidence gaps and types of evidence within a particular field and can help guide future research and the possibility of conducting systematic reviews on the topic (Tricco et al. 2018). The scoping review is reported in accordance with the Preferred Reporting Items for Systematic reviews and Meta-analysis extension for Scoping reviews (PRISMA-ScR) (Tricco et al. 2018).

Inclusion criteria

The inclusion criteria for the scoping review were guided by a modified PICO, which includes population, concept, and context (PCoCo) as recommended for scoping reviews (Peters et al. 2020). The review considered athletes of any age with a diagnosis of patellar tendinopathy for any time duration or athletes with healthy patellar tendons at risk for patellar tendinopathy. Included participants must be athletes competing in any sport at any level such as recreational, amateur, elite, or professional. Any patellar tendon condition characterised by common tendinopathy symptoms, in the absence of a full thickness tendon rupture was considered for inclusion. A clinician's diagnosis based on symptoms including pain location and a symptom altering response to palpation or tendon loading with specific tendinopathy tests such as the loaded decline squat test were accepted for inclusion. Studies including participants with other concurrent injuries or medical conditions were excluded. Studies that have provided an intervention while withdrawing athletes from sports participation were excluded. The concept of interest is prevention and in-season management interventions for patellar tendinopathy in athletes, including any type or format of intervention using active or passive modalities, in a supervised or unsupervised manner. The intervention may be delivered in isolation or combined with other interventions. Rehabilitation interventions such as resistance training protocols, injections or ESWT were considered as in-season management interventions if athletes continued sports participation while receiving them. The context considered for inclusion included any health or exercise setting in which prevention and in-season management interventions for patellar tendinopathy in athletes have been provided. This scoping review considered both experimental and quasi-experimental study designs including randomized controlled trials and non-randomized controlled. In addition, prospective and retrospective cohort studies, case series and case reports were considered for inclusion. Unpublished studies, reviews or reports were not considered for inclusion.

Search strategy

A 3-step search strategy was implemented in this scoping review. It incorporated the following: 1) a limited search of MEDLINE and CINAHL using initial keywords, followed by analysis of the text words in the title/abstract and those used to describe articles to develop a full search strategy; 2) The full search strategy was adapted to each database and applied to MEDLINE, CINAHL, AMED, EMBase, SPORTDiscus, Cochrane library (Controlled trials, Systematic reviews), JBI Evidence Synthesis, and PEDro. The following trial registries were searched: ClinicalTrials.gov, ISRCTN, The Research Registry, EU-CTR (European Union Clinical Trials Registry), ANZCTR (Australia and New Zealand Clinical trials Registry). Databases were searched from inception to January 20th, 2022. The search for grey literature included Open Grey, MedNar, Cochrane central register of controlled trials (CENTRAL), EThOS, CORE, and Google Scholar. 3) For each article located in steps 1 and 2, a search of cited and citing articles using Scopus and hand-searching where necessary, was conducted. Studies published in a language other than English were only considered if a translation was available as translation services were not available to the authors.

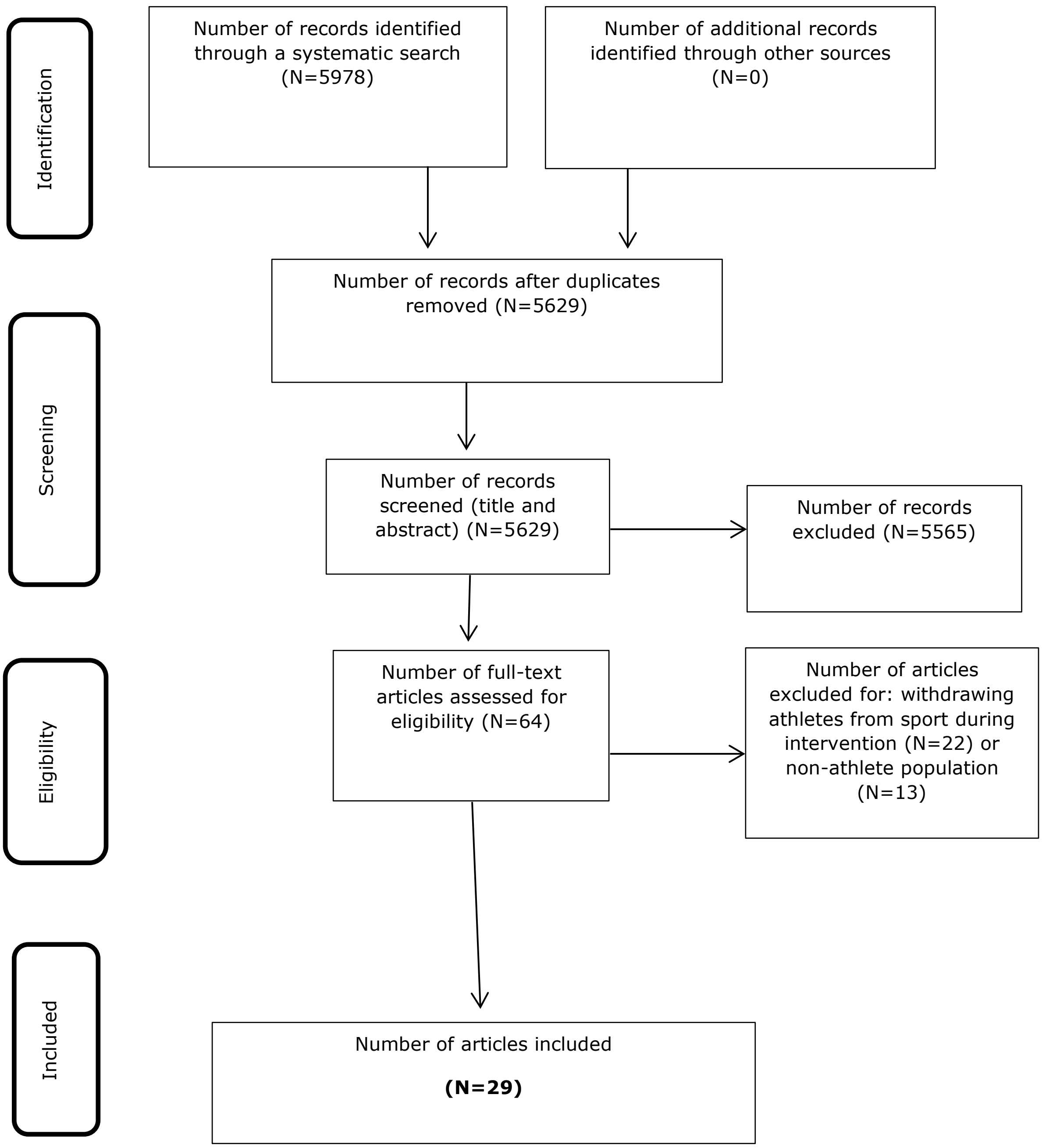
Study selection

Following the search, all identified citations were collated and uploaded into RefWorks and duplicates removed. Titles and abstracts were screened by two independent reviewers (IB and AM) and assessed against the review inclusion criteria. Potentially relevant studies were retrieved in full, with their details imported into Covidence software (Veritas Health Innovation, Melbourne, Australia). Two independent reviewers (IB and AM) assessed the full text of selected articles in detail against the review inclusion criteria. Any disagreements that arose at any stage of the study selection process were resolved through discussion. The results of the search are reported in accordance with the PRISMA-ScR (Figure 1). In accordance with guidance on conducting scoping reviews, critical appraisal was not conducted (Peters et al. 2020).

Data extraction and analysis

Data were extracted from sources included in the scoping review by one reviewer (IB), with independent data extraction by a second reviewer (AM) for 10% of studies. The data extracted included dimensions such as study type, purpose, population & sample size, methods, details of intervention, outcome measures used and clinical outcomes. Interventions details included type, dosage, intervention parameters, and any methods used for progression and monitoring compliance. Data were also extracted on any physiological mechanisms such as effects on tendon morphological and mechanical properties, which have been investigated to explain the effects of the interventions on patellar tendinopathy or healthy patellar tendons. The extracted data are presented in Tables 1 and 2 with a narrative synthesis accompanying the tabulated results. The extracted data were analysed using descriptive statistics, with findings presented in tabular form as tables and figures, along with a narrative synthesis.

FIGURE 1: PRISMA study flow diagram



RESULTS

Included study characteristics

The literature search yielded 5978 articles, reduced to 5629 after removing duplicates, of which 29 met the inclusion criteria and were included in the review. The search results are summarised in the PRISMA flow chart (Figure 1). An overview of the characteristics, intervention parameters and outcomes of the included studies are provided in Tables 1 and 2. Five studies investigated the effects of exercise-based prevention interventions on athletes at risk for patellar tendinopathy, including two randomized controlled trials (RCTs), two cohort studies and one case-control study. 24 studies investigated the effects of in-season management or rehabilitation in athletes with patellar tendinopathy, including 18 RCTs, three case reports, one cohort study, one case series, one retrospective review. Of these 24 studies, 22 used an exercise-based intervention, one used ESWT and one used patellar strapping and taping. The types of exercise interventions included eccentric training, HSRT, isometric training, inertial flywheel training, blood-flow restriction training (BFRT), and general isotonic training. The most common type of training was eccentric training, used in 9 studies, with eccentric single leg decline squats the most common exercise used in 7 studies. The sample sizes of included studies ranged from 1-209 and intervention duration ranged from a single session to three years, with 12 weeks being the most common intervention duration, used in 13 studies. All studies included competitive athletes as their population and did not withdraw athletes from competitive sport during the intervention period. Various categories of athletes were described, including recreational (9), elite (8), collegiate (2), professional, or the type of sport played, mainly basketball, volleyball, handball, and soccer (5).

Outcome measures

Of the 29 included studies, 24 assessed pain and or function as a main outcome measure of the intervention, using measures such as the visual analogue scale (VAS) (11), Victorian Institute of Sport Assessment – Patellar (VISA-P) (20), and the pain numeric rating scale (NRS-P) (5). Other outcome measures included tendon properties assessed by ultrasound (6), MRI (1) or electromyography (1), patellar tendinopathy incidence (6), measures of strength (6), measures of power (3), quality of life (1) and biomechanics (1).

Outcomes

Four of the five studies investigating the effects of preventative exercise interventions in athletes with patellar tendinopathy found a reduction in tendinopathy incidence following the intervention (Kramer et al. 2008, Gual et al. 2016, Bittencourt et al. 2022, Mersmann et al. 2021). One study did not find reduced incidence despite finding reduced risk for developing patellar tendon abnormalities on ultrasound (Fredberg et al. 2008). The four studies finding reduced incidence all included progressively loaded isotonic exercises, whereas the study finding no reduction used stretching and unloaded eccentric exercises, which may have been underdosed to derive significant tendon adaptations. The RCT using ESWT in isolation in in-season athletes did not find any clinical benefit of the intervention over placebo (Zwerver et al. 2011). Two RCTs combined ESWT with eccentric training in competing athletes, with both finding no additional effect of ESWT over eccentric training alone (Thijs et al. 2017, Lee et al. 2020). These findings suggest ESWT is not an effective management option for in-season athletes who continue to compete in sport. One RCT found that the use of a patellar strap or sports tape provided short-term pain relief in competing athletes with patellar tendinopathy, suggesting it may be a useful adjunctive management option to reduce pain in the short-term (De Vries et al. 2016). Significantly, all the 22 studies investigating an exercise-based intervention for in-season management of patellar tendinopathy found positive clinical outcomes in terms of pain and function improvement. Eccentric training (Cannell et al. 2001, Visnes et al. 2005, Young et al. 2005, Biernat et al. 2014, Lee et al. 2020, Thijs et al. 2017, Basas et al. 2018), HSRT (Ruffino et al. 2021, Kongsgaard et al. 2009, Sprague et al. 2021, Agergaard et al. 2021), isometric training (Van Ark et al. 2016, Rio et al. 2015, Rio et al. 2017, Pietrosimone et al. 2020, Holden et al. 2020), isotonic training (vander Doelen et al. 2020, Bianco et al. 2019, Silva et al. 2015), inertial flywheel training (Romero-Rodriguez et al. 2011, Ruffino et al. 2020), and BFRT (Cuddeford et al. 2020, Sata et al. 2005), were all feasible and effective intervention methods for managing patellar tendinopathy in competing athletes. Although determining which of these exercise training methods is the most effective option is beyond the scope of this review, the quantity of evidence from RCTs is currently greater for eccentric training, followed by HSRT and isometric training. Preliminary evidence suggests inertial flywheel training and BFRT may be comparable in terms of in-season effectiveness, but further large-scale RCTs are required to determine their true effectiveness due to a paucity of current research.

Training parameters

Of the 29 included studies in this scoping review, 27 used an exercise-based intervention. As various types of exercise were used, there was significant heterogeneity in the exercise training parameters and prescription across studies (Tables 1 & 2). Exercise types included, eccentric (10), isotonic (9), isometric (7), HSRT (5), BFRT (2), and inertial flywheel (2). Specific exercises used more than once throughout studies included, single leg decline squats (7), squats (10), leg press (8), knee extension (4) and heel raises (2). The number of exercise sets ranged from 1-6, repetitions ranged from 4-30, and frequency ranged from a single session to 7 days a week, twice a day. In studies that reported exercise progression methods, the most common method was to progressively increase training resistance based on pain response, typically with small increments in external weight. The most common rest time reported between training sets was 2-3 minutes, with many studies not reporting rest times. Adherence to exercise was poorly reported across studies, with 16 studies not reporting exercise adherence level, and seven studies supervised all exercise so did not report adherence. Only five studies fully reported exercise adherence, which ranged from 67-100% per intervention, with all five studies reporting an overall high level of exercise adherence of more than 70% (Ruffino et al. 2021, Young et al. 2005, Kongsgaard et al. 2009, Sprague et al. 2021, Agergaard et al. 2021).

DISCUSSION

This scoping review aimed to assess what interventions have been used for prevention and in-season management of patellar tendinopathy in athletes and what outcomes have been reported. Despite a paucity of literature on prevention programs for patellar tendinopathy, four studies have found positive effects of exercise-based interventions for reducing the incidence of patellar tendinopathy in athletes (Kramer et al. 2008, Gual et al. 2016, Bittencourt et al. 2022, Mersmann et al. 2021). Despite these encouraging findings, further high-quality large scale RCTs are required to confirm the prophylactic effect of exercise in reducing patellar tendinopathy incidence, as only one of these studies was a RCT, which found benefit of inertial flywheel training in preventing patellar tendinopathy in athletes (Gual et al. 2016). Despite the common practice of withdrawing athletes from sports training and competition during patellar tendinopathy, findings from this review suggest that practice may be unwarranted and perhaps even counterproductive for competing athletes, given the consequences of sport withdrawal. Of the 24 studies using an in-season management intervention while maintaining athletes in sports participation, 22 used an exercise-based approach. Whilst it may not be surprising that most interventions were exercise-based given that exercise is the most recommended treatment intervention for patellar tendinopathy, the lack of other interventions employed could be considered surprising, given the plethora of methods used in treating patellar tendinopathy. An advantage of exercise over other common treatments such as injection-based therapies is that a period of sport withdrawal is not necessary while undergoing treatment. In comparison, common treatments such as percutaneous electrolysis and injection-based therapies such as corticosteroid, blood-derived, and hyaluronic acid, typically stipulate a period of rest is required after treatment (Mendonca et al. 2020). Despite conflicting evidence of its effectiveness for patellar tendinopathy compared to other lower limb tendinopathies, ESWT is a commonly used treatment option, particularly in competing athletes (Zwerver et al. 2011). However, findings from this review suggest ESWT offers no benefit over eccentric resistance training during in-season management for athletes, suggesting it should not be recommended and should only be considered as adjunct to exercise (Lee et al. 2020, Thijs et al. 2017). Recently, it has also been suggested that ESWT offers little benefit in any population with patellar tendinopathy, not just competing athletes subjected to high training loads (Challoumas et al. 2021). Patellar strapping and taping were found to offer short-term pain reduction in competing athletes, suggesting it may be an appropriate adjunctive treatment to resistance exercise, particularly for short-term pain management during training and competition (De Vries et al. 2016).

A significant finding from this review, was that despite a range of exercise types and prescription parameters being used across studies, all exercise interventions found clinical improvement in patellar tendinopathy in athletes while maintaining sports participation. All exercise interventions were progressive resistance training in varying formats, suggesting the type of resistance training is less important, provided it is appropriately loaded and progressed to stimulate positive tendon adaptations. The four out of the five prevention studies using adequately loaded resistance exercise found it had a prophylactic effect, whereas the study using an unloaded exercise intervention found no benefit. Resistance exercise types such as eccentric, isotonic, isometric, HSRT, BFRT, and inertial flywheel training all showed clinical benefit in athletes when used during the competitive season. However, despite all these options being potentially feasible and effective for patellar tendinopathy in-season, there is a clear hierarchy in terms of the strength of evidence behind each method at present, due to the overall body of evidence and number of adequately powered RCTs that have been conducted. As also found in recent systematic reviews, it appears the strength of evidence from RCTs is currently greater for eccentric training, followed by HSRT and isometric training (Challoumas et al. 2021, Mendonca et al. 2020, Irby et al. 2020, Girgis et al. 2021). Preliminary evidence suggests inertial flywheel training and BFRT may be comparable in terms of in-season effectiveness, but further large-scale RCTs are required to determine their true effectiveness due to a paucity of current research.

Although local strengthening of knee musculature is a proven method for treating patellar tendinopathy, it is important that clinicians also consider non-local factors, such as kinetic chain strength, hip muscle weakness and ankle range of motion (Cook and Purdam 2013, Silva et al. 2016, Mendonca et al. 2016, Mendonca et al. 2018). Only one study in this review had an intervention focused on hip muscle strengthening, which was found to be an effective management strategy despite not including recommended eccentric knee focused exercise (Silva et al. 2015). None of the included studies had a primary or secondary focus on education within their intervention, which is concerning as education within tendinopathy rehabilitation is normally a significant clinical intervention component, which is known to also affect exercise adherence (Vicenzino 2015, Nunez-Martinez et al. 2021, Sancho et al. 2019, Mellor et al. 2018, Alghamdi et al. 2021). For example, a recent survey found that 80% of physical therapists routinely implement education within their patellar tendinopathy rehabilitation interventions (Mendonca et al. 2020). Return to sport criteria is a rehabilitation component that appears to be overlooked within patellar tendinopathy rehabilitation research, despite its importance for guiding clinicians in safely returning athletes to sport (Rudavsky and Cook 2014). Although studies in this review did not withdraw athletes from sport, doing so is still common practice in patellar tendinopathy (Kulig et al. 2005). In clinical practice, physical therapists typical rely on measures of pain and function such as the VISA-P, and functional tests, such as hopping and single-leg decline squats to make decisions on return to play (Hernandez-Sanchez et al. 2012, Larsson et al. 2012). While these methods may be helpful, better guidelines and consensus criteria are required to guide clinicians in returning athletes with patellar tendinopathy to sport, if the decision is made to undergo a period of sport withdrawal.

This scoping review is not without limitations. The review has included a range of study designs from RCTs to individual case reports, so there is therefore vast heterogeneity in interventions and findings across all the studies. Therefore, the findings should be interpreted with caution. However, determining effectiveness of interventions through meta-analysis techniques was not the objective of the review, with the aims focused on understanding what interventions and outcomes have been found for prevention and in-season management of patellar tendinopathy in athletes. Only studies available in English language were included, which may introduce language bias. Although all primary research designs were considered for inclusion, this review did not consider review papers or clinical practice guidelines, which may have included detailed information on prevention and in-season management interventions.

CONCLUSION

Despite a dearth of studies to date on preventative interventions for athletes with patellar tendinopathy, preliminary evidence suggests that progressive resistance training is an effective prophylactic method, which should be recommended to all athletes at risk such as those in jumping sports. There is a significant body of evidence suggesting that resistance training interventions are effective for managing patellar tendinopathy during the competitive season, without the need to withdraw athletes from sport, negating the associated deleterious consequences. The strength of evidence from RCTs is currently greater for eccentric training, followed by HSRT and isometric training, with preliminary evidence suggesting inertial flywheel training and BFRT may also be effective in-season management strategies. There is currently no evidence to suggest that ESWT offers any additional benefit over resistance training, in competing athletes, so it should only be considered as a possible adjunct to resistance training, alongside patellar strapping and taping, which may offer short-term pain relief during training and competition. The main recommendations from this review, is that high risk athletes, particularly those participating in jumping sports, should be required to undergo progressive resistance training as a preventative method for patellar tendinopathy. Similarly, athletes already diagnosed with clinical patellar tendinopathy should undergo a progressive resistance training intervention while maintaining sports participation, prior to considering sport withdrawal.

Acknowledgements: None declared

Authorship contributions: IB conceptualised the work and developed the methods, search strategy and framework for the review. IB and AM contributed to the development of the research questions and the study design. All authors developed the first and subsequent drafts of the manuscript and reviewed and approved the manuscript.

Funding: No sources of funding were used to assist in the preparation of this article.

Conflicts of interest/Competing interests: None declared.

Patient consent: Not required.

Provenance and peer review: Not commissioned; externally peer reviewed.

Data availability statement: All data relevant to the study are included in the article or uploaded as supplementary information.

Appendix 1: Search strategy

- Information sources and search strategy.

Databases: MEDLINE (PubMed), CINAHL, AMED, EMBase, SPORTDiscus CENTRAL of Cochrane Library

Search fields: Title, abstract, key words

Search terms (database subject headings)

1. - "prevention" OR "preventative" OR "in-season" OR "management" OR "rehabilitation" OR "treatment" 2 - "patellar tendon" OR "patellar tendinopathy" OR "patellar tendinitis" OR "patella tendon" OR "knee tendon"

3. 1 AND 2

Table 1: Prevention studies in athletes at risk for patellar tendinopathy

Author, Study design, population	Intervention, exercises, duration	Training parameters	Outcome measures	Outcomes, results
Fredberg et al. 2008, RCT, n=209, professional male soccer players	1. ECCT (heel raises, step-ups), stretching (calf & quadriceps). 12 months	Sets: 1, Reps: 25, Freq: 7 x WK, Prog: NR, Int: 25-RM. Adherence: NR	PT incidence, tendon changes (US)	ECCT and stretching program reduced the risk of developing ultrasonographic abnormalities in the patellar tendons but had no positive effects on the risk of PT.
Kraemer et al. 2009 Cohort, n=24, elite female soccer players	1. Soccer specific balance training: (sitting, standing, and jumping based balance exercises). 3 years	Sets: 1, Reps: 15-30 seconds, Freq: NR, Prog: increase difficultly, Int: 25-RM. Adherence: 100%	PT incidence	Soccer-specific balance training can significantly reduce the incidence of PT. A dose-effect relationship between duration of balance training and injury incidence is evident.
Gual et al. 2016, RCT, n=81, athletes at risk for PT	1. Normal sports training + inertial flywheel training, YoYo-squat 2, normal sports training.24 weeks	Sets: 4, Reps: 10, Freq: 1 x WK, Prog: NR, Int: 8-RM, reps 1–2 were used for increasing inertial resistance, and reps 3–10 were executed with maximal effort. Rest: 2 MIN between sets. Session time: 20 MIN. Adherence: supervised, %NR	Pain & function (VISA-P), Vertical counter movement jump, and squat power, both concentric and eccentric strength, PT incidence	Countermovement jump scores (power) and concentric and eccentric strength improved more in flywheel group, with no cases of PT recorded.
Bittencourt et al. 2022, Cohort, n=271, elite youth jumping athletes (basketball and volleyball)	1. Individually tailored exercise program: warm-up drills, ankle stretches, hip bridge, squats, lateral and frontal planks, SL balance, trunk mobility, landing pattern training. 1 year	Sets: NR, Reps: NR, Freq: 2 x WK, Prog: NR, Int: NR, Time; 15-20 MIN per session. Adherence: NR	PT incidence	Intervention showed 51% less risk of developing PT. 26 athletes developed PT in the observation year, whereas 13 developed PT in the intervention year. A tailored preventive program may be able to reduce the incidence of PT in male youth volleyball athletes.
Mersmann et al. 2021, Case control, n=34, elite adolescent handball players	1. Functional high-load exercise: single & double leg squats 2. Control: regular training: explosive strength &	Sets: 5, Reps: 4, Freq: 2 x WK, Prog: increase resistance, Int: 4-RM, Rest; 2-3 MIN between sets, Time; 20 MIN per session. Adherence: NR	PT incidence, muscle, and tendon mechanical properties (US), quadriceps strength (dynamometer)	30% of control athletes reported a clinically significant aggravation of symptoms, all players in the experimental group remained or became pain-free until the end of the

	muscular endurance training. 1 year.			season. There was a similar increase of strength and VL thickness in both groups, but no significant changes of tendon stiffness or tendon strain. High-load exercises reduced the prevalence of patellar tendon pain.

Table 2: In-season management studies in athletes with patellar tendinopathy

Author, Study design, population	**Intervention, exercises, duration**	**Training parameters**	**Outcome measures**	**Outcomes, results**
Ruffino et al. 2021, RCT, n=42, recreational athletes (Volleyball, basketball, soccer, Running)	1. HSRT (squat, hack squat, leg press). 2. Inertial Flywheel training (squat, leg press, knee extension). 12 weeks	Sets: 4, Reps: 12(10 max effort), Freq: 1 x WK, Prog: NR, Int: 8-RM, reps 1–2 were used for increasing the inertial resistance, and reps 3–12 were executed with maximal effort. Rest: 2-3 MIN between sets. Session time: 20 MIN. Adherence: 88-90%	Pain & function (VISA-P, SLDS, PSFS), health status (EuroQol-5D), physical tests (strength & power), tendon properties (US)	Both groups improved clinical outcomes, with no significant difference between groups in clinical outcomes, physical tests (strength & power), or tendon thickness & neovascularization.
Cannell et al. 2001, RCT, n=19 athletes	1. ECCT: Progressive drop squats and leg extension/curl exercises 2. Isotonic Ex. 12 weeks	Sets: 6, Reps: 15, Freq: 7 x WK, 2 x day, Prog: increase resistance, Int: 15-RM, pain response. Adherence: NR	Pain (VAS), return to sport	Progressive drop squats and leg extension/curl exercises both reduced pain and enable return to sport.
Visnes et al. 2005, RCT, n=29, elite volleyball athletes	1. ECCT (SLDS) 2. Normal volleyball training. 12 weeks	Sets: 6, Reps: 15, Freq: 7 x WK, 2 x day, Prog: increase resistance in 5kg increments, Int: 15-RM, pain response. Adherence: NR	Pain & Function (VISA-P)	No effect of ECCT compared with those who continued volleyball training.
Young et al. 2005, RCT, n=17, athletes	1. ECCT step 2. ECCT decline (SLDS). 12 weeks	Sets: 6, Reps: 15, Freq: 7 x WK, 2 x day, Prog: increase speed & resistance in 5kg increments, Int: 15-RM, pain response. Adherence: 72%	Pain (VAS), function (VISA-P)	Both groups improved pain and sporting function at 12 months. Decline squat more effective.
Kongsgaard et al. 2009, RCT, n=39 recreational athletes	1. CSI 2. HSRT (squat, leg press, hack squat) 3. ECCT (SLDS). 12 weeks	Sets: 3-4, Reps: 6-15, Freq: 3 x WK, Prog: increase resistance, Int: 6-15-RM, pain response. Adherence: 89-91%	Pain (VAS), Function (VISA-P), tendon properties (US)	All groups improved, with only exercise groups maintaining improvements at 6 months. HSRT

				has good short and long-term clinical effects.
Cuddeford et al. 2020, Case report, n=2, 2 male college decathletes	1. Low-load BFRT: SL leg press, SLDS. 12 weeks	Sets:4, Reps:15-30; Freq 2 x WK: Prog: increase resistance (10lbs Inc), Int: 15-30RM (1RM load). Occlusion pressure: 80% restriction of arterial inflow. 30 second rest between sets (cuff not removed). Adherence: supervised, NR.	Pain (VAS), Function (VISA-P), Tendon size (US), Hip & knee strength (handheld dynamometry, SL leg press 1RM)	Patients improved clinical outcomes and returned to sports activity. Improvements in tendon thickness and resolution of hypoechoic region. Increased lower limb strength.
Sata et al. 2005, Case report, n=1, male basketball player	1. Low-load BFRT: straight leg raises, hip abduction & adduction, calf raise, toe raise, squat, crunch, back extension, basketball shooting. 3 weeks	Sets: 3, Reps; 15, Freq: 5-6 x WK, Prog: Int:15rm (30% of 1RM). Occlusion pressure range: 160-180 mmHg. Adherence: NR	MRI (signal intensity). Thigh circumference	Patient improved clinical outcomes and returned to playing basketball
Romero-rodriguez et al. 2011, case series, n=10, national level athletes (soccer, basketball, running)	1. Isoinertial flywheel ECCT, maximal effort, leg press. 6 weeks	Sets: 4, Reps: 10, Freq: 1 x WK, Prog: NR, Int: 8-RM, reps 1–2 were used for increasing the inertial resistance, and reps 3–10 were executed with maximal effort. Rest: 2 MIN between sets. Session time: 20 MIN. Adherence: NR	Pain (VAS), function (VISA-P), lower limb maximal strength and vertical counter-movement-jump (CMJ) height, SEMG	Intervention was effective for improving clinical outcomes. Eccentric strength increased but power (CMJ) did not.
Biernat et al. 2014, RCT, n=28 male volleyball players	1. ECCT (SLDS) 2. Normal training, 12 weeks	Sets: 6, Repetitions: 15, Freq: 7 x WK, Prog: increase difficulty (unstable surface), Int: 15RM, pain response. Adherence: NR	Pain & Function (VISA-P), PT incidence	ECCT group superior for pain and function improvement Patellar tendinopathy was observed in 18% of the tested young volleyball players.
De Vries et al. 2016, RCT, n=97, athletes	1. Patellar strap 2. Sports tape 3. Placebo 4. Control. 2 weeks	Adherence: NR	Pain (VAS) & Function (VISA-P), SLDS, vertical jump test, triple hop test	VAS reduced significantly in the patellar strap and the sports tape condition, compared with control, but not placebo. Orthosis during sports can reduce pain in the short term.
Vander Doelen et al. 2020, retrospective, n=9 basketball players	1. Multimodal rehabilitation (isometric knee extension, isotonic HSRT leg press, squat, hack squat), DN, ESWT, MT. 32 weeks	Sets: 3-4, Reps: 6-15, Freq: 3 x WK, Prog: increase resistance, Int: 6-15-RM, pain response, 70% MVIC for isometric. Adherence: NR	Pain (NRS-P), Function (VISA-P)	Patients improved clinical outcomes and returned to sports activity.

Lee et al. 2020, RCT, n=34, recreational athletes	1. ECCT (SLDS) 2. ECCT + ESWT. 12 weeks	Sets: 6, Reps: 15, Freq: 7 x WK, 2 x day, Prog: increase speed & resistance in 5kg increments, Int: 15-RM, pain response. Adherence: NR	Pain (VAS), Function (VISA-P), tendon properties (US)	Combining exercise and ESWT could not been shown to be more effective than exercise alone
Van Ark et al. 2016, RCT, n=29, recreational athletes	1. isotonic (leg extension) Ex 2. Isometric Ex (leg extension). 4 weeks	Sets: 4-5, Reps: 5-8, Freq: 4 x WK, Prog: increase resistance in 2.5% weekly increments, Int: 5-8-RM, 80% MVIC for isometric, pain response. Adherence: NR	Pain (NRS), function (SLDS)	Both isometric and isotonic exercise programs improved pain and function
Thijs et al. 2017, RCT, n=52, recreational athletes	1. ECCT (SLDS) + ESWT 2. ECCT. 12 weeks	Sets: 6, Reps: 15, Freq: 7 x WK, 2 x day, Prog: increase resistance, Int: 15-RM, pain response. Adherence: NR	Pain & function (VISA-P)	No additional effect of ESWT to ECCT for pain and function improvement.
Zwerver et al. 2011, RCT, n=62, basketball, volleyball & handball athletes	1. Focused ESWT. 3 weeks	3 sessions at 1-week, 2000 impulses at a frequency of 4 Hz were administered. The energy flux density was titrated according to individual pain tolerance up to a possible maximum of 0.58 mJ/mm2 (level 20). Adherence: supervised	Pain (VAS), Function (VISA-P),	ESWT during the competitive season had no benefit over placebo treatment in competing jumping athletes with PT
Rio et al. 2015, RCT, n=6, elite athletes	1. Isometric EX (biodex leg extension) 2. Isotonic EX (leg extension machine). Single session	Sets:4 Reps: 8 Freq: single session, Int: 8-RM. Adherence: supervised	Pain & function (SLDS, VISA-P), MVIC	A single session of isometric EX significantly reduced pain & increased MVIC compared to isotonic EX.
Rio et al. 2017, RCT, n=20, elite athletes	1. Isometric EX (leg extension) 2. Isotonic EX (leg extension). 4 weeks	Sets: 4, Reps: 8, Freq: 4 x WK, 2 x day, Prog: increase resistance by 2.5% weekly, Int: 8-RM, pain response. Adherence: supervised	Pain & function (SLDS, VISA-P)	Both groups reduced pain, Isometric EX had significantly greater immediate analgesic effects
Sprague et al. 2021, pilot RCT, n=15, recreational athletes	1. HSRT (squat, knee extension, leg press) + PGA 2. HSRT + PFA. 12 weeks	Sets: 4, Reps: 6-15, Freq: 3 x WK, Prog: increase resistance, Int: 6-15-RM, pain response. Adherence: 67-86%	Trial measures, Pain & function (VISA-P)	A fully powered RCT would be feasible, both groups improved clinical outcomes.
Agergaard et al. 2021, RCT. N=44, recreational athletes	1. HSRT (leg press, knee extension) 2. Moderate HSRT. 12 weeks	Sets: 3-5, Reps: 4-15, Freq: 3 x WK, Prog: increase resistance (% of 1-RM), Int: 6-15-RM, 55-90% of 1-RM, pain response. Adherence: 78-86%	Pain (NRS-P), Function (VISA-P)	Both groups improved clinical outcomes, with no significant difference between groups.
Pietrosimone et al. 2020, RCT, n=28, recreational athletes	1. Isometric EX 2. Sham TENS. Single session	Sets: 5, Reps: 1 x 45 seconds, Freq: single session, Prog: increase resistance, Int: 70% MVIC. Adherence: supervised	Pain & function (VISA-P), biomechanics	Single session isometric EX did not have acute effects on pain or landing biomechanics.
Holden et al. 2020, RCT, n=21, recreational athletes	1. Isometric EX (biodex) 2. Dynamic EX	Sets: 3, Reps: 8, Freq: single session, Prog: increase resistance, Int: 8-RM. Adherence: supervised	Pain (NRS, PPT)	Both groups immediately decreased pain but not after 45

	(leg extension). Single session			mins, no difference between groups.
Basas et al. 2018, cohort, n=6, elite jumping athletes	1. ECCT + isometric quadriceps exercises + Electro stimulation. 12 weeks	Sets: NR, Reps: NR, Freq: 3 x WK, Prog: increase resistance, Int: NR, pain response. Adherence: NR	Pain (VAS)	Intervention was effective for improving clinical outcomes.
Bianco et al. 2019, case series, n=3, college male basketball athletes	1. MT + Exercise (Wall decline squat, SL mini squat, squat, DSLS, drop squat, SL squat, jump downs). 12 weeks	Sets: 2-3, Reps: 10-15, Freq: NR, Prog: increase speed, Int: 10-15-RM, pain response. Adherence: NR	Pain (VAS), Function (VISA-P)	Patients improved clinical outcomes and returned to sports activity
Silva et al. 2015, case report, n=1, elite male volleyball athlete	1. Hip strength exercise (Prone hip extension, birddog, SL deadlift, drop jumps). 8 weeks	Sets: 3, Reps: 15, Freq: 3 x WK, Prog: increase resistance in 2kg increments, Int: 15-RM, 50% of 1-RM, pain response. Adherence: NR	Pain (VAS), Function (VISA-P)	Patient improved clinical outcomes and returned to sports activity

Abbreviations: Abbreviations: PT: Patellar tendinopathy, ECCT: eccentric training, ESWT: extracorporeal shockwave therapy, DN: dry needling; MT: manual therapy, EX: exercise; VAS: visual analogue scale, NRS-P: pain numeric rating scale, VISA-P: Victorian Institute of Sport Assessment – Patellar, WKS: weeks, US: ultrasound, HSRT: heavy slow resistance training: CONCT: concentric training, E-STIM: electrical stimulation, CSI: corticosteroid injection: LLLT: low-level laser therapy, BFRT: blood flow restriction training, MRI: magnetic resonance imaging, PPI: pain pressure intensity, SLDS: single leg decline squat, SL: single leg, Reps: repetitions, Freq: frequency, Prog: progression, Int: intensity, RM: repetition maximum, NR: not reported, TENS: transcutaneous electrical nerve stimulation, n: number, RCT: randomized controlled trial, VL: vastus lateralis, SEMG: Surface electromyography, CMJ: countermovement jump, PGA: pain-guided activity, PFA: pain-free activity.

REFERENCES

AGERGAARD, A.S., SVENSSON, R.B., MALMGAARD-CLAUSEN, N.M., COUPPE, C., HJORTSHOEJ, M.H., DOESSING, S., KJAER, M. and MAGNUSSON, S.P., 2021. Clinical Outcomes, Structure, and Function Improve With Both Heavy and Moderate Loads in the Treatment of Patellar Tendinopathy: A Randomized Clinical Trial. *The American Journal of Sports Medicine,* **49**(4), pp. 982-993.

ALGHAMDI, N.H., POHLIG, R.T., LUNDBERG, M. and SILBERNAGEL, K.G., 2021. The Impact of the Degree of Kinesiophobia on Recovery in Patients With Achilles Tendinopathy. *Physical Therapy,* **101**(11), pp. 10.1093/ptj/pzab178.

ARVINEN-BARROW, M. and CLEMENT, D., 2017. Preliminary investigation into sport and exercise psychology consultants' views and experiences of an interprofessional care team approach to sport injury rehabilitation. *Journal of interprofessional care,* **31**(1), pp. 66-74.

BASAS, A., COOK, J., GOMEZ, M.A., RAFAEL, M.A., RAMIREZ, C., MEDEIROS, B. and LORENZO, A., 2018. Effects of a strength protocol combined with electrical stimulation on patellar tendinopathy: 42 months retrospective follow-up on 6 high-level jumping athletes. *Physical therapy in sport : official journal of the Association of Chartered Physiotherapists in Sports Medicine,* **34**, pp. 105-112.

BIERNAT, R., TRZASKOMA, Z., TRZASKOMA, L. and CZAPROWSKI, D., 2014. Rehabilitation protocol for patellar tendinopathy applied among 16- to 19-year old volleyball players. *Journal of strength and conditioning research,* **28**(1), pp. 43-52.

BITTENCOURT, N.F.N., OLIVEIRA, R.R., VAZ, R.P.M., SILVA, R.S. and MENDONCA, L.M., 2022. Preventive effect of tailored exercises on patellar tendinopathy in elite youth athletes: A cohort study. *Physical therapy in sport : official journal of the Association of Chartered Physiotherapists in Sports Medicine,* **53**, pp. 60-66.

BREDA, S.J., OEI, E.H.G., ZWERVER, J., VISSER, E., WAARSING, E., KRESTIN, G.P. and DE VOS, R.J., 2021. Effectiveness of progressive tendon-loading exercise therapy in patients with patellar tendinopathy: a randomised clinical trial. *British journal of sports medicine,* **55**(9), pp. 501-509.

CANNELL, L.J., TAUNTON, J.E., CLEMENT, D.B., SMITH, C. and KHAN, K.M., 2001. A randomised clinical trial of the efficacy of drop squats or leg extension/leg curl exercises to treat clinically diagnosed jumper's knee in athletes: pilot study. *British journal of sports medicine,* **35**(1), pp. 60-64.

CHALLOUMAS, D., PEDRET, C., BIDDLE, M., NG, N.Y.B., KIRWAN, P., COOPER, B., NICHOLAS, P., WILSON, S., CLIFFORD, C. and MILLAR, N.L., 2021. Management of patellar tendinopathy: a systematic review and network meta-analysis of randomised studies. *BMJ open sport & exercise medicine,* **7**(4), pp. e001110.

COOK, J.L. and PURDAM, C.R., 2014. The challenge of managing tendinopathy in competing athletes. *British journal of sports medicine,* **48**(7), pp. 506-509.

CUDDEFORD, T. and BRUMITT, J., 2020. In-Season Rehabilitation Program using Blood Flow Restriction Therapy for Two Decathletes with Patellar Tendinopathy: a Case Report. *International journal of sports physical therapy,* **15**(6), pp. 1184-1195.

DE VRIES, A., ZWERVER, J., DIERCKS, R., TAK, I., VAN BERKEL, S., VAN CINGEL, R., VAN DER WORP, H. and VAN DEN AKKER-SCHEEK, I., 2016. Effect of patellar strap and sports tape on pain in patellar tendinopathy: A randomized controlled trial. *Scandinavian Journal of Medicine & Science in Sports,* **26**(10), pp. 1217-1224.

FENDRI, T., REBAI, H., HARRABI, M.A., CHAARI, F., BOYAS, S., BEAUNE, B. and SAHLI, S., 2021. Athletes with unilateral patellar tendinopathy have increased subsequent lower extremity musculoskeletal injury risk. *European journal of sport science,* , pp. 1-8.

FORD, J.L., ILDEFONSO, K., JONES, M.L. and ARVINEN-BARROW, M., 2017. Sport-related anxiety: current insights. *Open access journal of sports medicine,* **8**, pp. 205-212.

FREDBERG, U., BOLVIG, L. and ANDERSEN, N.T., 2008. Prophylactic training in asymptomatic soccer players with ultrasonographic abnormalities in Achilles and patellar tendons: the Danish Super League Study. *The American Journal of Sports Medicine,* **36**(3), pp. 451-460.

GAIDA, J.E. and COOK, J., 2011. Treatment options for patellar tendinopathy: critical review. *Current sports medicine reports,* **10**(5), pp. 255-270.

GIRGIS, B. and DUARTE, J.A., 2020. Physical therapy for tendinopathy: An umbrella review of systematic reviews and meta-analyses. *Physical therapy in sport : official journal of the Association of Chartered Physiotherapists in Sports Medicine,* **46**, pp. 30-46.

GUAL, G., FORT-VANMEERHAEGHE, A., ROMERO-RODRIGUEZ, D. and TESCH, P.A., 2016. Effects of In-Season Inertial Resistance Training With Eccentric Overload in a Sports Population at Risk for Patellar Tendinopathy. *Journal of strength and conditioning research,* **30**(7), pp. 1834-1842.

HARRIS, M., SCHULTZ, A., DREW, M.K., RIO, E., ADAMS, S. and EDWARDS, S., 2020. Thirty-seven jump-landing biomechanical variables are associated with asymptomatic patellar tendon abnormality and patellar tendinopathy: A systematic review. *Physical therapy in sport : official journal of the Association of Chartered Physiotherapists in Sports Medicine,* **45**, pp. 38-55.

HERNANDEZ-SANCHEZ, S., HIDALGO, M.D. and GOMEZ, A., 2014. Responsiveness of the VISA-P scale for patellar tendinopathy in athletes. *British journal of sports medicine,* **48**(6), pp. 453-457.

HOLDEN, S., LYNG, K., GRAVEN-NIELSEN, T., RIEL, H., OLESEN, J.L., LARSEN, L.H. and RATHLEFF, M.S., 2020. Isometric exercise and pain in patellar tendinopathy: A randomized crossover trial. *Journal of science and medicine in sport,* **23**(3), pp. 208-214.

IRBY, A., GUTIERREZ, J., CHAMBERLIN, C., THOMAS, S.J. and ROSEN, A.B., 2020. Clinical management of tendinopathy: A systematic review of systematic reviews evaluating the effectiveness of tendinopathy treatments. *Scandinavian Journal of Medicine & Science in Sports,* **30**(10), pp. 1810-1826.

JANSSEN, I., VAN DER WORP, H., HENSING, S. and ZWERVER, J., 2018. Investigating Achilles and patellar tendinopathy prevalence in elite athletics. *Research in sports medicine (Print),* **26**(1), pp. 1-12.

KONGSGAARD, M., KOVANEN, V., AAGAARD, P., DOESSING, S., HANSEN, P., LAURSEN, A.H., KALDAU, N.C., KJAER, M. and MAGNUSSON, S.P., 2009. Corticosteroid injections, eccentric decline squat training and heavy slow resistance training in patellar tendinopathy. *Scandinavian Journal of Medicine & Science in Sports,* **19**(6), pp. 790-802.

KRAEMER, R. and KNOBLOCH, K., 2009. A soccer-specific balance training program for hamstring muscle and patellar and achilles tendon injuries: an intervention study in premier league female soccer. *The American Journal of Sports Medicine,* **37**(7), pp. 1384-1393.

KULIG, K., NOCETI-DEWIT, L.M., REISCHL, S.F. and LANDEL, R.F., 2015. Physical therapists' role in prevention and management of patellar tendinopathy injuries in youth, collegiate, and middle-aged indoor volleyball athletes. *Brazilian journal of physical therapy,* **19**(5), pp. 410-420.

LARSSON, M.E., KALL, I. and NILSSON-HELANDER, K., 2012. Treatment of patellar tendinopathy--a systematic review of randomized controlled trials. *Knee surgery, sports traumatology, arthroscopy : official journal of the ESSKA,* **20**(8), pp. 1632-1646.

LEE, W.C., NG, G.Y., ZHANG, Z.J., MALLIARAS, P., MASCI, L. and FU, S.N., 2020. 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,* **30**(1), pp. 25-32.

LIAN, O.B., ENGEBRETSEN, L. and BAHR, R., 2005. Prevalence of jumper's knee among elite athletes from different sports: a cross-sectional study. *The American Journal of Sports Medicine,* **33**(4), pp. 561-567.

LIM, H.Y. and WONG, S.H., 2018. Effects of isometric, eccentric, or heavy slow resistance exercises on pain and function in individuals with patellar tendinopathy:

A systematic review. *Physiotherapy Research International : The Journal for Researchers and Clinicians in Physical Therapy,* **23**(4), pp. e1721.

MALLIARAS, P., COOK, J., PURDAM, C. and RIO, E., 2015. Patellar Tendinopathy: Clinical Diagnosis, Load Management, and Advice for Challenging Case Presentations. *Journal of Orthopaedic & Sports Physical Therapy,* **45**(11), pp. 887-898.

MELLOR, R., BENNELL, K., GRIMALDI, A., NICOLSON, P., KASZA, J., HODGES, P., WAJSWELNER, H. and VICENZINO, B., 2018. Education plus exercise versus corticosteroid injection use versus a wait and see approach on global outcome and pain from gluteal tendinopathy: prospective, single blinded, randomised clinical trial. *British journal of sports medicine,* **52**(22), pp. 1464-1472.

MENDONCA, L.D., OCARINO, J.M., BITTENCOURT, N.F.N., MACEDO, L.G. and FONSECA, S.T., 2018. Association of Hip and Foot Factors With Patellar Tendinopathy (Jumper's Knee) in Athletes. *The Journal of orthopaedic and sports physical therapy,* **48**(9), pp. 676-684.

MENDONCA, L.D., VERHAGEN, E., BITTENCOURT, N.F., GONCALVES, G.G., OCARINO, J.M. and FONSECA, S.T., 2016. Factors associated with the presence of patellar tendon abnormalities in male athletes. *Journal of science and medicine in sport,* **19**(5), pp. 389-394.

MENDONCA, L.M., BITTENCOURT, N.F.N., ALVES, L.E.M., RESENDE, R.A. and SERRAO, F.V., 2020. Interventions used for Rehabilitation and Prevention of Patellar Tendinopathy in athletes: a survey of Brazilian Sports Physical Therapists. *Brazilian journal of physical therapy,* **24**(1), pp. 46-53.

MENDONCA, L.M., LEITE, H.R., ZWERVER, J., HENSCHKE, N., BRANCO, G. and OLIVEIRA, V.C., 2020. How strong is the evidence that conservative treatment reduces pain and improves function in individuals with patellar tendinopathy? A systematic review of randomised controlled trials including GRADE recommendations. *British journal of sports medicine,* **54**(2), pp. 87-93.

MERSMANN, F., LAUBE, G., MARZILGER, R., BOHM, S., SCHROLL, A. and ARAMPATZIS, A., 2021. A Functional High-Load Exercise Intervention for the

Patellar Tendon Reduces Tendon Pain Prevalence During a Competitive Season in Adolescent Handball Players. *Frontiers in physiology,* **12**, pp. 626225.

MILLAR, N.L., SILBERNAGEL, K.G., THORBORG, K., KIRWAN, P.D., GALATZ, L.M., ABRAMS, G.D., MURRELL, G.A.C., MCINNES, I.B. and RODEO, S.A., 2021. Tendinopathy. *Nature reviews.Disease primers,* **7**(1), pp. 1-020-00234-1.

NUNEZ-MARTINEZ, P. and HERNANDEZ-GUILLEN, D., 2021. Management of Patellar Tendinopathy Through Monitoring, Load Control, and Therapeutic Exercise: A Systematic Review. *Journal of Sport Rehabilitation,* , pp. 1-14.

PETERS, J.A., ZWERVER, J., DIERCKS, R.L., ELFERINK-GEMSER, M.T. and VAN DEN AKKER-SCHEEK, I., 2016. Preventive interventions for tendinopathy: A systematic review. *Journal of science and medicine in sport,* **19**(3), pp. 205-211.

PIETROSIMONE, L.S., BLACKBURN, J.T., WIKSTROM, E.A., BERKOFF, D.J., DOCKING, S.I., COOK, J. and PADUA, D.A., 2020. Landing biomechanics are not immediately altered by a single-dose patellar tendon isometric exercise protocol in male athletes with patellar tendinopathy: A single-blinded randomized cross-over trial. *Physical therapy in sport : official journal of the Association of Chartered Physiotherapists in Sports Medicine,* **46**, pp. 177-185.

RIO, E., KIDGELL, D., PURDAM, C., GAIDA, J., MOSELEY, G.L., PEARCE, A.J. and COOK, J., 2015. Isometric exercise induces analgesia and reduces inhibition in patellar tendinopathy. *British journal of sports medicine,* **49**(19), pp. 1277-1283.

RIO, E., PURDAM, C., GIRDWOOD, M. and COOK, J., 2017. Isometric Exercise to Reduce Pain in Patellar Tendinopathy In-Season; Is It Effective "on the Road?". *Clinical journal of sport medicine : official journal of the Canadian Academy of Sport Medicine,* .

ROMERO-RODRIGUEZ, D., GUAL, G. and TESCH, P.A., 2011. Efficacy of an inertial resistance training paradigm in the treatment of patellar tendinopathy in athletes: a case-series study. *Physical therapy in sport : official journal of the Association of Chartered Physiotherapists in Sports Medicine,* **12**(1), pp. 43-48.

ROSEN, A.B., WELLSANDT, E., NICOLA, M. and TAO, M.A., 2021. Current Clinical Concepts: Clinical Management of Patellar Tendinopathy. *Journal of athletic training,* .

RUDAVSKY, A. and COOK, J., 2014. Physiotherapy management of patellar tendinopathy (jumper's knee). *Journal of physiotherapy,* **60**(3), pp. 122-129.

RUFFINO, D., MALLIARAS, P., MARCHEGIANI, S. and CAMPANA, V., 2021. Inertial flywheel vs heavy slow resistance training among athletes with patellar tendinopathy: A randomised trial. *Physical therapy in sport : official journal of the Association of Chartered Physiotherapists in Sports Medicine,* **52**, pp. 30-37.

SAITHNA, A., GOGNA, R., BARAZA, N., MODI, C. and SPENCER, S., 2012. Eccentric Exercise Protocols for Patella Tendinopathy: Should we Really be Withdrawing Athletes from Sport? A Systematic Review. *The open orthopaedics journal,* **6**, pp. 553-557.

SANCHEZ-GOMEZ, A., JURADO-CASTRO, J.M., MATA, F., SANCHEZ-OLIVER, A.J. and DOMINGUEZ, R., 2022. Effects of beta-Hydroxy beta-Methylbutyric Supplementation in Combination with Conservative Non-Invasive Treatments in Athletes with Patellar Tendinopathy: A Pilot Study. *International journal of environmental research and public health,* **19**(1), pp. 10.3390/ijerph19010471.

SANCHO, I., MORRISSEY, D., WILLY, R.W., BARTON, C. and MALLIARAS, P., 2019. Education and exercise supplemented by a pain-guided hopping intervention for male recreational runners with midportion Achilles tendinopathy: A single cohort feasibility study. *Physical therapy in sport : official journal of the Association of Chartered Physiotherapists in Sports Medicine,* **40**, pp. 107-116.

SCATTONE SILVA, R., FERREIRA, A.L., NAKAGAWA, T.H., SANTOS, J.E. and SERRAO, F.V., 2015. Rehabilitation of Patellar Tendinopathy Using Hip Extensor Strengthening and Landing-Strategy Modification: Case Report With 6-Month Follow-up. *The Journal of orthopaedic and sports physical therapy,* **45**(11), pp. 899-909.

SCATTONE SILVA, R., NAKAGAWA, T.H., FERREIRA, A.L., GARCIA, L.C., SANTOS, J.E. and SERRAO, F.V., 2016. Lower limb strength and flexibility in athletes with and without patellar tendinopathy. *Physical therapy in sport : official journal of the Association of Chartered Physiotherapists in Sports Medicine,* **20**, pp. 19-25.

SCOTT, A., LAPRADE, R.F., HARMON, K.G., FILARDO, G., KON, E., DELLA VILLA, S., BAHR, R., MOKSNES, H., TORGALSEN, T., LEE, J., DRAGOO, J.L. and ENGEBRETSEN, L., 2019. Platelet-Rich Plasma for Patellar Tendinopathy: A Randomized Controlled Trial of Leukocyte-Rich PRP or Leukocyte-Poor PRP Versus Saline. *The American Journal of Sports Medicine,* **47**(7), pp. 1654-1661.

SCULLY, D., KREMER, J., MEADE, M.M., GRAHAM, R. and DUDGEON, K., 1998. Physical exercise and psychological well being: a critical review. *British journal of sports medicine,* **32**(2), pp. 111-120.

SECRIST, E.S., BHAT, S.B. and DODSON, C.C., 2016. The Financial and Professional Impact of Anterior Cruciate Ligament Injuries in National Football League Athletes. *Orthopaedic journal of sports medicine,* **4**(8), pp. 2325967116663921.

SPRAGUE, A.L., COUPPE, C., POHLIG, R.T., SNYDER-MACKLER, L. and SILBERNAGEL, K.G., 2021. Pain-guided activity modification during treatment for patellar tendinopathy: a feasibility and pilot randomized clinical trial. *Pilot and feasibility studies,* **7**(1), pp. 58-021-00792-5.

SPRAGUE, A.L., SMITH, A.H., KNOX, P., POHLIG, R.T. and GRAVARE SILBERNAGEL, K., 2018. Modifiable risk factors for patellar tendinopathy in athletes: a systematic review and meta-analysis. *British journal of sports medicine,* **52**(24), pp. 1575-1585.

THIJS, K.M., ZWERVER, J., BACKX, F.J., STEENEKEN, V., RAYER, S., GROENENBOOM, P. and MOEN, M.H., 2017. Effectiveness of Shockwave Treatment Combined With Eccentric Training for Patellar Tendinopathy: A Double-Blinded Randomized Study. *Clinical journal of sport medicine : official journal of the Canadian Academy of Sport Medicine,* **27**(2), pp. 89-96.

TRICCO, A.C., LILLIE, E., ZARIN, W., O'BRIEN, K.K., COLQUHOUN, H., LEVAC, D., MOHER, D., PETERS, M.D.J., HORSLEY, T., WEEKS, L., HEMPEL, S., AKL, E.A., CHANG, C., MCGOWAN, J., STEWART, L., HARTLING, L., ALDCROFT, A., WILSON,

M.G., GARRITTY, C., LEWIN, S., GODFREY, C.M., MACDONALD, M.T., LANGLOIS, E.V., SOARES-WEISER, K., MORIARTY, J., CLIFFORD, T., TUNCALP, O. and STRAUS, S.E., 2018. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. *Annals of Internal Medicine,* **169**(7), pp. 467-473.

VAN ARK, M., COOK, J.L., DOCKING, S.I., ZWERVER, J., GAIDA, J.E., VAN DEN AKKER-SCHEEK, I. and RIO, E., 2016. Do isometric and isotonic exercise programs reduce pain in athletes with patellar tendinopathy in-season? A randomised clinical trial. *Journal of science and medicine in sport,* **19**(9), pp. 702-706.

VAN DER WORP, H., VAN ARK, M., ROERINK, S., PEPPING, G.J., VAN DEN AKKER-SCHEEK, I. and ZWERVER, J., 2011. Risk factors for patellar tendinopathy: a systematic review of the literature. *British journal of sports medicine,* **45**(5), pp. 446-452.

VAN DER WORP, H., VAN ARK, M., ZWERVER, J. and VAN DEN AKKER-SCHEEK, I., 2012. Risk factors for patellar tendinopathy in basketball and volleyball players: a cross-sectional study. *Scandinavian Journal of Medicine & Science in Sports,* **22**(6), pp. 783-790.

VAN RIJN, D., VAN DEN AKKER-SCHEEK, I., STEUNEBRINK, M., DIERCKS, R.L., ZWERVER, J. and VAN DER WORP, H., 2019. Comparison of the Effect of 5 Different Treatment Options for Managing Patellar Tendinopathy: A Secondary Analysis. *Clinical journal of sport medicine : official journal of the Canadian Academy of Sport Medicine,* **29**(3), pp. 181-187.

VANDER DOELEN, T. and JELLEY, W., 2020. Non-surgical treatment of patellar tendinopathy: A systematic review of randomized controlled trials. *Journal of science and medicine in sport,* **23**(2), pp. 118-124.

VANDER DOELEN, T. and SCOTT, A., 2020. Multimodal management of patellar tendinopathy in basketball players: A retrospective chart review pilot study. *Journal of Bodywork and Movement Therapies,* **24**(3), pp. 267-272.

VICENZINO, B., 2015. Tendinopathy: Evidence-Informed Physical Therapy Clinical Reasoning. *The Journal of orthopaedic and sports physical therapy,* **45**(11), pp. 816-818.

VISNES, H., HOKSRUD, A., COOK, J. and BAHR, R., 2005. No effect of eccentric training on jumper's knee in volleyball players during the competitive season: a randomized clinical trial. *Clinical journal of sport medicine : official journal of the Canadian Academy of Sport Medicine,* **15**(4), pp. 227-234.

WIESE-BJORNSTAL, D.M., 2010. Psychology and socioculture affect injury risk, response, and recovery in high-intensity athletes: a consensus statement. *Scandinavian Journal of Medicine & Science in Sports,* **20 Suppl 2**, pp. 103-111.

WITVROUW, E., BELLEMANS, J., LYSENS, R., DANNEELS, L. and CAMBIER, D., 2001. Intrinsic risk factors for the development of patellar tendinitis in an athletic population. A two-year prospective study. *The American Journal of Sports Medicine,* **29**(2), pp. 190-195.

YOUNG, M.A., COOK, J.L., PURDAM, C.R., KISS, Z.S. and ALFREDSON, H., 2005. Eccentric decline squat protocol offers superior results at 12 months compared with traditional eccentric protocol for patellar tendinopathy in volleyball players. *British journal of sports medicine,* **39**(2), pp. 102-105.

ZWERVER, J., BREDEWEG, S.W. and VAN DEN AKKER-SCHEEK, I., 2011. Prevalence of Jumper's knee among nonelite athletes from different sports: a cross-sectional survey. *The American Journal of Sports Medicine,* **39**(9), pp. 1984-1988.

ZWERVER, J., HARTGENS, F., VERHAGEN, E., VAN DER WORP, H., VAN DEN AKKER-SCHEEK, I. and DIERCKS, R.L., 2011. No effect of extracorporeal shockwave therapy on patellar tendinopathy in jumping athletes during the competitive season: a randomized clinical trial. *The American Journal of Sports Medicine,* **39**(6), pp. 1191-1199.