Management of patellar tendinopathy in athletes

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Patellar tendinopathy (PT) is a painful musculoskeletal condition that particularly affects athletes participating in jumping sports. Symptoms of PT are difficult to manage, affect sports and physical activity participation, and may even become a career-ending problem for professional athletes. The recovery rate of PT is low with a high recurrence rate. It is important to manage the physiotherapy programme in order to improve athletes' compromised sports participation. Therefore, we aim to present available evidence to guide clinicians in key elements of management of PT in athletes.

LEARNING OUTCOMES
TO SUPPORT PHYSIO FIRST QAP

1 Physiotherapists have an important role in managing patellar tendinopathy as load management with appropriate exercises is the best treatment approach, with a strong level of evidence.
2 Restoring patellar tendon function is the primary focus of rehabilitation, prior to pain and tendon structure.
3 Pain monitoring is important for loading exercise progression during rehabilitation.

Introduction

Injuries in the lower limb account for more than 50% in all levels of sports (Hootman *et al* 2007). Approximately between 30% to 50% of all sports related injuries are reported as tendinopathy (Järvinen *et al* 2005). Across different sports, patellar tendinopathy (PT) demonstrates an overall prevalence of approximately 14% of all injuries in elite athletes and 8.5% in non-elite athletes (Lian *et al* 2005; Zwerver *et al* 2011). The most recent reported prevalence rates, based on a systematic review of 28,171 participants, are 18.3% and 0.1% for athletic and general populations respectively (Nutarelli *et al* 2023). The highest prevalence rates of PT are in volleyball, with 45% for elite and 14% for non-elite, and basketball where PT is prevalent in 32% of elite and 12% of non-elite athletes (Lian *et al* 2005). The distribution by sex is 11.2% in female and 17% in male athletes (Nutarelli *et al* 2003). For older athletes, i.e. >18 years, the prevalence rate is 21.3%, twice that of younger athletes of <18 years with a rate of 10.1% (Nutarelli *et al* 2023). Overall, PT is a very common musculoskeletal (MSK) injury in both elite and non-elite athletes who participate in sports that have a high impact loading on the knee, such as those requiring jumping, landing and sprinting. It is important, therefore, to understand and manage the condition based on the latest available evidence. Physiotherapists have an important role in managing PT, as exercise is the primary treatment strategy. This article presents the available evidence to guide clinicians in key elements of current approaches for the management of PT in athletes from a physiotherapy perspective.

Injury mechanism

Tendons make joint movement possible by transmitting the force created in the muscle to the bone (Tayfur & Tayfur 2023). They are designed to transfer forces with minimal deformation or energy loss thanks to the parallel arrangement of collagen (Kirkendall & Garrett 2007). There are two types of tendons that are based on their function, i.e. positional or energy storing (Thorpe *et al* 2015). Positional tendons transfer force from muscle to bone to facilitate locomotion, whereas tendons such as patellar and Achilles have an additional function of storing and releasing energy as they stretch and recoil, thereby increasing the efficiency of locomotion (Finni 2006; Thorpe *et al* 2015). This is known as the "stretch-shortening cycle" (SSC), or "energy storage activities" (Finni 2006). Thanks to

> "PHYSIOTHERAPISTS HAVE AN IMPORTANT ROLE IN MANAGING PATELLAR TENDINOPATHY, AS EXERCISE IS THE PRIMARY TREATMENT STRATEGY"

this mechanism, energy storing tendons provide an efficient movement model that increases power and performance, and reduces the cost of locomotion as tendon recoil acts as a power multiplier, that decreases the muscle work and metabolic energy expenditure (Finni 2006; Thorpe *et al* 2015).

Whilst the SSC mechanism in patellar tendon enables athletes to jump more and higher, for longer periods of time, the load on the tendon varies depending on the task. For instance, faster movements generate greater patellar tendon rate of force development during squat and jumps, although the patellar tendon force is similar during both tasks (Earp *et al* 2016). In their 2020 study, Tayfur *et al* produced similar findings with graded jump-landing related tasks based on vertical ground reaction forces that ranged from 1 x to 3.8 x body weight, while the rate of force development ranged from 24 x to 107 x body weight (Tayfur *et al* 2020). These results show that the patellar tendon has the ability to withstand not only high loads, but also high-speed loads. However, this may also be a potential injury mechanism in repetitive use.

A high proportion of load during jump-landing activities is transmitted through the patellar tendon (Decker *et al* 2003) as a way of distributing kinetic energy through lower limb joints (Devita & Skelly 1992). This is proposed as one of the causal biomechanical factors for PT onset, with increased vertical jump height, or the number of jumps performed being other potential causes (van der Worp *et al* 2011). This is likely to be a result of greater mechanical overload related to high eccentric knee loads instigated during repeated high jumps, increasing the risk of developing PT (van der Worp *et al* 2011).

Clinical presentation

The main clinical features of PT include anterior knee pain and tenderness localised at the inferior patella pole (Lui *et al* 2011; Tayfur *et al* 2023). The key characteristic is load-dependent pain (Lui *et al* 2011) which is very important during the examination (figure 1). Owing to the non-inflammatory nature of the condition, swelling is mostly not present (Tayfur *et al* 2023). Jumping athletes may present symptoms on both legs, but generally one side is more severe. The possible reason being that athletes generally try to avoid loading on the injured side at the beginning, and use the contralateral side more during the activity, hence developing the condition on the contralateral side due to increased load. Another typical tendon related symptom is pain that is present during warm up, but that may resolve during the activity, on completion of the activity, after cool-down or the following day (Tayfur *et al* 2023). Another feature of PT is that the tendon becomes thicker owing to fibroblast proliferation and collagen synthesis during the healing process.

Symptoms of PT are difficult to manage due to its complicated prognosis and this results in a low recovery rate. The highest reported rate of recovery, irrespective of treatment, is 65% at six months (Cook *et al* 1997; Kettunen *et al* 2002). The most recent reported recovery rate is 45% at six months by the largest prospective cohort in jumping athletes (Tayfur *et al* 2022a).

Although it is possible for some cases to recover quickly, up to 60% of athletes take more than four weeks off participating in sport (Cook *et al* 1997; Hägglund *et al* 2011), which may further last for years (Morton *et al* 2017; Tayfur *et al* 2023). The recurrence rate of PT is also high at over 25% (Hägglund *et al* 2011) and flare up episodes can occur during rehabilitation which is further explained later in this article. Symptoms of PT generally occur insidiously and many athletes often continue to play despite PT presence (Tayfur *et al* 2023). However, sports and physical activity participation is vastly affected because of long-term recalcitrance, and up to 50% of professional jumping athletes with PT make the decision to end their sports careers because of it (Kettunen *et al* 2002).

It is reported that jumping athletes with PT tend to train or play more, and practice more court based jumping sports such as volleyball, basketball and handball. They have bilateral injury, experience localised pain on the inferior patella pole, gradual pain onset, have morning pain, but do not have swelling

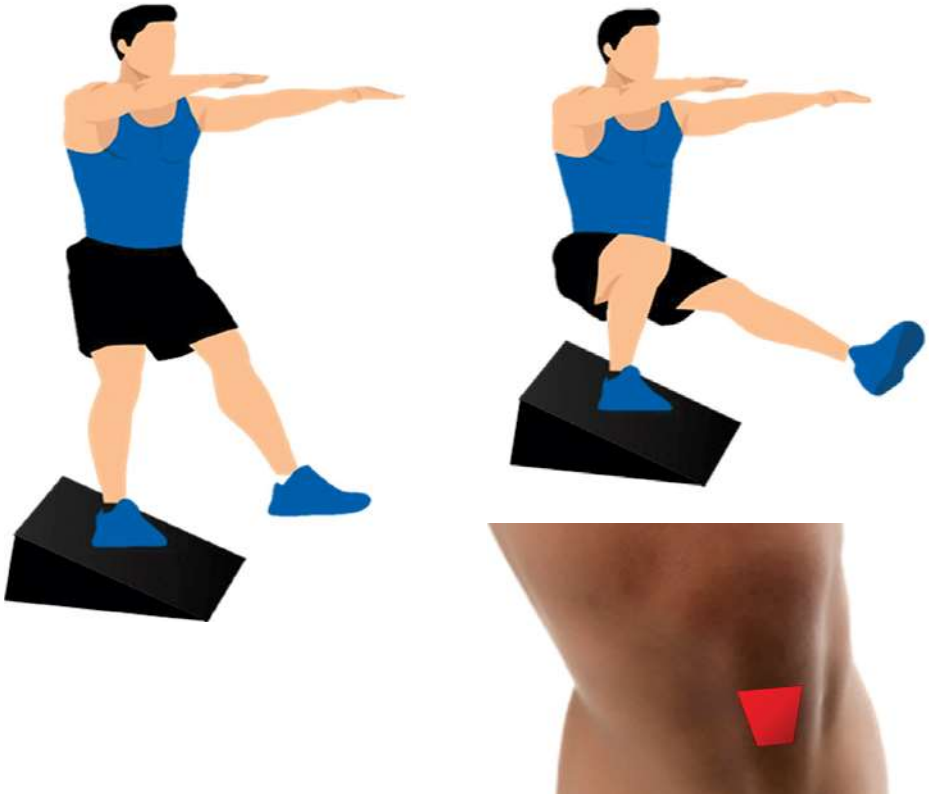

FIGURE 1: Load dependent localised pain and tenderness at the inferior pole of the patella (images reproduced with permission)

in comparison to other knee problems (Tayfur *et al* 2023). Greater severity of PT is associated with a lower quality of life and worse sports specific function, indicating the impact of PT on both daily and athletic life (Tayfur *et al* 2023). These factors could help clinicians to improve their understanding and assessment of the condition for better identification and management of PT.

Clinical diagnosis and examination

Tendinopathy is diagnosed with a detailed patient history and clinical assessment (Rio *et al* 2020). Clinical diagnosis of PT is based on the load dependency (Brukner 2012; Lian *et al* 2005) of localised pain to the inferior patella pole (Figueroa *et al* 2016), by simply asking patients about their pain after a single leg declined squat (figure 1). Using a pain map during the squat is recommended (Coombes *et al* 2020; Tayfur *et al* 2020, 2023). Although imaging is not always necessary for diagnosing tendinopathy (Scott *et al* 2020), ultrasound or magnetic resonance imaging (MRI) may be used to eliminate other types of anterior knee pain (Hoksrud *et al* 2008; Malliaras *et al* 2015).

A recent consensus suggests the following nine core domains for the examination of all tendinopathies (Vicenzino *et al* 2020):

- patient rating of condition
- participation in work and sport
- pain on activity or loading
- function
- psychological factors
- physical function capacity
- disability
- quality of life
- pain over a specified time.

Although range of motion is not a core domain (Vicenzino *et al* 2020), the angle of ankle dorsiflexion is a risk factor for PT (Tayfur *et al* 2022b) and needs to be measured ideally with the knee-to-wall test (Krause *et al* 2011). Lower limb examination, functional clinical tests, strength, flexibility, ankle dorsiflexion angle, foot posture and alignment, and ultrasound imaging to investigate, for example tendon thickness or neovascularisation, are all valid, reliable and feasible measures to assess PT (Tayfur *et al* 2020). Additionally, during rehabilitation, patient reported outcome measures (PROMs) are very important to measure and track changes in pain severity, function, disability, quality of life, pain catastrophising and kinesiophobia. Paper or digital formats of measures specific to PT such as VISA-P, Health-related Quality of Life, Pain Catastrophising Scale and the Tampa Scale for Kinesiophobia can be used in clinical settings (Tayfur *et al* 2020).

Physiotherapy and rehabilitation

Function is the primary focus of PT rehabilitation. Tendon structure seen on imaging does not always correlate with the outcome (McAuliffe *et al* 2016; Sprague *et al* 2022). Athletes may become pain free and restore function, but tendon structure could stay the same. Similarly, pain does not always correlate with the amount of load (Sancho *et al* 2022, 2023; Tayfur *et al* 2020), meaning that athletes may feel high or low severity pain during any loading activities. However, pain is important to monitor the loading exercise progression during rehabilitation. Docking *et al* (2014) suggest that we "treat the donut, not the hole", advice that is based on thickness measurements of the tendon via imaging. The volume of normal tendon structure is significantly greater in pathological tendons than normal ones, thus the increase in volume may be a response to ensure there is sufficient normal tendon tissue to compensate for the pathological area (Docking *et al* 2014). Thickness is a good symptom as it allows loading the tendon, which is the most important part of rehabilitation especially for energy storing tendons such as the patella and Achilles.

LOADING PROGRAMMES

Biomechanically, collagen tissue becomes stronger with load, but with insufficient load, particularly during energy storing activities, the tendon becomes weaker and does not function properly. Rehabilitation does not, therefore, include long periods of rest as this causes unloading, resulting in weaker tendon tissues. Tendons are, however, also at risk of injury with overloading, so optimal loading, especially during rehabilitation, is very important for tendon health. The primary progression criteria for optimal loading is pain monitoring (Escriche-Escuder *et al* 2020), which can be applied to monitor and progress the ideal loading on the tendon (Silbernagel *et al* 2007). Acceptable pain does not mean harm, and it can help with managing and progressing optimal loading based on the athlete's capacity. Pain can be monitored using the visual analogue scale (VAS) (Silbernagel *et al* 2007) which considers 0-3 out of 10 to be the safe area, 4-5 as acceptable but needs attention, and that it is a risk to perform exercise at >5. Attention should also be paid to flare-up episodes, i.e. pain >5 on the VAS scale, 24 hours after loading. In this case, and if post-loading pain does not resolve, the programme can be modified by continuing at the same level instead of advancing it. This should result in the pain lessening, or disappearing completely, although it may take a little longer than 24 hours to do so. If pain is still present at two to three days, the loading programme should be reduced, and / or jumping and landing activities discontinued.

> "LOADING IS THE MOST IMPORTANT PART OF REHABILITATION, ESPECIALLY FOR ENERGY STORING TENDONS"

ISOMETRIC EXERCISE

Exercise is the primary approach and has the greatest evidence level for PT as it is the only way to load the tendon in line with its function. The general method is to start with isometric exercises, proceed to isotonic and energy storage loading, such as SSC activities, and finally return to sport activities (Malliaras *et al* 2015). Based on the athlete's capacity, loading can start with isotonic exercises and, for all individuals, when progressing the loading programme, exercises in the previous level should be continued. Isometric exercise is very helpful when the athlete has unacceptable pain during isotonic exercise, i.e. >5 on VAS. Rio *et al* (2015) showed that isometric quadriceps exercises at 70% of maximal voluntary contraction (45 seconds x 5 repetitions), before and after training and competition, reduced pain during activities. Isometric exercises are also clinically useful and more effective during the competition season for short-term pain relief (Lim & Wong 2018) and are as effective as isotonic exercises for immediate pain relief (Challoumas *et al* 2021).

ISOTONIC EXERCISE

Isotonic exercises should be commenced as soon as pain is in the acceptable level of <3 on the VAS. Eccentric exercise, e.g. single leg decline squat (three sets x 15 repetitions, twice a day) was, for years, the most common and popular treatment for PT, with a between 50% to 70% chance of improvement at three to six months (Gaida & Cook 2011). Eccentric exercises are clinically useful and more suitable for long-term pain reduction and improvement in function (Lim & Wong 2018). A disadvantage of eccentric exercise, however, is that it may be too aggressive for athletes with a high level of irritability, especially during the competition season (Visnes *et al* 2005). Heavy slow resistance (HSR) training is the most common alternative to isolated eccentric exercise, as it consists of both concentric and eccentric contractions with, for example, squats, hack squats, and leg press on both legs, that are performed between 90° knee flexion and full extension. This programme is generally required for between six to 12 weeks, with a two to three times per week frequency, commencing with four sets x 15 repetitions, progressing to an increase in weight for each exercise as tolerated, whilst tapering to six repetitions. The advantage of HSR is that its two to three times per week frequency is way less than the twice daily programme for isolated eccentric exercises, so athletes have a significantly greater, i.e. 70% satisfaction with HSR than with isolated eccentric exercises at 22%, even though pain and functional outcomes are similar at six months (Malliaras *et al* 2013). Whilst HSR is clinically useful and suitable for long-term pain reduction and improvement in function, the use of heavy weights should be applied carefully in clinical circumstances (Lim & Wong 2018).

ENERGY STORAGE EXERCISE

Energy storage exercise, incorporating SSC activities, should be commenced when athletes have adequate strength, and pain is in the acceptable <3 on VAS level. Adequate strength is defined as the ability to perform a minimum of four sets x eight repetitions of single-leg press, with around 1.5 times body weight (Malliaras *et al* 2015). Energy storage activities could be considered as preparation for return to sport participation, as this level introduces different types of jump-landing activities such as vertical jump, drop landing, countermovement jump, jumping forward and backward, step jump and stop jump. Choice and progression of SSC activities should be tailored, based on the athlete's capacity, as the amount of load on the tendon depends on the tasks (Silva *et al* 2023; Tayfur *et al* 2020a). A recent biomechanical study ranked 35 different loading exercises for PT, within three tiers ranging from low to high (Silva *et al* 2023). Clinicians could use the tiers to choose and progress the best available exercises based on the athlete's capacity.

RETURN TO SPORT

When athletes can reach the competition demands of their sport with SSC exercises, they are ready to start sport specific exercises such as the spike jump and block jump in volleyball. At this stage, clinicians should grade sports specific patterns and integrate equipment, e.g. a ball and volleyball net into the exercise programme. Consequently, athletes may start ball training with their team at a submaximal level, mimic their training regime and gradually progress to competition level. Maximal vertical jump height is the most common test to measure and compare the athlete's current and pre-injury levels in order to decide on a complete return to sport. Additionally, there should be no symptoms or strength deficits when the athlete is in full training for return to sport (Malliaras *et al* 2015). To maintain the optimal loading on the tendon on their return to sport, athletes should continue to perform isometric exercises before and after training / competition, and isotonic exercises twice a week, ideally during fitness training.

PREVENTION

Resistance training may be a useful cautionary approach (Burton 2022) as it includes eccentric, HSR and isometric exercises which are clinically beneficial during the competition season (Burton 2022). Patellar strapping and sports taping can be useful for short-term pain relief during and after training and competition (Burton 2022; Vander Doelen & Jelley 2020). A recent review suggests increasing the angle of ankle dorsiflexion to improve the absorption of ground reaction forces from landing, to potentially decrease excessive load on the tendon (Tayfur *et al* 2022b). Increasing truncal flexion during landing is another approach, as this may help reduce pain and tendon forces (Tayfur *et al* 2022b). Working on lower limb flexibility and soft landing patterns can be beneficial for decreasing landing stiffness (Tayfur *et al* 2022).

OTHER PHYSIOTHERAPY MODALITIES

Other modalities that are used in isolation generally do not work well but may be used as an adjunct to exercise. However, if symptoms persist, especially after six months of exercise rehabilitation, incorporating other

treatment methods may be useful. Extracorporeal shockwave therapy (ESWT) is the most common modality at this stage and it has promising outcomes. The latest evidence shows that ESWT based on 2,000 pulses, 4-8 Hz, 2-2.5 bar, once a week for two to six weeks is clinically beneficial for PT (Challoumas *et al* 2021). In contrast, ultrasound does not have any clinical benefits (Larsson *et al* 2012) and there is very limited research indicating the use of medium / long-term dry needling (Mendonça *et al* 2020; Vander Doelen & Jelley 2020) and short-term iontophoresis treatments for reducing pain (Mendonça *et al* 2020).

Conclusion

Patellar tendinopathy is a very common and painful condition in athletes participating in jumping related sports. Athletes who present with PT participate in their sport twice as much as athletes with other knee problems, yet they are less satisfied with their recovery (Tayfur *et al* 2023), as the rate of recovery is low, and those who do recover take a long time to do so. Symptoms are difficult to manage and negatively affect participation in sport and other physical activity. It is therefore important that any physiotherapy programme is designed to improve the athlete's participation in the sport that has been compromised by injury, through the evidence-based approach for PT of load management, appropriate exercises and progression.

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REVIEW SUPPORTING QAP

This article provides us with a very important focus on patella tendinopathy and how physiotherapists should approach rehabilitation, especially as the evidence shows how low the recovery rate is and that there is a high recurrence of injury.

The authors have categorised the tendons into two types; positional, which transfer force from muscle to bone to facilitate locomotion, and energy storing through the patellar and Achilles that stretch and recoil to store energy and then release it to increase the efficiency of locomotion.

Furthermore, this article breaks rehabilitation down into the range of exercises, such as isometric, isotonic, energy storage and loading programmes.

The categories covered aren't mutually exclusive or exhaustive, but they can be mutually inclusive within a patient's exercise programme depending on pain levels. This can be very helpful to us as physiotherapists as it enables us to guide patients through their rehabilitation, which at times can be frustratingly slow. It can also give us confidence in how we manage the patient's approach to the exercises we give them as part of a rehabilitation programme and highlights the best way to progress exercises with the knowledge that there is a strong level of evidence for treating patella tendinopathy with physiotherapy.

Reviewed by
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Abdulhamit Tayfur, sports physiotherapist, received his BSc degree in Physiotherapy and Rehabilitation (2013) and MSc degree in Sports Physiotherapy (2016) from Hacettepe University, Turkey. In 2013-2017, he worked as a sports physiotherapist in Turkish National Volleyball Teams and Turkish Super League volleyball and basketball teams. In 2022, he completed his PhD on recovery of patellar tendinopathy at the Sports and Exercise Medicine Department, Queen Mary University of London. Subsequently, he started to work as an Assistant Professor at School of Physical Therapy and Rehabilitation, Kırşehir Ahi Evran University, Turkey. He is interested in tendon injuries, jump-landing biomechanics, prevention and exercise.

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References

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