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Patellar Tendinopathy in Athletes

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Abstract

Purpose of Review This review discusses the current practice of evaluation and treatment of patellar tendinopathy with emphasis on rehabilitation.

Recent Findings The latest studies revolve primarily around implementation of isometric and heavy slow resistance (HSR) exercises in the rehabilitation of patellar tendinopathy rather than the traditional rehabilitation method of eccentric exercise.

Summary Patellar tendinopathy is a common injury of the inferior anterior knee seen in athletes but predominantly in jumping athletes. Onset is insidious and frequently noted in a loaded position with knee flexion. Physical exam finds tenderness along the patellar tendon with pain recreated while squatting. Treatment initially includes conservative measures such as guided physical therapy, medical therapy, and modalities. If recalcitrant, injections may be warranted, or rarely surgery may be considered.

Keywords Runner · Tendinitis · Tendinosis · Knee pain · Jumper's knee

Introduction

Patellar tendinopathy (PT), formerly known as patellar tendinitis [1••], is a common source of inferior anterior knee pain that has long plagued athletes of all varieties. Jumping athletes in particular are commonly impaired by this condition, first called "jumper's knee" in 1973 by Blazina and colleagues [2].

Epidemiology and Risk Factors

Jumping sports such as volleyball and basketball require frequent and powerful contractions of the knee extensor mechanism as athletes propel themselves into the air. All levels of jumping athletes—both elite [3•] and non-elite [4•]—are affected more commonly than those participating in other sports. The highest prevalence of PT was found in volleyball (44.6 ± 6.6%) and basketball (31.9 ± 6.8%) players in one Norwegian study [3•]. Both of these sports require high volumes of ballistic drop jumps and eccentric loading across the knee extensors. However, those participating in sports requiring a higher volume or running or cycling, both of which require less ballistic loading of the knee extensor musculature, had the lowest prevalence of patellar tendinopathy [3•]. Similarly, prevalence of PT in 891 non-elite athletes was nearly twice as high for basketball (11.8%) and volleyball (14.4%) compared with track and field (6.9%) [5]

Athletes develop PT due to a multitude of risk factors. Previously, both intrinsic (sex, age, knee alignment, Q angle, patella position, tibial/femoral rotation, knee stability, morphotype) and extrinsic (hard playing surfaces, length of training sessions) risk factors were thought to contribute [6], but a more recent systematic review [7••] found only low-quality evidence [8–11] to suggest nine associated risk factors for PT. These risk factors include weight, body mass index, waist-to-hip ratio, leg-length difference, foot arch height, quadriceps flexibility, hamstring flexibility, quadriceps strength, and vertical jump performance [12–16]. In runners, PT may be related to training volume [17, 18] and the eccentric contraction of the quadriceps may overload the knee extensor mechanism especially while running downhill [18, 19]. Some suggest [7••, 19] foot hyper-pronation is a risk factor and that poor joint coordination contributes as well. One study [20] suggested that single-sport female adolescent athletes were at fourfold greater relative risk of patellar tendinopathy compared with multisport athletes.

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Anatomy and Pathophysiology

The patellar tendon originates proximally as a continuation of the quadriceps tendon across the patella and the apex of the patella distally to its insertion into the tibial tuberosity [21]. It provides a link between the tibia and the powerful quadriceps muscle via the patellar sesamoid bone. Forceful concentric and eccentric quadriceps activation can greatly increase the force through the tendon [22].

As noted above, both extrinsic and intrinsic factors contribute to PT pathogenesis [23], with the most commonly cited extrinsic cause being the mechanical overload of the patellar tendon through repeated heavy loading of the knee extensor mechanism [24]. Microscopically, this leads to tendon microfracture and uncoupling of tenocytes from the mechanical signal of tendon loading with subsequent tendon disarray and degeneration [25]. Histopathologic studies reveal tendon disarray [25] with disorganized collagen bundles that lack reflectivity under polarized light, clefts filled with mucoid ground substance, increased fibroblasts, plump tenocytes, prominent capillary proliferation, and a lack of inflammatory cells [1••, 26•]. Neovascularization and subsequent innervation along with increased amount of protein and enzyme generation may cause increased pain [27, 28]. Macroscopically, tendon lesions appear gray and amorphous compared with healthy tissue which is glistening and white [1••]. The characteristic lesion usually develops in the deep posterior portion of the tendon close to the center of rotation of the knee and the inferior patellar pole which strains the most during increased knee flexion [27]. While some athletes develop the above noted changes from extrinsic risk factors, others do not despite similar loading. This indicates that intrinsic factors can play a large role. These include inferior patellar pole impingement onto the tendon [29], malalignment, patella alta, abnormal patellar laxity, and muscular imbalance.

Diagnosis

History

Athletes typically present with insidious onset of anterior knee pain provoked by jumping or early- to mid-squat stance [2] that is localized to the proximal patellar tendon at the inferior pole of the patella. Less commonly, pain is localized over the tibial tuberosity insertion or mid-tendon [30]. Pain is often absent at rest but present with loading. Often times, athletes will notice that initially the pain temporarily improves with warm-up but worsens after completing the exercise session. Over time, however, it tends to worsen to the point where increased activity causes increased pain. The condition is not necessarily self-limiting, with athletes often reporting reduction of pain with rest but persistent symptoms upon return to training and/or sport [31]. Some athletes report persistent symptoms up to 15 years after treatment and retirement from sport [32]. Previously, patellar tendon pain was evaluated and categorized using the Blazina classification system [2, 33]. Patellar tendon pain is now more commonly assessed using the Victorian Institute of Sport Assessment-Patella (VISA-P) questionnaire [34••] to reliably measure the severity of patellar tendinopathy upon presentation and follow-up as a measure of improvement.

Physical Exam

Patients are best examined supine with palpation of the inferior patellar pole, mid-tendon, and insertion with superior to inferior pressure on the superior pole of the patella, though this technique is only moderately sensitive and not specific in symptomatic patients [35]. Mild tenderness in jumping athletes should be considered asymptomatic; if the patient has unilateral symptoms, the contralateral side can be compared. Functional maneuvers such as the decline squat test [23] (single leg squat performed to 30° of knee flexion with simultaneous contralateral knee extension) can be used to reproduce the athlete's characteristic pain and to monitor clinical recovery.

Differential Diagnosis

Other pathologies to consider in the inferior anterior knee include patellofemoral pain syndrome (PFPS), bone stress injury, infrapatellar (Hoffa's) fat pad impingement, patellofemoral cartilage lesions or osteoarthritis, referred pain, meniscal injury, or pes anserine tendinopathy/bursitis. In the pediatric patient, consideration should also be made for Sinding-Larsen-Johansson disease, Osgood-Schlatter disease, or a patellar sleeve fracture.

Imaging

Often times, no imaging is required to confirm the diagnosis. X-rays may be performed to evaluate for other sources of pathology and for presence of tendon thickening or intratendinous calcifications. Imaging studies of choice include ultrasonography (Fig. 1) and/or magnetic resonance imaging (MRI) [36••], with a combination of gray scale and color Doppler ultrasound being shown to more accurately confirm clinically diagnosed patellar tendinopathy [37•]. Ultrasound findings include hypoechoic and thickened areas of tendon with possible intra-tendinous calcifications, increased vascularity, and patellar tip erosion [23] (Fig. 2). Though ultrasound is specific (94%), it has limited sensitivity (58%) [23], and evaluation is confined to the superficial portions of the knee. Conversely, MRI also provides an intra-articular view [38••] of the knee in addition to the patellar tendon; it will typically reveal focal thickening and increased signal of the proximal

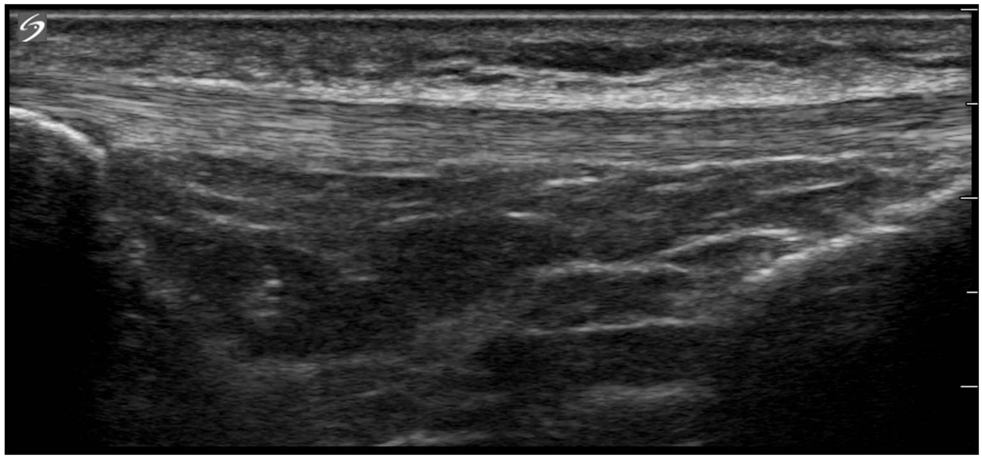

Fig. 1 Longitudinal ultrasound image of patellar tendon

tendon and inferior pole of the patella. Sensitivity and specificity of MRI have previously been reported as 78 and 86%, respectively [23]. No association has been shown between ultrasound or MRI findings and disease severity or change after treatment [39•, 40]. Asymptomatic tendon abnormalities are quite common, with one meta-analysis [41•] demonstrating ultrasound abnormalities in 159 out of 590 (26.9%) athletic patellar tendons, and another smaller study including 33 asymptomatic athletic tendons [37•] revealing a prevalence of 18%. However, studies [39•, 42] have reported that athletes with asymptomatic hypoechoic changes in the patellar tendon were at greater risk (RR = 4.2, OR = 3.3) of developing symptoms compared to control subjects, so previously seen incidental abnormalities could be considered a potential pain generator if demonstrated on prior ultrasound or MRI studies in an athlete with new onset anterior knee pain.

Management and Rehabilitation

Patellar tendinopathy (PT) can be difficult to manage. Cook et al. [43] found greater than one third of athletes presenting for treatment for this condition were unable to return to sport within 6 months. Other studies have found 53% of athletes with patellar tendinopathy were forced to retire from sport [32] and only 46% of athletes had returned to full training with no pain at 12 months after performing rehabilitation [44].

Conservative Management

Conservative therapy should be the initial treatment for patellar tendinopathy. First, activity should be modified through decreased frequency and volume of eccentric loading of the knee extensor mechanism. Gait analysis or review of jumping/landing technique may reveal poor ROM in the calf/ankle complex which may be targeted with stretching to unload the patellar tendon through increased forefoot use and dorsiflexion when landing, leading to decreased ground reaction forces [45–47]. Strength imbalances involving the quadriceps and hamstring muscles, if present, may be corrected as well as poor hip and/or knee flexibility (though evidence is limited).

Rehabilitation Protocol The most investigated intervention for patellar tendinopathy is eccentric exercise [48, 49••], which is often limited by pain. A recent review [50] found a small but statistically significant short-term (< 3 months) benefit from

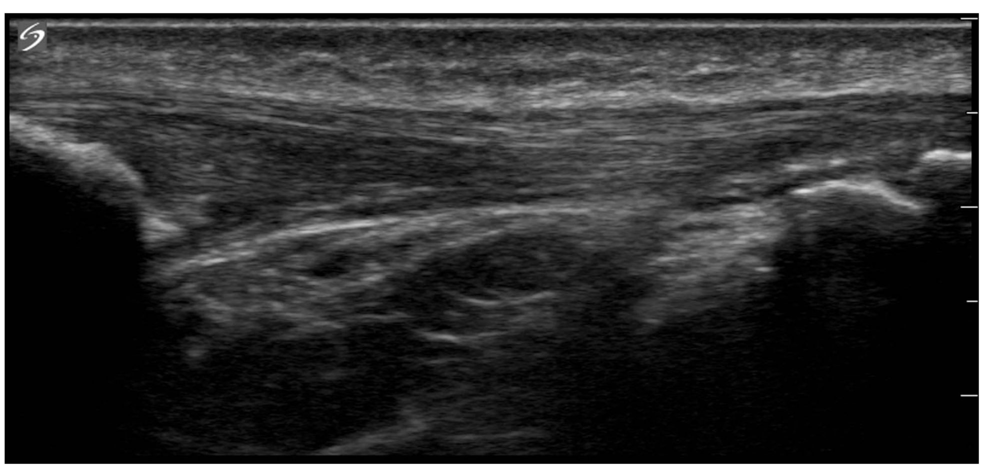

Fig. 2 Longitudinal ultrasound image of patellar tendon with tendinopathic features. Note thickening of tendon with increased hypoechogenic features and less fibrillar echotexture. Small hyperechogenic foci at each end of the tendon may represent calcifications embedded within the tendon. Osteophytosis can also be noted

painful eccentric exercise compared with pain free; however, no superior effect is noted in the medium (3–12 months) or long term (> 12 months) when compared with other protocols. Additionally, Visnes et al. [51•] demonstrated that eccentric exercise may be of no benefit to patients demonstrating a high level of irritability or actively participating in sport. Isolated eccentric exercise may also fail to address other common impairments associated with this condition, such as weight-bearing ankle dorsiflexion range of motion [47, 52].

Though eccentric exercise is commonly utilized, there is limited high-quality data demonstrating positive clinical outcomes from this approach [48, 53••]. Heavy slow resistance (HSR) has recently been investigated as an alternative treatment for patellar tendinopathy. One randomized clinical trial [54••] compared HSR exercise with the eccentric decline squat protocol for subjects with patellar tendinopathy and found that while functional outcomes were similar at 6 months, patient satisfaction was significantly greater (70%) for the HSR protocol compared with the decline squat program (22%). Additionally, Malliaras et al. [53••] found moderate-quality evidence supporting HSR and limited evidence supporting the eccentric decline squat for subjects with patellar tendinopathy. This appears to carry over to the microscopic level as well. One systematic review [49••] found moderate evidence from one randomized controlled trial that pain reduction and functional improvement from HSR was associated with observable structural changes, such as decreased tendon diameter and reduced neovascularization. Strong evidence was also found to refute any observable structural change as an explanation for the response to eccentric exercise. A prospective cohort study [55] found that HSR improved the clinical outcome and was associated with normalization of tendon fibril morphology. These findings should be interpreted with caution when correlating exercise response and structural tendon changes since the majority of available evidence indicates treatment progress should be guided by clinical examination and patient-reported outcome measures rather than structural imaging [49••]. Overall, current evidence seems to favor HSR, but eccentrics can be effective in the management of patellar tendinopathy so clinicians should be familiar with this exercise method [56–58].

Isometric exercise appears to be a means of treatment for in-season athletes, providing significant relief of patellar tendon pain for up to 45 min following exercise [59]. Rio et al. [60] performed a within-season randomized-controlled trial which demonstrated that isometric contractions produced significantly greater immediate analgesia and improved pain and function at 4 weeks compared with isotonic exercise in 20 basketball and volleyball players.

Higher velocity and tendon loading rates are often provocative exercises for patients with tendinopathy, with neuroplasticity potentially playing a significant role in recalcitrant cases. Patients have higher levels of cortical reorganization and reduced motor unit activation secondary to cortical inhibition [59]. Babault et al. [61] found lower levels of quadriceps femoris activation during maximal eccentric and concentric contractions compared to maximal isometric contractions [61]. Further understanding of this information may be an important step in how clinicians prescribe exercise-based rehabilitation for patients with patellar tendinopathy. The aforementioned effects from isometrics and low-velocity exercise in the treatment of tendinopathy suggest a velocity-dependent component to motor control, pain modulation, and tendon load tolerance with this condition. The authors have found that tracking velocity with a metronome during rehabilitation provides an easy objective measurement and may allow a faster loading progression with improved tolerance. External cuing, whether auditory or visual, has been shown to promote positive neural adaptations such as decreased cortical inhibition [62].

The following three-stage rehabilitation protocol is introduced (Fig. 3), based on current evidence and the authors' opinion. This protocol is suggested as a general guide to familiarize physicians with the different phases of exercise progression as well as common pitfalls in rehabilitation. Exercise parameters will not be discussed in detail as the authors find that exercise dosage varies significantly and is based on individual factors which require a thorough evaluation from an experienced physical therapist.

Stage 1: Pain Modulation and Addressing the Kinetic Chain The goal of rehabilitation for patients with patellar tendinopathy is to improve tendon load tolerance. The initial stage of rehabilitation should focus on pain modulation, especially for in-season athletes and those regularly participating in provocative activities. Absence from sport may be avoided if isometric exercises are utilized appropriately. An isometric exercise protocol with the knee at 60° has previously been described by Rio et al. [59, 60]. These exercises should be performed with adequate resistance to invoke an analgesic response. A positive response from isometrics is an immediate reduction in pain when loading the patellar tendon (i.e., a partial or full squat or lunge). This phase should also consist of identifying impairments throughout the lower extremity that may be associated with patellar tendinopathy.

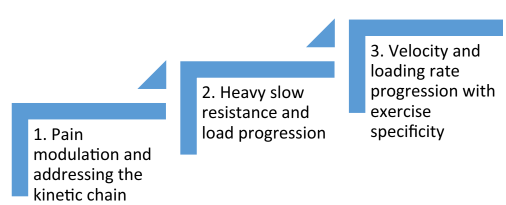

Fig. 3 Proposed rehabilitation protocol in the treatment of patellar tendinopathy in the athlete

Stage 2: Heavy Slow Resistance and Load Progression Once patients can perform isotonic exercise with minimal (1–3/10 pain), a HSR protocol is recommended. A conservative progression for in-season athletes to minimize pain with performance and improve exercise adherence is recommended. A HSR protocol has been previously described by Kongsgaard et al. [54••]. This exercise method typically consists of a bilateral lower extremity squat, hack squat, and leg press, performed from zero to 90° of knee flexion. Velocity has been prescribed by allowing 3 s to complete each of the eccentric and concentric phases (i.e., 6 s/repetition). The use of a metronome to provide an external auditory cue and allow objective progressive increases in velocity is recommended. Single-limb exercises are strongly recommended to improve symmetry in lower extremity strength and motor control.

Stage 3: Velocity and Loading Rate Progression with Exercise Specificity When the patient demonstrates 90–95% symmetry in lower extremity quadriceps strength and the ability to perform HSR exercises to fatigue with minimal pain (1–3/10), the last stage can begin. This stage requires progressive increases in exercise loading rate and velocity. Using a metronome is recommended to progress exercise. Loading rate is often progressed using plyometric exercises. A strong focus to all three phases (i.e., eccentric, amortization, and concentric) of the plyometric movement is recommended. Plyometric exercises should be progressed from a low intensity and volume to the specific demands of the patient's sport or desired activity level. A strong emphasis on sport-specific exercises is recommended throughout this phase. Specificity of training can often be overlooked in rehabilitation, and this may result in a poor transition back to the patient's sport or desired activity.

Rehabilitation Pitfalls Management of patellar tendinopathy can be a prolonged and frustrating process for the patient, physical therapist, and physician. Common pitfalls during rehabilitation include unrealistic expectations [48], inaccurate beliefs about pain [48], poor exercise progression, as well as inadequate evaluation of single limb strength and motor control. Failure to evaluate single limb strength, endurance, and motor control throughout the kinetic chain can result in prolonged rehabilitation and poorer outcomes. Bilateral exercises can allow the patient to develop a weight shift toward the unaffected limb and this motor pattern can be difficult to correct. A thorough evaluation of the entire lower extremity is needed to identify relevant deficits at the adjacent joints. Poor motor control and reduced strength in gluteus maximus and gastrocnemius is often observed by the authors and progressive single leg exercise can be used to evaluate and correct these impairments. Clinicians should educate patients about the recalcitrant nature of patellar tendinopathy, discussing realistic time frames with consistent information given by both the physician and physical therapist. Pain education is also crucial with emphasis on how a low level of pain does not necessarily equate with tissue damage and is allowable during therapy. Focusing on tendon load tolerance rather than healing observable structural tendon properties can help shift the patient's beliefs that tendon tearing leads to harm and dysfunction. This change in belief is crucial as fear avoidance has been shown to negatively affect prognosis with chronic lower extremity pain and tendinopathy [63, 64]. Failure to continually progress exercise is another common rehabilitation error. Once patients are able to perform a required number of repetitions or isometric contractions at a given load, it is important to continue load progression. Failure to do this can result in poor load tolerance with exercises performed at higher velocities and loading rates. The authors have noted a correlation between static exercise programming and failed attempts to progress rehabilitation.

Medical Therapy Medical therapy options include oral analgesics for pain relief. Non-steroidal anti-inflammatories (NSAIDs) may be used for analgesic purposes and less likely for anti-inflammatory properties given the evidence supporting tendinopathy as a non-inflammatory degenerative condition. One systematic review [65] concluded that NSAIDs were useful for short-term treatment of 7–14 days. Studies conflict on whether NSAIDs affect tendon healing [38••]. While corticosteroid injections may provide short-term relief, they are not recommended [27, 38••] due to increased risk of tendon rupture without long-term benefits after 6 months. High-volume image-guided injections under ultrasound guidance shows promise [66]. Platelet-rich plasma (PRP) shows promise as a potential injection therapy. However, studies [67] reveal inconsistent protocols (obtaining the PRP injectate, number of injections, concentration, etc.) and results vary [68] with therapy remaining investigational [38••]. There is some emerging evidence that extracorporeal shock wave therapy (ESWT) is a potentially effective and safe means of treatment [69], possibly through hyperstimulation analgesia, increased mechanical load leading to tissue regeneration, and destruction of intra-tendinous calcifications [70]. However, findings differ among studies [5, 71]. Some suggest [72, 73] that ESWT may be considered following 6 months of non-surgical treatment with an eccentric exercise therapy and PT or if patients are not progressing with PT and do not want or do not qualify for surgery. Another emerging intervention is the use of percutaneous ultrasonic tenotomy with or without orthobiologic agents. Case reports have demonstrated efficacy in those suffering from chronic patellar tendinopathy refractive to extensive rehabilitation, surgical debridement, and platelet-rich plasma injections [74] with 10 of 16 patients returning to their prior level of competition or activity in one case series [75]. Needle tenotomy has also demonstrated good outcomes in case reports, though study numbers are small [76, 77]. Other potential future therapies include cell-based therapies, scraping [78], hyaluronic acid, and sclerosing agents, but evidence demonstrating clinical efficacy is currently lacking or conflicting [38••]. There appears to be very little evidence to support the use of nitric oxide patches [26•].

Other Therapies Modalities such as cryotherapy, transverse friction massage, therapeutic ultrasound, phonophoresis, and iontophoresis appear to have very little evidence to support their use [26•]. Cryotherapy may be used for analgesic purposes but not prior to sport since it may mask pain and impair motor function, potentially leading to worsening injury or new injury [27]. Counterforce bracing or taping may improve patellar strain by altering the angle between the patella and the patellar tendon [79] with one study showing improvement in single-leg decline squat [80] during sport activity when taped or braced [80]. However, no difference between taping, sham taping, and bracing was found. Pronation may be corrected with foot orthotics though there is no direct evidence for or against use [38••].

Surgical Management

While the vast majority of patients respond to conservative management, a few progress to surgery if not responding to non-surgical treatment by 4 to 6 months. Both open and arthroscopic techniques are used, with the same overall goals of tenotomy, debridement of gray amorphous tissue, and drilling and marginal resection of the inferior patellar pole to stimulation repair [38••]. The advantages of arthroscopic surgery are the ability to inspect the intra-articular knee and rule out patellar chondral lesions. Similar rehabilitation protocols (pain management, eccentric squats on an incline board, and a strengthening program) are used after either technique with full-weight bearing and free range of motion as tolerated [38••] and wound healing generally occurring at about 10 days later. Return to sport usually occurs about 3 months after surgery when athletes are pain free during supervised rehabilitation and strengthening exercises.

Surgical Outcomes Surgical literature describes comparable results for both open and arthroscopic techniques with 87 and 91% of success, respectively, according to one systematic review [81]. However, return to sport took longer after open repair (8.3 months) compared with arthroscopic repair (3.9 months) [81], and average rates of return to sport were similar (82.3 vs. 78.4% for open and arthroscopic). For those who did undergo open repair, better clinical scores were achieved if the inferior pole of the patella was resected while no difference in rate of return to sport [81]. This was different than those undergoing arthroscopic repair, where patients had better rates of return to sport if the inferior patellar pole was resected. As a result, some [38••] recommend arthroscopic technique given that the average rate of return to sport was similar and occurred in less time.

Injury Prevention One systematic review [82] evaluated methods of tendinopathy prevention for the major regions, including the knee. While one study [83] found that a program which included soccer-specific balance training reduced tendinopathy with a dose-effect relationship between duration of balance training and injury incidence, other studies did not find such a relationship. However, this study included longer-duration exercise protocols compared to other studies, which may suggest that a longer exercise duration is necessary for significant results [82]. Prophylactic eccentric training and stretching in one study [84] prevented the development of patellar tendon abnormalities but without any positive effect on injury risk. Conversely, those with asymptomatic patellar tendon abnormalities were at increased risk of injury if performing such a program [84]. Other preventative methods studied included static stretches, core stability, shock-absorbing insoles, custom-made foot orthotics and modified basketball shoes, hormone replacement therapy in women, and information provision about the prevention of running injuries with an instructional group session [82]. However, these areas of study did not prevent development of patellar tendinopathy or were used to prevent Achilles tendinopathy and as a result are not generalizable to other forms of tendinopathy. A limited amount of studies are available regarding the prevention of patellar tendinopathy, and study of one prevention method is difficult as long as the etiology itself remains multifactorial with an unclear level of contribution from each factor [82].

Conclusion

In conclusion, patellar tendinopathy is a common injury of the inferior anterior knee seen in athletes, predominantly in sports requiring jumping. It tends to manifest insidiously and felt in a loaded position with the knee in flexion. Physical exam usually finds tenderness along the patellar tendon, and pain can be recreated in the squat position. Treatment predominantly consists of physical therapy, focusing on appropriate strengthening of the musculotendinous unit. Those who fail to respond to this treatment may respond to medication or injection treatment; few require surgical intervention, but it remains an option.

Compliance with Ethics Guidelines

Conflict of Interest Keith Cummings, Lee Skinner, and Daniel Cushman declare no conflicts of interest relevant to this manuscript.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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