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Diagnosis and treatment of patellar tendinopathy to improve athlete outcomes

**Introduction:**

Injuries caused by repetitive motions are a common occurrence in athletes and can be a significant cause for an athlete to miss time away from the sport. Sports that involve repetitive jumping such as volleyball, basketball, and long jumping or high jumping in track and field have been highly correlated with the development of overuse injuries.1 While many injuries occur in these athletes, patellar tendinopathy or “jumpers’ knee” is one of the most common. Patellar tendinopathy is an injury of the extensor mechanism of the knee which is suspect to injury following repetitive mechanical stress from movements such as jumping, landing, acceleration, deceleration, and cutting.1 Due to multiple factors such as poor vascularity and a slow metabolic rate. Tendon often requires a prolonged period of heling.2 This often creates a problem for the majority of athletes since they have immense pressure to return to sport as quickly as possible. Due to this pressure athletes with mild to moderate symptoms still train and compete which only further prolongs the healing process.1,3 The prevalence of this condition is often debated in the literature as the condition is often under-reported.1 Current literature found that the overall prevalence of jumper’s knee was around 14% in athletes who participated in jumping sports, and is as great as 40% of male volleyball players being affected.4 This pathology is estimated to be twice as common in male athletes than female athletes.3,4 This prevalence rate and a prolonged period of healing have immense implications for physical therapists who are often sought after to treat this condition. The overall treatment of this condition has mixed results when it comes to treatment outcomes. Studies report around 53% of athletes with patellar tendinopathy were unable to return to sport and were forced to retire.1,13 This is often due to the clinicians’ poor understanding of the causes of this pathology, a paucity of time-efficient treatment methods, and not addressing the risk factors that are contributing.3 Due to the high incidence rate and murky treatment outcomes clinicians need to be knowledgeable of the pathogenesis of jumper’s knee, the proper use of diagnostic screening tools to identify any contributing risk factors, literature supported treatment approaches, and general rehabilitation guide to help improve treatment outcomes.

**Anatomy and Biomechanics:**

The anatomy and biomechanics of the patellofemoral joint have large implications on the underlying pathology of the causation of patellar tendinopathy. For the scope of this paper, the anatomy and biomechanics will largely focus on the areas directly contributing to this pathology. The patellar tendon originates at the distal portion of the patella, also known as the apex, and inserts into the tibial tubercle of the tibia.5 This along with the quadriceps tendon, the proximal attachment of the patella, is known as the extensor mechanism of the knee. The function of the extensor mechanism is to act as a mechanical pulley to increase the moment arm for the quadriceps muscle and help transmit the force produced by the quadriceps muscle to the tibia which helps drive extension.5,6 When there are problems with the inferior pole of the patella or where the patellar tendon inserts micro-tearing can occur if the load is more than the tendon is capable of handling.1 A common area of pain is at the proximal insertion of the tendon into the patella. This is often because of the large amount of stress concentration as the bone (patella) becomes the tendon.7 This combined with the large magnitude of loading caused by an athlete’s activity is often a key contributor to the injured tissue.

 Proper treatment of this condition requires knowledge of the pathomechanics of the injury and the factors that may affect the healing response of the tissue.7 The main tissue involved in this condition is the tendon. Tendon is primarily made up of type 1 collagen making up around 95% of the dry weight of the tendon.2,7 This structure is the primary driver for the mechanical properties of the tissue. The majority of the collagen fibers are aligned in parallel orientation and are closely packed together. When unloaded the fibers are in a crimped formation. This structure helps transmit the force from muscle to the bony target as the force quickly straightens out the orientation of the collagen fibers.2 The tendon is also comprised of tenocytes which are cells that help sense loads and properly modulate them.2,8 The problem with these cells is that there often few in number and have poor metabolic capability.2 This becomes problematic because when there is too much-repeated stress being delivered to the tissue this leads to micro-failures within the tissue as the tissue is unable to properly heal.2 The stress-strain curve is often used as a visual example of what is occurring and can be beneficial for clinicians to gain a better understanding of the mechanical behavior of the tissue (see appendix A figure 1). When these multiple micro tears or yield points occur in the tissue it leads to a mechanically weaker tissue which predisposes it to ultimately fail.2 The primary pathophysiologic phenomenon that distinguished patellar tendinopathy is tendinosis instead of the previously thought tendonitis which indicates there is some form of inflammation.1,10 Understanding what the difference is a key factor that should be considered when treating this condition. Tendinosis is considered a chronic degeneration of the tendon which leads to a reduced amount of collagen content and the collagen fibers become oriented in a different direction which once again makes the tissue structurally weaker and less capable to transmit the necessary loads.2 Due to the structure and function of tendons, they require several obstacles to be overcome for proper healing to take place. Because tendons are load-bearing structures they require a properly dosed load to allow for a proper repair process. This has been proven in multiple studies as immobilization of the tissue leads to a decrease in size and the number of collagen fibers.2 This is problematic because you now have the same amount of stress occurring over a smaller cross-sectional area which leads to higher stress concentrations.2 Another main obstacle is that when the tendon “heals” it is often structurally weaker. This is thought to be because of changes in the extracellular matrix and the promotion of scar tissue formation.8 All of these obstacles should be properly addressed and identified if proper healing is going to take place. Subsequent content in this paper will detail the risk factors associated with the development of this condition and treatment options/protocols that are effective.

**Intervention:**

Due to the difficulty when attempting to treat this condition classification schemes have been developed to help clinicians properly identify the phases of healing. Some of the main difficulties with this condition is that patients present with varying degrees of pain, irritability, and functional capacity.14 Cook and Purdam state to properly treat this pathology it needs to be considered as a continuum with each of the phases being treated individually.14 The three distinct stages of tendinopathy include reactive tendinopathy, tendon disrepair (failed healing), and degenerative tendinopathy.14 Appendix A figure 2 helps highlight this continuum and how to utilize this approach to help properly treat this pathology. Reactive tendinopathy is thought to be an acute overload of the tendon that is common in younger individuals who drastically change part of their training volume.14 Some of the proposed treatment options in this phase deal with assessing and modifying the intensity, duration, frequency, and type of load the individual is undergoing.14 Non-steroidal anti-inflammatory medications (NSAIDs) have been suggested as helpful with reducing pain and slowing the upregulation of tenocytes and excess ground substance.2,14 This phase may be thought of as the acute phase which is noted as being symptomatic for 0-6 weeks.1 While this classification or stage of injury responds the best to conservative treatment majority of clinicians will fail to see a true acute tendonitis.2 Tendon disrepair or failed healing is a chronic condition that may demonstrate thickening of the tendon or focal changes following imaging.14 This phase may also be thought of as the sub-acute phase with symptoms being present between 6 and 12 weeks.1 Degenerative tendinopathy occurs primarily in the older population, however, can be seen in a younger elite athlete with a chronically overloaded tendon. Tendons in this stage may present with one or more focal nodular areas and are at higher risk for rupturing.14 This stage is also thought to be considered chronic with symptoms being present for longer than 3 months.1 Treatments in both of these classifications need to focus on activities that stimulate cell activity, increase protein production, and help restructure the matrix. Cross friction massage and exercise (especially eccentric exercise) has been shown to influence the tendon structure and help mediate pain.14 Two other classification schemes have also been established. Both of these classifications have 4 distinct phases and are based around an athlete’s presentation. The four-stage Blazina jumper’s knee scale is as follows: stage I pain after activity only, stage II pain that occurs at the beginning of sporting activities disappears after warmup and then reappears when fatigue is present (does not interfere with an athletes participation), stage III is classified based on constant pain during activity and at rest (interferes with competition), and stage IV is a complete rupture of the tendon.10,15 The Kennedy tendinopathy stages are as follows: stage I is pain only after activity, stage II is pain at the beginning and after activity, stage III is pain at all times (beginning, during, and after) of activity however performance is not affected, and stage IV is the same as phase III however performance is now affected.15 (see appendix B figure 1 for classification schemes according to Blanzina and Kennedy) Each of these classification schemes and the stage of healing/injury should be considered when evaluating and treating this pathology.

**Risk Factors:**

As mentioned previously patellar tendinopathy or “jumper’s knee” is described as an overuse injury of the extensor mechanism of the knee that is caused by repetitive athletic activities such as jumping, landing, acceleration, deceleration, and cutting.1 However, participation in these sports alone does not automatically contribute to the development of this condition. For this reason, there is much speculation as to why some athletes develop the condition and others do not. There are multiple intrinsic risk factors along with environmental factors that contribute to this pathology. To properly treat these individuals, it is recommended to address the underlying causes that have contributed to the development of this condition. Some of the risk factors that have been associated with a higher prevalence of developing this disorder are increased training volume, training on harder surfaces, increased body mass, limb-length discrepancies, weak quadriceps muscle strength, decreased hamstring and quadriceps flexibility, and muscle imbalances.9,10 Other risk factors that have been identified as contributing factors include impairments at the hip and foot/ankle. Some of the identified risk factors associated with the hip and ankle include decreased passive hip internal rotation, forefoot valgus, decreased hip external rotation and abduction strength, a pes planus or flat foot orientation, and lack of ankle dorsiflexion range of motion.9-12 All of these risk factors associated with the hips, foot, and ankle contribute due to the lower extremity being placed in a more internally rotated position which places the tendon in a more vulnerable position. This position also increases the individuals Q-angle which is associated with an increased risk for developing the condition.9-12 This Q-angle is significant because it disrupts the line of mechanism's pull thus disrupting the extensor ability to properly transmit forces. Multiple factors that can be contributing to altered or impaired mechanics that lead to the development of this pathology. These factors must be taken into consideration when treating individuals affected by this pathology as it is necessary to identify the underlying cause or the condition will likely re-manifest.

 **Pathomechanics:**

Repetitive jumping is highly correlated with the development of patellar tendinopathy. Thus, it is important to understand the biomechanics behind jumping. It is also important to highlight that risk factors may predispose the individual to have altered mechanics during jumping. Jumping requires large amounts of eccentric force production, around three times the force of a similar concentric force, one of the primary causes of the patellar tendons microtraumas.12 As the athlete begins their jump there is a large eccentric quadriceps force. This allows the athlete to have a greater knee flexion angle to improve force production. Following the "take-off phase" of the jump, an athlete falls through space until the landing phase. During this, the force generated at take-off has to be properly mitigated to avoid injury. The landing phase requires another high eccentric quad force to help moderate the force produced during the initial take-off.12 Appendix C figure 1 demonstrates a visual representation of the take-off and landing phase dynamics as it pertains to the knee and ankle. In a study by Bisseling et al, elite male volleyball players were evaluated and different jump mechanics were evaluated to identify movements that predisposed an individual to the development of patellar tendinopathy. Ankle plantar flexion and the amount of knee flexion range of motion at touch down were both significantly predictive towards if the athlete has experienced patellar tendinopathy. Thus, the smaller amounts of ankle and knee flexion during the take-off phase and the landing phase of a jump was a significant predictor of if an athlete will develop the condition.12 It is important to consider the mechanics of an athlete's jump and should be evaluated when treating these individuals.

**Clinical Evaluation:**

This condition is difficult to treat due to the multiple underlying risk factors, tendons' ability to heal, and clinician’s ability to properly identify the risk factors and address them. One of the first clinical challenges, when a patient presents for treatment, is to establish if the patient’s symptoms are coming from the patellar tendon or another tissue. Patellar tendinopathy can have symptoms that are similar to other knee pathologies such as prolonged sitting, squatting, and climbing stairs.1 Developing a working differential diagnoses list is imperative and should commonly include patellofemoral pain syndrome (PFPS), fat-pad syndrome, meniscal tears, cartilage lesions, referred pain, and Osgood Schlatter’s disease.10,15 In true patellar tendinopathy the symptoms are as follows, pain localized to the inferior pole of the patella, the pain increases with load-related activity, relief of symptoms upon resting, and those previously mentioned.1,10,13 It is also extremely important to have a proper subjective history as this can help guide your clinical decision making. Proper questions should include the onset of symptoms, what sport/position the patient plays, how often they practice, if they recently changed shoes or training volume, how long have the symptoms persisted, and what makes the pain better/worse.1,10,13 Following the subjective history it is important to perform a proper objective examination. An examination of the hip, knee, and ankle/foot region should be performed as malalignments of the ankle or hip have been identified as contributing risk factors.10 The individual will likely be tender to palpation with pain over the inferior pole of the patella and will likely have pain with resisted knee extension.1,10,15 As mentioned previously looking for muscle atrophy, reduced strength especially those of the hip lateral rotators and quadriceps, any malalignment of the foot, quadriceps, calf, and hamstring inflexibility, reduced ankle dorsiflexion is highly correlated with patellar tendinopathy and need to be assessed.10,13,15,16 The use of imaging such as ultrasound and magnetic resonance imaging (MRI) may be useful in identifying other pathology that may cause anterior knee pain, however, it is not highly recommended for the diagnosis of patellar tendinopathy.10,13,16 Research has found that abnormal results from imaging have been highly associated with asymptomatic individuals and thus the diagnosis of patellar tendinopathy needs to remain a clinical diagnosis.13,16

While there are not many special tests used to specifically diagnose this condition one study by Rath et al, evaluated two clinical signs used to help diagnose patellar tendinopathy. The first sign is the passive extension-flexion sign which has the patient in a supine position with the therapist palpating the most tender portion of the tendon and passively flexing the knee to 90 degrees. A positive sign is if the pain is decreased after the clinician flexes the knee to 90 degrees. The next test is the standing active quadriceps sign in which the patient has their patellar tendon palpated while the patient stands. Once the point of max tenderness has been identified the patient is asked to only stand on the involved extremity with around 30 degrees of knee flexion and the area is re-palpated. Once again there should be a reduction in overall pain during the palpation in a flexed position.22 While these tests do not have well-established psychometrics they may be useful in helping to confirm a diagnosis.

Other key items to consider when evaluating a patient with suspected patellar tendinopathy through the utilization of outcome measures. The Lower Extremity Functional Scale (LEFS) and the visual analog scale for pain may be beneficial in measuring general pain and overall function in an individual. One measure has been validated for patellar tendinopathy specifically. The Victorian Institute of Sport Assessment Questionnaire for Patellar Tendon (VISA-P) is a patient-reported measure that helps clinicians measure severity and improvement in a patient’s symptoms.17 (See Appendix D figure 1 for VISA-P) One study by Wilgen et al, evaluated the use of the VISA-P and found that a score of less than 80 was indicative of the patient having patellar tendinopathy.18 It should be noted that just scoring under an 80 does not mean that an individual has patellar tendinopathy but should be used in concordance with a proper evaluation.

The final portion of the evaluation should look at functional movements. These allow the clinician to visualize any movement discrepancies and may help formulate the plan of care. Activities such as squatting, jumping, and a lateral step down test may be beneficial in identifying any faulty movement patterns that may be contributing to the condition.1,10,13,15,18 Jumping mechanics have previously been discussed and the findings support that athletes who land with a decreased knee flexion angle are more likely to develop patellar tendinopathy.12 In a study by Rabin et al, they found that individuals who demonstrate loss of balance or medial collapse of the lower extremity during a lateral step down were also found to have decreased ankle dorsiflexion and weaker hip external rotator strength.18 Both of these are risk factors for the development of patellar tendinopathy. These tests are beneficial because it is repetitive motions that contribute to the degeneration of the patellar tendon and these functional movements can help identify them.

**Conservative Intervention:**

While this condition is multifactorial and often difficult to treat the majority of patients can be managed through conservative treatment. The majority of treatment options are focused on eccentric exercises due to the majority of research demonstrating benefits following this type of intervention.10,13 Larsson et al, evaluated 9 randomized control trials to assess treatment options for patellar tendinopathy. The results of this study illustrated that eccentric training demonstrated strong evidence, while surgical intervention demonstrated limited evidence for the treatment of patellar tendinopathy. It should be noted that all athletes may not be ready for eccentric loading and may need to be progressed slowly into an eccentric loading program. For this reason, treatment should be focused on a continuum as suggested earlier.13 Research supports an initial rest period focused on controlled movements and avoiding activities that induce high amounts of load into the tissue.10,13,15,19 Initial treatments of patellar tendinopathy should focus around stretching the lower extremity, transverse friction massage of the patellar tendon, eccentric quadriceps exercises, and strengthening of the hip and knee. The use of an orthotic has also been found to alleviate symptoms through helping prevent pronation of the foot.19,21 By controlling pronation this helps limit a valgus malalignment and decreasing the Q angle. Patellar tendon straps and foot orthotics can be beneficial in decreasing the amount of load the patellar tendon has during the activity which can be beneficial while allowing the tissue to heal.19,21 During this period, it is important to progressively challenge and load the tissue with appropriate exercises using patient symptoms as a guide.13,15,19 Once an individual’s pain decreases progressing to an eccentric exercise program beginning at partial weight-bearing is recommended.13,15 Following this phase an athlete is likely ready for sport-specific training or return to play exercises such as plyometrics and agility focused exercises. An example rehab protocol with proper progressions can be found in Appendix E.

**More Invasive Interventions:**

While exercise is highly supported for improving patient outcomes there is a magnitude of other interventions that should be discussed as not all patients will respond positively to exercise. One of the first treatment options that may be suggested is the use of steroid injections. Multiple studies state that steroid injections should not be utilized for the management of patellar tendinopathy and may increase the risk of rupturing.2,7,10,15 Another treatment is platelet-rich plasma (PRP) injections which are thought to enhance tissue repair due to the high concentration of growth factors. There are mixed results on the benefits of PRP injections as it relates to patellar tendinopathy and thus should be considered as a questionable and inconclusive treatment option.2,10 One relatively new treatment option is extracorporeal shockwave therapy (ESWT). ESWT is a non-invasive procedure that provides high energy shock waves to provide an analgesic effect and stimulating tissue regeneration.20 While there is still limited research for patellar tendinopathy one systematic review found that ESWT appears to be a safe and effective treatment for patellar tendinopathy. However, there is no distinct treatment protocol and it is still early in the research process so no concluding statement can be formulated.20 Insulin Growth Factor (IGF) has been found to stimulate tenocytes to increase the production of collagen and produce higher quality healing tendons.2 When conservative treatment fails surgical intervention may be warranted to provide the individual relief from pain. It should be noted, however, that arthroscopic treatment has similar patient outcomes as those with open surgical intervention with less time required for healing. One study found that the average return to sport following arthroscopic surgery was 82.3% while open surgery was 78.4%.10

**Summary:**

In summary, patellar tendinopathy or “jumpers’ knee” remains one of the more challenging clinical conditions. To properly treat the condition, it is of the utmost importance for a clinician to perform a thorough subjective and objective evaluation of not only the knee but the hip and foot/ankle as well. One of the most important details when treating this condition is to be patient, set realistic expectations for how long the rehab process may take and to address the underlying risk factors that are contributing to the condition.2,10,13 To improve treatment outcomes clinicians must apply an individualized plan of care and apply the current concepts of tissue healing discussed previously.

Appendix A: Mechanical Behavior of Tendons

(Figure 1) Stress-Strain Relationship for Tendon demonstrating multiple yield points before ultimate failure.2



Figure 2: Pathology continuum which demonstrates the tissues transition from normal to degenerative tendinopathy.14



Appendix B: Classification Schemes for Patellar Tendinopathy

Figure1: Blanzina knee scale and Kennedy tendinopathy stages15



Appendix C: Biomechanics of Jumping

Figure 1: Take-off and landing phase dynamics of an individual performing a volley ball spike. VGRF=vertical ground reaction force, Ma=ankle moment, Mk=knee moment. Ankle dorsiflexion and knee extension are demonstrated in the positive direction.



Appendix D: Victorian Institute of Sport Assessment Questionnaire, Patellar Tendon (VISA-P)17



Appendix E: Suggested 12 Week Rehab Protocol for Patellar Tendinopathy

Figure 1: Rehab protocol for patellar tendinopathy as suggested by Rutland et al.15

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Week** | **Rest** | **Eccentric Exercise** | **Transverse Friction Mobilizations** | **Stretching (30 secs x 3-4x)** |
| 1 | No Jumping or running; can ride bike; do pool work \*No sports specific training  | \*Around the world eccentric lowering leg raise (4 way) increase weight by 1# each week\*Eccentric squats on total Gym/Shuttle on decline board 15 reps x 3 sets 1-2x per day  | 5-10 min firmly 1-2x a day  | Hip flexors, Quadriceps, Hamstrings and heelcords before/after activity  |
| 2 | \*No Jumping or running; can ride bike; do pool work \*No sports specific training  | \*Around the world eccentric lowering leg raise (4 way) increase weight by 1# each week\*Eccentric squats on total Gym/Shuttle on decline board 15 reps x 3 sets 1-2x per day  | 5-10 min firmly 1-2x a day | Continue Stretching as above  |
| 3 | \*Begin jumping squats in short range on Total gym/shuttle \*No sports specific training  | \*Around the world eccentric lowering leg raise (4 way) increase weight by 1# each week\*Eccentric squats on total Gym/Shuttle on decline board 15 reps x 3 sets 1-2x per day \*Progress to upright decline board squats  | 5-10 min firmly 1-2x a day | Continue Stretching as above  |
| 4 | \*Cylce, exercise in water\*Begin eccentric step downs standing (no step) \*No sports specific training  | \*Upright squats on decline board double leg to single leg; add 10# to backpack; \* Around the world eccentric lowering leg raise (4 way) increase weight by 1# each week | As needed  | Continue Stretching as above  |
| 5 | Begin eccentric step downs on 6” step \*No sports specific training | Upright squats on decline board double leg to single leg; add 20# to backpack; \* Around the world eccentric lowering leg raise (4 way) increase weight by 1# each week\*Begin Jumping squats on Total Gym/shuttle with both legs  | As needed  | Continue Stretching as above  |
| 6 | Begin eccentric step downs on 8” step \*No sports specific training | Upright squats on decline board double leg to single leg; add 30# to backpack; \* Around the world eccentric lowering leg raise (4 way) increase weight by 1# each week\* Jumping squats on Total Gym/shuttle with both legs  | As needed  | Continue Stretching as above  |
| 7 | Begin Eccentric step downs on 8” step \*No sports specific training  | Upright squats on decline board double leg to single leg; add 40# to backpack; \* Around the world eccentric lowering leg raise (4 way) increase weight by 1# each week\* Jumping squats on Total Gym/shuttle with single legs  | As needed  | Continue Stretching as above  |
| 8-12 | \*Progressive return to jumping/ squatting/ jump boxes\*Begin Sports specific training with gradual return to sporting events  | \*Jumping squats on total Gym/shuttle with single leg; \*upright squats on decline board with 50#\*Jumping squats one leg on Total Gym/shuttle with max resistance  | As needed  | Continue Stretching as above  |

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