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CLINICAL COMMENTARY

EVIDENCE-SUPPORTED REHABILITATION OF PATELLAR TENDINOPATHY

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ABSTRACT

Chronic tendinopathy is a common musculoskeletal disorder that frequently affects athletes who train and compete at all levels. This Clinical Commentary presents a review of the etiology, incidence, and contributory factors related specifically to patellar tendinopathy. Examination and differential diagnosis considerations are provided, and an evidence-based, staged rehabilitation program is described.

Key Words. Jumper's Knee, patellar tendonitis

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INTRODUCTION

Chronic tendinopathy is a common musculoskeletal disorder affecting both recreational and elite athletes potentially leading to disability lasting several months. Overuse tendon injuries account for 7% of the injuries seen in United States physician offices[1] and 40% of knee injuries in volleyball players.[2] Chronic patellar tendon conditions, also known as patellar tendinosis or "jumper's knee", are numerous in elite athletes who run and jump as in volleyball (44%) and basketball (32%).[3] Similar activity occurs in soccer and dancers, who also participate in repetitive kicking, jumping, and landing.[2,3] A higher prevalence is noted in sports with high impact ballistic loading of the knee extensors.[3] This disorder is a nemesis in weight lifters due to recurrent heavy load squatting.[4] Patellar tendon overuse is also seen in military recruits, accounting for 15% of all of their soft tissue injuries[5] and up to 22% incidence in the overall athletic population.[3]

Microtrauma can occur when the patellar tendon is subjected to extreme forces such as rapid acceleration -deceleration, jumping, and landing.[2] The posterior proximal patellar tendon is subjected to greater tensile tendinous forces as compared to the anterior region, especially with jumping activities and deep squat exercises, with forces up to 17 times body weight being placed on the patellar tendon in Olympic weight lifters.[2,4,6,7] Patellar tendinopathy occurs more frequently in those skeletally mature adolescents or adults, ranging from ages 16-40 years.[8–10] There is disagreement as to whether the incidence is more common in males than females, although recent studies show equal occurrences in both genders.[2,11,12] Acute tendinitis involves an active inflammatory process, often occurring following an injury, which if treated, properly heals in 3-6 wks.[13] In contrast, chronic patellar tendinopathy, also referred to as patellar tendinosis, manifests itself after 6 wks-3 months as degenerative changes occur in the tendon[13,14] These changes include absence of inflammatory cells in the tendon, a tendency toward poor healing, and decreased quality and disorganization of collagen fibers, both of which may lead to decreased tensile strength.[13,14] Additionally, neovascularization, the growth of new vasculature in areas of poor blood supply, is common in chronic tendinopathy and may contribute to pain perception.[13,15] While the relationship between pain perception and neovascularization is not clearly understood, it is believed that increased levels of the neurotransmitter glutamate may play a role.[16] Overuse in athletes who continue to push past pain may contribute to the development of a chronic and problematic condition taking 3-6 months to heal.[17]

Many factors, both intrinsic and extrinsic, contribute to patellar tendinopathy.[11,12] Intrinsic factors such as strength imbalance,[1,12] postural alignment,[11,12] foot structure,[11,12] reduced ankle dorsiflexion,[18] and lack of muscle strength or flexibility[12] may play a role. However the primary cause appears to relate to the extrinsic factor of overuse. For example, an increased physical load, repetition, intensity, frequency, and or duration of greater than 10% per week in the training schedule all contribute to this overuse syndrome.[19] Additionally fatigue, poor technique, and training errors may play a role in this disorder.[20,21] Further extrinsic etiologic considerations for injuries may include improper training surfaces, insufficient footwear or inappropriate equipment.[20] Progressing physical loading, high intensity training, or repetitive loading too fast may contribute to the development of patellar tendinopathy.[20] This microtrauma or "overuse" injury develops from repetitive mechanical loading of the tendon through excessive jumping and landing activity. Training duration within a session or a season is the most common reason for overuse.[21] Drastic changes in frequency and or intensity of training may also lead to overuse training errors.[19] A general rule of thumb for acceptable progression of training is a 10% increase in intensity, duration, and frequency per week.[19]

EVALUATION

The purpose of the evaluation is to differently diagnose between conditions affecting the patella. A comprehensive evaluation includes detailed examination of both intrinsic and extrinsic factors. A detailed history of a patient's workout schedule and duration of symptoms is paramount to making a correct diagnosis. If symptoms have lasted longer than 6 weeks, tendinopathy should be suspected. Evaluation of chronic patellar tendinopathy should include the utilization of Blazina's knee scale[22] or Kennedy's scale[23] *(Table 1)* which both assist the rehabilitation professional to gauge the severity of the tendinopathy. Patients with

Table 1. *Scales to assist in evaluating patellar tendinopathy.*

PHASES	BLAZINA JUMPER'S KNEE SCALE	KENNEDY TENDINOPATHY STAGES
PHASE 1	Pain after activity only	Pain after activity
PHASE 2	Pain/discomfort during and after activity with the subject still able to perform at a satisfactory level (does not interfere with participation)	Pain at the beginning and after activity
PHASE 3	Pain during and after activity with more prolonged, with subject having progressively increasing difficulty in performing at a satisfactory level (interferes with competition)	Pain at the beginning, during, and after activity, but the performance is not affected
PHASE 4	Complete tendon disruption	Pain at the beginning, during and after activity, and the performance is affected

patellar knee pain may grade pain as general achiness after activity (Blazina Stage 1) to pain during and after activity which interferes with competition (Blazina Stage 3). Total tendon disruption is present in Blazina Stage 4.[22]

Physical examination during all stages reveals tenderness to palpation and pain over the inferior pole of the patella[24] and possibly in the body of the tendon.[24] Thickness of the tendon may be noted also in all stages, but it is rare to see effusion. Pain in the patellar tendon may be reproduced with resisted knee extension.[24] Additional functional tests of ascending or descending stairs, performing single leg declining squats, jumping or hopping will most likely reproduce patellar pain symptoms.[25] Patients such as weight lifters may complain of a "giving way" or a perception that knee will "buckle" under load as well as stiffness or achiness after activity.[22] Additionally, they may complain of stiffness or achiness after activity (Blazina stage 3 or Kennedy Stage 4).

The evaluation should include history, age and any recent growth spurts, location of pain, and special tests. The rehab professional should be able to differentiate between patellar tendinopathy and additional diagnoses of 1) patellofemoral dysfunction (more diffuse patellar pain),[12] 2) Sinding-Larsen-Johansson Syndrome(skeletally immature adolescents with pain in the inferior pole of the patella),[26] and 3) Osgood Schlatter's disease (skeletally immature adolescents with pain at the attachment of patellar tendon at the tibial tubercle with possible tibial tubercle enlargement).[10]

REHABILITATION

Stage 1: Initial Rehabilitation Controlled Rest

Controlled rest is critical in the recovery of patellar tendinopathy. During this phase of rehabilitation, the athlete should refrain from sports activity or abstain from the overuse abuse, and practice controlled exercise without load.[11,27] During this phase, patient education regarding activity is paramount. It is critical to recovery to avoid jumping or deep squatting (*Table 2*). Progressing to relatively pain free activities, such as stationary cycling, performing exercises on a Total Gym®, or working in an aquatic environment can help maintain physical stamina, and yet unload the tendon. Kennedy et al[23,28] suggested subjects with pain in stage 1 tendinopathy (pain only after activity) or stage 2 (pain during and after activity) adapt their training schedule, whereas subjects in stage 3 (pain during and after workouts that affects performance) may need total rest from aggravating activities. The athlete in stage 3 may still exercise aerobically, but must avoid irritating activities.[23,28] Visnes et al[29] reported that volleyball players who continued to train and compete during an eccentric rehabilitation exercise program showed no benefit from rehabilitation exercises. Therefore, Visnes et al[29] suggested that patients be removed from sports participation while undergoing an eccentric-only rehabilitation program, then resume competitive sports training after 8 weeks, with a gradual return to sporting activity over the next 4 weeks.[29,30]

Table 2. *Progression of rehabilitation exercises for patellar tendinopathy.*

Week	Rest	Eccentric Exercise	Transverse friction mobilization	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 raises(4 way) increase weight by 1# each week) *Eccentric squats on Total Gym/Shuttle on decline board 15 reps x 3 sets 1-2 x a day/	5-10 minutes firmly 1-2x a day	Hip flexors, quadriceps, hamstrings, & 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 raises(4 way) increase weight by 1# each week) *Eccentric squats on Total Gym/Shuttle on decline board 15 reps x 3 sets 1-2 x a day/	5-10 minutes 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 raises(4 way) (increase weight by 1# each week) *Eccentric squats on Total Gym/Shuttle on decline board 15 reps x 3 sets 1-2 x a day/; *Progress to upright decline board squats	5-10 minutes firmly 1-2x a day	Continue stretching as above
4	*cycle, 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 raises(4 way) (increase weight by 1# each week)	As needed	Continue stretching as above
5	Begin eccentric step downs on 4" step; *No sports specific training	*Upright squats on decline board double leg to single leg; add 20# to backpack; *Continue Around the world eccentric lowering leg raises(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 6"; *No sports specific training	*Upright squats on decline board double leg to single leg; add 30# to backpack; * Continue Around the world eccentric lowering leg raises(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	*Upright squats on decline board double leg to single leg; add 40# to backpack; *Continue leg lifts with weights; * Jumping squats on Total Gym/Shuttle with single leg	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 maximal resistance	As needed	Continue stretching as above

Interventions

Rehabilitation incorporates three stages ranging from limited partial weight bearing loaded exercise to a sports specific return to play protocol. Since overuse is a primary contributor to patellar tendinopathy, it is important to avoid rapid progression in frequency, intensity, and duration in rehabilitation and functional progression.[19] Since most athletes with patellar tendinopathy are treated non-operatively,[31] it is imperative to understand rehabilitation protocols and implement them wisely. Eccentric exercise has been promoted as an important conservative treatment choice for patellar tendinopathy[2,32,33,34,35,36] as well as for Achilles tendinopathy.[37,38] However, a variety of protocols have been implemented for rehabilitation intervention.[2,25,32–37] For example, the Alfredson protocol[37] of eccentric exercise intensity to pain level up to 5/10 directly contrasts the early work of Stanish and Curwin[34] who suggest that exercise only be performed without pain. Because no standard rehabilitation protocol has been established as it relates to pain symptoms secondary to tendinopathy, the following protocol has been developed by this author, involving a pain-free intervention progressing from partial body weight to full body weight positions.

Initial treatment for patellar tendinopathy includes the following: absence from jumping, relative rest (absence of abuse),[27] stretching of lower extremity musculature, deep transverse friction massage of the patellar tendon, eccentric quadriceps exercises, strengthening of hip and knee musculature, utilization of a patellar orthotic (if needed), and cryotherapy. Since patellar tendinosis is a chronic, non-acute condition, inflammation is absent. Thus, anti-inflammatory medications (NSAIDs) are seldom effective.[39] Additionally, the use of cortisone injections may negatively affect tendon strength and may possibly result in tendon rupture.[16]

Prior to initiating exercise, a warm-up and stretching period is recommended.[38] Cycling on a stationary bicycle for 5-10 minutes with minimal resistance is suggested as an active warm-up. Next, stretching should be incorporated into the program before and after the exercise routine in order to address any flexibility imbalances *(Table 2)*. Hip flexor, quadricep, hamstring, and gastrocnemius and soleus tightness may contribute to tendon overload during jumping and landing activities.[12] Lower extremity stretching of 15, 30, 45, or 60 seconds or 2 minutes produces significant gains in flexibility in healthy young or middle age adults.[40,41] Static stretching of 30 seconds at least three to four times per day is recommended by various authors.[34,40,41]

Soft tissue mobilization (STM) is used to reduce pain and fibrotic limitations in tissue found in patellar tendinopathies.[42] Deep transverse friction massage for 5-10 minutes twice daily is recommended to help promote normalized collagen alignment.[43–45] Hunter found that firm pressure during cross friction massage is more effective than light to moderate pressure.[43,44] Use of a rigid instrument, such as a stainless steel or hard plastic tool, may provide accelerated early tissue level healing in ligamentous and tendinous injuries *(Figure 1)*.[45,46] Furthermore, STM applied transversely to the line of collagen fibers while the tissue is placed under tension may assist damaged tissue to regain tensile strength and proper fiber orientation in the early stages of healing.[44] Patients can be educated to perform STM daily until tissue is normalized and pain is absent with palpation.

Eccentric exercises play an important role in chronic patellar tendinopathy rehabilitation. Performing eccentric squats on a 25° decline board for 3 set of 15 repetitions twice daily is suggested.[2,22,23,25,36,37,47] Loading a tendon in a controlled environment free from overuse with progressive stress improves

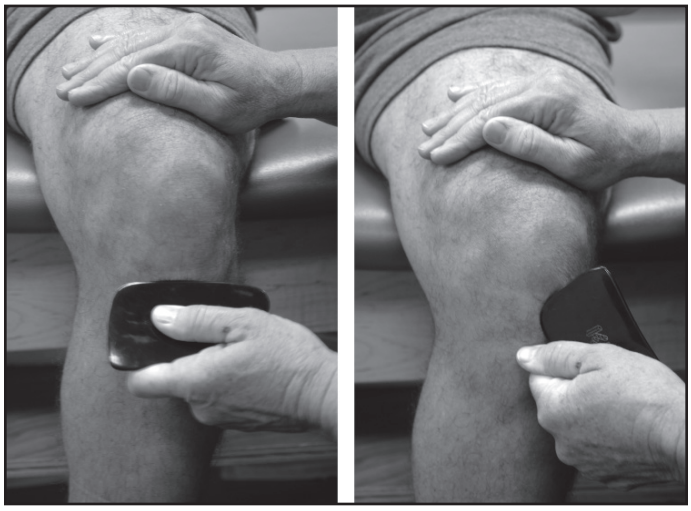

Figure 1. *Soft tissue mobilization. 1a: Deep friction with use of device (longitudinally). 1b: Deep friction with use of device (cross-friction).*

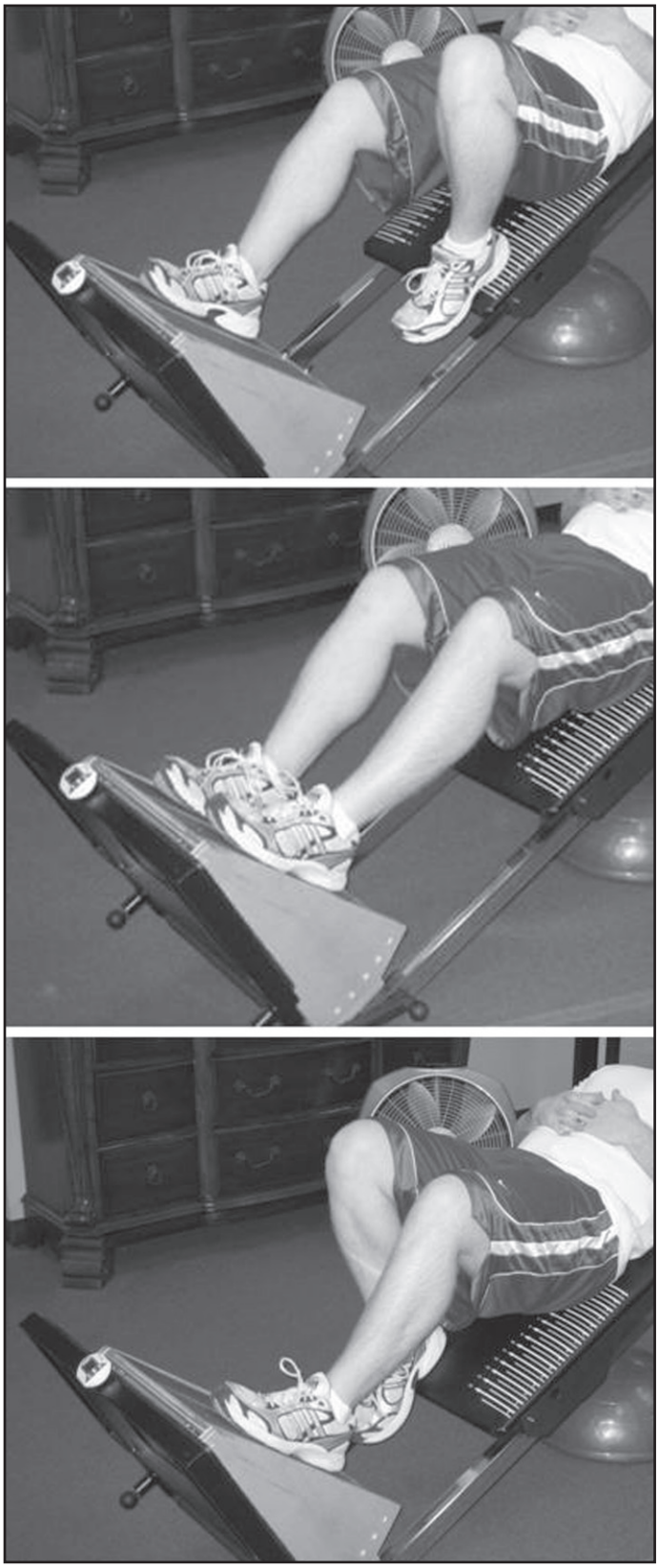

Figure 2. *2a: Patient initiates knee extension concentrically by extending the unaffected extremity. 2b: Progression to bilateral eccentric lowering with both lower extremities 2c: Progression to full weight bearing on the affected extremity eccentrically descends to at least a 60˚ angle.*

Figure 3. *Unloaded squats can be performed on a Shuttle®. If significant pain with eccentric lowering, eccentric squats can performed bilaterally.*

tendon function.[31] A controlled tendon loading exercise program can be initiated through utilization of a Total Gym® (*Figure 2*), Shuttle® (*Figure 3*), or a pool. Using a decline board, more specifically targets the patellar tendon (25-30% higher patellar tendon forces)[35] as compared to squats performed on flat surfaces which more likely targets the quadriceps muscle. This specificity of tendon training allows the patient to progress faster than on a squat on flat surface secondary to a better isolation of the knee extensor mechanism. The patient performs partial weight bearing eccentric squats in a pain-free range of motion by placing a 25˚ decline board on a Total Gym® (*Figure 2*) or Shuttle® (*Figure 3*). Progression occurs as the angle of the Total Gym® or the resistance on the Shuttle® is increased. Likewise, a similar approach can be used in the pool with a decline board on the pool floor in shoulder deep water. Progression occurs from moving to waist deep water, then shallower hip deep water.

A patient is ready to progress when they can easily complete the 3 sets of 15 repetitions of eccentric squats on a decline board pain-free. As one improves, decline squats can increase in difficulty from bilateral eccentric to unilateral eccentric, then to concentric-eccentric contractions,[37,49] During the concentric phase of the squatting motion, initially one should use the unaffected leg to extend the knee, then lower eccentrically bilaterally; progressing to

single limb eccentrics using the affected leg. Additionally, speed should be addressed throughout rehabilitation. Bilateral slow speed decline squats are encouraged during the first week of rehabilitation while faster speeds are encouraged during the second week. Although pain reported by the patient of up to level 5/10 on the Visual Analog Scale is common with some of the documented eccentric progressions of exercise,[37,49] other authors have found exercising without induced pain to be beneficial to healing.[34,50] This non-painful protocol may benefit the non-athlete as well. Sayana et al[50] found only 56% of non-athletic subjects benefitted from full weight bearing eccentric painful squat exercises. Therefore, this pain-free protocol is recommended by the author of this commentary for all individuals with patellar tendinopathy.

Squatting depths are controversial among health professionals and coaching instructors. Squatting should be limited to no greater than 60-70° knee flexion[51,52,53] due to the excessive forces on the patellofemoral joint, patellar tendon, and the meniscus, although some studies encourage full depth squats to 90 degrees.[30,36] Other patellar tendinopathy protocols[36,53] had subjects performing squats slowly to 60° and 70° knee flexion respectively. Dillon et al[52] found significantly greater forces on the posterior fascicles of the patellar tendon between 60-90° of squatting. Squatting depths can be easily controlled on a Total gym®, Shuttle®, or in the upright, full-weightbearing position.

A proximal hip and thigh strengthening program including "around the world" leg raises (straight leg raises, sidelying hip abduction /hip adduction and prone hip extension) with concentration on eccentric lowering is important *(Figure 4)*. Hip strengthening exercise with a 2 second concentric leg lift, followed by a 4 sec eccentric leg lowering is encouraged. Hip strengthening exercises (with no weight initially) combined with the decline eccentric squats should be an essential element of injury and rehabilitation programs.[55–57] Education of the patient to perform exercises at home is also key to full recovery.

Although ice has been shown to reduce inflammation in acute conditions, varied results are found with the use of ice in chronic conditions.[34,58] Ice massage for

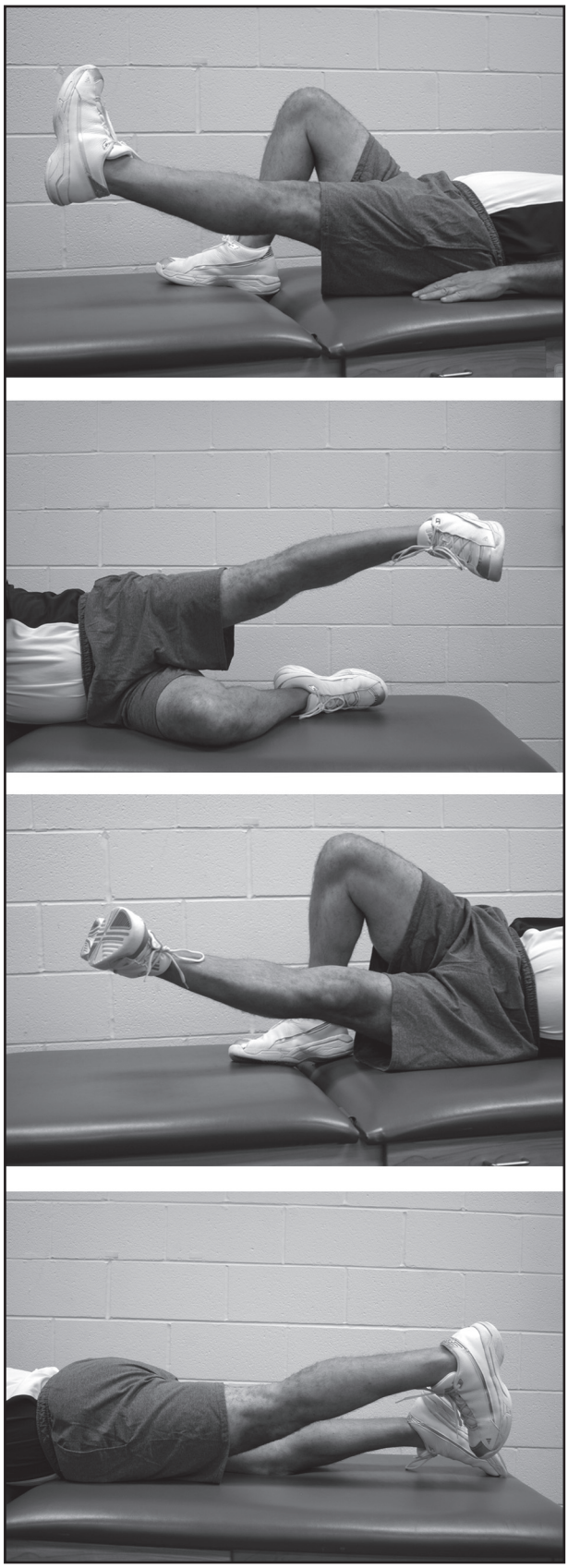

Figure 4. *"Around the World" leg raises. 4a. Straight leg raise 4b. Hip Abduction side leg raise 4c. Hip adduction inside leg raise 4d. Hip extension prone leg raise.*

5 minutes or ice pack to the patellar tendon can be applied for up to 10 minutes following the exercise program.[34] Knobloch et al[58] found intermittent cryotherapy of 3 sets of 10 minutes significantly decreased local Achilles tendon mid-portion capillary blood flow by 71%, thus promoting venous capillary outflow in the tendon. Many common modalities, such as iontophoresis,[59] ultrasound,[60,61] and electrical stimulation[62,63] have not been found to be effective in treatment of chronic tendinopathy. Extracorporeal shock wave therapy (ESWT) for patellar tendinopathy shows promise as a safe treatment based upon a literature review of seven studies, although no specific treatment regime is recommended.[64] A systematic review of low level laser treatment (LLLT) shows potential effectiveness for treating tendinopathy when recommended dosages are used.[65]

Orthotics or taping may be beneficial for patellar tendinosis. The Chopat® strap, or other varied patellar tendon straps can help stabilize the tendon with jumping activities, and may be used during rehabilitation. Although various authors[25,66–68] suggest use of such orthotics, no randomized controlled trials have been conducted examining their efficacy in patellar tendinosis, and therefore evidence is lacking to the effectiveness of a patellar strap. Further research need to be conducted regarding the use of such devices.

Stage 2: Progression

After pain symptoms decrease, progress the patient to upright 25° decline eccentric squats (3 sets of 15 repetitions twice daily), utilizing the bilateral- unilateral- eccentric-concentric progression as outlined previously. The eccentric exercise program should be progressed from partial-weight bearing to full weight bearing *(Figure 5),* then to weighted resistance using a back pack or weighted vest *(Figure 6)*. Speed can be increased during the concentric-eccentric phase, finally progressing to more ballistic type activity (jump squats) to prepare for return to functional activities. Once symptoms have subsided, patients with tendinopathy should be encouraged to continue eccentric strengthening exercise even after their return to sport.

As previously mentioned, resistance weight may be added to the single squat eccentrics, either through a weighted belt, vest or bag, or by using a backpack with weights. Once the subject can perform decline squats easily and without pain, weights can be added in 5 kg increments, starting with 10% of body weight.[29,53] Double leg jumping squats on the Shuttle® or Total gym® may be initiated at weeks 4-5 at a progressive resistance level that does not produce patellar pain. The stretching program as well as the "around the world" leg raise routine using progressive ankle weights (1-2# per week) should be continued. Additionally, deep-friction massage and ice following exercise should be

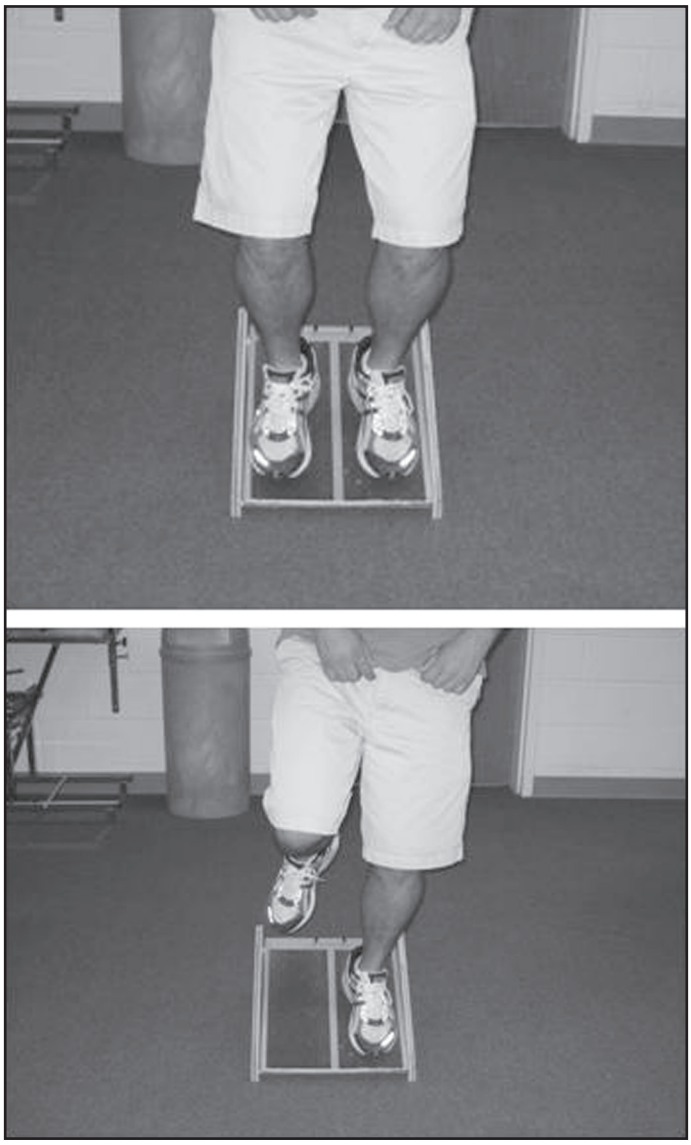

Figure 5. *Decline squats. 5a. Ascending to upright can be performed with the majority of weight on the unaffected leg. 5b.Upon descent, full weight is placed on the affected extremity as the patient eccentrically lowered to at least a 60° angle.*

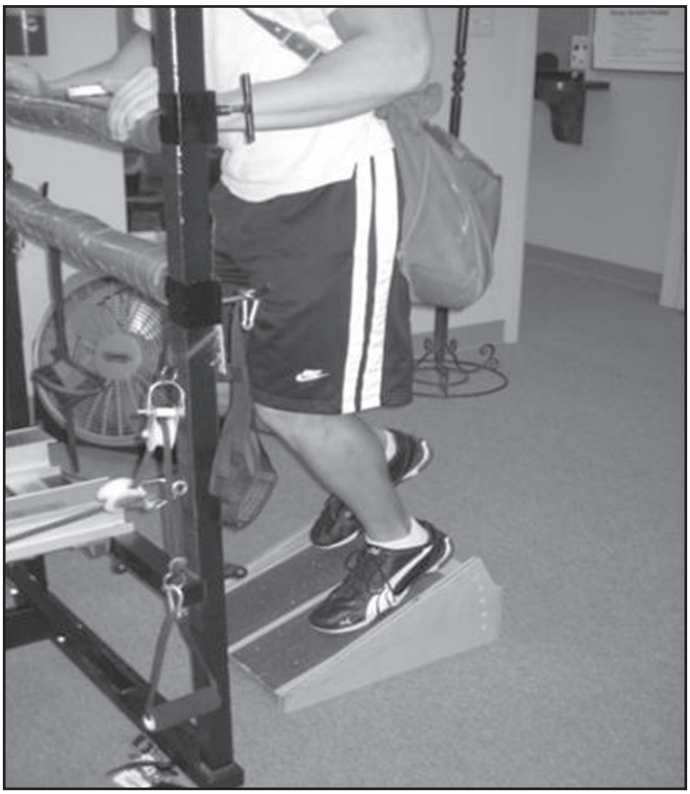

Figure 6. *To progress patient, add weighted backpack.*

maintained. At 4 weeks, slow pain-free jogging on flat ground, as well as resisted cycling or water jogging can be added.[30]

Avoidance of sports activity during the first 8 weeks is crucial for continued healing. Those who have continued to train and compete in sports activities during treatment progression have demonstrated little change in prognosis.[29]

Stage 3: Sports Specific: Return to Play

In this phase, the athlete should continue the above routine, adding more weight in 5 kg increments with the weighted eccentric decline squats. Progression to a drop squat, involving rapidly eccentrically dropping into a stationary squat position, should include 3 sets of 20 reps with incremental weight as above.[69] Three sets of 15 repetitions daily of eccentric step downs off of 4″, 6″ and 8″ height steps performed with minimal to no discomfort are appropriate as well *(Figure 7)*.[54] Jumping activities can then be added to this routine. Progression of double leg jumping squats (involving concentric and eccentric jumping in a squat position repetitively) on the Shuttle® or Total gym® to a single leg jump should be initiated before beginning standing jumps. Following pain-free movement off of the 6-8″ step down, progress to drop jumps.[34,69] Progression includes drop jumping off small step (4″), progressing to 6″ and 8″ steps when 3 sets of 20 repetitions daily are

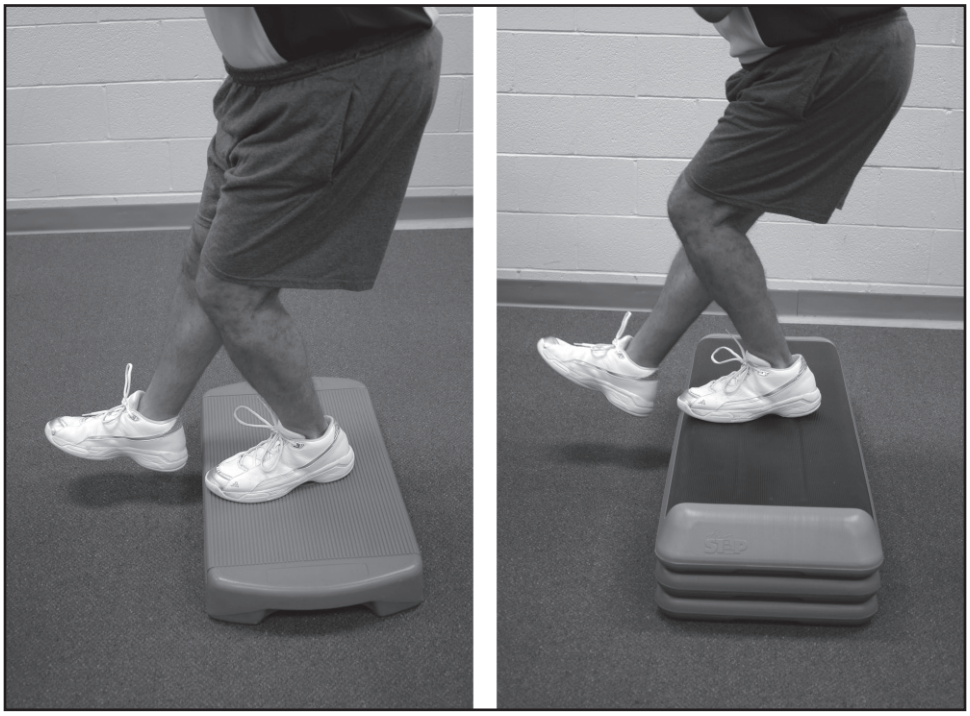

Figure 7. *Step Downs. 7a. Step down off 4″ step. 7b. Step down off 8″ step.*

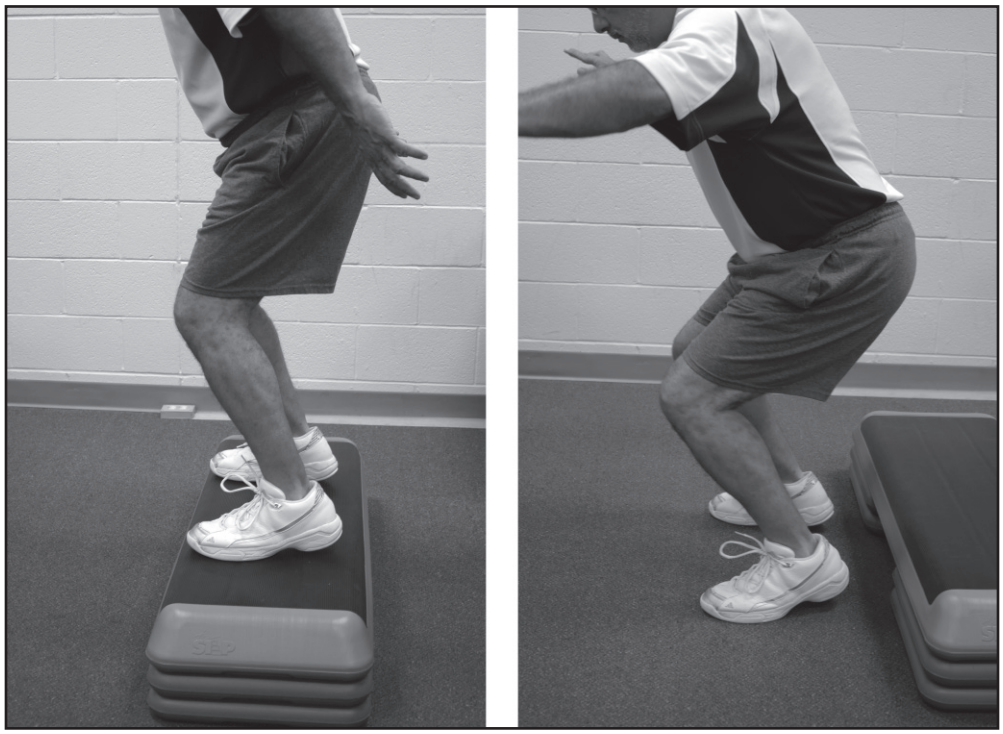

Figure 8. *"Jump downs" off step. 8a. Beginning position of "jump downs" 8b. Landing of "jump down".*

easy *(Figure 8)*[34,69] Forward and backward hop jumps, side to side jumps, jumping rope, and run and turn activities such as figure of 8's are all functional activities athletes should perform. Additionally, running and kicking may be incorporated in this stage. Education regarding exercise activity should include performance of exercises above at home or the gym, and avoidance of training on concrete surfaces.

SUMMARY

While various rehabilitation techniques exist to treat patellar tendinopathy, eccentric exercise has been found to be safe and effective[29,30,36,53] and should be included as part of the comprehensive rehabilitation of this pathology. Additionally, deep transverse friction massage, strengthening of the hip musculature and stretching are all suggested initially and throughout the recovery of this type of injury. The protocol presented in this commentary uses partial body weight decline eccentric squats as the initial exercise prior to progressing to upright, fully loaded decline squats. The rehabilitation specialist should include eccentric squats in a "safe" 60-70 degree knee flexion range on a decline board progressing from the partially loaded position to the upright position at a dosage of 3 sets of 15 repetitions twice daily for 12 weeks. Progressive jumping activities are added midway through the program. Other considerations may include slow progression back to sporting events after 2-3 months, assuming the tendon site is pain-free in all activities.

A variety of rehabilitation techniques are necessary to assist an individual in returning to recreational activities following patellar tendinopathy. A combination of active rest, education, eccentric exercise, progressing the training regime by 10% weekly, and modifying activity have all been found to be effective in tendinopathy treatment.[19,70]

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