Eccentric Training for the Treatment of Tendinopathies

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Abstract

Tendinopathy can result from overuse and is experienced in the affected tendon as pain with activity, focal tenderness to palpation, and decreased ability to tolerate tension, which results in decreased functional strength. While tendinopathy often occurs in those who are active, it can occur in those who are inactive. Research has shown that an eccentric exercise program can be effective in the treatment of tendinopathies. The earliest studied was the Achilles tendon, and subsequent studies have shown benefits using eccentric exercises on other body regions including the patellar tendon, proximal lateral elbow, and rotator cuff. In this article, we review the research on using an eccentric exercise program in the treatment of painful tendinopathy and proposed mechanisms for why eccentric exercises are effective in treating this and then finish by providing a general framework for prescribing an eccentric exercise program to those with a symptomatic tendinopathy.

Background

Tendinopathy is a term used commonly to describe any painful condition occurring within or around a tendon. It can result from overuse and is experienced as pain with activity, focal tenderness to palpation, and decreased ability to tolerate tension, which results in decreased functional strength (88). While some define tendinopathy and tendinosis differently, for simplicity, tendinopathy will be used in this article for both entities, and the treatment of symptomatic tendinopathy will focus on those with our macroscopic tendon tears, partial or complete. We will review the evidence for treating tendinopathy using an eccentric exercise program, address possible mechanisms by which eccentric exercises positively affect the tendon in the treatment of tendinopathies, and provide a framework for the implementation of an eccentric training program.

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Epidemiology

Overuse injuries, including tendinopathies, represent approximately 7% of all primary care physician visits in the United States (18,88). Tendinopathies are a common source of pain encountered in the sports medicine setting (40,63,93). More than 30% of injuries related to sports activity arise from or have an element of tendinopathy (33). In particular, the prevalence of patellar tendinopathy is 45% in volleyball players and 32% in basketball players (40,42). The prevalence of Achilles tendinopathy in runners is approximately 11% to 29% (27,51), and up to 40% of all elbow injuries in tennis players are due to tendinopathy (40). Tendinopathies also have been described at the rotator cuff, hamstring, hip adductor, and posterior tibialis tendons (74).

Tendinopathy is not limited to those participating in sports activities as it occurs in individuals who are inactive (19,48). A large cross-sectional study showed that the overall incidence of symptomatic midportion Achilles tendinopathy in the general population was 1.85 per 1,000 registered persons in primary care practices, with the incidence rate of 2.35 per 1,000 in those between 21 and 60 years old (9). Lateral elbow tendinopathy affects as many as 15% of workers in jobs that require repetitive movements of the hand and upper limb (5,26).

Risk Factors for Tendinopathy

Risk factors for tendinopathy include intrinsic or extrinsic factors. Systemic intrinsic risk factors include older age (91,97), obesity (15,23,103), increased waist circumference (52), diabetes (14), hypertension (23), dyslipidemia (20), and genetic predisposition (48). The aging process may result in histologic findings similar or identical to those seen in tendinopathy, predisposing patients to partial tears and the development of pain (23). Obesity, increased waist circumference, diabetes, hypertension, and dyslipidemia all affect microvascularity, and this may play a key role in the development of tendinopathy. The lipid profile of some with Achilles tendinopathy is very similar to the lipid profile that is associated with increased insulin resistance (19). Furthermore lipid accumulation has been found in biopsies from tendinopathy subjects (19,102). In fact, one study gives dimensions of the Achilles tendon that can be used as a screening tool to diagnose those with familial hypercholesterolemia (10). Genetic risk factors for tendinopathy also have been described in several studies (31,32,43,48,58,59, 68,71,82). An interaction between other risk factors and one's genetic make-up may further increase the likelihood of developing tendinopathy (48). Nonsystemic intrinsic risk factors include abnormal biomechanics (3,37,62,104), muscle inflexibility (105), decreased muscle strength (20,49,50,51,76), malalignment (76), and joint laxity (76).

Extrinsic risk factors include excessive mechanical load (76,85), training errors (*e.g.*, overtraining, rapid progression, running surface, and poor technique (76,104)), improper equipment (*e.g.*, footwear, racquets, and seat height), and work tasks with repetitive movements (85). Current and former smoking has been associated with lateral elbow tendinopathy (85). However smoking was not found to be associated with chronic rotator cuff tendinopathy in a cross-sectional study of Finnish subjects (72). Medications, such as fluoroquinolones (96), steroids (23), hormone replacement therapy (23), oral contraceptives (23), nonsteroidal anti-inflammatory drugs (NSAIDs) (12,94,95), and retinoids (22), also have been associated with tendon pathology.

In summary, the clinician should be aware of the potential risk factors when managing patients with tendinopathy. It is unclear how risk factors may affect one's response to eccentric training, especially those with systemic intrinsic risk factors. Further research may clarify this.

Pathophysiology

Many causes of tendinopathy have been proposed, but the etiology has not yet been elucidated fully. Some proposed mechanisms include hypoxia, oxidative stress, hyperthermia, excessive apoptosis, inflammation, and matrix metalloproteinase imbalance (84). In the past, the term tendinitis was used widely because the etiology of this condition was thought to be associated with an inflammatory process. However, in most cases, the tendon involved shows no signs of inflammation but instead shows fibroblasts, vascular hyperplasia, hypercellularity, and disorganized collagen (84). The affected tendon also shows an increased infiltration of new blood vessels, which is known as neovascularization (88). With these changes identified, tendinopathy has been accepted as a more appropriate term. In one study, histopathologic findings were similar when comparing patellar and Achilles tendinopathy (44), which suggests that tendinopathy has a similar appearance at different body regions.

The source of pain in tendinopathy is unknown. Theories on the causes of pain in tendinopathy suggest that a combination of mechanical and biochemical factors may play a role. Tendon degeneration with mechanical breakdown of collagen could theoretically generate pain. Chemical irritants and neurotransmitters also have been proposed as causing pain. These include lactate, glutamate, and substance P, all of which have been found to be elevated in tendinopathy (84). More recently, the nonneuronal cholinergic system has been implicated as a factor in chronic tendinopathy with evidence of both acetylcholine and a marked increase of muscarinic receptors; however its role in pain mechanisms is unclear (13). For a detailed review of the potential causes of tendinopathy and pain related to it, see the review by Sharma and Maffulli (84).

General Approach to Treatment of Symptomatic Tendinopathy

Conservative care for managing tendinopathy includes modification of activity, ice, and analgesics. Some avoid use of NSAIDs since there usually is no inflammation, and NSAIDs may have deleterious effects on long-term tendon healing (47). Furthermore studies using NSAIDs in the treatment of tendinopathy show minimal, if any, difference in recovery time or long-term management of pain (88). If the patient is active but unable to participate in usual fitness activities due to a symptomatic tendinopathy, then alternatives for maintenance of fitness need to be discussed. Bracing should be considered and may allow individuals to remain more active, though evidence is mixed on its effectiveness (5,67,79). Imaging with either a magnetic resonance imaging (MRI) study or ultrasound should be considered prior to initiating an eccentric exercise program if there is concern for a macroscopic partial or complete tendon tear. Given that many of the studies involving use of an eccentric training program do not include those with tears of the involved tendon, if a tear is present, then either the eccentric program needs to be progressed more slowly or the clinician should consider other options (*e.g.*, injections or surgery) with the patient's level of pain and weakness helping to guide this decision. In addition to instruction on an eccentric exercise program, physical therapy should address any biomechanical issues that may have caused or contributed to the patient's problem. Other treatments, including extracorporeal shock wave therapy (77,78), glyceryl trinitrate patch (60), percutaneous tenotomy (25), and injection of substances such as autologous blood (65), corticosteroid (21), prolotherapy (106), or platelet-rich plasma (57), may be considered if the patient does not respond to the mentioned treatments and remains limited significantly in function or activity due to pain. Some of these treatment options may be considered sooner rather than later or in combination with an eccentric exercise program, particularly in the patient with severe pain or in the elite level athlete where time to return to play may be critical. Surgery is needed rarely and usually reserved for only the most refractory cases (41).

Eccentric Exercises in the Treatment of Tendinopathy

The current most common therapeutic exercise regimen for treatment of tendinopathy involves mechanically loading the painful or abnormal tissue with the use of eccentric exercises. Eccentric exercises involve lengthening of the musculotendinous unit while a load is applied to it. While eccentric muscle strengthening has been used for some time, until recently, little was known about how eccentric exercises result in decreased pain and normalization of the tendon in those with tendinopathy. Many of the studies included patients diagnosed with tendinopathy by history and physical examination alone, but some studies used imaging to confirm the diagnosis and/or rule out other causes of pain.

Achilles Tendinopathy

Stanish *et al.* (89) were the first in the medical literature to propose an eccentric exercise program for the treatment of tendinopathy, specifically the Achilles tendon. Based on the research of Komi and Buskirk (36) and other investigators, Stanish and Curwin understood that more force can be generated on the musculotendinous unit using maximum eccentric contractions than with concentric and isometric contractions, and they hypothesized that microtrauma of the tendon occurs during an eccentric load. In order for the injured tendon to be adequately rehabilitated, they postulated that the treatment program should include eccentric exercises in order to train the tendon to withstand loads that could have caused the initial damage. The protocol involved once-daily exercises, stretching, and a progressive increase in the speed of movements, which occurred over a 6-wk period. Their study demonstrated that an eccentric exercise program, in 200 patients with Achilles tendinopathy with a mean duration of symptoms for 18 months, led to complete relief in 44% of patients and marked improvement in an additional 43% with a mean follow-up period of 16 months (89). However, as with a number of studies using eccentric training, this study did not include a placebo control group.

Alfredson *et al.* (2) was the first to perform a controlled study using eccentric exercises in patients with midportion Achilles tendinopathy. In this study of patients that had a mean duration of symptoms for 18 months, he compared an eccentric exercise program to conventional therapy followed by surgical intervention. His eccentric calf muscle exercise protocol involved using 3 sets of 15 repetitions with the knee fully extended and 3 sets of 15 repetitions with the knee partially flexed. This program was repeated twice daily, every day for 12 wk. Producing patients' tendon pain during the exercises was expected, but patients were told that pain should not be progressive or disabling. Additional resistance was added (*e.g.*, by wearing a back pack with weights) when the exercises became easier. This study showed a high success rate for Achilles tendinopathy using this protocol. After the 12-wk training period, all 15 patients returned to their preinjury running activity and, in addition, improved their calf strength. Interestingly Alfredson (1) began using eccentric exercises in the treatment of tendinopathy out of necessity as a result of having a painful Achilles tendinopathy himself. There have been several other studies on eccentric exercises in the treatment of Achilles tendinopathy using Alfredson's protocol, and most of these have confirmed his initial findings (45,61,78–80,87). Eccentric exercise also has been shown to be better than wait-and-see (78) or cryotherapy (35). However one study reported significant improvements in patients treated with 12 wk of eccentric exercises as well as those treated with a heel brace alone, with no significant difference between the two groups at 1 year (67). Nevertheless a recent systematic review of randomized controlled trials (RCTs) supports use of eccentric training as an integral component in the treatment of symptomatic Achilles tendinopathy (92).

When comparing eccentric exercises and concentric exercises in midportion Achilles tendinopathy, patients performing eccentric exercises improved more than the concentric group (45). The results showed that after the eccentric training regimen, 82% of the patients were satisfied and had resumed their previous activity level, compared to 36% of the patients who were treated with the concentric training regimen. Another study comparing eccentric exercises with concentric exercises showed significantly greater pain reduction in the eccentric exercise group at 4, 8, and 12 wk (61). In another group of patients who underwent a training regimen that included an eccentric exercise program for midportion Achilles tendinopathy, 65% had no symptoms at 5-year follow-up (86).

While most of the studies on eccentric exercises have concentrated on pathology of the midportion of the tendon, this protocol has been less studied in the treatment of insertional Achilles tendinopathy. In one study, 89% of patients with midportion tendinopathy had a good response, compared to only 32% in those with insertional tendinopathy (11). In this study, patients loaded the Achilles tendon into full ankle dorsiflexion. A small pilot study of 27 patients with insertional tendinopathy examined a modified protocol where eccentric exercises were performed without loading into dorsiflexion. Three sets of 15 repetitions were performed twice daily for 12 wk. Greater satisfaction levels (67%) were reported with this regimen. However this study did not include a control group (29).

Positive changes in tissue structure and mechanical properties as a result of eccentric training also have been investigated, though the reason why these changes occur is unknown. Shalabi *et al.* (83) evaluated 25 patients with chronic Achilles tendinopathy before and after an eccentric exercise program using the Alfredson's protocol. Eccentric training resulted in decreased tendon volume and decreased intratendinous signal on MRI, which correlated with improved pain and subjective performance. Ohberg and Alfredson (64) also found a decrease in tendon thickness and normalized tendon structure measured by ultrasound in most patients with chronic Achilles tendinopathy who were treated using eccentric exercises, and this normalization correlated with decreased pain. In a separate 5-year follow-up study of patients with Achilles tendinopathy that used Alfredson's 3-month eccentric exercise program, symptoms improved significantly. Average tendon thickness decreased from 8.05 mm at baseline to 7.50 mm at 5 years, although this did not reach statistical significance (100). In contrast to the Ohberg study, the positive changes seen within the tendon did not clearly correspond to improved symptoms.

The optimal protocol using eccentric exercises for midportion Achilles tendinopathy has to be established yet. One systematic review of RCTs was completed to try to resolve this issue (55). The review included three RCTs, which all showed positive effects of the eccentric exercise protocols. However, due to insufficient data and a similar number of repetitions and sets among all three protocols, an optimal regimen could not be determined.

Patellar Tendinopathy

There have been a few studies on eccentric exercises in the treatment of patellar tendinopathy. One study used a protocol similar to that used by Stanish and Curwin, where patients were directed to exercise daily with a warm-up and stretching, incorporating progressively faster drop squat eccentric exercises. This was compared to a control group performing leg extension or leg curl concentric exercises (6).

This protocol was followed for 12 wk and performed by patients with a mean duration of pain over 3 months. There was a significant pain reduction and return to sport in both groups, but no difference was observed between the two groups. However a limitation of this study is that there were only a total of 19 patients. In a study by Jonsson and Alfredson (28), patients with patellar tendinopathy with a mean duration of pain of 17 months were randomized to use either an eccentric or concentric quadriceps exercise on a decline board and treated for 12 wk. At mean follow-up of 32 months, 7 out of 8 patients in the eccentric exercise group still were satisfied subjectively and 6 patients returned to previous sports activities, while 1 patient did not return due to reasons other than patellar pain. All seven patients in the concentric exercise group were not satisfied and had undergone surgery or sclerosing injections.

A pilot study by Purdam *et al.* (70) compared two different eccentric exercise regimens. One group performed exercises using a decline board, while the other group performed squats on a level surface. In this study, patients were instructed to perform exercises slowly, twice daily with no stretching or warm-up, and exercises were performed with reproduction of tendon pain. The study showed a prominent positive effect in the group using the decline board compared with the standard squat group. However this study was limited by a small number of patients. A study by Young *et al.* (107) also supported greater improvements in elite volleyball players with patellar tendinopathy who performed eccentric exercises using a decline board compared to those with a traditional eccentric protocol using a flat 10-cm step. A study by Frohm *et al.* (16) examined the efficacy of two different 12-wk eccentric rehabilitation protocols, one with a daily eccentric exercise program on a decline board and one twice-per-week program using a Bromsman eccentric overload training device, which consists of a barbell suspended from wires that could be moved vertically at a chosen distance and with speed that was controlled by a hydraulic machine. Both groups had improved pain and functional scores at 12 wk, with no difference between the groups. One study of elite volleyball players who continued to compete through the season during the treatment period found no benefit from eccentric exercises compared to a control group who continued to train as usual, although there was a compliance of only 59% of the recommended volume of exercises in the eccentric treatment group (101). Overall current research suggests that an eccentric exercise program with use of a decline board generally has been more effective when compared to other training regimens, though clearly the results have been mixed.

A study by Bahr *et al.* (4) that compared eccentric exercises with open tenotomy surgery showed equal improvement in both groups. The association between the location of pathology (*i.e.*, at the proximal attachment vs at midportion of tendon) within the patellar tendon and the effectiveness of eccentric exercises remains unclear (75). Further research may eventually clarify this issue definitively.

Lateral Elbow Tendinopathy (aka Lateral Epicondylitis)

There have been only a few studies that have investigated the use of eccentric exercises in the treatment of lateral elbow tendinopathy. Eccentric exercises have been shown to result in increased function compared with therapeutic ultrasound in the treatment of lateral elbow tendinopathy (81). Also, compared to a passive rehabilitation program (ice, therapeutic ultrasound, massage, and stretching), the addition of an isokinetic eccentric protocol using a dynamometer that maintains a preset speed showed significantly better pain reduction, disability questionnaire scores, muscle strength, and ultrasonographic tendon imaging, including decreased tendon thickness and a more homogenous tendon structure (8). Since an isokinetic dynamometer is expensive and not widely available, Tyler *et al.* (98) conducted a study to assess the efficacy of a novel eccentric wrist extensor exercise, using an inexpensive flexible rubber bar, for the treatment of chronic lateral elbow tendinopathy. In comparison to a control therapy that included stretching, cross-friction massage, ultrasound, heat, and ice, the addition of daily eccentric exercises using the flexible rubber bar resulted in superior results for pain reduction, strength, and subjective disability. Another study showed that a supervised eccentric exercise and stretching program was found to be superior to a home-based eccentric exercise and stretching program to reduce pain and improve function in patients with lateral elbow tendinopathy (90). However there is a poorer prognosis with use of an eccentric exercise program in those patients diagnosed with lateral elbow tendinopathy and found to have a large intrasubstance tear or lateral collateral ligament tear on ultrasound (7). A recent review of eccentric exercises in the treatment of lateral elbow tendinopathy concluded that eccentric training produced encouraging results, although the literature is limited and eccentric programs have been varied (53). Therefore further research is needed.

Rotator Cuff Tendon Disorders

Only a few studies have examined the effect of eccentric exercises on shoulder pain, including rotator cuff disorders. One pilot study specifically evaluated eccentric training in chronic painful impingement syndrome of the shoulder (30). Nine patients were used in the study, and all patients were on the waiting list for surgery, with a mean duration of symptoms of 41 months. All patients had tried different treatment regimens, including rest, steroid injections, NSAIDs, and different types of shoulder rehabilitation exercises. Patients with arthrosis in the acromioclavicular joint or with large calcifications causing mechanical impingement were not included. The patients completed a painful eccentric training program directed at the supraspinatus and deltoid musculotendinous units, consisting of 3 sets of 15 repetitions, twice per day, for 12 wk. At the 52-wk follow-up, 5 patients were satisfied with treatment and had withdrawn from the waiting list for surgery. Among the satisfied patients, 2 had a partial supraspinatus tendon tear, and 3 had a Type 3 shaped acromion. One other study evaluated the effect of strengthening eccentric exercises of the rotator cuff and concentric or eccentric exercises of the scapula stabilizers on the need for surgery in patients with subacromial impingement syndrome (24). The control group performed an exercise program of nonspecific exercises for the neck and shoulder. In both groups, patients received 5 to 6 sessions of supervised physical therapy with home exercises once or twice per day over a 12-wk period. There was significantly greater improvement in pain and function in the exercise group that included use of eccentric exercises compared to the control exercise group that did not. Also a significantly lower proportion of patients in the treatment exercise group chose to undergo surgery.

Why Are Eccentric Exercises Effective?

Stanish *et al.* (89) suggested that eccentric exercises expose the tendon to a greater load than concentric exercises and proposed an eccentric exercise program as the best mechanism for strengthening the tendon. Alfredson originally hypothesized that eccentric exercises may cause changes in the metabolism of the tendon, which therefore result in altered pain perception. He later noted that there was a temporary interruption of blood flow in the tendon neovessels during each eccentric exercise sequence (75). In one study, a reduction of neovascularization was demonstrated with color Doppler sonography after 12 wk of eccentric training (64). In addition, 12 wk of eccentric training reduces pathologically increased capillary blood flow without changes in tendon oxygen saturation (34). Furthermore 12 wk of eccentric training reduced the abnormal paratendinous capillary blood flow in Achilles tendinopathy by as much as 45% and also decreased pain levels (35). Since ankle dorsiflexion has been shown to limit the blood flow in neovessels (35), it has been suggested that the good results of eccentric exercises in Achilles tendinopathy may be due to this intermittent disruption of this blood flow. Given that Alfredson's eccentric exercise protocol results in patients completing more than 15,000 repetitions over a 12-wk period, the success of an eccentric exercise program may be due to this repeated interruption of blood flow over time (73).

There is some evidence that eccentric exercises can develop greater forces in muscle during dynamic movements (17,36). However this was not found when forces were measured during specific eccentric exercises, such as those used in the Alfredson protocol for the Achilles. Rees *et al.* (73) found no significant difference in peak tendon force or tendon length change when comparing eccentric with concentric exercises. Yet they did find that the tendon is subjected to repeated loading and unloading in a sinusoidal-type pattern during eccentric exercises, with high-frequency oscillations in tendon force. This was largely absent during concentric exercises. These findings suggest that tendon force magnitude, as originally suggested by Stanish *et al.* (89), alone cannot be responsible for the therapeutic benefit seen in eccentric loading. Rather the pattern of tendon loading and unloading, with its force fluctuations, may provide an important stimulus for tendon remodeling and be responsible for the therapeutic benefit in eccentric exercises (73). This may be similar to how bone responds to high-frequency loading and mechanical signals, leading to increases in bone density (73). The data in this study were collected in healthy subjects, and it is possible that patients with tendinopathy have impaired eccentric control causing even more prominent force fluctuations. One other difference between eccentric and concentric exercises is that force rises through the course of an eccentric loading movement and falls during a concentric loading movement (73).

Langberg *et al.* (38) investigated the effect of eccentric exercises on collagen synthesis. The study included 12 patients, 6 with healthy Achilles tendons and 6 with Achilles tendinopathy, who performed eccentric exercises over a 12-wk period. In those with Achilles tendinopathy, eccentric training was found to increase collagen synthesis, whereas this was unchanged in the healthy tendons. Specifically there was increased peritendinous Type I collagen, which is the main type of collagen in normal tendons, and this occurred without a corresponding increase in collagen degradation. These changes corresponded with a decrease in pain levels. Other proposed mechanisms for the effectiveness of eccentric exercises include pain habituation as a result of completing several weeks of pain-provoking eccentric exercises, neuromuscular benefits through central adaptation of both agonist and antagonist muscles (73), and increases in tendon stiffness (69).

It is clear that the exercise regimen for tendinopathy is a different stress to the musculotendinous unit than that for muscle strengthening since the recommended muscle strengthening protocol is to perform exercises one time per day with at least 1 d of rest between workouts (54). Studies have shown better strength gains with training at least every other day compared to daily (54). In a study by Komi and Buskirk (36), 7 wk of eccentric muscle conditioning produced greater measurements in muscle tension than with concentric muscle conditioning; however integrated electrical activity was less in eccentric group. This could explain why twice-daily eccentric training sessions can be performed without overtraining muscles. Given the adaptations that take place with the eccentric training protocol described in this article compared to muscle strengthening recommendations, the current eccentric training for tendinopathy could be thought of as a "tendon-strengthening" program.

Although eccentric exercises have been shown to be effective in the treatment of tendinopathy, there are many questions that still remain. The speed of the eccentric movement may be an area of further research. A program with faster eccentric movements may lead to more force fluctuations, as seen in the study by Rees *et al.* (73), and therefore provide a greater remodeling stimulus. Furthermore the optimum load, repetitions, frequency, and duration of treatment remain unknown. Thus far, the original protocol developed by Alfredson remains the most commonly used, and few studies have compared his protocol to other regimens (39). Since collagen synthesis following exercise has been shown to peak at 24 h and decrease toward baseline at 72 h, it may be reasoned that the optimum frequency be less than that of the current twice-daily protocol (39,46,56,66,99). For example, one study found that eccentric training with very high loads twice weekly was an effective regimen in the treatment of patellar tendinopathy (16). More research is needed regarding the proposed mechanisms behind the positive effects of eccentric exercises in tendinopathy, including its effects on tendon histology, structure, and function.

Prescribing an Eccentric Training Program for Tendinopathy

Based on research to date, the therapeutic exercise program to treat painful tendinopathy should consist of eccentric exercises that target the affected area with 3 sets of 15 repetitions once to twice per day for at least 12 wk. Despite the research to date that supports this recommendation, an optimal dosage of exercise to provide the best results has yet to be determined (55). Patients should be encouraged to reproduce tendon pain during therapy sessions, but pain should not be progressive or disabling. The concentric portion of the exercise may be performed passively or with the assistance of the uninvolved limb during closed kinetic chain exercises, with the affected limb performing the eccentric portion of the exercise independently. The eccentric exercises should be performed slowly initially, with the speed of movement increased as the rehabilitation protocol progresses. If there are weaknesses in the kinetic chain that contribute to the problem, then these need to be addressed prior to returning to unrestricted athletic activity. Communication with both the patient and the physical therapist about this protocol may be needed, as some therapists are not accustomed to producing patients' pain during the exercise regimen. If a patient returns after performing the prescribed program for several weeks and reports no improvement in pain, then a detailed assessment of the home exercise program is warranted. Patients should be asked if the exercises are being performed at the prescribed frequency and if the exercises are painful and difficult. Only after it is confirmed that the prescribed exercise regimen has been completed and failed should other options be considered. If the program is too painful to perform, then imaging or other treatments (*e.g.*, injections) should be considered. Patients may continue routine fitness activities if these provoke minimal or no pain at the affected tendon (11).

Conclusions

This article has attempted to summarize up-to-date research regarding the mechanisms for eccentric training for tendinopathy as well as outline a specific eccentric program to follow in the treatment of painful tendinopathy. Eccentric exercises have been shown to be effective in the treatment of tendinopathies at various locations of the body. The area studied earliest was the Achilles, although benefits have been seen using eccentric exercises on other body regions including the patellar tendon, lateral elbow, and rotator cuff. Further research is necessary to determine the optimal protocol for eccentric exercises in the treatment of tendinopathies.

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