TENDINOPATHY REHABILITATION: Choosing the Correct Loading Strategy

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The causes of tendinopathy are complex and not fully understood but the results – ranging from mild pain and swelling to complete loss of function – and the frustratingly slow recovery can be devastating, particularly for an athlete. The current consensus is that the best treatment is a careful programme of strengthening and load management. This article clearly describes how to tailor a rehab programme to your patient's precise needs, and, importantly, what not to do. Read this article online https://spxj.nl/2We8459

Tendon overuse injuries, namely tendinopathies, pose a significant clinical problem, particularly in musculoskeletal and sports-related medicine, accounting for up to 30% of general practice musculoskeletal consultations. The pathogenesis of tendinopathy is multifactorial and complex and, even though several theories have been suggested, the exact causative factors remain unknown. The incomplete understanding of the mechanisms underpinning tendon pathophysiology continues to hamper the development of targeted therapies, which have been successful in other areas of musculoskeletal medicine. The most common exacerbating factor is thought to be overuse (particularly during sporting activities) causing repetitive microtrauma and consequent degeneration due to failure of the healing process. Manifestations range from mild pain and swelling to complete loss of function, and diagnosis is usually based on a thorough history and physical examination; however, imaging modalities such as ultrasound and MRI can be useful, especially for identifying tears. Tendinopathy appears to result from an imbalance between the protective/regenerative changes and the pathological responses that result from tendon overuse. The net result is tendon degeneration, weakness, tearing and pain.

As the basic science of tendinopathy has evolved, so have the treatment options for these conditions. First-line treatment comprising several modalities ranging from relative rest and progressive loading to invasive pharmacological interventions continue to be the mainstay of treatment. Apart from loading, which is widely recognised to be effective for the treatment of tendinopathies, the benefits of the remaining available therapies are equivocal, and treatment options are usually tried sequentially starting from the least noxious (1*).

There has been a lot of progress over the last two decades with tendinopathy treatment. Most physical therapists have (hopefully) moved on from the days of ultrasound, interferential and tendon massage, to strengthening, load management and helping patients prepare their body for the demands of running, sport and everyday life. There are a lot of exercise options – eccentrics, isometrics, isotonics, functional, plus hopping, jumping and plyometric programmes, which all seem to have benefits. Once you decide on the type of exercise, you have to figure out the weight, sets and repetitions to use, and how quickly your patients can get back into running or sport.

Back in 2015, a new paper by Rio et al. (2*) reported a large reduction in tendon pain with the use of isometric exercises. The study participants' pain dropped from an average of 7 out of 10 (during a single-leg decline squat) down to an average of 0; yes – zero! Research results like this aren't common so the news spread quickly and isometrics were soon widely adopted for reducing pain in tendinopathy. It definitely has its merits but like any study one needs to delve deeper beneath the headlines; for example, the sample size was only six men with no control group. It's not to say isometrics don't help; however, several research groups have examined the effects of isometrics

●● THE MOST COMMON EXACERBATING FACTOR IN TENDINOPATHY IS THOUGHT TO BE OVERUSE ●●

since this key paper and their findings have been far more mixed (which will be highlighted later in this article).

Well, what about the eccentric loading exercises that become highly popularised after a Scandinavian author (3) showed hugely successful results in 1998? Though effective, the results of eccentric exercises observed from other study groups have been less convincing than originally reported, with only around 60% of good outcomes reported after a regime of eccentric training both in athletic and sedentary patients. The best evidence to date does demonstrate that eccentric exercise is likely to be a useful management modality for tendinopathy, but this evidence is currently insufficient to suggest it is superior to other forms of therapeutic exercise (4,5).

These mixed findings needn't mean you have to consign isometric or eccentric exercises to the scrapheap when dealing with tendinopathy. They are effective possibly at different times during the rehabilitation process and to different levels of efficacy in different individuals.

So, that raises the question of what to use when? It can be frustrating not having a handful of clinical trials with conclusive results pointing to one exercise type. Consensus, however, does exist for an exercise-based loading regime when managing tendinopathy injuries (4,6*). This article will discuss the options of what exercises to use when and how to progress them, with the ultimate goal of getting your patient back to full sport or activity.

What NOT to Do!

This may be a good starting point to narrow down the options. The pathogenesis of tendinopathy and the primary biological change in the tendon that precipitates pathology have historically generated several patho-aetiological models. The continuum model of tendon pathology, proposed in 2009, synthesised clinical and laboratory-based research to guide treatment choices for the clinical presentations of tendinopathy. Although the continuum has been cited extensively in the literature, its clinical utility has yet to be fully elucidated. The continuum model (7*) proposed a model for staging tendinopathy based on the changes and distribution of disorganisation within the tendon. However, classifying tendinopathy based on structure in what is primarily a pain condition has been challenged. The interplay between structure, pain and function is not yet fully understood, which has partly contributed to the complex clinical picture of tendinopathy (8*).

It may be beneficial to revisit this model (7*,8*) to better understand tendon morphology, pathology, tenocyte and collagen response, inflammation, degeneration and more. The continuum model suggests that management may be optimised by tailoring interventions to the stage of pathology and targeting the primary driver (cell activation) and inter-related alterations in matrix integrity (8*). Although exercise and load are fundamental to management, a plethora of intratendinous and peritendinous interventions exist to 'treat' tendinopathy – this increases the complexity of the clinical decision-making process (8*).

Tendinopathy is a heterogeneous clinical presentation because of the variable change in matrix structure, pain and dysfunction. Phenotyping of patients based on structure, pain, dysfunction and load capacity may allow you to direct appropriate treatments at the critical limiting factors (6*,8*). To revise the continuum and phenotyping for tendinopathy patients you can access the free articles via: https://spxj.nl/38KwUfe and https://spxj.nl/38KwXaU.

Research has investigated many treatment options, but consistent, positive, clinical outcomes remain elusive. Treatment should be active (eg. exercise-based), and a consistent and ongoing investment in rehabilitation is required. It is important to maximise this investment by understanding (and conveying to patients) the **treatments that do not help**. Jill Cook (9) suggests, therefore, a good starting point may be one of considering what not to do with a tendinopathy patient.

> ●● THERE HAS BEEN A LOT OF PROGRESS OVER THE LAST TWO DECADES WITH TENDINOPATHY TREATMENT ●●

1. Don't Rest Completely

Treatment should initially reduce painful, high tendon load (point 2 below) and introduce beneficial loads [eg. isometrics (2*)]. Once pain is low and stable (consistent on a loading/provocative test each day), load can be increased slowly to improve the capacity of the tendon (9).

Rest decreases the load tolerance of tendons, and complete rest decreases tendon stiffness within 2 weeks. It also decreases strength and power in the muscle attached to the tendon and the function of the kinetic chain, and likely changes the motor cortex, leaving the person less able to tolerate load at multiple levels.

2. Don't Prescribe Incorrect Exercise

Understanding the concept of 'load' is essential for correct exercise prescription. High tendon load occurs when it is used like a spring, such as in jumping, changing direction and sprinting (10). Tendon springs must be loaded quickly to be effective. So slow exercises, even with weights, are not high tendon load and can be used early in rehabilitation. Bear in mind,

TENDINOPATHY BEGINS WITH A MISMATCH BETWEEN THE TENDON'S LOAD CAPACITY AND LOAD PLACED ON THE TENDON

however, that exercising at a longer muscle–tendon length can compress the tendon at its insertion (11), which adds substantial load and should be avoided (even if done slowly) early in rehabilitation (9).

3. Don't Rely On Passive Treatments

Passive treatments are not helpful in the long term as they promote the patient as a passive recipient of care and do not increase the load tolerance of the tendon. Treatments like electrotherapy and ice temporarily ameliorate pain only for it to return when the tendon is loaded (9).

4. Avoid Injection Therapies

Clinicians who support injection therapies incorrectly suggest they will return a pathological tendon to normal. Injections of substances into a tendon have been shown to be no more effective than placebo in good clinical trials (9). There is little need to intervene in the pathology as there is evidence that the tendon adapts to the pathology and has plenty of tendon tissue capable of tolerating high load. Injections may change pain in the short term as they may affect the nerves, but should only be considered if the tendon has not responded to a good exercise-based programme (9).

5. Don't Ignore Tendon Pain

Pain usually increases 24 hours after excess tendon load. An increase in pain of 2 or more (out of 10) on a daily loading test should initiate a reduction in the aspects of training that are overloading the tendon (point 2 above). The overload is likely to be due to excessive spring-like movements such as jumping, running and changing direction (9). Daily recording of pain (documented by the patient or therapist on treatment days) will provide feedback to their tolerance and response to loading which will guide progression either forward or backwards when necessary.

6. Don't Stretch The Tendon

Aside from the load on a tendon in sport, there are compressive loads on the bone–tendon junction when it is at its longest length. Stretching only serves to add compressive loads that are detrimental to the tendon (9).

7. Don't Use Friction Massage

A painful tendon is overloaded and irritated (reactive tendon pathology). Massaging or frictioning the tendon can increase pain and will not help the underlying pathology. An effect on local nerves may reduce pain in the short term only for it to return with high tendon loads (9).

8. Don't Use Tendon Images for Diagnosis, Prognosis or as an Outcome Measure

Abnormal tendon images (ultrasound and MRI) in isolation do not support a diagnosis of tendon pain as asymptomatic pathology is prevalent. There are also no aspects of imaging, such as vascularity and 'tears', that allow a clinician to determine outcome. Pathology on imaging is usually very stable and does not change with treatment and reduction in pain, so images are not a good outcome measure (9).

9. Don't Be Worried About Rupture

Pain is protective as it causes unloading of a tendon. In fact most people who rupture a tendon have never had pain and do not present clinically, despite the tendon having substantial pathology. Fear of rupture or 'permanent' damage may inhibit the patient's ability or willingness to load the injured area (6*).

10. Don't Rush Rehabilitation

A tendon needs time to build its strength and capacity. So does the

TABLE 1: EXAMPLES OF OVERLOADS ON THE ACHILLES TENDON

Reproduced with permission from Cook JL, Purdam CR. The challenge of managing tendinopathy in competing athletes. British Journal of Sports Medicine 2014;48:506–509 (12)

Type of overload	Example
Single high-intensity session	Repeated uphill running
Increased frequency of training	High-load training more than five times a week
Different drills	Rapid introduction of plyometric training
High loads when fatigued	Sprints at the end of training
Change in footwear	Shoes that provide less support, or stiff soles, shoes mandate a forefoot strike or have a lower heel wedge
Change in surface	Running in soft sand, running on uneven surfaces
Training with muscle stiffness	Training session following heavy-weight session

muscle, the kinetic chain and the brain. Although this can be a substantial time (3 months or more, sometimes up to 12 months), the long-term outcomes are good if the correct rehabilitation is completed (9). Setting unrealistic timeframes can be a major pitfall. Understandably there may be great pressure from an athlete, coach or parent (6*). Malliaris and Cook et al. (6*), comment that in their experience, poor baseline neuromuscular function, muscle atrophy, pain irritability, as well as multiple previous intratendinous interventions (eg. platelet-rich plasma or other injections) appear to be associated with longer rehabilitation times (6*). This point should possibly not be last, as in number 10, but rather the first point – to suggest having these timeline discussions with patients and their stakeholders (be it parents or coaches) right at the onset of treatment.

The idea is not to waste valuable time and resources. A progressive programme that starts with a muscle strength programme and then progresses through to more spring-like exercises and including endurance aspects will load the tendon correctly and give the best long-term results.

What to DO!

Tendinopathy begins with a mismatch between the tendon's load capacity and load placed on the tendon, most commonly through a sudden and/or substantial change in the load. This can include a return to sport from an (often unrelated) injury or after the off season, where the load capacity of the tendon is reduced owing to a loss of a regular high-load stimulus, or a sudden change in training intensity; or simply the couch potato who wants to now run 5km. As tendons respond very slowly to load, a tendinopathic response is triggered if the magnitude or temporal distribution exceeds the tendon's threshold (12).

In a runner presenting with Achilles tendinopathy, examples of the types of overloading can be seen in Table 1.

A rehabilitation protocol for a runner suffering from Achilles or patellar tendinopathy may consist of simple and pragmatic exercises designed to incorporate progressive load to the tendon: isometric work, strength (including eccentric and concentric), functional strength, speed and jumping exercises to adapt the tendon to the ability to store and release energy (Link 1) (13*).

First, load modification is used with the goal of reducing pain. This involves initially reducing high-load energy-storage activities that may be aggravating the pain. Intensity seems to be the most important feature; therefore this is the first factor you should modify by removing intensity peaks (ie. sprinting, sets, Fartlek, fast changes of direction, explosive jumping) (13*). Frequency is a very flexible value that we can use to adapt the load (more or less resting hours between workouts depending on the pain level of the next day). Volume seems to be the less aggressive feature, if there is enough time of rest among workouts; therefore, at early stages you can keep the volume of training and change intensity and frequency (13*). Volume and frequency (number of days per week they are performed) of the highest-intensity activities, such as maximal jumping, cutting, and pivoting may need to be reduced in consultation with both the athlete and coach. Both load modification and eventual progressive loading are based on careful pain monitoring. Some pain is acceptable during and after exercise, but symptoms should resolve reasonably quickly after exercise and should not progressively worsen over the course of the loading programme, as monitored by the 24-hour response (6*).

Pain response should be closely monitored on a daily basis throughout rehabilitation. Patients will need to be responsible for recording their pain and reporting back to the therapist so as to adjust exercises accordingly. Pain response can be measured using provocation tests (Table 2). The test is administered daily, at the same time of day, throughout the entire rehabilitation process. As tendon pain is intimately linked with load, the response to the test as called 'load tolerance'. If the pain score on the load test (eg. 1 repetition of the single-leg decline squat test at the same depth) has returned to baseline within 24 hours of the activity or rehabilitation session, the load has been tolerated. If the pain is worse, load tolerance has been exceeded. Some studies have suggested that a pain level of up to 3–5 on a 0-to-10 numeric rating scale (0 is no pain and 10 is the worst pain imaginable) during exercise is acceptable (6*). However, a pain rating of 3/10 or less is defined as acceptable and 'minimal' pain. This should be a guide and can be adjusted according to the individual. It is reiterated that greater emphasis should be placed on the 24-hour pain response to a predefined load test, rather than to pain during or immediately before an activity (6*).

TABLE 2: PROVOCATIVE CLINICAL TESTS USEFUL TO MONITOR TENDON PAIN
Reproduced with permission from Cook JL, Purdam CR. The challenge of managing tendinopathy in competing athletes. British Journal of Sports Medicine 2014;48:506–509 (12)

Tendon	Low-load clinical test	High-load clinical test
Achilles	Single-leg heel raise	Hop
Patellar tendon	Decline squat	High single-leg jump, landing from a height
Hamstring tendon	Single-leg bent knee bridge	Single-leg dead lift
Gluteal tendon	Single-leg stance	Hop

THE KEY TO TENDINOPATHY REHAB IS TO PROGRESS THE LOAD BASED ON TOLERANCE

Video 1: Isometrics Exercise for GTPS | Gluteal Tendinopathy (Courtesy of YouTube user Physiotutors) https://youtu.be/YNkxh046sa4

Managing tendinopathy in season is a challenge for all sports medicine practitioners. Early intervention in athletes with tendinopathy is a key element. As with managing stress fractures, early identification, modification of training and return to sport using realistic timelines are fundamental to a good outcome. Identification of at-risk athletes, individualising training, monitoring changes in pain and immediate adjustment of loads are essential. Maintaining well-distributed functional loads relevant to the sport during the off season in an effort to reduce deconditioning of the muscle–tendon unit and kinetic chain appears to be a key consideration. Further, for athletes who have had significant downtime as a result of surgery or illness, avoiding a rapid return to high tendon load is also essential (12).

Rehabilitation

Stage 1: Isometric Loading

Isometric exercise can be used as an initial treatment and/or in-season pain management for tendinopathies. Isometric exercises are indicated to reduce and manage tendon pain and initiate loading of the muscle–tendon unit when pain limits the ability to perform isotonic exercises. Performing the isometric exercises in mid-range is often more comfortable initially. Resistance should be increased as quickly as tolerated and the exercise should be performed on a single leg where possible (6*).

The exercise dosage depends on individual factors; however, 5 repetitions of a 45-second hold, 2 to 3 times per day, with 2 minutes of rest between holds to allow recovery is a good place to start. A 70% maximal voluntary contraction load, which has been associated with reduced pain, can be estimated clinically (6*). The key is to progress the load based on tolerance and, as discussed earlier, regular reassessment of pain response with load tests. A good prognostic sign for isometrics is an immediate reduction in pain with loading tests (eg. a single-leg decline squat test) after isometric exercise. It is important that there be no muscle fasciculation during the isometric exercises, as this may indicate that the load is too high. In stage 1, isometric exercises should be used in isolation. This stage may last a few weeks (sometimes longer) when managing individuals with a high level of pain irritability. Other exercises, involving surrounding muscles and joints of the kinetic chain, to address strength or flexibility deficits throughout the lower extremity can be initiated during this initial phase (6*).

Does isometric contraction provide the strongest initial pain relief for tendinopathy? Four recent studies have addressed this question (14*). The studies showed mixed results with some patients reporting no change in pain, some an increase in pain, others no difference in pain when performing isometric or isotonic exercises. Interestingly, the original study from Rio et al. (2*), could not be replicated in a pre-registered replication study using the same methods and outcomes in 20 individuals suffering from patellar tendinopathy (14*). A recent study by Clifford et al. (15*) found that both isometric and isotonic exercises were effective in reducing pain by 55% and 58%, respectively, in patients with greater trochanteric pain syndrome (GTPS) (15*). An example of isometric exercises for GTPS can be found in Video 1.

When used as in-season management, there have been suggestions of immediate pain relief following both isometrics and isotonics in athletes with patellar tendinopathy with no superiority of isometrics over isotonics (14*). Recent large-scale studies with sample sizes in excess of 600 suggest that maintained pre- and in-season strengthening and conditioning without any specific bias towards concentric, isometric or eccentric modes reduce the in-season prevalence of shoulder and groin problems (approx. 30–40%). Furthermore, there is evidence that using a pain-monitoring model and adequate adaptation periods during rehabilitation will enable continued sporting without adverse effect on recovery (14*).

Key points for stage 1 (13*):

1. Pain inhibits the athlete using

the elastic (energy storage and release) capacity of the tendon, thereby compromising function and performance.
2. Excessive training volume or too intense training involving the elastic function of tendons may induce tendon overload and are important factors in the onset of athletic tendinopathy.
3. Repeated training combined with too short resting periods can result in a net degradation of the matrix and lead to overuse injury.
4. Managing tendinopathy in season centres around load management: this includes strategies that control pain, both reducing aggravating loads and introducing pain-relieving loads.
5. No medication or injectable treatment to date has been shown to alter tissue properties – only tendon load can stimulate remodelling.
6. Loads that reduce pain should be introduced as early as possible. Loading to decrease pain will maintain a load stimulus on the tendon that is critical to maintain cell function and matrix integrity.
7. In highly reactive and painful tendons, bilateral exercises, shorter holding time and fewer repetitions per day may be indicated.

Stage 2: Isotonic Loading

Loaded isotonic exercise is initiated when it can be performed with minimal pain (3/10 or less on a numeric pain-rating scale). A positive response to regular reassessment of pain with load tests continues to be important. Isotonic load is important to restore muscle bulk and strength through functional ranges of movement. A common pitfall is including only double-leg, multi-joint exercises (eg. double-leg squats) that may not address quadriceps strength asymmetry if the athlete spares (protects) the affected side. Exercises that can be progressed easily to single-leg loading, including leg press, split squat, and seated knee extension (leg extension machine) may be beneficial (6*).

Eccentric musculotendinous loading has become the dominant conservative intervention strategy for Achilles and patellar tendinopathy over the last two decades. Eccentric loading involves isolated, slow lengthening muscle contractions. Systematic reviews have evaluated the evidence for eccentric muscle loading in tendinopathy, concluding that outcomes are promising but high-quality evidence is lacking (13*). Video 2 demonstrates a routine proposed by Alfredson et al. (3) for Achilles tendinopathy. Eccentric loading may not be effective for all patients (athletes and non-athletes) affected by tendinopathy (13*). It is possible that in athletes, eccentric work alone is an inadequate load on the muscle and tendon. A rehabilitation programme aiming to increase tendon load tolerance must obviously include strength exercises, but should also add speed and energy storage and release.

Despite the widespread clinical use of eccentric exercise for the treatment of tendinopathy, there are limited high-quality data that demonstrate positive clinical outcomes of this approach (4,6*,13*,16). Kongsgaard et al. (17*) performed a randomised clinical trial comparing heavy slow resistance (HSR) exercise and the decline squat programme. The HSR programme consisted of concentric/eccentric squats, hack squats, and leg presses, using both lower extremities. For each exercise, 3 to 4 sets were performed, progressing from an initial load based on 15 repetition maximum (15RM) to 6RM. Pain and functional outcomes on the VISA-P were similar at 6 months, but patient satisfaction of those using the HSR programme was significantly greater (70%) than patient satisfaction of those using the decline squat programme (22%). The authors of a recent systematic review (16) determined that there was limited evidence supporting the decline squat programme and moderate evidence supporting the HSR programme (16). As isometric exercises appear to be more effective during the competitive seasons for short-term pain relief, HSR or eccentric exercises are more suitable for long-term pain reduction and improvement in function (18). Stage 1 exercises should be continued on the 'off' days to manage pain within the limits of muscle fatigue and soreness associated with the isotonic loading. Stage 2 exercises should be continued

Video 2: Alfredson Achilles Tendinopathy Rehab Protocol (Courtesy of YouTube user Physiotutors) https://youtu.be/fHHbn_Odk4E

Video 3: GTPS Exercise Protocol | Gluteal Tendinopathy (Courtesy of YouTube user Physiotutors) https://youtu.be/477OFkR0syE

TABLE 3: EXAMPLES OF FORCE AND LOADING RATE ON THE PATELLAR TENDON
Sourced from Malliaris P et al. Patellar Tendinopathy: clinical diagnosis, load management, and advice for challenging case presentations. Journal of Orthopaedic & Sports Physical Therapy 2015;45(11):887–898 (6)

Exercise/activity	Force	Loading rate
Bilateral leg press (not an energy-storage loading exercise)	5.2× body weight	2× body weight per second
Landing phase of vertical jump	5.17× body weight	38× body weight per second
Horizontal landing – stop, land/jump sequence	6.6× body weight	93× body weight per second

LOAD MODIFICATION AND PROGRESSIVE LOADING ARE BASED ON CAREFUL PAIN MONITORING

throughout rehabilitation and return to sport. Video 3 demonstrates some rehabilitation exercises for GTPS.

Stage 3: Energy-Storage Loading

The power needed for jumping, landing, cutting and pivoting when participating in sports requires tendons to repetitively store and release energy. Energy storage and release (similar to a spring) from the long tendons of the lower limb are key features for high performance while reducing the energy cost of human movements. Repetition of this spring-like activity over a single exercise session, or with insufficient rest to enable remodelling between sessions, can induce pathology and a change in the tendon's mechanical properties, which is a risk factor for developing symptoms.

Reintroduction of energy-storage loads on the myotendinous unit is critical to increase load tolerance of the tendon and improve power as a progression to return to sport. Initiating this stage is based on the following strength and pain criteria: (1) good strength (eg. ability to perform 4 sets of 8 repetitions of single-leg press with around 150% body weight for most jumping athletes); and (2) good load tolerance with initial energy-storage exercises, defined as minimal pain (3/10 or less on a numeric pain-rating scale) while performing the exercises, and return to baseline pain (if there was an initial increase) during load tests, such as the single-leg decline squat, within 24 hours (6*).

As with the other stages, individualisation and clinical reasoning are necessary. In addition, progression should be developed within the context of the loads the individual patient is required to attenuate for their sport and performance level. Table 3 provides an understanding of the major change through activities in the rate of loading of the tendon, which should be progressed gradually through relevant energy-storage activities for the individual athlete.

Exercise choice will depend on the demands of the individual sport. Thus, the selection and parameters of energy-storage programmes may vary greatly among individuals who participate in different sports, as well as among positions in the same sport. Planning for this stage requires close consultation with the athlete and coach to appropriately determine the training frequency, volume, and intensity of the energy-storage exercise, and the type of exercise. Energy-storage exercise options may include jumping and landing, acceleration, deceleration, and cutting/change-of-direction activities, depending on the demands of the sport (6*). The progression can take several weeks to months for some athletes (eg. for volleyball players to build up to the 300 landings typically performed in a single training session). For athletes who do not require significant volumes of jumping and landing in their sport (sprinters, rugby players), a similar progression targeting acceleration, deceleration, and/or cutting/change-of-direction manoeuvres may be emphasised (6*).

Accurate quantification of load is important at this stage. In jumping sports, the number and intensity of jumps and all other energy-storage activities should be considered to ensure that loads are progressively applied to meet the ultimate demands of the sport. For example, a high jumper may progress through double- to single-limb small vertical jumps and hops, to horizontal bounding (eg. 4–6 times, 8–12 contacts), 2-legged hurdle jumps up to 1m high (eg. 3 times, 8 contacts), scissor jumps over the bar from 5-step run-up (8–10 contacts), then flop jump from 5-step run-up (8–10 contacts), and finally to a full run-up flop jump (8–10 contacts). In essence, the volume (ie. number of contacts or jumps) is progressed before the intensity (jump height and speed) for each exercise to approach the optimal training intensity and energy-storage exercise demands of the sport (6*).

The introduction of energy-storage exercises is often the most provocative stage, so loading is performed every third day initially, based on a 72-hour collagen response to high tendon loading (6*). Progressions are guided by pain experienced in the provocative test 24 hours after exercise, as described earlier. Stage 1 isometric loads can be used in combination to manage stable pain following energy-storage exercise; however, increased pain in the load response test the day after a stage 3 training session indicates that load tolerance has been exceeded (irritable pain) and loading should be adjusted accordingly (eg. regress to the previous level of training, or further, to restore load tolerance on load tests again). In some instances, pain may increase for days after an energy-storage progression that was not gradual enough (6*).

Stage 4: Return to Sport

Progression to sport-specific training can be commenced when the individual has completed energy-storage progressions that replicate the demands of his or her sport in regard to the volume and intensity of relevant energy-storage functions. In the early phases, training should match the volume and intensity of final progression of stage 3 exercises, gradually replacing stage 3 activities with a volume and intensity similar to those of training drills to replicate the participation and fitness demands of the sport.

Return to sport is recommenced when full training is tolerated without symptom provocation (24-hour response on provocation test) and any existing power deficits have been resolved (6*).

Maintenance Exercise

It has been suggested that a maintenance programme, once athletes have returned to sport, continues with stage 2 strengthening exercises. They should be performed at least twice per week, preferably using loaded and single-leg exercises (for example split squats, seated knee extension, leg press in patellar tendinopathy). Stage 1 isometric exercises can be continued and performed intermittently (eg. before or after training) for their immediate effect on pain. Athletes should also continue addressing other relevant flexibility and strength deficits identified throughout the lower extremity, such as gluteal or calf-strengthening exercises (6*).

Kinetic Chain Considerations

Management focusing on the presenting tendinopathy is simplistic, as the distribution of absorption of energy across the kinetic chain is an important consideration and each tendinopathy requires a holistic approach to rehabilitation. For example, a restriction of ankle dorsiflexion in a landing has the potential to increase the load on the patellar tendon (12). Other considerations for patellar tendinopathy may include gluteal strengthening and recruitment, calf strengthening and landing re-education, encouraging energy absorption to be distributed across all three major joints or segments. Much of this can be commenced very early in the management cycle, providing symptomatic gains as the presenting tendinopathy is effectively unloaded (12).

Links 2 and 3 show examples of progressions for exercises and rehabilitation for patellar tendinopathy in Malliaris et al. (6*).

Conclusion

Tendinopathy can frequently be difficult to manage often resulting in frustration and disappointment with continued pain and prolonged recovery time. The cornerstone of tendinopathy management and rehabilitation remains a highly specific and thorough approach to progressive loading of the tendon as well as the associated kinetic chain. Rehabilitation should progress through stages of off-loading and pain reduction followed by gradual strengthening and introduction of plyometric and sports specific exercises. No one exercise type has been found to be superior or inferior to the other. The focus should be on load response and increasing load tolerance. Each individual will present differently and the exercise prescription will need to be altered according to their pain, function and tendon reactiveness. The ultimate goal is that the athlete should be able to use the elastic capacity of their tendon and regain function of the kinetic chain suitable to the sport and level of performance.

References

Owing to space limitations in the print version, the references that accompany this article are available at the following link and are also appended to the end of the article in the web and mobile versions. Click here to access the references https://spxj.nl/2wlzdli

KEY POINTS

- Tendons are highly responsive to increased mechanical loading and adapt through changes of their mechanical, material and morphological properties.
- Each component of the rehabilitation programme, in particular loading, must be handled in relation to the nature, speed and magnitude of the forces applied to the muscle–tendon–bone unit in order to achieve the goals of the particular management phase without causing exacerbation of the pathological state or pain.
- Rehabilitation can progress through 4 stages: isometric early stage; isotonic or strengthening stage including both concentric and eccentric as well as functional exercises; energy-storage stage involving plyometric type activities; final stage of return to sport.
- Provocative testing and daily documentation of pain scores is crucial in determining load tolerance and progression.
- Individuals display a very varied response to isometric exercises used for pain management.
- Although a number of exercise-based interventions have significant positive effects on pain and function in tendinopathy, the current evidence does not support the recommendation of one type of exercise programme over another. There seems to be not one exercise type, be it eccentric or isometric, that is superior to or inferior to other exercises.
- Progressive load may be more important than the exercise type.
- Kinesiophobia may influence both short- and long-term response to load.
- Patients and therapists should not have unrealistic time frames: recovery from tendinopathy can take in excess of 12 weeks.
- The ultimate goal is that the athlete should be able to use the elastic capacity of the tendon and have regained function of the kinetic chain suitable for performance.

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DISCUSSIONS

- For the most common tendons (Achilles, patellar, hamstring and gluteal), which provocative tests do you use and find most accurate in testing tendon pain?
- What do you believe is an acceptable pain score in order to progress the exercise load: less than 3/10 or can a patient work into some degree of pain with ratings of 3–5/10?
- What exercise do you prefer to use for each tendinopathy (Achilles, patellar…) where you can progress it over the different rehabilitation stages?

Want to share on Twitter?

Here are some suggestions

Tweet this: Isometric exercises are a useful initial treatment to reduce and manage tendon pain. https://spxj.nl/2We8459
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LINKS

LINK 1: Figure 1: Programme to incorporate progressive load to the tendon. Mascaro A et al. Load management in tendinopathy: clinical progression for Achilles and patellar tendinopathy. **Apunts Sports Medicine 2018;53(197):19–27 (13)** https://spxj.nl/2HPXybL

LINK 2: Figure 2. Progression of patellar tendinopathy rehabilitation. Malliaris P et al. Patellar tendinopathy: clinical diagnosis, load management, and advice for challenging case presentations. **Journal of Orthopaedic & Sports Physical Therapy 2015;45(11):887–898 (6)** https://spxj.nl/3bX4Jwy

LINK 3: Table 1: Rehabilitation stages and progression criteria. Malliaris P et al. Patellar tendinopathy: clinical diagnosis, load management, and advice for challenging case presentations. **Journal of Orthopaedic & Sports Physical Therapy 2015;45(11):887–898 (6)** https://spxj.nl/3bX4Jwy

Owing to the important performance benefits of strength training (ST), it should be considered an essential addition to a well-planned training programme for middle and long distance runners of all levels. There is a belief among some health professionals, running coaches and runners, that to maximise the benefits to running performance, ST should be high repetition, low resistance to mimic the endurance demands of running. This is incorrect. Improvements in muscular endurance are achieved specifically by running and should not be the goal of a ST programme. Completing endurance type exercises (eg. 3 sets of 20 reps or more with light resistance) has been reported to be less effective than heavy resistance and explosive resistance training in achieving benefits to running performance (1). As such, ST should include heavy resistance, explosive resistance and plyometric training for endurance runners (1,2,3,4).

Key Benefits

1. Improved Running Economy (RE) (4)

ST interventions lasting 6–20 weeks, added to the training programme of a distance runner with >6 months running experience, have been reported to enhance RE by 2–8% (1). RE improvements will theoretically enhance endurance running performance by allowing the runner to run at a lower oxygen or energy cost during training and racing (1). These benefits have been reported in runners from a recreational level through to highly trained elite athletes (1). Although the impact of ST on RE is well established, the mechanisms that explain this phenomenon are still not clearly understood.

Plausible mechanisms underpinning the mechanism of RE improvements with ST are:

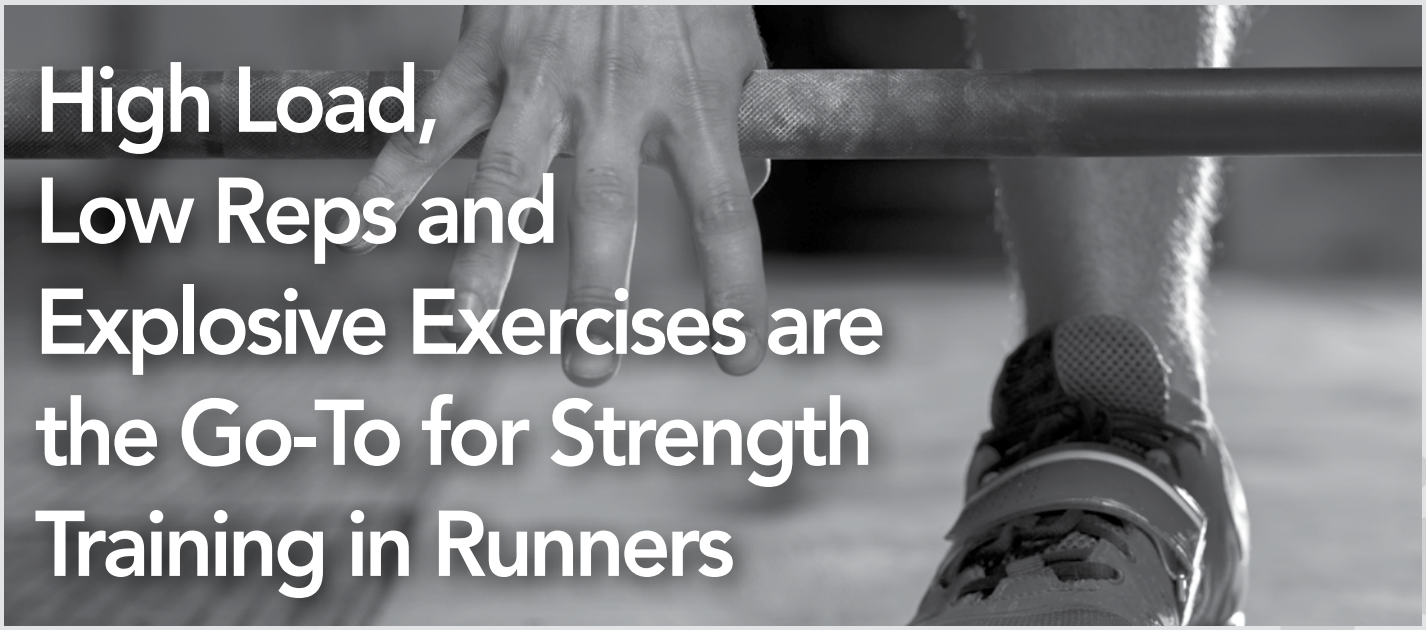
a. Agonist-antagonist co activation (3)
- ST improves motor unit recruitment and co-ordination, therefore the relative proportion of active muscle is reduced.
- Decreased activation of antagonist muscles during swing and propulsion phase during running can attenuate unnecessary exergy expenditure.

b. Trunk kinematics (3)
- Free weight training improves trunk kinematics.
- Improved trunk kinematics might reduce energy expenditure with lateral oscillation and trunk rotation.

c. Relative load (3)
- Resistance training increases maximal strength.
- In stronger muscles, submaximal contractions performed while running might recruit smaller and more efficient motor units.

d. Achilles tendon stiffness (3)
- Maximal strength and power training increases Achilles tendon stiffness.
- Stiffer tendons allow for lesser shortening length and velocity of active muscles during the stretch-shortening cycle, which could result in lesser energy expenditure.

e. Vertical oscillation (3)
- Rate of force development increases following power training.



High Load, Low Reps and Explosive Exercises are the Go-To for Strength Training in Runners

- Greater rate of force development shortens the interval required to produce the force required to sustain body mass during ground contact, potentially reducing vertical oscillation.

2. Faster Time Trial Performance (4)

Faster time trial performances over middle (1500–3000m) and long distance (5–10km) events, with improvements ranging from 2 to 5%, have also been reported in groups of runners who undertake ST (1). For a recreational runner with a personal best 10km time of 50min, this equates to an improvement of between 1 and 2.5 minutes.

3. Faster Maximal Sprint Speed (4)

Faster maximal sprint speed following ST may be another benefit for distance runners (1).

Consistency is key. If ST is removed from a training programme, loss of performance benefits occur within 6 weeks (4). Therefore, staying consistent with appropriately periodised ST leading into goal events may be needed to maximise performance.

Although there is evidence that consistent ST, when combined with other exercise interventions, may assist in reducing the risk of overuse injuries in other sporting populations, the effect on injury risk in runners remains unclear (5). Further high-quality research is required to establish if the important physiological adaptations that occur in response to ST result in increased tissue capacity and reduced injury risk in running populations.

Practical Considerations

Heavy resistance exercises commonly used include barbell squats, deadlifts, steps-ups, lunges and calf raise variations. Completing exercises with moderate resistance, for example, 60–80% of 1 repetition maximum for 3–6 sets of 5–15 repetitions has been reported to benefit performance. For distance runners, training to repetition failure is not recommended (1).

The addition of two to three supervised strength sessions per week, initially focusing on a periodised heavy resistance training programme is recommended (1). For runners without ST experience gradual progress to reduce the risk of injury and overtraining would be required (1). A well-planned programme should not negatively impact other running sessions. At least 3 hours' recovery after high-intensity running before completing ST, and at least 24 hours' recovery after ST before a high-intensity running session is scheduled (1).

ST can be the vaccine against injuries. Physically training harder and smarter (choosing appropriate exercises) can develop physical qualities in a runner that can protect them against injury (6)!

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