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Loading the Plantar Fascia

A Comment on High-Load Exercise

Plantar fasciopathy (PF) can often be recalcitrant, with pain that persists in some cases for years. Exercise therapy involving plantar-fascia-specific stretching (PFSS) can be beneficial. However, more is now understood about the pathology of the condition, which is akin to a degenerative tendon disorder. Therefore, high-load strength training, which is known to be effective in treating other tendinopathies, is also being applied to PF. This third of three articles discusses the effect of high-load strength training for PF compared to PFSS, helps you to understand the biology behind the mechanotherapy of strength training and allows you to decide if and how this therapy is appropriate to use with your patient. Read this article online https://bit.ly/3N8LLXo

Background

One of the most prevalent musculoskeletal conditions, that will affect one in every ten people during their lifetime is plantar fasciopathy (PF). Formerly known as 'plantar fasciitis' the name changed with a greater understanding of the histopathology, which is similar to that seen with tendinopathies. PF is characterised by severe and well-localised pain that often persists for several months or even years. People often experience pain during the first steps in the morning or after inactivity, which can improve with ambulation or in some cases worsen during the day. The condition can affect runners, inactive people, and those with a higher body mass index. Persistent pain can affect an individual's mental health and impact their ability to perform activities that contribute to their emotional wellbeing.

A variety of treatments have been used for PF and studies reveal conflicting evidence about their use. Systematic reviews and meta-analyses have noted that 'no one treatment' is superior to another (1). Exercise therapy, notably plantar-fascia-specific stretching (PFSS) may offer some benefit. However, even with PFSS, approximately 40% of patients experience symptoms more than 2 years after diagnosis. Clearly, other treatment options should be researched further (1). High-load strength training that causes high tensile loads across a tendon is now known to be effective in degenerative tendon disorders such as Achilles and patellar tendinopathy and may yield a greater treatment effect compared with PFSS. However, the clinical effect of high-load strength training manifests slowly and studies with a primary endpoint of 3 months may not give adequate time to reap significant benefits (1,2*).

The plantar aponeurosis acts as a pulley system, described as the windlass mechanism, which functions to develop tension through the foot during dorsiflexion of the big toe. This in turn shortens the distance between the calcaneus and the metatarsal heads, elevating the medial longitudinal arch. The intrinsic foot muscles (IFMs) work together with the plantar aponeurosis to stabilise the foot and provide dynamic sensory and motor control of the foot during locomotion. It is not surprising, therefore, that a significant association between IFM weakness and painful foot pathologies, such as PF, exists. It would, therefore, seem logical that strengthening exercises for the foot would result in better outcomes and improved symptoms of PF.

How might someone load the plantar fascia? One option is to induce controlled high-load tensile forces across the Achilles tendon, loading it in combination with the windlass mechanism. The close anatomical connection between the Achilles

●● PLANTAR FASCIOPATHY (PF) IS NOW KNOWN TO BE A DEGENERATIVE TENDON DISORDER ●●

tendon, para-tendon, and the plantar fascia suggests that high loading of the Achilles tendon is transferred to the plantar fascia. This can be achieved by performing unilateral heel raises combined with dorsiflexion of the metatarsophalangeal joints (essentially a rolled towel under the toes).

Clinical trials by Rathleff et al. testing this theory used a high-load protocol as follows (2).

- Unilateral heel raises with a towel inserted under the toes to activate the windlass mechanism.
- Perform the exercise on a stairway or similar location.
- Perform the exercises every second day for 3 months.
- Every heel raise consisted of a 3-second concentric phase (going up) and a 3-second eccentric phase (coming down) with a 2-second isometric phase (pause at the top of the exercise).
- The high-load strength training was slowly progressed throughout the trial – starting at a 12-repetition maximum (RM) for 3 sets. After 2 weeks, the load was increased by using a backpack with books and the number of repetitions was reduced to 10RM, simultaneously increasing to 4 sets. After 4 weeks, patients were instructed to perform 8RM and do 8 sets.
- If patients could not perform the required number of repetitions, they were instructed to start the exercises using both legs until they were strong enough to perform unilateral heel raises. They were instructed to keep adding books to the backpack as they became stronger.

The results showed a 29-point greater improvement in foot function index in patients randomised to high-load strength training at the primary endpoint of 3 months. This exceeded the 7-point difference, considered to be the minimal requirement for clinical relevance (2). These results were encouraging, but they raised questions about why the high-load strength training was associated with larger improvements compared with patients that performed PFSS. Studies have shown that large tensile forces are associated with improvements in symptoms in tendinopathies and other conditions involving degenerative changes. Although both the high-load strengthening and the stretching groups had a significant reduction in the thickness of the plantar fascia on enrolment to the study, interestingly the strengthening group did not show significant improvements in thickness on follow-up. This suggests some abnormalities within the fascia may persist even though symptoms have improved. Another observation from this study was that the improvement in symptoms between both groups was similar at secondary endpoints of 6 and 12 months (2).

The Difference Between Stretching and Loading

Traditionally, if someone were to say to 'load' a structure during rehabilitation, one would immediately think of resistance and weight training. Strengthening exercises clearly do load the structure; with the result being structural adaptation, increased strength and resilience in the tissue. However, stretching can have a similar effect on tissue. Both stretching and strengthening exercises provide a tensile 'load' to the tissue. The main difference is how much strain they induce. Strain is the change in length divided by total length.

This is discussed in Carlson et al. and exemplified below (3).

1. Maximal dorsiflexion of the ankle and toes, as in a plantar fascia-specific stretch, induces a force of approximately 146N across the plantar fascia. This generates a 1% strain to the fascia.
2. A calf raise, for an individual weighing approx. 55kg, generates a load of 550N on the Achilles tendon. This in turn creates a strain across the plantar fascia of 4%.
3. By increasing toe dorsiflexion from 0 to 45° while performing a calf raise (same person and body weight as in point 2 above), the force on the plantar fascia doubles and the strain increases to 50%.

Thus, both stretching and strengthening exercises load the plantar fascia, with the strain having the potential to stimulate physiological change. However, high-load strengthening exercises generate a greater strain. Hypothetically, this may bring about greater change in pathophysiological and clinical outcomes over time (3).

> HIGH-LOAD STRENGTH TRAINING IS KNOWN TO BE EFFECTIVE IN TENDINOPATHIES SUCH AS ACHILLES AND PATELLAR TENDINOPATHY

Understanding Mechanotherapy

The benefit of high-load therapy seen with tendinopathies relates to mechanobiological stimuli. It is possible that cyclic strain of fibrous connective tissues, such as tendons and fascia, may activate mechanotransduction pathways within the extracellular matrix that influence the anabolic and catabolic responses of the tissue. It appears that the magnitude, frequency, rate and duration of strain (the mechanical stimuli) may influence the cellular biochemical response specific to tissue adaptation (4*,5*).

Research has shown that in the Achilles tendon, the strain magnitude should exceed the habitual value (2–3% strain), to trigger an adaptational response. A higher tendon strain of 4.5–5.0% led to a superior adaptation. This translates to improved mechanical and structural properties of the Achilles tendon (6*). Many variables may impact loading and subsequent mechanical adaptations; however, studies suggest that the force and strain magnitude applied from exercise therapy should exceed the load during daily activities. Interestingly, short cyclic loading, even with a higher force and strain magnitude, may provide less adaptation. Thus, the benefits of a loading programme should include progressive strength training of high loads performed under slow repetitions (3 seconds or more) (6*).

In a study of patients with chronic

HIGH-LOAD STRENGTH TRAINING MAY BE MORE EFFECTIVE THAN STRETCHING IN PF, BUT THE CLINICAL EFFECTS MANIFEST SLOWLY

Achilles tendinopathies, Beyer et al. compared an eccentric (ECC) training programme to a heavy slow resistance (HSR) programme, and then to a non-exercise group that received an ultrasound-guided corticosteroid injection (8*). Results showed that both ECC and HSR training provided superior benefits compared to corticosteroid injection. Additionally, HSR training (including 36% more time under tension and RM-based contraction) was associated with more normal tendon structure and changes in the extracellular matrix composition. This is an indication that greater matrix turnover and collagen synthesis resulted from the HSR programme. It seems unimportant whether the load originates from concentric or eccentric contractions: as long as the load is of sufficient magnitude and duration, a beneficial adaptation may result (8*)."Table 1. Example of mechanobiological descriptors of resistance exercise stimuli in Kongsgaard et al and Rathleff et al"(https://bit.ly/43IY8k5) in Rathleff and Thorborg (5*) illustrates different high-load exercise protocols that have shown promising results in symptom improvement in patients with Achilles tendinopathy and PF (2*).

Most systematic reviews to date that discuss treatment protocols for PF do not include this new approach of HSR training, which involves repeated slow contractions through concentric, isometric and eccentric phases against a heavy load. Although this approach has been proven to be effective in other tendinopathies, there is limited evidence for its use in PF. Preliminary evidence, as discussed above, has found HSR training to be superior to stretching in PF, but the exercise dose was still far lower than that prescribed in trials of other tendinopathies. Increasing exercise dose could lead to greater improvement in outcomes through a greater mechanobiological stimulus.

Traditionally, increasing exercise dose can result in drop out-of patients in clinical trials or poor compliance, as compliance is often compromised by low self-efficacy (9*). An alternative approach is to encourage patients to be in charge of their own rehabilitation and thereby increase exercise dose through increased self-efficacy. A recent study by Riel et al. had two groups of PF patients perform a repeated heel raise exercise in standing for 12 weeks (10*). Participants in the experimental group were self-dosed (ie. they performed as many sets as possible with as heavy a load as possible, but no heavier than 8RM). The exercise regimen for the control group was pre-determined using the progressive protocol described above by Rathleff et al. (2*).

Interestingly, the self-dosed programme was not associated with larger improvements in self-efficacy or larger exercise doses during the trial. Both groups showed improvements in pain larger than the minimum clinically important difference, but less than 9% of patients in either group achieved Patient Acceptable Symptom State, indicating a need for continued improvement in long-term treatments (10*). Therefore, advising people with PF to self-dose their HSR training regimen does not substantially increase the achieved dose compared with prescribing a pre-determined regimen. Similar effects are seen with both options and, thus, may be used at the therapist's discretion and understanding of the patient's attitude towards exercise therapy.

Increasing dose and improving the strength of the IFMs through changes in footwear has been considered for PF patients. Studies evaluating the effect of minimalist footwear in runners to strengthen IFMs lack clinical relevance to the PF population. Studies used asymptomatic subjects and the mileage prescribed was well below the average weekly mileage for a distance runner who might be susceptible to developing PF. This reduced the validity of the results, even though IFM strength significantly increased when subjects transitioned to minimalist footwear (11*,12). Despite impact forces generally being lower when minimally shod, there is a lack of evidence supporting the loading effect and injury rates, as well as the safety and effectiveness of minimal running shoes in symptomatic populations (13).

Conclusion

So, where does that leave you in loading the plantar fascia to effect change in PF patients' long-term symptoms? Future research into high-load training is needed so that this can be confidently prescribed to PF patients, as we do in other tendinopathies. At present there is some evidence to suggest that this form of exercise may be beneficial (as well as plantar-specific stretching). With that in mind, using HSR training on an individual basis and closely monitoring progress, avoiding setbacks due to symptom flare-up, may be a considered treatment option.

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KEY POINTS

- Plantar fasciopathy (PF) is one of the most prevalent musculoskeletal conditions.
- Systematic reviews and meta-analyses have noted that 'no one treatment' is superior to another.
- Exercise therapy, notably plantar-fascia-specific stretching, may offer some benefit.
- High-load strength training that causes high tensile loads across a tendon is now known to be effective in degenerative tendon disorders such as Achilles and patellar tendinopathy.
- The close anatomical connection between the Achilles tendon, para-tendon, and the plantar fascia suggests that high loading of the Achilles tendon is transferred to the plantar fascia.
- Loading the Achilles tendon, in combination with the windlass system (toes in dorsiflexion) to load the plantar fascia, has shown encouraging results.
- High-load strength training may therefore include calf raise/heel raise off a step with the toes in dorsiflexion.
- Loading should be slow, 3 second concentric contraction, 2 second isometric hold, 3 second eccentric contraction.
- A weighted backpack can be used to progressively increase the load.
- More studies including this loading protocol are needed in the future.

DISCUSSIONS

- Traditionally, what strengthening exercises and dose do you use for your plantar fasciopathy patients?
- Have you used a high-load, slow, progressive protocol in any plantar fasciopathy patients?
- Do you have any concerns using a high-load strength training protocol with patients?

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