'Load me up, Scotty': mechanotherapy for plantar fasciopathy (formerly known as plantar fasciitis)

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Plantar heel pain is often caused by plantar fasciitis (fasciopathy) and treatment has traditionally included stretching, gel heel inserts and injections. However, in line with the increased clinical focus and evidence regarding mechanotherapy, as re-introduced by Khan and Scott,[1] a novel approach was recently taken by Rathleff *et al*[2] using exercise and load (mechanotransduction) to treat the injured plantar fascia. The rationale for applying mechanotherapy was that plantar fascia consists of type 1 collagen and exhibits tendinopathy traits, including degenerative changes, deterioration of collagen fibres, increased secretion of ground substance proteins, focal areas of fibroblast proliferation and increased vascularity.[3 4]

A NEW 'FASCIAL' TREATMENT

The new treatment of plantar fasciopathy consists of slow, high-load strength training and is comparable to plantar fascia-specific stretching among patients with plantar fasciopathy.[2] The patients performed heel-raises using a towel underneath the toes to increase dorsiflexion of the metatarsophalangeal joints. Slow high-load strength training in addition to heel inserts was superior to plantar fascia-specific stretching in addition to heel inserts after 3 months.[2]

STRETCHING: INFERIOR LOADING OF THE TISSUES?

Plantar fascia-specific stretching and high-load strength training both provide tensile loads. Their main difference is how much strain they induce (strain is the change in length divided by total length). Plantar fascia-specific stretching consists of maximal dorsiflexion of the ankle and toes—it induces a force of ≈146N across the plantar fascia which generates 1% strain.[5] However, when the Achilles tendon is loaded by 550N (≈55 kg), for example, the force across the plantar fascia increases 400% and strain increases fourfold—4%.

Similarly, going from 0 to 45° of toe dorsiflexion doubles the force on the plantar fascia and increases strain by ≈50%.[5] This suggests that both stretching and high-load strengthening load the plantar fascia, but the strain is much larger during high-load strengthening.

UNDERLYING MECHANISMS OF MECHANOTHERAPY

To optimise mechanotherapy for plantar fasciopathy and other tendinopathies,[1] some important questions remain about effective mechanobiological stimuli. Cyclic strain of fibrous connective tissues, such as tendons, may activate mechanotransduction pathways within the extracellular matrix that influence the anabolic and catabolic responses of the tissue.

The magnitude, frequency, rate and duration of force and strain are important elements of the mechanical stimuli and influence the cellular biochemical responses and specific tissue adaptation.[6] The strain magnitude applied to the Achilles tendon should exceed the habitual value (2–3% strain), to trigger an adaptational response on the tendon mechanical properties.[7] A higher tendon strain duration per contraction (3 s cycling loading vs 1 s cycling loading) led to a superior adaptation, improving mechanical and structural properties of the Achilles tendon.[7] This suggests that the force and strain magnitude applied from exercise should exceed the loading set point occurring during daily activities. Short cyclic loading, even while of higher force and strain magnitude, may provide less adaptation—this points towards the possible benefits of progressive strength training, including high loads performed under slow repetitions (3 s or more).

CLINICAL APPRECIATION OF LOAD AND TIME-UNDER-TENSION WHEN PRESCRIBING MECHANOTHERAPY

In one of the few studies that compared different mechanotherapy programmes, Kongsgaard *et al*[8] compared an eccentric training programme (ECC) to a heavy slow resistance programme (HSR), and then to a non-exercise group who received an ultrasound-guided corticosteroid injection (table 1).

The main results were that both eccentric and heavy slow resistance training proved superior to corticosteroids. Additionally, heavy slow resistance training (including 36% higher time under tension and repetition maximum-based contraction failure loading, see table 1) was associated with more normal tendon structure and changes in the extracellular matrix composition, which indicated an increased matrix turnover and de novo synthesis of the collagen network. Of further importance, it does not seem to matter if the load originates from concentric or eccentric contractions as long as the load is of sufficient and similar magnitude and duration.

THE LOADING INGREDIENTS OF OPTIMAL MECHANOTHERAPY NEEDS TO BE BETTER DESCRIBED

We believe the most important component in mechanotherapy for fasciopathy and other tendinopathies is optimising the

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Table 1 Example of mechanobiological descriptors of resistance exercise stimuli in Kongsgaard *et al* and Rathleff *et al*

	Eccentric (ECC). Kongsgaard *et al*	Heavy slow resistance training Kongsgaard *et al*	High-load strength training for plantar fasciitis. Rathleff *et al*
1. Load magnitude	Body weight at beginning. Progress from there as pain diminished	15 RM at week 1 and progressed to 6 RM at week 9–12	12 RM at week 1 and progressed to 8 RM at week 4
2. Number of repetitions	15	15	12
3. Number of sets	3	12	3
4. Rest in between sets	?	?	?
5. Number of exercise interventions (per (day) or week)	2/day	3/week	3.5/week
6. Duration of the experimental period ((day) or weeks)	3 months	3 months	3 months
7. Fractional and temporal distribution of the contraction modes per repetition and duration (s) of one repetition	0 s conc 0 s iso 3 s ecc	3 s conc 0 s iso 3 s ecc	3 s conc 2 s iso 3 s ecc
8. Rest in-between repetitions ((s) or (min))	?	?	?
9. TUT ((s) or (min))	3×15×3×2=270 s per day. Total TUT during 3 months: 22.680 s	4×15×4×6=1.440 s per training session during week 1. Total TUT during 3 months: 30.816 s	3×15×8=288 s per training session during week 1. Total TUT during 3 months: 11.424 s
10. Volitional muscular failure	?	Yes	Yes
11. Range of motion	?	?	Full range of motion
12. Recovery time in-between exercise sessions ((h) or (d))	12 h	48–72 h	48 h
13. Anatomical definition of the exercise (exercise form)	?	?	Yes

RM, repetition maximum; TUT, time-under-tension.

loading of the tissues and that many important mechanobiological parameters are often not adequately considered in clinical and research contexts. New commercially available technologies, such as accelerometers, gyroscopes, video systems and 'intelligent' elastic bands, make it possible to measure the most important mechanobiological descriptors described in table 1. We have recently shown how 'intelligent' elastic bands can measure time-under-tension (a proxy of the total exercise dose) using exercise-integrated technology.[9] This will provide clinicians the opportunity to measure, monitor and report important mechanobiological descriptors, even in home-based unsupervised mechanotherapy sessions. Therefore, future clinical application and research on mechanotherapy for tendinopathy still has a huge potential for improvement.

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