"Rehabilitation will increase the 'capacity' of your …insert musculoskeletal tissue here…." Defining 'tissue capacity': a core concept for clinicians

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Capacity is a helpful term in clinical practice to indicate to clients that they (and more importantly their musculoskeletal tissues) are either able or unable to complete a task or participate in physical activity. In the context of injury—having *exceeded the capacity* of the tissue—the term has immediacy for muscle and ligament: a musculotendinous or ligament strain is an acute injury due to a loading event beyond the tissue's capacity. The tissue response in tendon is usually more gradual—acute traumatic injury of normal tendon is rare, whereas the pathological tendon can fail catastrophically (rupture).

DEFINITION

A tissue is at full capacity when the individual is able to perform functional movements at the volume and frequency required without exacerbating symptoms or causing tissue injury. The capacity of a tissue clearly varies between individuals and the load they place on their tissues. Elite athletes require greater tissue capacity than recreational players, tissue of young people has greater capacity than that of older people (all other things being equal) and normal tissue has greater capacity than pathological tissue. As functional movements require full capacity in a number of musculoskeletal tissues, injury occurs when the capacity of the weakest link in the lower limb is exceeded.

CLINICAL IMPLICATIONS

In the clinical setting, the specificity of loading tissue to increase capacity is both simple (load the injured tissue and allow a period for adaptation) and complex (load multiple tissues within the lower limb). After injury, rehabilitation is directed mostly at the injured tissue but specific rehabilitation may result in synergists or unrelated regions being under-loaded, and this will reduce the capacity of those tissues.

For example, rehabilitation of a hamstring strain will undoubtedly increase capacity in the hamstring to sporting capacity. However, capacity in the adductor tendons and groin tissue will be reduced if a progressive change of direction stimulus is not included in rehabilitation. The hamstring may be fine (or not), but the groin may fail on return to change of direction sport such as football. Thus, the initial hamstring injury may predispose the groin to subsequent injury due to reduced capacity in this region. This association between sequential injuries may be unrecognised if anatomical regions are considered in silos. Better data collection methods are needed to explore possible injury associations.[1] Clinicians need to be thoughtful and skilled in normalising capacity across all the soft tissues of the kinetic chain after injury to a single tissue.

A clinician can build capacity in tissue with considered, gradual overload by progressing intensity and complexity of movements specific for that tissue and region. This includes progression to maximal loading—examples of which include high impact loads for bone, eccentric contractions for muscle, and energy storage and release loads for tendon. These tissue loads are often delivered in the same rehabilitation programmes; imposing high impact on bone requires high load on muscle and tendon. Once the injured musculoskeletal tissue regains capacity, the key consideration is to build capacity in the entire lower limb by replicating the movements, loads (frequency, time, intensity) and skills required in sport. Outmoded passive therapies, biological injections[2] and loading that is not progressive cannot deliver this outcome.

MEASURING CAPACITY IN SPECIFIC TISSUES

Bone is the musculoskeletal structure that has the most evidence for its restructure with the application of load (especially up to the end of puberty). We can measure changes relatively easily and structure is clearly linked to capacity (at least at the extremes such as osteoporosis). Muscle bulk can easily be estimated clinically and measured with imaging but may not be an accurate representation of capacity. Similarly, dynamometry may reflect aspects of capacity (strength and endurance) but cannot easily measure power.

There are no easy measures of tendon capacity; even extensively pathological tendons appear to have the capacity to

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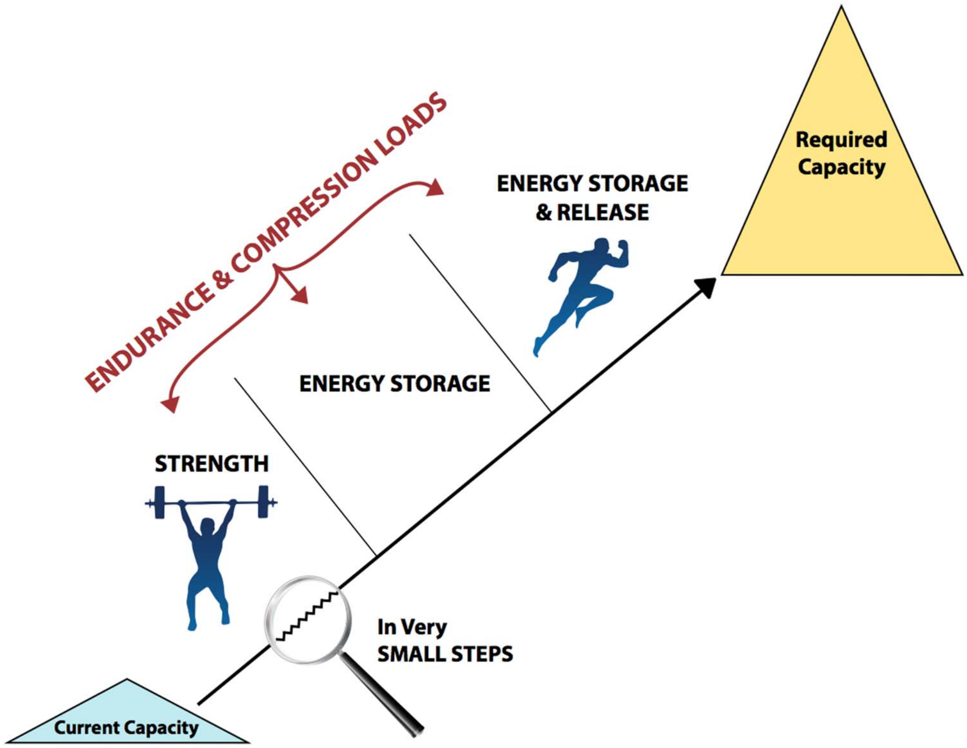

Figure 1 Schematic of tendon rehabilitation, improving tendon capacity with progressive loads. Introduction and progression of endurance and compressive loads are critical within each stage. The start and end points of rehabilitation will vary between individuals.

tolerate very high sporting loads. We espouse increasing tendon capacity through rehabilitation[3] with gradual tendon loading that reduces pain and improves function allowing the athlete to return to sport pain-free (figure 1). The mechanisms by which the tendon increases capacity in response to load is unclear as the tissue pathology may not change. Perhaps we are merely increasing the capacity of the normal part of the tendon.[4]

Answers to additional key questions about tendon capacity, such as, 'Do tendons continue to develop after puberty?' and 'How do they adapt to increasing loads?', are unknown. There is evidence that the collagen in the tendon matrix is stable and has limited turnover after puberty.[5] Loading tendon appears to give different results depending on the age and gender of the participants;[6] again, younger tendons appear to be able to adapt structurally,[7] whereas adult tendons may not change in structure but adapt mechanically.[8] Structural adaptation is easy to understand, with more matrix proteins organised into viable matrix structure, while mechanical adaptation is less clear as the changes in the tendon that make it stiffer and more tolerant to higher loads are unknown.

THE OPPOSITE OF CAPACITY—TISSUE WEAKNESS

The opposite of loading is unloading, and the opposite of capacity is tissue weakness. The 'use-it or lose-it' phenomenon of tissue capacity has been extensively described in bone. While injury may be limited to one tissue, pain and reduced loading must reduce capacity in associated tissues within the kinetic chain. Failure to return capacity in all these tissues may result in reinjury or subsequent injury. Understanding the mechanobiology of musculoskeletal tissues, and how loading and unloading affects the capacity of these tissues is critical to clinicians if we are to rehabilitate resilient athletes.

Funding Sean Docking was funded as part of the Monash University Postgraduate Publication Award.

Competing interests None declared.

Provenance and peer review Commissioned; externally peer reviewed.

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To cite Cook JL, Docking SI. *Br J Sports Med* 2015;**49**:1484–1485.

Received 23 March 2015
Accepted 17 July 2015

Published Online First 8 August 2015

Br J Sports Med 2015;**49**:1484–1485.
doi:10.1136/bjsports-2015-094849

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