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Biomechanical Properties of Fascial Tissues and Their Role as Pain Generators

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ABSTRACT. Objectives: While fasciae have virtually been treated as the "Cinderella tissue of orthopedic research" during recent decades, new methodological findings and hypotheses suggest that the body-wide fascial network may play a more important role in musculoskeletal medicine than assumed ordinarily. However, there is a great diversity in literature, as to which tissues are included under the term "fascia," be it the superficial fascia, the endomysium, perineurium, visceral membranes, aponeuroses, retinaculae, or joint/organ capsules. Following the proposed comprehensive terminology of the 1st Fascia Research Congress, this brief review considers all collagenous connective tissues as "fascial tissues" whose morphology is dominantly shaped by tensional loading and can be seen to be a part of an interconnected tensional network throughout the whole body (1). While morphological differences between aponeuroses and lattice-like or irregular fasciae can still be properly described with this terminology, it allows one to see tissue specifications, such as septae, capsules, or ligaments, as local adaptations of this ubiquitous network based on specific loading histories.

What are the biomechanical functions of this fascial network, and what role do they play in musculoskeletal dysfunctions? This brief review will highlight the load-bearing function of different fascial tissues and also their proneness to microtearing during physiological or excessive loading. It will review histological studies, indicating a proprioceptive as well as nociceptive innervation of fascia. Finally, the potential role of injury, inflammation, and/or neural sensitization of the posterior layer of the human lumbar fascia in nonspecific low back pain will be explored.

Findings: While the tensional load-bearing function of tendons and ligaments has never been disputed, recent publication o Huijing (2) has revealed that muscles also transmit a significant portion of their force via their epimysia to laterally positioned tissues, such as synergistic or antagonistic muscles. The reported contribution of M. transversus abdominis to dynamic lumbar spinal stability has been associated with the load- bearing function of lumbar fasciae's middle layer in humans (3). Similarly, electromyography-based measurements of the "flexion–relaxation phenomenon" suggest a strong tensional load-bearing function of dorsal fascial tissues during

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healthy forward bending of the human trunk [with a reported absence of such load shifting in low back pain patients] (4).

Recent ultrasound-based measurements indicate that fascial tissues are commonly used as elastic springs [catapult action] during oscillatory movements, such as walking, hopping, or running, in which the supporting skeletal muscles contract rather isometrically (5).

Fascial tissues are prone to viscoelastic deformations, such as creep, hysteresis, and relaxation. Such temporary deformations alter fascial stiffness, which may take several hours for complete recovery. Load-bearing tests also reveal the existence of a gradual transition zone between reversible viscoelastic deformation and complete tissue tearing. Various degrees of microtearing of collagenous fibers and their interconnections have been documented to occur within this zone (6).

Fascia is densely innervated by myelinated nerve endings that are assumed to serve a proprioceptive function. These include Pacini's [and paciniform] corpuscles, Golgi tendon organs, and Ruffini endings (7). In addition, they are innervated by free endings. Newer histological examinations have shown that at least some of these free nerve endings are substance P-containing receptors that are commonly assumed to be nociceptive (8). Delayed onset muscle soreness can be induced by repetitive eccentric contraction. A recent experimental study suggests that the epimysial fascia plays a major role in the generation of related pain symptoms (9).

Panjabi's (10) new explanatory model of low back pain injuries suggests that single trauma or cumulative microtrauma causes subfailure injuries of dorsal fascial tissues and their embedded mechanoreceptors, thereby leading to corrupted mechanoreceptor feedback and further resulting in connective tissue alterations and neural adaptations. Langevin (11) reports that the posterior layer of lumbar fascia tends to be thicker in chronic low back pain patients and also expresses less shear motion during passive trunk flexion. In addition, our group has shown a high density of myofibroblasts, whose existence is usually associated with excessive loading or injury repair in the same fascial layer (12). Surgical examinations by Bednar et al. (13) and Dittrich (14) report frequent signs of injury and inflammation of the lumbar fascia in low back pain patients. Finally, injection of an inflammatory agent into the rat's lumbar back muscles resulted in a dramatic increase of the proportion of dorsal horn neurons with input from the superficial lumbar fascia (15).

Conclusions: Fascial tissues serve important load-bearing functions. Severe tensional loading can induce temporary viscoelastic deformation and even microtearing. The innervation of fascia indicates a potential nociceptive function. Microtearing and/or inflammation of fascia can be a direct source of musculoskeletal pain. In addition, fascia may be an indirect source of back pain due to sensitization of fascial nerve endings associated with inflammatory processes in other tissues within the same segment.

KEYWORDS. Myofibroblasts, fascial tonicity, delayed onset muscle soreness [DOMS], fascial innervation, microtearing

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