

FASCIA IS ABLE TO CONTRACT IN A SMOOTH MUSCLE-LIKE MANNER AND THEREBY INFLUENCE MUSCULOSKELETAL MECHANICS

R Schleip¹, W Klingler^{1,2}, F Lehmann-Horn¹, ¹Department of Applied Physiology, Ulm University, Germany

² Department of Anesthesiology, Ulm University, Germany

Summary

With immunohistological analysis we demonstrate the presence of myofibroblasts in normal human fasciae, particularly the fascia lata, plantar fascia, and the lumbar fascia. Density was found to be highest in the lumbar fascia and seems to be positively related to physical activity. For in vitro contraction tests we suspended strips of lumbar fascia from rats in an organ bath and measured for responsiveness to potential contractile agonists. With the H1 antagonist mepyramine there were clear contractile responses; whereas the nitric oxide donator glyceryltrinitrate induced relaxation. The measured contraction forces are strong enough to impact upon musculoskeletal mechanics when assuming a similar contractility in vivo.

Introduction

Fascia is usually considered to be a passive force transmitter in musculoskeletal dynamics. Nevertheless the literature mentions indications for an active contractility of fascia due to the presence of contractile intrafascial cells (1, 2, 3). This study for the first time shows clear evidence, that human fascia is able to actively contract and thereby may influence biomechanical behavior.

Materials and Methods

Rodent, porcine and human tissue samples from different fasciae were collected and used for the experiments according to the guidelines of the ethics committee of Ulm University, Germany. Fascia samples from 32 human bodies (ages 17-91, 25 male, 7 female) were analyzed for the presence of myofibroblast, by immunostaining for α -smooth muscle actin, which was digitally quantified. Samples of lumbar fascia from rats and mice were used for comparison. Additionally fresh samples of fascia were exposed to mechanographic force registration under isometric strain in vitro. These were conducted in an immersion bath and in a specifically modified superfusion bath. Tissues were challenged mechanically, electrically and pharmacologically, and changes in tissue tension were registered electronically. Unviable fascia tissues were investigated to elucidate the cellular contribution.



Fig. 1: Typical immunohistochemical section from human lumbar fascia. Arrows indicate examples of stress fiber bundles containing α -smooth muscle actin (a differential marker for myofibroblasts), which are stained in dark red. Length of image 225 μ m.

Results

The histological examination revealed that myofibroblasts are present in normal fasciae. The human lumbar fascia with its lattice-like fiber orientation exhibits a higher myofibroblast density (Fig. 1), compared with other examined fasciae of both humans and rats. There is generally a large variance in myofibroblast density between different persons. The data indicate a positive correlation between myofibroblast density and physical activity.

It was shown that the increase in initial stiffness in response to repeated *in vitro* stretching (as reported in the literature) was due to changes in matrix hydration. No responses could be detected with electrical stimulation. However, smooth muscle-like contractions could be induced pharmacologically. High dosages of the antihistaminic substance mepyramine had most reliable and sustaining effects ($n=29$, $p<0.05$); while histamine and oxytocin induced shorter contractile responses in selected fasciae only; and addition of an NO donator triggered brief relaxation responses in several samples. No response could be elicited with epinephrine, acetylcholine, and adenosine. The mepyramine induced tissue contractions demonstrated very slow and enduring response curves, lasting up to 2 h (Fig. 2). Since the histological examination had revealed an increased myofibroblast density in endo- and perimysial intramuscular fasciae (4), mepyramine was additionally applied to whole muscular tissue pieces including their fasciae, which showed similar contractile response curves as pure fascia, apparently not due to myogenic contraction.

The maximal *in vivo* contraction forces were hypothetically calculated and applied to the human lumbar area. The resulting forces are strong enough to alter normal musculoskeletal behavior, such as mechanical joint stabilization or γ -motor regulation.

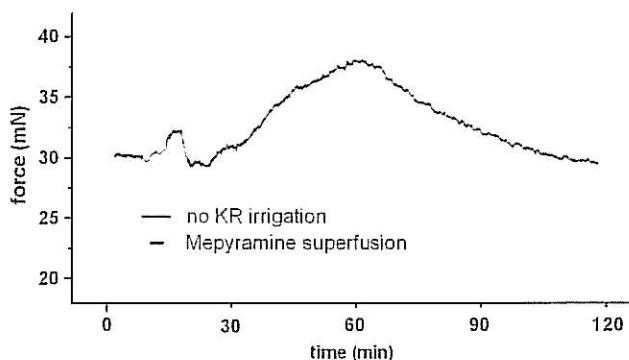


Fig. 2: Typical response curve of fascia to mepyramine. A bundle of rat lumbar fascia is exposed to 250 x 10⁻³M mepyramine in a superfusion organ bath. To allow optimal tissue saturation with the substance, the constant Krebs-Ringer (KR) irrigation is interrupted 2 min before substance addition (Mep) and restarted again 2 min afterwards. The brief initial force increase is due to temporary weight gain of the tissue due to the mepyramine solution, which is then quickly washed off. Note the slow and sustained duration of the reaction, a typical feature of fascial tissue response to mepyramine.

Conclusions

These results suggest, that fascia is a contractile organ, due to the presence of myofibroblasts. This ability is expressed on the one hand in chronic tissue contractures which include tissue remodeling; and on the other hand in smooth muscle-like cellular contractions over a time frame of minutes to hours, which can be strong enough to influence low back stability and other aspects of human biomechanics. This offers future implications for the understanding and clinical management of pathologies which go along with increased or decreased myofascial stiffness (such as low back pain, tension headache, spinal instability, or fibromyalgia). It also offers new insights

for treatments directed at fascia, such as osteopathy, the Rolfing method of myofascial release, or acupuncture. Further research on fascial contractility is indicated and promising.

This study has been supported by grants from the International Society of biomechanics (USA), the Rolf Institute of Structural Integration (USA), and the European Rolfing Association e.V. (Germany).

References

1. Yahia LH, Pigeon P, DesRosiers EA: *Viscoelastic properties of the human lumbodorsal fascia. J Biomed Eng* 15: 425-429 (1993)
2. Staubesand J, Li Y: *Zum Feinbau der Fascia cruris mit besonderer Berücksichtigung epi- und intrafaszialer Nerven. Manuelle Medizin* 34: 196-200 (1996)
3. Schleip R, Klingler W, Lehmann-Horn F: *Active fascial contractility: fascia may be able to contract in a smooth muscle-like manner and thereby influence musculoskeletal dynamics. Med Hypotheses* 65: 273-277 (2005)
4. Schleip R, Naylor IL, Ursu D, Melzer W, Zorn A, Wilke HJ, Lehmann-Horn F, Klingler W: *Passive muscle stiffness may be influenced by active contractility of intramuscular connective tissue. Med Hypotheses* 66: 66-71 (2006)