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The Functional Coupling of the Deep Abdominal and Paraspinal Muscles: The Effects of Simulated Paraspinal Muscle Contraction on Force Transfer to the Middle and Posterior Layer of the Thoracolumbar Fascia

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Abstract

The thoracolumbar fascia (TLF) consists of aponeurotic and fascial layers that interweave the paraspinal and abdominal muscles into a complex matrix stabilizing the lumbosacral spine. To better understand low back pain, it is essential to appreciate how these muscles cooperate to influence lumbopelvic stability. This study tested the following hypotheses: (i) pressure within the TLF's paraspinal muscular compartment (PMC) alters load transfer between the TLF's posterior and middle layers (PLF and MLF); and (ii) with increased tension of the common tendon of the transversus abdominis (CTra) and internal oblique muscles and incremental PMC pressure, fascial tension is primarily transferred to the PLF. In cadaveric axial sections, paraspinal muscles were replaced with inflatable tubes to simulate paraspinal muscle contraction. At each inflation increment, tension was created in the CTra to simulate contraction of the deep abdominal muscles. Fluoroscopic images and load cells captured changes in the size, shape and tension of the PMC due to inflation, with and without tension to the CTra. In the absence of PMC pressure, increasing tension on the CTra resulted in anterior and lateral movement of the PMC. PMC inflation in the absence of tension to the CTra resulted in a small increase in the PMC perimeter and a larger posterior displacement. Combining PMC inflation and tension to the CTra resulted in an incremental increase in PLF tension without significantly altering tension in the MLF. Paraspinal muscle contraction leads to posterior displacement of the PLF. When expansion is combined with abdominal muscle contraction, the CTra and internal oblique transfers tension almost exclusively to the PLF, thereby girdling the paraspinal muscles. The lateral border of the PMC is restrained from displacement to maintain integrity. Posterior movement of the PMC represents an increase of the PLF extension moment arm. Dysfunctional paraspinal muscles would reduce the posterior displacement of the PLF and increase the compliance of the lateral border. The resulting change in PMC geometry could diminish any effects of increased tension of the CTra. This study reveals a co-dependent mechanism involving balanced tension between deep abdominal and lumbar spinal muscles, which are linked through the aponeurotic components of the TLF. This implies the existence of a point of equal tension between the paraspinal muscles and the transversus abdominis and internal oblique muscles, acting through the CTra.

Keywords: abdominal muscles; erector spinae; middle lamina; multifidus; posterior lamina; spine; thoracolumbar fascia; transversus abdominis.

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Figures

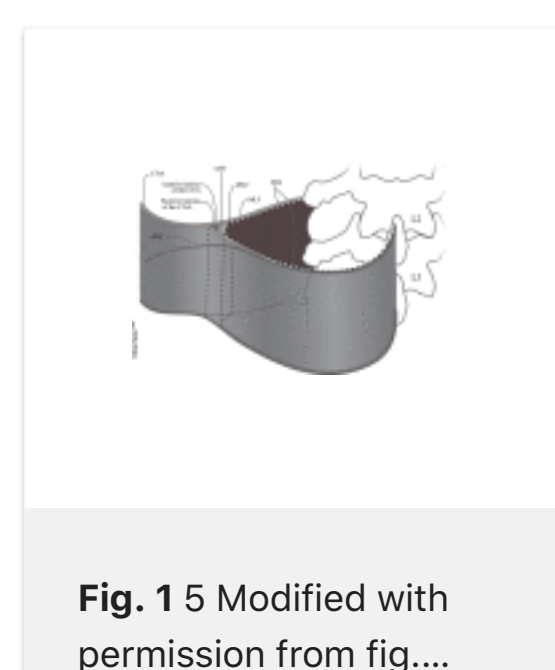


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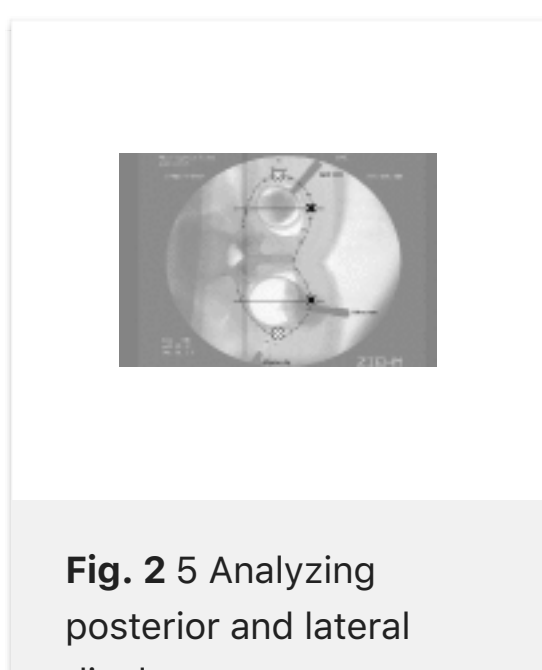


Fig. 2 5 Analyzing posterior and lateral displacement...

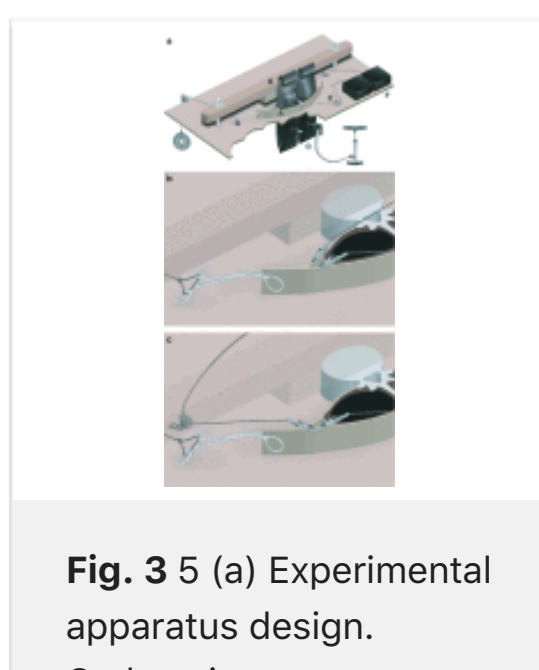


Fig. 3 5 (a) Experimental apparatus design. Cadaveric...

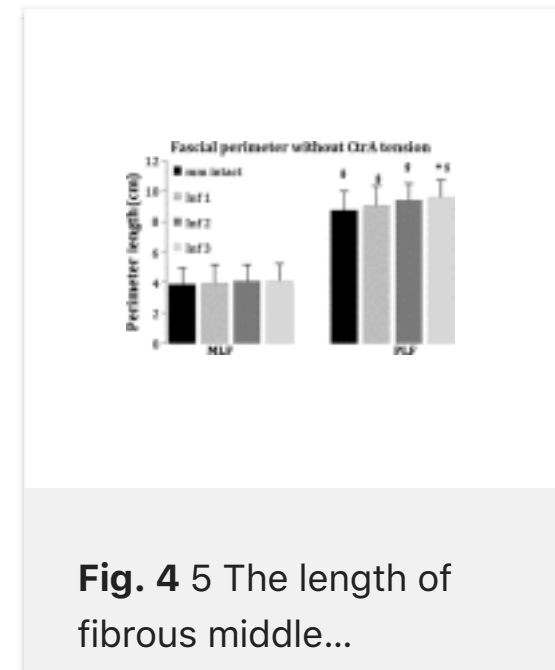


Fig. 4 5 The length of fibrous middle...

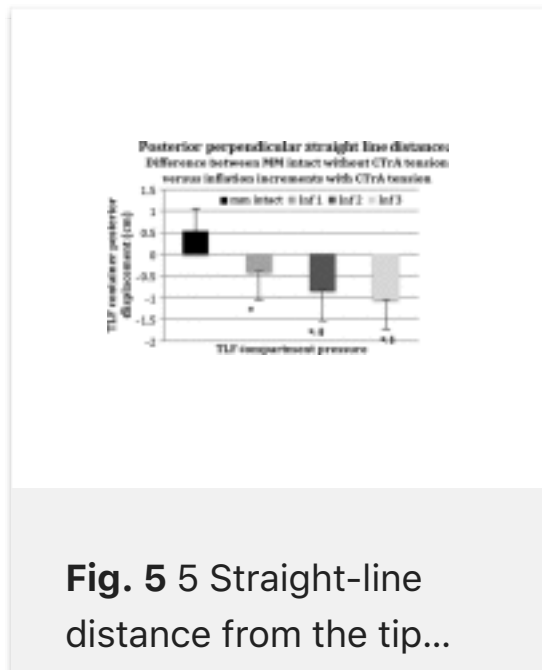


Fig. 5 5 Straight-line distance from the tip...

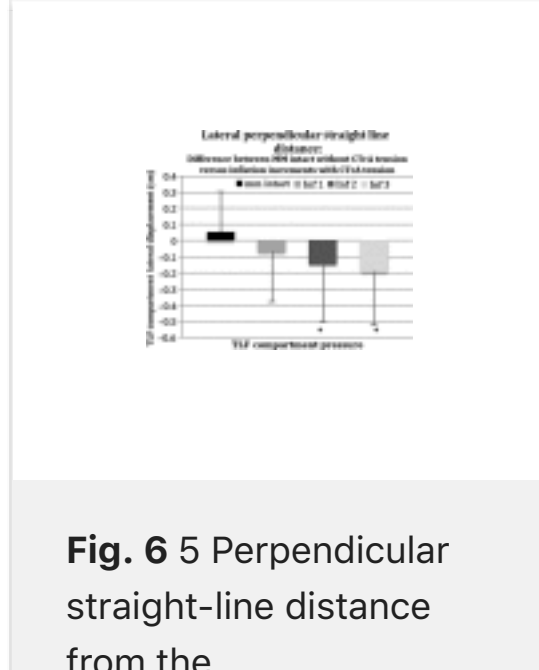


Fig. 6 5 Perpendicular straight-line distance from the...

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