Mechanical Evaluation of the Role of Intra-Abdominal Pressure within the Thoracolumbar Fascia in Postural Asymmetry: A Finite Element Study

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BACKGROUND The mechanism of Intra-Abdominal Pressure (IAP) variation remains enigmatic and has been previously proposed to perform spinal unloading, a backward bending moment, and/or a preparatory role[1]. This study invests a 2D Finite Element Model that works towards a better understanding of the IAP role when an asymmetric posture is induced. METHODS A model was extracted from a transverse plane situated at a 19° angle positioned at the L2-L3 spinal level from the sagittal plane. A two-layered Thoracolumbar Fascia (TLF) model was subsequently created (Fig. 1). Material properties of the soft tissues were based on previously published ex-vivo data and assumed to be linear and uniform. Boundary conditions designate a fixed support of the L3 vertebra and the compartment pressures were designated as the input values based on previously established in-vivo data. A symmetric case ($P_L = P_R = 24.2 \text{ mmHg}$), defining the control, with equal Paraspinal Muscle Compartmental (PMC) pressure was compared to imposed asymmetric cases ($P_R = 24.2 \text{ mmHg}, P_L = 11.8 \text{ mmHg}$) using a finite element platform (ANSYS v18.1). For each case, the intra-abdominal pressure ($P_A$) was varied between 3.4 and 20.4 mmHg. The reaction force outputs were then validated with an analogous in-vitro experiment using load cells[2]. RESULTS Simulation results displayed similar decreasing trends for the posterior force on the spinous process ($T_{PLF}$) in both cases. Moreover, the contact forces between the abdominal muscles and the TLF ($T_{CL}$ and $T_{CR}$) identically increased in both cases. The symmetric case portrayed equal reaction forces at the transverse processes ($T_{ALFL}$ and $T_{ALFR}$). However, asymmetric pressures in the PMC resulted with a shift to the $T_{ALFL}$ curve to, consequently, intersect with the $T_{ALFR}$ curve at a single point of equal tension. CONCLUSION Increasing IAP tended to decrease the reaction force on the spinous process which may allude towards a relieving role. Moreover, the elevation of IAP resulted with a point of equal tension between the $T_{ALFL}$ and $T_{ALFR}$. This suggests that one role the IAP may possess is a neutralizing effect in asymmetric postures by compensating for the higher-pressure difference between the left and right PMC.

Fig 1: Finite element Model. $P_R$: Right Paraspinal Compartmental Pressure, $P_L$: Left Paraspinal Compartmental Pressure, $P_A$: Intra-Abdominal Pressure, $T_{ALFL}$: Left Anterior Layer of the TLF Reaction Force, $T_{ALFR}$: Right Anterior Layer of the TLF Reaction Force, $T_{PLF}$: Posterior Layer of the TLF Reaction Force, $T_{CR}$: Right Contact Reaction Force and $T_{CL}$: Left Contact Reaction Force.

REFERENCES