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EFFECTS OF DAMAGE TO THE PELVIC LIGAMENTS IN THE BIOMECHANICS OF THE PELVIC CAVITY.

<u>Hypothesis / aims of study</u>

The purpose of this work was to evaluate the stress over some of the pelvic cavity support structures for valsalva maneuver, and also when considering ligament impairment. This was performed taking into account live subject data and computational modeling using the Finite Element Method.

<u>Study design, materials and methods</u>

The IRB approved this work. A young healthy female volunteer gave informed and written consent. Pelvic multiplanar T2-w high-resolution continuous 3mm Magnetic Resonance images were acquired to build a biomechanical model. It included the pelvic bones, organs (bladder, uterus, rectum and anus), and some of the main supporting structures (the *levator ani* muscle, the pubourethral, uterosacral, cardinal and lateral rectal ligaments, the pubocervical fascia and the *arcus tendineous fasciae pelvis*. Two readers confirmed anatomical landmarks *in consensus*, and additional details were retrieved from the literature.

Material properties and constitutive models used to define each structure were based previous work [1,2]. The Abaqus® software (version 6.12) was used to perform biomechnical simulation. Beginning from supine rest intra-abdominal pressure (0.50 KPa), the model was tested for increasing values until simulation of valsava maneuver (4.00 KPa). The displacement of the pelvic organs was assessed to validate the model. Afterwards, ligament impairment was simulated by reducing its stiffness. The stress over the pelvic ligaments and the pubocervical fascia were evaluated for these two conditions.

<u>Results</u>

Figure 1 shows the stress induced in the support structures when intra-abdominal pressure was increased. The pubourethral ligaments suffered the highest tension (233 KPa), while the cardinal ligament demonstrated the least strain (46 KPa). The connective tissue evidenced mild stress, with 76 and 95 KPa for the cervical fascia and the *arcus tendineous fasciae pelvis*, respectively. Figure 2 shows structures displacement in result of simulation of valsalva maneuver. The uterus and the body of the bladder showed the highest magnitude of postero-inferior displacement (2.9cm and 1.5cm).

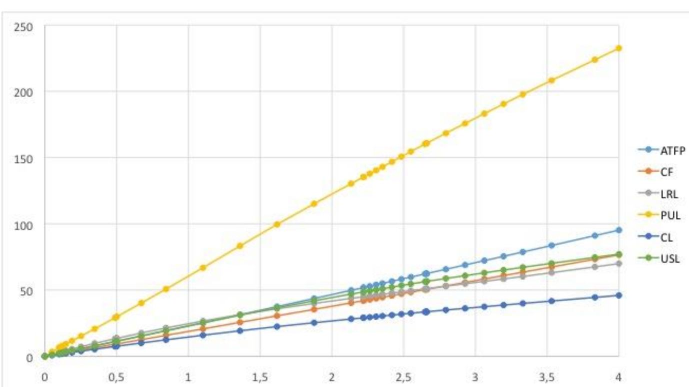

Fig.1 - Tension (KPa) over some of the pelvic support structures for increasing values of intra-abdominal pressure, until valsalva maneuver. ATFP - *arcus tendineous fasciae pelvis*; CF - pubocervical fascia; LRL - lateral rectal ligaments; PUL - pubourethral ligaments; CL - cardinal ligaments; USL - uterosacral ligaments.

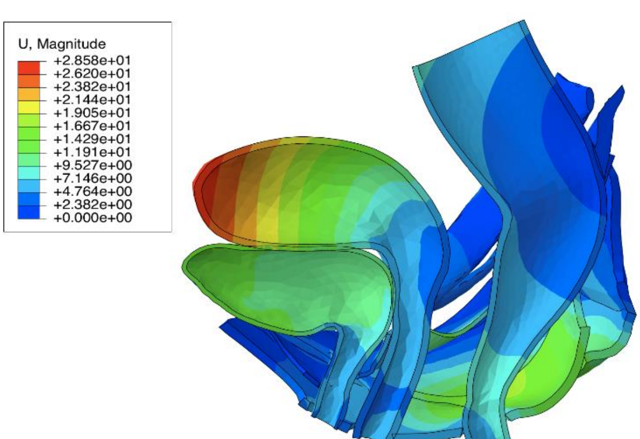

Fig.2 – Values of magnitude displacement of the pelvic structures.

Damage over the ligaments resulted in reduced tension (Figure 3), especially after 75% decrease in material stiffness. A slightly steeper decline is evident for the pubourethral ligaments, with 76.4%, when compared to the uterosacral and cardinal ligaments, with 71.3% and 71%, respectively. At that point, the stress over the pubocervical fascia almost doubled from what it had increased until that point.

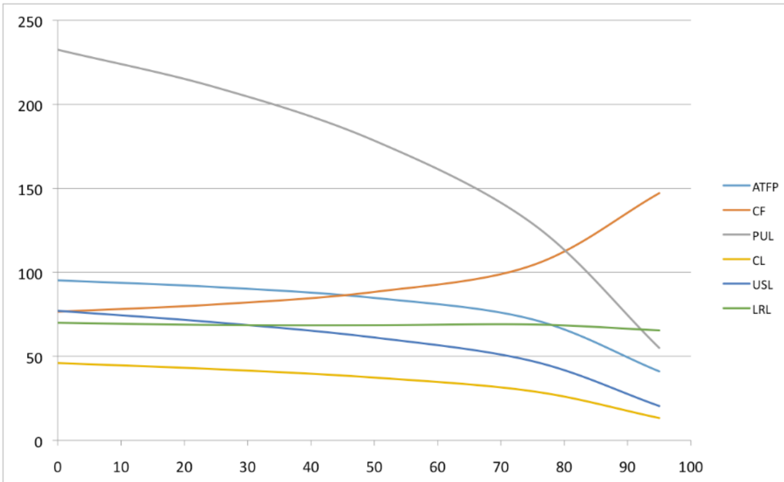

Fig.3 - Tension (KPa) over the pelvic ligaments and cervical fascia when simulating ligament damage.

Interpretation of results

Daily actions such as defecating, coughing or practicing sports induce higher load over the pelvic organs and pelvic floor muscles. The pelvic ligaments help to maintain organs position, but their strain also increases. The pubourethral, cardinal and uterosacral ligaments avoid an excessive movement of the urethra and the vagina by suspending them. The pubourethral ligament, which is one of the main supporters for the bladder neck, evidenced higher tension when compared to the uterosacral-cardinal complex, which may be due to its reduced size and thickness. It may also be partially explained by the fact that these two structures divide the tension when the vagina and the bladder and ladder neck descend. In the case of ligament damage or aging, the pubocervical fascia may have an additional supportive role to avoid bladder neck dislocation or vaginal prolapse.

Concluding message

This biomechanical simulation could reproduce the effect of intra-abdominal pressure, and the effect of ligament impairment over the connective tissue. It showed that the pubocervical fascia supports part of the organ load when ligaments fail.

References

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Disclosures

Funding: NONE **Clinical Trial:** No **Subjects:** HUMAN **Ethics Committee:** Eyhics Committe of Centro Hospitalar de São João-EPE (protocol: CES195/12). **Helsinki:** Yes **Informed Consent:** Yes