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EXPLORING THE BIOMECHANICAL IMPACT OF A SECOND CHILDBIRTH ON FEMALE PELVIC FLOOR INTEGRITY

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1 INTRODUCTION

Throughout their lives, more than one-third of women will experience pelvic floor dysfunction (PFD). This condition has been the focus of extensive research in recent years, particularly about childbirth and pregnancy [1]. Modelling the pelvic cavity provides a comprehensive way to study PFD, allowing for a detailed analysis of the stresses and strains on these structures during events such as childbirth [2]. Among the various software options available for such simulations, Abaqus is particularly prominent due to its robust scripting capabilities, which enable efficient model parameterization and the ability to conduct simulations under diverse conditions with speed and practicality.

This work aims to fill a gap in current knowledge, as no published research has investigated the damage to the female pelvic floor from subsequent births using biomechanical models. As a novel contribution to the field, this work integrates the ability to model cumulative damage cyclically, specifically examining the effects of the first and second vaginal births on pelvic floor integrity.

2 MATERIALS AND METHODS

The geometric model of the pelvic floor muscles (PFM) used includes the levator ani muscle and the coccygeal muscles. The model was obtained from magnetic resonance images of a healthy 30-year-old woman. The PFM was characterized using a quasi-incompressible, transversely isotropic viscohyperelastic with cumulative damage [3], while the fetal head was modeled as a stiff elastic body to simulate rigidity.

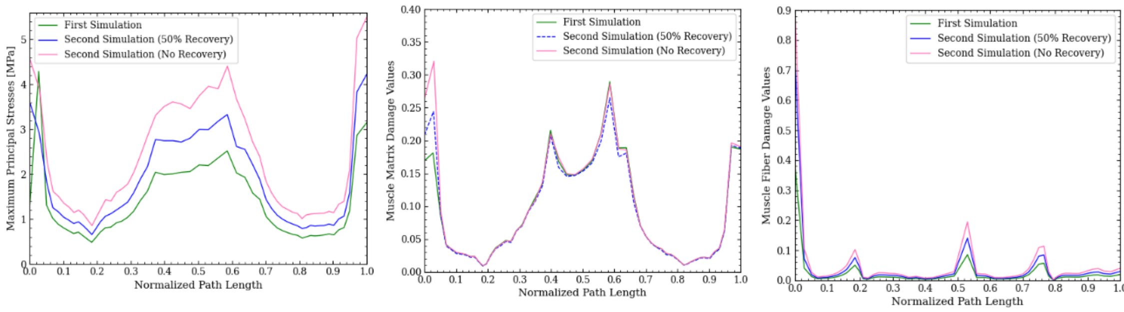
Childbirth simulations were conducted with the fetus in a vertex presentation and occipito-anterior position, focusing on three scenarios: a first vaginal delivery, and two second-birth simulations (one with 50% muscle recovery and another without recovery). The boundary conditions involved fixing the PFM at its extremities.

Key biomechanical parameters, such as muscle stretch, maximum principal stresses, and muscle damage, were tracked throughout the simulations. Muscle damage was measured in both the muscle fibers and extracellular matrix at the point of maximum stretch.

3 RESULTS

This section details the analysis of maximum principal stress and muscle damage during childbirth simulations. The stress exerted by the fetal head on the pelvic floor muscles was measured, showing peaks at the ends and midpoint of the muscle stretch path, as can be seen in Figure 1. The highest stress was observed at the insertion points of the rectus area of the levator ani at the coccyx and the pubic symphysis, aligning with previous studies. Surprisingly, the second birth simulation without recovery exhibited higher tension than expected, suggesting that damaged muscle regions shifted stress to intact areas, leading to localized increases in stress.

Matrix damage was evaluated, revealing peaks at the same points as stress, with similar values across simulations but higher damage in the second simulation without recovery, particularly on the right side. For muscle fibers, the most damage occurred near the right pubovisceral muscle, a known vulnerable area during childbirth. As expected, the second simulation without recovery showed the most fiber damage, while the first simulation showed the least due to the absence of accumulated damage.



a. b. c.

Figure 1 – a. Maximum principal stresses (MPa), b. matrix and c. fibers damage calculated along the normalized path, at the moment of maximum stretch.

4 Discussion and Conclusions

This study reinforces that vaginal birth is a highly complex process, with well-established links to PFD. While there are limitations to computer models, they provide crucial insights into the biomechanics of childbirth.

The study reached several important conclusions. First, the location of critical injury risk remained consistent across all simulations, with the area near the right lateral origin of the pubovisceral muscle identified as the most vulnerable, a finding that aligns with previous studies on childbirth. Additionally, the simulations showed that the number of damaged muscle elements increases with subsequent births, particularly when recovery rates are lower. This is consistent with the literature, which suggests that multiple births increase the likelihood of developing PFD, especially when recovery time between deliveries is short.

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