PhD position – Excellence Doctoral Thesis (IMT – Futur, Ruptures Impacts 2026)

Title: Biomechanical impact of menopausal transition on pelvic soft tissues: characterizing and modelling tissue fragility

Supervisory team:
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Host laboratories:
Mines Saint Etienne (18 months), IMT Mines Alès (18 months)

Keywords:
Menopause – Biomechanics – Soft tissues – Damage – Fracture

Scientific context:
Menopause is associated with major changes in soft tissues due to estrogen decline, leading to frequent disorders such as pelvic organ prolapse, urinary incontinence and tissue fragility. Despite their prevalence, the biomechanical mechanisms underlying these pathologies remain poorly understood.

PhD objectives:
Menopause is a major physiological transition marked by a sharp decline in estrogen and progesterone levels, leading to profound alterations in the structure and mechanical behavior of soft tissues. These changes are associated with frequent pathologies such as pelvic organ prolapse, urinary incontinence, loss of skin elasticity and muscle weakening. However, the direct relationship between menopausal hormonal changes and soft tissue biomechanics remains poorly understood.
The objective of this PhD is to characterize and model the biomechanical consequences of menopausal tissue remodeling in five pelvic-related soft tissues: skin, fascia, muscle, perineal connective tissue and vaginal mucosa. The work builds on the European PELVITRACK Pathfinder project (Grant 101186212). To isolate the mechanical effects of estrogen-deficiency–related remodeling, ex vivo porcine tissues subjected to controlled enzymatic degradation (collagenase, elastase) will be used as a reproducible experimental proxy. While this approach does not reproduce the full endocrine regulation of menopause, it captures key microstructural and mechanical consequences of tissue degradation relevant to menopausal fragility. This ex-vivo model will be validated against control and post-menopausal animal tissue.
The PhD aims to identify objective biomechanical markers of tissue stiffening, dissipation and fragility, as well as associated microstructural alterations. Experimental investigations will combine uniaxial and biaxial tensile tests with fracture-oriented mechanical tests specifically adapted to soft biological tissues. Mechanical responses will be analyzed in terms of hyperelasticity, viscoelasticity, stress softening (Mullins effect) and damage.
These experimental data will feed advanced constitutive and fracture models, including phase-field approaches, to analyze tissue rupture mechanisms and their sensitivity to degradation. Histological analyses (collagen, elastin, actin, myosin, desmin) will complement mechanical results and enable structure–property correlations.

The outcomes of this PhD include:
(i) the development of an original fracture-testing methodology for pelvic soft tissues,

(ii) the identification of biomechanical biomarkers of menopausal tissue fragility, and
(iii) the integration of enzymatic ex vivo models with advanced constitutive and damage laws.

In the longer term, this work will contribute to a predictive framework of menopausal tissue fragility, as a first step toward a digital twin of the menopausal transition, with perspectives toward Horizon Europe and ERC projects, and potential applications in women's health and medical devices.

Profile sought
We are looking for a highly motivated candidate with:

- A Master's degree in mechanics, biomechanics, biomedical engineering or applied physics,
- A strong interest in experimental mechanics, constitutive modeling and biology,
- Programming skills (Python),
- Ability to work in a multidisciplinary and collaborative research environment.

Why this PhD?
This PhD offers a unique opportunity to work at the interface of biomechanics, advanced modeling and women's health, within the IMT Futur, Ruptures & Impacts excellence doctoral program. The project provides strong perspectives toward academic careers and competitive European research programs (Horizon Europe, ERC).

Funding
Full PhD funding for 36 months under the IMT Futur, Ruptures & Impacts excellence program with a gross monthly salary of approximately €2,500.

How to apply?
Applications must be submitted exclusively through the official IMT application platform
IMT PhD application platform
