Development and validation of a Finite Element model for the female torso under dynamic loading ans evaluation of brawear in sports conditions.

Co advising

Aline Bel-BRUNON, assistant professor

Scientific competence: soft tissue characterization and modeling: hyperelasticity, damage, viscoelasticity; experimental characterization, full-field measurements; material parameters identification. Finite Element simulation.

Personal page: http://scholar.google.fr/citations?user=nthENtsAAAAJ&hl=en Email: aline.brunon@insa-lyon.fr

2 major publications in the field:


Topic

The transverse axis « Mechanics of living tissues » at LaMCoS laboratory is interested in the modeling and characterization of biomechanical phenomena in the human body. For several years, our interest has focused on modeling breast during sports, in order to better understand the effect of the bra on the breast and in-fine, to optimize the design of sports bra with numerical simulation. One can find in the literature numerical models for female breast that are effective in static conditions [1,2], developed primarily for medical purposes, but to our knowledge, no models under dynamic loadings have been proposed so far.

In this context, a first model with two independent deformable bodies (breast skin and inside part of the breast) has been developed [3]. It was used to assess the feasibility of various aspects of the model: the construction of a generic model from a surface scan; the adaptation of the generic model by morphing to different morphologies; the identification of the non-linear material properties of the deformable parts from local (indentation) and global (morphological measurements with and without gravity) measurements; the simulation of the bra wearing; the simulation of dynamic stress on the bust, with and without bra, to assess the comfort and support of the bra.

The current model has limitations: the two deformable bodies do not form a continuum; the brawaer is not optimized (many manual steps). Dynamic simulation results are not satisfactory (the bra/body interaction is unrealistic). Based on this experience, the aim of this PhD is first, to develop and validate a new model of female torso; second, to optimize the implementation of the bra ; third, to evaluate the comfort and support of the bra in sports.

The steps of this project are:
- To continue with the development of a new generic model initiated in a student’s project at INSA Lyon, to better represent the anatomy of the breast (particularly its holding means) while keeping the computational cost; numerical modeling is made in Abaqus / Explicit.

- To develop experimental methods to validate the model in static and dynamic conditions, that is to say to develop experimental protocols to acquire relevant data to identify the model parameters. In particular, we consider measuring morphological parameters under water to mimic a no-gravity condition.

- To adapt the existing mesh morphing procedure to simulate different morphologies.

- To optimize the implementation of the bra on the generic model to obtain a satisfactory dynamic simulation and to develop methods to make this step automatic for different morphologies and different styles of bra.

- To evaluate the performance of the bra, especially in terms of pressure, support, friction.

The scientific challenges lie in the numerical modeling of mechanical phenomena involved in this issue (geometric and material nonlinearities, viscoelasticity, friction, dynamic effects) and in the validation of the model based on relevant experimental measurements.

References: