
# NUMERICAL ALGORITHMS FOR PATIENT-SPECIFIC PREDICTIONS OF PROXIMAL FEMORAL LOADS

**Noelia Garijo[1], Ali Vahdati [2], G. Harry van Lenthe [2], José Manuel García-Aznar [1], Mª Ángeles Pérez [1]**

*[1] Multiscale in Mechanical and Biological Engineering (M2BE) - Aragón Institute of Engineering Research (I3A), University of Zaragoza, Spain - [2] Biomechanics section, KU Leuven, Leuven, Belgium;*

Patient-specific finite element models are standard tools for the analysis of the biomechanical competence of human bones. One of the most challenging difficulties in creating patient-specific models is the determination of the specific load that each bone is experiencing (inverse problem). Many mathematical theories have been developed to analyse the evolution of bone microstructure and its dependence mechanical properties depending on a certain loading pattern. Bone remodeling simulations seek to predict bone density patterns resulting from normal physiological loading (direct problem). These simulations are typically based on computer tomography (CT) images, which provide accurate quantitative information on bone geometry, and are validated by comparing the predicted bone density of bone tissues from bone remodelling simulations with the CT-based material properties [Vahdati et al., 2013]. These methods are very laborious.

Although these simulations are based on patient-specific geometry of the bones, additional density variations can be found between individuals that are due to physiological differences. Hence, a relevant aspect in the creation of patient-specific models is the determination of the subject-specific loads that each bone is subjected to. Solving the inverse problem is certainly very important.
Therefore, the main objective of this work was to develop patient-specific simulations integrating, musculoskeletal loading and numerical algorithms for solving the inverse problem.

Three patient-specific data sets were used, which included CT scans of the proximal femur, and musculoskeletal loading characteristics as well as the precise locations for load application [Vahdati et al., 2013]. Finite element models incorporating the subject-specific geometry as well as the subject-specific hip contact forces and associated muscle forces were used to predict the density distribution in the proximal femur of the three individuals. Next, the subject-specific musculoskeletal loads were interchanged between the subjects and the resulting changes in bone remodeling of the proximal femur were analyzed. We used these combinations of the bone density distribution as input data for the mathematical techniques. The inverse problem was solved using artificial neural networks (ANN) and the input data for these techniques were the solution of bone density distribution obtained from solving patient-specific bone remodeling problems [Garijo et al., 2014]. Finally, we obtained the subject-specific load.

Simulation-results of ANN were compared to musculoskeletal loading obtained from gait analysis. The methodology proposed predicts the loads in the femur accurately. Good agreement was obtained (qualitatively and quantitatively) in the load predictions. ANN demonstrates a good load prediction with a low relative error for training and testing. These techniques could provide a database, which allows us to obtain a specific load case in a short time, and thus reduce the calculation time of the patient-specific load compared to loads obtained by means of gait analysis.

***References***

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