First results on bone density variation under high loads through the competition between osteoblasts and osteoclasts

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Abstract

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Abstract

For many years, bone mineral density (BMD) evolution was numerically predicted based on the classical assumption that it is directly dependent on the intensity of the mechanical energy developed with the material. However, with new mechanobiological comprehension of the mechanisms at the origin of this evolution [1], this idea is slowly fading away lately as

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it is becoming more and more evident that biological activity, although being dependent on the mechanical forces, is the main driving parameter of the BMD distribution. Models were lately developed trying to fill this gap [2-4], but transposing the local cellular activity at the organ scale remains challenging [5, 6].

Here, we propose a new continuous model validated on experimental data showing the interplay between the two types of cells at the origin of bone remodeling, namely osteoblasts and osteoclasts. The model was developed in parallel with experiments made on running whistar rats to predict BMD evolution for different running activity intensity as previously shown [7, 8]. The proposed model contains only four parameters that were evaluated from experimental data. A geometry of rat tibia was modeled within the software Comsol Multiphysics ®. The theoretical model was used to predict the variation of BMD as a function of time for different intensity of mechanical loads. We show that for medium intermediate running activity, the BMD increases whereas for higher continuous running activity, the BMD is decreasing. We also show that BMD evolution is dependent on the evolution of the porosity within the bone both experimentally and numerically. Overall average predicted BMD as a function of time is also correlated with experiments. Foreseen developments are the prediction of optimum activity for sport training or bone recovery through physical activity after injury.

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