

The aim of the present study is to develop a mechanobiological model able to predict bone stiffness variations in accordance with the active local mechanical environment on bone tissues. The development of such a computational model will be important to understand and to improve treatments based on specific local mechanical environments to maintain bone mass equilibrium despite critical load situations such as occurred during inactivity (immobility, zero gravity) or as caused by bone diseases (osteoporosis). Specifically Frost curves for describing osteoblastic and osteoclastic activities and its values for rates of physiological equilibrium could be determined as a subject specific function. It is expected that a rule of bone-cell behavior under specific and controlled mechanical conditions (e.g. training during bed rest) exist.

First objective

The main aim of this proposal is to develop and validate the mechanobiological model used to simulate bone remodeling by comparing predicted bone remodeling (FEM) with in vivo bone and density parameters after HR-3DpQCT (High resolution- 3D peripheral Quantitative Computer Tomography

Second objective

To estimate the effectiveness of vibration alone and vibration plus a compressive resistive force as training to avoid loss of bone mass after non-gravitational conditions simulated by a long bed rest period (60 days). In vivo compressive stiffness and load support capacity could be compared before, during and after bed rest for the training groups against a control group. Patterns and magnitudes of compressive strain fields and von Mises stress distribution could be assumed as a parameter to estimate bone stiffness. Also finite element analysis of 3D reconstructed bone sections (radius and tibia) of follow-up HR-3DpQCT measurements need to be performed. After analysis apparent density (e.g. cortical bone density: D_{comp} , trabecular bone density: D_{trab}) and bone structure parameters (e.g. Trabecular number TbN , Trabecular thickness ($Tb.Th$), cortical perimeter ($Ctpm$) will be compared with regions of high von Mises stress and strains distributions.

Hypothesis

Following Wolffs and Roux rules it should be possible to determine quantitatively specific ranges of compressive strains to maintain bone mass equilibrium for avoiding damage accumulation. We believe that specific in vivo determinable thresholds of strains exist in which a rule controlled bone-cell activity (osteoblastic, osteoclastic) could occur. A high correlation between the observed changes after subject specific reconstructions under specific physiological load conditions with the predicted ones from the models could be expected.