Keywords: Augmented reality, Balance disorder, Cognitive training, physiotherapy

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EFFECT OF THE FEMORAL BONE MATERIAL PROPERTIES ON THE NUMERICAL SIMULATION RESULTS

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Abstract:
Application of the appropriate material properties is one of the major issues for any numerical simulation. This is especially noticeable in the numerical analyses that deal with bone models. The femoral bone consists of cortical and cancellous bone. Both types have complex material properties. Although it is known that realistic material properties lead to obtaining more realistic numerical results, these properties are usually simplified. Most commonly, both types are considered to be linear elastic, isotropic and homogeneous. Our aim was to analyze the mechanical behavior of the femoral bone and hip implant, using two types of material properties (isotropic and orthotropic cancellous bone material properties) during standing. For the evaluation of the effect that the material properties have on the results of the numerical simulation, the finite element method was used.

Key words: femoral bone, material properties, finite element analysis

1. Introduction

Finite element model of the hip implant and the femoral bone provides opportunity to improve the design of the implant as well as its performance. The biggest challenge with the analysis of biological models is defining the appropriate material properties that can predict the behavior of the models. Femoral bone consists of cortical and cancellous bone that have different degree of porosity, strength and stiffness. Although, both types are known to be anisotropic, due to the complexity of the problem they are commonly considered to be homogeneous, linear elastic and isotropic. The goal was to analyze the effect that cancellous bone material properties have on the von Mises stress distribution in the femoral bone and the femoral implant during the standing.

2. Materials & Methods

Analyzed model included femoral bone and hip implant. The femoral bone model was developed based on the CT scans and included both types of bone (cancellous and cortical). The implant model was created using technical drawings. The applied boundary conditions were adapted from paper [1]. Two cases were analyzed, the first case included isotropic [2] while the second case included orthotropic [3] material properties of cancellous bone. In both cases, material properties of implant [4] and cortical bone [5] were considered to be isotropic. Static analysis was performed.

3. Results & Conclusions

As a result of the finite element analysis, the von Mises stress distribution was obtained. The maximum values for the implant, cancellous and cortical bone are presented in Table 1.

Results	Case 1	Case 2
Implant	145 MPa	145 MPa
Cancellous bone	0.509 MPa	1.863 MPa
Cortical bone	20.76 MPa	18.52 MPa

Table 1. Maximum von Mises stress values for both cases

The obtained stress distribution indicated that the isotropic material properties of the cancellous bone could be used to predict the bone response during standing. Bone material properties had no effect on the implant stress distribution. Considering that the second case provides more accurate results, we could conclude that isotropic material properties of the cancellous bone lead to higher cortical and lower cancellous bone stress values. Comparison of the von Mises stress distribution indicated that both isotropic and orthotropic material properties have similar stress distribution, which meant that either could be used to predict the bone behavior during static analysis.

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