EXPERIMENTAL VALIDATION OF A COMPUTATIONAL HUMAN SEATING MODEL

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INTRODUCTION

Pressure ulcers are a frequent complication to spinal cord injury (SCI) patients. The disease can have various ethiologies and is in general poorly understood. It is well acknowledged that pressure ulcers are primarily caused by sustained mechanical loading of the soft tissues [1]. The types of loading can be described as pressure, pressure gradients and shear forces [2]. These loads conspire in a complicated fashion to generate stress states varying from point to point in the soft tissues. An understanding of the input loads is therefore the first step towards a genuine understanding of pressure sore formation.

This study proposes that an analytical approach could contribute to understanding of how the seating posture affects the mechanical loading of the soft tissue in the buttock region. A validated analytical model could be used to predict load values from different seating postures without the need for costly experiments. Therefore the objectives of this study is to validate a musculo-skeletal model with respect to its ability to predict reaction forces and how these change with a change in the seated posture.

METHODS

The study was divided into an experimental and a modeling part. Subsequently the two were compared. The experiment was conducted for three healthy male subjects (27±2 years; 76±3 kg; 177±3 cm). The experimental setup included measurements of reaction forces on a custom-built wheelchair that was mounted with force-measuring equipment. The reaction forces were measured in various seated postures. The postures were adjusted by changing seat and backrest inclination angle, and height and depth of the seat and backrest. The postures were measured using a motion capture system.

The modeling part was done using the AnyBody modeling system, which is software designed for constructing musculo-skeletal models of the human body and its environment and for determining how they interact. The model used was the "Seated Human" from the public domain AnyBody model repository [3]. The model is described in detail by Rasmussen et al. [4]. The connection between the chair and the human musculoskeletal model was modeled as contact elements perpendicular to the contact surfaces and capable of taking Coulomb friction into account. Notice that the contact forces between the chair and the human, are solved by the systems equilibrium equations.

The different measured postures were input into the AnyBody model after which the software calculates the unknown support forces (normal and shear forces). The experimentally measured forces and the forces calculated by the AnyBody model could be directly compared as absolute values, and also as trends, i.e. changing the seat angle results in an equal change of output parameter.

RESULTS AND DISCUSSION

The preliminary results from forces measured during the experiment and estimated forces from the AnyBody model were compared as absolute values and trends while changing one parameter at the time. One of the most discussed parameters in seating biomechanics related to pressure ulcers is the shear force between the buttocks and the seat, and is therefore an important parameter to validate. Figure 1 shows the shear force from the experiment as a function of the shear force calculated by the model for different seat angles. The correlation between the experiment and the model is good. Ideally the graph would show a linear relationship with a slope of 1 and intersection through 0 N.

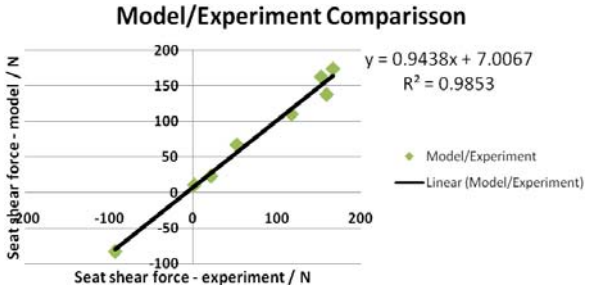

Figure 1 illustrates a preliminary result of the seat shear force comparison between the experiment and the model result

CONCLUSIONS

It could be concluded that a computational seated human model can be used as a tool to calculate the normal and shear forces between the human body and a chair. It is anticipated that this information will lead to more insight how seating posture affects the mechanical loading of the soft tissue.

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