MUSCULOSKELETAL MULTIBODY SIMULATION OF PAEDIATRIC PATIENTS BEFORE AND AFTER FEMUR OSTEOTOMY

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Introduction

Severe rotational malalignment of the lower extremity of paediatric patients can lead to increased joint loads and non-physiological gait patterns and, therefore, to symptoms such as premature osteoarthritis [1]. One surgical treatment option is to perform derotational osteotomies [2]. The corrected bone position is expected to lead to an improvement of the gait pattern as well as a reduction of joint loading [3,4].

Experimentally capturing the joint loads of the lower extremities of children is complex and invasive. By means of software based musculoskeletal multibody simulations (MMBS) biomechanical data of joint dynamics based on gait analysis can be derived [5].

Because of the lack of data regarding joint loads of paediatric patients with rotational malalignment, the aim of our present study was to generate a MMBS model to simulate paediatric patients before and after osteotomy using 3D gait analyses as input to evaluate joint dynamics.

Methods

The pre-/postoperative gait of two patients of a similar age (patient1: 26/28 kg, 134/142 cm; patient2: 32/44 kg, 138/147 cm) treated with intertrochanteric osteotomy were simulated. Marker trajectories and ground reaction forces were captured with a motion capturing system collecting data from 21 skin markers and 3D force plates.

A generic model of the lower limb [6] in AnyBody (Anybody Technology, Denmark) was used to calculate joint angles and loads. This model comprised six degrees of freedom per lower limb.

On this basis, the model was adapted to the individual patients by integrating the marker data and scaling of segment dimensions based on that data. Precisely, scaling was performed according to the height and weight of each patient.

Subsequently, inverse kinematic and inverse dynamic analyses were performed to calculate joint angles and forces during the gait.

Results

Within the generated MMBS model we simulated paediatric patients with rotational malalignment, before and after osteotomy, showing differences in joint angles up to 20° and resultant joint forces up to 2.5 times body weight (Figure 1).

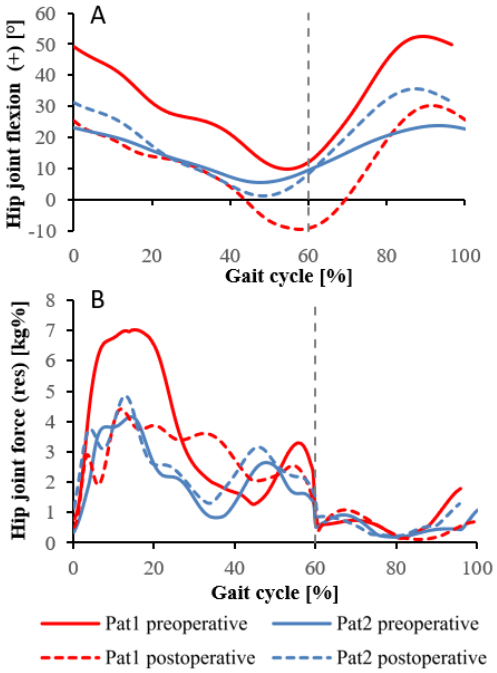

Figure 1: Hip joint flexion angle and resultant (res) hip joint force over the gait cycle of two patients (pre- and postoperative situation) during gait. Vertical dashed line marks the toe-off-event at 60% gait cycle.

Discussion and Outlook

The joint dynamics of paediatric patients with rotational malalignments have been insufficiently investigated so far [5]. For this reason, we adapted an existing MMBS model to simulate the gait of two paediatric patients before and after osteotomy, successfully calculating joint angles and loadings. In future studies, more patients and healthy subjects will be simulated to allow statistical comparison. The results of these simulations will also be used as boundary conditions for finite element analyses of the femoral bone.

References

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