The associations between variables and support moment in typical children

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Abstract. The support moment is defined as the sum of all joint moments in the lower extremity. Positive values are regarded as extensor moments which prevent collapse and negative values as flexor moments which facilitate collapse. The purpose of the study was to determine associations between chosen variables and support moment in typical children population.

Keywords: typical children, regression analysis, support moment, gait analysis.

Introduction

The support moment is defined as the sum of all joint moments in the lower extremity. Positive values are regarded as extensor moments which prevent collapse and negative values as flexor moments which facilitate collapse [1]. The lower limb joint moment is determined by using Newton-Euler equations [2]. The purpose of the study was to determine associations between chosen variables and support moment in typical children population.

The study examined 92 control children. Inclusion criteria were: age range 5–16 years without any disorders that would affect their gait. The study received ethical approval in accordance with the local health committee. All parents provided informed consent prior to the start of measurement. Each child's height was measured to the nearest 0.1 cm using a stadiometer, and the mass of each child was measured to the nearest 0.05 kg using calibrated electronic scales. The natural gait pattern was assessed in the sagittal plane of movement. Reflective markers were placed on the body according to the Oxford model [3]. The subjects were analyzed while walking barefoot. The kinematic and kinetic data were obtained with an optoelectronic system consists of 6 cameras and two platforms. The joint moment at the hip, knee and ankle was computed using an inverse dynamic approach, and then the support moment and the contributions to the support moment was calculated using Eqs. 1 [4]:

$$\overrightarrow{M_s} = \overrightarrow{M_H} + \overrightarrow{M_K} + \overrightarrow{M_A}, \tag{1}$$

where: $\overrightarrow{M_s}$ is support moment, Nm/kg; $\overrightarrow{M_H}$ is hip moment during the stance phase, Nm/kg; $\overrightarrow{M_K}$ is knee moment during the stance phase, Nm/kg; $\overrightarrow{M_A}$ is ankle moment during the stance phase, Nm/kg.

The joint moment was normalized to the body mass. For determining the joint's participation in the support moment the area under the curve of suport moment for the hip joint, knee joint, and ankle joint was calculated as below [4]:

$$\int_{t_1}^{t_2} \overrightarrow{M_s}(t)dt = \int_{t_1}^{t_2} \overrightarrow{M_H}(t)dt + \int_{t_1}^{t_2} \overrightarrow{M_K}(t)dt + \int_{t_1}^{t_2} \overrightarrow{M_A}(t)dt, \tag{2}$$

where: t_1, t_2 is the time of signal duration.

The support moment curve has the characteristic double bump. It is very similar to vertical ground reaction force [4]. A regression approach was used to estimate associations between support moment and chosen variables during walking [5]. Possible independent variables included: body mass, body height, walking speed, single support phase, double support phase, vertical ground reaction force, gender, stride length, and step length. The number of predictors included in the multiple regression models was limited to three predictors due to high correlation between independent variables [5]. Significant effects and the degree of correlation between independent and dependent variables were examined using the Spearman's rank correlation. Finally, dependent variables were as follow: step length normalized to body height (denoted as x_1), maximal vertical ground reaction force normalized to body weight (denoted as x_2), and single support phase (denoted as x_3). The dependent variable was support moment. The following regression equation was as follow:

$$\hat{y} = 51.3 - 4.31x_1 + 4.62x_2 - 4.51x_3 + 8.2x_2x_3 + 5.6x_2^2 - 3.6x_3^2. \quad (3)$$

where: $\hat{y}$ is the dependent variable (model output), $x_1 \ldots x_3$ are the independent variables (model inputs), $a_1 \ldots a_3$ are model coefficients.

Coefficients were assumed to have no significant impact on the output if their p-values were greater than 0.05. Accuracy was examined using root mean square error (RMSE) between measured y and predicted data $\hat{y}$. The model was fitted the measured in 88%. The results indicate that maximal vertical ground reaction force has the highest impact on support moment in typical subjects. Lower impact has step length and single support phase.

Conclusions

This study showed that support moment in typical subjects depends significantly on maximal vertical ground reaction force, step length, and single support phase. The influence of the presented factors on support moment was estimated by a multiple regression model. The proposed method can be used to determine the difference in support moment in children with lower limbs deformities.

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