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Extended Abstract

Motion analysis of infants using musculoskeletal model

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Abstract

A safer and simpler examination method for screening spastic gait is desired because sedatives may be administered in infant examinations using MRI, and serious complications such as respiratory arrest due to administration have been reported. In this study, we attempted to analyze the motions of infants using a musculoskeletal model as a first step to construct a method that can be used to screen for central nervous system disorders. We analyzed the tension in the muscle of the infant’s lower limbs during walking using the musculoskeletal model software OpenSim. We concluded that the tensions in the muscles differed in the different scaling patterns.

Keywords

Infant, Muscle tension, OpenSim, Scaling, Spastic gait

1. Introduction

Spastic gait caused by central nervous system disease in infants is difficult to distinguish from internal rotation gait, making it difficult to detect central nervous system disease by methods other than MRI brain imaging. A safer and simpler examination method is desired because sedatives may be administered in infant examinations using MRI, and serious complications such as respiratory arrest due to administration have been reported [1]. Excessive muscle tension in the ankle plantar flexors muscles occurs at the end of the swing phase in patients with spastic hemiplegia during walking [2]. Therefore, a safer and simpler examination method for screening spastic gait is desired. In this study, we attempted to analyze the motions of infants using a musculoskeletal model as a first step to construct a method for analyzing behavior that can be used to screen for central nervous system disorders. We analyzed the tension in the muscle of the infant’s lower limbs during walking using the musculoskeletal model software OpenSim. The two scaling patterns for a healthy infant model were performed in the analysis.

2. Experiment

A 2-year-old healthy boy participated in the experiment (height: 100 cm, weight: 12 kg). Following an explanation of the purpose and requirements of the study, the participant’s parent gave her written informed consent to the participation of her child in the study. Study approval was obtained from the Research Ethics Board, Kogakuin University. During the experiment, kinematic data were collected using an optical 3D motion analyzer (MAC3D, MOTION ANALYSIS Co. Ltd.) and a 6-axis force sensor (FFS080F102M10106IO, Leptrino Co. Ltd.). The sampling frequencies of the optical 3D motion analyzer and the 6-axis force sensor were 100 Hz. For the gait measurement, 19 reflective markers were attached to the subject's lower limbs, referring to the Helen Hayes marker set [3]. Marker positions are shown in Fig. 1. Markers attached to subject are shown in Fig. 2. The subject started walking at his own timing, after starting the measurement.

3. Muscle tension analysis using OpenSim

3.1 Conditions

The software OpenSim3.3 [4] was used to

estimate the lower limb muscle tension during walking. The model used in the analysis was Gait2392, which has 23 degrees of freedom and 92 musculotendon actuators. The two scaling patterns were performed: Pattern A, which scaled the whole body parts based on height, and Pattern B, which scaled each bone with reference to the subject's body dimensions. Then, muscle tension was calculated by Static Optimization.

3.2 Results

The results for the rectus femoris muscle which is agonist for hip flexion, and the biceps femoris LH muscle which is antagonist for hip flexion, are shown in Fig. 3 and 4, respectively. The horizontal axis shows the normalized time, where one stance phase is 100%, and the vertical axis is the result of the muscle tension calculated by OpenSim. Black solid curves present results obtained using the scaling pattern A, and black dashed curves present results obtained using the scaling pattern B. Fig. 3 shows that the rectus femoris muscle tensions calculated by scaling patterns A and B are both activated throughout the stance phase. In toddler gait, many lower limb muscles are generally involved and fired simultaneously. Therefore, the rectus femoris muscle that is the antagonistic muscle of the biceps femoris LH may not have developed completely.

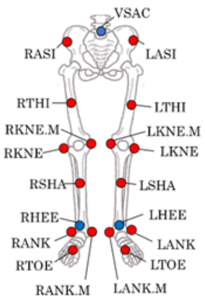

Fig. 1 Marker positions

(a) Front *(b) Back*

Fig. 2 Markers attached to subject

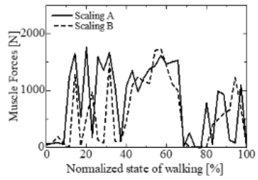

Fig. 3 Rectus Femoris

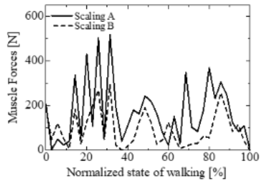

Fig. 4 Biceps femoris LH

Fig. 4 shows that the biceps femoris muscle tensions calculated by scaling patterns A and B both have the largest peak in the early stance phase. The results are similar muscle activities in adult walking. Since the development of antagonism differs from muscle to muscle to muscle [5], the results indicated that the biceps femoris muscle may have developed its antagonism earlier than the rectus femoris muscle. Focusing on the results of scaling patterns A and B, muscle tensions obtained by pattern A changed in a wide range and had a larger number of changes compared to pattern B. It is considered that infants have different proportions of body dimensions than adults. Hence, a more rigorous scaling method is required to calculate appropriate muscle tensions.

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