Research on Inter-joint Coordination in Abnormal Gait

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Abstract

This study investigated the kinematic characteristics of a case of gait disturbance caused by spastic paraplegia. From the results of the joint angles, we determined the asymmetry between the left and right sides.

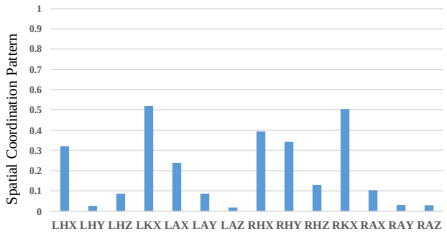
Spasticity is a symptom that is characterized by tight or stiff muscles and an inability to control those muscles. It is caused by diseases of the spinal cord and nerves. Spasticity is one of the most common manifestations of cerebral palsy (CP). CP is a nonprogressive disorder, often congenital, caused by brain damage during pregnancy, before and after childbirth, or within the first 4 weeks of life.

CP is difficult to diagnose during early infancy. A comprehensive diagnosis is made by monitoring motor milestones. A doctor would observe the gait as children walk and run in the Health Checkup for Infants. If a child's symptoms are mild, it is sometimes difficult to make a diagnosis until the child is a few years older. Early rehabilitation for children with CP can bring their latent potential and promote growth. Therefore, in this study, as the first step in proposing a new gait evaluation method for children, we extract gait features in spastic gait.

The three healthy adult males (height 1.73±0.03 m, weight 57.3±3.05 kg), a healthy 2-year-old boy (height 1.04 m, weight 16 kg), a spastic 4-year-old girl (height 1.04 m, weight 16 kg) participated in the experiment. Study approval was obtained from the Research Ethics Review Committee, Kogakuin University, and the National Institute of Technology, Akita College. The optical 3D motion analysis system captured the participants during walking. The sampling frequency of the system was 100Hz. The participants walked with natural stride length and speed. The coordination between the joint angles of a person walking was examined by applying singular value decomposition. First, the joint angles obtained in the experiment were normalized from -1 to 1. Then, an observation matrix was constructed using normalized joint angles. Finally, singular value decomposition was performed on the observation matrix to obtain the dominant motion modes defined as the main coordination patterns.

One gait cycle including one stance phase and one swing phase was defined as 100%, and 0% was the beginning of the stance phase. Although the toe-off (TO) in adult males and a 2-year-old boy were 60% and 55%, respectively, that of 4-year-old girl with gait disturbance was 70% for left and 65% for right.

The results indicate that the tendency of joint angle changes of adult males and the 2-year-old boy



(a) Results of mode 1 during the left gait cycle

(b) Results of mode 1 during the right gait cycle

Fig. 1. Spatial coordination patterns

were bilaterally symmetrical movements, while the joint angles of the 4-year-old girl showed bilaterally asymmetrical except for the hip joint. The results of 4-year-old girl describes that the internal rotation of the left hip joint increased during the stance phase of the left leg. During the stance phase of the right limb of 4-year-old girl, the right hip abduction increased, the right hip joint internally and externally rotated, and the right ankle joint internally and externally rotated.

In addition, we evaluated the inter-joint cooperation of each subject by applying the evaluation method [1][2] of inter-joint cooperation based on the singular value decomposition of the measurement results. The spatial basis results, which represent the coordination patterns of the 4-year-old girl, are shown in Fig. 1. Fig. 1 shows the result was left-right asymmetric. The results indicate that the joint coordination of the 4-year-old girl was clearly different from that of a healthy person.

References:

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