CONTRIBUTIONS OF LOWER LIMB JOINTS TO SUPPORT THE BODY IN UNEXPECTED STEP-DOWN WALKING

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INTRODUCTION

The generation of the forward movement and the stable support of the upper body are two important roles of the lower limb in walking [1]. The function of the body support has been recently received much attention. The concept of the support moment, defined as the sum of all joint moments in the lower limb, has been used to determine the relative contribution of the lower limb joint moments to prevent the collapse [2].

Falling is a serious problem among the elderly population, frequently resulting in physical injuries. The unexpected walking is one of the most probable cause of falling in the elderly [3]. However, the postural recovery mechanism based on the support moment in the unexpected walking has not been clearly defined yet.

In this study, dynamic simulations were performed to analyze contributions of the lower limb joints for the support moment in the unexpected step-down walking based on 3-D motion analysis data.

METHODS

A 27 year-old male subject (height: 170cm, weight: 68kg), with no gait problems in gait, participated in the 3D motion analysis. Six infrared cameras (Vicon 612, USA) were used to capture movements of sixteen reflective markers based on the Davis protocol for the gait analysis of the lower extremity [4]. For the unexpected step-down walking, a movable platform was designed to provide vertical perturbations during gait. Computer simulations were performed using Lifemode (Biomechanics Research Group, USA). A 3D virtual skeletal model for the simulation was composed of seven segments. Gait simulations were performed by translational and rotational motion capture data. Motion capture data obtained by the 3D motion analysis system were imported to the generated skeletal model. The model for this study calculated the vertical acceleration of the upper body, which was produced by the support moment estimated at each joint. In order to calculate joint moments for the support in walking, gait phases were divided into right mid-stance, double limb support, and left mid-stance (Figure 1).

Figure 1: Simulation results from the forward dynamics in unexpected step-down walking.

RESULTS AND DISCUSSION

Figure 2 shows vertical accelerations of the pelvic center in the unexpected step-down walking. In the unexpected step-down walking, the right ankle joint was the most primary contributor for vertical accelerations. In the unexpected step-down walking, the vertical acceleration at right mid-stance, contributed by the right ankle and knee joints, was very large. Since in the unexpected step-down walking, no roll-over mechanism of the foot exists, at first the forefoot contacted to the ground and then progressed to double-limb-support. At left mid-stance phase, the subject kept his balance for repositioning of the over-advanced COG through that the subject stepped left foot forcefully. This caused the left ankle moment large during left mid-stance.

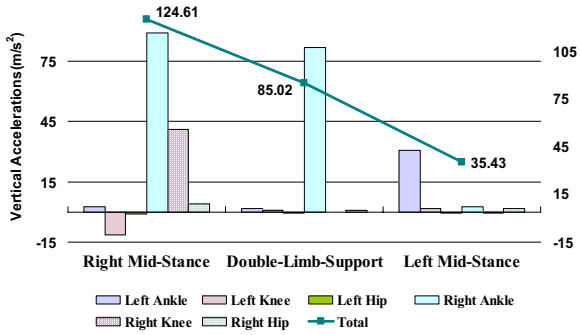

Figure 2: Vertical accelerations of the pelvic center in unexpected step-down walking.

CONCLUSIONS

In the unexpected step-down walking, the important contributors during single-limb-support are not only ankle plantar flexors but also knee extensors.

This study, analyzing the relative contributions of the lower limb joint moments for the body support would be helpful to understand many unexpected walking and compensatory mechanisms for various pathological gaits.

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