Effects of wearing slippers on walking locomotion on stairs in female elderly

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1. Introduction of Objectives

Falling is one of the most serious problems for the elderly because it often causes a bed-ridden or sedentary lifestyle due to bone fractures or anxiety about falling again. It is often said that the elderly fall when multiple risk factors coincide. For example, at home, residents often walk while wearing slippers, which might increase the risk of falls, especially on stairs.

Although slippers have some advantages, such as being easy to put on and take off, ensuring hygiene of the feet, warming the feet, and absorbing shocks from the floor, they easily drop off the feet during locomotion. This disadvantage could be one of the risk factors for falls (Saito et al. 2012). On the other hand, locomotion on stairs requires different movement and higher muscle activities of the lower limbs, as well as body balance, compared with locomotion on a flat floor. In the elderly, deterioration of these abilities would increase the risk of falling on stairs. Mori et al. (2011) reported a decrease in the distance between the toes and the edge of the stairs, especially in the elderly. Therefore, this combination of two risk factors (slippers and stairs) might further increase the risk of falling in the elderly.

Against this background, the present study investigated the effects of wearing slippers on walking motion while climbing up and down stairs in the elderly.

2. Method

Fourteen adult females whose ages ranged between 69 and 74 years participated in this study (mean body height: 152.3 cm, mean foot length: 230.8 mm). All participants had sufficient ability to climb up and down stairs on their own without assistance and without using handrails. This study was approved by the Ethics Committee of the Faculty of Design, Kyushu University.

We observed their walking motion while going up and down stairs (tread: 223 mm, rise: 204 mm) under two conditions (with and without wearing slippers (length: 285 mm, width: 104 mm) using three-dimensional motion analysis system including 9 infrared cameras. The step pace was controlled by metronome so as to be the same under both conditions. After the measurements, we obtained the trajectory of the feet (tip of toe and heel) and the slippers (tip and end), distance between tip of foot (or slipper) and stair edge (nose), and changes in joint angles (hip, knee, ankle) on the sagittal plane during the swing phase (toe off to initial contact) using software (Kineanalyzer, Kissei Comtec Co., Japan).

3. Results and Discussion

In the case of climbing up stairs, the slipper condition showed 1) significant decreases in extension of the hip and knee joints after toe off and before foot contact (hip joint: 0 to 43% and 86-100% of swing phase, knee joint: 0 to 39 and 75 to 100% of swing phase), 2) significant decreases in the plantar flexion of the ankle joint throughout most of the swing phase (0 to 95%), and 3) a significantly shorter distance between the top of the slipper and the edge of a step.

In the case of climbing down stairs, the slipper condition showed 1) significant decreases in extension of the hip and significant decrease in the extension of knee joints before and after the toe off (hip joint: 94 to 100%, knee joint: 0 to 3% of swing phase), 2) significant decreases in the plantar flexion of the ankle joint at the latter stage of the swing phase (41 to 100%), and 3) a significantly shorter distance between the end of the slipper and the edge of a step.

The decrease in distance between the foot and the edge of the step might have been mainly contributed to by the extension of the foot length due to wearing slippers (240.1 mm to 285.5 mm). This phenomenon implies that wearing slippers increases the risk of stumbling and catching the edge of a step. Furthermore, when the tip of a slipper faces down, it easily drops from the foot. Participants adjusted the joint angles in the lower limbs, especially decreased plantar flexion of the ankle joint, in order to prevent the slippers from
falling from the feet in the swing phase. Thus, wearing slippers requires different movements of the lower limbs on stairs, which might increase the risk of falls on stairs for the elderly.

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References
