CHARACTERISTICS OF JOINT MECHANICAL WORK IN MALE AND FEMALE ELDERLY DURING WALKING IN CONSIDERATION OF VELOCITY

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INTRODUCTION: Previous studies about how the elderly walk have reported their kinematical and kinetic characteristics by comparing their motions with those of young walkers (Murray et al., 1969; Hageman and Blanke, 1986; Blanke and Hageman, 1989; Winter et al., 1990; Kaneko et al., 1991; Judge et al., 1996). The results from these studies contain both the effects of aging and walking velocity because walking velocities of the elderly and the young differed from each other and the velocity strongly affects most biomechanical variables. In addition, the change in walking motion with aging after sixty has rarely been reported, and the differences between elderly male and female walkers were also not clear. This study seeks to clarify the differences in the characteristics of joint mechanical output and contribution during walking between different age groups and sexes for the elderly in consideration of walking velocity.

METHOD: The subjects were 213 healthy Japanese male and female elderly who were divided into six groups according to their age and sex (Table 1). They were instructed to walk about 10m at four self-selected speeds (Slow Walk (SW), Normal Walk (NW), Fast Walk (FW), and Maximum-speed Walk (MW)). We videotaped them during walking with a digital VTR camera at 60fps in order to analyze their motion in the sagittal plane. The ground reaction forces on the right foot were measured by a force platform installed below the walkway. Two-dimensional coordinates of the eight body landmarks were obtained by using a video digitizing system (Frame-DIAS, DKH Co., Ltd., Japan). Four trials (one for each walking speed) per each subject were analyzed. The coordinates were smoothed by a fourth-order, zero-phase-shift Butterworth digital filter at the optimal cut-off frequencies that were derived from residual analysis (Winter, 1990). After synchronizing the smoothed coordinate data and ground reaction forces, we calculated joint torques at the ankle, knee and hip using a link-segment model based on the inverse dynamics method. Joint torque powers were next calculated by multiplying the joint torque by the joint angular velocity. Finally, joint mechanical work was calculated by integrating the joint torque power over time and the joint contribution to the total lower limb work was expressed as the percentage of each joint work to the total. In order to test the differences in the work and the contribution between the groups without the effect of walking velocity, two-way analysis of covariance (ANCOVA) was done in which the walking velocity was set as the covariate. When a significant effect of age or sex or their interaction was recognized, a multiple comparison (Scheffe test) was done.

RESULTS AND DISCUSSION: Figures 1 and 2 plot the positive work done by the ankle and the hip during one walking cycle. Both the ankle and hip positive work increased with the

Table 1 Profile of subjects

Sex		Range of Age [yr.]	n	Age [yr.]	Standing Height [cm]	Body Mass [kg]
Male	E1	65–69	38	67.5 ± 1.3	162.0 ± 5.0	63.6 ± 7.0
	E2	70–74	42	72.5 ± 1.5	163.2 ± 5.0	64.0 ± 7.0
	E3	75+	24	77.9 ± 2.6	161.3 ± 6.1	62.4 ± 7.2
Female	E1	65–69	47	67.6 ± 1.3	149.2 ± 4.7	55.7 ± 7.8
	E2	70–74	44	72.5 ± 1.4	149.3 ± 5.7	53.4 ± 6.5
	E3	75+	18	77.0 ± 1.7	148.2 ± 4.8	52.6 ± 6.5

walking velocity. Regardless of sex, the ankle positive work at the same walking velocity decreased with age, and that of E3 was significantly smaller than that of E2 (p<0.05). In contrast, the hip positive work at the same walking velocity increased with age, and that of E3 was significantly larger than that of E2 (p<0.05) and E1 (p<0.01). Although the knee positive work also increased with walking velocity, no significant differences between age groups were seen. The contribution of the ankle and knee joint to the total positive work differed with the change of the walking velocity. The contribution of the ankle decreased and that of the knee increased with the increase in walking velocity. In contrast, the contribution of the hip was almost the same at different walking velocities. The contributions of the ankle and the hip differed between the age groups. The contribution of the ankle for E3 was significantly smaller than that for E2 (p<0.01) and E1 (p<0.05). In contrast, the contribution of the hip for E3 was significantly larger than that for E2 (p<0.05) and E1 (p<0.01). These results indicated that the function of plantar flexors during walking deteriorates with aging and the hip joint must then exert more power to compensate for the decline in ankle function, and this tendency was seen in both of male and female walkers.

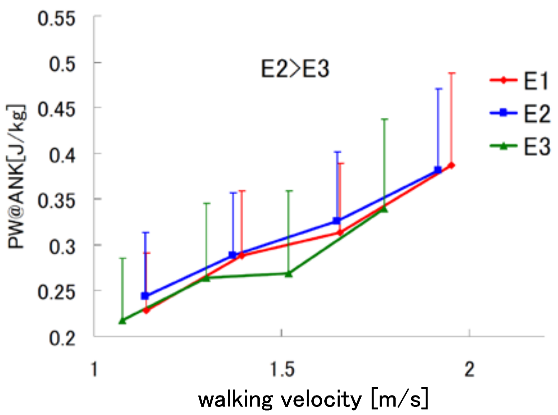

Figure 1 Ankle positive work

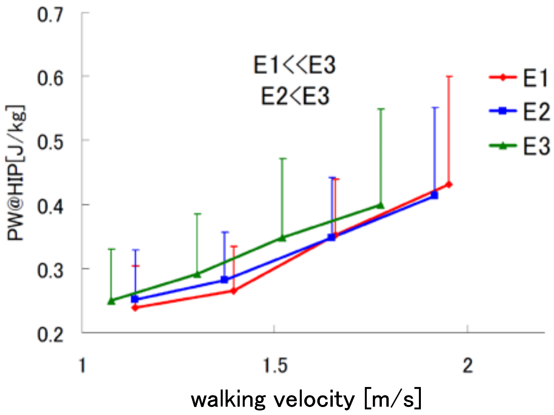

Figure 2 Hip positive work

CONCLUSION: This study examined the effect of age and sex on the characteristics of joint kinetics in consideration of walking velocity by using two-way ANCOVA. The results from the positive work and the joint contribution to the positive work indicated that power generation in the ankle joint deteriorated with aging, and this deterioration was seen in both sexes. This indicates that maintaining the ankle power is very important for male and female elderly to keep their walking ability.

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