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GAIT DIFFERENCE ON IRREGULAR SURFACE UNDER COOLING LOWER-LEG MUSCLE

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SUMMARY
The purpose of this study was to investigate the effect of an uneven surface on muscle spindle function in lower-leg muscles during walking. Subjects included 3 healthy young adult males. Normal and high-speed walking motion ware measured on two surfaces: an even surface and an uneven surface. Healthy and reduced muscle spindle function conditions were compared. The ice immersion approach was applied on the lower-leg muscles as a method of reducing muscle spindle function. To create an irregular surface, a thin cloth carpet was modified by blocks beneath the carpet. During normal walking on even surface, the step length was significantly decreased ($p<0.01$) and, during normal walking on even and uneven surface, the step width was significantly increased by icing ($p<0.01$). During normal and high-speed walking on even surface, walking velocity was significantly decreased by icing ($p<0.01$). These results mean that the muscle spindle function is related to walking. However, standard deviations of walking parameters were not significantly changed and the rates of accelerations were significantly decreased. Therefore, this study suggests that the muscle spindle function is not important in order to walk on irregular surface.

INTRODUCTION
Walking is one of basic motion of human. However, walking has risk of falling accident. Falling accident is large problem for elderly people. One of the causes of falling for elderly people is reduced sensation [1]. Some studies pay attention to plantar sensation during walking. Suzuki et al. investigated difference of walking on irregular surface made from some blocks between health young group and reduced plantar sensation group. As a result, they demonstrated that plantar sensation is important to walk on the irregular surface [2]. On the other hand, Höhne et al. [3] investigated difference of walking on stiffness change surface made from sponge between health young group and reduced plantar sensation group. As a result, they demonstrated that plantar sensation is not important to walk on the stiffness change surface. Our previous study paid attention to muscle spindle function of lower-leg. We hypothecated that muscle spindle function is important to walk on stiffness change surface. We investigated difference of walking on a stiffness change surface made from sponge between health young group and reduced muscle spindle functional condition group. As a result, we demonstrated that muscle spindle function is important to walk on the stiffness change surface [4]. There is an open question that muscle spindle function is important to walk on irregular surface. So in this study, we investigated difference of walking on irregular surface made from some blocks between health and reduced muscle spindle functional condition.

METHODS
The subjects were 3 healthy young adult males (age: 22.0 ± 1.41 year; body height: 172.0 ± 0.04 cm; body mass: 60.0 ± 4.32 kg). The methods were explained and informed consent was obtained from all the subjects. This study adopted applying ice water over lower-leg muscles 30 min as a method of reducing the muscle spindle function. After icing, the subjects took a break 7 min to recover from loss of muscle strength, and conducted walking experiments within 20 min because of effect of icing [4]. The walking experiment conditions were normal and high speed walking on even and irregular surface, and compared health and reduced muscle spindle functional conditions. To create an irregular surface, a thin cloth carpet was modified by blocks (30 mm long × 50 mm wide × 15 mm high Figure 1) beneath the carpet.
The walking parameters measured by the motion-capture system were the step length, step width and velocity. The postural movement was measured by 3-axis accelerometer. Moe-Nilssen reported that increased postural movement means walking instability. And, postural movement is reflected in the effective value of the lower back transverse acceleration [5]. On the other hand, Menz reported that the effective value of the lower back transverse acceleration depends strongly on walking velocity [6]. In order to remove the influence of walking velocity, we used the effective value of transverse acceleration rate of 3-axis acceleration as following equation:

$$A = |\overrightarrow{a_y}| / \sqrt{a_x^2 + a_y^2 + a_z^2}, \quad (1)$$

where is rate of acceleration, a_x is anteroposterior acceleration, a_y is transverse acceleration, a_z is vertical acceleration.

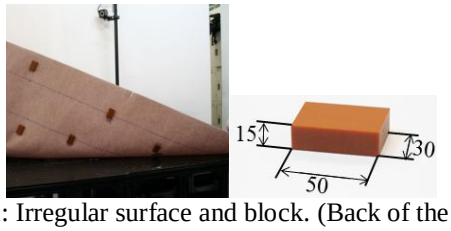

Figure 1: Irregular surface and block. (Back of the carpet.)

Table 1: Measured walking parameter.(Normalized by parameter during walking on even surface in healthy condition.)

	Normal walking				High-speed walking			
	Even surface		Uneven surface		Even surface		Uneven surface	
	Normal <Base>	Iced	Normal	Iced	Normal <Base>	Iced	Normal	Iced
Step length (SD)	1.00 (0.07)	0.95 (0.07)	0.97 (0.07)	0.97 (0.07)	1.00 (0.07)	0.94 (0.06)	0.98 (0.07)	0.97 (0.06)
Step width (SD)	1.00 (0.16)	1.09 (0.21)	1.00 (0.21)	1.07 (0.18)	1.00 (0.16)	1.03 (0.17)	0.99 (0.17)	0.99 (0.19)
Velocity (SD)	1.00 (0.01)	0.94 (0.04)	0.98 (0.03)	0.98 (0.03)	1.00 (0.02)	0.90 (0.03)	0.97 (0.03)	0.96 (0.04)
Acceleration (SD)	1.00 (0.10)	0.95 (0.15)	1.05 (0.15)	0.97 (0.19)	1.00 (0.10)	0.93 (0.13)	1.00 (0.13)	0.93 (0.14)

*:p<0.03, **:p<0.01

RESULTS AND DISCUSSION

Table 1 shows results of all parameters measured in this study. During high-speed walking on even surface, the step length was significantly decreased by icing ($p<0.01$). During normal walking on even surface, the step length was significantly decreased ($p<0.01$) and, during normal walking on even and uneven surface, the step width was significantly increased by icing ($p<0.01$). In addition, during normal and high-speed walking on even surface, walking velocity was significantly decreased by icing ($p<0.01$). These results suggest that the walking becomes a conservative walk by reduced muscle spindle function [2,4]. During normal walking in healthy condition, the rate of acceleration was significantly increased by uneven surface ($p<0.01$). This increased acceleration means that the walking becomes unstable due to uneven surface. During normal and high-speed walking in healthy condition, the walking velocity and step length were significantly decreased by the uneven surface ($p<0.03$). These results mean that the walking adapted to uneven surface. On the other hand, during normal and high-speed walking in reduced muscle spindle functional condition, walking velocity was increased by uneven surface ($p<0.01$). In addition, during normal walking in reduced muscle spindle functional condition, the step length was increased by uneven surface ($p<0.01$). These increased parameters suggest that the muscle spindle function is important to adjust forward-bent posture while uneven surface walking [4]. During normal and high-speed walking on even and uneven surface, the rate of acceleration was decreased by reduced muscle spindle function ($p<0.01$). The decreased acceleration suggests that the walking becomes stable due to the change to stabilize walking. These changes in walking suggest that the muscle spindle function is related to walking.

Standard deviations for all walking parameters were not significantly difference between not only even and uneven surface, but also between healthy and reduced muscle spindle functional condition. Standard deviations did not distinguish in all conditions. The obtained results suggest that muscle spindle function is not important to walk on irregular surface.

CONCLUSIONS

In this study, we obtained difference of walking on irregular surface made from some blocks between health and reduced muscle spindle functional condition. This study measured the change to walking stability by reduced muscle spindle function. The experimental results suggest that the muscle spindle function is related to walking. However, standard deviations for all walking parameters were no significantly difference. Therefore, these results demonstrated that the muscle spindle function is not important to walk on irregular surface.

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