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Urinary Protein Excretion after Low-Intensity Walking in Healthy Japanese Elderly Women

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Summary. Postexercise proteinuria is a well-considered phenomenon in humans. The purpose of this study was to determine if low-intensity walking on underwater and land treadmills would induce urinary protein excretion in elderly people. Urinary protein concentration was measured on 10 healthy elderly women during the normal fasting state, both before and immediately after underwater and land treadmill walking at a speed of 2.0 Km/h for 15 min. As indicators for assessing physiological responses to the walking, we used heart rate, skin blood flow, muscle hardness, and subject judgment scores (ratings of thermal sensation, comfortable sensation, and perceived exertion). In the underwater treadmill walking, urinary protein concentration corrected for creatinine (CRE) concentration increased significantly (P = 0.013) after the walking (666 mg/gCRE) than before the walking (404 mg/gCRE), although none of the measured indicators of heart rate, skin blood flow, muscle hardness, or mean subjective judgment scores changed significantly after the walking. The increase in the corrected urinary protein concentration was attributed to the decreased urinary CRE concentration after the walking. In the land treadmill walking, however, none of the indicators significantly changed after the activity. Urinary protein excretion after underwater treadmill walking may reflect the greater resistance to movement encountered in water than on land. Although further studies applying different walking intensity are needed, the possibility that urinary protein can be used as an indicator to assess walking intensity in the elderly women could not be ruled out. Our results provide preliminary rationale for further studies on basic information for promoting walking for elderly women.

Key words— underwater treadmill, land treadmill, walking exercise, exercise intensity, urinary protein, elderly people.

INTRODUCTION

Japan is well on the way to being an aged society.[1)] In general, elderly people are recommended to engage in walking for exercise. Accordingly, knowledge of optimal walking intensity for elderly people should provide useful information for health maintenance. In recent years, in addition to walking on land, people have become aware that walking in a pool is good not only for healthy people but also for some suffering from knee and joint pain. The health benefits of underwater walking have been confirmed in these studies regarding metabolic and cardiorespiratory responses during walking and jogging in a pool.[2,3,4,5)] Although underwater treadmill walking is different from walking in a pool, the human body immersed in water floats because of the buoyancy effect. Since the rating of perceived exertion (RPE) was significantly higher in underwater treadmill walking than

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Abbreviations – HR, heart rate; CRE, creatinine.

land treadmill walking,[6] a different exercise intensity should be prescribed for walking in water or on land.

The intensity and duration of walking for health maintenance differs depending on gender, age, and personal health condition. Although a number of previous studies have reported physiological responses to underwater treadmill walking,[7,8,9] Criteria for the assessment of underwater walking for health maintenance is unclear. Elderly people tend to get insufficient exercise, leading to decreased muscle bulk, which causes a decreased basal metabolic rate, a decline in muscle strength, and a reduction in exercising.[10]

According to the National Livelihood Basic Survey in Japan in 2003, most Japanese elderly people suffer from muscle skeletal disorders such as lumbago, a stiff back, and joint aches.[11] Physical activity can help prevent these diseases and provide symptomatic relief.[12] Earlier, Gregg et al.[13] reported that increasing and maintaining physical activity levels could lengthen life for older women. This supports the idea that regular walking can advance the quality of life (QOL) or activities of daily living in elderly people. However, studies of optimal exercise intensity for elderly people have been less conclusive. Excessive physical exercise would more likely to be a chief cause of fatigue and instead to be a deterimental factor to well-being.

Heart rate (HR) is commonly used to prescribe and regulate exercise intensity. Oxygen consumption, ventilation, and other cardiorespiratory parameters also have been used as useful indicators to assess physical activity. In addition, it is reported that excessive physical activity can be evaluated by checking the amount of proteins and the components extracted in urine after exercise.[14] This finding suggests that urinary protein excretion may be induced in elderly people after walking on land. However, there is a paucity of studies on urinary protein excretion in elderly people after low- or moderate-intensity walking. We therefore examined urinary protein concentration in addition to the ordinary indicators such as HR, skin blood flow, and femoral muscle hardness to assess physiological responses to low-intensity treadmill walking in healthy elderly women. The purpose of this study was to determine if low-intensity underwater and land treadmill walking would induce urinary protein excretion in healthy elderly women.

SUBJECTS AND METHODS

Subjects

A total of 10 healthy Japanese elderly women in age who ranged from 61 to 77 years (66.5 ± 5.32 years) participated in this study. Subjects had a mean height of 1.51 m (SD 0.053), a mean body weight of 54.9 Kg (SD 6.47), a mean body mass index (BMI) of 23.8 (SD 1.64), and a mean waistband of 0.74 m (SD 0.081). No subject reported having had a recent acute illness, and all were free from chronic diseases. All subjects provided written informed consent immediately after they were informed of the purpose, procedure, and anticipated results of this study. The Ethics Committee at Niigata University School of Medicine approved our methods.

Protocol

We used an underwater treadmill (AquaCiser II, Model 100R, Ferno Japan Inc.,Tokyo) and a land treadmill (Landice 8700, Nihon Medix, Tokyo) in this study. The experiments using the treadmills were conducted at the same time on two consecutive days during the normal fasting state in the morning (8 a.m.-12 a.m.).

All subjects took a short rest for 15 min before the start of walking. After the rest, the first urine sample (before walking) was collected, and subject's judgment scores were recorded. The rating of thermal sensation (RTS) was evaluated using the following categories:[15] 1) cold; 2) cool; 3) slightly cool; 4) neutral; 5) slightly warm; 6) warm; and 7) hot. The ratings of comfortable sensation (RCS) and of perceived exertion (RPE) were evaluated as follows: for the sensation of comfort: 1) unpleasant, 2) slightly unpleasant, 3)indifferent, 4) slightly pleasant, and 5) pleasant;[16] for perceived exertion: (0) nothing at all, (0.5) very, very weak, (1) very weak, (2) weak, (3) moderate, (4) somewhat strong, (5) strong, (7) very strong, and (10) very, very strong, (X) maximal.[17] In addition, HR was measured using a heart rate monitor FS-1 (Polar Electro, Finland). Skin blood flows of the forehead and upper arm were measured at a position marked in advance using a laser-Doppler flow meter FLO-N1 (Omegawave,Inc.,Tokyo). Using a muscular hardness gauge PEK-1 (Imoto Co.Ltd.,Tokyo), femoral muscular hardness was measured at three spots for observation that were marked in advance on three determined areas between the knee and groin. These measuring devices were operated as prescribed in each manual. After the measurements, the subject moved to the room containing the underwater or land treadmills for walking, where the temperature (22-25°C) and the relative humidity (40-42%) for the underwater treadmill or the temperature (22-25°C) and the relative humidity (33-35%) for the land treadmill were controlled. Subjects walked on the underwater or land treadmills at a speed of 2.0 Km/h for 15 min. Both the speed and duration were set by the following reasons: By using an underwater treadmill, it was demonstrated that the most comfortable speed for the patients with rheumatoid arthritis or joint pain was 2.0 Km/h.[18] Older people were most adjusted to the protocol after 14 min on a land treadmill. Also,

Table 1. Changes in mean values for heart rate, skin blood flow, and femoral muscle hardness before and after underwater and land treadmill walking

	Underwater treadmill		Land treadmill	
	Before walking	After walking	Before walking	After walking
Heart rate (beats per min)	63.9 ± 6.0	66.2 ± 9.9	63.0 ± 5.8	66.4 ± 6.0
Skin blood flow (ml/min/100 g)				
Forehead	13.4 ± 3.8	13.4 ± 4.9	11.9 ± 5.9	10.7 ± 3.6
Upper arm	4.5 ± 2.0	5.4 ± 2.0	3.9 ± 0.8	3.4 ± 1.0
Femoral muscle hardness (tone)				
Inside	42.6 ± 6.0	41.0 ± 4.1	41.8 ± 4.3	42.0 ± 5.8
Center	55.0 ± 3.5	54.7 ± 2.5	56.5 ± 2.3	57.8 ± 3.5
Outside	60.9 ± 7.9	57.8 ± 3.2	59.6 ± 3.3	60.2 ± 4.5

Values are shown as the mean ± SD of 10 subjects.

Table 2. Changes in leading judgment scores

	Underwater treadmill		Land treadmill	
	Before walking	After walking	Before walking	After walking
Rating of thermal sensation (RTS)	5.0 ± 1.6	4.7 ± 1.8	5.1 ± 1.4	6.1 ± 1.4
Rating of comfortable sensation (RCS)	4.0 ± 0.9	3.9 ± 1.2	4.0 ± 0.9	4.2 ± 0.8
Rating of perceived exertion (RPE)	1.6 ± 1.0	2.2 ± 0.8	2.2 ± 0.4	2.7 ± 0.5

Scores indicate; for thermal sensation: (1) cold, (2) cool, (3) slightly cool, (4) neutral, (5) slightly warm, (6) warm, (7) hot; for comfortable sensation: (1) unpleasant, (2) slightly unpleasant, (3) indifferent, (4) slightly pleasant, (5) pleasant; for perceived exertion: (0) nothing at all, (0.5) very, very weak, (1) very weak, (2) weak, (3) moderate, (4) somewhat strong, (5) strong, (7) very strong, (10) very, very strong; (11) maximal.

Table 3. Changes in mean values for urinary protein, creatinine, and corrected urinary protein before and after underwater and land treadmill walking

	Underwater treadmill		Land treadmill	
	Before walking	After walking	Before walking	After walking
Urinary protein (mg/L)	119 ± 27	124 ± 54	98 ± 29	115 ± 38
Urinary creatinine (mg/L)	403 ± 204	238 ± 172*	293 ± 149	265 ± 119
Corrected urinary protein (mg/gCRE)	404 ± 284	666 ± 443*	421 ± 240	557 ± 381

CRE, creatinine; Urine samples were collected from 10 subjects before walking and immediately after walking. Values are shown as the mean ± SD of 10 subjects. Corrected urinary protein concentration was expressed as the value per gram of creatinine. *$p < 0.05$ (Comparison with before and after walking).

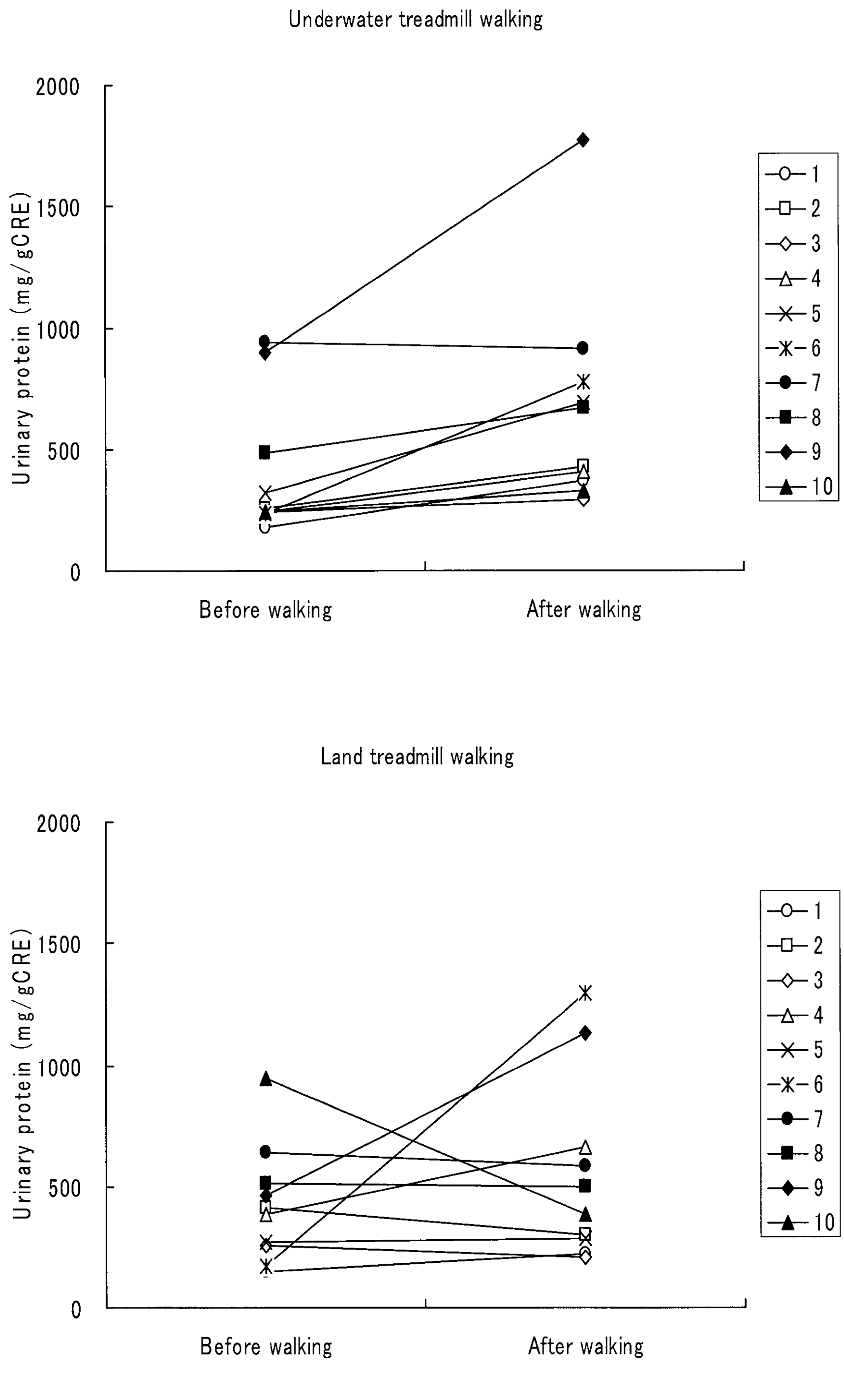

Fig. 1. Changes in the corrected urinary protein concentrations before and after underwater and land treadmill walking.

highly reliable knee joint kinematics and cadence values were achieved with 14 min of treadmill walking.[19] In the underwater treadmill walking, subjects were immersed to the level of the xiphoid process, and the water was heated to 36°C during the walking. The water temperature was selected because the rate of increase of HR compared to oxygen consumption was significantly greater at 36.1°C than 30.5°C.[3] Subjects were asked in advance to walk with a reciprocal arm swing. Immediately after walking for 15 min, the second urine sample (after walking) was collected, and after that HR, skin blood flow, and femoral muscular hardness were measured.

Assays for urinary proteins and creatinine

Total urinary protein concentration was determined using the pyrogallol red-molybdate protein assay (Micro TP-AR, Wako Pure Chemicals Co. Ltd., Osaka) and its dedicated device (Quick Run, Wako Pure Chemicals Co., Ltd.).

An automatic analyzer (Clinical Analyzer 7170, Hitachi High-Technologies Corporation, Tokyo) was used for the determination of urinary creatinine (CRE) concentration. The reagent of the enzyme assay for CRE and the calibrator were purchased the following site (Nitto Boseki Co.,Ltd.,Tokyo). We also obtained the urinary protein concentration per gram of CRE that was calculated based on the values of urinary protein and CRE (corrected urinary protein concentration).

Statistical analysis

All data were expressed as means ± standard deviation. The statistical procedures were performed using a Statistical Analysis System software (SAS Institute Inc.,Cary, NC, USA). To reveal the differences in mean values of HR, skin blood flow, and muscular hardness, urinary protein, CRE, and the corrected urinary protein, or the mean scores of leading judgments between before and after walking, we used a paired-*t* test. P values of less than 0.05 were considered to be statistically significant.

RESULTS

Table 1 shows the changes in mean values for HR, skin blood flow, and femoral muscle hardness before and after underwater or land treadmill walking. Mean values of HR after walking in water and on land increased 3.4 and 2.3 beats per minute, respectively. Although the mean value of skin blood flow after land treadmill walking decreased, those after underwater treadmill walking showed a similar value, or a slightly increased value. Mean values of femoral muscular hardness showed downward tendencies after underwater treadmill walking, or upward tendencies after land treadmill walking. However, none of the measured indicators of HR, skin blood flow, or muscular hardness changed significantly after both activities.

Table 2 shows the changes in the leading judgment scores before and after underwater or land treadmill walking. The mean scores of RTS and RCE showed a slight increase after land treadmill walking, though the values after underwater treadmill walking showed a slight decrease. The mean scores of RPE increased slightly after underwater and land treadmill walking compared with before walking. However, no significant change in either mean score was observed after both activites.

Table 3 shows the changes in mean values for urinary protein, CRE, and the corrected urinary protein before and after underwater or land treadmill walking. No significant differences in the mean concentrations were found between water and land at the two measuring points. Although no significant changes in the mean concentrations of urinary protein and CRE were found after the land treadmill walking, the corrected urinary protein concentration was significantly higher ($P = 0.013$) after the underwater treadmill walking than before the walking (Table 3 and Fig.1). This change was attributed to the decreased urinary CRE concentration after the walking.

DISCUSSION

We examined the changes in urinary protein excretion in addition to those of the ordinary indicators such as HR, skin blood flow, muscular hardness, and leading judgment scores after a low-intensity walking on underwater and land treadmills in healthy Japanese elderly women. Although the ordinary indicators did not show any significant difference after either activity, the corrected urinary protein concentration increased significantly after the underwater treadmill walking. Our findings suggest that urinary protein can be used as an indicator for prescribing walking exercise intensity.

In general, HR, oxygen consumption, cardiac output, minute ventilation, and other cardiorespiratory parameters have been used as useful indicators to assess exercise intensity. There have been significant linear relationships between HR and oxygen consumption both walking on land and in water.[8] The skin blood flow measured by laser-Doppler flowmeter decreased after the onset of exercise in a cold environment.[20] Muscular fatigue from walking in water has been shown to differ from walking on land because of water resistance, water buoyancy, water viscosity, and water friction drag.[21] Since quantitatively investigated muscle hardness is an important indicator of musculoskeletal complaints,[22] we examined the muscle hardness which seems to reflect the changes in muscle stiffness and swelling. Therefore, HR, skin blood flow, and femoral muscular hardness were selected as indicators for assessing physiological responses to the walking in this study.

No significant differences in HR, skin blood flow, or femoral muscular hardness were found between values recorded before and after the underwater treadmill walking. Whitley and Schoene[2] reported that the underwater walking HR was significantly higher than the responses from land treadmill walking. In addition, no significant differences in cardiorespiratory responses except for HR have been reported between land and underwater treadmill walking conducted under identical conditions.[18] In the present study, however, HR did not show significant differences after walking compared with before walking in water or on land. The physical activity in our study may not have been set high enough to detect the differences between the two trials. One positive explanation for the both is that no significant changes in the mean leading judgment scores were found after walking in water and on land.

We therefore have focused on urinary protein excretion after walking exercise for the following reasons. Postexercise proteinuria is a well-considered phenomenon in humans.[23,24] Poortmans and Haralambie[25] previously reported that the changes of protein concentrations excreted in urine after a 100-Km race were greater than those in serum. In addition, Sugimoto[14] has pointed out that runners should decrease the intensity or duration of exercise when total protein excretion within three h after running is more than 5000 mg/L, or other protein bands with higher molecular weight than albumin are seen three h after running. These findings and recommendations suggest that urinary protein excretion could be induced after a low-intensity walking in healthy people. However, the amount of protein excreted in urine after exercise changes the concentration according to the urinary output from the kidneys. Since the daily urinary CRE excretion is practically constant in a healthy individual basis,[26] urine volume can be corrected based on the urinary CRE concentration. For this reason, we examined not only urinary protein concentration but also urinary CRE concentration.

There were no significant differences in the mean concentrations of urinary protein, CRE, or the corrected urinary protein before and after the land treadmill walking (Table 3). In the underwater treadmill walking, however, significant differences in the mean concentrations of urinary CRE and the corrected urinary protein were found before and after the walking. Walking in water required approximately a twofold stronger energy consumption than that on land at a similar walking speed.[18] In addition, blood flow in the veins is increased by hydrostatic pressure applied to the human body, causing an increased cardiac output and a decreased HR.[21] Because a stronger exercise intensity was required on the underwater treadmill than the land treadmill at a similar walking speed,[6] our finding that urinary protein was excreted after walking on the underwater treadmill alone was a valid result. While we do not know the detailed mechanism for urinary protein excretion after the low-intensity walking on an underwater treadmill, the increase in urinary protein excretion may be due to the increased cardiac output according to the increase of the blood back-flow in the veins caused by the resistance of water. Therefore, further study should be conducted to clarify the mechanism for urinary protein excretion after the low-intensity underwater treadmill walking as well as to reveal the relationship between exercise intensity and urinary protein excretion in elderly women. The detection of the components excreted in the urine after walking on an underwater treadmill may help to clarify the mechanism.

In summary, we observed a significantly higher concentration of corrected urinary protein after the underwater treadmill walking, despite a low-intensity walking. It would be interesting to test the urinary protein excretion after a higher-intensity walking than that used in this study in healthy elderly people. The possibility that urinary protein can be used as an indicator to assess walking intensity in elderly women could not be ruled out and needs further explanation. Our results provide preliminary rationale for further studies on urinary protein as an indicator for prescribing walking intensity in elderly people.

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