



Original Article

Therapeutic efficacy of walking backward and forward on a slope in normal adults

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Abstract. [Purpose] In this study, the therapeutic effects of backward walking were examined. [Subjects and Methods] In all, 16 subjects were randomly assigned to an experimental group and 17 to a control group. All subjects walked barefoot on a treadmill (HM50EX, Daeho, Korea) for 20 min, five times per week, for a total of 4 weeks. The average gait velocity of the subjects was 3 km/h on a 10% slope. The experimental group walked backwards and the control group walked forwards. [Results] The experimental group showed significant increments in both medial-lateral and anterior-posterior balance, step length, and velocity compared with the pre-intervention results. In addition, the control group showed significant increments in anterior-posterior balance and velocity compared to the pre-intervention results. Significant differences in post-training gains in anterior-posterior balance, step length, and velocity were observed between the experimental and control groups. [Conclusion] Backward walking positively affected gait and balance ability after intervention.

Key words: Backward walking, Adult, Slope

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INTRODUCTION

Independent functioning is at the core of successful aging, and independent mobility is critical to independent function. Exercise is recommended for older adults because it promotes physical and mental health, may improve mobility, and prevents walking difficulties¹⁾. Walking places demands on the musculoskeletal (the muscles, bones, and joints), cardiopulmonary (the heart and lungs), and nervous (the brain, spinal cord, and peripheral nerves) systems¹⁾.

Such persistent walking exercises not only prevents lifestyle diseases such as hypertension, arteriosclerosis and diabetes, but also aids their treatment while also improving the potential positive effects such as improved pulmonary function, stronger immunity, enhanced muscle strength, higher bone density, stress reduction, and better emotional stability.

Balance has been defined as the ability to maintain one's equilibrium as the center of gravity shifts (dynamic balance e.g. walking and running), and while the center of gravity remains stationary (static balance e.g. standing or sitting)²⁾.

Balance can be largely divided into static balance and dynamic balance. Static balance refers to the ability to maintain the center of gravity within the base of support during the stationary phase, while dynamic balance refers to the ability to maintain the center of gravity within the base of support during movement. Dynamic balance ability is closely associated with walking; hence, its loss weakens a person's ability to appropriately respond to different environments and tasks³⁾. According to previous studies that compared forward and backward walking, backward walking was reported to stimulate muscles in the lower limbs more than forward walking⁴⁾. In addition, it contributed to improved gait ability as it increased the strength of knee joints and activities of the quadriceps. Recently, such effects have been manifested through the application

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of various approaches such as walking exercises on treadmill and flat land, backward walking exercises, and robot-assisted walking exercises in stroke patients with hemiplegia to improve gait and balance ability⁴). Moreover, a variety of studies on forward walking have been conducted to improve gait and balance ability. However, little research has been carried out to determine the therapeutic effects of backward walking. Therefore, the present study aimed to examine the effects of forward and backward walking on gait and balance ability.

SUBJECTS AND METHODS

In all, 33 healthy subjects without a history of orthopedic surgery were selected, and the study was conducted after consent for participation was obtained for this study. All procedures were reviewed and approved by the Institutional Ethics Committee of Eulji University Hospital. In all, 16 subjects were randomly assigned to the experimental group and 17 subjects to the control group. Subject's average age, height, and weight in the experimental and control groups were 21.45 ± 2.12 and 20.15 ± 1.07 years; 176.54 ± 11.05 and 174.12 ± 7.38 cm; and 77.05 ± 6.21 and 72.11 ± 7.62 kg, respectively. Sufficient explanation of this study's intent and the overall purpose was given, and voluntary consent for participation in this study was obtained from all subjects.

Subjects walked for 1 min to determine their natural gait velocity before the experiment, and all subjects walked barefoot on a treadmill (HM50EX, Daeho, Korea), for 20 min, five times per week, for a total of 4 weeks. The average gait velocity was 3 km/h on a 10% slope. The experimental group walked backward and the control group walked forward.

After the intervention, equipment to measure balance (Good Balance, Metitur, Finland) was used to quantitatively measure balance ability. To measure balance functions, the subject was instructed to stand on a triangular platform and maintain a symmetric standing posture with the legs shoulder-width apart. A fixed visual point was marked in front to minimize head movements. The arms were placed comfortably by the sides of the hip joint and the center of pressure (COP) was measured for 30 s in this posture with the eyes open. The COP was measured three times and the average value was calculated.

A pedometer (Gait Rite, K634-DB, Epson Inc., USA) was used to collect data for temporo-spatial gait characteristics such as velocity, step length, stride length, single support, double support and cadence of the experimental and control groups. For precise analysis of gait, the subjects were asked to walk along a 2 m-long walkway for three sessions, and the average values were used. The subjects, with heads lifted and looking straight ahead, walked barefoot while lightly shaking their upper arms⁵).

Data analysis was performed using SPSS version 20.0 (SPSS Inc., Chicago, IL, USA). Mean and standard deviation (SD) were calculated for each variable. Before the intervention, differences in the general characteristics of the experimental and control groups were compared using independent t-tests. Comparisons of variables before and after training within each group were made using paired sample t-tests. Comparisons of pre- and post-test differences in variables between the experimental and control groups were performed using the independent t-test. Intergroup effect sizes were calculated using Cohen's d coefficient⁶). An effect size <0.2 reflects a negligible mean difference; $0.2-0.5$, a small difference; $0.5-0.8$, a moderate mean difference; and >0.8 , a large difference. Statistical analysis was performed at a 95% confidence level, and p values <0.05 were considered statistically significant.

RESULTS

No significant differences in the baseline characteristics were observed between the two groups ($p>0.05$) (Table 1). Thirty-three subjects (experimental group=16, control group=17) completed this experiment. The experimental group showed sig-

Table 1. Characteristics of the experimental and control groups, with values presented as mean (standard deviation)

	EG (n=16)		CG (n=17)	
	Pre-test	Post-test	Pre-test	Post-test
Balance				
Medial-lateral (mm/s)	147.0 (41.6)	138.1 (38.6)*	142.1 (36.4)	138.8 (35.2)
Anterior-posterior (m/s) ^a	188.2 (39.1)	180.5 (36.2)*	183.4 (37.2)	179.6 (43.6)*
Gait				
Step length (cm) ^{a,b}	55.4 (6.4)	59.9 (7.3)*	55.2 (5.2)	57.1 (6.7)
Velocity (m/s) ^{a,b}	84.6 (4.3)	94.5 (5.2)*	78.3 (4.2)	82.3 (3.2)*
Double support (%)	16.9 (9.4)	20.3 (8.1)	17.5 (7.2)	19.8 (8.7)
Cadence (steps/min)	101.4 (13.2)	108.4 (12.4)	81.6 (11.2)	84.5 (15.2)

EG: experimental group; CG: control group

^aSignificant difference in gains between two groups, $p<0.05$.

^bEffect size greater than 0.80.

nificant increments in medial-lateral and anterior-posterior balance, step length, and velocity compared to the pre-intervention results ($p<0.05$). In addition, the control group showed significant increments in anterior-posterior balance and velocity compared to the pre-intervention results ($p<0.05$). Significant differences in post-training gains in anterior-posterior balance, step length, and velocity were observed between the experimental and control groups ($p<0.05$). The effect size for gains in the experimental and control groups was very marked in step length, and velocity (effect size=0.82, 0.91, respectively).

DISCUSSION

Backward walking exercise has been the point of interest in many studies⁷). Furthermore, this exercise can minimize the burden on joints and increase muscle strength in the lower limbs. In addition, this exercise does not cause adverse effects on the body through the stimulation of the major muscle in a rhythmic and dynamic fashion. This exercise does not require any special tools or equipment, which makes it effective and safe to reduce health risks.

The present study investigated the effects of forward and backward walking on gait and balance ability of healthy subjects. According to the research findings, backward walking has positive effects on gait and balance ability. Previous studies have reported that backward walking reduced step length and improved gait speed, indicating that it was an effective to increase the endurance of lower limbs⁸).

The findings of the present study are in line with previous research findings. According to another comparison study, backward walking stimulated muscles in the lower limbs and showed higher energy consumption in the lower limbs when combined with knee flexion and hip extension⁹). In addition, greater activity of the quadriceps during backward walking as well as increased stability in the stance phase of walking was reported with this intervention¹⁰).

As for the mechanism of walking, backward walking has less impact on the kneecaps and patello-femoral joints as the metatarsal joints come in contact with the surface first. However, forward walking has a relatively greater impact on the ankle and knee joints since walking is only possible with flexion of the knee or hips because ankles show minor movement. Even though backward walking is not practiced in day-to-day life, it is effective in stimulating muscles of the knee joints and quadriceps in a more balanced manner¹¹). Therefore, it appears that people who complain of pain in the knees may note some positive therapeutic effects with backward walking exercise.

The present study has limitations, as the intervention period was too short to generalize the effect of backward walking. In addition, there has been no post-study follow-up of the participants; moreover, there were a small number of participants. Therefore, more significant results will be noted in future studies if the intervention period is extended and environmental factors are accounted for more thoroughly. In addition, in order to prevent monotony while performing backward walking alone, a walking exercise program that combines forward and side walking would be necessary.

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