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Original Article

Effects of running in place accompanied by abdominal drawing-in on gait characteristics of healthy adults

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Abstract. [Purpose] This study was conducted to investigate the effects of running in place accompanied by abdominal drawing-in on the gait characteristics of healthy adults. [Subjects] The total number of subjects was 30, and 15 were randomly placed in the training group (TG) and 15 in the control group (CG). [Methods] To determine the gait characteristics of TG and CG, step length difference (SLD), stance phase difference (STPD), swing phase difference (SWPD), single support difference (SSD), and step time difference (STD) were evaluated using OptoGait, a gait analysis system. [Results] When the pre-intervention and post-intervention results of TG and CG were compared, statistically significant differences in SLD, SWPD, SSD, and STD of TG were found. [Conclusion] Running in place accompanied by abdominal drawing-in might help reduce the deviation between left and right gait variables during walking.

Key words: Running in place, Abdominal drawing-in, Gait characteristics

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INTRODUCTION

Walking is the most frequent movement in the daily lives of humans, and stable walking is a basic element of a healthy and pleasant life[1)]. Maintaining stability is most important in moving the body forward through repeated use of the legs[2)]. The muscles of the hip joint are responsible for stabilizing the pelvic and lumbar regions and play an important role in kinematic control during walking[3)].

The increased incidence of a sedentary lifestyle and the lack of exercise among modern people has resulted in an increased incidence of back pain, and a habitual sedentary lifestyle decreases abdominal muscle strength and increases the degree of body imbalance[4)]. An excessive biomechanical load on the lumbar area can induce pain in the lumbar region, due to abdominal muscle atrophy and weakening, and spinal joint instability, and decrease joint endurance, flexibility, and range of motion[5)]. Lumbar muscle weakness and imbalance are major factors in reduced exercise performance, and strengthening the muscles in the lumbar region reportedly facilitates efficient functioning of the upper and lower body[6)].

Back pain decreases an individual's walking speed and pain-related gait disturbances typically appear association with in back pain[7)]. The walking characteristics of patients with back pain include decreased walking speed and an asymmetrical gait posture[8)]. To prevent and treat these conditions, strength training and stabilization exercises are performed, including mat, ball, and sling exercises, and plyometric and circuit training. Ultimately, the purpose of stabilization exercises is to recover movement control and balance by increasing spinal and pelvic stability during functional posture and movement[9)].

To increase the exercise performance rate, an exercise that can easily be performed by anyone is needed. Walking is a simple exercise with a low probability of injury that requires no special technique and can be performed by anyone[10)]. However, walking is a representative aerobic exercise, and improper walking form with body imbalance may cause pain. Therefore, in this study, we investigated the effects of running in place accompanied by the abdominal maneuver, a basic stabilization exercise, on gait characteristics.

SUBJECTS AND METHODS

This study selected 30 male and female college students who were randomly assigned to either the training group (TG) (male, 2; female, 13), which performed a walking in place exercise, or the control group (CG) (male, 2; female, 13), which did not perform the walking in place exercise. The selection criteria included people with no spinal abnormality, lumbar pain, or neurological disorders, who did not drink before the experiment, and who were neither overweight nor taking medicine. People who regularly performed weight training or other exercises were excluded, because these exercises may affect gait characteristics. This

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study was approved by the Korea Nazarene University's Institutional Review Board and the subjects were safely protected throughout the experiment. All of the subjects understood the purpose of this study and provided their written informed consent prior to participating in accordance with the ethical principles of the Declaration of Helsinki.

The mean age, height, and weight of the TG participants in this study were 21.5±0.5 years, 162.4±7.1 cm, and 55.4±6.7 kg, respectively, while those of the CG participants were 20.5±0.8 years, 163.3±4.9 cm, and 57.6±9.2 kg, respectively. Sex data were analyzed using the χ^2 test, while age, height, and weight data were analyzed using the independent t-test. There were no intergroup differences ($p>0.05$).

To maintain posture during the running in place exercise, the students were placed at the very center of a marked 30-cm square space. The waist was straightened and subjects' the gaze was directed to the front. The jaw was withdrawn to maintain the cervical spine in the neutral position and the transverses abdominis and multifidus muscles were contracted using the abdominal drawing-in maneuver to maintain the waist and pelvis in the neutral position. The participants' feet were positioned 10 cm apart and one knee was bent 90° and elevated to reach the hip joint; the elbow opposite to the elevated leg was bent 90° and elevated to eye level. Participants ran with arms and legs crossed in the sagittal plane, and the procedure was repeated for a set number of times. While exercising, the subjects were advised to maintain their posture with minimum deviation in all directions (left and right or to and fro) within the restricted space. A total of three exercise sets were performed, and each set consisted of 20 times running in place, a 15-s rest, 20 times running in place, a 15-s rest, 30 times running in place, a 20-s rest, 30 times running in place, a 20-s rest, and 30 times running in place. The rest between sets was 3 min long and one performance time was defined as when both feet touched the ground. Each participant made 17 running motions every 10 s. To apply the optimal exercise intensity setting for the students and to increase the load during the total 6-week exercise program, two sets were performed in the first and second week, and three sets were performed in the third to sixth weeks. A 5-min light stretching exercise was performed before and after the exercise sets. One 30-min round of exercise was performed three times a week for 6 weeks. The CG participants did not perform any particular exercise and they were assessed twice at the beginning and end of the exercise intervention.

Gait analysis was performed using the OptoGait gait analysis system (Microgate Italy, Bolzano-Bozen, Italy), a device consisting of an optical detection system. The transmitter bar has 96 light-emitting diodes (LEDs) that communicate in the infrared spectrum, the receiver bar, which is positioned opposite it, has the same number of LEDs. The transmitter and receiver bars of the OptoGait were installed on both sides of a treadmill. Communication between the bars is blocked by the subjects' movements during walking, and the interference is used to derive the step length difference (SLD), stance phase difference (STPD), swing phase difference (SWPD), single support difference (SSD), and step time difference (STD) are evaluated. Using a data capture rate of 1,000 transmissions/receptions per second, running, a series of jumping tests, or the time on the ground or in the air can be accurately measured. From these basic data, the software analyzes the data measured in real time in a series of movements. The data collected by the OptoGait uses the differences in gait variables between the left and right legs; the smaller the difference, the greater the stability and balancing ability.

Table 1. Comparison of pre- and post-intervention SLD, STPD, SWPD, SSD and STD in each group (mean±SD) (unit: SLD-cm, STPD, SWPD, SSD, STD-%)

Category	Group	Pre-intervention	Post-intervention
SLD	Training group*	3.4±1.5	1.6±0.8
	Control group	3.5±3.8	3.2±2.1
STPD	Training group	2.7±2.9	1.1±0.9
	Control group	2.2±1.5	2.6±1.4
SWPD	Training group*	3.0±1.8	1.8±0.8
	Control group	2.7±1.7	3.2±2.9
SSD	Training group*	3.3±2.3	1.5±1.0
	Control group	2.8±1.8	3.0±2.1
STD	Training group*	3.2±1.9	1.9±1.0
	Control group	3.4±1.6	3.0±1.9

* $p<0.05$; SLD, step length difference; STPD, stance phase difference; SWPD, swing phase difference; SSD, single support difference; STD, step time difference

The collected data were statistically processed using SPSS 12.0 KO (SPSS, Chicago, IL, USA). The paired t-test was used to test the significance of the differences between before and after the experiment in each group, and the independent t-test was used to test the significance of the differences between the two groups. All data are shown as means and standard deviation, and the significance level, α, was chosen as 0.05.

RESULTS

When pre- and post-intervention values of TG and CG were compared, SLD, SWPD, SSD, and STD of subjects in the TG were significantly different, but no significant difference in any parameter was found in the CG ($p<0.05$) (Table 1).

When pre-intervention, post-intervention, and the change between pre- and post-intervention of TG and CG were compared, there were no significant differences in any of the pre-intervention parameters; however, post-intervention SLD, STPD, and SSD values were significantly different, and the pre- and post-intervention changes in STPD, SWPD, and SSD values were also significantly different between the two groups ($p<0.05$) (Table 2).

DISCUSSION

The waist is the center of the body. During functional movements, it enables the body to assume a new posture

Table 2. Comparison of SLD, STPD, SWPD, SSD and STD between the training group and control group (mean±SD) (unit:SLD-cm, STPD, SWPD, SSD, STD-%)

	Category	Training group	Control group
Pre-intervention	SLD	3.4±1.5	3.5±3.8
	STPD	2.7±2.9	2.2±1.5
	SWPD	3.0±1.8	2.7±1.7
	SSD	3.3±2.3	2.8±1.8
	STD	3.2±1.9	3.4±1.6
Post-intervention	SLD*	1.6±0.8	3.2±2.1
	STPD*	1.1±0.9	2.6±1.4
	SWPD	1.8±0.8	3.2±2.9
	SSD*	1.5±1.0	3.0±2.1
	STD	1.9±1.0	3.0±1.9
Change between pre- and post-intervention	SLD	1.7±1.9	0.3±3.8
	STPD*	1.5±3.1	−0.3±1.6
	SWPD*	1.1±1.9	−0.4±2.5
	SSD*	1.8±2.6	−0.1±2.0
	STD	1.2±1.9	0.4±2.5

* $p<0.05$

with smooth movement of the center in preparation for the movement of the arms and legs against gravity[11]. In particular, when there is a problem in the lumbar region, the walking speed decreases and an asymmetric gait posture develops[8], suggesting that stability of the body center has a large impact on limb movement. Judge et al.[12] reported that muscle strengthening exercises, stretching, and balance exercises improve muscle strength and walking speed. Brill et al.[13] reported that the walking time and number of steps after exercise improved by 3.9% and 13.6% in elderly individuals, respectively. The abdominal drawing-in method effectively stabilizes muscles in the lumbar region, including the transversus abdominis[14, 15], and running in place, which is similar to plyometric exercise, effectively activates the muscles around the hip joint[3].

In this study, we observed a remarkable reduction in the differences in the gait characteristics of the left and right legs in TG compared with those in the CG, which suggests that the combination of dynamic lumbar stabilization exercises and upper and lower extremity movements improved subjects' stability and balancing ability. Panjabi[16] emphasized the importance of lumbar stabilization exercise in correcting a disturbed gait, and Topp et al.[17] asserted that a muscle strengthening program effectively improves stable walking speed and balancing capability. In addition, approximately 80% of the time used for walking is occupied by the body being supported on one foot. The alternating style of one-foot standing seems to be an important factor in balancing the trunk, and Grabiner et al.[18] reported that trunk muscle strength is an important factor in gait stability.

In conclusion, running in place accompanied by the abdominal drawing-in technique helps lumbar stabilization, strengthens and activates the muscles around the pelvis and hip joints, and seems to have a positive effect on gait symmetry.

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