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Original Article

Effects of orthosis on balance and gait in healthy adults

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Abstract. [Purpose] This study evaluated the effects of an oral orthosis that can change body alignment on the balance ability and gait of healthy adults. [Subjects and Methods] The subjects of this study were 21 University students. A gait analyzer was used to analyze the subjects' balance ability and gait quality. Two walking speeds were used: 2 km/h, a comfortable speed, and 4 km/h, a slightly faster walking speed. [Results] The step length, and base of gait at 2 km/h differed significantly after the intervention. The total step time and step length increased significantly after the intervention. Furthermore, the total base of gait decreased significantly after the intervention. The step times of the left lower limb at 4 km/h differed significantly after the intervention. [Conclusion] The oral orthosis tested positively affects the balance ability and gait of healthy adults.
Key words: Orthosis, Balance, Gait

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INTRODUCTION

As gait is a natural motion, people generally do not pay special attention to it. However, gait is a very complex process involving the nervous system and skeletal muscles. Gait is defined as a sequential and repetitive movement in which one leg moves the body ahead while the other leg maintains a stable condition in the stance phase. Furthermore, gait motion is a complex movement enabled by the coordination of the skeletal muscles with many joints in the arms and legs[1)].

Gait balance is divided into static and dynamic stability. In static stability, muscle activity and joint positions are controlled to maintain the body's center of gravity on the support surface. Meanwhile, in dynamic stability, the center of gravity and selective muscles are adjusted to maintain a normal walking speed. Gait is essential for the safe independent performance of daily movements. Furthermore, the lower limbs must be symmetrical for balanced gait; asymmetry is clinically important, because it is associated with poor outcomes[2)].

Gait is influenced by many bodily, social, and psychological factors. Pathological gait can occur because of disease. Therapeutic interventions have recently been applied during rehabilitation to treat abnormal gait patterns. Brain plasticity-based gait rehabilitation has been emphasized, because it is believed to change the brain structure through the application of orthoses and exercise therapy[3)].

Many studies on the effects of orthoses on the gait of healthy individuals and patients have been conducted worldwide. Lee and Lee investigated the effects of foot orthoses on the gait and task performance of children with cerebral palsy[4)]. Lee et al. examined the effects of orthoses that limit the movement of knee joints on the balance and gait of patients with hemiplegia[5)]. However, most of these studies analyzed gait by using orthoses applied to the lower limbs. This study investigated the effects of an oral orthosis that can change body alignment and muscular activity via brain plasticity on the gait of healthy adults.

SUBJECTS AND METHODS

Subjects

The subjects were 21 students from Kyungdong University. They were normal adults who had no problems in activities of daily living or orthopedic diseases that made walking difficult, or participated in any regular exercise programs within the previous 3 months. Those with a history of heart failure, neurological diseases, or psychiatric disorders; taking psychotropic drugs; or who vomited or experienced dizziness were excluded. The subjects were provided an explanation about the purpose and methods of this study. All subjects understood the purpose of this study, and provided informed consent prior to participation in accordance with the ethical standards of the Declaration of Helsinki.

Methods

An oral orthosis (Self Face22, G&G Beauty+, Korea) was applied to the subjects as described previously (Fig. 1). The orthosis was worn for five minutes before the experiment to allow the subject to adapt to the product. The subjects

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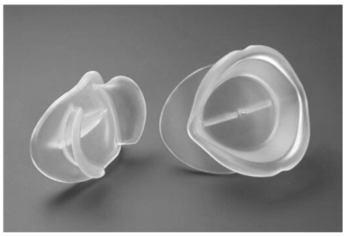

Fig. 1. Oral orthosis (Self Face22, G&G Beauty+, Korea)

were subsequently allowed to rest for 30 minutes. To apply the Self Face22, the subjects naturally locked their fingers together and found which thumb came up was on top. If the left thumb was on top, the subject was instructed to bite the product with his/her mouth, with the letters "A" and "B" on the product on his/her left side and vice versa. After the Self Face22 was applied depending on the subjects' hand dominance, the positions of their lips and mouth were corrected.

With the Self Face22 in their mouth, the subjects were instructed to fix their upper teeth with their fingers, bite the product with their lower teeth, and suck the product while blocking the hole at the center of the product with their finger, pressing down on the product, and clamping their mouth shut by straining their lips. After sucking as much as possible, they held their breath for 10 seconds, exhaled, and took a 10-second rest. The subjects were instructed to move their chest up for thoracic breathing during suction for 5 minutes. The researchers ensured the subjects used the orthosis correctly.

A gait analyzer was used to analyze the subjects' gait. Two walking speeds were used: 2 km/h (a comfortable speed) and 4 km/h (a slightly faster walking speed). After the subjects were instructed to comfortably walk on the gait analyzer, gait data were collected for 10 seconds. Balance between the two lower limbs, step time, step length, and base of gait were measured for gait analysis. In addition, the totals of both lower limbs for step time, step length, and base of gait were evaluated. Measurements were made before and after the intervention.

For data analysis, descriptive statistics were used to examine the subjects' general characteristics. A paired t-test was used to compare the data before and after the intervention. SPSS version 20.0 was used for statistical analysis, and the level of significance level was set at $p < 0.05$.

RESULTS

Left and right balance during gait at 2 km/h did not change significantly after the intervention. However, step time, step length, and base of gait during gait at 2 km/h differed significantly after the intervention ($p < 0.05$). The step time of the right lower limb increased significantly after the intervention, while the step length of both limbs increased significantly. Furthermore, the base of gait of the left lower limb decreased significantly after the test (Table 1).

All gait parameters of both lower limbs combined during gait at 2 km/h differed significantly after the intervention ($p < 0.05$) (Table 2). The total step time and length increased significantly after the intervention. Furthermore, the total base of gait decreased significantly after the intervention.

Table 1. Left and right balance and gait parameters during gait at 2 km/h

	Side	Pre-intervention	Post-intervention
Balance	Left	53.48 ± 9.74	54.38 ± 5.09
(%)	Right	46.52 ± 9.74	45.62 ± 5.09
Step time	Left	0.52 ± 0.21	0.49 ± 0.12
(s)	Right*	0.49 ± 0.24	0.65 ± 0.27
Step length	Left*	386.49 ± 62.11	424.85 ± 66.22
(mm)	Right*	400.32 ± 84.74	437.61 ± 85.08
Base of gait	Left*	168.65 ± 68.70	118.62 ± 49.65
(mm)	Right	173.23 ± 66.75	129.54 ± 65.34

Data are mean ± SD, *$p < 0.05$

Table 2. Gait parameters of both lower limbs during gait at 2 km/h

	Pre-intervention	Post-intervention
Total step time (sec)*	1.01 ± 0.19	1.15 ± 0.21
Total step length (mm)*	786.81 ± 132.88	862.45 ± 132.17
Total base of gait (mm)*	341.88 ± 130.29	248.17 ± 105.96

Data are mean ± SD, *$p < 0.05$

Left and right balance during gait at 4 km/h did not differ significantly after the intervention. However, the step times of the left lower limb during gait at 4 km/h differed significantly after the intervention ($p < 0.05$). The step time of the left lower limb increased significantly after the intervention. However, no other gait parameter differed significantly after the intervention (Table 3).

There were no significant changes in any gait parameter during gait at 4 km/h after the intervention ($p > 0.05$) (Table 4). Although the differences in the total step time and length were not significant, they tended to increase after the intervention. Furthermore, the total base of gait tended to decrease after the intervention.

DISCUSSION

The number of individuals with disabilities is expected to increase because of increasing injuries and disorders due to traffic accidents, industrial disasters, and environmental pollution caused by rapid industrialization. Orthoses are generally used to address clinical issues such as pain, muscle fatigue, balance, joint stability, and muscle weakness. As gait disturbance due to injuries and disorders can have adverse physical, physiological, and psychological effects on patients and their families, normal gait should be achieved by using methods such as orthoses and therapeutic interventions[6].

Gait analysis is mainly used to assess and quantify the effects of therapeutic or surgical interventions on healthy adults and patients. Clinical trials demonstrate how patients' gait follows a normal flow after an intervention, and special patterns of changes in gait can be quantified through gait

Table 3. Left and right balance and gait parameters during gait at 4 km/h

	Side	Pre-intervention	Post-intervention
Balance	Left	51.48 ± 5.81	50.86 ± 4.67
(%)	Right	48.52 ± 5.81	49.14 ± 4.67
Step time	Left*	0.37 ± 0.16	0.45 ± 0.12
(s)	Right	0.55 ± 0.25	0.49 ± 0.24
Step length	Left	462.81 ± 89.31	482.47 ± 95.43
(mm)	Right	474.28 ± 70.55	488.87 ± 88.11
Base of gait	Left	102.47 ± 61.35	79.70 ± 50.67
(mm)	Right	117.64 ± 73.56	100.80 ± 68.53

Data are mean ± SD, *$p < 0.05$

Table 4. Gait parameters of both lower limbs during gait at 4 km/h

	Pre-intervention	Post-intervention
Total of step time (sec)	0.91 ± 0.19	0.94 ± 0.53
Total step length (mm)	937.09 ± 156.81	971.34 ± 174.09
Total base of gait (mm)	220.12 ± 132.90	180.50 ± 114.91

Data are mean ± SD, *$p < 0.05$

analysis[7]. Most studies using gait analysis have evaluated the surgical prognosis and effects of therapeutic interventions[8].

The demand for commercial orthotic devices and tools has been increasing sharply. Such products assist not only people with disabilities in their lives, but also healthy individuals performing daily living and leisure activities. In particular, orthotic tools improve quality of life and prevent disease[9]. Bani et al. investigated changes in gait through the use of ankle orthoses after neurological injuries[10]. After wearing the orthoses, the patients exhibited significant increases in walking speed and stride length. Spaich et al. examined the effects of combined treatment with gait orthosis and functional electrical stimulation on foot drop; they report that the combination treatment significantly increased the mean swing phase and mean ankle angle[11]. Furthermore, Tommaso et al. investigated the effects of an intraoral orthosis on patients with chronic tension headache and report that the orthosis as well as drug administration reduced headache[12]. Moreover, Jung et al. report that a mouth guard significantly improves the muscle strength and endurance of the lower limbs in healthy individuals[13]. These studies collectively suggest orthoses positively affect the gait of both healthy individuals and patients with various diseases.

The present study evaluated the balance, step time, step length, and base of gait of healthy subjects on a treadmill (at 2 and 4 km/h) while wearing an oral orthosis. At 2 km/h, no significant changes were observed in the balance between the lower limbs. However, the step length of both lower limbs increased significantly after the intervention, whereas the base of gait of the left lower limb decreased significantly. Increased step length increased corresponds to the qualitative component of gait; this is due to enhanced muscular strength and endurance of the lower limbs caused by the application of an oral orthosis. Meanwhile, the gait base decreased because of the improved balance ability. Menotti et al. studied the effects of an orthosis on muscle endurance and found the orthosis decreased energy consumption during walking, which increased walking distance[14].

The total step time, step length, and base of gait of both lower limbs at 2 km/h differed significantly after the intervention. The significant increases in total step time and step length likely occurred because the position alignment and coordinated contraction of adjacent muscles required for normal gait occurred when stimuli from the oral orthosis was delivered to the brain nerves. Zissimopoulos et al. report the application of an orthosis significantly improves the balance ability of patients with chronic stroke[15].

The total base of gait decreased significantly after the intervention. The onset of a disease generally increases the base of gait. In clinical settings, the base of gait is an important gait-related item when assessing the effects of a therapeutic intervention. A very important finding of the present study is the significant decrease in the base of gait during gait at 2 km/h, a common walking speed, after the intervention. In other words, the results indicate training with an oral orthosis positively affects the gait of healthy adults.

However, the number of subjects in this study was small, and the intervention time was short. Furthermore, as the subjects were healthy adult students, it is difficult to generalize the findings to other populations. Future studies should apply similar interventions for longer periods in patients with diseases such as back pain, stroke, cerebral palsy, and shoulder joint impact syndrome. Finally, the findings of this study will be useful as basic data for future studies.

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