Effects of shoe-type walking assistive device for the blind on gait characteristics: a pilot study

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Abstract: - Until now, shoe-type walking assistive device for the blind have not been fully studied. Accordingly, in this study, the gait characteristics were analyzed by comparing the differences in the foot pressure, number of collisions, and required time between when walking with the white cane and walking with shoe-type walking assistive device. Ten male subjects were instructed to walk on the experimental area which was composed of obstacles randomly. The foot pressure data were analyzed by the mean force and it was divided into four regions such as whole foot, forefoot, midfoot and rearfoot region. The number of collisions and required time was also measured during walking. In the results, the foot pressure in the forefoot regions on both sides decreased significantly while that in the rearfoot region on left side only increased when walking with shoe-type walking assistive device. In addition, the required time increased significantly when walking with shoe-type walking assistive device. From the results of this study, we suggests shoe-type walking assistive device for the blind may influence positively on gait of users by reliving high pressure of the foot during walking.

Key-Words: - Blind people, shoe-type walking assistive device, gait characteristic, foot pressure, white cane

1 Introduction

Most of the blind people have difficulty walking due to a lack of visual information [1]. People who are blind can walk around and cross streets using various walking assistive devices [2]. To improve the quality of life for the blind, walking independently with a walking assistive device is necessary. The walking assistive device transform visual information into auditory or tactile information [3-5]. The most commonly used walking assistive device for blind is a white cane.

The white cane, which is a symbol of blindness, has been designed simply considering usability. It is swept from side to side in an arch in front of the user for detecting obstacles and proving mobility support while walking. However, the white cane has some disadvantages as it can cause body asymmetry and muscle fatigue around the wrist by repeated patterns.

To solve these problems, various types of walking assistive devices for blind such as the shoes, glasses, a cap, and belt have been developed [6]. Although shoe-type walking assistive device is more efficient in detecting obstacles on low position and improving body balance while walking than other types of walking assistive devices, researches on the gait characteristics while walking with shoe-type walking assistive devices have not been performed enough not yet.

Therefore, in this study, the gait characteristics were assessed using shoe-type walking assistive device with infrared distance sensors and buzzers for the blind which was developed to solve disadvantages of the white cane.

2 Methods

2.1 Subjects

The present pilot study was conducted to evaluate the effects of shoe-type walking assistive device on gait characteristic during walking. Therefore, ten male volunteers with normal eyes were selected in this study. The mean age, height, and body weight were 22.7±2.5 years, 174.3±5.7 cm and 72.4±8.1 kg, respectively. The blindfold was used to remove visual information. Exclusion criteria were history of injury in the musculoskeletal system, low back pain, and gait abnormalities. All participants were informed a full explanation with respect to the protocol and provided written consent prior to their participation. This study was approved by Institutional Review Board of Chonbuk National University.

2.2 Device design

The shoe-type walking assistive device was manufactured in this study. This device was designed to transform~~ation~~ visual information into auditory information. It consists of shoes, infrared distance sensors, Genuino 101s, servo motors, buzzers, and battery packs, as shown in Fig. 1. The infrared distance sensors, Genuino 101s and servo motors were attached to the front upper of the shoes. The infrared distance sensors were used to detect obstacle on the ground. The genuine 101 was utilized to calculate the differences between foot direction and walking direction. And then, it was adjusted using the servo motors. As shown in Fig. 2, the information distance between user and obstacle was delivered with the changing sound from the buzzers according to distance. The range of detecting distance was set at 2 meters which is similar to the length of the white cane. A detailed specifications of the module is shown in Table 1.

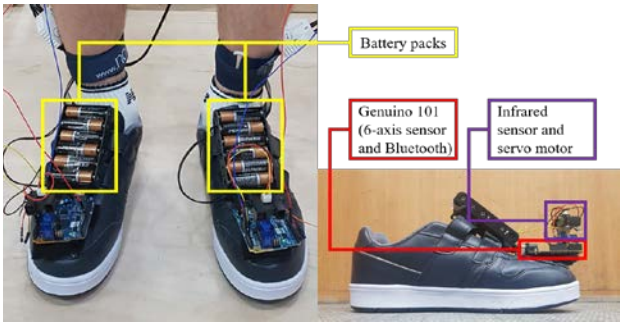

Fig. 1. Designed shoe-type walking assistive device

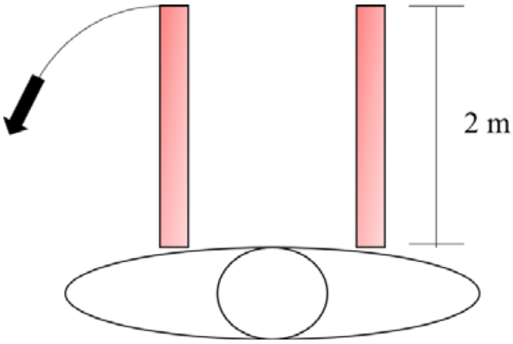

Fig. 2. Detecting direction and distance

2.3 Experimental procedure

As shown in Fig. 3, experimental area with length 11 m and width 8 m was designed for this study. In this area, the obstacles with small size were placed randomly.

All subjects were asked to walk on the corridor under two conditions: walking with the white cane and walking with the shoe-type walking assistive device. It was repeated for 3 times in all sections. To evaluate the effect of walking assistive device on gait characteristics, the foot pressure was assessed by Pedar-X system (Novel Gmbh, Munich, Germany). This system composed of 99 capacitive sensors (sampling rate with 50 Hz) and data were transmitted to a computer using a Bluetooth connection. In addition, the required time and number of collisions were measured using the smartphone's stopwatch.

Table 1. Specifications of the used modules

Classification	Manufacturer	Model name	etc.
Infrared distance sensor	SHARP, Japan	GP2Y0A710K0F	Size : 58×17.6×22.5 mm Weight : 11g Distance measuring range : 100 to 550 cm
Buzzer	GEC	GEC09D	Size: 9mm(D)x4mm(H) Weight : 0.8g Min. Sound Output at 10cm : 86 dB
MCU	Arduino	Genuino 101	Size : 68.6×53.4 mm Weight : 34g Clock Speed : 32MHz

Fig. 3. Designed experimental area

2.4 Data analysis
The foot pressure data was analyzed by the mean force. And, it was divided into four regions of the foot such as whole foot, forefoot, midfoot, and rearfoot.

Statistical analysis was performed using SPSS 12.0 (IBM Corp, Chicago, USA). Normality Shapiro-Wilk test was conducted for normality of all variables. Differences in the foot pressure between the left and right sides were compared by Wilcoxon signed-rank test. All measured variables between walking with the white cane and walking with shoe-type walking assistive device were analysed using Mann-Whitney U test. The level of significance was at $p < 0.05$.

3 Results
3.1 Foot pressure
Fig. 4 shows the differences in the foot pressure between when walking with the white cane and walking with shoe-type walking assistive device. The force more increased significantly when walking with the white cane than walking with shoe-type walking assistive device in both L_forefoot and R_forefoot region ($p = 0.000$ and p 0.007, respectively). However, significant difference in the force between two types of walking assistive devices was only presented in L_rearfoot region ($p = 0.001$). In the whole foot and midfoot regions, there were no big differences in the force between walking with the white cane and walking with shoe-type walking assistive device.

3.2 Number of collisions and required time
Fig. 5 and Fig. 6 presents the differences in the number of collisions and required time between when walking with two types of walking assistive devices. There was no significant difference in the number of collisions between when walking with the white cane and walking with shoe-type walking assistive device. However, the required time increased significantly when walking with shoe-type walking assistive device ($p = 0.006$).

4 Discussion
In this study, we confirmed that the foot pressure in the forefoot region on both sides decreased significantly while it increased significantly in the rearfoot region on left side only when walking with shoe-type walking assistive device. This may result from the characteristic of right-handed subjects. Previous research suggested that reduced foot pressure in the forefoot region can provide a comfort during walking and help to reduce falls in

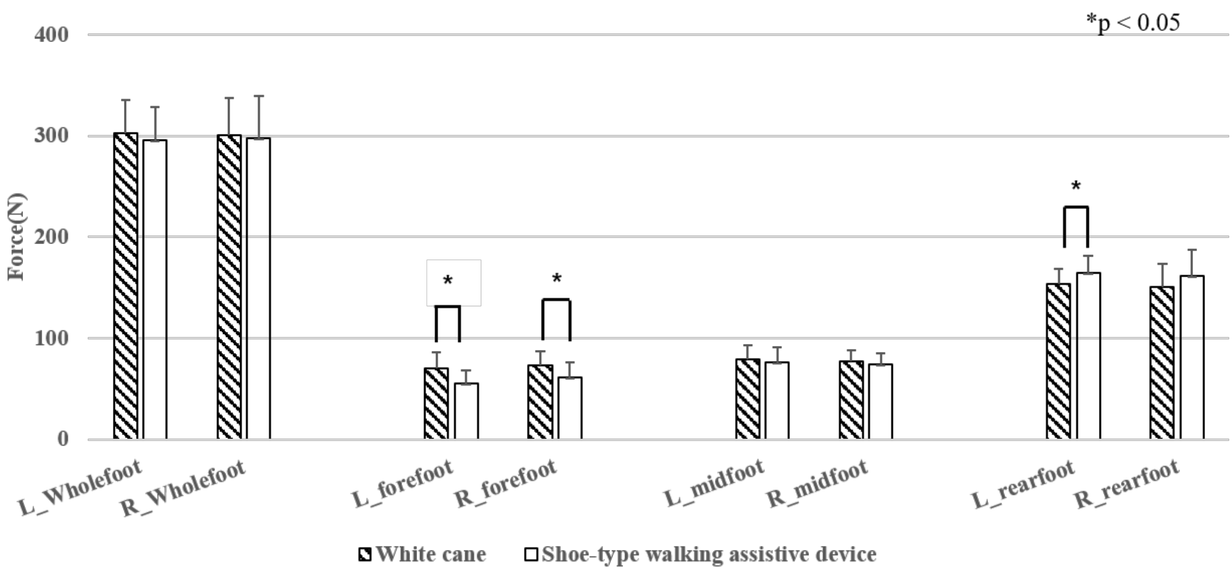

Fig. 4. Foot pressure

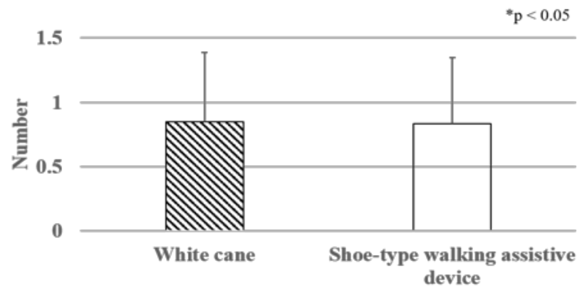

Fig. 5. The number of collisions

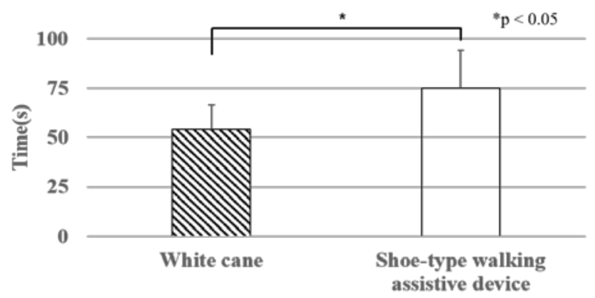

Fig. 6. The required time

the elderly [7]. In contrast, although other researchers reported an association between increased foot pressure in the rearfoot region and rates of foot pain, this is the result from subjects who had pes cavus [8]. It is very important to consider changes of the foot pressure distribution pattern for developing shoe-type walking assistive device. Because increased foot pressures were reduced when walking with shoe-type walking assistive device, we suggested that it can be helpful in reliving fatigue and pain of users.

When walking with shoe-type walking assistive device, the required time increased significantly. This result may be induced by some internal and external factors including a fear of user and adaptability for developed device [9]. Therefore, further research is needed to solve these limitations.

5 Conclusion

The purpose of this study was to assess the differences in gait characteristic between when walking with two types of walking assistive device. From the results of this study, we confirmed that shoe type walking assistive device for the blind may can be utilized in various fields due to it can provides more comfortable walking for user than previous white cane by reducing foot pressure distribution.

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