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Original Article

The effects of smartphone multitasking on gait and dynamic balance

Jeon Hyeong Lee, PT, PhD[1], Myoung Hee Lee, PT, PhD[2]*

[1] Department of Physical Therapy, Daegu Health College, Republic of Korea
[2] Department of Physical Therapy, Uiduk University: 261 Donghae-daero, Gangdong-myeon, Gyeongju-si, Gyeongsangbuk-do, Republic of Korea

Abstract.   [Purpose] This study was performed to analyze the influence of smartphone multitasking on gait and dynamic balance. [Subjects and Methods] The subjects were 19 male and 20 female university students. There were 4 types of gait tasks: General Gait (walking without a task), Task Gait 1 (walking while writing a message), Task Gait 2 (walking while writing a message and listening to music), Task Gait 3 (walking while writing a message and having a conversation). To exclude the learning effect, the order of tasks was randomized. The Zebris FDM-T treadmill system (Zebris Medical GmbH, Germany) was used to measure left and right step length and width, and a 10 m walking test (10MWT) was conducted for gait velocity. In addition, a Timed Up and Go test (TUG) was used to measure dynamic balance. All the tasks were performed 3 times, and the mean of the measured values was analyzed. [Results] There were no statistically significant differences in step length and width. There were statistically significant differences in the 10MWT and TUG tests. [Conclusion] Using a smartphone while walking decreases a person's dynamic balance and walking ability. It is considered that accident rates are higher when using a smartphone.
Key words: Multitasking, Gait, Dynamic balance

INTRODUCTION

The smartphone is a device that integrates personal scheduling, faxing, and email sending and receiving, as well as data communication functions, by adding computer operations such as internet access and information search to a cellular phone and allows users to install and delete various applications as needed. In addition, it is possible to run 2 or more of the various functions simultaneously. Owing to the convenient features of the smartphone, the number of smartphone users in South Korea reached 43.23 million in 2012 and they are using it for a large part of the day[1]. However, the indiscriminate use of smartphones has many problems[2].

In a study of physical and mental health status according to degree and addiction of smartphone use by university students, many subjects showed physical signs such as ocular fatigue (31%), myalgia (15%), and neural dysfunction (5%). Furthermore, most subjects showed social disabilities including unhealthy mental conditions such as smartphone dependence, anxiety, and interpersonal disorder[3]. In addition, long periods of smartphone use can cause incorrect posture such as forward head posture and rounded shoulder[4, 5] and injuries in surrounding tissues including ligaments[6–9]. In particular, visual and auditory inattentions inevitably occur when walking while using a smartphone.

One previous study reports that visual inattention can affect postural sways such as static imbalance during simple and dual tasks[10]. In a study with children aged 5 to 7, an auditory task was the most significant obstacle to walking velocity, cadence, and step length[11]. Today, people use a smartphone even while walking, and this behavior interferes with the percep-

tion of moving cars and surrounding objects, decreases walking velocity, and increases car accident risks such as the sudden speed reductions of cars to avoid such persons[2].

The purpose of this study was to investigate the effects of smartphone use while walking (which has been increasing dramatically) on the walking ability and dynamic balance and to examine how it differs from general walking when various smartphone functions are used as dual- or multitasking, to suggest the danger of using a smartphone during walking. Specially this study was conducted based on writing a message and listening to music, which is the most used multitask in the twenties.

SUBJECTS AND METHODS

The present study was performed with 19 male and 20 female asymptomatic participants who were recruited from a local university. Informed consent was received from every subject prior to the study. The inclusion criteria of subjects were as follows: no problems in the visual or vestibular system, no structural issues in a lower extremity or foot, and no musculoskeletal or neurological disorders that affect walking, as well as a minimum smartphone use of one year. The general characteristics of the subjects were an age of 22.26 ± 0.27 years, a height of 169.28 ± 1.21 cm tall, and a weight of 63.31 ± 1.81 kg.

This study was approved by the Daegu University Institutional Review Board (1040621–201611-HR-017–02) in accordance with the ethical principles of the Declaration of Helsinki

General Gait was walking without a task, Task Gait 1 was walking while writing a message, Task Gait 2 was walking while writing a message and listening to music, and Task Gait 3 was walking while writing a message and having a conversation.

The Zebris FDM-T treadmill system (Zebris Medical GmbH, Germany) was used to measure left and right step length and width. A 10 m walking test (10MWT) was conducted for gait velocity. In addition, a Timed Up and Go test (TUG) was used to measure dynamic balance. All the tasks were performed 3 times, and the mean of the measured values was calculated. The order of tasks was randomized to exclude the learning effect.

For the 10MWT, the subjects walked at a comfortable speed for 14 m. In consideration of acceleration and deceleration, the time taken to walk the 10 m was measured, excluding the first and last 2 m. The 10MWT is a method of predicting the gait performance of stroke patients and shows high reliability (r=0.97) (Hunt et al., 1981). The Zebris FDM-T treadmill has 10,240 pressure sensor mats attached to the bottom of the treadmill belt and can control velocity in 0.1 km/h intervals in the range of 0.2–22 km/h. As a subject walks on the treadmill, the plantar pressure is recorded at the rate of 120 Hz. For the input pressure signals, the temporospatial values are displayed in 2D/3D graphs including the center of pressure during standing or walking.

The TUG test evaluates basic mobility skill. The subjects must stand up from a chair, walk for 3 m, turn around and return to sit again on the chair. The score of the test is the time that is required to complete the test. For this test, the subjects were instructed to walk with or without a gait assistive device at a comfortable speed and the time was recorded in seconds with a stopwatch. All statistical tests were performed with SPSS version 12.0. The results are described as means and standard errors (Mean $\pm$ SE) for various tasks. A one-way ANOVA test compared left and right step length, step width, the TUG test, and the 10 m walking test according to performed tasks. In addition, Fisher's least significant difference test (LSD) was performed as a post hoc test. A value of $p < 0.05$ was used to indicate statistical significance.

RESULTS

In step length and width, there were no statistically significant differences among tasks ($p > 0.05$) (Table 1).

In the 10MWT, there were statistically significant differences among tasks ($p < 0.05$) (Table 2). The results of the post hoc test showed there were statistically significant differences between General Gait and other conditions, Task Gait 1 and 3, and Task Gait 2 and 3 ($p < 0.05$).

In the TUG test, there were statistically significant differences among tasks ($p < 0.05$) (Table 2). The results of the post hoc test showed there were statistically significant differences between General Gait and other conditions, Task Gait 1 and 3, and Task Gait 2 and 3 ($p < 0.05$).

DISCUSSION

This study was conducted to investigate the effect of multitasking with a smartphone while walking on the gait parameter and dynamic balance.

In the results, the gait time of the task gait using a smartphone was longer than the gait time without using a smartphone and this difference was statistically significant. Brown et al.[12] report that gait velocity decreased during the dual task. In a study on the elderly and balance disturbance by Silsupadol et al.[13], gait velocity decreased in the experimental group who performed dual tasks in 3 different conditions. Furthermore, Choi et al.[14] examined the effects of a visual cognitive task on gait and argue that while performing the visual cognitive task, the subjects lost the ability to control a constant gait pattern. The findings of these studies agree with the results of our study.

However, there were no statistically significant differences in step length and width between the General Gait and task gaits. This is different from the result of the study by Kim et al.[15], who claim that the visual and auditory cognitive tasks

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Table 1. Comparison of the spatial gait element with the various task performance (unit: cm)

	Left step length	Right step length	Step width
General Gait	46.9 ± 0.9	46.5 ± 1.1	9.8 ± 0.6
Task Gait 1	46.7 ± 0.9	46.0 ± 1.0	10.1 ± 0.6
Task Gait 2	47.2 ± 0.9	46.4 ± 1.1	9.7 ± 0.5
Task Gait 3	46.4 ± 0.9	45.9 ± 1.1	10.8 ± 0.7

Table 2. Comparison of the 10MWT and the TUG with the various task performance (unit: sec)

	10MWT	TUG
General Gait	$4.4 \pm 0.1^{‡}$	$9.1 \pm 0.2^{‡}$
Task Gait 1	$5.6 \pm 0.1^{†‡}$	$10.7 \pm 0.4^{†‡}$
Task Gait 2	$5.7 \pm 0.2^{*‡}$	$11.1 \pm 0.5^{*‡}$
Task Gait 3	$6.5 \pm 0.2^{*†‡}$	$13.3 \pm 0.5^{*†‡}$

*, †, ‡ $p < 0.05$.
*Significant difference between Task Gait 2 and Task Gait 3.
†Significant difference between Task Gait 1 and Task Gait 3.
‡Significant difference between Normal Gait and Task Gait 1, Task Gait 2, Task Gait 3.

decreased step length and width. However, this can be regarded as the habituation of some gait parameters during the continued task gait, just as de Bruin et al.[16] reports that if there were no particular external stimuli for a certain time during walking task, which is classified as a continuous task, it would become automatic and habitual.

Regarding dynamic balance during the smartphone multitasking, sways increased as the tasks increased and became more complex, resulting in a longer gait time. In Hyong[17], in a dual task situation using a smartphone, anterior balance, posterolateral balance, and posteromedial balance required attention during simple tasks such as listening to music and web surfing, but they decreased greatly during complex tasks such as writing a document and game playing. Furthermore, Kim et al.[2] examined the effect of using a smartphone on obstacle gait, and while overcoming the obstacles, the subjects showed noticeably sizeable motion and sway and their gait velocity and cadence decreased. This result agrees with the result of dynamic balance during the task gaits using a smartphone in the present study.

Cohen et al.[18] argue that balance is achieved by the integration of information that flows through the interaction of the vestibular system and visual and proprioception in the central nervous system. Geurts et al.[19] claim that balance disturbance or loss restricts the activity of daily living. In this way, various sensation participate in walking, and when walking using a smartphone, visual and auditory factors are lacking, so afferent information required for normal walking depends on only superficial sensory perceptions and proprioception. As confirmed in this study, walking while using a smartphone decreases gait velocity and dynamic balance to compensate for more stable walking. This will lower the walker's ability to detect potential risk factors around them or to cope with sudden dangerous situations, thus increasing the accident rate during walking.

The limitations of this study were as follows. The older generation who are unskilled in smartphone use were excluded because this study focused on young people, more diverse features of smartphones were not assigned as tasks, and the speed during the treadmill test was specified and did not match the speed of individuals at ordinary times.

The results of this study suggest that smartphone use during walking decreases balance and changes gait parameters. Thus, the lack of attention and cognition in the information processing function is likely to increase the incidence of accidents when walking in complex and varied outdoor places, as well as when walking indoors. Therefore, it is recommended that individuals refrain from smartphone use while walking. The limitation of this study is that it has been experimented in general environment, so it is necessary to study the risk of multitasking in various environments in the future.

Conflict of interest
None.

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