

Influence of mobile phone texting on gait parameters during ramp ascent and descent

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Objective: The purpose of this study was to examine the influences on gait features during mobile phone use while ramp walking.

Design: Cross-sectional study.

Methods: Thirty-three healthy adult subjects performed four walking conditions on an outside ramp with a 5 m length, 1.5 m width, and a 5° angle. All participants were touch screen mobile phone users. Four walking conditions were used: 1) ramp ascent, 2) ramp descent, 3) texting during ramp ascent, and 4) texting during ramp descent. In conditions 3) and 4), subjects texted the words of “Aegukga” – the song of patriotism – while walking. Upon the signal of start, the subjects walked the ramp during texting. Gait parameters were measured at the length of 3 m excluding 1 m of the start and end of the total length. Each situation was repeated three times for each subject, and mean values were calculated. For gait examination, a gait analyzer was used (OptoGait).

Results: Subjects ranged in age from 23 to 38 years (mean age, 27.73). Eighty-three percent of subjects in our study had experienced an accident during mobile phone use. Texting on a mobile phone while walking significantly decreased ramp gait, speed, cadence, stride length, step length, and single support ($p<0.05$) and significantly increased stride time, step time, gait cycle, and double support ($p<0.05$). There was a significant difference in cadence, step length, stride time, step time, and single support during ramp ascent and descent ($p<0.05$).

Conclusions: Texting on a mobile phone while walking significantly decreased gait quality.

Key Words: Cellular phone, Gait, Text messaging

Introduction

Seventy-seven percent of the world’s population use personal mobile phones as a communication tool and texting and transmission of data using mobile phones has been sharply increasing [1,2]. Increased mobile phone use has initiated many safety-related issues [3]. Previously, there were many concerns about the risk of using mobile phones during driving. However, concerns on the risk of using mobile phones during walking have increased recently [4,5]. For example, pedestrian accidents related to mobile phone use have increased since 2006 [6]. Mobile phone use during walking is

eroding cognitive and situational awareness skills, and it increases dangerous situations that lead to injury and death [3,7-9]. Previous studies show that mobile phone use during walking causes narrow vision [3], slows down gait speed, and increases risk while crossing the street [8].

When individuals are using a mobile phone, they need to focus on a small, hand-held screen; as hand dexterity is needed, this requires a high level of concentration [10]. While humans perform multi-tasking in daily life to deal with various external environments in a proper way, posture and balance need to be maintained [11,12]. This is called dual-task performance and it is defined as performing one task

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while doing another task or to persistently perform more than two tasks simultaneously [13]. Therefore, mobile phone use during walking can be considered a type of dual-task performance. Gait is controlled by automatic factors and could be influenced by cognitive tasks [14]. In practice, pedestrians walk slowly to compensate on tasks and to avoid falling when using mobile phones; this is because they are exposed to many risks [15].

Previous studies have reported that mobile phone use during walking changes gait pattern and increases risks while sending a text message or passing obstacles while sending email [2,10]. However, these previous studies were conducted on a flat-surfaced walkway of an indoor laboratory. In normal human environments, an inclined plane is more applicable than a flat surface. Accordingly, the risk of falling is increased on an incline. Nevertheless, there are relatively few studies using an inclined surface. The present study examines influences on gait features during mobile phone use while ramp walking.

Methods

Subjects

This study took place on an outside ramp of S hospital in Seoul and included 33 healthy adult subjects. Inclusion criteria were healthy adult subjects with no medical problem and touch screen mobile phone users. Participants were ex-

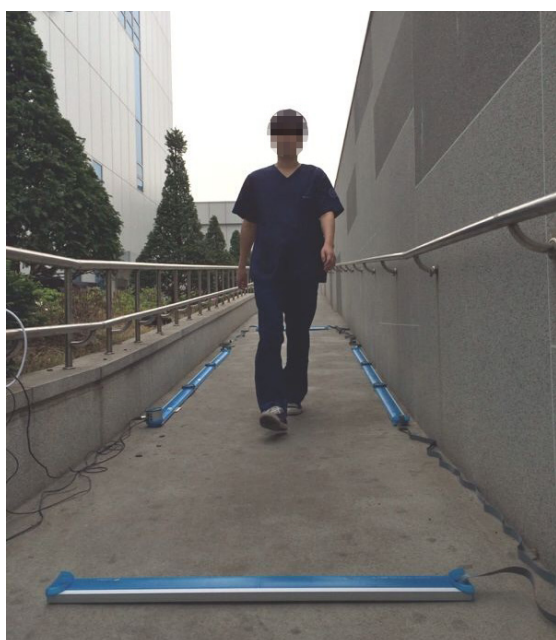


Figure 1. Outdoor ramp walking.

cluded if they had musculoskeletal or nervous system diseases affecting gait, did not use a mobile phone with a touch screen or had used a mobile phone for less than three months. The study was conducted after obtaining approval from the ethics committee of Sahmyook University. Prior to participation, subjects received an explanation of the objective and methods of the study and completed a consent of agreement.

Procedures

The experiment was performed on an outside ramp with a 5 m length, 1.5 m width, and a 5° angle (Figure 1). Four walking situations were used: 1) ramp ascent, 2) ramp descent, 3) texting during ramp ascent, and 4) texting during ramp descent. In situations 3) and 4), subjects texted the words to “Aegukga”—the song of patriotism—while walking. Upon the start signal, subjects walked on the ramp while texting. Gait parameters were measured at the length of 3 m excluding 1 m of the start and end of the total length. Each situation was repeated three times for each subject, and mean values were calculated.

For gait examination, a gait analyzer was used (OptoGait; Microgate S.r.l, Italy, 2010). The gait analyzer consisted of two transmission and receiving bars of 1 m and a webcam (Logitech Webcam Pro 9000). The gait parameter data was processed with OptoGait software, version 1.5.0.0. The intra-class correlation coefficients for test-retest reliability of OptoGait were between 0.785 to 0.982 [16].

Data analysis

Data was analyzed using IBM SPSS Statistics 19.0 (IBM Co., Armonk, NY, USA). For general features of the subjects, descriptive statistics were used. All variables were compared between conditions with a two-way ANOVA. A significance level of $p < 0.05$ was applied for all analyses.

Table 1. General characteristics of subjects (N=33)

Characteristic	Value
Gender (male/female)	18/15
Age (y)	27.73 (5.53)
Height (cm)	168.09 (7.62)
Weight (kg)	65.00 (10.63)
Dominant hand (right/left)	30/3
Phone OS type (ios/android)	15/18
Number of months using current mobile phone	10.82 (7.69)
Number of hours using a mobile phone per day	5.09 (1.64)
Number of subjects who using mobile phone to experience accident	27

Values are presented as n or mean (SD).

Table 2. Comparison of normal ramp gait and texting ramp gait

(N=33)

Parameter	Ascent		Descent	
	Normal	Texting	Normal	Texting
Speed (m/s)	1.38 (0.13)	0.98 (0.24)	1.47 (0.18)	1.01 (0.20) ^a
Cadence (steps/s)	114.23 (8.35)	96.55 (19.47)	123.59 (9.90)	107.13 (15.81) ^{a,b}
Stride length (cm)	137.05 (14.68)	108.09 (18.50)	131.00 (17.24)	106.73 (8.86) ^a
Step length (cm)	72.23 (8.01)	60.18 (8.28)	70.68 (7.94)	54.95 (4.79) ^{a,b}
Stride time (s)	1.06 (0.08)	1.26 (0.22)	0.98 (0.08)	1.15 (0.17) ^{a,b}
Step time (s)	0.52 (0.04)	0.62 (0.12)	0.48 (0.04)	0.56 (0.09) ^{a,b}
Gait cycle (s)	4.35 (2.53)	7.97 (4.37)	7.29 (4.45)	7.70 (5.19) ^a
Single support (s)	33.56 (2.04)	32.53 (4.07)	39.20 (13.05)	31.95 (1.56) ^{a,b}
Double support (s)	31.84 (3.68)	36.37 (5.73)	31.45 (7.67)	36.06 (3.44) ^a

Values are presented as mean (SD).

^aSignificant difference between normal and texting ($p < 0.05$), ^bSignificant between ascent and descent ($p < 0.05$).

Results

The general features of the 33 participants are listed in Table 1. Subjects ranged in age from 23 to 38 years (mean age, 27.73). Eighty-three percent of subjects in our study had experienced an accident during mobile phone use.

General ramp gait and ramp gait while texting showed a significant difference in all parameters of ascent and descent ($p < 0.05$). When comparing ramp ascent and descent, there was a significant difference in cadence, step length, stride time, step time, and single support ($p < 0.05$; Table 2, Figure 2).

Discussion

Human environments are not normally flat, so gait on an incline is not avoidable, and comprehension of the biomechanical requirements of ramp gait is important to therapists [17]. The ramp is a tool of vertical movement that can be used in place of stairs, and it is a necessary amenity, especially for the handicapped, seniors, and pregnant women. At similar angles, ramp gait has a greater risk of falling than does stair gait [18]. In comparison with ground gait, ramp gait differs in kinematic and kinetic perspectives [17], and identifying the features of ramp gait is essential to determine which factors contribute to the risk of falling [19]. This study showed that texting on a mobile phone while walking significantly decreased ramp gait, speed, cadence, stride length, step length, and single support ($p < 0.05$) and significantly increased stride time, step time, gait cycle, and double support ($p < 0.05$). There was a significant difference in cadence, step length, stride time, step time, and single support during ramp ascent and descent ($p < 0.05$). Dual-

task performance is an important parameter for postural control in humans. When performing a dual task, body variability increases [20,21]. Ebersbach *et al.* [22] reported that gait pattern is significantly changeable, depending upon the task. Cognitive motor interference is a phenomenon that happens when simultaneously performing one or two tasks that interfere with each other, such as performing a cognitive and motor task. When performing two simultaneous tasks, it interferes with the cognitive activity, as more than the maximum concentration ability is required [23]. Demura and Uchiyama [10] reported that there was interference between gait and manipulation of the mobile phone; moreover, velocity and stride width decreased and stance phase increased during mobile phone use. This is consistent with the present report, which also shows that mobile phone use while walking decreases speed, cadence, stride length, step length, and single support and increases stride time, step time, and double support.

When comparing gait parameters during ramp ascent or descent, there was a significant difference in cadence, single support, step length, step time, and stride time. Previous studies have reported step length increases and cadence decreases in healthy adults during ramp ascent and that step length decreases and cadence increases during ramp descent [24-26]. During descent, gravity supports the driving force for gait, but it decreases gait stability [27]. In addition, Startzell *et al.* [28] reported a more than three-fold likelihood of falling during descent than ascent. A compensatory decrease in step length during ramp descent helps to prevent falls [29]. Reduced speed, shorter step length, and stride length are related to fear regarding falling [30,31]. Kawamura *et al.* [24] reported that during ramp descent,

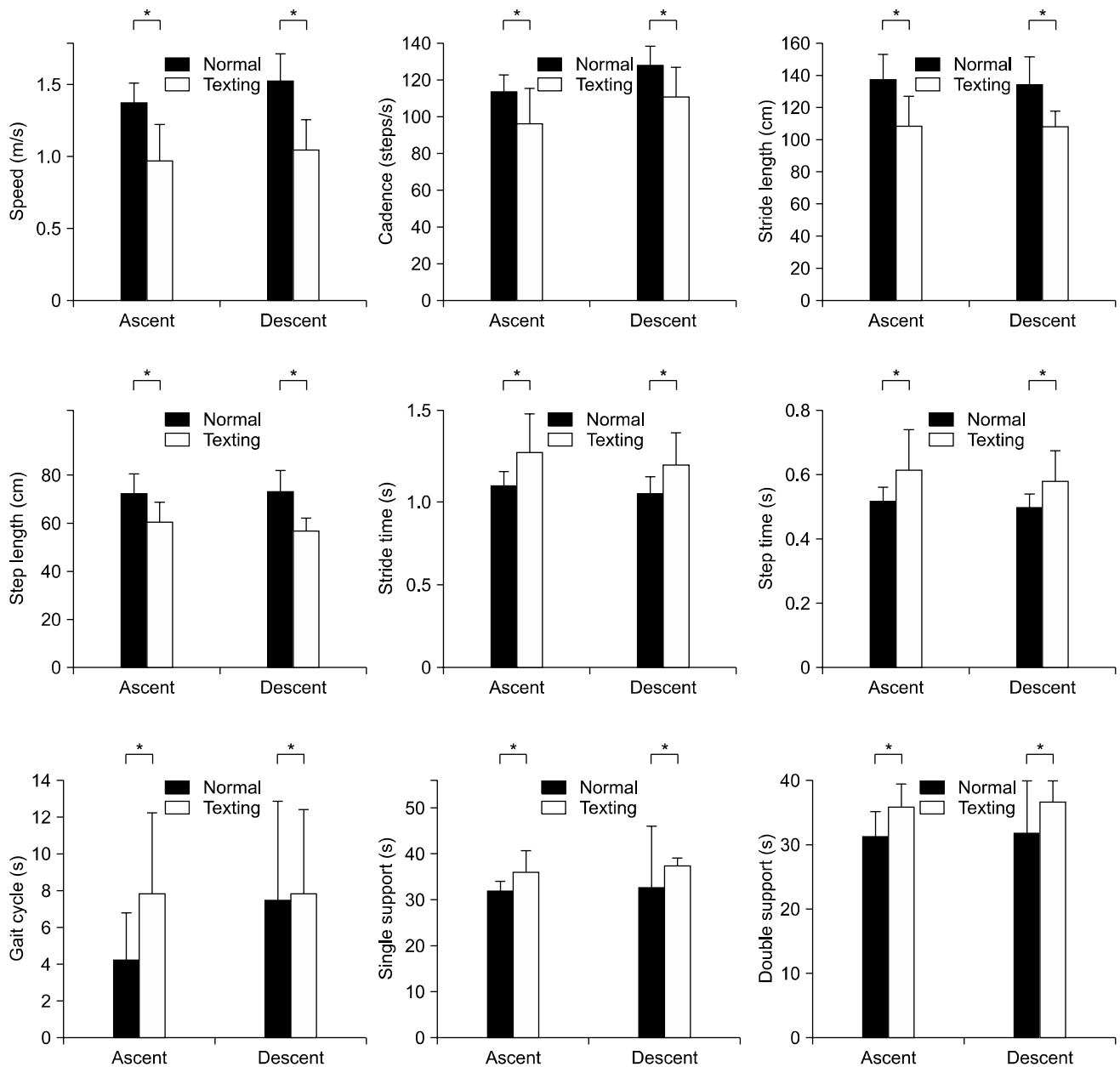


Figure 2. Differences of gait parameters in normal ramp gait and texting ramp gait. *Significant difference between normal ramp gait and texting ramp gait ($p < 0.05$).

stride length and step period decreased as the angle increased.

To manipulate mobile phones, humans need to focus the eyes on the screen, hold it by hand, and bend the head and neck. Tasks necessitating concentration require postural control [32]. When fixing gaze on a mobile phone, visual information regarding the walking environment is reduced [33]. Schabrun *et al.* [2] reported that, to minimize neck movement during mobile phone use while walking, neck range of motion and gait speed reduced. Decreased gait

speed could be caused by a decreased arm swing [34]. Arm swing helps to restore balance after disturbances in gait balance, and decreased arm swing negatively impacts balance during walking [35,36]. The present study shows that mobile phone use on a ramp changes gait quality. Individuals performing cognitive tasks while walking have a higher risk of collision and falling [32]. Pedestrians using mobile phones have a lack of situational cognition, and distracted and unstable actions increase [4]. Gait change with regard to mobile phone use threatens pedestrian safety [10]. When

crossing the street, individuals texting on a mobile phone are more likely to be struck by a car than those with high concentration [5]. In the practical study of Schabrun *et al.* [2] 35% of subjects had experienced an accident during mobile phone use, and 83% of the subjects in our study had an increased risk of accident resulting from mobile phone use.

This study has some limitations. First, gait change at various ramp angles was not tested. Second, gait changes were only tested during texting. As mobile phones have numerous other functions, it is difficult to generalize the risks to all mobile phone use. Future studies should focus on gait changes while using several mobile phone functions in a variety of environments affecting gait.

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