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Article *in* Gait & posture · January 2012

DOI: 10.1016/j.gaitpost.2011.12.005 · Source: PubMed

2 authors:

Eric M Lamberg
Stony Brook University

Lisa M Muratori
Stony Brook University

Gait & Posture 35 (2012) 688–690

Contents lists available at SciVerse ScienceDirect

Gait & Posture

journal homepage: www.elsevier.com/locate/gaitpost

Short communication

Cell phones change the way we walk

Eric M. Lamberg, Lisa M. Muratori *

Department of Physical Therapy, School of Health Technology and Management, Stony Brook University, Stony Brook, NY 11794, USA

ARTICLE INFO

Article history:
Received 14 July 2011
Received in revised form 9 November 2011
Accepted 1 December 2011

Key words:
Gait
Dual-task
Texting
Working memory
Attention

ABSTRACT

Cell phone use among pedestrians leads to increased cognitive distraction, reduced situation awareness and increases in unsafe behavior. Performing a dual-task, such as talking or texting with a cell phone while walking, may interfere with working memory and result in walking errors. At baseline, thirty-three participants visually located a target 8 m ahead; then vision was occluded and they were instructed to walk to the remembered target. One week later participants were assigned to either walk, walk while talking on a cell phone, or walk while texting on a cell phone toward the target with vision occluded. Duration and final location of the heel were noted. Linear distance traveled, lateral angular deviation from the start line, and gait velocity were derived. Changes from baseline to testing were analyzed with paired *t*-tests. Participants engaged in cell phone use presented with significant reductions in gait velocity (texting: 33% reduction, $p = 0.01$; talking: 16% reduction, $p = 0.02$). Moreover, participants who were texting while walking demonstrated a 61% increase in lateral deviation ($p = 0.04$) and 13% increase in linear distance traveled ($p = 0.03$). These results suggest that the dual-task of walking while using a cell phone impacts executive function and working memory and influences gait to such a degree that it may compromise safety. Importantly, comparison of the two cell phone conditions demonstrates texting creates a significantly greater interference effect on walking than talking on a cell phone.

1. Introduction

While the dangers of cell phone use when driving dominate public discussion, concerns have recently been raised about the effects talking and texting may have on walking. Cell phone use among pedestrians leads to increased cognitive distraction, reduced situation awareness (SA) and increases in unsafe behavior leading to injury and death [1–5]. Results from the few studies conducted on cell phone use while walking show that cell phone users recall fewer objects when conversing [1], walk slower [4] and are more unsafe when crossing a street [1].

Although well-practiced, gait is not automatic; instead, cognitive areas of executive function and attention are active [6,7]. Using dual-task methodology and evaluating performance changes, we can assess the extent of the cognitive demand. Successful performance of walking while using a cell phone requires cognitive and motor abilities and an appropriate division of attention to each. Engaging in a dual-task, such as talking or texting while walking, may interfere with working memory and result in walking errors. To our knowledge, this is the first time a direct examination of gait during talking and texting has been undertaken. We propose that cell phone use will negatively influence walking, and that the more novel task of texting while walking will lead to greater disruptions in gait. We discuss our findings in relation to pedestrian safety and models of control underlying memory and attention.

2. Methods

2.1. Subjects

Thirty-three healthy participants (13 male, mean age = 26 (SD 4)) were randomly assigned (11 per group) to either walk, walk while talking on a cell phone (TALK), or walk while texting on a cell phone (TEXT). All participants reported owning a cell phone and familiarity with texting. Approval from the Institutional Review Board at Stony Brook University was obtained.

2.2. Protocol

To assess how gait is affected by cell phone use, participants initially completed a baseline assessment. During baseline participants visually located a target 8-m ahead. Then, vision was occluded using a hood that obscured both the floor and target but would allow the cell phone to be seen and manipulated. With vision occluded participants were instructed to walk at a comfortable pace until they thought they reached the previously seen target. Duration and final location of the heel were noted and hooded participants were guided back to the start in a

* Corresponding author at: Department of Physical Therapy Stony Brook University School of Health Technology and Management Stony Brook, NY 11794, USA. Tel.: +1 631 444 6583.
E-mail address: lisa.muratori@stonybrook.edu (L.M. Muratori).

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doi:10.1016/j.gaitpost.2011.12.005

Table 1
Conversation list and questions used for participants.

Questions used for the talking while walking participants
Participant was called prior to the start of a trial, once a connection was confirmed the caller would read a question from below. The participant was engaged in conversation with the caller for the entire walking trial. If the participant completed a question before the trial was complete the caller would move onto the next question.
Describe where everyone sat during the most recent orthopedics exam.
Name the professors and lab assistants who taught the first year PT classes.
Give me the directions from your home to school today – be specific.
Name as many states as you can.
Describe the phases of gait.
Name the origins and insertions of all the muscles in the upper extremity.
Tell me about two different patients you saw on your clinical or when volunteering.
Include diagnoses, treatment and anything that made that patient stand out to you.
Name the origins and insertions of all the muscles in the lower extremity
Questions used for the texting while walking participants
Participant was told to text their answers to one of the following statements from below.
The participant was engaged in texting for the entire walking trial.
Type the names of all the students in our class.
Type the names of all the PT professors.
Type as many states as you can think of.
Type the names of all the muscles in the upper extremity.
Type the names of all the muscles in the lower extremity.
Type the classes you have taken since beginning PT school.
Type the names of all the students in our class.
Type the names of all the PT professors.

circuitous route to complete two additional trials. One week later the WALK group repeated baseline. The TALK and TEXT groups followed the same protocol as the WALK group however they were provided with a cell phone (LG Env3) to either talk or text with while walking with vision occluded. Questions to be answered while talking and texting covered topics familiar but challenging enough to ensure adequate cognitive engagement (Table 1).

2.3. Data analysis

Three trials were completed. Trial 1 familiarized participants with the experiment, trials 2 and 3 were used for analysis. Longitudinal and lateral error (cm) were measured (Fig. 1A), similar to methodology by Paquet et al. [8]. Linear distance traveled was determined as:

$$\text{linear distance (m)} = \sqrt{\text{lateral}^2 + (\text{longitudinal} + 800)^2}.$$

Lateral angular deviation from the start was determined as:

$$\text{laterral deviation } (^\circ) = \tan^{-1}\left(\frac{\text{lateral}}{\text{long} + 800}\right)$$

Gait velocity was derived using duration and linear distance.

2.4. Statistical analysis

Univariate ANOVA's were used to assess performance across the groups at baseline. Because of the small number of participants in this exploratory study, two-tailed paired *t*-tests were used to identify differences in velocity, linear distance, and lateral deviation from baseline to testing for the three groups. Statistical significance was considered at $p < 0.05$.

3. Results

This study demonstrates that walking while texting or talking on a cell phone leads to gait disruptions when navigating toward a remembered target and highlights the greater influence of texting. At baseline, no significant differences were found between the groups for velocity ($p = 0.66$), lateral deviation ($p = 0.36$), or linear distance ($p = 0.98$). When comparing baseline to testing, the TEXT group had a 33% reduction (7.0 vs. 4.7 m/s, $p = 0.01$) and the TALK group a 16% reduction (7.5 vs. 6.3 m/s, $p = 0.02$) in velocity (Fig. 1B). Furthermore, the TEXT group demonstrated a 61% increase in lateral deviation (6° vs. 10°, $p = 0.04$) (Fig. 1D) and a 13% increase in linear distance traveled (7.5 vs. 8.5 m, $p = 0.03$) (Fig. 1C). In contrast, the

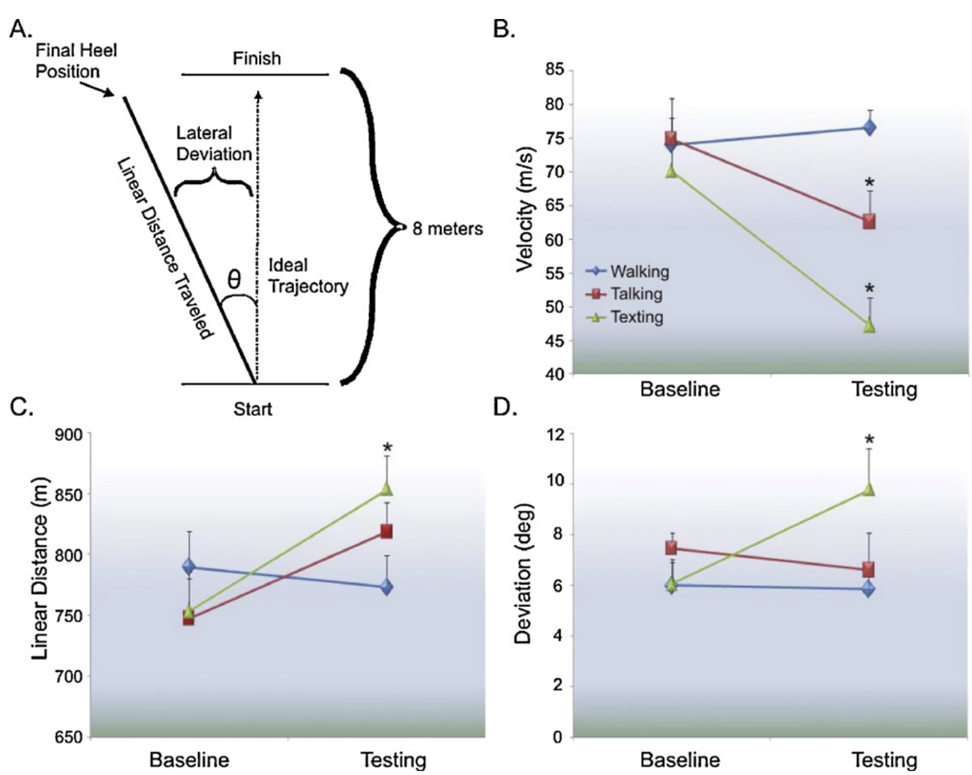

Fig. 1. (A) Illustration of the experimental setup and an example of how measurements were derived. (B) Mean (SEM) of gait velocity, (C) linear distance traveled, (D) and amount of lateral deviation obtained during baseline walking and during testing for the three different experimental groups (WALK, TEXT, and TALK). * Significant change ($p < 0.05$) from baseline to testing for the experimental group in question.

WALK group did not slow (Fig. 1B; $p = 0.51$) and neither the WALK nor the TALK group increased lateral deviation (Fig. 1D; WALK $p = 0.93$; TALK $p = 0.57$) or linear distance traveled (Fig. 1C; WALK $p = 0.61$; TALK $p = 0.12$).

4. Discussion

These results show that texting or talking on mobile devices influences walking. Similar to findings by Hyman et al. [9], we demonstrated that participants engaged in cell phone use were unable to maintain walking speed or retain accurate spatial information suggesting an inability to adequately divide their attention between two tasks. We theorize that the addition of texting or talking while walking with vision occluded increased the demands placed on the working memory system resulting in gait disruptions. Baddeley [10] describes a tripartite system for working memory which includes a central executive responsible for coordinating two slave systems: the visual–spatial sketchpad and the phonological loop. Here vision was occluded for all groups. Thus, all participants were required to maintain visual spatial information about the target in working memory. However, we suggest that because changes in walking speed and accuracy were found when texting and talking compared to baseline, increased demands were placed on the working memory system, particularly the phonological loop (to produce accurate verbal/written responses to questions) and central executive during dual-task performance. Further, although not compared statistically, the TEXT condition led to greater disruptions in gait than the TALK condition. This could be the result of additional visual attention demands required to locate keyboard letters and type responses in the TEXT condition, increasing the load on the visual–spatial sketchpad and making it more difficult to maintain the target location image.

Alternatively, within a hierarchical model, task execution may depend on the interaction of higher and lower level control elements, with lower level elements consisting of well-practiced tasks and having the ability to run simultaneously while the combination of lower and higher level elements requires sequential processing [11]. The dual-task of walking while talking may engage only lower level elements (walking and talking) whereas walking while texting may require execution of a higher level (texting) and lower level (walking) element. Although the act of texting may be increasingly common, it is unlikely to be as well-practiced as walking or talking. As the executor must allocate appropriate resources, the increased attentional demands required for texting may lead to errors in the otherwise sub-conscious task of walking. These results imply that there is a greater cognitive effort involved in texting leading to decreased SA, particularly the ability to extract relevant spatial and temporal information from the environment.

The gait deviations we found may have significant real-world repercussions. This study took place on a smooth surface with no obstacles. However the significant deviations suggest participants were distracted to a degree that could impact their safety in the community. Specifically, increased longitudinal and lateral deviation can reasonably correlate to overstepping a curb or missing environmental cues (inattentional blindness) [9]. These findings raise new concerns about a pedestrian's ability to avoid obstacles, maintain path direction, and safely cross intersections when using a cell phone, particularly while texting.

Conflict of interest statement

The authors have no conflict of interest to declare.

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