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The Effects Of The Dual-Tasking: Walking While Texting On Slip Recovery Mechanics

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ABSTRACT

Introduction: The number of induced falls has increased exponentially over the last decade. Previous studies have determined that the cognitive demands of texting affect the processing of cognitive and motor tasks.

Research question: What effect does the dual-tasking of texting and walking has on slip recovery mechanics?

Methods: Three-dimensional kinematic data were collected while 20 participants between the ages of 18 and 30 years three different conditions; 1) baseline, 2) walking + slip perturbation, and 3) texting and walking + slip perturbation.

Results: Walking speed, numbers of falls, and recovery time from the slip were not affected by the texting dual-task. It was also determined that the step length employed to recover the slip perturbation was significantly affected. Additionally, stride width was significantly increased during the texting condition but not during the no texting condition when compared to baseline in an effort to recover from the slip perturbation.

Significance:

These results indicate that texting and walking does not affect the slip recovery mechanics. Thus, this study suggests that the processing of texting while walking does not increase the risk of falling.

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CHAPTER1. INTRODUCTION

Dual-task walking is defined as performing a co-occurring task while maintaining upright locomotion[1]. Dual-task walking also occurs with the individual not consciously adapting and maintaining their gait mechanics, some examples of this are chewing gum or maintaining a conversation while walking[2]. Dual-task walking has been examined through different theoretical constructs, such as the sharing model and the bottleneck model. The sharing model proposes that dual-tasking shares the central resources, which are described as a central reservoir where activities requiring attention compete, and processing both concurrent tasks impairs the signals of both[3]. The bottle neck model states that processing several tasks cannot occur at the same time, thus the brain should select which stimulus deserves a response[2]. Shumway-Cook et al. introduced the strategy of "posture first," which suggests that healthy individuals prioritize gait stability over cognitive tasks[4]. However, it was later suggested that healthy individuals could prioritize a cognitive task over gait when the motor cost is lower than the cognitive cost[5]. Other studies investigating walking while performing a secondary cognitive dual-task reported no effects on the cognitive performance[6,7]. However, Patel and colleagues observed that tasks requiring higher attentional demand also have higher motor costs (e.g., gait velocity)[5]. Whereas lower gait velocity reduced cognitive cost, suggesting that stability was gained during slow gait allowing for faster processing[5]. Texting and walking is categorized as motor-cognitive dual-task where an individual focuses on using a cell phone screen while also being attentive to the surrounding environment[8].

The number of cellphone users increased worldwide every year with 3.67 billion cell phone users in 2016 which then increased 73.88 % by 2021. It was also estimated that by the year 2025 the number of smartphone users will increase to 7.52 billion users[9]. Furthermore, the number of falls and accidental injuries associated with walking while using a cell phone has increased in recent years and it is hypothesized that this trend will continue as the number of cell phones and the time spent on them increase[10]. Crucial characteristics observed during texting while walking are visual distraction[11] and missing almost 50% of visual cues that allow for situational awareness (i.e., observe cars, street lights), meaning that this dual-task interference affects the ability to identify changes in the surrounding environments and may increase the risks of falling[12]. Other studies have established that texting while walking affects gait parameters in a variety of manners including decreased walking speed[8,13] cadence[8,14], stride length[8,14], step time[14], increased double support time[8], and affecting spatial temporal information, such as the ability to avoid obstacles while walking[13] when compared to over-ground walking**.** Furthermore, Koa et al., found that limb joint was decreased lower-limb joint variability and wider steps when walking and texting on a treadmill, suggesting that such as gait patterns are to employed to compensate for decreased stability changes during this dual-task[15].

Slip and trip initiated-falls can be avoided by the ability to generate a quick and effective corrective response to reestablish balance[16]. Recovery balance strategies are described as somatosensorial and vestibular responses that trigger the appropriate postural response to a determined event[17]. Following Patel and colleagues[5] findings recovery balance strategies would be affected due to the simultaneous demands of the cognitive and motor tasks. To the best of our knowledge, no study has yet researched the recovery responses employed when experiencing a slip while dual-tasking. Thus, this study aimed to investigate the slip recovery mechanics during dual-tasking: walking while texting. It was hypothesized that the stability responses would be affected during the dual-task condition due to the altered processing of both concurrent tasks explained by the sharing model theory.

CHAPTER 2. METHODS

Participants

A power analysis (G*Power v3.1, Dusseldorf, Germany) was conducted with anterior/posterior position data from Kao et al., (2015)[15]. It was determined that a total sample of four participants was required for sufficient statistical power, based on a proposed effect sized of 2.14, power of 0.08, alpha (α) of 0.05, and correlation between groups of 0.7. Due to the exceptionally large effect size produced by the first power analysis, a second power analysis was performed to ensure the adequate statistical power was achieved. The second power analysis was performed with medial/lateral position young data from Kao and colleagues[15]. Based on a proposed effect sized of 1.33, power of 0.08, alpha (α) of 0.05, and correlation between groups of 0.07, it was determined that a total of six participants are required for sufficient statistical analysis. Given the large effect size magnitudes from both power analyses, 20 participants (7 females and 13 males; 25.55 ± 3.33 years; 73.15 ± 17.89 kg; 1.72 ± 0.11 m) were recruited for this study. To be included in the study, participants were required to use their own phone for the study, use their phone on a daily basis, and have at least one-month of experience with it. Participants were excluded if they self-reported any neurological or musculoskeletal disorders, or injuries that interfered with walking and texting. Prior to completing any laboratory activities, participants provided informed consent on institutionally approved documentation and in accordance with the Declaration of Helsinki.

Experimental Procedures

Prior to completing any texting activities, participants were asked to turn off the autocorrect function on their phones and to report their cell phone experience (e.g., daily time spent on the phone) and any previous accidents, such as falling or getting injured while using their phone and walking. Then demographic and anthropometric data (age, mass, height, and sex) was measured and recorded. Once demographic data were obtained, participants warmed up on a regular treadmill (Tracmaster TMX425, Newton, KS, USA) for five minutes and to determine their preferred pace for the experimental conditions. After participants were warmed up and their pace had been established, participants were secured in a full body harness. Then retroreflective markers were adhered to the following anatomical landmarks: bilaterally on acromion processes, posterior superior iliac spine, iliac crest, great trochanters, lateral and medial epicondyle, lateral and medial malleoli. Single markers on manubrium, sternal process, seventh cervical vertebrae, tenth thoracic vertebrae, inferior angle of the right scapula, and the base of the second toe. Additionally, three-non-collinear reflective markers were placed bilaterally over the calcaneus. Lastly, thermo-plastic shells with four non-collinear markers were placed bilaterally, mid-segment, on the thighs and legs using elastic wraps. Cover-all tape and Leuko-tape were use on the correspondent locations to prevent the markers from falling and to assure accurate data was collected. Participants were required to wear tight-fitting clothing for accurate marker placement and segment representation.

Instrumentation

Kinematic data were obtained with a 10-camera three-dimensional motion capture system (200 Hz; Vicon Motion Systems, Ltd., Oxford, UK) interfaced to a computer running Vicon Nexus software (version 2.9.1). Participants were instructed to stand in the middle of the capture volume in the laboratory with arms extended in a “T” position for subject calibration. Then to prevent any falling on the ActiveStep (Simbex, Lebanon, NH) treadmill, the participants’ harness was secured by shock-absorbing ropes at the shoulders to the ceiling. Once participants were setup on the ActiveStep treadmill they walked on the treadmill for one-minute to allow for familiarization. Then participants performed the baseline condition, which consisted of walking on the treadmill at their previously selected pace without any additional tasks. After the 12-baseline trials were recorded, participants completed two randomized experimental walking conditions. Participants complete two experimental conditions, 12 trials per condition, and the conditions were: 1) walking and slip perturbation; and 2) walking + texting and slip perturbation. The slip perturbations occurred after five to nine randomized steps with an abrupt backward movement of the belt at speed of 0.5 m/s, and then returning to its normal direction. During the texting conditions, a research team member texted participants open-ended questions such as: “What is your favorite hobby? How often do you practice it? How long have you been practicing it?”. Text messages were sent prior to the start of each trial to ensure participants received the message. Participants were informed that they could request a different question if they were uncomfortable answering any question. All questions were sent in English and participants were required to respond in English, using complete words and sentences, and refrain from using emojis, memes, or gifs in their responses. Participants were free to hold their phone with one or two hands[18].

Data Reduction

All raw kinematic variables were exported from Vicon Nexus and computed in Visual 3D software (C-Motion, Inc., Germantown, MD, USA) where marker trajectories were filtered with a low-pass Butterworth digital filter (6 Hz). An eight-segment model was constructed from smoothed marker trajectories, including the trunk, pelvis, left and right thigh, leg, and foot segment. Heel strike and toe-off events will be determined by the velocity-based algorithm from

Zeni and colleagues (2008). Variables of interest included: right and left stride length, stance width, time in double limb support, and anterior/posterior COM.

Statistical Analysis

Statistical tests were performed in SPSS Software (v27; IBM Corp ©, Armonk, NY). Mean and standard deviation values were computed for each of the variables of interest for each condition. One-way repeated measures analyses of variance (ANOVA) were conducted to test for significant differences ($\alpha = 0.05$) among conditions (walking, walking + texting – no slipping, and walking + texting and slip perturbation) for stride width and step length. For significant difference detected in the omnibus ANOVA test, pairwise comparisons were interpreted after applying Sidak adjustment.

CHAPTER 3. RESULTS

Participants reported an average of 1.23 (±1.23) daily hours spent texting, 4.15 (±1.81) daily hours spent on the cell phone, and 11.62 (±3.04) years of experience owning a cell phone. Among the 20 participants recruited for the aim of this study 85% reported to regularly text and walk, 55% reported slipping while walking and texting, 15% reported falling while texting and walking, and 15% reported hurting themselves while walking and texting.

No significant differences in speed were found between the texting and no texting conditions ($p = 0.066$) Means and standard deviations are displayed in Table 1. No significant differences were observed for the number of falls ($p = 0.330$) and recovery time ($p = 0.551$) when comparing between conditions.

The repeated measures ANOVA revealed a significant difference among conditions for stride length, $F_{(1.07,20.28)} = 195.043$, $p < 0.001$, $\eta^2 = 0.911$, with post-hoc comparisons revealing that significant differences existed between baseline an both experimental conditions ($p < 0.001$ in both comparisons). However, no significant differences were found between texting and no texting ($p= 0.999$) conditions. A statistically significant difference among conditions was also revealed in stride width, $F\ (_{1.31,\ 24.97}) = 12.60$, $p = 0.001$, $n^2 = 0.399$. Post- hoc comparison revealed significant difference between baseline and texting ($p = 0.004$) and baseline and no texting ($p = 0.005$) However, no differences were determined between texting and no texting ($p = 0.501$).

Table 1. Spatial-temporal characteristics among baseline, no texting, and texting slipping conditions

	Baseline	No Texting	Texting	p-value
Speed (m/s)	-	1.25 (0.23)	1.22 (0.22)	0.066
Number of falls	-	0.10 (0.45)	0.05 (0.22)	0.330
Recovery time (s)	-	0.27 (0.07)	0.27 (0.07)	0.551
Recovery step length (m)	1.34 (0.32)	0.33 (0.10) †	0.32 (0.09) †	<0.001*
Recovery stride width (m)	0.12 (0.04)	0.15 (0.05) †	0.16 (0.05) †	<0.001*

Note: * = significant difference ($p < 0.05$) from conditions; † = significant difference from baseline

Discussion

The purpose of the current study was to examine recovery mechanics induced by treadmill slip perturbations between texting and no texting. It was hypothesized that recovery mechanics would be affected due to shared central resources caused by the dual-task of texting and walking. The current study found that walking speed, numbers of falls, and recovery time from the slip were not affected by the texting dual-task. However, it was determined that the step length employed to recover the slip perturbation was significantly reduced when compared to baseline by both conditions. Additionally, stride width was significantly increased for both slipping conditions b when compared to baseline in an effort to recover from the slip perturbation.

Previous literature examining gait patterns while walking and texting have shown that speed is decreased [8,13]; although the results of the current study is not aligned with those findings. It was previously determined that walking traits, such as decreased speed and stride length, longer stance direction, and walking symmetry were adopted to maintain a more cautious gait as a consequence of visual distraction caused by observing the phone screen [19-21]. However, since the current study was performed on a treadmill, participants may not have needed to split the visual demands between the two tasks. Aligned with these outcomes, Lövden et al.[22] previously revealed that when performing a secondary task on a treadmill individuals adopted smoother and automatic patterns, meaning that individuals required minimal attention to walking when compared to overground walking. The findings from Lövden suggest that preferred speed could be maintained since treadmill walking allows for a faster processing since individuals may not have to adapt to environmental information[22].

The current study revealed no difference in falls between texting and no texting slip conditions. Additionally, it was observed that years of cell phone experience was not previously reported by other studies examining texting and walking [8,13,15]. Findings of the current study reported that on average participants had 12 years of experience owning a cell phone. It is suggested that such years of cell phone experience may decrease the cognitive cost of texting while walking. Participants of the current study could be categorized as "texting experts," [23] allowing participants to previously create walking and texting gait pattern, thus motor and cognitive demands created by this study did not elicit any novel slip responses. Additionally, previous studies testing expert athletes have determined that they are able to maintain the level of performance better while performing a secondary task when compared to novices[24,25]. Even though these studies do not directly relate with the current study, it is important to keep these findings in consideration when examining the evidence in the current study.

Ferber et al.[26] previously divided the postural responses into three categories: 1) responses observed immediately after the onset perturbation are considered mechanically; 2) adjustments observed between 0.07 s and 0.25 s are considered a combination of mechanical and spinally mediated neuromuscular responses; and 3) responses observed after 0.25 s are considered a combination of mechanical, spinal, and cortically mediated, meaning that these responses are voluntary and involuntary. The current study found an average recovery time of 0.27 s for both conditions, meaning that the processing of the recovery balances was not affected by the dual task of texting. Following the sharing model, it was hypothesized that recovery time would be increased during the texting condition. As previously stated, the author of the current study attributes these results to the low cognitive and motor costs produces by the treadmill walking and the individuals' cell phone experience. Additionally, it is important to notice that the first balance responses are mechanical, the viscoelastic changes in the tissues surrounding the lower extremity could also be significant important to recover balance.

As previously stated, young adults have the capability to adapt a "cautious" gait that increases stability, by reducing speed and stride length and increasing step width and double support time. The current study found that after the slip perturbation recovery step length was reduced and stride width was reduced for both walking + slip conditions when compared to baseline, suggesting that this pattern was used to maintain stability.

Limitations and Directions for Future Research

The main limitation of the current study is the slip perturbations treadmill created. Even though slips were unannounced and randomized, participants may have preemptively adapted to the slip stimulus after several trials. Bhatt and colleagues[27] previously reported that after the first three treadmill slips individuals were capable to adapt their COM before the onset of the perturbation. Another limitation of this study is that only young adults were recruited. Future research should consider including older adults, since it is suggested that elderly have decreased mental flexibility to prioritize the cognitive task. Future research should include the elderly population and adults that are not proficient with cell phone use. As well, individuals should be tested in an environment that exposed them to more spatial cues, that imitates everyday multiple obstacles in the walking path.

Conclusion

The findings of the current study reported no effects on the recovery mechanics when texting and walking. In contrast with the hypothesis, we suggest that central resources were not affected by the texting task, allowing individuals to properly adapt gait and slip recovery mechanics simulated slip perturbations on a treadmill. It is suggested that treadmill walking had a significant impact on the findings, decreasing the motor demands of walking; as well, as the individual’s proficiency of texting. It is hypothesized that as individuals spend more time on their cell phone cognitive demands will be lower and the capability to adapted a slip stimulus will be higher.

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VITA

Ileana Abril Jarquín graduated from the University of Texas at El Paso in 2019, with a Bachelor of Science (B.S) in Kinesiology. As undergraduate student she started with the master's credits as part of the fast-track program. Upon graduating, she enrolled in the University of Texas at El Paso's Masters in Kinesiology program and joined the Stanley E. Fulton Gait and Research Analysis Lab under Dr. Jeffrey D. Eggleston. During her master studies Ileana was employed as a graduate teaching assistant. She assisted in the instruction of various undergraduate labs including biomechanics and exercise prescription. As well, she assisted in the grading and supervising of the geriatric undergraduate lecture and fieldwork. Ileana will pursue her doctoral degree in 2022, expecting to continue her research in fall prevention and dual-task gait patterns.