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The Effects of Dual Processing on Gait Pattern: An Analysis of Texting and Walking

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Abstract Dual-tasking is a common practice that humans use in today's society to save time and increase task efficiency. Dual-tasking requires the ability of an individual to process two or more pieces of information at once. One prime example of human dual-tasking performed in today's society is texting while walking. Although texting while walking is considered to be a common practice for younger and older generations, performing this type of dual-tasking may lead to greater distraction, posing potential risks of fall or injury to oneself or others due to alterations in normal gait patterning. Based on these concerns, the purpose of this study was to examine the effect of texting while walking on gait pattern in healthy young adults. The dependent variables measured in this study were mean claw back, mean breaking and propulsive forces, and normalized velocity. The independent variables were type of force and walking condition. Twenty-two participants were recruited for this study. Participants walked across a force platform during three conditions: undistracted walking, walking while receiving a text, and walking while sending a text. Inferential statistics were conducted using one way ANOVAs and a mixed factorial ANOVA to address the purpose of the study. Results indicated no significant difference among the three conditions on average claw back. There was, however, a marginally significant interaction effect between type of breaking and propulsive forces across the three conditions when measuring the ground reaction forces, $F\ (2, 84) = 2.58$, $p = 0.082$, $\eta^2 = 0.058$. There was also a statistically significant difference in normalized velocity between undistracted walking and walking while sending a text, as well as between walking while receiving a text and walking while sending a text, $F(2,42)=14.63$, $p < 0.05$, $\eta^2 = 0.411$. The outcomes of this study may set a foundation for future research examining the risks associated with texting while walking and the effect of dual-tasks on gait pattern.

Keywords Dual-tasking, Walking, Texting, Claw back, Normalized velocity, Braking, Propulsion

1. Introduction

Executing two tasks simultaneously is a common practice in today's society as a means of saving time and increasing task efficiency [14]. Multitasking, also known as dual-tasking, requires the ability to process two or more pieces of information at once [7, 14]. The effectiveness of dual-processing is unclear, although it is believed that cognitive interference during dual-processing negatively affects the outcome of one or both of the involved tasks [14].

When combining a cognitive task with a motor task, such as walking, research suggests that areas of the cerebellum are activated to help coordinate the motor components of the task [14]. During dual-tasks involving walking, it is theorized that the gait pattern may be altered due to dual-task interference, as information processing and cognitive prioritization is altered [14]. To examine the gait pattern, some of the more common variables of interest include braking and propulsive forces, claw back, and normalized velocity of gait [2, 9, 11]. Braking and propulsive forces represent the anterior and posterior forces applied to the ground during heel strike and toe-off, respectively [8]. Braking forces help to halt the forward momentum of the swing leg as it contacts the ground and propulsive forces initiate the next swing with the opposing leg [8]. A variable that is associated with braking and propulsive forces during gait is claw back. In the first stage of double support (heel strike), a forward directed force is created; however, just before the heel contacts the ground, the foot is drawn back in anticipation. This force variance created by hesitation is recorded by force transducers and is referred to as claw back [8]. Finally, normalized velocity of gait describes the average velocity of the gait in relation to the average length of the stride [9].

A prime example of a common dual-task that has caused a cultural shift in today's society and may also cause cognitive interference in task outcomes is texting and walking [13]. This dual-task has led to an exponential increase in the use of cellular phones and other mobile devices besides using these devices to make voice calls [13].

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The issue surrounding this cultural shift, however, revolves around the potential risk of falling, which is a safety concern of texting while walking in today's society [10, 12, 13]. These safety concerns highlights the need to examine the effect of texting and walking on gait pattern characteristics to determine potential risks associated with gait abnormalities, which may compromise task outcomes.

Based on these potential safety issues, the purpose of this study was to examine the effect of texting and walking on gait characteristics in healthy young adults. Three separate gait pattern variables were analyzed as the dependent variables in the current study including normalized velocity, claw back; braking and propulsive forces. Normalized velocity was calculated by dividing the distance walked in meters by the time taken to walk in seconds. Claw back was measured through the ground reaction forces captured by the vertical component recorded on a force platform. Breaking and propulsive forces were also captured by the ground reaction forces measured by the force platform. The independent variables included in the current study were texting condition and type of force (braking or propulsive). The three texting conditions used were walking with no texting (control), walking while receiving a text and reading it aloud, and walking while sending a text.

2. Methods

2.1. Participants

Twenty-two healthy young adults (14 female, 8 male; mean age 20.95 ±0.88years) participated in the current study. Each participant was required to be between the ages of 18 and 25 years with no lower limb musculoskeletal injuries or balance issues, including no concussion within the last three months, which may have altered their normal gait pattern. Participants were also required to have no cognitive deficits to ensure dual-processing was normal and they were required to send or receive a text while walking at least five times per day on most days of the week.

2.2. Instruments

The Advanced Mechanical Technology Incorporated (AMTI) force platform was used to measure the claw back forces, as well as the braking and propulsive forces. This force platform simultaneously measures three force components along the xyz axes and three moment components about the xyz axes [1]. The software program used to collect and analyze force measures from the AMTI biomechanics platform was Biosoft AMTI software for gait analysis. Brower Timing Gates were also used to measure the walking time for the purposes of calculating normalized velocity. The timing gates were situated on either side of the AMTI platforms, exactly one meter apart, as shown in Figure 1. A participant Pre-Screening Questionnaire that analyzed the participants' texting habits and medical history and a Par-Q Questionnaire were used to ensure the participant met the inclusion criteria and could safely participate.

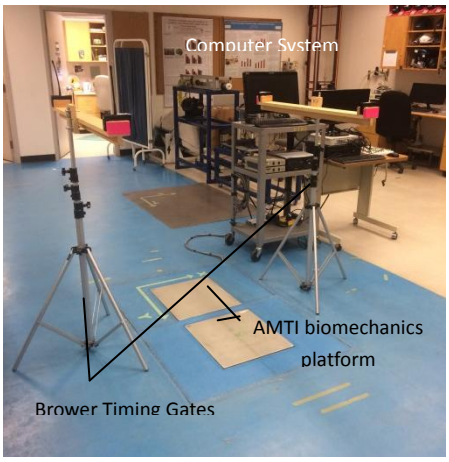


Figure 1. Data collection setup, including AMTI biomechanics platforms and Brower timing gates

2.3. Procedure

After obtaining ethical approval, participants were recruited via posters and miniature presentations in various classes around campus. Potential participants were provided with a letter of recruitment and a letter of informed consent to fill out and return to the researchers. After completing the informed consent, potential participants were administered a Pre-Screening Questionnaire, and Par-Q Questionnaire as a method of screening the participants before partaking in the study. Participants, who met the inclusion criteria, performed a light warm-up, which included approximately five minutes of walking on the university track at a self selected speed followed by gentle stretching exercises. After completing the warm up and prior to data collection, each participant performed five practice trials of walking across the AMTI biomechanics platform by executing one complete gait cycle prior to striking the first platform with their right foot and the second platform with their left foot. The practice trials were implemented to ensure proper footfall on the AMTI platforms.

Participants'data collection included three conditions: (1) undistracted walking, (2) walking while receiving a text, and (3) walking while sending a text. Three trials were performed for each condition; braking and propulsive ground reaction forces were measured, as displayed in Figure 2 example.

For the data collection process, each participant started walking at a marked location that was predetermined during the practice trials. The Biosoft AMTI data acquisition software was activated prior to the each participant striking the force plates. For condition 1, participants walked across the AMTI platforms without texting or any other distractions. For Condition 2, participants walked across the AMTI platforms while receiving a standardized text from the researcher. The participants read the received text aloud. Finally, for Condition 3, participants walked across the AMTI platforms while sending a standardized text to the researcher.

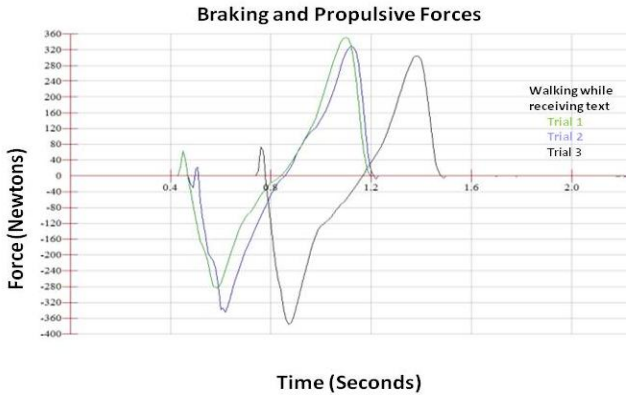


Figure 2. Braking and propulsive ground reaction forces of the right foot while walking and receiving a text message (Condition 2)

The data collection process lasted approximately 45 minutes and each participant attended only one testing session. To ensure confidentiality of the participant, the researcher obtained each participant's cellular telephone number for the purposes of exchanging text messages; however, both the participant and researcher were required to delete the text messages and contact information prior to leaving the testing room. The text messages were standardized and consistent across participants to ensure reliability. A different text message was implemented for each of the three trials. The text message for trials one, two, and three, respectively, were as follows: "*Hey! What's up?*"; "*Do we have class today?*"; and "*Have a good day. I'll ttyl"*. Text messages for each trial were consistent across Condition 2 and Condition 3. Following the completion of data collection, a cool-down, which included gentle stretching, was performed by each participant.

2.4. Data Analysis

Descriptive and inferential statistical analyses were performed for each dependent variable via IBM SPSS. Means and standard deviations were calculated for normalized velocity, claw back, and braking and propulsive forces. A one-way repeated measures ANOVA was conducted to compute the effect of each texting condition on normalized velocity and claw back. A Bonferroni post-hoc analysis was conducted to identify the pairwise mean comparisons between the texting conditions that were significantly different. Finally, a mixed factorial ANOVA was conducted to examine the interaction effect between texting condition and type of force on ground reaction force measures.

3. Results

Descriptive statistics, as depicted in Figure 3, revealed that the normalized velocity (meters per second) for undistracted walking (M=1.29, SD=0.11) was faster than the normalized velocity while receiving a text (M=1.24, SD=0.13) and sending a text (M=1.17, SD=0.15). One-way repeated measure ANOVA, revealed a statistically significant difference across conditions for normalized velocity, $F(2,42)=14.63$, $p<0.05$, $\eta^2=0.411$. The post-hoc analysis, however, revealed that the differences were between the following mean comparisons: a) undistracted walking and walking while sending a text and b) between walking while receiving a text and walking while sending a text.

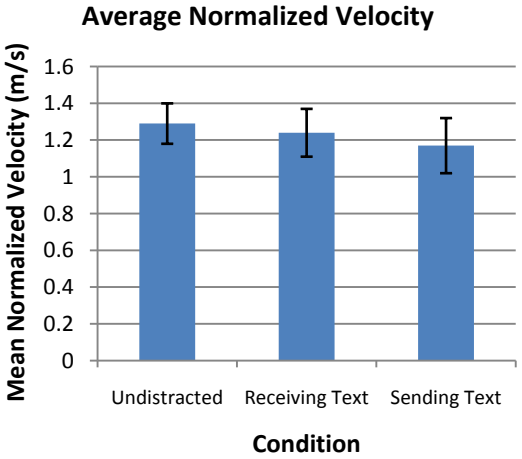


Figure 3. Mean normalized velocity for each texting condition

Descriptive statistics, as displayed in Figure 4, revealed that the claw back force measured in Newtons for undistracted walking (M=89.26, SD=49.01) was greater than the claw back force for walking while receiving a text (M=87.07, SD=55.98) and sending a text (M=83.20, SD=45.89). One way repeated measures ANOVA revealed no statistically significant difference across conditions for claw back force measures, $F(2, 42)=0.882$, $p>0.05$.

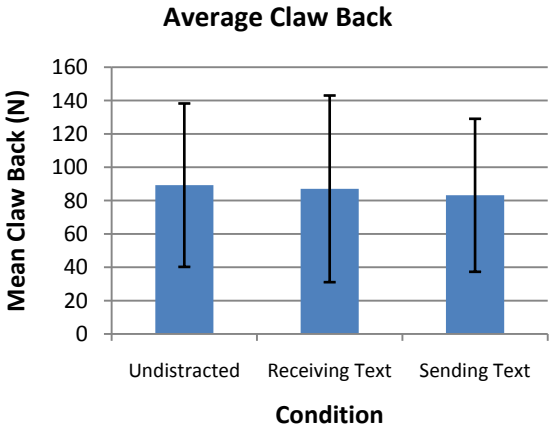


Figure 4. Mean claw back for each texting condition

Finally, descriptive statistics revealed that braking force for undistracted walking measured in Newtons, (M=295.06, SD=90.01) was less than the braking force for walking while receiving a text (M=306.71, SD=96.09), but greater than walking while sending a text (M=281.54, SD=96.86). Similarly, the propulsive force for undistracted walking (M=197.80, SD=67.44), was greater than the propulsive

force during walking while receiving a text (M=283.24, SD=62.78) and while sending a text (M=275.60, SD=72.40). After conducting a mixed factorial ANOVA, the results as displayed in Figure 5, revealed a marginally significant interaction effect between texting condition and type of force, $F(2,84)=2.58$, $p=0.082$, $\eta^2=0.058$ for the ground reaction force measures.

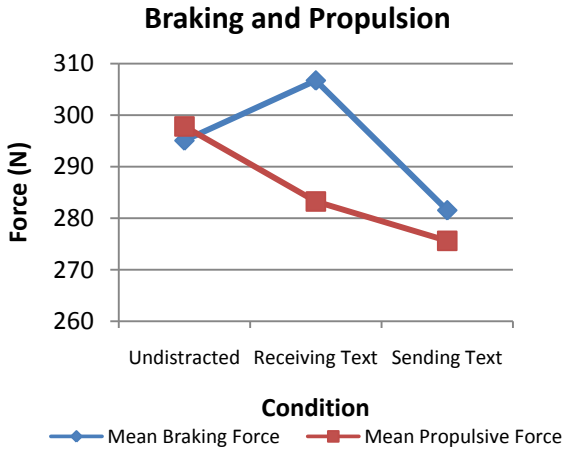


Figure 5. Interaction effect between texting condition and type of force

4. Discussions

Texting and walking is becoming increasingly common in today's busy society and the risks associated with this dual-task paradigm are becoming more apparent. Current research examining the effect of dual-processing on gait characteristics and the risk involved when texting and walking is sparse and unclear; however, significant differences in stride timing and stride length have been observed with dual-tasking [15]. The results from the present study support this observation as participants significantly slowed down their walking speed when a dual-task was introduced. Research findings also suggest that this alteration in gait speed, as a function of manipulating gait stride and timing, is likely associated with the ability of the individual to maintain balance when texting and walking [15].

When analyzing the results for normalized velocity, the condition in which participants were required to send a text seemed to be most affected by this dual task paradigm. Mechanisms responsible for this effect may be associated with taxing cognitive demands such as texting accuracy while sending a text as compared to receiving a text. Research by Drews et al. [4], however, found that receiving and reading text messages caused more cognitive interference than did composing and sending messages. While the results of the current study revealed the opposite, this discrepancy may be related to the type of dual-task paradigm used. For example, texting while driving as investigated by Drews et al. [4] may involve different attentional demands and task prioritization as compared to texting while walking.

Contrary to the significant effect of texting and walking on normalized velocity, claw back was not significantly influenced by texting conditions. Although the general trend in the claw back results showed a decrease in the claw back force, inferential statistics did not reveal significance differences across conditions. The limited sample size may have been a factor within this data set affecting the significance of the results. Furthermore, it was difficult to compare the claw back force findings of this research across conditions to existing literature as the empirical research being conducted on claw back forces during gait is limited.

The initial hypothesis was that claw back would increase with increasing complexity of dual-tasking because the participant would theoretically assume a more cautious gait pattern, which would be evident through a more dramatic pull-back of the foot instantaneously before heel-strike. This outcome, however, was not observed. Rather, claw back appeared to decrease as a dual-task was incorporated, indicating an alteration in normal gait pattern. The precise biomechanical foundations contributing to this alteration warrants further investigation.

Finally, results indicated that the texting condition and type of force had a significant interaction effect. During a normal gait pattern, braking and propulsive forces should be very similar in magnitude to ensure equal force application on both lower extremities [3]. This pattern was observed in the control condition (i.e., Condition 1), which was an expected outcome as depicted in Figure 2. When a dual-task was implemented in Condition 2, however, the braking and propulsive forces deviated drastically, indicating an apparent alteration in the normal gait pattern when the participant was receiving a text and reading it aloud. Finally, the braking and propulsive forces converged when the participant was sending a text; however, the forces did not return to the baseline parameters observed within the control condition.

The large deviation in braking and propulsive forces while receiving a text may be related to an increase in cognitive loading as participants were required to read the message aloud for reliability purposes. The verbal component of this task theoretically added a third cognitive task, additional to the motor and visual components already employed during texting and walking. It is believed that this increased demand for dual-processing increased the cognitive interference, thereby compromising the outcome of the task. This rational is supported by the findings of Drews et al. [4] in which receiving and reading a text message resulted in greater cognitive interference than composing and sending a message.

The results from the current study may have been limited by a few factors, one of them being sample size. Power analysis calculations, however, indicated adequate sample size to reject the null hypotheses. Another limiting factor was that only the right foot was analyzed during the gait cycle for claw back and braking and propulsive forces because the force platform measuring ground reaction forces for the left foot had a calibration issue. Analyzing both feet during the

gait cycles via both AMTI force platforms would provide a better indication of the effect of texting on walking pattern abnormalities. Finally, participants reported that in some instances it was difficult to have a normal footfall on both AMTI platforms in succession while still trying to maintain a normal walking pattern when performing the texting task. Conducting this data collection using a continuous biomechanics platform in which there was not a gap between two plates or using accelerometer technology may help to eliminate this constraint.

There are a few recommendations for future research that may help understand the effect of dual-processing, specifically texting and walking, on gait pattern characteristics. Future research should focus on examining the full gait cycle for force measures, as well as, increasing the sample size to be able to make stronger generalizations from the results. Furthermore, research should focus on including a wider age demographic since nowadays older adults engage in texting behaviours, a cohort that is more susceptible to balance disturbances and fall risk [5, 6]. The current research, however, can serve as a foundation for future research examining the effects of various dual-task paradigms on gait pattern.

5. Conclusions

This study examined the effect of texting and walking on gait pattern characteristics for measures of normalized velocity, claw back, and braking and propulsive forces. The outcomes indicated that texting while walking had varying effects on gait pattern characteristics as statistical significant differences were found in normalized velocity between undistracted walking and sending a text, as well as, between receiving a text and sending a text. Claw back, however, was not found to have statistically significant differences across the three texting conditions. Finally, a marginally significant interaction effect was found between the texting condition and type of force (braking and propulsive) on ground reaction force measures. These results build on the existing literature and may have implications for researchers and clinicians in the development of testing protocols to monitor patients' or subjects' walking patterns and gait abnormalities in injury rehabilitation. Thus, aligning with relevant research literature on texting and walking, the results of the current study indicate that texting while walking impairs normal gait patterning, which can put an individual at an increased risk for falling and resultant acute and chronic injury.

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