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Everyday multitasking habits: University students seamlessly text and walk on a split-belt treadmill

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ABSTRACT

With increasing numbers of adults owning a cell phone, walking while texting has become common in daily life. Previous research has shown that walking is not entirely automated and when challenged with a secondary task, normal walking patterns are disrupted. This study investigated the effects of texting on the walking patterns of healthy young adults while walking on a split-belt treadmill. Following full adaptation to the split-belt treadmill, thirteen healthy adults (23 ± 3 years) walked on a tied-belt and split-belt treadmill, both with and without a simultaneous texting task. Inertial-based movement monitors recorded spatiotemporal components of gait and stability. Measures of spatial and temporal gait symmetry were calculated to compare gait patterns between treadmill (tied-belt and split-belt) and between texting (absent or present) conditions. Typing speed and accuracy were recorded to monitor texting performance. Similar to previous research, the split-belt treadmill caused an alteration to both spatial and temporal aspects of gait, but not to time spent in dual support or stability. However, all participants successfully maintained balance while walking and were able to perform the texting task with no significant change to accuracy or speed on either treadmill. From this paradigm it is evident that when university students are challenged to text while walking on either a tied-belt or split-belt treadmill, without any other distraction, their gait is minimally affected and they are able to maintain texting performance.

1. Introduction

Students walking while texting is a common phenomenon on the University campus. Young adults maintain balance and avoid tripping or falling while simultaneously texting on a cell phone, requiring cognitive input to understand the screen's contents and fine hand control movements to respond. Despite the fact that locomotion is a well-practiced motor task, it involves both executive functions and attention [1,2]. When challenged with a secondary cognitive task while walking, healthy young adults decrease the level of attention used to maintain gait performance during normal steady-state walking in order to transfer attention to perform the concurrent task [3,4].

Typical gait can be adapted to the environment where it is performed, such as during walking on a split-belt treadmill (SBT) where both feet are driven by independent belts capable of operating at different speeds. Over the course of gait adaptation to the SBT, initial gait asymmetries are reduced [4–6]. Several mechanisms, facilitated by both peripheral (i.e. proprioceptive) and central (i.e. spinal) feedback signals, are used during asymmetric gait to control muscular co-ordination of both lower limbs [5,7]. Once adaptation has occurred, the resulting walking pattern utilizes a decreased step frequency, increased gait cycle time and an increased time spent in double support (DS) as compared to tied-belt treadmill (TBT) walking [5,7,8]. Furthermore, asymmetric walking induced by SBT increases the overall attentional requirements of walking as compared to typical walking [9] and could be used to manipulate the attentional requirements of locomotion.

Texting on a cellular phone requires visual attention for reading, cognitive processing for communication and fine motor coordination for typing [10]. Its demands on working memory to maintain communication has an influential role on maintaining attention on surroundings while walking overground [11,12]. It does appear that texting performance is prioritized while walking: dialing speed on a phone was unaltered from standing [13], calculations performed on a phone did not change in accuracy [14] and texting increased the likelihood of unsafe walking behavior (i.e. improper road crossings, inattentiveness) in young adults [15,16]. In addition, participants had trouble retaining certain spatial information by inadequately dividing attention between texting and walking [11]. Finally, changes in mediolateral stability during texting and walking have mainly been attributed to the physical constraints of holding the cellular phone and therefore,

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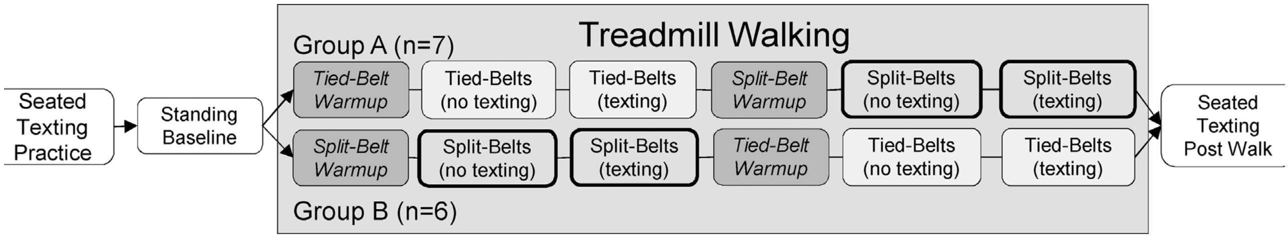

Fig. 1. Protocol timeline illustrating periods of texting practice, baseline and post-walking assessments. Grey shaded area shows treadmill walking conditions alternating between tied-belts and split-belts with and without texting. All participants completed a 25-min split-belt adaptation protocol prior to testing.

no arm swing [13,14,17,18].

The purpose of this study was to examine changes to gait biomechanics due to texting during SBT in an adapted state. Since SBT walking requires more attention, we expected texting performance during SBT walking to decrease in speed and accuracy. We also expected an increase in overall temporal, spatial and step phasing asymmetry with minimal change in medio-lateral stability. Finally, texting on the SBT was expected to further exacerbate gait asymmetries.

2. Methods

2.1. Participants

Thirteen healthy University students (6 males, mean age 23 ± 3 years) with normal or corrected-to-normal vision and no history of vestibular dysfunction or musculoskeletal or neurological disorders participated in the current study. Participants completed a 25-min SBT adaptation protocol (Hinton et al., in preparation) immediately before their participation in this study and were therefore adapted to the SBT. Written informed consent was obtained from all participants who were frequent smartphone users, owned a phone with touch screen and were familiar with smartphone text messaging. The experimental protocol was approved by the McGill Institutional Ethics Review Board.

2.2. Equipment

Spatiotemporal measures of gait and stability (trunk movement) were measured and analyzed using the APDM Mobility Lab System (Opal™, APDM Inc., Portland, OR). Participants wore seven wireless inertial sensors (triaxial accelerometers, gyroscopes and magentometers; weight 22 g) on the sternum, forehead, sacrum, left and right wrist, and left and right lower shank which continuously streamed data to a computer with Mobility Lab™ software. Participants walked on a treadmill (Forcelink Dual Belted Treadmill on N-Mill Frame) consisting of two independently-operating belts with a 3 cm gap and three safety bars while wearing a safety harness. The harness provided no mechanical support nor hindered movements and was only engaged in the case of a fall.

A texting application (TapTyping™), installed on a touchscreen cellular telephone (iPhone5c) produced a three-sentence paragraph of logical, on-screen text. Participants re-typed a series of three consecutive, and different, TapTyping paragraphs for a single texting trial (approximately 90 seconds). Participants were instructed to continue without correcting texting errors (shown in red) and were given no instruction for their gaze while texting.

2.3. Procedure

All participants first completed a seated texting familiarization trial, followed by two texting trials while standing upright, wearing the safety harness beside the running treadmill. Participants were instructed to “type as fast as possible while making minimal mistakes”. Baseline texting performance was deemed the mean typing accuracy and speed of these two trials.

Seven participants started with the TBT condition followed by the SBT condition, with the reverse order for the remaining participants (See Fig. 1, groups A and B). This protocol aimed to assess participants’ gait in an *adapted* state while walking on the TBT and SBT. All participants began with a 5-min familiarization period to generate reproducible gait patterns [19–22] followed by the no-texting condition.

The no-texting condition required participants to maintain gaze on a 10 × 10 cm ‘X’ on the wall 1-meter ahead of the treadmill, and walk without the phone and normal arm swing. The treadmill speed was set to each participants’ self-selected pace (mean = 0.72 ± 0.14 m/s). To determine walking pace, both treadmill belts’ speeds were increased by 0.08 m/s increments until participants reported the speed most closely resembled daily walking. The texting condition required participants to walk at their self-selected pace while holding the phone with both hands and texting. In the SBT condition, the belt underneath the dominant leg was reduced to one-half of the speed of the non-dominant leg (Waterloo Footedness Questionnaire [23]). Gait data was collected for two 1-minute bouts without texting and two bouts while texting (90 seconds). Participants ended with a seated texting trial to determine if any changes in texting performance occurred over the entire walking protocol.

2.4. Data analysis

Texting speed (words per minute, WPM) and accuracy (percentage letters correct) were automatically calculated by the TapTyping™ application. Spatiotemporal gait outcomes were directly obtained from the Mobility Lab™ algorithms of the iWalk plugin. Evidence from SBT adaptation indicates spatial and temporal aspects of gait are adapted separately [24]. Stride length (SL; distance (meters) between consecutive heel contacts of the same foot) and SL symmetry (SLS [24]) assessed spatial aspects of gait. SLS was calculated via Eq. (1) using the SL of each leg. Temporal measures of gait included step time (ST; duration (seconds) between consecutive opposite heel contacts), ST symmetry (STS, Eq. (1)), time spent in dual support (DS) and dual support symmetry (DSS, Eq. (1)). Dual support was divided based on the leg which was at the end of stance [12]; (i.e. left DS was from right foot contact to left foot toe-off). Variability was assessed via coefficient of variation (COV) for SL, ST and DS of each leg (Eq. (2)). Stability was assessed by frontal plane (i.e. lateral flexion) trunk range of motion (ROM, degrees) and peak frontal plane trunk velocity (degrees/second).

$$Symmetry = \frac{Fast\ Leg - Slow\ Leg}{Fast\ Leg + Slow\ Leg} \quad (1)$$

Stride Length (SL), Step Time (ST) and time spent in Dual Support (DS) were substituted into Eq. (1) to calculate Stride Length Symmetry, Step Time Symmetry and Dual Support Symmetry values. A symmetry value of 0 represents symmetrical gait with no difference between each leg’s spatiotemporal parameter (ie, SL, ST or DS). A positive value indicates a longer spatiotemporal parameters of the leg driven by the fast belt and a negative value indicates the opposite.