ORIGINAL ARTICLE

The Dual-Task Effects of Conversating While Walking on Gait Spatiotemporal Parameters in Healthy Young Adults

Aliff Latir[1], Maria Justine[1], Robert van Deursen[2]

[1] Centre for Physiotherapy studies, Faculty of Health Sciences, Universiti Teknologi MARA Selangor branch, Puncak Alam Campus, 42300 Puncak Alam Selangor, Malaysia
[2] School of Healthcare Sciences, Cardiff University, Heath Park Campus, Cardiff CF14 4XN, Wales, UK

ABSTRACT

Introduction: Conversating during walking is an everyday multitask activity, if compromised may lead to gait instability or a fall. This study aims to examine the dual tasking effects of conversating while walking on gait performance conducted in a virtual reality environment. **Methods:** This cross-sectional study recruited thirty healthy individuals (27.3 ± 5.7 years, 23 males) through a purposive sampling method. They completed two sessions of three-minute tasks on an instrumented dual-belt treadmill: silent walking (ST) and conversational dual-tasking (DTC) in a Real-Time Gait Analysis Lab, Cardiff University. The gait speed, stride length, and step width between ST and DTC were compared using a two-way repeated-measures analysis of variance (RM ANOVA), with a p-value of 0.05. **Results**: The results of this study showed a significant (Cond x phase) interaction effect on gait speed, stride length, and step width ($p<0.05$), respectively. In contrast, no significant (Cond) main effect was found on any gait parameters ($p>0.05$). **Conclusion:** Conversating while walking may influence gait performance, possibly through the extrinsic focus of attentiveness in healthy adults.
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Corresponding Author:
Aliff Latir, MSc
Email: aliff533@uitm.edu.my
Tel: +603-32584367

INTRODUCTION

Conversating while walking is a cognitively demanding multitask that is frequently undertaken. Walking is a complex motor task that requires a person to be cognitively aware of their desired destination, regulate their lower limb's movement, and manoeuvre around obstacles to reach their destination efficiently and safely (1). Spontaneous speech requires information retrieval from memory, selecting suitable grammatical and word structures, and converting these phrases into verbal motor responses (2). While these tasks may be automatic and overlearned in a healthy population, both have the potential for negative consequences. For instance, impaired speech articulation is related to reduced gait performance and quality of life (3,4). The concept of the dual-task effect was proposed by Bloem et al. (5) and Shumway-Cook et al. (6) in explaining the detrimental effect of multitasking by comparing parameters in two different conditions; when the tasks are performed in isolation and performed concurrently. It is hypothesised that when two concurrent tasks demand a significant amount of divided attention in the brain, it may lead to negative consequences for either one or both tasks (1,7).

In-depth examination of the dual-task effect on motor task behaviours such as walking is complicated by various dual-task methods, including visuospatial, memorisation, arithmetic, and Stroop tests (1,8). These conventional cognitive tasks are advantageous because their difficulty can be controlled and graded systematically, allowing researchers to observe motor performance when the difficulty of the cognitive task is manipulated. These chores, however, are rarely carried out in daily life. Additionally, these tasks are not mandatory for participants to complete with total effort, as their performance has only a minor impact on their everyday functions. For example, significant reductions in gait speed are observed during an impromptu speech (activity with substantial consequences of disability) compared to the auditory Stroop test (activity with minor consequences of disability) (9). Additionally, variations in consequences of disability associated with conventional concurrent dual-task studies might limit its generalisation of results to daily activities.

Spontaneous speech is an excellent concurrent activity since it is difficult, frequently practised, continual, and dramatically influences walking when performed poorly. Besides, spontaneous speech requires a more significant cognitive load from narrating or reading text (2,10–12). According to Yogev-Seligmann, Hausdorff, and Giladi's (13) integrated model of task prioritisation; healthy people can modify task prioritisation based on the difficulty and value of concurrent tasks. In this scenario, speech is changed to guarantee sufficient attentional resources to prevent a fall while doing a problematic gait task. When faced with less complex situations, healthy individuals may choose to divert their attention to talk over walking when the task is perceived as more valuable in their social environment (14–16).

The argument for conversating while walking is exemplified because this dual activity frequently results in poorer gait or falls in cognitively deficient individuals (3,4) and even young adults (17). When cognitively challenged people to converse, they may demonstrate gait cessation or instability. These indicate a compromised ability to assign the two tasks concurrently among high-risk fallers (3,4). Even among adolescents and young adults, conversating with a buddy while walking is a frequent dual-task activity related to falls (17). Thus, conversating while walking may present difficulties even in young adults who appear to be in peak cognitive and physical fitness.

Therefore, the current study will examine how conversating while walking affects the spatiotemporal aspects of gait, including gait speed, stride length, and step width. These variables encompass spatial and temporal gait characteristics and are frequently assessed in dual-task paradigms (1,18–20). Because previous research indicates that people can prioritise one task above another when instructed (1,21), no prioritisation instructions were provided in this investigation to measure self-selected priority. Additionally, this study will examine the extent of dual-task effects on the increased cognitive burden associated with conversating while walking. This study will utilise Gait Real-time Analysis Interactive Lab (GRAIL) to facilitate a self-paced walking environment comparable to over-ground walking.

MATERIALS AND METHODS

This cross-sectional study used a repeated measure approach. Our study sampled a minimum of 30 individuals using a G*Power (22), assuming power at 80% and effect size from medium to high (0.65). A purposive sampling strategy was used to enrol 30 healthy young individuals aged between 18 to 35 years old. The participants were recruited by advertising on social media platforms including WhatsApp, email, and flyers. Participants with abnormal eyesight, musculoskeletal, cardiovascular, fracture, neurological, or vestibular problems or were currently taking medication that could affect the study's outcome were excluded. Before enrollment, all participants provide informed consent. The Ethics Committee of the School of Healthcare Science's Research, Cardiff University, gave the ethical permission.

Experimental procedures

Gait in both tasks was analysed using the Gait Real-time Analysis Interactive Lab system (GRAIL) in Ty Dewi Sant, Cardiff University. The system consisted of a 12-camera Vicon optical, infrared motion-capture system with a sampling rate of 100Hz, instrumented self-paced dual-belt treadmill, and 1800 virtual-reality projected screen integrated into a D-flow software. The motorised treadmill system's speed is automatically adjusted to match each participant's preferred walking style, simulating an overground walking environment. Gait parameters were captured and constructed using the VICON MX system equipped with 47 retroreflective markers. Three experienced physiotherapists positioned reflective markers based on the Motek HBM schematic. Throughout the gait trial sessions, a continuous road scene was presented in front of each participant on an 1800-pixel screen synchronised with the treadmill. The safety harness and emergency stop buttons ensured safety during the gait trial. Before data collection, participants were provided three minutes to familiarise themselves with the treadmill. Participants were allowed to rest for a minute in between the tasks.

Each participant was directed to walk on the treadmill at their own pace for three minutes under two distinct conditions: walking silently as a single-tasking (ST) and conversational dual-tasking (DTC). In DTC, participants simultaneously answered four sets of recorded verbal questions corresponding to the four gait phases, each lasting thirty seconds. Each inquiry prompt includes a 7.5-second pause for voice response. The context of the question prompts gradually increased in complexity from the first to the fourth phase, requiring more attention and cognitive load to listen, memorise, and react. To determine the dual-task effects of DTC, the ST was utilised as a baseline. Both ST and DTC tasks were performed in the same order to avoid affecting the ST's baseline gait performance, supported by the previous dual-tasking studies that demonstrated altered gait performance possibly due to the effects of cognitive load (23). All participants were given a standardised instruction in both gait conditions; "please walk on the treadmill as if you are strolling in the park while looking at the screen" in ST, or "while responding to all sixteen question prompts" for DTC, respectively.

Data processing

The VICON Nexus programme was used to process and generate gait parameters from the raw data obtained from GRAIL. The parameters - gait speed average, step length average (SLave) and the average step width (SWave) were then derived from the mid-two minutes of the full gait trial by using the MATLAB software (MathWorks, Natick, Massachusetts).

Statistical Analysis

All data were statistically analysed using the SPSS Statistics version 23. A descriptive analysis was used to describe the demographic and gait characteristics (mean±standard deviation) of our participants. A two-way repeated-measures analysis of variance (RM ANOVA) was used to compare the gait parameters of ST and DTC, with a significance level of 0.05. The amplitude of the dual-task impact pattern about increasing cognitive load was determined using a linear interaction plot across the four measurements.

RESULTS

This study enrolled 30 participants (23 males) with a mean age of 27.3±5.7. Their average BMI was 24.29±5.7 kg/m2, and their average self-paced walking speed was 1.32±0.2 m/s. The mean and standard deviations (SDs) of gait speed, SLave and SWave were summarised in Table I.

Comparison of Gait Parameters between ST and DTC

The two-way ANOVA revealed no significant difference in the average gait speed, SLave, or SWave between two tasks (F (1, 28) = 0.07, p=0.79; F (1, 28) = 0.02, p=0.89; and F (1, 28) = 0.66, p=0.52, respectively). On the other hand, with respect to the Condition x Phase interaction, significant differences were observed for gait speed (F (2.40, 67.17) = 4.31, p=0.012), SLave (F (3, 84) = 3.72, p=0.015), and SWave (F (1.98, 55.39) = 4.77, p=0.013) (Table I). Figs. 1 (a), (b) and (c) depicted the interaction plots for gait speed, SLave, and SWave. The crossing lines in all interaction plots illustrate the significant difference in response to the ST and DTC conditions over time.

DISCUSSION

This research aimed to determine whether conversational dual-tasking influences gait spatiotemporal parameters in a virtual reality environment; by raising cognitive load and dividing attention between task components, conversational dual-tasking significantly affected gait speed and stride length step width.

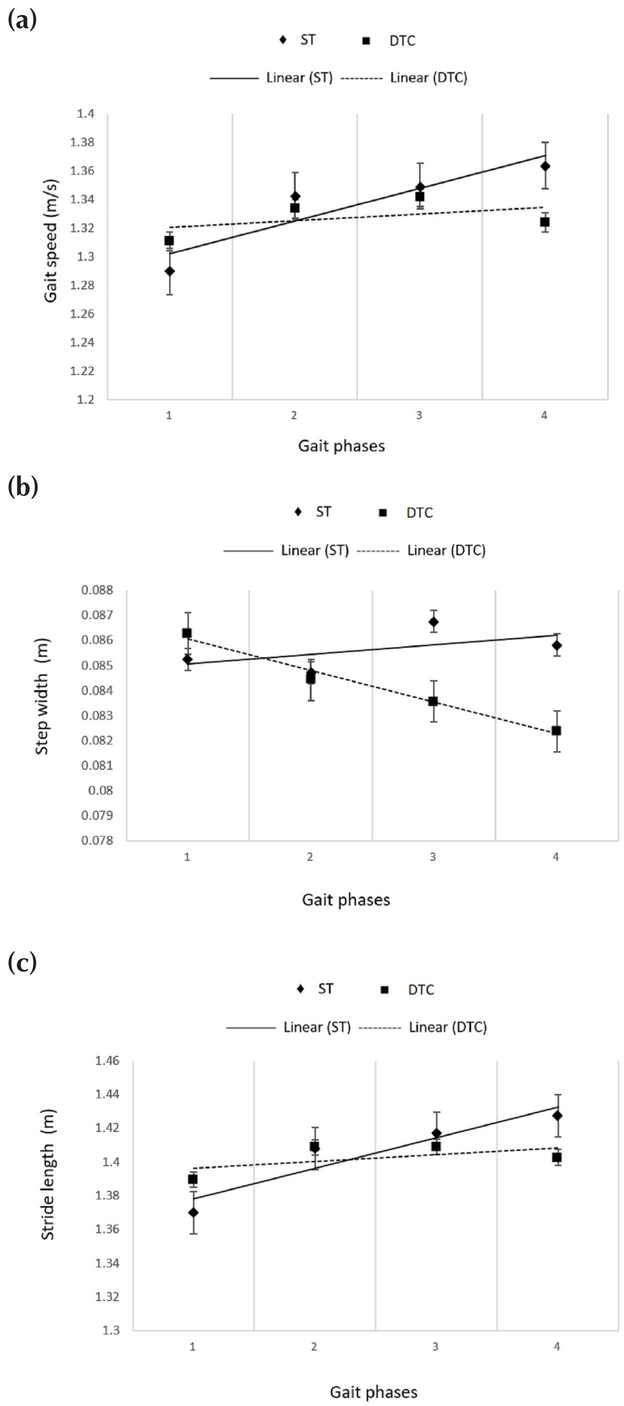

Figure 1: (a) Interaction plot - Gait speed (b) Interaction plot - SL_{av} (c) Interaction plot - SW_{av}. Means and standard deviations of gait speed, length and width in single-tasking (ST) and conversational dual-tasking (DTC) across four measurements (n=30).

Table I: Comparison of Gait Spatiotemporal Parameters Between Single-Tasking (ST) and Conversational Dual-tasking (DTC).

	1st phase		2nd phase		3rd phase		4th phase		Average		p-value
	ST	DTC	ST	DTC	ST	DTC	ST	DTC	ST	DTC	
Gait speed (m/s)	1.29±0.20†	1.31±0.15†	1.34 ±0.19†	1.33 ±0.19†	1.35 ±0.18†	1.34 ±0.18†	1.36 ±0.17†	1.32 ±0.18†	1.34 ±0.19	1.33 ±0.17	0.012†
SL_{ave} (m)	1.37 ±0.13†	1.39 ±0.10†	1.41 ±0.12†	1.41 ±0.13†	1.42 ±0.12†	1.41 ±0.12†	1.43 ±0.11†	1.40 ±0.12†	1.41 ±0.12	1.40 ±0.12	0.015†
SW_{ave} (m)	0.0852 ±0.023†	0.086 ±0.023†	0.085 ±0.025†	0.084 ±0.022†	0.087 ±0.022†	0.084 ±0.023†	0.086 ±0.023†	0.082 ±0.022†	0.086 ±0.023	0.084 ±0.022	0.013†

Note: Values are mean ± SD. Abbreviation: SL_{ave}, Stride length average; SW_{ave}, Step width average; ST, Single-tasking; DTC, Conversational Dual-tasking.
Significant level at $p < 0.05$. Significant (Cond) main effect †Significant (Cond x phase) interaction effect

Our investigation on (Cond x phase) interaction effects is denoted by the substantial increase in gait speed and SLave, and the decreased SWave observed in DTC. These findings confirmed earlier research findings (24,25). Kelly et al. (24) demonstrated an increase in walking speed when attention was diverted from cognitive tasks to walking. Kizony et al. (25) showed an increase in gait speed when walking was performed concurrently with carrying groceries in a virtual environment. The authors hypothesised when an individual paid more attention to other concurrent tasks, it would result in more spontaneous walking, which led to faster walking. The findings are consistent with the study's selection of a healthy young cohort — our sample maintained regular and inclining gait patterns in response to escalating cognitive challenges.

There are few possible explanations for increasing gait speed, stride length, and decreasing step width while performing simultaneous conversational tasks. There is a possibility that our participants had prioritised the new walking task over the typical conversational task, even though they were not instructed to do so. Prioritising gait, particularly in novel contexts, is seen as a suitable strategy (1,16) and one of the hypothesised compensatory mechanisms for dual-tasking in healthy individuals (18,28). Perhaps the concept of increased gait speed and stride length is more critical to older adults, as those who walk quicker will increase their risk of falling. Ayers (4) discovered stride length and pace domain as fall indicators in community-dwelling elderly. On the other hand, people with Parkinson's Disease (PD) who performed dual-tasking (carrying objects while walking) were able to replicate walking speed similar to single-tasking when instructed to divert attention to walking (29), suggesting the role of attention in preventing falls associated with walking in this population.

A different interpretation of our results can be taken from the literature on motor learning. According to Wolf (30) and Emanuel (31), focusing attention on the external object and results of the activity (the extrinsic focus of attentiveness) improves motor execution compared to focusing attention on the walking activity (the intrinsic focus of attentiveness) in non-disabled individuals and older individual with PD (30,31). Our participants were likely concentrated exclusively on the conversational task. To respond to the questions verbally, they must perform information retrieval from the brain, select fitting grammar and word structure, and convert the word articulations into speech. As a result, they focused less on walking, which became more intuitive, faster, and closer to their overground pace.

The linear patterns observed between gait speed and stride length in the interaction plots corroborate previous research demonstrating a significant association between gait speed and other gait spatiotemporal parameters. Laufer (26) and Kelly (24) had shown increasing speed in forwarding gait is associated with increased stride length. Fukuchi et al. (27), in their systematic review, have concluded that gait spatiotemporal parameters declined at a slow pace in young and older populations and inclined at a fast pace in the adult population. The implication of these findings is; that the effects of gait speed should be taken into account in a comparison study that involves morbid individuals (slow pace) and healthy individuals (fast pace) (26).

There are a few limitations to this study. First, conversating while walking might be a less challenging dual-tasking activity that young adults can perform with minimal cognitive effort. Second, the participants were unfamiliar with the concept of walking on the self-paced treadmill in a virtual environment. Despite the practice and habituation conducted before the commencement of the gait trial and fixed order of ST and DTC, it is possible the motor learning process occurred when they performed a relatively unfamiliar walking task. This study only explored the dual-task effect on gait speed, stride length and step width. Thus, recommended that additional research explore other gait components and stability and the effects of more complicated cognitive activities or different forms of cognitive load and concurrent speech output.

CONCLUSION

The investigation of conversating while walking in a virtual reality showed that conversation's gradual load cognitively might significantly impact gait spatiotemporal parameters through the extraneous focus of attentiveness in healthy young adults. Higher patterning observed in stride length and narrowing step width could result from increased gait speed. Thus, assessing the verbal dual-tasking effect in a virtual reality setting may reveal a valuable understanding of gait performance for clinical assessment and management.

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