Gait & Posture 55 (2017) 43–48

Contents lists available at ScienceDirect

Gait & Posture

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

Continuous and difficult discrete cognitive tasks promote improved stability in older adults

Yves Lajoie*, Deborah A. Jehu, Natalie Richer, Alan Chan

School of Human Kinetics, University of Ottawa, Ottawa, ON, Canada

ARTICLE INFO

Keywords:
Dual-task
Postural control
Continuous cognitive task
Discrete cognitive task
Older adults

ABSTRACT

Directing attention away from postural control and onto a cognitive task affords the emergence of automatic control processes. Perhaps the continuous withdrawal of attention from the postural task facilitates an automatization of posture as opposed to only intermittent withdrawal; however this is unknown in the aging population. Twenty older adults (69.9 ± 3.5 years) stood with feet together on a force platform for 60 s while performing randomly assigned discrete and continuous cognitive tasks. Participants were instructed to stand comfortably with their arms by their sides while verbally responding to the auditory stimuli as fast as possible during the discrete tasks, or mentally performing the continuous cognitive tasks. Participants also performed single-task standing. Results demonstrate significant reductions in sway amplitude and sway variability for the difficult discrete task as well as the continuous tasks relative to single-task standing. The continuous cognitive tasks also prompted greater frequency of sway in the anterior-posterior direction compared to single-standing and discrete tasks, and greater velocity in both directions compared to single-task standing, which could suggest ankle stiffening. No differences in the simple discrete condition were shown compared to single-task standing, perhaps due to the simplicity of the task. Therefore, we propose that the level of difficulty of the task, the specific neuropsychological process engaged during the cognitive task, and the type of task (discrete vs. continuous) influence postural control in older adults. Dual-tasking is a common activity of daily living; this work provides insight into the age-related changes in postural stability and attention demand.

1. Introduction

Dual-task paradigms have been widely used to study the influence of automatic and controlled processing involved in postural stability in young and older adults. Postural control and attention capacity deteriorate in older compared to young adults [1]. In fact, limited attentional resources have been shown to predict falls [2] and reduce the ability to independently perform daily activities [3] in older adults. As the complexity of the postural task increases, performance of postural, concurrent, or both tasks is more affected in older compared to young adults [4]. Limited research has examined the age-related link between attention demand and postural performance; therefore a better understanding of these influences is necessary.

Postural control synergies have been suggested to be responsive to cognitive manipulations. In young adults, performing a cognitive task while standing has led to attenuated [5,6], increased [7,8], as well as null effects [9] on postural sway. Similarly, in older adults, performing a cognitive task while standing has exposed improvements [5,10,11] and declines [12,13] in postural control. These inconsistent results have been proposed to stem from the difficulty and type of cognitive task [1,7], the difficulty of the postural task [14,15] or the use of a stiffening strategy [6,16]. Improved postural control can be identified by attenuated displacement and variability coupled with increases in frequency [5,16,17], which may also be reflective of automatic postural control. Interestingly, increased center of pressure (COP) velocity in the sagittal plane may be an indication of a stiffening strategy [18]. Recent work in young and older adults has shown that directing attention onto a continuous cognitive task while standing leads to reductions in sway area and variability [11,19], which could indicate improved postural control. It was proposed that since these continuous tasks require greater attention capacity, less attention was available for the postural task, leading to the use of a more automatic type of postural control [19]. Automatic postural control has been postulated to permit unconscious, fast, and reflexive processes to regulate posture [20]. It is characterized by a smaller amplitude and higher frequency of postural adjustments [21]. Continuous tasks may also be less susceptible to distractions relative to discrete tasks, as they continuously require attention [22]. Conversely, during single-task conditions with

* Corresponding author at: University of Ottawa, Health Sciences, School of Human Kinetics, 125 University St, Ottawa, ON, Canada K1N6N5.
E-mail address: ylajoie@uottawa.ca (Y. Lajoie).

http://dx.doi.org/10.1016/j.gaitpost.2017.04.003
Received 30 September 2016; Received in revised form 24 January 2017; Accepted 1 April 2017
0966-6362/

no cognitive task, the participant may inherently allocate attention onto postural control; this thereby consciously interferes with automatic processes, leading to less efficient postural control [19,20]. Presumably, discrete cognitive tasks allow for lapses of time between stimuli wherein attention could be allocated to posture, resulting in less efficient postural control than during continuous tasks. To verify these assumptions, a recent experiment examined the influence of discrete and continuous cognitive tasks in young adults and showed significant reductions in sway area and variability during continuous compared to discrete cognitive task performance [22]. Authors suggested that continuous tasks provide less opportunity to consciously attend to postural control, thereby facilitating postural automaticity [22]. It remains unknown whether discrete tasks would benefit postural control to the same or similar extent as continuous tasks in older adults.

The purpose of this study was to extend the work of Lajoie and colleagues to compare the effect of discrete and continuous cognitive tasks on postural control in the older population [22]. The hypothesis was that continuous tasks would elicit decreased sway area and variability, and increased mean power frequency (MPF) compared to the discrete tasks and single-task standing [22]. It was also hypothesized that the discrete tasks would lead to reduced sway area and variability, and increased MPF as opposed to single-task standing [22].

2. Methods

2.1. Participants

Twenty healthy older adults (4 males; 69.9 ± 3.5 years) were recruited. Participants signed an informed consent form approved by the Research Ethics Board at the University of Ottawa in accordance with the ethical standards of the Declaration of Helsinki. Additionally, participants completed a health questionnaire disclosing age, sex, and history of disease to ensure they had no musculoskeletal, sensory, or neurological deficits that could interfere with balance. Finally, the mini-mental state examination was administered as a screening tool for cognitive impairment, with a minimum required score of 24 [23].

2.2. Apparatus

An AMTI force platform (ORG-6-1000, Don Mills, ON, Canada) was used to record COP data at a sampling frequency of 500 Hz. A piezoelectric speaker placed in front of the participant was used to emit high- and low-pitched tones used for the reaction time (RT) tasks. The high pitched signal was administered at a fixed frequency of 2850 Hz at 99 dB whereas the low pitched signal was administered at a fixed frequency of 970 Hz at 95 dB for approximately 100 ms. The cognitive tasks were presented using a digital media player and two speakers placed on either side of the participants.

2.3. Experimental protocol

The postural task consisted of standing on the force platform with feet together, arms hanging loosely at the sides and eyes directed to an eye level target 3 m ahead. Participants were instructed at the beginning of the session to maintain this position throughout all experimental conditions while performing the secondary tasks. Participants' foot placement was marked on the force platform to maintain consistency across trials. In conjunction with the postural task, participants were asked to perform four cognitive tasks: two discrete and two continuous. The two discrete tasks consisted of a simple reaction time (SRT) and a go/no go reaction time (GO/NG) task. In the SRT task, only high-pitched auditory stimuli were presented and participants were asked to verbally respond "top" as fast as possible upon stimulus presentation. Between 9 and 11 auditory stimuli were administered randomly per trial at intervals ranging from 3 to 8 s. In the GO/NO task, high- and low-pitched auditory stimuli were presented. Participants were instructed to verbally respond "top" as fast as possible only when the high-pitched beep was emitted, and not to respond during the low-pitched beeps. Between 11 and 12 stimuli were randomly administered per trial at intervals ranging from 3 to 8 s, and 5–7 of these stimuli were high-pitched. If participants made more than one mistake in the SRT or GO/NG trials, the trial was discarded and repeated. The continuous cognitive tasks consisted of the sequence and equation tasks. In the sequence task, participants were presented with an auditory recording consisting of a series of 30 3-digit numbers presented at 2 s intervals. Prior to each trial, participants were asked to keep track of a specific single digit within this sequence. Specifically, they were instructed to mentally count and sum the occurrence of this digit in the number sequence (e.g. count and sum the number of 5s in the following sequence: 354, 687, 135, 426, etc.). Six different sequences were used to reduce the chance of memorization, and the requested digit was varied for each trial. In the equation task, participants were asked to mentally perform a series of 20 simple mathematical equations presented at 3-s intervals in a recording (e.g. $5 - 3 + 10 \div 2$, etc.). Eight different equations were used throughout the testing. For both continuous cognitive tasks, participants verbally reported their final answer at the end of each trial. The use of fingers as a counting aid was prohibited in order to ensure that postural sway was unaffected and cognitive effort was maximized. If participants lost track during the continuous tasks, they were instructed to use the last number they remembered in order to ensure cognitive effort was maintained. To verify if they followed these instructions, participants were asked at the end of each trial if they lost track of their answer, and if so, if they guessed the answer. If participants guessed the answer, the trial was discarded and repeated. Both continuous tasks required constant monitoring of the presented numbers or mathematical operations and updating of the remembered answer, while the discrete tasks did not require the use of working memory. The discrete tasks consisted of an easy task (SRT) and a challenging task (GO/NG). Similarly, for the continuous tasks, the equation task has been considered to be easier than the sequence task [22]. Eight 60-s trials were performed for each condition, in a randomized order. Additionally, four 60-s single-task standing trials were included in a random order in the experimental conditions. The force platform was synchronized with the start of the number recording, while the auditory beeps were not synchronized between trials as they were emitted at random by the experimenter. Four different testing protocols were used to vary the order of trials across participants. Prior to the experimental conditions, a familiarization period consisting of one 30-s practice trial per condition was completed.

2.4. Data analyses

COP data recorded from the force platform was processed using MATLAB software (7.0, MathWorks, Nadick, MA, USA) in order to extract the following dependent variables: Area of 95% confidence ellipse (Area), Standard Deviation (SD) of the COP in the medial-lateral (ML) and anterior-posterior (AP) directions, and Velocity of the COP in the ML and AP directions. Bioproc3 software (D.G.E. Robertson, Ottawa, ON, Canada) was used to perform a Fast Fourier Transform on the COP data to determine MPF in the ML and AP directions. Data was averaged across each experimental condition and used for statistical analysis.

2.5. Statistical analyses

Separate repeated measures ANOVAs on Condition (single-task standing, SRT, GO/NG, sequence, equation) were performed for each of the outcome measures (Area, SD of COP, Velocity, and MPF). If Mauchly's Test of Sphericity was violated, Greenhouse–Geisser corrections were performed. Tukey Honest Significant Difference post hoc comparisons were used to determine location of significance. Statistical