DOI: 10.590/1809-2950/14145522042015

ORIGINAL RESEARCH

Impact of two different dual tasks on obstacle crossing in elderly

Impacto de duas tarefas duplas diferentes em idosos durante a transposição de obstáculos

Impacto de dos dobles tareas diferentes en las personas mayores durante la transposición de obstáculos

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ABSTRACT | The performance of a dual task increases risk of falling during walking in the elderly. Such impact of a dual task may depend on its complexity regarding information processing. Therefore, different dual task configurations may elicit different demands for information processing. We investigated whether different dual task configurations can differently affect the performance of obstacle crossing in the gait of elderly. Ten independent elderly performed vertical obstacle crossing while performing two dual tasks during walking: (a) with auditory input (variation of Stroop task), and (b) without auditory input (report the days of the week in reverse sequence). We hypothesized that a dual task effect would be related with the type of dual task input, and the auditory input would require further information processing and therefore could have larger impact on gait. We found that performance of obstacle crossing was similar regardless of the dual task configuration. Both dual task conditions affect the obstacle crossing in the same extent in the elderly.

Keywords | Aging; Walking; Lower Extremity; Gait.

RESUMO | O desempenho de uma dupla tarefa pode aumentar o risco de quedas durante a marcha em idosos. O impacto de uma dupla tarefa pode depender de sua complexidade em relação ao processamento de informação. Diferentes configurações de duplas tarefas deduzem diferentes demandas para o processamento de informação. Neste estudo investigamos se diferentes configurações de duplas tarefas podem afetar o desempenho da transposição de obstáculo na marcha de idosos. Dez idosos independentes foram avaliados durante a marcha cruzando um obstáculo vertical enquanto desempenhando duas duplas tarefas: (a) com input auditório (variação da tarefa de Stroop), e (b) sem imput auditório (falar os dias da semana em ordem reversa). Nós hipotetizamos que um efeito da dupla tarefa seria relacionado com o tipo de seu *input*, e o *input* auditório requereria maior processamento de informação; portanto, poderia ter maior impacto na marcha. Nós encontramos que o desempanho de transpor obstáculo foi similar nas duas condições de dupla tarefa. Sendo assim, ambas duplas tarefas testadas afetam a transposição de obstáculo na mesma medida em idosos.

Descritores | Envelhecimento; Caminhada; Extremidade Inferior; Marcha.

RESUMEN | El desempeño de una doble tarea puede aumentar el riesgo de caídas durante la marcha en personas mayores. El impacto de una doble tarea puede depender de su complejidad en cuanto al procesamiento de información. Las distintas configuraciones de dobles tareas infieren distintas demandas para dicho procesamiento. En este estudio se investigó si las distintas configuraciones de dobles tareas pueden afectar el rendimiento de la transposición de obstáculo en la marcha de personas mayores. Han participado diez personas mayores independientes y evaluadas durante la marcha cruzando un obstáculo vertical mientras hacían dos dobles tareas: (a) con input auditorio (variación de la tarea de Stroop) y (b) sin input auditorio (hablar los días de semana en orden reverso). Se dedujo que el rendimiento de la doble tarea estaría relacionado con el tipo de su input, y el input auditorio exigía un

Funding: ESR was supported by a Student Research Fellowship from CNPq. This study was granted to FPC by CNPq (grant nº 476163/2010-2).
This research was approved by the Federal University of Pampa committee of ethics in research with humans (IRB #0172011).
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mayor procesamiento de información; por lo tanto, podría tener un mayor impacto en la marcha. Se encontró que el rendimiento en la superación de obstáculos fue semejante en las dos condiciones de doble tarea evaluadas. Así, ambas afectan a la superación del obstáculo en igual medida en personas mayores.

Palabras clave | Envejecimiento; Caminata; Extremidad Inferior; Marcha.

INTRODUCTION

Dual task (DT) performance is often requested in daily life activities, such as during walking while answering a phone call[1]. In older adults, a DT increases risk of fall[2]. The motor performance impairments observed during performance of a DT may result of decreased activity of information processing areas, most likely due to decentralization of attention processes[3]. In addition, the performance of a primary task can be directly influenced by the sensorial input from the secondary task [4]. When 377 elderly were examined concerning DT performance in concurrent reaction time tests, the performance in timed walking tests and recent history of recurrent falls, poor walking-time responses due to a timed visual-spatial decision task were associated with higher odds of recurrent falls history[5].

DT paradigms are often used in rehabilitation routines[6,7]. The use of a DT paradigm in chronic stroke rehabilitation improved walking ability under single and DT conditions[6]. When a DT involving balance training was considered, participants significantly improved executive function, complex attention, cognitive flexibility, and some balance indicators[7].

Baetens et al.[8] evaluated the effects of two different dual tasks on paretic step and stride length among stroke survivors. They found a different effect when a verbal fluency DT (verbally enumerate names of animals starting with a given letter) and a counting DT (serial subtraction by 3, starting from 100) were compared[8]. It suggests that different DT can differently affect motor performance of gait. Moreover, performance of a DT during gait with obstacle crossing seems related to a higher risk of fall[2,9,10]

Plummer-D'Amato et al.[11] investigated interactions between gait and performance in three different cognitive tasks in stroke survivors. The cognitive tasks were the auditory 1-back (working memory), auditory clock task (visuospatial cognition), and spontaneous speech. In the 1-back task participants heard a sequence of letters, presented one at a time, and they should reply, after each letter: "*yes*" when the last preceding letter was repeated, or "*no*" when it was not repeated. In the auditory clock task participants heard a specific time and were asked to say "*yes*" if both their hands were positioned in the particular place of the clock and "*no*" if they were not. In the spontaneous speech task, speech samples were requested from the participants using a set of questions. Results showed a significant difference in gait speed between the three cognitive tasks, with slower gait in the speech task than the 1-back and clock tasks, as well as slower speed in the clock task than the 1-back, without differences in cadence[11].

The performance of a dual task increases risk of falling in the elderly[12], and such effect may depends on the complexity of the secondary task[13]. However, there is little information on the effects of different dual tasks when considering independent elderly. Most of studies addressed such question considering participants with some degree of motor and/or cognitive impairment. However, we consider that the inclusion of activities requesting dual task performance is often reported in fall prevention programs[14–16], and therefore, it would be valuable to know whether the impact of different dual tasks in the elderly. In the end, such results could be important to provide activities for independent elderly in healthy quality programs based in scientific background, even those not requiring the permanent presence of a trainer or therapist. Therefore, here we investigated whether different dual task configurations can differently affect the performance of obstacle crossing in the gait of elderly. Our main hypothesis was that the effects of DT could vary with the presence of an auditory input due to the interaction with the experimenter and the need for further information processing.

METHODOLOGY

Participants

Fifty elderly communities dwelling that were regular participants (not residents) in a public elderly care house were invited to participate in this study transversal study.

Twenty were volunteers, and after the applications of inclusion criteria eleven elderly were selected. Data from ten elderly community dwelling volunteers (four male) were considered in the present study. The mean (standard-deviation) age was 74.4 (5.2) years; height 1.57 (0.05) m, and body mass 66 (9) kg. To participate elderly should be able to walk independently, without auditory or visual commitments that could impair gait performance. Elderly with neurological diseases (*e.g.* Parkinson's, Huntington's disease or stroke), vestibular or visual problems (clinically detected) or with lower limb prosthesis were excluded. All the subjects signed a written informed consent approved by the Federal University of Pampa committee of ethics in research with humans (IRB #0172011) and in agreement with the Declaration of Helsinki.

Neuropsychological and independence assessment

To exclude influence of cognitive deficits[17] and education level, all subjects had cognitive status assessed by Mini-mental State Examination[18]. To exclude effects of a depressive status or emotional alterations, humor status was assessed using the Geriatric Depression Scale[19]. The Instrumental Activities of Daily Living Scale (IADL) was used to quantity independence of the participants ensuring all of them were able to perform daily life tasks and were independent[20]. Leg preference was verified using the Waterloo inventory [21].

Gait assessment

Elderly that filled the inclusion and exclusion criteria were invited to visit the laboratory of neuromechanics. When they arrived, the laboratory room was showed in order to familiarize the elderly with the space and instruments. Afterwards, one experienced examiner applied an anamnesis form and the aforementioned questionnaires. Next, spherical reflexive markers (diameter of 15 mm) were placed over specific anatomical references at the hallux, head of 5th metatarsal, and calcaneus tuberosity in both the feet of the elderly. After marker placements participants were requested to walk around the laboratory space to get used with the markers placed in the specific sites of the body.

All participants performed a protocol of overground gait crossing an obstacle as described elsewhere[22]. Five familiarization trials with and without the obstacle were permitted. They walked wearing their habitual shoes (flat, rubber soled walking shoes) and clothes. Gait analyses considered self-selected speed along a walkway of 6 m with a foam obstacle positioned in the halfway (obstacle dimension: 15 cm height, 34 cm width and 11 cm length). After a "go" command from the experimenter, participants should walk normally, cross the obstacle when it was place in the halfway, and continue walking until the end of the path. Color tapes were placed in the ground to delimit the walkway.

Movement was recorded in the sagittal plane for subsequent analyses. The video was analyzed at 60 Hz. A motion analysis tool for Windows® (SkillSpector version 1.2.4, Video4coach, Denmark) was used to digitalize and track the markers' position providing the two-dimensional data position. The camera (S2000HD, FUJI, Japan) was calibrated considering a calibration frame with known dimensions. Video was captured with resolution of 12.2 megapixels using a CCD sensor of 1/2.3 inch. The estimated error in the tracking markers was of 4 mm. The toe clearance was calculated as the vertical distance between the hallux marker and the obstacle when the swing limb was just crossing above the obstacle[23]. A Butterworth digital filter with low-pass cut-off frequency of 6 Hz was applied to filter the data. The kinematics parameters monitored were: trail limb step length pre-obstacle, trail limb pre-obstacle distance, lead limb toe clearance, lead limb post-obstacle distance and lead limb stride length (Figure 1). Step variables were normalized to the participant's height.

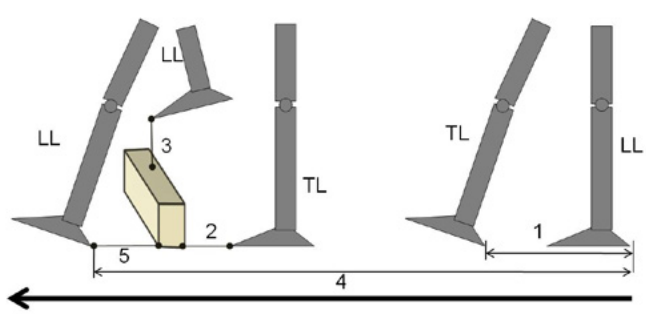

Figure 1. Illustration of the kinematics variables considered in this study. LL represents the lead limb (i.e. the first limb to cross the obstacle). TL represents the trail limb (i.e. the contralateral limb crossing the obstacle). Variables: (1) trail limb step length pre-obstacle, (2) trail limb pre-obstacle distance, (3) lead limb toe clearance, (4) lead limb stride length and (5) lead limb post-obstacle distance. Black arrow indicates the movement direction

Dual tasking performance

Participants were requested to cross the vertical obstacle while performing two different dual tasks: the first DT (t1) was a variation of the Stroop task. In the second (t2) they should walk while reporting verbally the days of the week in the reverse sequence, starting from Sunday. Two valid trials from each subject in each condition were considered for posterior analysis. The order of the dual tasks was randomized.

In the t1 condition, participants should say "*yes*" when the examiner said "*blue*", and "*no*" when the examiner said "*red*". For any other color name the examiner said, participants should only repeat the color name (for example, if examiner said "*yellow*", subject should repeat "*yellow*") and so on.

For t2 condition, participants should report the days of the week in reverse sequence starting on Sunday, without interaction with the examiner. For a valid trial, DT should be performed without stop walking.

STATISTICAL ANALYSIS

Data normality was verified using Shapiro-Wilk. Statistical comparisons between tasks (t1 *vs* t2) were performed using paired t-test for parametric and Wilcoxon test for non-parametric data. The level of significance was set at 0.05. Statistics procedures were performed using a commercial statistics package (SPSS Inc. 20.0, Chicago, USA).

RESULTS

Neuropsychological and mobility

All participants presented MMSE mean (standard-deviation) 26.6 (1.7) points excluding any cognitive disorder[18]. Results from the Geriatric Depression Scale excluded risk of depression in all the participants, and all of them were classified as independent regarding daily life tasks.

Differences between dual tasks

When we compared the kinematic data (Figure 2) to verify the effect of dual tasks, we did not find differences for trail limb step length pre-obstacle of preferred ($t_{(9)}$=1.492; p=0.170) and non-preferred ($t_{(9)}$=-0.402; p=0.697), for trail limb pre-obstacle distance of preferred ($t_{(9)}$=1.470; p=0.176) and non-preferred ($t_{(9)}$=-0.109; p=0.915), for lead limb toe clearance of preferred ($t_{(9)}$=1.492; p=0.170) and non-preferred ($t_{(9)}$=0.737; p=0.480), for lead limb stride length of preferred ($t_{(9)}$=0.398; p=0.722) and non-preferred ($t_{(9)}$=0.197; p=0.848), and for lead limb post-obstacle distance of preferred (z=-0.051; p=0.959) and non-preferred (z=-1.274; p=0.203).

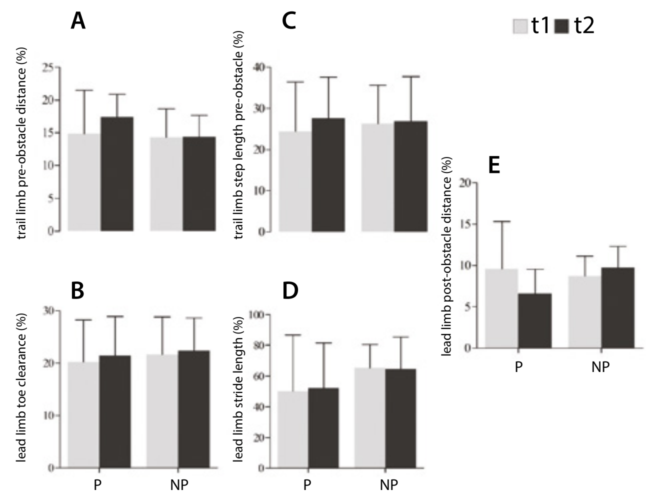

Figure 2. Kinematics data were similar between the two different dual task conditions. A) Trail limb pre-obstacle distance; B) Lead limb toe clearance; C) Trail limb step length pre-obstacle; D) Lead limb stride length; E) Lead limb post-obstacle distance. Gray bars represent data from task 1 (t1) and dark bars represent data from task 2 (t2). Values are normalized to the participant's height, except by toe clearance. P represents the preferred limb and NP represents the non-preferred leg

DISCUSSION

We investigated the impact of different dual tasks on the performance of obstacle crossing in the gait of independent elderly. Our findings suggest that obstacle crossing did not differ between the two DT tested. Our main hypothesis was that the effects of DT could vary with the presence of an auditory input due to the interaction with the experimenter, and the need for further information processing. Our results differed from those previously reported for stroke survivors, when different dual tasks had specific effects on gait performance[8,11]. It may suggest that responses in independent elderly can be different and need to be considered when designing intervention programs.

Ingriselli et al.[7] found no difference between single and DT training in young adults evaluated for executive function, complex attention, cognitive flexibility, and balance. However, they were unable to confirm the hypothesis of DT training resulting in greater improvement for cognitive and balance performance than a single-task[7]. Indeed, an auditory input impaired performance of gait with obstacle in both cognitive and motor tasks, which may increase risk of falling in elderly[9]. Similar effects were observed in postural tasks performed by elderly trained for Tai-Chi Chuan[24]. When the DT involved a memory task (report objects which names start by "R" or "G"), gait speed and stride frequency decreased significantly[17], but stride-to-stride variability (mean stride time, coefficient of variation of stride times) and the phase variability index increased significantly[17]. Finally, Simoni et al.[25] reported decreases in gait performance when the DT involved a cognitive task (e.g., recitation of alternated letters from the alphabet) requiring memory and attention resources.

Our experiment considered a task involving an auditory input (response to experimenter's verbal interaction) (t1) and another task in which participant should verbally name the days of the week from Sunday backwards, without any interaction with the experimenter (t2). Although we observed that both DT impaired obstacle crossing, effects were similar between the dual tasks considered, and this is our main result. From the previous reports in the literature, we may suggest that our results most likely rely on the fact that our participants were independent elderly. In a recent study by Patel, Lamar[26] the effect of different cognitive tasks and gait speeds on cognitive-motor interference of dual task during walking was compared between healthy young adults. Young adults showed increased motor cost and deterioration of cognitive task performance during the dual task conditions compared to conditions without the dual task[26]. In our study, results suggest that both DT can be strategies to challenge gait in the elderly, especially when interaction with a second person is not possible (e.g., during individual or group exercise sessions).

Different of our observation, Plummer-D'Amato, Altmann[27] showed that dual task involving speech (narrative answer to a question) had greater effects on the gait of slow walker healthy community-dwelling older adults than an auditory Stroop task. Such results were described as dependent on the complexity of the secondary task. Differences between dual tasks were also found when the dual task involved or not a visual input[28]. In this study, performance was evaluated during walking at self-selected speed while performing the color Stroop-congruent test (reading out loud the colors of 24 color circles), walking while performing the color Stroop-incongruent test (reading out loud the color words representing names of colors that differed from the color of the printed words), and walking while counting serial seven subtractions from 200 backwards[28]. The authors investigated how the complexity and the type of dual task affected trunk movements, and suggested that an arithmetic task had greater effects on trunk movements during dual task than Stroop task.

Our study has some inherent limitations. Although a significant effect the dual task on gait kinematics was observed, the lack of difference between the dual tasks may depend on the tasks selected. Therefore, comparison of other different dual tasks may elicit different results. However, our results still have importance if considering that the tasks we considered can be easily included in programs for falling prevention in the independent elderly. We did not conduct a sample size determination due to the few number of elderly voluntary for the experiments.

CONCLUSION

The different dual task configurations used in our study affected obstacle crossing in the elderly at the same extent.

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Acknowledgments: The authors are thankful for Álvaro Sosa Machado and Pedro Silvelo Franco for assistance with the data collection.