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Effects of regular exercise and dual tasking on spatial and temporal parameters of obstacle negotiation in elderly women

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ABSTRACT

This study investigated the effects of regular exercise and dual tasking on bilateral spatial and temporal parameters of obstacle negotiation in elderly women. Sedentary ($n = 12$) and physically active ($n = 12$) elderly women volunteered to participate in this study. Gait kinematics were recorded during obstacle crossing when performing a dual task and when not performing a dual task. Physically active participants crossed obstacles more safely, in terms of clearance or distance to or over the obstacle, both with and without dual tasking, and usually for both lead and trail legs. Performing the dual task increased toe distance, and decreased heel distance and gait speed in the active participants, and increased toe clearance and heel distance, and decreased gait speed in the sedentary participants. Differences between preferred and non-preferred leg were accentuated for toe clearance in the lead limb. These results suggest that specialized exercises may not be needed for improvement in obstacle avoidance skills in the elderly, and participation in multi-activities, including aerobic exercises, may be sufficient.

1. Introduction

Although various short-term exercise modalities have been shown to improve obstacle avoidance during gait in elderly individuals [1–4], it remains unclear whether or not a long-term active lifestyle can provide similar benefits. Obstacle avoidance success rates were higher following a 5-week exercise programme including a functionally oriented obstacle course, walking and fall techniques [3]. The training improved time-critical obstacle avoidance skills. As such, the central question is whether or not long-term regular exercise and/or an active lifestyle can have similar effects. It is important to note that the effects of exercise can differ depending on whether or not the testing is performed under dual-task conditions. Regular exercise was associated with significantly faster voluntary step times during a single-task condition but not during a dual-task condition [5]. Similarly, dual tasking affects obstacle avoidance during gait (for further details, see [6] and [7]).

It is unclear if the effects of exercise differ between the preferred and the non-preferred leg. The investigation of both lead and trail limbs (LL and TL) is important as most contacts with obstacles affect the TL [8]. In elderly people, foot to ground clearance is greater in the non-preferred limb [9], and asymmetric obstacle crossing has been observed in the TL under dual-task conditions [10].

This study investigated if bilateral spatial and temporal parameters of obstacle negotiation differed between sedentary and physically active elderly people when performing or not performing a dual task.

2. Methods

2.1. Participants

Participants were assigned to either the sedentary group ($n = 12$) or the active group ($n = 12$). The sedentary group comprised women who did not undertake regular physical exercise {mean age 63 [standard deviation (SD) 3] years, mean height 1.53 (SD 0.07) m, mean weight 68 (SD 15) kg}. The active group comprised women who had participated in regular physical exercise, including activities performed in groups, at least three times per week over the past year (details in Appendix A, see online

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supplementary material), at least 150 min of activity per week as recommended by the American College of Sports Medicine, and at least 72 sessions of exercise in the last 6 months [mean age 71 (SD 8) years, mean height 1.55 (SD 0.04) m, mean weight 63 (SD 6) kg]. All participants signed an informed consent form in accordance with the Declaration of Helsinki and the local ethics committee (IRB#0172011).

Inclusion criteria for both groups were: able to walk independently; and no auditory, vestibular, visual and/or musculoskeletal impairments that could influence locomotion or communication with the researchers. None of the participants had cognitive deficits, as verified by the Mini-Mental State Examination [11] [mean score 27 (SD 1)]. All participants were right footed, as verified by the revised Waterloo Footedness Questionnaire.

2.2. Gait assessment

Gait kinematics were recorded during barefoot overground walking and obstacle crossing at self-selected speeds. A dual task was added for half of the obstacle crossing trials. Data were sampled at 200 Hz using six MX T10 cameras (Vicon Motion Systems, Oxford, UK). Spherical reflective markers were attached to the participant's body surface according to the Plug-in Gait Full Body Model (Vicon Motion Systems, Oxford, UK), and additional reflective markers were attached to the obstacle to determine its edges. Data were low-pass filtered with a fourth order Butterworth filter with cut-off frequency of 8 Hz. Two force plates (OR6-6-2000, Advanced Mechanical Technology, Watertown, MA, USA) were used to identify the foot off gait events base in changes in ground reaction forces. The obstacle was made of polystyrene (length $\times$ width: 80 cm $\times$ 20 cm, height defined as 20% of participant's leg length) and positioned halfway along an 8-m walkway. Leg length was defined as the vertical distance from the greater trochanter of the femur to the ground.

The dual task was a variation of the Stroop task in which the participant was required to answer verbal commands [10]. When the experimenter said 'red' or 'blue', the participant replied 'no' or 'yes', respectively. If the experimenter said any other colour, the participant repeated the name of the colour. Ten trials were recorded at random with the preferred leg and the non-preferred leg crossing the obstacle first, when performing the dual task and when not performing the dual task. Participants did not receive instructions about which leg should cross the obstacle first. In order to record crossings for both legs as the LL, after some familiarisation trials, the experimenter asked the participant to start walking at different distances from the obstacle. Valid trials were those in which failures or trips were not observed. No complete failures occurred, but a few trips were observed (nine trials, 0.93% of all trials).

Kinematic variables considered in this study were:

- for LL (i.e. first leg to cross the obstacle): toe clearance, heel clearance, heel distance and crossing step length; and
- for TL (i.e. second leg to cross the obstacle): toe clearance, toe distance and crossing step length.

In addition, gait speed, step length and crossing stride length were computed. Step and stride values were normalized to the participant's leg length. Kinematic variables of obstacle crossing were determined as shown in Fig. 1.

2.3. Statistical analyses

Data normality was verified using the Shapiro-Wilk test. A $2 \times 2 \times 2$ analysis of variance with Bonferroni's correction was performed to verify effects and interactions for group (sedentary vs. active), condition (with or without dual task) and leg (preferred vs. non-preferred) on kinematic variables, followed by post-hoc pairwise tests when statistical significance was detected. All tests were performed using Statistical Package for the Social Sciences Version 20.0 (IBM Corp., Armonk, NY, USA), with $p < 0.05$ considered to indicate significance.

3. Results

Statistical analyses showed similar height ($p = 0.365$) and weight ($p = 0.295$) between the groups. The active participants were older than the sedentary participants ($p = 0.004$). Four sedentary participants and two active participants had experienced one fall in the past year.

3.1. Comparison of lead limb and trail limb between groups

A main effect for group was found for LL toe clearance, TL toe clearance, TL toe distance, LL heel distance and LL crossing step length (Table 1). A significant interaction between group and condition was observed for TL toe distance, and between group and leg for LL toe clearance and LL heel clearance (Table 2).

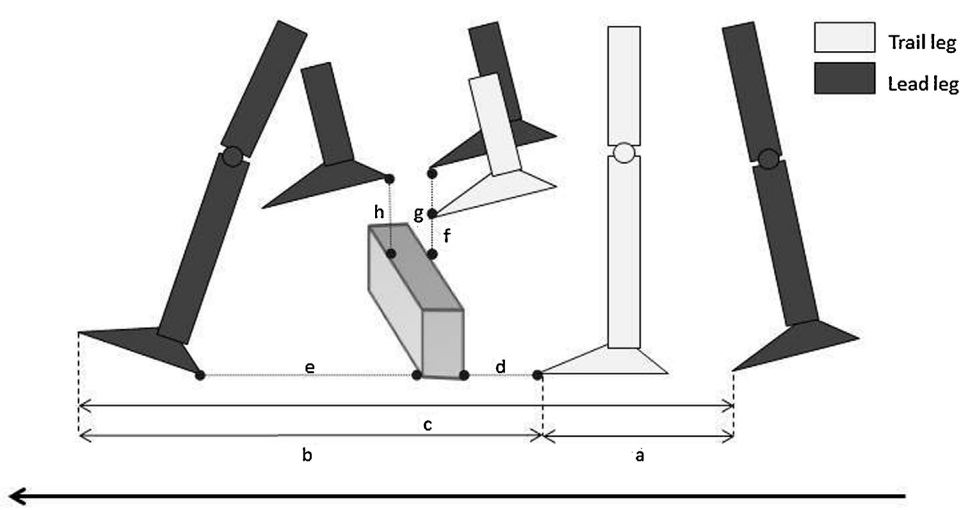

Fig. 1. Graphical representation of obstacle-related kinematic variables considered in this study. A, lead limb (LL) crossing step length; b, trail limb (TL) crossing step length; c, crossing stride length; d, TL toe distance; e, LL heel distance; f, TL toe clearance; g, LL toe clearance; h, LL heel clearance.