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Gait initiation time is associated with the risk of multiple falls—A population-based study

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ABSTRACT

Aims: In a population-based study of older people to examine whether 1) overall gait initiation (GI) time or its components are associated with falls and 2) GI under dual-task is a stronger predictor of falls risk than under single-task.
Methods: Participants aged 60–85 years were randomly selected from the electoral roll. GI was obtained with a force platform under both single and dual-task conditions. Falls were ascertained prospectively over a 12-month period. Log multinomial regression was used to examine the association between GI time (total and its components) and risk of single and multiple falls. Age, sex and physiological and cognitive falls risk factors were considered as confounders.
Results: The mean age of the sample (n = 124) was 71.0 (SD 6.8) years and 58.9% (n = 73) were male. Over 12 months 21.8% (n = 27) of participants reported a single fall and 16.1% (n = 20) reported multiple falls. Slower overall GI time under both single (RR all per 100 ms 1.28, 95%CI 1.03, 1.58) and dual-task (RR 1.14, 95%CI 1.02, 1.27) was associated with increased risk of multiple, but not single falls ($p < 0.05$). Multiple falls were also associated with slower time to first lateral movement under single-task (RR 1.90 95%CI 0.59, 1.51) and swing time under dual-task condition (RR 1.44 95%CI 1.08, 1.94).
Conclusion: Slower GI time is associated with the risk of multiple falls independent of other risk factors, suggesting it could be used as part of a comprehensive falls assessment. Time to the first lateral movement under single-task may be the best measures of this risk.

1. Introduction

Falls occur in over 30% of people older than 60 years living in the community in a one-year period [1], and can result in injury, loss of independence and nursing home admission [2]. Identified risk factors for falls include impaired physiological (e.g. muscle strength, gait, balance) and psychological factors (e.g mood, processing speed and attention), with a greater number of impairments increasing the risk [3]. However, falls remain a significant problem with further investigation of risk factors required in order to identify and prevent older people from falling.

Falls can occur during gait initiation (GI)—the transition stage from standing still to steady state walking [4]. Previous studies have found the slower GI time is associated with impairment in both physiological and cognitive falls-risk factors [5], and prevention of a fall often requires a quick change in posture or a protective step. Taken together these factors indicate that poorer GI time may provide a good summary measure of an individual's falls-risk.

GI can be described by its three components: Time to the first lateral movement (FLM); FLM to when the lead foot leaves the platform; and from foot off to contact with the adjacent surface [5,6]. GI time increases whilst performing a simultaneous task in older people [6], such as talking to another person. This is thought to be due to the increased load on executive and attentional resources, which may be limited in older age, and result in slower GI. The competition for attention between the cognitive and GI tasks may further increase risk of falls [7–9]. Examining the individual components of GI under single and dual-task may assist in further refining the assessment of falls risk and design of effective intervention programs.

Previous findings have differed in the relationship between GI [8,10–12] or stepping tests [13] and falls risk, with some reporting an increased risk under single [12,13] or dual-task [8,11,12], while

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others reported no association under single-task [8,10]. Conflicting findings may be explained by the use of differing samples including volunteers [8,10] or residents from retirement villages [11–13] or by retrospective falls ascertainment, potentially leading to recall bias [8,10,11,13]. To our knowledge there has only been one prospective study, where slower step execution times were associated with recurrent falls [12]. This study included volunteers from retirement homes which may not be generalizable to all older people living in the community.

Therefore, in a population-based sample of older people the aims of this study were to examine whether: 1) overall GI time or its components were associated with falls 2) GI time under dual-task was a stronger predictor of falls risk than under single-task. 3) Whether associations between GI and falls were independent of other physiological and psychological factors. We hypothesized that overall GI time under dual-task would be the strongest predictor of falls independent of other falls risk factors.

2. Methods

2.1. Participants

The sample consisted of 128 consecutive participants who completed the GI task from the Tasmanian Study of Cognition and Gait (TASCOG), starting in 2007. The overall larger TASCOG study (n = 431) commenced in 2005 and randomly selected residents from the Southern Tasmanian Electoral roll aged between 60–85 years using age- and sex-stratified random sampling. Participants were excluded if they resided in a nursing home, were unable to walk without the use of a gait aid or if there were any contraindications to having a MRI scan. Participants with Parkinson's disease and dementia were excluded due their know effects on GI and falls. The Southern Tasmanian Health and Medical Human Research Ethics Committee approved this study and written consent was obtained from all participants.

3. Measures

3.1. Gait initiation

GI was measured under single- and dual-task using a 200 Hz AccuGait force-platform and Advanced Mechanical Technology Inc.-NetForce software as described previously [5]. Participants stood on the force-platform with heels spaced by 6 cm and at approximately a 10 degree angle [6]. In the single-task condition participants were asked to start walking in response to a buzzer activated at random times. Under the dual-task condition the participant was asked to count backwards in threes from a number that varied with each trial. Six trials were performed for each task alternating between the two. As previously described [5] we examined 3 components of GI (see Fig. 1), using a program written in Visual basic 6.0: Time from stimulus to FLM (change in mediolateral velocity of >100 mm/s in the centre of pressure towards the swing leg as detected by the force plate and provided by Netforce software); Transfer time: FLM to toe off of the leading foot (the second time velocity crossed 0 mm/s after FLM); Swing time: time from toe off to foot contact (the beginning of a continual drop in vertical force that passed 75% of baseline). We also examined the overall time from stimulus to initial contact of the leading foot as this measures was found to be the most strongly associated with a falls risk score comprising of physiological measures [5]. The median of the six trials was calculated as this was found to be the best summary index across trials [5].

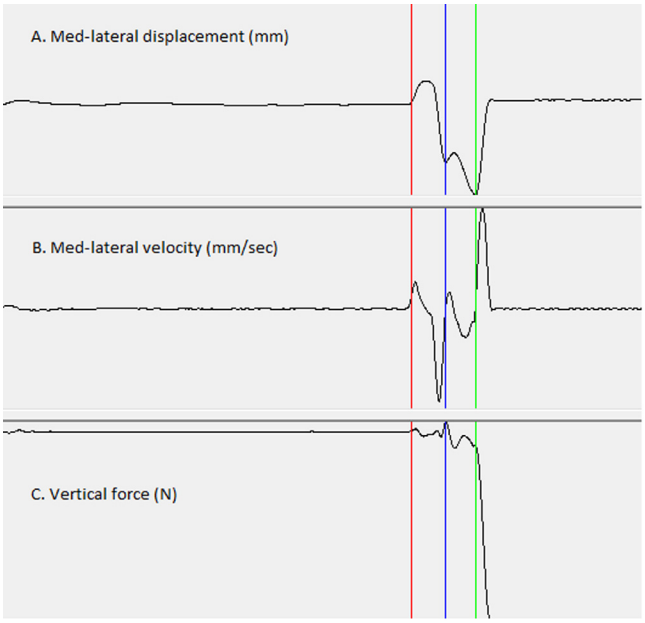

Fig. 1. Force plate data provided by AMTI-NETsoftware illustrating the components of gait initiation.
Legend: First (red) line = time to first lateral movement (change in med-lateral velocity of >100m/s); Second (blue) line = toe off (the second time velocity crosses 0 mm/s after the first lateral movement; Third (green) line = foot contact of swing leg (the beginning of a continual drop in vertical force that passed 75% of baseline)

3.2. Falls

Participants were sent a falls questionnaire and a pre-paid envelope every 2 months for 12 months. A fall was defined as 'an unexpected event in which the participant comes to rest on the ground, floor or lower level' [14]. Participants were also asked to keep a falls calendar to record any falls. If a participant did not return a questionnaire they were followed-up with a phone call. Any participant not reporting a fall and returning fewer than 10 months of questionnaires was excluded. Those who fell once during the 12-month period were classified as having a single fall and those that fell more than once were classified as having multiple falls.

3.3. Physiological and psychological falls risk measures

Physiological factors were measured using the short form of the Physiological Profile Assessment [15] (visual contrast sensitivity [dB] using the Melbourne Edge Test; proprioception (cm) using a lower limb matching task, with a vertical protractor placed between participant legs; isometric quadriceps strength [kg] using a spring gauge; simple reaction time (ms) using a light stimulus and press of a switch; postural sway (mm) using a swaymeter to measure body displacement at the waist level while standing on a foam mat for 30 s); gait speed (cm/s) was obtained using the 4.6 metre GaitRite mat as previously described [1]. Psychosocial factors included: mood using the Geriatric Depression Scale (short version) [16] and scores >5 were classified as depressed; executive function/attention was assessed with the Victoria Stroop test (time to read a list of coloured words printed in non-corresponding colours of ink, e.g. the participant reads the colour of ink, not the colour word) [17] and the Digit Symbol Coding subtest of the Weschler Adult Intelligence Scale—Third Edition (time to match a list of symbols with corresponding digits) [18].