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Different cognitive functions discriminate gait performance in younger and older women: A pilot study

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ABSTRACT

Aim: Cognitive dysfunction is associated with slower gait speed in older women, but whether cognitive function affects gait performance earlier in life has yet to be investigated. Thus, the objective of this study was to test the hypothesis that cognitive function will discriminate gait performance in healthy younger women.

Methods: Fast-pace and dual-task gait speed were measured in 30 young to middle-aged (30–45 y) and 26 older (61–80 y) women without mild cognitive impairment. Visuoperceptual ability, working memory, executive function, and learning ability were assessed using neuropsychological tests. Within each age group, women were divided by the median into lower and higher cognitive function groups to compare gait performance.

Results: Younger women with higher visuoperceptual ability had faster fast-pace (2.25 ± 0.30 vs. 1.98 ± 0.18 m/s, $p \leq 0.01$) and dual-task gait speed (2.02 ± 0.27 vs. 1.69 ± 0.25 m/s, $p \leq 0.01$) than women with lower visuoperceptual ability. The difference in dual-task gait speed remained significant ($p = 0.02$) after adjusting for age, years of education, and other covariates. Dividing younger women based on other cognitive domains showed no difference in gait performance. In contrast, working memory and executive function discriminated dual-task gait speed ($p < 0.05$) in older women after adjusting for age and education.

Conclusion: To our knowledge, this is the first study to show that poorer cognitive function even at a relatively young age can negatively impact mobility. Different cognitive functions discriminated gait performance based on age, highlighting a possible influence of aging in the relationship between cognitive function and mobility in women.

1. Introduction

Older women walk slower and have a higher prevalence of gait abnormalities than older men [1,2]. This is a significant health concern as walking is important for many activities of daily living, thus gait abnormalities can substantially reduce quality of life and contribute to loss of independence [3]. Investigation into contributing factors for mobility loss in women is therefore necessary to reduce disability. However, markers of gait impairment may depend on age thus investigation of healthy younger and older women are warranted to expose novel, possibly age-specific indicators that can increase options for interventions to reduce gait deterioration with aging.

Evidence is accumulating that cognitive function as assessed using neuropsychological tests is a strong predictor of mobility. Older adults that have lower cognitive ability to perform complex, goal-oriented behavior (i.e., executive function) are reported to have slower gait speed [4–6], as well as poor performance during dual-task gait activities such as talking while walking [4,7] as compared to adults with higher cognitive ability. This has also been shown for older adults with poorer memory [5,6,8] and/or slow information processing speed [6,9] with impairment of multiple cognitive functions associated with a greater decline in gait speed over time [10]. Of important note, the strong association between cognitive function and gait performance is also found in older adults without dementia, history of stroke, or other brain disorders

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[8]. This indicates that neuropathology is not a requisite for a relationship to exist between cognition and gait. This is due to the shared brain regions that regulate gait and cognitive functions, thus impairment in shared neural substrate may manifest as gait abnormalities, cognitive deficits, or both. Indeed, gait speed has been shown to predict incident cognitive decline suggesting that gait abnormalities may be an indicator of cognitive dysfunction in otherwise healthy adults [11]. While it is appreciated that an association exist between cognitive function and gait performance in older adults, it is unknown if a similar link is present in younger adults before the progression of potentially confounding factors that often accompany advancing age.

The present pilot study was designed to explore whether the aforementioned relationship between cognitive function and gait performance in older individuals is also present earlier in life, particularly in women. In doing so, this pilot study will provide preliminary new insight into the influence of age on the relationship between cognition and gait, along with results that could be used as evidence of feasibility for larger studies on this topic. We hypothesized that cognitive function will relate to gait performance during fast-pace gait and dual-tasking in younger women as well as older women. Fast-pace was examined since it may be more sensitive to cognitive dysfunction than usual-pace [12,13], and dual-tasking was used to increase cognitive demand during walking to assist in determining if younger women with lower cognitive capacity have altered gait performance.

2. Methods

2.1. Participants

Women were recruited for this study using newspaper advertisements, email announcements, and university website postings. To be eligible to participate, women had to walk without an assistive device and have no orthopedic limitations that caused visual gait abnormalities. No women had osteoporosis, but four participants had osteopenia. Using a medical history questionnaire, we excluded women with a personal history of cardiovascular disease, current smoker, and taking medication for hypertension or hyperlipidemia since these variables could impact cognition or gait by altering perfusion. Height and weight were measured using a standard scale. Women were excluded if their body mass index was $\geq$30 kg/m^2 to remove the influence of obesity on gait. Women were also screened for mild cognitive impairment using the Montreal Cognitive Assessment (MoCA; version 7.1) [14]. Women with a MoCA score $\leq$25 were considered to have mild-cognitive impairment and excluded. After screening, 30 young to middle-aged (30–45 y) and 26 older (61–80 y) women were included in this study.

2.2. Study procedures

This study was comprised of three visits approved by the IRB at Texas Tech University Health Sciences Center. The first visit was a screening visit and assessed cognitive function. Participants that met study criteria were invited for two study visits after providing written informed consent. The first study visit involved testing for body composition, vascular function, and muscle power. During the second study visit, participants completed gait performance testing. On average, there were 17 days (range = 11–27 days) separating the first and last visit.

2.3. Cognitive function assessments

The Rey Auditory Verbal Learning Test (RAVLT) was used to assess learning ability. The RAVLT includes a list of 15 words the administrator reads out loud to the participant, who immediately repeats as many words as she can remember. These retention trials are repeated five times, and the total number of words recalled (sum of trials 1–5, max score = 75) represents the participant's ability to learn verbal information. The Trail Making Test part A (TMT-A) was used to assess visuoperceptual abilities (attention, visual search, perceptual speed), and the TMT part B (TMT-B) was used to assess the ability to manipulate information in working memory while task-switching [15]. TMT-B also reflects visuoperceptual abilities, but to a lesser extent [15]. The TMT-A test involves tracing the correct sequence of a series of numbers randomly dispersed on a sheet of paper, while the TMT-B test alternates between sequences of numbers and letters. Time to complete each test was recorded using a stopwatch. Executive function was estimated by subtracting the time to complete the TMT-A from the time to complete the TMT-B (B-A) [15].

2.4. Gait performance

Thirty-nine lightweight reflective markers were attached to the subject's feet, legs, arms, trunk and head using a Plug-In Gait full-body marker set (Vicon, Inc.). Each participant was asked to walk at a self-selected fast-pace along a 12 m walkway while being recorded by an 8-camera integrated motion capture system (Vicon, Inc.). The motion capture system permitted measurement of gait speed, step width, stride length, and cadence. The 12 m course was divided into a 3 m acceleration zone, 6 m calibrated measurement zone, and 3 m deceleration zone. Participants initiated gait from a standing position. Dual-task gait performance was measured during walking at a fast-pace while attempting to maintain a light weight plastic food container with a lid in a level position. The task was designed to mimic a common activity of daily living, and is similar in nature to the dual-task of carrying a tray with glasses of water [16,17]. A custom-designed leveling device was secured to the lid to provide visual feedback. The leveling device was constructed of a metal ball-bearing immersed in vegetable oil and sealed in a clear Petri dish. A bulls-eye and reference lines were drawn on the underside of the Petri dish in black ink. Participants were instructed to keep the ball-bearing centered on the bulls-eye. Container leveling error was measured by tracking reflective markers using the motion capture system. No differences were found in leveling errors between cognitive subgroups or age groups, thus these data are not presented.

2.5. Other measurements

In order to control for potential covariates in the relationship between cognitive function and gait performance, we collected parameters associated with body fat, vascular function, and leg muscle power (in this order). Total percent body fat was measured using dual-energy X-ray absorptiometry (Lunar Prodigy, GE Medical). Aortic blood pressure was estimated using radial artery applanation tonometry and a general transfer function (SphygmoCor PVx, AtCor Medical). Pulse pressure amplification, or amplitude of pressure wave increase from the central aorta to the brachial artery, was calculated by dividing brachial pulse pressure by aortic pulse pressure. Carotid-femoral pulse wave velocity, an index of aortic stiffness, was calculated using an online standardization tool that uses blood pressure, carotid-femoral distance, and transit time to calculate pulse wave velocity [18]. Participants rested in the supine position for at least 10 min prior to vascular measurements. Peak leg muscle power was attained from participants performing countermovement vertical jumps on a force platform (AccuPower 2.0, AMTI). Three no-step maximal jump attempts were performed with hands placed on the hips and with 1 min of rest between trials. The highest power generated