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The slowing down phenomenon: What is the age of major gait velocity decline?

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ABSTRACT

Decreased gait velocity is associated with limited mobility, community participation, cognitive decline, and increased risk of falls in elderly women. Therefore, early detection of reduced gait velocity allows proper monitoring and treatment to prevent or delay the associated limitations. This study determined the age of major gait velocity decline in a large sample of women. The participants were 653 healthy women, aged 18–89 years, who were divided in five age groups: ≤26, 36–45, 46–60, 61–70 and ≥71 years. Their spatiotemporal gait parameters were collected using the GAITRite® computerized carpet. Two piecewise regression models – known and estimated breakpoint – with age as the independent variable and gait velocity as the dependent variable were used to determine the age of major gait velocity decline. ANOVAs were performed to identify differences in gait spatiotemporal variables between the five age groups with $\alpha = 0.05$. The estimated age of major gait velocity decline was 71 years. Age significantly predicted gait velocity ($p < 0.0001$), explaining 23% of its variability. Gait velocity decline starts at 65 years and becomes more pronounced at 71 years. The estimated model showed that an increase of one year in age decreases gait velocity on average by 0.31 cm/s. If age is > 71 years, velocity will decrease on average by 1.75 cm/s per year. The average velocity of women over the age of 71 years was 115.4 cm/s, which as 7.8% less than a decade earlier. The five age groups demonstrated differences in gait velocity, step length, stance, swing, step, and double support time. This is the first study conducted in a large sample of women to have determined 71 years as the age of major gait decline. Identifying the age of gait velocity decline of healthy women could allow timely interventions to slow the general decline associated with lower gait velocities, such as falls, lower mobility, frailty, and death. Therefore, women near and above 71 years of age should be closely monitored due to the adverse health effects associated with reduced gait velocity.

1. Introduction

Gait velocity is an important clinical tool for assessing and monitoring the functional status of elderly individuals [1,2]. Walking velocities between 100 and 130 cm/s are indicative of good health, with the latter associated with an extremely fit individual; velocities between 60 and 105 cm/s are suggestive of cognitive decline in the next 5–6 years, lower limb limitation, limited community participation, and the need for close monitoring [1,3]. Gait velocities below 60 cm/s are associated with high risk of falls, frailty, cognitive decline, institutionalization, and death [3]. Physiological aging is responsible for a decrease of 1.2% in gait velocity yearly [4], and a drop of 10 cm/s in velocity from baseline is considered a clinically significant change [5]. Conversely, prospective studies have shown that every 10 cm/s increase in gait velocity decreases the risk of falls by 7%, decreases frailty, and decreases the incidence of other adverse health effects [5,6]. Therefore, early detection of decreased gait velocity is imperative for appropriate interventions.

Although gait disorders in older adults have multiple causal factors [6], decreased gait velocity has been generally accepted as an attempt to become more stable [7,8]. However, this compensatory strategy results in decreased step length and swing time, increased stance and double support time [9,10], decreased joint excursion, and decreased ankle power during push-off [11–13]. These adaptations are associated with greater gait variability, which considerably increases the risk of falls [4,9,14]. For example, increased stride time variability might be a result of abnormally high cortical levels of gait control disturbing the stepping mechanism [15]. Gait decline has also been associated with

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cumulative impairment of multiple systems and organs, such as cardiovascular, lungs, kidneys and brain [16]. The increased number of chronic diseases associated with aging is also reflected in gait changes [17]. The age-related changes in the motor, skeletal, and sensory systems, such as lower muscle strength and range of motion, and decreased postural control, vision, proprioception, and vestibular function, are accepted to be the mechanisms behind gait changes [10,18,19]. In 2011, a systematic review based on 41 studies showed that at the age of 50–59 years the average gait velocity of community-dwelling women was 131 cm/s, at the age of 60–69 was 124 cm/s, at the age of 70–79 was 113 cm/s, and at the age of 80–89 was 94 cm/s [20]. In acute and subacute care, and outpatient or ambulatory care, the overall gait velocity is reported to range from 0.58 m/s to 0.89 m/s [21], much lower than the gait velocities reported for community-dwelling older adults [20]. Therefore, regardless of the mechanism, gait velocity decreases with aging and could be an indicator of an underlying physiological health problem in older adults [16].

Considering the importance of gait velocity in screening for different health conditions in elderly individuals – cognitive decline, mobility limitations and disability, falls, fall-related fractures, frailty and mortality [3,17] – defining the age at which gait velocity critically declines could help us understand the extent of the physiological aging effects on gait. Therefore, this study determined the age of major gait velocity decline in a group of women between the ages of 18 and 89 years. This information is critical since people are living longer, and is particularly important for women, due to their greater risk of falling compared with men [22].

2. Methods

2.1. Study design and ethics

A cross-sectional observational study was conducted in female individuals recruited from the general community in the city of Belo Horizonte, Minas Gerais, Brazil. The present study was approved by the Research Ethics Committee of the Universidade Federal de Minas Gerais (number ETIC 644/10) and all participants read and signed the written informed consent prior to data collection.

2.2. Participants

Six hundred and fifty-three (653) women aged 18–89 years participated in this study. The inclusion criteria were: female sex, age ≥18 years and ability to walk independently without assistance or use of aids. The exclusion criteria were: visual impairment not corrected by lenses, vestibular symptoms and motor sequelae due to rheumatic, orthopedic and/or neurological diseases (e.g. scoliosis, stroke and Parkinson's disease) that could affect gait performance. In addition, elderly women (≥65 years) with cognitive impairment, detected using the Mini-Mental State Examination (MMSE) with the Brazilian cutoff points based on degree of education [23], were excluded. Descriptive data included age (years), height (cm), body mass (kg) and body mass index (kg/m^2).

2.3. Gait assessment

A 5.74 m computerized carpet (GAITRite®, CIR Systems Inc., Havertown, PA, USA) placed on a well-illuminated hallway and free of noise and visual distraction was used to collect the spatiotemporal gait parameters. Data were sampled at 120 Hz and processed using the GAITRite® software version 3.9. Participants were asked to walk at their usual pace on the carpet wearing their own clothes and low-heel footwear for six trials. The start and end points were marked 2 m before and after the carpet in order to ensure a steady walking velocity. Data from all trials were combined and considered as a single test. The spatial and temporal parameters investigated were: velocity (cm/s), cadence (steps/min), step time (s), step length (cm), base of support (cm), swing time (s), stance time (s) and double support time (s) as defined by the GAITRite® manual.

2.4. Statistical analysis

Anthropometric data and spatiotemporal measurements were summarized using means and standard deviations. The normality of the distribution was observed using histograms. Based on the age frequency of the distribution on the histogram, the sample was divided into five age groups: ≤26, 36–45, 46–60, 61–70 and ≥71 years. Differences among the groups were determined using analysis of variance (ANOVA) followed by the Duncan test. To determine the age of major gait decline, we applied piecewise regression, which allows multiple linear models to be fitted to the data for different ranges of *x*. The breakpoints are the value of *x* where the slope of the linear function changes. The breakpoint can be known or estimated. Considering only one breakpoint (Θ), the linear regression model with one independent variable is described as:

$$y = \beta_0 + \beta_1 x, \quad x \le \Theta$$

$$y = \beta_0 + \beta_2 x + \Theta(\beta_1 - \beta_2) \quad x > \Theta$$

If *x* is greater than Θ, the model has a new straight line $\beta_0 + \beta_2 x + \square (\beta_1 - \beta_2)$ that begins on the breakpoint and has a new slope. The quality of the models was analyzed through normality, independency, and homoscedasticity of the residuals.

In the first regression model, we used velocity (dependent variable) and age (independent variable) with a pre-defined age breakpoint – Θ = 65 years. The pre-defined age of 65 was chosen based on the dispersion of the data (N = 653) showing a change in gait velocity behavior around 65 years of age (Fig. 1). For the second model, the estimated age breakpoint was determined using the segmented package proposed by Muggeo [24]. The segmented approach estimates linear models and generalized linear models with one or more segmented relations in the linear predictor. The technique is interactive and needs initial "kicks" to determine the breakpoint. The analyses were conducted using the statistical software R and with a 95% level of confidence.

3. Results

Table 1 presents the means of the anthropometric data for the

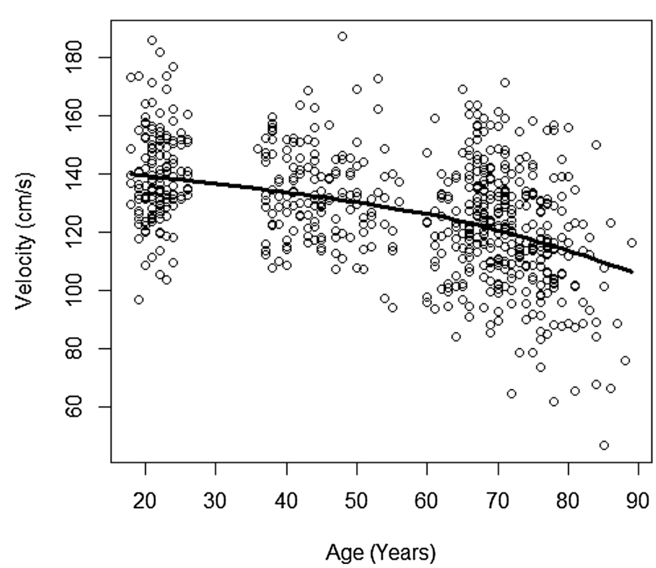

Fig. 1. Scatter plot of Age X Velocity showing the change in gait velocity behavior around 65 years of age (N = 653).