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Original Study

Greater Fall Risk in Elderly Women Than in Men Is Associated With Increased Gait Variability During Multitasking

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A B S T R A C T

Objective: As 90% of fractures are caused by falls, and as fractures are more common in elderly women than in elderly men, a better understanding of potential sex differences in fall rates and underlying mechanisms is needed. The purpose of this study was to determine whether women are more prone than men to falling, and to evaluate whether the risk of falling is associated with variations in gait patterns.

Design, setting, and participants: The cohort for this prospective observational study consisted of 1390 community-dwelling men and women aged 70 years, examined in a health survey between July 2012 and November 2014.

Measurements: Gait patterns were measured using a computerized walkway system during normal-speed, fast-speed, and dual-task trials. Triaxial accelerometers were used to collect objective data on physical activity, and self-reported fall data were collected by telephone 6 and 12 months after examination. Incident low-energy falls were defined as unexpected events in which participants came to rest on the ground.

Results: During the follow-up period, 148 study participants (88 women, 60 men; $P = .01$) reported falls. After adjusting for multiple confounders, including objective measures of physical activity, socioeconomic factors, cardiovascular disease, and cognitive function, the odds ratio for falling in women was 1.49 (95% confidence interval [CI] 1.02–2.19). Variations in gait pattern were significantly (20%–40%) increased in fallers compared with nonfallers during the dual-task trial for step width, step length, stride length, step time, stance time, stride velocity, and single support time (all $P < .05$). Furthermore, women showed 15% to 35% increased variability in all of these gait parameters during the dual-task trial compared with men (all $P < .01$).

Conclusion: In the present cohort, 70-year-old women were at greater risk of falls compared with their male counterparts. This increased risk was associated with increased variation in gait pattern during dual-task activities, and may contribute to women's greater fracture risk compared with men.

Each year, approximately 1.6 million individuals older than 50 years worldwide sustain hip fractures.[1] These severe events burden health care systems and reduce individuals' ability to perform daily life activities.[2] Hip fractures are at least twice as common in elderly community-dwelling women than in their male counterparts,[3] which has traditionally been attributed to women's lower bone mass.[4] However, we have published results suggesting that the difference in areal bone density (g/cm^2), and thus osteoporosis, does not explain the greater incidence of fractures in women than in men.[5] Investigation of other underlying factors leading to fracture, such as risk of falling, is thus of interest, especially as approximately 90% of hip fractures are caused by falls.[6]

Women report more falls and experience more fall-related injuries than men,[7,8] although the mechanisms behind this difference seem to be of multifactorial nature and further investigation would be of value.[9,10] Increased variability in gait patterns has been proposed as a marker of fall risk in elderly individuals,[11] especially during ambulation under dual-task conditions.[12,13] Such conditions are thought to challenge an individual's executive functions, also expressed as the ability to simultaneously plan and execute motor and cognitive processes, which has been shown to decrease more in women than in

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men with age.[14] In this regard, few studies have investigated whether gait variability differs between men and women, and no study has prospectively evaluated sex differences in gait patterns relative to incident falls.

Hence, this study aimed to investigate variability in gait patterns among 1390 men and women aged 70 years during progressively challenging gait conditions. Another aim was to investigate associations of gender with gait patterns and the risk of incident falls.

Methods

Participants

This prospective observational study was part of the Healthy Ageing Initiative at Umeå University, Sweden (www.healthyageinginitiative.com). The inclusion criteria for this study were (1) residence in the Umeå municipal area and (2) age of exactly 70 years at the time of testing. Information from population registers was used to contact eligible individuals who received printed information about the research project. Telephone contact was made shortly thereafter, during which time individuals accepted or declined the invitation to participate. As we aimed to investigate a sample representing the general population, no eligible participant was excluded. Thus, for the present study, the first 1421 individuals were considered for inclusion, and data are presented for 1390 individuals who completed all gait measurements.

Gait Measurement

Gait measurements were obtained using the validated GAITRite system (CIR Systems, Sparta, NJ), an 8.6-m-long and 0.88-m-wide electronic walkway containing sensors situated 1.27 cm apart.[15] The GAITRite system measures temporal and spatial gait parameters, with automatic initiation of the gait sequence from the first footfall contact and termination after the last. The sensors detect footfalls during ambulation, and raw data on gait parameters are subsequently transmitted to the application software for processing. The gait parameters measured and analyzed for this study have been described elsewhere.[16]

Participants performed 3 progressively challenging gait trials. During the first trial, participants walked normally at a preferred pace. In the second trial, participants were asked to walk as rapidly as possible while maintaining control. During the third trial, we introduced dual tasking, where participants walked at a self-selected pace while counting backward from 100 in increments of 1. Participants removed footwear and were instructed to start each trial 1 m ahead of the walkway to reduce acceleration effects.

The software calculated means and SDs (M ± SDs) of gait parameters for each trial. Combined M ± SDs for parameters with separate values for the left and right legs were calculated manually. Coefficients of variation (CVs; SD/M × 100) were then calculated for all gait parameters.

Self-Reported Falls

A research nurse contacted participants by telephone 6 and 12 months after the examination to assess incident falls, by asking: "Have you experienced a fall in the same level during the last 6 months?" This question was further clarified by explaining that qualifying falls were low energy, where the participant had unexpectedly come to rest on the ground by him/herself.

Assessment of Physical Activity

After gait testing, participants wore triaxial accelerometers (GT3X+, 4.6 × 3.3 × 1.5 cm; Actigraph, Pensacola, FL) for 7 days. These devices are capable of measuring acceleration in the range of ±6 G. Measured accelerations are digitalized, transformed into "counts," and stored in a resilient flash memory. For this study, the total numbers of counts in all 3 axes were analyzed separately, as well as combined and expressed as total physical activity.

Participants wore the accelerometers on their nondominant hips, removing them only when showering, swimming, or during nighttime sleep. They also received instructions to be normally active during the measurement period, to obtain accurate reflections of their lifestyles. Participants were given the option to start a new 7-day measurement if the accelerometer malfunctioned or they forgot to wear the device. Accelerations were registered at 30-Hz frequency with an activity threshold of 100 counts per minute (CPM). Upon completion of measurements, the ActiLife 6.11.2 software (Actigraph) was used to define nonwear time as periods <60 minutes at <100 CPM, which facilitated the exclusion of sleep time.

Covariables

Anthropometric variables were measured after participants had provided written consent. Height (m) was measured using a gauge (Holtain Limited; Crymych, Dyfed, UK) and weight (kg) was measured with a scale (HL 120; Avery Berkel, Fairmont, MN). Body mass index (BMI) was then calculated as weight divided by height squared. Experienced research nurses performed waist measurements with a measurement tape. Participants took the Mini-Mental State Examination (MMSE), a very commonly used screening instrument for the assessment of cognitive function. The MMSE requires participants to answer questions and complete tasks in 6 cognitive domains, with a maximum score of 30.[17] Participants also reported smoking, as well as histories of cardiovascular disease and diabetes. Information on participants' educational levels was collected from the Statistics Sweden database.

Ethical Approval

This study was granted permission by Umeå University Research Ethics Committee, and follows the World Medical Association's Declaration of Helsinki.

Statistical Analysis

All analyses were performed with Stata version 13.1 (StataCorp, College Station, TX). M ± SDs were used to present descriptive data. For the analysis of gait variability, participants were divided into groups based on sex and incident falls, and Student *t* tests were used to compare data. Categorical variables were analyzed using χ^2 tests. Independent exposures of incident falls were investigated with multiple logistic regression models, with calculation of odds ratios (ORs) and 95% confidence intervals (CIs). The first model included only sex as a predictor of incident falls. The second model additionally included total physical activity and educational level, and the third model further included smoking, cardiovascular disease history, diabetes, and MMSE score. Gait variability and gait speed during dual tasking was added to the fourth model to investigate the potential influence of gait patterns on differences in fall incidence between men and women.

Results

Study Cohort Characteristics

At the time of this study, the participation rate was approximately 70% (706 men and 684 women) and 1350 of 1390 participants had been contacted 6 or 12 months after the examination and asked to recall any falls. Incident falls were reported at least once for 148 (11%) of 1350