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Changes in physical activity, sedentary time, and risk of falling: The Women's Health Initiative Observational Study

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ABSTRACT

Falling significantly affects quality of life, morbidity, and mortality among older adults. We sought to evaluate the prospective association between sedentary time, physical activity, and falling among post-menopausal women aged 50–79 years recruited to the Women's Health Initiative Observational Study between 1993 and 1998 from 40 clinical centers across the United States. Baseline (B) and change in each of the following were evaluated at year 3 (Y3) and year 6 (Y6; baseline $n = 93{,}676$; Y3 $n = 76{,}598$; Y6 $n = 75{,}428$): recreational physical activity (MET-h/wk), sitting, sleeping (min/day), and lean body mass by dual energy X-ray absorptiometry (subset $N = 6475$). Falls per year (0, 1, 2, ≥3) were assessed annually by self-report questionnaire and then dichotomized as ≤1 and ≥2 falls/year. Logistic regression models were adjusted for demographics, body mass index, fall history, tobacco and alcohol use, medical conditions, and medications. Higher baseline activity was associated with greater risk of falling at Y6 (18%; p for trend <0.0001). Increasing sedentary time minimally decreased falling (1% Y3; 2% Y6; $p < 0.05$). Increasing activity up to ≥9 MET-h/wk. (OR: 1.12, 95% CI: 1.03–1.22) or maintaining ≥9 MET-h/wk. (OR: 1.20, 95% CI: 1.13–1.29) increased falling at Y3 and Y6 (p for trend <0.001). Adding lean body mass to the models attenuated these relationships. Physically active lifestyles increased falling among post-menopausal women. Additional fall prevention strategies, such as balance and resistance training, should be evaluated to assist post-menopausal women in reaching or maintaining levels of aerobic activity known to prevent and manage several chronic diseases.

1. Introduction

The propensity to fall increases with aging, often due to other age related issues, such as impaired vision, balance, and mental acuity (Rubenstein, 2006). Although many falls result in minor injuries, approximately 10% will result in fractures which are associated with significant morbidity and mortality in the aged (Gillespie et al., 2012). Reductions in falls among community dwelling older adults engaging exercise interventions offers hope (Gillespie et al., 2012), as does the protection against fracture with higher baseline physical activity demonstrated in the Women's Health Initiative (WHI) (Robbins et al., 2007), but overall, the association between physical activity and falls in the literature has been inconsistent (Clarke et al., 2015). Physical activity patterns over time may prove to be more predictive of falls than exercise interventions or assessment of physical activity at a single

Abbreviations: ANOVA, Analysis of variance; BMI, Body mass index; DXA, Dual energy X-ray absorptiometry; MET, Metabolic equivalent of task; H-EPESE, Hispanic Established Population for the Epidemiologic Study of the Elderly; SD, Standard deviation; WHI, Women's Health Initiative.

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time point. Longitudinal changes in physical activity and body composition, which may mediate the falls benefit of physical activity through preservation of muscle mass (LaStayo et al., 2003), are needed to better understand their independent and joint roles in falls risk. However, because prospective studies on older adults typically do not have repeated prospective measures on these factors, they have yet to be fully explored with respect to incidence of falling.

In the United States, physical activity decreases dramatically in adulthood, stabilizing at relatively low levels in middle aged women (Caspersen et al., 2000). Low levels of physical activity have been associated with decreased muscle mass (Morley et al., 2001). Meanwhile, sedentary time, distinctly different than insufficient moderate to vigorous physical activity (Owen et al., 2010), increases with aging (Clark et al., 2010). High sedentary time may also aid in skeletal muscle decline and has been shown to be a risk factor for falling in studies with 1–2 years follow-up (Thibaud et al., 2012).

We sought to determine whether prospectively assessed physical activity patterns, including sedentary time, are associated with the risk of falling over several years and whether risk of falling is mediated by body composition. We hypothesized that decreasing physical activity over time would be associated with increased risk of falling among postmenopausal women (Fig. 1). High sedentary time was also hypothesized to increase risk of falling.

2. Methods

2.1. Study population

The WHI Study recruited postmenopausal women aged 50–79 years at 40 WHI clinical centers across the United States between 1993 and 1998 to four clinical trials and an observational study (Design of the Women's Health Initiative Clinical Trial and Observational Study, 1998; Hays et al., 2003). Only women enrolled in the observational study were included in this analysis ($N = 93,676$); body composition was measured in those enrolled at the Pittsburgh, PA; Birmingham, AL; and Tucson-Phoenix, AZ sites ($N = 6475$) (Chen et al., 2008). The protocol and consent forms were approved by each institutional review board at each site and all participants provided written informed consent. For the present study, measurements taken at baseline, year 3 and year 6 of follow-up were used. The average follow-up time for incident falls in this study was 54 months.

2.2. Physical activity assessment

The frequency, intensity, and duration of walking, as well as moderate and vigorous recreational physical activity, were assessed using a reliable and valid questionnaire. Test-retest reliability was 0.67–0.71 (weighted κ coefficient) for individual physical activity variables on the WHI questionnaire and the questionnaire assessed activity levels correlated well with accelerometry ($r = 0.73$) in a subset of the WHI. (Eaglehouse et al., 2016; Johnson-Kozlow et al., 2007; Langer et al., 2003; Manson et al., 2002; Meyer et al., 2009; Nguyen et al., 2013). Energy expenditure (MET-h/wk) was computed, as previously published (Ainsworth et al., 2000; Sims et al., 2012).

Based on the continuous physical activity data, 4 categories of baseline physical activity were created: no physical activity (0 MET-h/wk), ≤ 3 MET-h/wk., 3.1 to 8.9 MET-h/wk., and ≥9 MET-h/wk. Participants were classified as physically inactive (0 MET-h/wk), insufficiently active (>0 to <9 MET-h/wk), and active (≥9 MET-h/wk. of moderate-vigorous intensity physical activity) in approximate alignment with recommended physical activity levels (Physical Activity Guidelines Advisory Committee Report, 2008). *Change* in physical activity from baseline to year 3 and year 6 was categorized as follows:

a) change/inactive: remaining in the inactive or insufficiently active category at baseline and follow-up
b) increased activity: inactive or insufficiently active at baseline, but increased to ≥9 MET-h/wk. at follow-up
c) active maintainer: maintained ≥9 MET-h/wk. at baseline and follow-up
d) decreased/inactive: decreased physical activity categories from sufficiently active to insufficiently active or inactive, or decreased from insufficiently active to inactive category

Sedentary time was quantified separately by two questions in the questionnaire that asked how much time was spent sitting per day and lying down per day (h/day). Sedentary time is not equivalent to the inactive or insufficiently active terms above.

2.3. Anthropometry and body composition assessment

Height and weight were measured without shoes on a wall-mounted stadiometer to the nearest 0.1 cm and balance-beam scale to the nearest 0.1 kg, respectively. BMI was calculated as weight (kg)/height (m)^2. Body composition was determined by performing dual energy X-ray absorptiometry scans (DXA; QDR2000, 2000 +, or 4500 W; Hologic Inc., Bedford, MA) at 3 WHI clinical centers (Pittsburgh, PA; Birmingham, AL; and Tucson-Phoenix, AZ), each using the rigorous WHI quality assurance program (Chen et al., 2005). Measurements included both whole body and regional bone mineral density, lean body mass, and fat mass. Calibration equations were developed when an older DXA machine was replaced with a newer model (QDR2000 to QDR4500W) (Chen et al., 2005). Participants who completed the baseline and at least year 3 or year 6 follow-up visits were included in this analysis.

2.4. Assessment of falls

A self-report medical history questionnaire that included the following question was collected at baseline and by mail annually: "During the past 12 months, how many times did you fall and land on the floor or ground: none, 1 time, 2 times, 3 or more times?" Participants were asked not to include falls due to sports activities such as snow- or water-skiing or horseback riding (Anderson et al., 2003).

2.5. Assessment of covariates

Years since menopause were determined by last reported menstrual bleeding, time of bilateral oophorectomy, or initiation of menopausal hormone therapy. Self-report questionnaires were used to obtain information on demographics, medical history, medications, smoking and alcohol use, and prior hormone therapy use at baseline. Diet and physical function were assessed by a validated food frequency questionnaire (Block et al., 1990) and the Medical Outcomes Study Scale (Ware and Sherbourne, 1992), respectively.

2.6. Statistical analysis

Descriptive statistics were computed and tests for significant differences were performed using analysis of variance (ANOVA) for

Fig. 1. Hypothesized mediation model among participants in the Women's Health Initiative Observational Study recruited between 1993 and 1998 from 40 clinical centers across the United States ($n = 93,676$).