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Original Article

Associations between walking parameters and subsequent sleep difficulty in older adults: A 2-year follow-up study

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Purpose: This 2-year follow-up study aimed to examine the associations between total volume, frequency, duration, and speed of walking with subsequent sleep difficulty in older adults.
Methods: A total of 800 older adults aged 65 years and over participated in the first survey in 2012 and 511 of them were followed 2 years later. The 5-item Athens Insomnia Scale (AIS-5) was used to measure sleep difficulty. Frequency, duration, and speed of outdoor walking were self-reported. Walking speed was assigned a metabolic equivalent value (MET) from 2.5 to 4.5. Total walking volume in MET-h/week was calculated as frequency × duration × speed. Negative binomial regressions were performed to examine the associations between volume and components of walking with subsequent sleep difficulty with covariates of age, sex, education, marital status, living arrangement, smoking, alcohol consumption, mental health, Charlson index, exercise (excluding walking), and sleep difficulty at baseline.
Results: Participants with low walking volume had a higher level of sleep difficulty 2 years later compared with those with high walking volume (incident rate ratios = 1.61, $p = 0.004$). When speed, frequency, and duration of walking were simultaneously entered into one model, only walking speed was significantly associated with subsequent sleep difficulty (after the model was adjusted for covariates and baseline sleep difficulty). Sensitivity analyses showed that walking duration emerged as a significant predictor among 3 walking parameters, with 2-year changes of sleep scores as dependent variable.
Conclusion: Total amount of walking (especially faster walking and lasting for more than 20 min) is associated with less subsequent sleep difficulty after 2 years among older adults.

Keywords: Disturbed sleep; Exercise; Insomnia; Physical activity; Prospective study; Sleep disorder

1. Introduction

Poor sleep quality is associated with increased risks of several medical conditions including inflammatory diseases, cardiovascular disease, diabetes, obesity, depression, and also mortality.[1–5] Older people are especially susceptible to sleep related problems. With increasing age, sleep quantity and quality may change considerably with more sleep fragmentation, earlier awakening, and reduced slow-wave sleep.[6–8] The increased prevalence of chronic conditions in later life may contribute to sleep difficulty for older adults.[6]

Physical activity (PA) has increasingly been recognized for its beneficial effects on sleep quality and reduced risk of insomnia in older adults.[9–13] Walking is the most common PA among older adults across different countries.[14,15] It does not require special skills and equipment; it is an accessible and inexpensive form of physical activity that carries minimal adverse effects;[16–18] and it

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can be incorporated into everyday life. Therefore, for older adults, walking provides an ideal way to increase their PA levels.[18] Hence, it has been featured prominently in national guidelines for health, especially for those who are initially inactive or frail.[19]

Several causal pathways between exercise or PA and sleep have been proposed.[20,21] The thermogenic hypothesis suggests that exercise or PA raises body temperature, and as a result, body heating acclimation helps to promote sleep.[22] Also, exercise and PA both deplete energy stores, which increases the need for sleep due to energy conservation or body restoration.[20]

Walking can be quantified through the assessment of overall volume, which is usually expressed in terms of 3 parameters: frequency, duration, and intensity.[18] Volume as an overall estimate can indicate the degree to which walking is associated with sleep. However, each of the underlying parameters may expose different mechanisms underpinning walking-sleep relationships. For example, higher speeds or intensities of walking may stimulate greater metabolic adaptation whereas frequency will reflect regularity of exposure, which might be critical to sustained sleep benefits. Thus, it may be beneficial to examine the independent effects of the 3 parameters in addition to volume of walking. Previous research has examined the relationships of these parameters of PA with depressive symptoms[23] and activities of daily living.[24] The results showed that while controlling for the other parameters of PA, only intensity was an independent predictor of depressive symptoms and only duration was associated with activities of daily living. However, no study, either cross-sectional or longitudinal in design, has been identified that has investigated the independent associations between walking parameters and sleep among older adults. This prospective cohort study was therefore designed to explore, in addition to total volume of walking, the independent relationships between frequency, duration, and intensity of walking with self-reported sleep difficulty in older adults 2 years later.

2. Methods

2.1. Participants

A total of 800 older adults who attended the 2012 health examination at Taiwan Taipei City Hospital were selected and consented to participate in this study. Quota sampling by sex and age group was employed to provide a sample that was similar to the total Taipei older population (aged 65 years and older). Those who were prescribed psychotropic medications (e.g., antipsychotics, antidepressants, anti-anxiety medications, and mood stabilizers) ($n = 5$) were excluded due to the possible influence on their sleep by these medications. Among the selected participants, 511 older adults also completed the health examination and questionnaire surveys at follow-up in 2014 (response rate = 63.9%). The study was approved by the Institutional Review Board of Taipei City Hospital. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional review board, national research committee, or both, and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The written informed consent was obtained from all individual participants included in the study.

2.2. Measures

In both surveys, all participants completed a comprehensive medical examination, which included anthropometric measures, scans, and the collection of blood samples. While attending, they also had face-to-face interviews with doctors of family medicine about health conditions and were asked to complete a questionnaire to assess sleep and PA.

2.2.1. Outcome variable: sleep difficulty

The Athens Insomnia Scale (AIS) was used to measure sleep difficulty at baseline and follow-up. It has an 8-item version (AIS-8) and a brief 5-item version (AIS-5). The Chinese version of AIS-5 was used in this study, which has been shown to be valid and reliable in the Chinese population.[25] The AIS-5 assesses time to sleep induction, number of awakenings during the night, time of the final awakening, sleep duration, and sleep quality during the last month. A higher score indicates greater sleep difficulty.[26] The cut-off point for defining sleep difficulty (insomnia symptoms) for the Chinese version of AIS-5 is suggested to be 5.[27]

2.2.2. Exposure variable: walking

Participants were asked to estimate the frequency and the average daily amount of time they had spent walking outdoors during the past 7 days. They were also asked to indicate their usual outdoor walking speed: easy (<2 mile/h), average (2–2.9 mile/h), brisk (3–3.9 mile/h), or very brisk (≥4 mile/h).[28] Walking speed was assigned a metabolic equivalent value (MET): 2.5 METs for easy pace, 3.0 METs for average pace, 3.5 METs for brisk pace, and 4.5 METs for very brisk pace. Self-reported walking speed has been shown to be a good marker of measured walking speed in older adults[29] and has been used in several studies.[28,30,31] The total walking volume in MET-h/week was calculated by multiplying frequency by duration and by walking speed (METs).[30] Each walking parameter was categorized into tertiles: low, moderate, and high.

2.2.3. Covariates

Sex, age, education, marital status, living arrangements, smoking habits, alcohol consumption, metabolic syndrome, mental health, exercise (excluding walking), and sleep difficulty at baseline were used as covariates in the regression analyses. Age (65–74 and 75+) and education (schooling ≤9 years and >9 years) were both separated into 2 groups. Marital status was grouped into married or cohabitating and others (including never married, divorced, widowed, and separated). Living arrangements were categorized into "living alone" and "living with others." Smoking and alcohol consumption was categorized as "Yes (current smoker or drinker)" or "No."

Health conditions among participants (which included heart disease, hypertension, hyperlipidemia, diabetes, stroke, pulmonary disease, physical pains, gout, arthritis, Parkinson disease, dementia, liver disease, renal disease, and cancer) were checked from the medical records and diagnosed by medical doctors. As a small proportion of our sample was found to have these

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