Gait & Posture 49 (2016) 127–131

Contents lists available at ScienceDirect

Gait & Posture

journal homepage: www.elsevier.com/locate/gaitpost

Full length article

Sleep quality is associated with walking under dual-task, but not single-task performance

Maayan Agmon[a,*], Tamar Shochat[a], Rachel Kizony[b,c]

[a] The Cheryl Spencer Department of Nursing, Faculty of Social Welfare & Health Sciences, University of Haifa, Mount Carmel, Haifa 3498838, Israel
[b] Department of Occupational Therapy, Faculty of Social Welfare & Health Sciences, University of Haifa, Mount Carmel, Haifa 3498838, Israel
[c] Center of Advanced Technologies in Rehabilitation, Sheba Medical Center, Tel Hashomer, Israel

ARTICLE INFO

Article history:
Received 3 February 2016
Received in revised form 1 May 2016
Accepted 11 June 2016

Keywords:
Gait variability
Dual- task
Fall risk
Older adults
Sleep efficiency
Sleep latency

ABSTRACT

Objectives: The objective of this study was to assess the relationship between sleep behavior and gait performance under single-task (ST) and dual-task (DT) walking conditions in community- dwelling older adults.
Methods: Walking under ST and DT conditions was evaluated in 34 community-dwelling older adults, 64.7% women, mean age 71.5 (SD ± 5.8). Gait-speed and gait-variability data were collected using the OPAL wearable sensors of the Mobility Lab. Sleep behavior (sleep efficiency [SE] and sleep latency [SL]) was assessed using actigraphy, over 5 consecutive nights.
Results: Lower SE was associated with decreased gait speed and increased stride-length variability during DT (rs = 0.35; p = 0.04; rs = −0.36; p = 0.03, respectively), whereas longer SL was associated with increased stride-length variability during DT (rs = 0.38; p = .03). After controlling for age and cognition, SE accounted for 24% and 33% of the variability in stride length and stride time. No associations were found between sleep and gait measures under ST walking.
Conclusions: Lower SE is associated with decreased gait speed and increased gait variability under DT conditions that are indicative of an increased risk for falls in older adults. Our findings support clinical recommendations to incorporate the evaluation of sleep quality in the context of risk assessment for falls.

1. Introduction

Older age is most often accompanied by gait abnormalities. More than a third of adults over 70 years of age and most elderly people over 85 years of age have a clinical diagnosis of walking deterioration [1]. Gait decline leads to loss of independence, a significant reduction in quality of life, an increased risk of falls, and, consequently, increased mortality and morbidity [2,3]. Thus, understanding the mechanisms underlying the development of gait abnormalities is an important health priority.

In recent years there is a growing understanding that the control of gait involves a delicate equilibrium between automatic and executive control mechanisms [4]. Most gait abnormalities in the elderly are characterized by reduced automaticity and greater reliance on executive control. This shift in the equilibrium requires more cognitive resources, subsequently leading to slower processing and an alteration in gait pattern [5].

The most common method developed to distinguish between automatic and executive control processing of gait is the dual-task (DT) paradigm [4,6]. DT is the ability to conduct two tasks simultaneously, such as walking while talking on the phone or while talking with a companion. The ability to divide one's attention between two tasks deteriorates as a part of the aging process [7]. The predominant manifestations of decreased automaticity during DT while walking in older adults are decreased gait speed and increased gait variability (i.e., increased stride length and time variability) [4]. A growing body of evidence shows that older adults require more attentional control than young adults do while walking simultaneously with another task [8,9]. Most falls in elderly people occur during DT situations which are highly prevalent in daily living [10,11]. Studying factors associated with DT while walking in relatively healthy and high-functioning older adults may disentangle the confounding effects of comorbidity and pave the way for strategies for early detection of increased risk for falls.

Abbreviations: CPAP, continuous positive airway pressure; DT, dual task; MoCA, Montreal Cognitive Assessment; PSG, polysomnographic; RBD, rapid eye movement behavior disorder; REM, rapid eye movement; SAST, short Anxiety Screening Test; SE, sleep efficiency; SL, sleep latency; ST, single task.

* Corresponding author. Fax: +972 04 828 8017.
E-mail addresses: agmon.mn@gmail.com (M. Agmon), tshochat@univ.haifa.ac.il (T. Shochat), racheli.kizony@gmail.com, rkizony@univ.haifa.ac.il (R. Kizony).

http://dx.doi.org/10.1016/j.gaitpost.2016.06.016
0966-6362/

Recent reviews have addressed several factors that affect reduced gait automaticity in older adults. These include hearing loss, cardiovascular disease, musculoskeletal problems, mood disturbances, central and peripheral nervous system abnormalities, and cognitive deterioration [4]. In addition, some evidence suggests that sleep is associated with gait abnormalities. Thus, in a cross-sectional investigation, short sleep duration and low sleep efficiency (SE, a measure used to estimate the proportion of time in bed spent asleep) were associated with a 30%–40% increased risk of falls in older women [12]. Moreover, treating sleep apnea in older adults with continuous positive airway pressure (CPAP) was found to improve gait variability during DT walking [13].

Sleep disturbances are highly prevalent; half of community-dwelling older adults report at least one chronic sleep complaint [14,15]. Most sleep disorders in the aging population are associated with other comorbidities rather than with the aging process *per se*; however, a decline in SE has been attributed to the aging process itself [16]. Although insomnia has been implicated as an independent risk factor for falls in older adults [12], no studies to date have investigated associations between sleep quality and locomotion in high-functioning community-dwelling older adults using the DT paradigm.

This study explored the associations between habitual sleep quality indices and gait quality, both based on objective measurements. Sleep quality indices included SE, measured as the percentage of time asleep of total time in bed; and sleep latency (SL), the amount of time taken to fall asleep when lying in bed and after lights are turned off. Gait quality was based on gait speed and gait variability: both are considered gold-standard measurements in single-task (ST; walking) and DT (walking while performing a cognitive task) conditions, in community dwelling older adults. We hypothesized that lower SE and longer SL are associated with higher gait variability and lower gait speed under DT conditions. Findings may contribute to more effective assessment and treatment strategies for both sleep disturbances and gait abnormalities in the older adult population.

2. Methods

2.1. Study sample

This cross-sectional study recruited 34 community-dwelling older adults. Inclusion criteria were (1) age 60 or older; (2) able to walk independently; (3) able to speak, understand, and read Hebrew; and (4) independent in basic and instrumental activities of daily living (e.g., dressing, shopping). Exclusion criteria were (1) the presence of neurologic diagnosis, such as cerebral vascular accident, Parkinson's Disease, Alzheimer's disease, or multiple sclerosis; (2) severe orthopedic restrictions such as acute back pain, recent fractures, or a total hip replacement; and (3) significant hearing or vision loss.

The study was approved by the Institutional Review Board of the University of Haifa, and written informed consent was obtained from all participants.

2.2. Actigraphy

For objective assessment of sleep, participants wore wrist activity monitors (actigraphs; Ambulatory Monitoring, Inc., Ardsley, NY, USA) during the night for 1 week. Activity data were downloaded and analyzed using ActionW software (version 2, UCSD algorithm). Sleep logs were used for editing to determine sleep onset and sleep offset. Measures included SE, SL, and sleep duration. The accuracy of this device is 90% of that of polysomnographic (PSG) testing [17].

2.3. Gait assessment under single-task and dual-task performance

The Mobility Lab System (http://www.apdm.com) was used to measure the following gait parameters: gait speed, stride length and stride time, and coefficient of variance (COV) of stride-length and stride-time (i.e., variability). The system consists of three small wireless OPAL movement sensors that are affixed to the participant's legs and waist. The sensors are wireless and do not interfere with walking. This mode of measurement has been shown to be sensitive and reliable [18]. Participants wore three OPAL wireless sensors and were asked to walk forward at a comfortable speed for 1 minute in a flat-surface corridor. They walked twice; once with (DT) and once without (ST) a cognitive task. The cognitive task was a subtraction task in which they were required to continuously subtract by 3 from a random number between 100 and 250. In addition, participants were asked to perform the cognitive subtraction task while sitting in a chair as a ST. The number of correct responses was calculated. The tasks were administrated in a random order. The subtraction-by-3 task is an internal mental processing task that has been shown, in comparison with tasks that involve reaction to external cues, to generate higher cognitive load and, consequently, to negatively affect gait performance. As such, the subtraction-by-3 task is a sensitive measure that is commonly used in DT walking studies, which enables standardization and comparisons between studies [19].

2.4. Other measures

Information about participants' age, gender, and education, as well as cognitive status and anxiety, were collected through self-report. Cognitive status was assessed using the Montreal Cognitive Assessment (MoCA) [20], a test that screens for cognitive abilities in seven domains (e.g., executive functions and memory) with scores ranging from 0 to 30. The test was developed to detect cognitive impairments and found to be reliable and sensitive enough to detect mild cognitive impairment. In addition, executive skills were evaluated with the Trail Making Test–B (TMT–B). The test measures complex visual scanning, motor speed, and cognitive flexibility [21]. The Short Anxiety Screening Test (SAST) [22] was used to measure anxiety. The SAST is a 10-item Likert-scale questionnaire that conforms to the criteria for anxiety described in the DSM-V. The instrument has a sensitivity of 75% and specificity of 79%, with a Cronbach's alpha of 0.70.

2.5. Statistical analysis

Data were analyzed using the IBM SPSS Statistics Version 21.0 (IBM Corporation, Armonk, NY) software. Variables were tested for normal distribution using the Shapiro–Wilk test. The main outcomes (SE, SL, and gait variability) were not normally distributed. Thus, descriptive data are presented as mean $\pm$ standard deviation (SD), as well as median and interquartile range (IQR). The non-parametric Spearman rho correlation test was used to examine correlations between sleep and gait parameters, cognitive ability, and age. In addition, in order to examine which of the variables explain the performance of DT, two exploratory hierarchical multiple linear regressions were performed; the dependent variable was stride-length variability in the first regression, and stride-time variability in the second regression. Based on the bivariate analyses, predictor variables were age, cognitive ability (MoCA score), and SE. Since the variables were not normally distributed, squared root transformations were performed in order to reduce the skewness.