Preventive Medicine 59 (2014) 68–72

Contents lists available at ScienceDirect

Preventive Medicine

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

Relationships between changes in time spent walking since middle age and incident functional disability

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ARTICLE INFO

Available online 27 November 2013

Keywords:
Walking
Physical activity
Disability
Cohort study
Longitudinal study

ABSTRACT

Objective. To examine the relationship between changes in time spent walking since middle age and incident functional disability.

Method. In 2006, we conducted a prospective cohort study of 7177 disability-free Japanese individuals aged ≥65 years who lived in Ohsaki City, Miyagi Prefecture, Japan. Participants were categorized into four groups according to changes in time spent walking based on two questionnaire surveys conducted in 1994 and in 2006. Incident functional disability was retrieved from the public Long-term Care Insurance database, and the subjects were followed up for 5 years. The Cox proportional hazards model was used to investigate the association between changes in time spent walking and the risk of incident functional disability.

Results. Compared with subjects who remained sedentary, the multivariate-adjusted hazard ratios (95% confidence intervals) were 0.69 (0.49–0.98) among those who became active and 0.64 (0.50–0.82) among those who remained active. These results did not alter when analyses were stratified by gender, age and motor function status.

Conclusion. An increase in time spent walking among sedentary adults is significantly associated with a lower risk of incident functional disability.

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Introduction

Physical activity is a well-known modifiable behavior associated with lower risks of mortality (Haskell et al., 2009; Leitzmann Mf, 2007; Nelson et al., 2007; Wagner and Brath, 2012; Wen et al., 2011). In addition to keeping physically active, increasing physical activity is also known to be beneficial in terms of cardiovascular risk and longevity (Aadahl et al., 2009; Balboa-Castillo et al., 2011; Gregg et al., 2003; Petersen et al., 2012; Schnohr et al., 2003; Talbot et al., 2007; Wannamethee et al., 1998). Previous longitudinal studies have shown that, in comparison with individuals who remain sedentary, those who increase their physical activity have a total mortality risk reduction of more than 40% (Balboa-Castillo et al., 2011; Gregg et al., 2003; Schnohr et al., 2003; Wannamethee et al., 1998).

In countries with rapidly aging populations, such as Japan, the health and economic impacts of disability have been attracting increasing attention (Fried et al., 2001). Disability is the endpoint of the disablement process, which includes four distinct but correlated concepts: active pathology, impairment, functional limitation, and disability (Nagi, 1991). According to the Nagi's disablement model, functional limitation is a limitation in performance at the level of the whole organism or person, which includes motor dysfunction; disability is an inability or limitation in performing socially defined roles and tasks expected of an individual within a sociocultural and physical environment. During the disablement process, not only physical inactivity could be a predisposing risk factor, but changes in physical behavior may avoid, retard or reverse the outcomes (Verbrugge and Jette, 1994). However, data are limited regarding the effects of changes in physical activity on disability or functional status. One study of older American women has shown that in comparison with women who remained inactive after middle age, those who remained active or became active had fewer difficulties with activities of daily living (ADL), better scores in the Physical Performance Test, and faster walking speeds (Brach Js, 2003). Another two recent studies have also observed that increasing physical activity from middle age was associated with a lower disability score in old age (Berk et al., 2006; Gretebeck et al., 2012). Otherwise, the British Regional Heart Study has also shown that in comparison with men who had remained inactive, those who became active or remained active had a lower risk of mobility limitation (Wannamethee et al., 2005).

However, those studies mostly employed self-reported endpoints (Berk et al., 2006; Gretebeck et al., 2012; Wannamethee et al., 2005), and some had small numbers of participants (Berk et al., 2006; Brach Js, 2003); furthermore, none of them measured the incidence of disability. In Japan, Long-term Care Insurance (LTCI) certification of requiring assistance with ADL, based on a nationally uniform standard of functional disability, has been frequently used in previous epidemiological

Abbreviations: ADL, activities of daily living; LTCI, Long-term Care Insurance.

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0091-7435/$ – see front matter © 2013 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.ypmed.2013.11.019

studies as a measure of incident functional disability in the elderly (Aida et al., 2012; Hozawa et al., 2010; Tomata et al., 2012). As the economic burden of taking care of older people with disability is increasing (Ministry of Health, 2012), studies of modifiable risk factors of functional disability have become necessary. To our knowledge, no prospective study has yet investigated the relationship between changes in physical activity since middle age and the risk of incident functional disability. Furthermore, the doubts of benefits of increasing or maintaining physical activity could result from younger age, better motor function or higher intensity of physical activity in men which allow those subjects to be more active than the others have not been well clarified.

In the present study, we chose to focus on walking, which is the most common type of physical activity among middle-aged or older individuals. Our previous studies have shown that spending a longer time walking per day is associated with lower medical costs and increased longevity (Fujita et al., 2004; Nagai et al., 2011; Tsuji et al., 2003). The objective of the present study was to investigate changes in time spent walking in relation to the risks of incident functional disability in a large community-dwelling population in Japan.

Methods

Study cohort

The present investigation used data from a population-based longitudinal study conducted in Ohsaki, a northern non-coastal rural area of Miyagi Prefecture, northeastern Japan. Between October and December 1994, all National Health Insurance beneficiaries aged 40 to 79 years who lived in the catchment area of Ohsaki Public Health Center (including one city and 13 towns) were invited to take part in a health survey with self-administered questionnaire on various lifestyle habits (1994 Survey) (Nagai et al., 2011; Tsuji et al., 2003). Among 54,996 eligible individuals, 52,029 (94.6%) responded.

During a period when a municipal merger occurred, one city and 6 towns in the study area were merged into a single new municipality, Ohsaki City, on 31 March 2006. Thereafter, we conducted a health survey on the citizens of Ohsaki City. Between 1 December and 15 December 2006, a self-administered questionnaire was distributed to subjects aged 65 years or older based on the Residential Registry for Ohsaki City (2006 Survey) (Koyama et al., 2010; Kuriyama et al., 2010; Nakaya et al., 2013; Tomata et al., 2012). Among 23,132 eligible individuals (aged 53 years or older in 1994 Survey), 12,676 (54.8%) responded. We considered the return of completed questionnaires to imply consent to participate in the 2006 Survey, and subsequent death and emigration were followed up. We also confirmed information regarding LTCI certification status after obtaining written consent from the subjects. The study protocol was approved by the Ethics Committee of Tohoku University School of Medicine.

For the present analysis, we further excluded 3610 persons who did not provide written consent for review of their LTCI information, one person who had been died, 973 persons who had already been certified as having disability by the LTCI at the time of the baseline survey, and 915 persons for whom responses to the questions on walking were missing. Thus, a final total of 7177 responses were analyzed for the purposes of this study.

Classification of exposures

Time spent walking was evaluated on the basis of the response to a specific question, 'How long do you walk a day, on average?' in both the 1994 and 2006 Surveys, and the subjects were asked to choose one out of three responses: '1 h or more', '30 min to 1 h' or '30 min or less'. The validity of self-reported time spent walking had been reported previously, which indicated that self-reported walking time was reasonably reproducible and sufficiently valid for studying the health effects of walking (Fujita et al., 2004; Nagai et al., 2011; Tsubono et al., 2002; Tsuji et al., 2003). According to the "Global Recommendations of Physical Activity for Health" developed by the WHO, at least a total of 150 min or 30 min of moderate-intensity activity 5 times per week is suggested for all adults (WHO, 2010). Therefore, participants who spent more than 30 min per day walking were considered to be active in this study. As shown in Table 1, four categories of changes in time spent walking were defined for each participant by his/her answers in 1994 and 2006: remained inactive (<30 min in both 1994 and 2006); became inactive (≥30 min in 1994 and <30 min in 2006); became active (<30 min in 1994 and ≥30 min in 2006); and remained active (≥30 min in both 1994 and 2006).

Table 1
Categories of changes in time spent walking (December 2006, Ohsaki City, Miyagi Prefecture, Northeastern Japan).

Time spent walking per day		2006 survey	
		≥30 min	≥30 min
1994 survey	<30 min	Remained inactive	Became active
	<30 min	Became inactive	Remained active

Follow-up and case ascertainment

The primary endpoint for the present analysis was incident functional disability defined as newly qualifying for LTCI certification and registration on the public LTCI database between 16 December 2006 and 30 November 2011. We collected LTCI certification data every year from the public LTCI database maintained by Ohsaki City. LTCI is a form of mandatory social insurance aimed at assisting the frail and elderly with daily activities (Ikegami, 1997; Imai et al., 2008; Ministry of Health, 2012; Tsutsui and Muramatsu, 2005). People aged 65 years or older who require assistance with ADL are eligible to apply for formal caregiving services, and undergo assessment by well-trained care managers based on a questionnaire developed by the Ministry of Health, Labour and Welfare. On the basis of standardized scores for functional and cognitive impairment calculated from the questionnaire and based on physician's judgment report including the elderly's disease status, physical and cognitive status and performance-based measures, the eligibility of applicants for insurance benefits is judged by the Municipal Certification Committee. LTCI certification has been used in previous epidemiological studies as a measure of incident functional disability in the elderly (Aida et al., 2012; Hozawa et al., 2010; Tomata et al., 2012).

All participants were followed up by reviewing information on the date of LTCI certification, death, or emigration from Ohsaki City, which had been transferred yearly each December from the Ohsaki City Government under an agreement related to Epidemiological Research and Privacy Protection.

Statistical analysis

The person-years of follow-up were calculated from 16 December 2006 to the date of incident functional disability, date of emigration from Ohsaki City, date of death, or 30 November 2011, whichever occurred first. Cox proportional hazards regression analysis was used to investigate the hazard ratios (HRs) and 95% confidence intervals (CIs) for incident functional disability according to changes in time spent walking, treating participants who had remained inactive as the reference category.

The following variables in the 2006 Survey, which were thought to be unfavorable conditions for being active and may be related to incident functional disability, were considered as potential confounders: age (in years), sex (men or women), body mass index (in kg/m^2), history of diseases (stroke, hypertension, myocardial infarction, arthritis, osteoporosis, cancer, falls or fractures), education level (junior high school, high school, or college or higher), smoking status (never smoked, smoked in the past, currently smoking <20 cigarettes/day or currently smoking ≥20 cigarettes/day), alcohol consumption (never drank, drank in the past or currently drinking), pain (none or mild pain, moderate pain or more), and motor function score based on the Kihon Checklist.

To assess whether the risk of incident functional disability associated with changes in time spent walking differed by gender, age or subjects' motor function, we further stratified the participants according to gender (men versus women), age at the time of the 2006 Survey (65–74 years versus ≥75 years) and motor function (without limitation versus with limitation). Motor function limitation was defined by a motor function score of 3 points or more based on the Kihon Checklist completed in the 2006 Survey. The motor function score based on the Kihon Checklist has been evaluated previously and shown to have predictive validity for functional disability (Fukutomi et al., 2013; Tomata et al., 2011). Statistical evidence for differences in effect between these subgroups was assessed on the basis of log-likelihood ratio tests of interaction.

All statistical analyses were performed using the SAS software package (version 9.2; SAS Institute, Inc., Cary, North Carolina, USA). All statistical tests described here were 2-sided, and differences at $P < 0.05$ were accepted as significant.

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