表３　痛みの強さ別に見た要介護認定リスクのハザード比(HR)と95%信頼区間(95%CI)

	痛みの強さ				
	痛みなし	弱い痛み	中等度の痛み	強い痛み	傾向性P値
全体(14,053名)					
追跡人年	16,011	36,703	14,746	4,706	
イベント数	519	1355	794	313	
補正なしハザード比(95%信頼区間)	1.00(reference)	1.14(1.03,1.26)	1.67(1.50,1.87)	2.08(1.81,2.39)	<0.001
モデル1ハザード比(95%信頼区間)[a]	1.00(reference)	1.07(0.97,1.19)	1.42(1.28,1.59)	1.85(1.60,2.13)	<0.001
モデル2ハザード比(95%信頼区間)[b]	1.00(reference)	1.07(0.96,1.18)	1.41(1.26,1.58)	1.80(1.56,2.07)	<0.001
モデル3ハザード比(95%信頼区間)[c]	1.00(reference)	0.98(0.88,1.09)	1.15(1.02,1.29)	1.33(1.14,1.54)	<0.001
モデル4ハザード比(95%信頼区間)[d]	1.00(reference)	0.98(0.88,1.08)	1.14(1.02,1.29)	1.32(1.14,1.53)	<0.001
男性(6,337名)					
追跡人年	8,896	16,486	5,312	1,634	
イベント数	269	580	264	84	
補正なしハザード比(95%信頼区間)	1.00(reference)	1.16(1.01,1.35)	1.66(1.40,1.97)	1.72(1.34,2.19)	<0.001
モデル1ハザード比(95%信頼区間)[a]	1.00(reference)	1.17(1.01,1.35)	1.52(1.28,1.80)	1.62(1.27,2.07)	<0.001
モデル2ハザード比(95%信頼区間)[b]	1.00(reference)	1.15(0.99,1.33)	1.47(1.24,1.75)	1.50(1.17,1.92)	<0.001
モデル3ハザード比(95%信頼区間)[c]	1.00(reference)	1.06(0.92,1.23)	1.18(0.99,1.41)	1.09(0.84,1.42)	0.133
モデル4ハザード比(95%信頼区間)[d]	1.00(reference)	1.06(0.93,1.23)	1.18(0.99,1.41)	1.10(0.85,1.42)	0.132
女性(7,716名)					
追跡人年	7,115	20,217	9,434	3,072	
イベント数	250	775	530	229	
補正なしハザード比(95%信頼区間)	1.00(reference)	1.09(0.95,1.26)	1.61(1.39,1.87)	2.15(1.80,2.58)	<0.001
モデル1ハザード比(95%信頼区間)[a]	1.00(reference)	0.98(0.85,1.13)	1.34(1.15,1.56)	1.89(1.58,2.26)	<0.001
モデル2ハザード比(95%信頼区間)[b]	1.00(reference)	0.99(0.86,1.15)	1.35(1.16,1.57)	1.89(1.57,2.26)	<0.001
モデル3ハザード比(95%信頼区間)[c]	1.00(reference)	0.91(0.79,1.06)	1.11(0.95,1.30)	1.43(1.19,1.74)	<0.001
モデル4ハザード比(95%信頼区間)[d]	1.00(reference)	0.91(0.79,1.05)	1.11(0.95,1.30)	1.41(1.17,1.71)	<0.001

a.性、年齢(連続変量)を調整
b.モデル1に加え、既往歴1(脳卒中、心筋梗塞、高血圧、糖尿病)、教育歴(中卒、高卒、大卒、無回答)、喫煙状況(現在喫煙者、過去喫煙者、生涯非喫煙者、無回答)、飲酒状況(現在飲酒者、過去飲酒者、生涯非飲酒者、無回答)、体格指数(18.5未満、18.5～24.9、25以上)を調整
c.モデル2に加え、運動機能(基本チェックリストに基づくスコア:3点未満、3点以上、無回答)、心理的ストレス(K6スコア:13点以上、12点以下、無回答)、既往歴2(関節炎、骨粗鬆症、転倒・骨折)を調整
d.モデル3に加え、ソーシャルサポートで調整

折・転倒を合わせると25.8%を占め、脳血管疾患の15.9%と認知症の17.5%をおさえて最多原因となっている。これは、性別による層別化解析を行ったところ、女性でのみ痛みと要介護認定リスクに有意な関連をみとめた、本研究の結果を支持するものと考える。

痛みは主観的な概念であり、その感じ方や表現には文化、習慣、宗教および社会環境などが背景となり個人差や民族差が存在することが知られている。我慢と忍耐を美徳と考える国民性から、日本人は長きにわたり‘痛み’も我慢すべき対象のひとつと認識してきた。それ故、日本人は、世界的にみても痛みの治療に極めて消極的な民族であることが知られており、最近の国内の調査からも、鎮痛薬の使用量などがそれを裏付けている。すなわち日本には、欧米と比較して、治療を行わないまま痛みに耐えて生活し、要介護認定となるリスクが高い高齢者が多い可能性がある。高齢化に伴い、今後も痛みを抱えた高齢者は増え続けることが予想される。痛みが、社会全体のヘルスケアコストや高齢者の致死率に与える影響は、欧米よりも多大であり、かつ膨大傾向にある可能性が示唆される。我々は、薬物療法や運動療法など、多領域を巻き込んでの積極的な疼痛治療の啓蒙が必要であると考える。

本研究は大規模地域居住集団を対象とした前向き研究であり、いくつかの重要な交絡因子（運動器疾患を含む主要な既往歴、運動機能状態、心理的ストレスなど）が痛みの強さ、および機能障害発症に及ぼす影響について評価を行った。

しかし、本研究では過去一カ月間に感じた痛みの強さのみを調査した結果であり、痛みの原因や性質（急性痛か慢性痛か）、痛みに対する治療の有無とその内容、痛みの継時的な変化などは考慮していない。また、要介護認定を受けた者について、その原因は不明である。今後、さらに検討を行う必要があると思われる。

E．結　論

日本の地域在住高齢者において、痛みと要介護認定リスクに有意な関連が認められた。

F．健康危険情報

なし

G．研究発表

1．論文発表

なし

2．学会発表

なし

3．報道・その他

なし

H．知的財産権の出願・登録状況

1．知的特許

なし

2．実用新案取得

なし

3．その他

なし

Ⅳ. 研究成果の刊行に関する一覧表

研究成果の刊行に関する一覧表

[論文発表]

1. Chou WT, Tomata Y, Watanabe T, Sugawara Y, Kakizaki M, Tsuji I.
   Relationships between changes in time spent walking since middle age and incident functional disability.
   Preventive Medicine, 2014;59:68-72.

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

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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.

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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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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Results

From 1994 to 2006, 13.0% of the study participants remained inactive, 22.5% became inactive, 11.6% became active, and 52.9% remained active. The baseline characteristics of participants according to the changes in time spent walking categories are summarized in Table 2. Compared with the rest of the study participants, those who had become active were younger, included a higher proportion of men, included a higher proportion of current drinkers, were less likely to have a history of myocardial infarction, osteoporosis or cancer, and were less likely to have pain and motor function limitation.

During the 5 years of follow-up from 16 December 2006, we documented 712 incident functional disability (9.9%), 619 deaths (8.6%) and 59 losses to follow-up (0.8%) because of emigration. Table 3 shows the multivariate-adjusted HRs for incident functional disability according to the changes in time spent walking categories. In comparison with individuals who remained inactive, those who became active had a 31% lower risk of incident functional disability (HR = 0.69, 95% CI: 0.49–0.98), and those who remained active had a 36% lower risk of incident functional disability (HR = 0.64, 95% CI: 0.50–0.82). The risk of incident functional disability among individuals who became inactive was similar to that for individuals who remained inactive. Furthermore, we repeated the analyses after excluding individuals whose disability event occurred in the first year of follow-up (Model 3). When we excluded 253 such participants, the associations became slightly weaker but did not change substantially. The multivariate-adjusted HRs (95% CIs) for incident functional disability were 0.89 (0.66–1.19) for individuals who became inactive, 0.75 (0.50–1.12) for those who became active, and 0.64 (0.48–0.85) for those who remained active.

Table 4 shows the associations between changes in time spent walking and incident functional disability, after stratification by 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). The associations did not vary substantially between men and women (p for interaction = 0.71). In women, became active or remained active was associated with a lower risk of incident functional disability, with HRs (95% CIs) of 0.61 (0.39–0.96) and 0.60 (0.44–0.80), respectively. Similar results were observed in men, but were not statistically significant. The risks of incident functional disability were not altered significantly by age (p for interaction = 0.10). The multivariate-adjusted HRs (95% CIs) for individuals who became active were 0.58 (0.24–1.37) for those aged 65–74 years and 0.73 (0.50–1.06) for those aged ≥75 years. Furthermore, irrespective of whether or not participants had motor function limitation, those who became active tended to have a lower risk of incident functional disability (p for interaction = 0.97). The multivariate-adjusted HRs (95% CIs) for became active were 0.75 (0.47–1.19) for individuals without motor function limitation and 0.69 (0.41–1.18) for those with motor function limitation, although this was not statistically significant.

Table 2
Baseline characteristics of participants according to the changes in time spent walking categories (December 2006, Ohsaki City, Miyagi Prefecture, Northeastern Japan).

	Remained inactive	Became inactive	Became active	Remained active	P-value[a]
Number at risk	937	1614	832	3794	
Age, mean (SD), years	75.8 (5.7)	76.1 (5.8)	74.0 (5.5)	74.2 (5.5)	<0.0001
Men (%)	43.3	41.3	46.9	45.9	0.0072
Body mass index, mean (SD), kg/m^2	23.9 (3.5)	23.6 (3.8)	23.7 (3.3)	23.4 (3.3)	0.0011
Current smoker (%)	12.4	14.0	12.4	13.5	0.7339
Current drinker (%)	33.6	30.2	38.8	37.3	<0.0001
Education until age 15 (%)	29.3	33.6	31.5	30.1	0.2239
History of diseases (%)					
Stroke	3.7	3.9	3.3	2.2	0.0021
Hypertension	47.1	50.7	42.2	40.1	<0.0001
Myocardial infarction	6.2	6.3	4.2	4.7	0.0244
Arthritis	20.3	19.0	15.1	14.8	<0.0001
Osteoporosis	14.1	13.4	8.5	9.7	<0.0001
Cancer	12.0	10.2	6.9	7.4	<0.0001
Falls or fractures	17.8	18.9	18.0	15.2	0.0036
Moderate pain or more (%)	36.8	37.4	24.0	24.7	<0.0001
Motor function limitation (%)[b]	38.3	40.6	18.0	16.7	<0.0001

[a] P-values were calculated by analysis of variance or chi-square test.

[b] With three points or more to the following five motor function questions in Kihon Checklist: 'Are you able to go upstairs without holding rail or wall?', 'Are you able to stand up from the chair without any aids?', 'Are you able to keep walking for about 15 min?', 'Have you fallen down during the past year?', 'Do you worry about falling down?'.

Discussion

In this large longitudinal population-based study of Japanese community-dwelling elderly, we observed that an increase in time spent walking among sedentary middle-aged adults was significantly associated with a lower risk of incident functional disability. Even in those who were very old or with limited motor function, becoming active from middle age tended to be associated with a lower risk of incident functional disability.

These results were consistent with previous longitudinal studies based on self-reported physical activity levels at different time points and subsequent functional status (Berk et al., 2006; Brach Js, 2003; Gretebeck et al., 2012; Wannamethee et al., 2005). Those studies found that in comparison with people who had always been inactive since middle age, those who increased their physical activity had better physical performance or lower disability scores in old age. In the present study, after 5 years of follow-up, we noticed that in a senior population aged more than 65 years, not only those who remained active also those who became active had lower risks of incident functional disability, than those who remained inactive for the previous 12 years. Furthermore, for those who became inactive, the risk of incident functional disability was similar to those who remained inactive, which was consistent with those of previous studies about changes in physical activity level and mortality (Balboa-Castillo et al., 2011; Gregg et al., 2003).

The British Regional Heart Study observed that the protective effects of maintaining or increasing physical activity against risks of mobility limitation were largely attenuated following adjustment for chronic diseases and clinical symptoms (Wannamethee et al., 2005). In the present study, after adjusting for possible confounders including history of diseases, body pain and motor function status, we found that an increase in time spent walking among sedentary middle-aged adults was still significantly associated with a lower risk of incident functional disability. Furthermore, the associations did not vary substantially by gender, age or motor function. This is important because it suggested that the lower risks of incident functional disability associated with increasing or maintaining physical activity level was not only a result of younger age, better motor function or higher intensity of physical activity in men. In our study population, even among individuals who were more than 75 years old or with motor function limitation, older adults who remained active since middle age had a significantly lower risk of incident functional disability. Therefore, even for those who may find it difficult to be physically active, maintaining or adopting an active lifestyle should be continuously promoted.

Most previous studies examining the health effect of changes in physical activity were focused on longevity (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). In the present study, we also observed that in comparison with individuals who remained inactive, those who became active tended to have lower risk of all-cause mortality (HR = 0.78, 95% CI: 0.54–1.09) (data not shown). We further observed that individuals who became active and those who remained active were also associated with a reduced risk of incident functional disability. The present study has expanded knowledge in this field because it showed that maintaining or adopting an active lifestyle not

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Table 3
Hazard ratios (HRs) and 95% confidence intervals (CIs) for incident disability according to the changes in time spent walking categories (December 2006, Ohsaki City, Miyagi Prefecture, Northeastern Japan).

	No. of cases	Person-years	Model 1	Model 2	Model 3
			HR (95% CI)[a]	HR (95% CI)[b]	HR (95% CI)[c]
Remained inactive	134	3924	1.00	1.00	1.00
Became inactive	252	6679	1.14 (0.96–1.36)	0.98 (0.78–1.25)	0.89 (0.66–1.19)
Became active	62	3779	0.62 (0.46–0.84)	0.69 (0.49–0.98)	0.75 (0.50–1.12)
Remained active	264	17,266	0.56 (0.45–0.68)	0.64 (0.50–0.82)	0.64 (0.48–0.85)

[a] Model 1 was adjusted for age (years), sex.
[b] Model 2 was adjusted for age (years), sex, BMI (kg/m^2), history of stroke (yes/no), history of hypertension (yes/no), history of myocardial infarction (yes/no), history of arthritis (yes/no), history of osteoporosis (yes/no), history of cancer (yes/no), history of falls or fractures (yes/no), education (junior high school or less, 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 limitations (yes/no).
[c] Model 3 was further excluded people whose event of disability occurred in the first year of follow-up.

only improved longevity, also resulted in healthier aging. Thus, for healthy aging, our message to those who are currently sedentary is that it is never too late to start walking.

This study had several strengths in addition to its prospective nature and large community-dwelling population base. First, we assessed the effects of several important confounding factors on changes in time spent walking and incident functional disability: history of diseases, body pain and motor function status. Subgroup analysis of motor function status was also conducted to confirm that there was no interaction between motor function limitation and time spent walking with incident functional disability. Second, the data on incident functional disability were more accurate than self-reported information because the outcome was obtained from the public LTCI database, which is based on uniform nationwide criteria of functional disability, and thus the data were considered reliable.

Several limitations should also be noted. First, we assessed walking using a simple questionnaire in which we asked the participants to report only the time spent walking and did not ask about walking pace, distance walked or any distinction between walking for exercise and other reasons, and there was no information about the reason of any change in time spent walking. However, physical activity level was noted to be affected by psychological distress and mental disorder in previous studies (Bonnet et al., 2005; Muhsen et al., 2010). It may be one reason for being or becoming inactive, where reverse causation may not be totally avoided. Second, we did not investigate the causes of functional disability in subjects who received LTCI certification. Thus, the most effective component responsible for reduction of functional disability by becoming or remaining active will need to be clarified in the future. Third, our endpoint could have been underestimated because the qualification process for obtaining LTCI benefit requires voluntary application. Furthermore, non-response bias and survival bias should be considered because the incidence rate of functional disability in the present study (9.9%) was much lower than that for all Japan (17.3%) (Ministry of Health, 2012).

Conclusion

An increase in time spent walking among sedentary middle-aged adults was significantly associated with a lower risk of incident functional disability. Even in those who were very old or with limited motor function, becoming active from middle age tended to be associated with a lower risk of incident functional disability. Our results suggest that, for healthy aging, active people should remain active as they age, and for those who are currently sedentary, it is never too late to start walking.

Conflict of interest statement

The authors declare that there are no conflicts of interest.

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Table 4
Hazard ratios (HRs) and 95% confidence intervals (CIs) for incident disability according to the changes in time spent walking categories, by gender, age and motor function status (December 2006, Ohsaki City, Miyagi Prefecture, Northeastern Japan).

	Gender		Age		Motor function	
	Men	Women	65–74	≥75	No limitation	With limitation
Remained inactive (cases/n)	49/406	85/531	21/385	113/552	50/578	84/359
HR (95% CI)[a]	1.00	1.00	1.00	1.00	1.00	1.00
Became inactive (cases/n)	95/666	157/948	42/671	210/943	88/958	164/656
HR (95% CI)[a]	1.16 (0.77–1.74)	0.88 (0.65–1.18)	1.17 (0.64–2.15)	0.96 (0.74–1.25)	0.98 (0.67–1.43)	0.99 (0.72–1.35)
Became active (cases/n)	31/390	31/442	10/447	52/385	38/682	24/150
HR (95% CI)[a]	0.83 (0.48–1.43)	0.61 (0.39–0.96)	0.58 (0.24–1.37)	0.73 (0.50–1.06)	0.75 (0.47–1.19)	0.69 (0.41–1.18)
Remained active (cases/n)	103/1740	161/2054	52/2036	212/1758	169/3162	95/632
HR (95% CI)[a]	0.72 (0.48–1.09)	0.60 (0.44–0.80)	0.65 (0.36–1.18)	0.63 (0.48–0.82)	0.69 (0.49–0.98)	0.62 (0.44–0.88)
p for interaction	0.71		0.10		0.97	

[a] Model was adjusted for age (years), sex, BMI (kg/m^2), history of stroke (yes/no), history of hypertension (yes/no), history of myocardial infarction (yes/no), history of arthritis (yes/no), history of osteoporosis (yes/no), history of cancer (yes/no), history of falls or fractures (yes/no), education (junior high school or less, 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 limitations (yes/no).

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